JIMMA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

JIMMA INSTITUTE OF TECHNOLOGY

FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING

CONSTRUCTION ENGINEERING AND MANAGEMENT

EFFECT OF MOLASSES ON PROPERTIES OF C-25 CONCRETE AS ADMIXTURE

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 Construction Engineering and Management.

BY:Meron Endalkachew

December, 2019

Jimma, Ethiopia

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EFFECT OF MOLASSES ON PROPERTIES OF C-25 CONCRETE AS ADMIXTURE

MERON ENDALKACHEW TAKELE

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DECLARATION

I declare that this thesis entitled "**Effect of Molasses on Properties of C-25 Concrete as Admixture**" is my original work. This study has not been presented for any other university and is not concurrently submitted in candidature of any other degree.

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ABSTRACT

Concrete is one of the most widely used construction materials. As the growth of construction industry increases, the demand and costs of construction material increases. In concrete technology, additional materials are needed to improve properties of concrete such as admixtures. The major advantage of admixtures in concrete is important to improveworkability, strength, and setting time, impermeability and colorof concrete. But, as we know in our country there is lack of admixtures and it is expensive to be used in construction. Hence, researcher is attempting to use the locally available waste materials (by product) as an effective and economical additive to maintain quality of concrete.

This research therefore evaluated the Effect of Molasses on properties of C-25 Concrete as Admixture. The study was conducted by laboratory Experimental design in order to detect the effect of molasses on concrete properties.A concrete without molasses for control sample and seven trial with varying percent of molasses were taken and three cubes of 150mm x 150mm x 150 mm for compressive strength at 3, 7,14 and 28 days of curing age was casted. These percentages were 0.1%, 0.2%,0.3%,0.4%,0.5%,0.6% and,0.7% of molasses by weight of cement. The materials used were batched by weight and mixing was carried out with concrete mixing machine in the mix ratio of 1:2:2.56 with w/c ratio of 0.5. While the percentage of molasses was dissolved in mix water before adding to the mix of the concrete.

As a result, it has been Noticed that the concrete production with the addition of successive percentage of molasses shows delay in the initial and final setting time and as the molasses dosage increase in the mix, the slump value also increased. Moreover, a concrete prepared with various percent of molasses shows a slight increase in compressive strength at later ages. The optimum value of compressive strength taken from concrete containing 0.1 up to 0.7% of molasses. Based on the test result,6.98%, 10.41% 13.54%,7.88%,3.86%, 2.43% and 1.03 % increase in compressive strength was observed for 0.1%,0.2%, 0.3%,0.4%, 0.5%, 0.6% and 0.7%, of molasses at 28-day curing age respectively when compared with the control sample. Therefore, the 0.3% of molasses was taken as optimum dosage of molasses.

Finally, it is concluded that When the amount of molasses increases in the cement paste, the initial and final setting time of the paste is prolonged. The Compressive strength of concrete with molasses at early age is lower than the concrete with zero molasses. But, the compressive strength at later age i.e. at 28 days is higher than the Compressive strength of concrete group.It is recommended that, to use molasses as a water reducing and retarding admixture in replacing the chemical admixture wherever required.

Keywords: Admixtures, Compressive Strengths, Concrete, Molasses, Setting time, Workability.

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ABREVIATIONS

ACI	American Concrete Institute
ASTM	American Standard Test for Materials
BS	British Standard
ES	Ethiopian Standard
FM	Fineness Modulus
Kg/m3	Kilogram per meter cubic
MMT	Million Metric Ton
MPa	Mega Pascal
OPC	Ordinary Portland Concrete
%	Percentage
SSD	Saturated surface dry
W/C	Water –cement ratio
WRA	Water Reducing Admixture

CHAPTER ONE
INTRODUCTION

1.1. Backgroundof The Study

Concrete is a heterogeneous material which consists of a chosen mixture of binding materials such as cement, fine and coarse aggregates, water and admixtures to produce concrete with special properties (Duggal, 2008).chemical admixtures are any chemical additives to the concrete mixture that enhances the properties of concrete in the fresh or hardened state. (ASTMC494, 2013)

Currently there are different and many types of admixtures are produced from different suppliers around the world in order to improve the fresh or hardened property of concrete,such asAdmixture retard the initial setting time of concrete, increase the strength, improve the workability and durability, reduce shrinkage during setting of concrete, increase the bond between old and new concrete surfaces and also between concrete and reinforcement Water-reducing admixture are used to reduce the water content for a given slump or increase workability without increasing water demand in concrete. Moreover, water-reducing and retarding admixture is an admixture that reduces the quantity of mixing water required to produce concrete of a given consistency and retards the setting of concrete(ASTM-C494, 2013)**.**

In developing country like Ethiopia, due to rapid infrastructural growth the demand for admixtures is very high. However, there is lack of admixtures and very expensive to be used in construction industry. For this reason, it is necessary to use easily available waste material like molasses, a byproduct of sugar industry. When sugar is extracted from the sugar juice, some amount of sugar remainsas the waste liquid material which is called as molasses(M'Ndegwa,J.K., 2016).

Molasses as an admixture can be used for preparation of concrete. The means of using molasses instead of conventional admixture will not only cut down the production cost of concrete but it will also enhance its resistance to compressive strength. In addition, it leads to the reduction in water utilization, expansion of setting time and likewise they improve the durability, workability and quality of concrete mixture(Jumadurdiyev et al., 2005).

Sugar is one of the best retarding admixture that can be used as water- reducing and set-retarder admixture. some researchers concluded that sugar allow a reduction in water content of the concrete without affecting its workability (Greesan et al., 2014).

The data from Sugar Corporation shows Every year, about half a million ton of molasses from sugar factories are produced in Ethiopia. The Government of Ethiopia predicts the country to become the world eighth largest sugar producer by 2023 with production estimate of 4.2MMT, following Australia (4.8MMT) and leading the United States of America (3. 3MMT). Such huge amount of molasses disposed by these sugar factories is a growing environmental threat to the country unless recycled or reused for other purposes. Some of the molasses produced in Ethiopia is used for the production of ethanol and animal food.

The aim of this research was toevaluate the effect of molasses on properties of C-25 concrete as admixture to reduce the cost of concrete as well as reducing the environmental pollution.

In this research to achieve the objectives, applying all the requirements procedure starting from Literature Review, sample collection, conducting relevant laboratory tests and analysis of results obtained from input data was necessary. Finally, conclusion has been formulated and recommendation was forwarded to whom it concerns.

1.2. Statement of the problem

Concrete consists of Ordinary Portland Cement, aggregates (coarse and fine) and water. To improve the characteristics of concrete, nowadays addition of admixtures to the concrete is widely used.The use of local materials is an important part of sustainability for the concrete industry(Muhammed,et al., 2016).

In developing country like Ethiopia, due to rapid infrastructural growth the demand for admixtures is very high. But, there islack of chemical admixtures andit is expensive to be used in construction and alsosome local construction parties that participate in the construction industry have little information and awareness about the uses and effects of admixtures on the production of quality concrete.Therefore, there should be a means how to use the locally available waste in replacing the chemical admixture so as to maintainproduction of qualityconcrete andto minimize the cost of concrete as well as reducing the environmental pollution.Here in this study, the researcher introduces easily available and cost effective admixture which is molasses, a byproduct from sugar factory.Molasses as an admixture can be used for preparation of concrete. This means of utilizing molasses instead of conventional admixture will not only cut down the production cost of concrete but it will also enhance its resistance to compressive strength (Jumadurdiyev et al., 2005).

Therefore,the main goal of this research was to evaluate the effect of molasses on the fresh and hardened property of C-25 concrete as a water reducing and retarding admixture.

1.3. Research Questions

1. What is the physical and chemical propertiesof molasses?
2. What is the effect of molasses on setting time, workability and compressive strength on C-25 concrete?
3. What is the optimum dosage of molasses as admixture in concrete?

1.4. Objectives

1.4.1. General objective: -

The main objective of this study was to evaluate the effect of molasses on properties of c-25 concrete as admixture.

1.4.2. Specific Objectives: -

1. To know the physical and chemical propertyof molasses
2. To evaluate the effects of molasses on setting time, workability and compressive strength of C-25 concrete.
3. To determinetheoptimumdosage of molasses as admixture inconcrete.

1.5. Significance of the Study

Some of the molasses produced in Ethiopia is used for the production of ethanol and animal food. The finding of this study will forward additional application of sugarcane-byproduct which is molasses as water reducing and retarding admixture for concrete and The successful use of molasses will help to reduce the amount of chemical water reducing and retarder admixture to be imported and purchased with hard currency. Besides, Contractors,Consultantsand local communities will benefit from the study as a source of information that can help to improve the setting time, workabilityand compressive strength of concrete inaddition to standard and specifications. And also other researchers will use the findings as a reference for further researches.

1.6. Scopeof the Study

The research focused on the effects of molasses as water reducer and retarder on the properties of concretes. The tests carried out in order to achieve the objectives of this research includes; workability test, setting time test and compressive strength test and the percentage addition of molasses were 0%,0.1%,0.2%,0.3%,0.4%,0.5% 0.6% and 0.7% by weight of cement. Curing ages were performed at 3,7,14 and 28 days.

CHAPTER TWO

LITERATURE REVIEW

2.1. Introduction

Concrete is basically a mixture of two components which are aggregates and paste. The paste, comprised of Portland cement and water, binds the aggregates (usually sand and gravel or crushed stone) into a rocklike mass as the paste hardens because of the chemical reaction of the cement and water. Supplementary cementations materials and chemical admixtures may also be included in the paste **(**Kosmatka et al., 2003)**.**

2.2. Materials for concrete

2.2.1. Cement

Portland cement is the most commonly utilized cement in almost every part of the world. Theunderstanding of the embodiment of Portland cement could lead to a more sustainable concreteand mortar design. It chemically reacts with water to attain setting and hardening properties when used in the construction of buildings, roads, bridges, and other structures. **(**Kosmatka et al., 2003)**.**

The main chemical compounds in cement are calcium silicates and aluminates. When water is added to cement and the constituents are mixed to form cement paste, chemical reactions occur and the mix becomes stiffer with time and sets.(Neville, A.M & Brooks,J.J., 2010)

- **Setting and hardening time of cement**

Portland cement is hydraulic; when mixed with water it forms a paste, which sets and hardens as a result of various chemical reactions between the cementitious compounds and water.The additional water is needed to ensure the workability of the mix when aggregates are added. Water in excess of that required for hydration will ultimately evaporate leaving capillary pores in the concrete and mortar products.It is therefore necessary to control carefully the water content of the mix by reference to the water/cement ratio.(Lyons, 2007).The setting and hardening processes should be distinguished. Setting is the stiffening of

the cement paste, which starts immediately the cement is mixed with water. Because the major cementitious constituents set at different rates it is suitable to refer to initial set and final set. Typically, Initial set is the point in time when the cement paste starts to harden considerably. Beyond this point, further mixing of the concrete is harmful. Final set on the other hand, is the point in time when the concrete starts to gain strength. Initial set frequently occurs within 1 hour, while final set takes 10 hours after initial watercement contact (Duggal, 2008).

2.2.2. Aggregates

Aggregates are the materials basically used as filler with binding material in the production of concrete and provide concrete with better dimensional stability and wear resistance. They are derived naturally from igneous, sedimentary and metamorphic rocks. Therefore, it is important to obtain right type and quality of aggregates (fine and coarse). Because aggregates occupy 60% to 75% of the concrete volume (70% to 85% by mass) and strongly influence the concrete's freshly mixed and hardened properties, mix proportions, and economy (Duggal, S.K., 2000).

Coarse Aggregates: Coarse aggregates are the material that will be retained on a No. 4 sieve. In determining the maximum size of coarse aggregate, there are factors that must be considered.

Fine Aggregates: Fine aggregate or sand is a product of natural or artificial disintegration of rocks and minerals. Sand is obtained fromriver, lake, marine, residual and wind-blown (very fine sand) deposits(Dinku A. , 2002).

2.3. Admixtures

Admixtures are the materials other than the standard combination of Portland cement, water and aggregates which are added to concrete to improve its properties. Some of these properties are workability, acceleration or retardation of setting time,control of strength development, and rate of setting, enhancement of resistance to frost actionimpermeability,thermal cracking,alkali-aggregate expansion and color (Oladiran et al., 2012)**.**

Neville , A.M, (2006)claimed that the radical growth of admixture application in concrete is due to the fact that the utilization of admixture in concrete mix grants considerable benefits with respect to physical and financial aspects. Admixture's are used, for example, to increase the plasticity of concrete without increasing the water content, to reduce bleeding and segregation, to retard or accelerate the time of set, to accelerate the rates of strength development at early ages, to reduce the rate of heat evolution, and to increase the durability of concrete to specific exposure conditions (Mehta, P. K., & Monteiro, P. J. M., 2001)

2.3.1. History of Admixtures

History has shown that admixture is as old as concrete itself. The Romans used animal fat, milk, and blood to improve their concrete properties. Although these were added to improve workability, blood was a very effective air-entraining agent and might well have improved Roman concrete durability. In more recent times, calcium chloride was often used to accelerate the hydration of cement(Li.Z, 2011)**.**In addition, admixture embraces a very massive in area of construction. Water reducers generally referred as plasticizers, retarders and super plasticizers are of recent interest. They are specifically developed in Japan and Germany around 1970. Later on, they were made popular in USA and Europe even in Middle East. Nowadays, admixtures are important and necessary components for modern concrete technology. The concrete properties, both in fresh and hardened states, can be modified or improved by admixtures. (Shetty, M.S., 2009)

2.3.2. Classification of Chemical Admixtures

Admixture broadly classified as mineral and chemical admixtures. Chemical admixtures are any chemical additives to the concrete mixture that enhances the properties of concrete in the fresh or hardened state. The general purpose chemicals include those that reduce the water demand for a given workability which are called water reducers, and those chemicals that control the setting time and strength gain rate of concrete are called accelerators and retarders. Chemical admixtures are categorized as Type A- water reducing admixture, Type B- retarding admixture, Type C- accelerating admixture, Type D- water-reducing and retarding admixture, Type E water- reducing and accelerating admixture, Type F- water- reducing, high range admixture, Type G water- reducing, high range and retarding and Type S- specific performance admixture(ASTMC494, 2013)**.**the most common types of admixture, their desired effect and materials according to main standards from two different organizations (ASTM and AASHTO). Table 2.1 Concrete Admixtures by Classification (Kosmatka et. al., 2003).

Table 2. 1 Water reducing admixture(Kosmatka et. al., 2003)

TYPE OF ADMIXTURES	Material	DESIRED EFFECT
Water Reducer (ASTM C494 and AASHTO M194,type A)	Lignosulfonates, Hydroxylated carboxylic acids, Carbohydrates (also tend to retard set so accelerator is often added)	Reduce Water content at least 5%
Retarders (ASTM C 494 and AASHTO M 194, Type B)	Lignin, Borax, Sugars ,Tartaric acid and salts	Retard setting time
Water Reducer and Retard (ASTM C494 and AASHTO M194,type D)	See water reducer, Type A (retarder is added)	Reduce Water content (min 5%)& Set Retard
Water Reducer and Accelerator (ASTM C494 and AASHTO M194,type E)	See water reducer, Type A (accelerator is added)	Reduce Water content (min 5%)& Set Accelerator
WaterReducing-High Range (ASTM C494 and AASHTO M194,type F)	See superplasticizers and also water reducers	Reduce Water content minimum 12%
WaterReducing-High Range and Retarding (ASTM C494 and AASHTO M194,type G)	See superplasticizers and also water reducersType A (retarder is added)	Reduce Water content minimum 12% and set retard

This research focus on the effect of water reducing and retarder admixture on the rate of setting and workability to utilize sugar by product which is molasses.

2.3.3. Water Reducing Admixtures (Type A)

Water-reducing admixtures are used to reduce the quantity of mixing water required to produce concrete of a certain slump, reduce water-cement ratio, reduce cement content, or increase slump. Typical water reducers reduce water content by approximately 5-10%.(ACI 2123R-04, 2001). *The* actual reduction in water depends on dose of admixtures, cement content and type of aggregate used(Li.Z, 2011)**.**The reasons for using water reducing admixtures as specified are to:

1. Achieve a higher strength by reducing water/cement ratio at the same workability.
2. Increase the workability of concrete so as to ease placing in inaccessible location. This is Particularly useful when concrete pores are restricted either due to congested Reinforcementordue to thin sections.
3. Save in the quantity of cement (approx. up to 10%) can be achieved keeping the same water/ Cement ratio and workability(Neville, A.M & Brooks,J.J., 2010)**.**

2.3.4. Retarding Admixtures (Type B)

This type of chemical admixtures is capable of delaying or prolonging the setting of cement paste, thus concrete remains plastic and workable for a longer time than normal concrete without changing its mechanical properties. It is also used to overcome the accelerating effect of hot weather on setting time of concrete. It functions by coating the surface of tricalcium silicate (C3S) components, thus delaying this reaction with the water(Greesan et al., 2014).

Retarders slow down the speed of the reaction between cement and water by affecting the growth of the hydration products and/or reducing the rate of water penetration to the cement particles. The use of a retarder will increase the setting time and the early strength may be reduced but the ultimate strength of the concrete can be improved (AFCA, 2005)**.**

At early age, addition of retarders not able to increase the compressive strength of concrete, on the other hand, it reduces the strength significantly, and become worse when the dosages increase. The reason for this phenomenon is that addition of retarder to the concrete will delay the reaction of C3S and C3A. As a result, strength development is low(Salahaldein, A., 2013).

- **Benefits of retarding admixtures**

According to Schaeffel et al. (2014) retarders are used to delay the setting of concrete:

1. to offset the accelerating effect of hot weather instead of expensive cooling

2. for long transport distances

3. when difficult or unusual condition of placement occur.

And also, when casting massive concrete structures:

1. to avoid construction joints or lack of bond between concrete layers

2. to reach a uniform strength developments

3. to reduce the maximum hydration heat (lower the risk of cracking)

2.3.5. Water reducing and retarding admixtures(type D)

An admixture that reduces the quantity of mixing water required to produce concrete of a given consistency and retards the setting of concrete.admixtures which are only water-reducing are called Type A, but if the properties are associated with retardation, the admixture is classified as Type- D (ASTMC494, 2013).the purpose of using a water reducing admixture in a concrete mix is to allow a reduction in the water cement ratio while retaining the desired workability or, alternatively, to increase its workability at a given water cement ratio. In general, they prolong the time and workability during which concrete can be transported, placed, and compacted (Kosmatka et al., 2003). Nowadays concrete material is feed to the site by truck mixers in which the mixing process takes place in a site other than the construction. During the hauling of this ready-mix concrete stiffens of the mix encountered to avoid this preventing strength development is essential. Thus usingwater reducing and retarding admixture maintains the problem.

2.4. Sugar Cane Molasses

Sugar cane molasses is a viscous byproduct of the processing of sugar cane into sugar. During the sugar making process, the juice extracted from sugar cane is boiled down until the sugars crystallize and precipitate out. The syrup left over after crystallization is referred to as molasses (Olbrich, H., 1963).Molasses consist of Dry 76-84% (including sucrose 46-51%) reducing substances 1-2.5%, raffinose 0.8-1.2%, inverted sugar 0.2-1.0%, volatile acids 1.2% and ash 6-10% (Peter et al, 2007).

2.4.1. Use of Molasses

Molasses have a wide range of usage, such as animal feed and in ethanol production. And also Molasses is applied in many food or non-food processes because of high content of nitrogenous compounds, carbohydrates and its sweet taste(BubnikaE, Z.,2012). In addition, Molasses as an admixture can be used for preparation of concrete. This means of utilizing molasses instead of conventional admixture will not only serve as minimizing the production cost of concrete but it will also enhance its resistance to compressive strength(Jumadurdiyev et al., 2005)**.**

A great amount of molasses has been used in cement concretes as a water-reducing and retarding admixture (Liu et al., 2009). The molasses produced in Ethiopia is mainly used in production of alcoholic drinks, and also used as animal feeds.The use of molasses in road sector is as soil stabilizing material (Taye, B, 2015).

2.4.2. Molasses Production in Ethiopia

The data from Sugar Corporation shows Every year, about half a million ton of molasses from sugar factories are produced in Ethiopia. Now days, the Government of Ethiopia is undergoing mega Sugar Development projects for improvementsugar production capacity to a significant level. Therefore, there will be significant supply of Molasses in the recent years. Using Molasses for concrete as admixture have significant socio-economic benefits namely; reducing industrial process wastes and cost minimization of concrete construction projects. The Molasses used for this study was sourced from Arjo didessa Sugarfactory. Based on a study conducted by the researcher; the indicative Molasses availability of the factory is estimated to be 8000tons/year. Some of the molasses produced in this factory was used for the production of ethanol and animal feedstock.

2.4.3. Chemical Composition of Molasses

Molasses is not just one chemical compound, but many. The main content is sugar (sucrose) ($C_{12}H_{22}O_{11}$). The composition of molasses is influenced by the soil where the cane is grown, climatic conditions, variety and maturity of the cane and the processing conditions at the factory.The chemical Composition of Kenyan molasses, Indian molasses and the world average of molasses composition have been **reported** **(Olbrich, H., 1963)** and **(M'Ndegwa,J.K., 2016)**on the following table 2.2

Table 2. 2Constituent value for cane molasses (M'Ndegwa,J.K., 2016)&(Olbrich, H., 1963)

Constituents	Kenya	India	World Average
pH	5.7	4.2	-
Specific gravity	1.46	-	-
Moisture (%)	21.9	19.1	20
Total Sugar	57.0	55.96	62
Sucrose (%)	37.1	22.93	32
Invert Sugar (glucose & fructose) (%)	19.9	-	30
Ash (%)	8.1	19.75	-
Major mineral elements found in Cane Molasses			
Ca (%)	1.09	2.27	1.5
Mg (%)	0.15	-	0.1
Na (%)	0.02	-	-
K (%)	2.97	-	3.5
Si (%)	0.30	-	0.5

2.4.4. Molasses as Water reducing and retarding admixtures

A great amount of molasses has been used in cement concretes as a water-reducing and retarding admixture in several countries(Liu et al., 2009)**.** Molasses improves the workability and fluidity of fresh concrete and delays setting period of cement paste(Jumadurdiyev et al., 2005)**.** Molasses is slightly a water-reducing admixture. By adding 5 percent molasses by weight of cement, water being reduced by 12 percent for the same workability of mortar.(Juneja et al., 2017)**.**

(Somawanshi et al, (2016) studied that the addition of molasses to the concrete greatly influenced the setting property of concrete. and also he observed a slight reduction of the mixing water for constant workability.In addition,(Kumar, D., 2015)**,** studied the effect of molasses on concrete property and he found that when molasses is added to the concrete mixture it will increase the mixture's initial and final setting times. Retarders generally slow down the hardening of the cement paste by stopping the rapid set shown by tricalcium aluminate but do not alter the composition of hydration products(Neville , A.M, 2006).

Retarders are used in concrete to offset the accelerating and damaging effect of high temperature and to keep concrete workable during the placing period. The use of retarder and water reducer admixture allows a reduction in the amount of water in the mixture, and therefore a decrease in the water/cement ratio and an increase in compressive strength(Khan , B . & Ullah, M., 2004).

2.5. Effect of Molasses on Concrete Properties

2.5.1. Effect of molasses on compressive strength of concrete

The compressive strength of concrete is one of the most important and useful properties of concrete. Molasses as an admixture can be used for preparation of concrete. This means of utilizing molasses instead of conventional admixture will not only cut down the production cost of concrete but it will also enhance its resistance to compressive strength (Jumadurdiyev et al., 2005)**.**

addition of molasses of by weight of cement gives an increased in initial and final setting time and also it increases the compressive strength of concrete when compared with the control sample atall day age(Pathan, S. B., 2017). Similarly, the molasses has a significant effect on the compressive strength. when molasses is added to the concrete mixture it will improve the mixture's initial and final setting times additionally, adding molasses to concrete improves the concrete's workability and compressive strength (Abalaka, A.E., 2011b).

Different researcher concluded that the use of molasses in concrete could modify the fresh and harden properties of concrete. However, there is a big difference in the optimum percentage of molasses to bring a positive effect up on the properties of concrete. some of the works related to this research is mentioned. The results showed that 0.15% addition of Molasses increased the compressive strength to about 43.9% at 28days hydration period.(Shantanu et al., 2017).

The 28-day compressive strength of mortar gets increased up to a dose of 0.25 percent by weight of cement and then decreases with lower rate so much so that at 0.50 percent dose the compressive strength is more than the reference strength(Juneja et al., 2017).

the compressive strength of mortar and the compressive strength of the concrete mixes are maximum at 0.25 percent dose of molasses by weight of cement. Hence in general he concluded that the most favorable dose of molasses is 0.25 percent dose, but it can be used safely in the range of 0 to 0.50 percent by weight of cement(Aalm, A., & Singh, P., 2016)**.**

2.5.2. Effect of molasses on workability of concrete

American Concrete Institute (ACI) 116R defines workability as "that property of freshly mixed concrete or mortar that determines the ease and homogeneity with which it can be mixed, placed, compacted and finished to a homogenous condition". Workability can be identified by three main parameters (Neville, A.M, 2006).

Cohesiveness: the resistance to segregation,

Consistency: the ease of flow, and

Plasticity: the ease of molding.

The purpose of using a water reducing admixture in a concrete mix is to allow a reduction in the water cement ratio while retaining the desired workability or, alternatively, to improve its workability at a given water cement ratio

Molasses improves the workability and fluidity of fresh concrete and delays setting period of cement paste.Retarding admixtures like molasses allow a reduction in water content of the concrete without affecting its workability (Shantanu et al., 2017)**.** the effects of Molasses on the strength properties of concrete was studied by Shahidkha. The findings revealed that as the percentage of molasses increased the workabilityalso increasedas compared to the controlsample(Pathan, S. B., 2017).

2.5.3. Effect of molasses on setting time of concrete

The times from the addition of water to the initial and final set are known as setting times.

It is identified as the transition of fresh concrete from liquid phase to solid phase. It is important to identify this phase change to plan transporting and placing of concrete. Current practice of determining initial setting time of concrete is based on (ASTM C403, 1999). Cane molasses delays the setting times, and that cements containing more cane molasses show the longer setting time(Jumadurdiyev et al., 2005)**.** when molasses is added to the concrete mixture it will improve the mixture's initial and final setting times(Kumar, D., 2015).

Retarders generally slow down the hardening of the cement paste by stopping the rapid set shown by tricalcium aluminate but do not alter the composition of hydration products (Neville , A.M, 2006).

Generally, retarding admixtures delay both initial and final setting time. The amount of retardation depends on the dosage of admixture used, the type of cement used, the amount of mixing water, and the temperature of the concrete.the initial and final setting times increased with molasses content of 0.25% by weight of cement(Abalaka, A.E., 2011b). Moreover, (Khan, B., & Baradan, B. , 2002)studied on the effects of sugar on setting time of various types of cements. The results revealed that sugar content of 0.15% limit extends the setting time of cement paste.

CHAPTER THREE
RESEARCH METHODOLOGY AND MATERIALS

This chapter focuses on over all methodology and material used in conducting the research .it includes the experimental investigations, mix proportioning, concreting process and method of analysis.

3.1. Study Area

The study was conducted at Oromia regional state of Jimma zone, southwestern Ethiopia which is located 346 km by road southwest of Addis Ababa. Its geographical coordinates are between 7° 13'- 8° 56N latitude and 35°49'-38°38'E longitude with an estimated area of 19,506.24. The town is found in an area of average altitude, of about 5400 ft. (1780 m) above sea level.

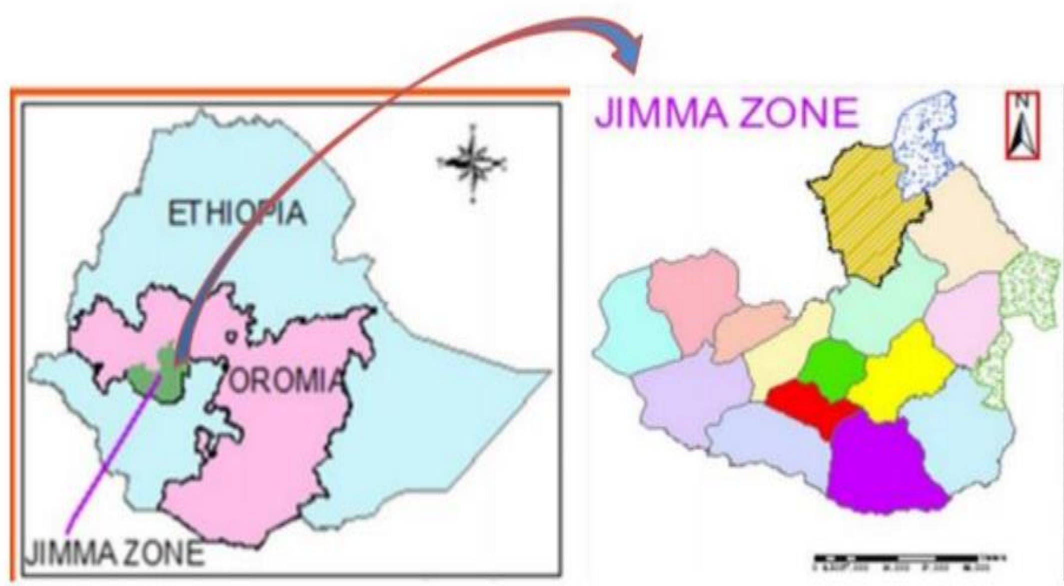


Figure 3. 1Map of study Area (Jimma Town)

3.2. Research Design

The study was conducted by laboratory Experimental design in order to evaluate the effect of molasses on concrete properties as admixture such as setting time, workability and compressive strength of concrete.

3.3. Sampling Size

Twelve cubic samples for eight trial batch was casted and Three individual cubic samples were used for each curing ages. A total of 96 number of concrete specimens were used to determine the compressive strength at the end of curing period of 3,7,14 and 28 days for each percentage addition of molasses of 0%, 0.1%, 0.2%,0.3%, 0.4%, 0.5%, 0.6% and 0.7% by weight of cement.

3.4. Study Period

The study was conducted from April 2019 to November 2019.

3.5. Study variables

The **dependent variable** of this study was effect of molasses as admixtures on concrete production while workability of fresh concrete, setting time, Compressive strength were used as **independent variable**.

3.6. Data collection process

The data for this research was collected from different site. Molasses was collected from Arjo Didessa sugar factories in Ethiopia and aggregates and cement were collected from market supply.

Figure 3. 2 Collecting Representative Sample from site

3.7. Data processing and analysis

In processing and analyzing, the gathered data has been tested experimentally and analyzed using mean and percentage method and came up with the research output. Workability, setting time and compressive strength of concrete for each mix was recorded and The average results of the concrete with varies dosage of molasses was compared with respect to the control (0% molasses). Finally, the results of analysis have been presented according to the research objectives and at the end conclusion was formulated and then recommendation was forward to concerned body.

3.8. Materials used for the study

The material used for this experimental research is: -

Cement: - Type of Cement used in the concrete mix was Dangote - Ordinary Portland cement (OPC) whose Cement Grade 42.5R which is locally available cement.

Coarse aggregate: -The coarse aggregate used was crushed granite with maximum normal size of 20mm and was collected from local market supply in Jimma town.

Sand: -The sand was collected from market supply point. Werabe sand was used for the whole experiment.

Water: -Drinking water from the laboratory was used for both curing and mix design works.

Molasses (admixture): -Molasses was obtained from Arjo Didessa sugar factory which is located at western Ethiopia of Oromia Regional State in Eastern wollega, Eiluababora and Jimma zones at the Didessa rift valley 194 Km distance from Jimma-Bedele Nekemt. Samples were taken from the containers of black strap molasses.

Figure 3. 3Molasses Sample

3.9. Instruments and Tools Used in the Study

Sieve for sand and coarse aggregate, Oven, Balance, Mixer, mixing tools, vibrating table, Mould for concrete specimens, curing tank and Compressive strength machine are some of the tools and instrument used in this study from material preparation to testing stage of the concrete.

3.10. Material preparation

Coarse aggregate: -Coarse aggregate sample was washed before using for concrete mix and sun dried on a clean platform as shown on fig 3.4

Figure 3. 4 Preparing Coarse Aggregate sample

Fine aggregate; -. The sand sample selected for the study was washed with potable water by using 75µm sieve in order to free of clay/silt content and sun dried on a clean platform. As shown in fig 3.5

Figure 3. 5 Washing of Sand to make free from silt & clay

3.11. Experimental investigation

Under this sectionalphysical and chemical characteristic of concrete making material was investigated before any concrete experiments were conducted. And also materials proportioning, concrete mixing and production process, casting, curing and finally compressive strength testing of the concrete cubes were included.

3.11.1. Chemical composition test of molasses

The chemical analysis test of the molasses was carried out at,Addis Ababa University, chemical and bio Engineering Laboratory

Figure 3. 6Chemical Composition Test of Molasses

3.11.2. Normal Consistency Test

Normal consistency water of cement paste was taken into consideration in preparation of paste for setting time test. Consistency and setting time were investigated by using Vi-cat needle apparatus. This test is done to determine the amount of water required to prepare cement paste for setting time test.Different trials were carried out with different water - cement ratio until the proportional of water in mix achieved for a paste that the rod of Vicat apparatus settles 10±1 mm below the original surface within 30 seconds. The usual range of water - cement ratio for normal consistency is between 26% and 33%.

Figure 3. 7 Normal consistency test

3.11.3. Initial and final setting time

Setting time tests were applied by using Automatic Vi-cat needle apparatus and cement paste mixer as shown on fig 3.8 Sample of cement paste with no molasses was prepared for the setting time test. This sample was taken as reference i.e. controls sample. Then seven sample were conducted on the cement pastes made with the percentage addition of successive molasses content by 0.1% increments by weight of cement.These were 0.1, 0.2, 0.3, 0.4, 0.5, 0.6 and 0.7% by weight of cement. The cement paste was prepared carefully by using 85% water that gave acceptable normal consistency then fill it in the mold and allow it to remain in a moist room for 30 minutes then the penetration tests were recorded at the regular time interval of 10 minute. Initial setting time in minutes was taken when the initial set needle penetrated into the paste to a depth of 25mm and for final setting time the researcher estimated by using the equation according to Jimma laboratory manual reference on page 14.

Final setting time (in minutes) = 90+ 1.2 x (initial setting time) ……. Equation 3. 1


Figure 3. 8Setting time test

3.11.4. Physical Property of Aggregates and Tests Method

In order to design and make a concrete mix, the aggregates properties have to be assessed. To do this a number of tests were carried out. The performed test includes: sieve analysis, bulk and dry density, moisture content, Specific gravity, water absorption, unit weight, etc. All of the aggregates tests were done in accordance with the Ethiopian standards and conforms to the ASTM requirements.In this research physical property of aggregates tests were conducted and the tests are as follows:

I. Silt Content of Sand

The material in fine aggregate, which is finer than 75µm, is generally regarded as silt. in this particular study both field and laboratory method was used in the determination of silt content of the washed were sand.

II. Field Test Method

This test was conducted based on the procedure stated on Ethiopian Standard (ES) which also limits the silt content in sand up to 6% of the total sand, and it has been calculated by the following formula.

Average values of silt content (%) = $\frac{V2}{V1} * 100$**……………………………………………….………equation 3.1**

Where: -

V1 = volume of sample sand + silt

V2 = volume of silt after an hour

In Ethiopian standard restricts the silt content to a maximum of 6 %. If it exceeds this maximum values, the standard recommends washing or rejecting the sand according Ethiopian standard.

III. Sieve Analysis of Fine and Coarse Aggregate

This test was conducted to determine the grading (particle size distribution) of aggregates and the fineness modulus.According to ASTMC33 (2011), depending upon their size, sand can be classified as coarse sand when a fineness modulus is between 2.90 to 3.20; medium sand with a fineness modulus of 2.60 to 2.90 and; fine sand with a fineness modulus of 2.20 to 2.60. The sieve analysis for both fine and coarse aggregate was done according to ASTM C136.After a series of procedures, to find out the fineness of the given aggregates was obtained by the following formula.

$$\mathbf{F.M} = \frac{\textbf{Cumulative retained \%}}{\mathbf{100}} \quad \text{.......... 3.2}$$

Where F.M=Fineness Modulus

IV. Unit Weight of Fine Aggregate and Coarse Aggregate

This test has been conducted to determine the weight for a given volume of the respective fine and coarse aggregate. In this particular study rodding method was used by filling a known volume container and weighing it. The rodded bulk density of aggregates used for normal weight concrete generally ranges from 1200 to 1760 kg/m3 (ACI318M, 2011). it has been calculated by the following formula.

$$\textbf{Unit Weight} = \frac{A}{B} \quad \text{.......... equation 3.3}$$

Where A= Mass of sample

B=Volume of the cylinder

V. Specific Gravity and Absorption Capacity of fine Aggregates

The test was conducted to determine the bulk specific gravity at oven dry and saturated surface basis, apparent specific gravity, and absorption of the given fine aggregates. The procedure used for this test was taken from ASTM C 128 and The procedure is presented in Appendix. 2.

VI. **Moisture Content of Sand and Coarse Aggregate**

The moisture content of the given sand and coarse aggregate was determined by oven drying 500 gm and 2 kg for the respective aggregate samples for about 24hrs with a temperature of 105 °C to 110 °C and cool for an hour and calculate it by the given formula.

$$W(\%) = \frac{A-B}{B} \quad \text{......equation 3.4}$$

Where W = Moisture content (%)

A = weight of original sample (g)

B = weight of oven dry sample (g)

VII. **Specific Gravity of Coarse Aggregate**

The bulk specific gravity at oven dry, saturated surface dry and apparent specific gravity of coarse aggregate was determined based on the procedures stated on ASTM C 127 and The procedure is presented in Appendix. 2

Based on test result, fine aggregate that used for this study hasbeen fineness modulus of 3.01 and this was within the range of ASTM standard.

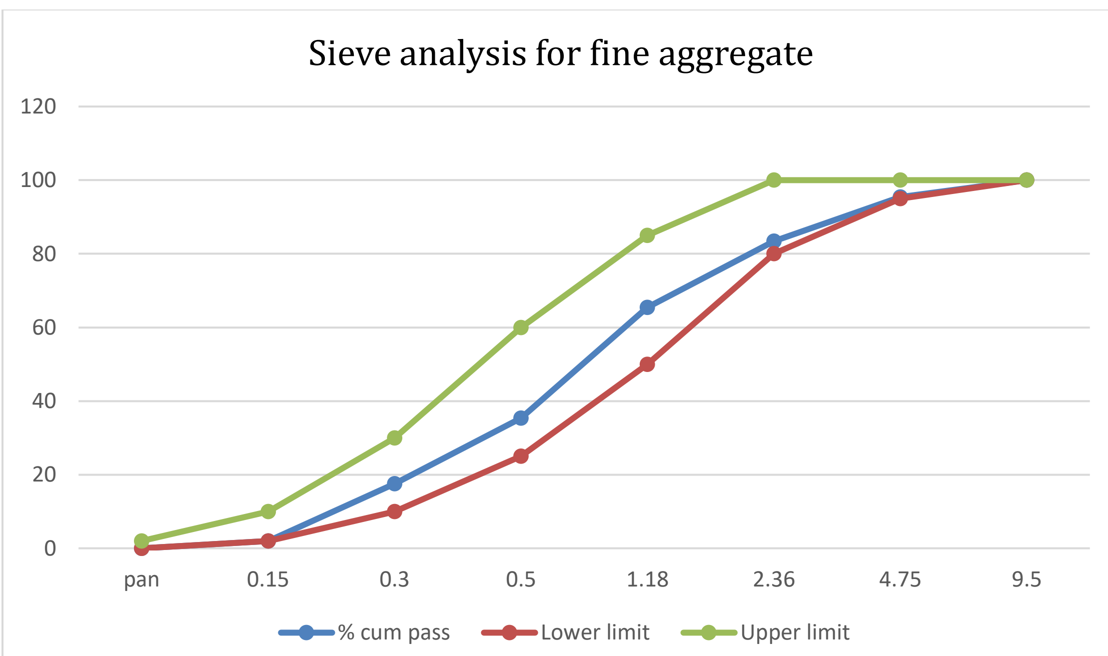


Figure 3. 9 gradation of fine aggregate

The physical properties of the fine aggregate that used for this study are given below in table 3.1

Table 3. 1Summarized test results for Physical property fine aggregate

Physical properties of fine aggregate		Laboratory experimental Result	Typical Ranges of ASTM C-33
Fineness modulus		3.01	2.0 to 3.1
Absorption		1.28	0 to 8 percent
Bulk specific gravity		2.51	2.30 to 2.90
Surface moisture content		1.03%	0 to 10 percent
Silt content	Field method	3.13	If it is > 6% rejects recommend to wash according ES Standard
	Laboratory method	1.52 %	-

The physical properties of the coarse aggregate that used for this study are given below in table 3.2

Table 3. 2Summarized test results for physical properties of coarse aggregate

Physical Properties of Coarse Aggregate	Laboratory Experimental Result	Typical Ranges of ASTM C-33
Absorption	1%	0 to 8 percent
Bulk specific gravity	2.64	2.30 to 2.90
Dry-rodded bulk density	1566.83kg/m^3	1280 to 1920 kg/m3
Surface moisture content	0.9%	0 to 2 percent

3.12. Concrete Mix Design and Materials Proportion

In this research work, the ACI Method of concrete mix design was used to design C-25 concrete grade having 33.5 MPa target mean strength with 0.5 of water to cement ratio. In addition to this, the slump was 25 to 50mm.The detail of mix design was shown on appendix -1. The quantity of concrete materials was calculated by using the physical properties of the materials and Table 3.3 show the quantity of materials for one cubic meter for C-25 concrete grade.

Table 3. 3 Mix proportion of Concrete

Materials	Weight in (kg/m3)	Weight in (kg) for 1 cube	Weight in (kg) for 12 cube	Weight in (kg) for 96 cube
Cement	370	1.34	16.1	128.8
sand	758.69	2.75	33.01	264.11
coarse aggregate	948.7	3.44	41.28	330.26
water	178.45	0.65	7.77	62.12

3.13. Preparation of specimen (cubes)

To know only the effect molasses as admixture the other factors which affect the property of concrete was taken as constant. So that the material used to prepare the test specimen are natural fine aggregate of Werabe sand, coarse aggregate and Dangote ordinary Portland cement from market supply.

The materials used were batched by weight and mixing was carried out with concrete mixing machine in the mix ratio of 1:2:2.56 with w/c ratio of 0.5. While the percentage of molasses was dissolved in water before adding to the mix water of the concrete. Eight different samples of concrete were produced using eight different percentage additions of molasses. These percentages were 0% as a control and the other seven were 0.1% 0.2%,0.3%,0.4%,0.5%,0.6% and,0.7% of molasses by weight of cement.

3.14. Concrete mixing and Production Process

The concrete molds, large flat plat and the mixer were cleaned from all contaminating materials and the concrete molds coated with releasing agent (oil) to smooth the surface and to prevent sticking of mixed concrete with the mold. The ingredients, such as; cement, fine aggregate (sand), coarse aggregate, water and molasses were measured to an accuracy of 0.5g balance. After that the weighted coarse aggregate was first added into mixer and the fine aggregate was added after the coarse aggregate and then the cement is added next to fine aggregate and dry mixed for a minute. Then, water and molasses was added and thoroughly mixed as shown on the below fig.

Figure 3. 10Concrete Mixing Process

3.14.1. Checking for workability

The mixed concrete was checked for workability by using the standard slump cone. The test was carried out for each batch of fresh concrete produced i.e. for each percentage addition of molasses which is for 0%,0.1% 0.2% ,0.3%, 0.4%, 0.5% ,0.6% and0.7% of molasses toassess the workability of the fresh concretes. The apparatus used to carry out this test consist of mould, scoop, sampling tray, trowel, tamping rod and measuring ruler. First the internal surface of the mould was cleaned, lubricated with oil and then placed on the sampling tray and hold firmly against the surface. The different between height of the mould and slump concrete was measured as a slump value. This test was carried out in accordance with ASTM C143 as shown in Figure

Figure 3. 11Slump Test

3.14.2. Casting of concrete specimens

After the concrete was thoroughly mixed and the slump test was carried out for each batch of percentage addition of molasses. The cube specimens were cast by filling each cube mould in three layers each layer been compacted manually with 25 blows from a steel rod of 25 diameters before the next layer was poured. The size of cube mould used for the production of concrete specimens was 150 mm × 150 mm × 150 mm.

Figure 3. 12Concrete Casting Processing

3.14.3. De-molding and Curing

The concrete mix was casted in the molds for the first 24 hours. After that, the concrete was removed from the molds and cured by complete immersion in water for the required period of hydration of 3, 7, 14 and 28 daysas shown in Figure

Figure 3. 13Removing of Concrete Cube from the mold & Immersion into curing water tank

3.15. Compressive strength testing of the concrete cubes

After3,7 ,14 and 28 days curing period, the concrete specimens (cubes) were removed from the curing tank and then placed in dry surface for 24 hours until the specimens was surface dried, then weighed and positioned at the centerof compression machine for crushing and then The force was applied at the specimen till it was crushed. The maximum load at failure was then recorded.

Figure 3. 14weighing & crushing of cubes

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1. Introduction

This chapter describes the result obtained from the laboratory experiment onCompressive strength results for C-25 concrete, which were obtained from the average of three cubes under the normal laboratory temperature and same curing conditions for 3,7, 14 and 28 days. For workability of the fresh concrete, slump test has been done to get the fresh properties of the concrete and also the initial and final setting time of cement paste was done with and without molasses dosage. In addition to that some chemical and physical property of molasses has been done in order to know the characteristics of molasses to be used as water reducing and retarding admixture for concrete.

4.2. Physical and Chemical Property of Molasses.

Th**e** first part of this chapter determine the physical and chemical composition of molasses. The physical and chemical composition of molasses was determined in Addis Ababa university, department of chemical and bio Engineering Laboratory. A Sample for this study was provided by Arjo Sugar Factory and It's some physical and chemical composition was shown on table 4.1. according to the test results, the brix is 78.1 which is an indicator of specific gravity which represents an approximation of total solids content of molasses. Brix is composed of glucose, fructose and numerous non sugar organic materials. The ash content of molasses is 8.21%and also Molasses exists in a viscous form of dark brown color, and is completely soluble in water. And also a higher amount of sugar existed in this molasses which is 46%. Sugar is one of the best retarding admixture that can be used as water- reducing and set- retarder admixture. some researchers concluded that sugar allow a reduction in water content of the concrete without affecting its workability (Greesan et al., 2014).

Table 4. 1Constituent Value Of Molasses

parameters	Values
PH	5.94
Brix	78.1
Viscosity	8.06
Specific gravity	1.39
Ash content(%)	8.21
Moisture Content(%)	16.67
Total sugar(%)	45.97
color	Dark brown
Appearance	syrupy liquid

4.3. Effect of Molasses On Setting Time of Concrete

Setting time tests were applied by using Vi-cat needle apparatus in accordance with ASTM C191.The test for initial and final setting times was conducted on the cement pastes made without molasses (0%) as control sample and the percentage addition of molasses of 0.1%, 0.2%, 0.3%,0.4%, 0.5%,0.6% and 0.7% by weight of cement. The setting times were recorded in minutes. The test results for initial and final setting times of various cement pastes made with and without molasses at the normal laboratory room temperature are shown in Table 4.2.

Table 4. 2Effect of Molasses on initial and final setting time of concrete

Molasses dosage (%)	Initial setting time(min)	Final setting time(min)
0%	**190**	318
0.1%	320	474
0.2%	385	552
0.3%	430	606
0.4%	495	684
0.5%	540	738
0.6%	620	834
0.7%	669	892

The observed values of both the initial and final setting times for the varying dosages of molasses is given against time in Figure 4.1.

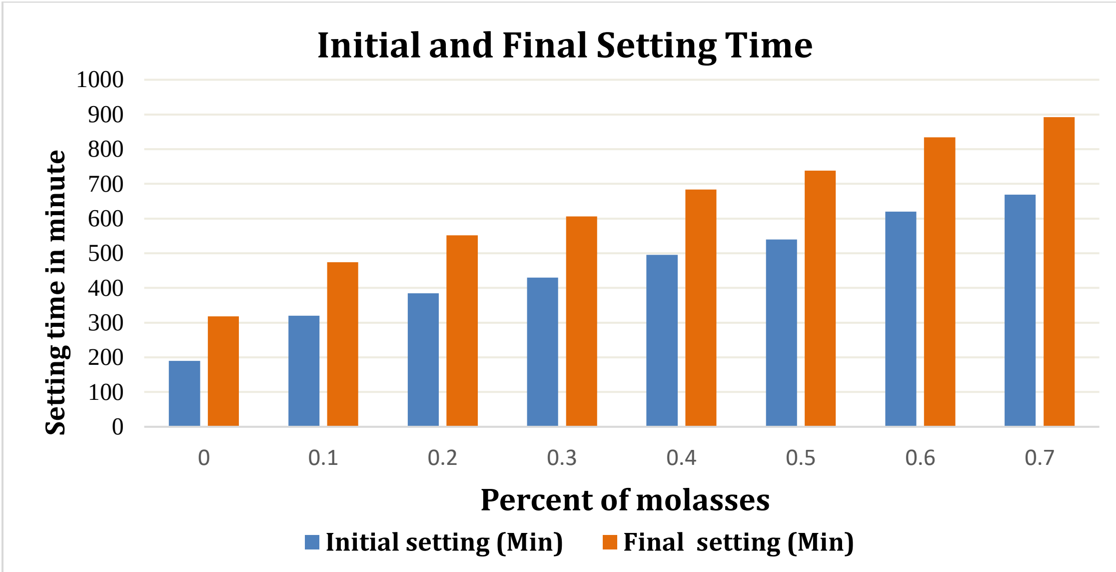


Figure 4. 1setting time vs percentage addition of molasses

As shown in fig 4.1, when 0% molasses was used, the initial and final setting times of cement pastes were 3:10 and 5:18 hr. respectively. For the molasses cement mixtures with minimum percentage of molasses (0.1%), the initial and final setting time were increased by 2:10 hr. and 2:36 hr. respectively and for maximum percentage (0.7%), the initial and final setting time was increased by 8:00 hr.,9:34hr when compared with control paste. Therefore, When the amount of molasses successively increases in the paste, the initial and final setting time of the paste is prolonged due to the retarding effect of molasses. This result is caused by the amount of sugar in molasses. The result of this study was conformed to other researches.

Among the reviewed papers, (Gupta,B.L and Gupta A., 2004) reported that Sugar (sucrose) is a very efficient retarder admixture which is capable of delaying or prolonging the setting of cement paste in concrete. besides (Yildirim, H., & Altun, B. , 2012) obtained that, Molasses based admixture delay final setting times up to 16:30 hr. while control paste was only 5:00 hr.

So it can be concluded that molasses can be used as retarding admixture in replacing the conventional chemical admixtures.

4.4. Effect of Molasses On Workability of Concrete

Workability of concrete has been measured by the slump cone test according to ASTM C143. Concrete has been prepared with addition of molasses admixtures with different percentages of 0%,0.1%,0.2%,0.3%,0.4%,0.5%,0.6% and 0.7%. All test result was compared with concrete without molasses and result of the slump test is shown in the below table 4.3 and fig.4.2.

Table 4. 3The relationship between dosage of molasses and slump value of concrete

Slump test result		
Sample	**% of Molasses added**	**Measured (mm)**
1	0.0%	25
2	0.1%	35
3	0.2%	40
4	0.3%	45
5	0.4%	65
6	0.5%	75
7	0.6%	100
8	0.7%	120

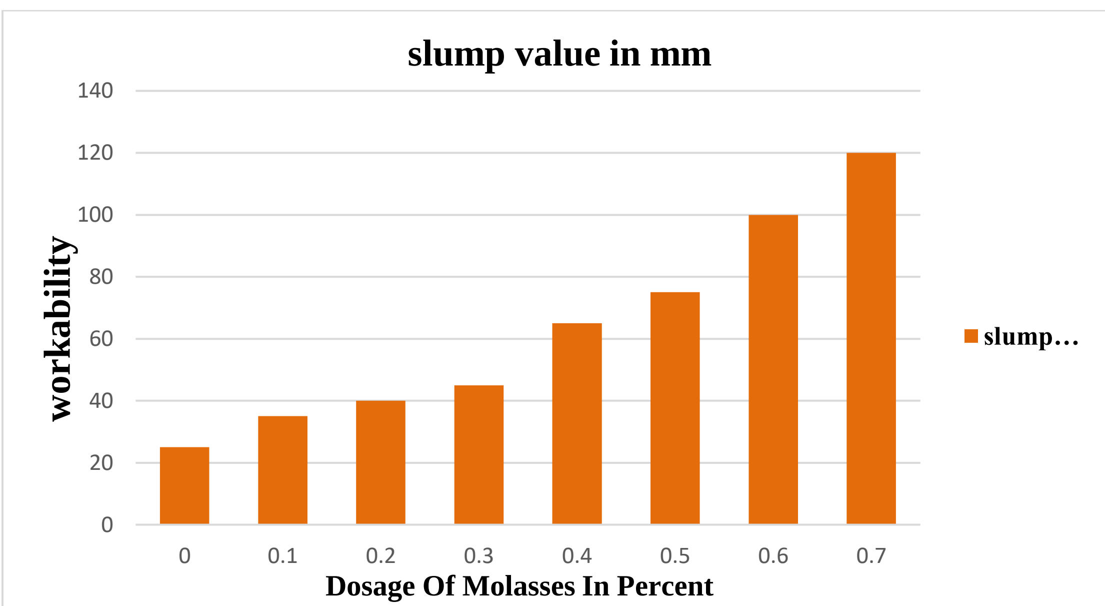


Figure 4. 2percent of molasses vs workability of concrete

Based on the experimental results, as the percentage of molasses increased, consequently, slump also increased. when the molasses content of the mix increase from 0% to 0.7%, the slump of the concrete increased by 95mm/400%. Therefore, the amount of water content can be reduced by adding molasses and retaining the desired workability of concrete. Moreover, Percentage of molasses increased to the concrete greatly influenced the setting time property. it has been noticed that the higher increases in the dosage of molasses above 0.6% shows difficulty in demolding cube specimens after 24hrs.

Different studies related to the workability of concrete with molasses have been done by different researchers and most of them obtained similar result with this study. (Shantanu et al., 2017)supported this idea through his investigation and he obtained thatas the dosage of molasses increases, the slump value also increases which indicates higher workability. Likewise, (Canbaz,M.,et al, 2011)stated that The amount of water can be reduced by 10% with adding molasses as water reducing admixture in concrete production and Reduction of water cement ratio by using molasses in concrete provides more environmental-friendly carbon dioxide emission by decreasing the cement production and also(Somawanshi et al, (2016) reported that, the setting of cube specimens was difficult. During the demoulding after 24hrs. So, demoulding of specimens carried out after 48hrs for 0.4% and above.

Therefore, it can be concluded that molasses can be used as a water reducing and retarding admixture.

4.5. Effect of Molasses On Compressive Strength of C-25 Concrete

The Compressive strength results for C-25 concrete were obtained from the average of three cubes for 3,7, 14 and 28 days. The compressive strength results of concrete cubes with different dosages of molasses are presented in table 4.4.

Table 4. 4Relationship of Molasses andMean Compressive strength of concrete

molasses percentage	Average compressive strength			
	3 day	7 day	14 day	28 day
0%	**14.78**	**19.33**	**21.72**	**30.07**
0.1%	**14.31**	**19.84**	**22.97**	**32.17**
0.2%	**12.77**	**20.69**	**23.92**	**33.28**
0.3%	**11.65**	**20.18**	**24.43**	**34.14**
0.4%	**11.16**	**19.56**	**23.02**	**32.44**
0.5%	**9.75**	**18.01**	**20.46**	**31.23**
0.6%	**7.39**	**15.87**	**19.56**	**30.80**
0.7%	**4.57**	**13.54**	**18.66**	**30.38**

4.5.1 Compressive Strengths at 3 Days

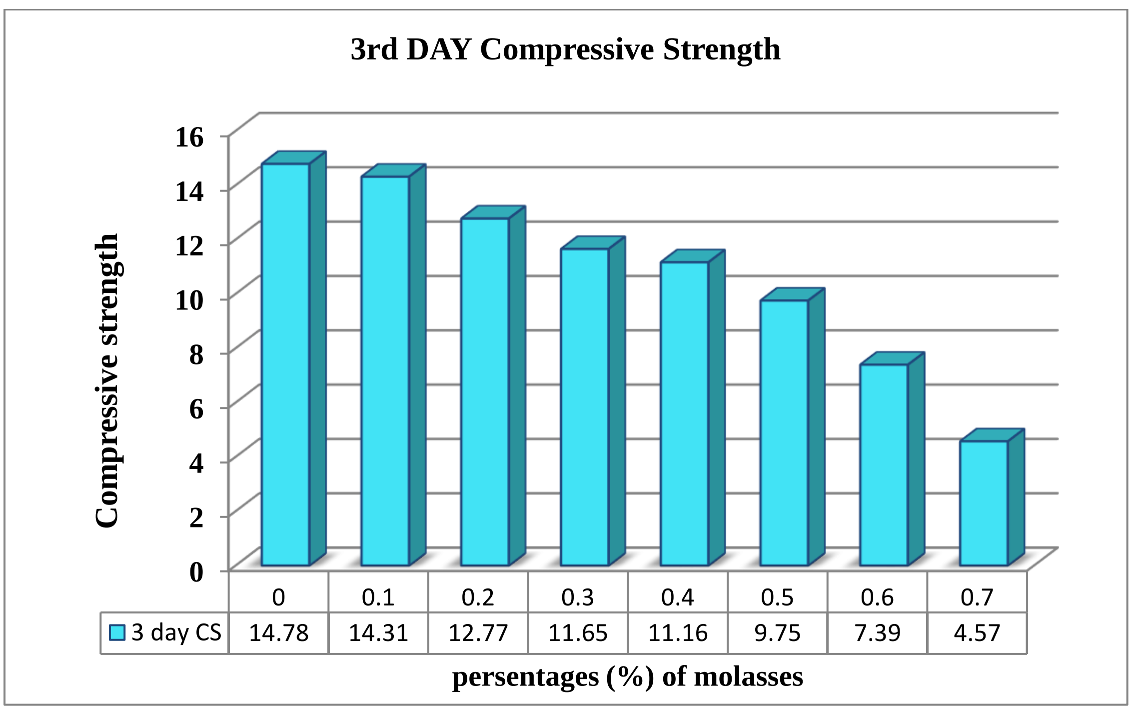
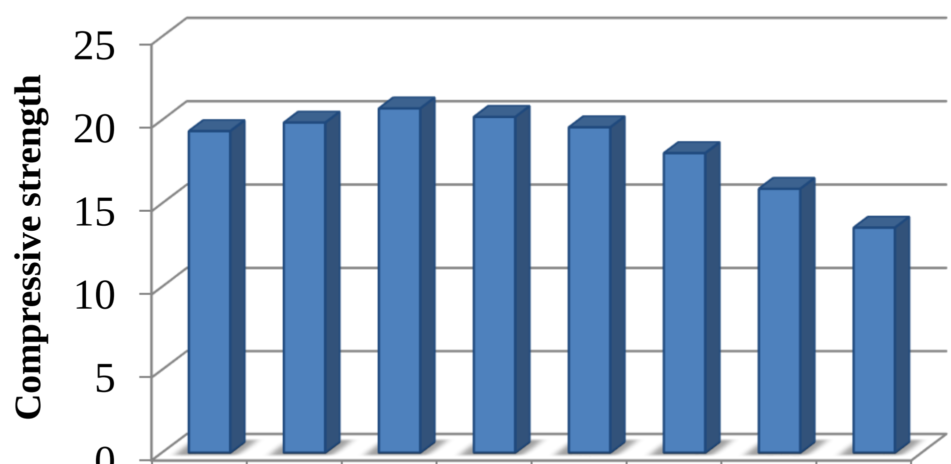


Figure 4. 3compressive strength vs percent of molasses at 3 days

As the experimental results shows, the early compressive strength of concrete for the control sample (without molasses) at 3 day of curing age is higher than a concrete casted with various percent of molasses. The compressive strength of concrete containing 0.1%, 0.2%, 0.3%, 0.4%, 0.5%, 0.6% & 0.7% of molasses by weight of cement at 3 days were decreased by 3.18%, 13.60%, 21.17%, 24.49%, 34.03%,50% &67.86% Mpa respectively when compared with control sample. The decrease in the early age strengths of concrete with molasses could be attributed to the fact that the use of a molasses as water reducing and retarding admixture in concrete severely reduces the early strength of concrete due to the hydration reaction of water and cement is slow down.

This result is conformed with previous researches like (Gao, et al, 2011)stated that early age strength reduction was more pronounced than the later age strength due to the retarding effects of molasses.

4.5.2 Compressive strengths at 7 days



	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7
7 day CS	19.33	19.84	20.69	20.18	19.56	18.01	15.87	13.54

Figure 4. 4Compressive strengthvs Percent of molasses at 7 days

Figure 4.4 presents the compressive strengths of concrete at 7 days curing period. The compressive strength of the control specimens is 19.33 Mpa. It can be observed that there is an increase in compressive strength by adding 0.1%,0.2%,0.3% and 0.4% of molasses by 2.64 %,5.40 %,4.39% and 1.19 respectively over the control sample. But for 0.5%,0.6% and 0.7% of molasses,a decrease in compressive strength was recorded by 6.83%,17.90% and 29.95% when compared with the control sample. The maximum compressivestrength was achieved at 0.3 % of molasses which is 24.43 Mpa.

4.5.3 Compressive strengths at 14 days

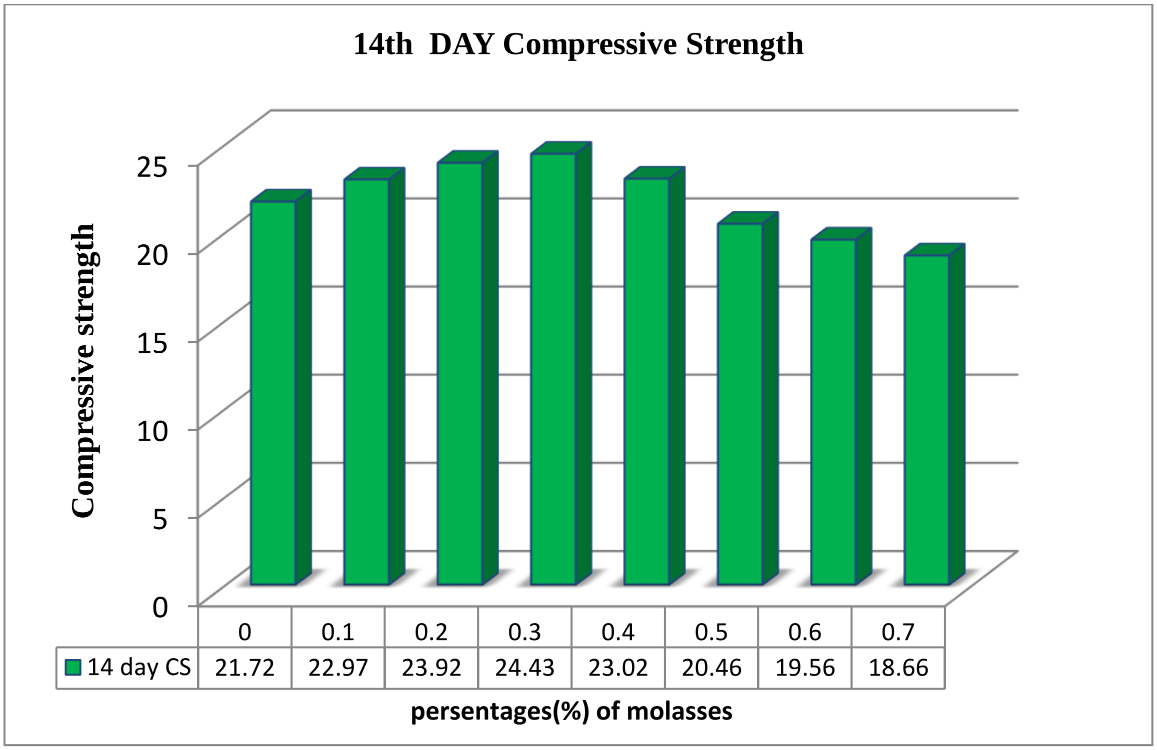


Figure 4. 5Compressive strengthvs Percentof molasses at 14 days

Fig 4.5 shows a concrete casted with 0% up to 0.7% of molasses by weight of cement with 0.1% increment and the observed results at 14 days of curing age for 0.1%, 0.2%,0.3% and 0.4% were increased by 5.76, 10.13, 12.48 and 6% respectively. Moreover, it was observed that the compressive strength of concrete decrease with increasing the molasses content beyond 0.4% at this curing age. But the 14th days compressive strength result of concrete with all percentage of molasses was higher than the 7th day result. It is obviously seen that, curing period of concrete plays a vital role for concrete with and without molasses for their strength development.

This observation agrees with previous finding of (Rathi ,V.R.and Kolase, P.K.,2013) and he reported that the early strength of concrete is reduced but beyond about seven daysthere is an increase in strength as compared with non-retarded concrete as a result of delayed the setting of cement paste.

4.5.4 Compressive strengths at 28 days

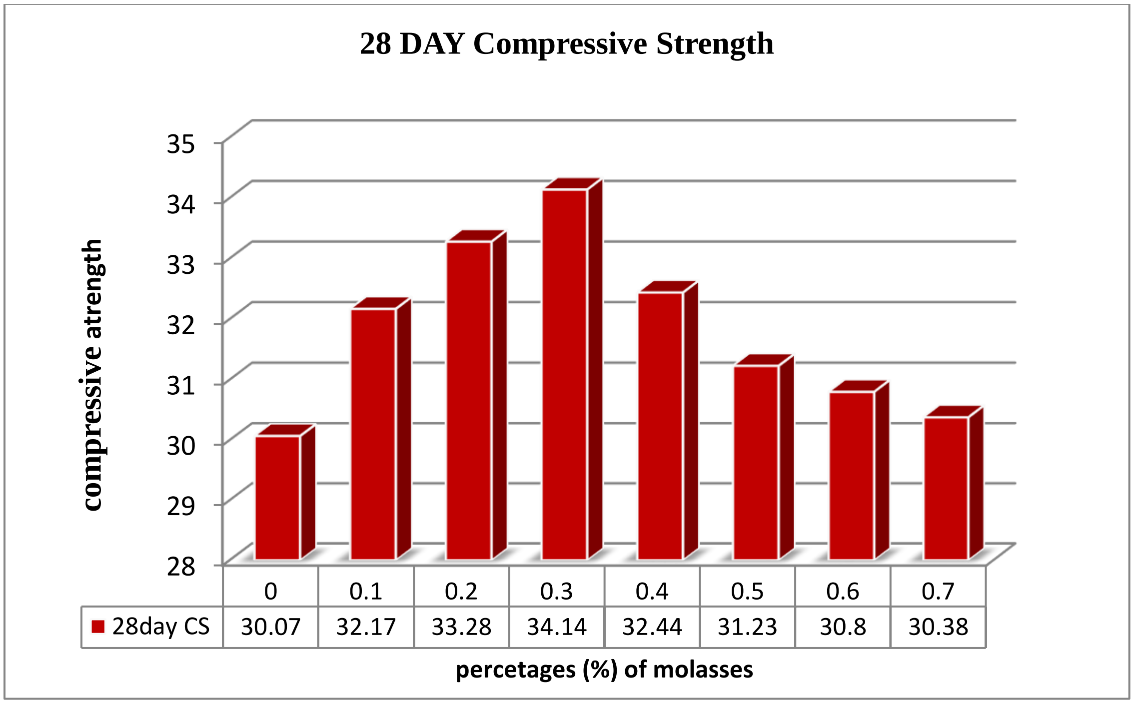


Figure 4. 6Compressive strengthvs Percentof molasses at 28 days

Figure 4.6 shows the compressive strengths of concrete at 28 days curing period. The compressive strength of the control sample was 30.07 Mpa. It can be observed that there is higher increase in compressive strength by adding 0.1%,0.2%,0.3%,0.4%,0.5%,0.6% and 0.7% of molasses by 6.98%, 10.41% 13.54%,7.88%,3.86%, 2.43% and 1.03 % respectively over the control specimens. When comparing the result of compressive strength of concrete with effect of molasses at the age of 3,7 ,14 and 28 days, the 28 days of concrete strength was better than the early compressive strength age. This is due to concrete gain 99% of its compressive strength at the age of 28. It was observed that, samples with molasses showed better strength than the control sample and molasses as admixture gives a good result at later age than the control sample.

When compared with some researches, (Shantanu et al., 2017) stated that concretes with molasses give higher strength than those without molasses at 28-day age.

4.6. Optimum dosageof Molasses On Concrete Properties

In this study, conventional admixture was replaced by molasses as water reducing and retarding admixture to produce concrete with same w/c ratio in order to increase workability and setting time and to improve compressive strength. According to laboratory experiment result, the optimum percentage of molasses which gives maximum strength was 0.3%. Therefore, this optimum percentage addition of molasses was recommended depending on compressive strength of concrete for better result.

When compared with the other researches,(Juneja et al., 2017) reported that the 28-day compressive strength of mortar gets increased up to a dose of 0.25 percent by weight of cement and also (Aalm, A., & Singh, P., 2016) **stated that** the compressive strength of mortar and the compressive strength of the concrete mixes are maximum at 0.25 percent dose of molasses by weight of cement. but it can be used safely in the range of 0 to 0.50 percent by weight of cement**.**

Therefore, the researcher concluded that a good result can be recorded in the range of 0.1%-0.3% of molasses. But at 0.3% of molasses gives highest compressive strength.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

1.1. Conclusion

This study was conducted toevaluate the effects of molasses on properties of C-25 concrete as admixture. The properties investigated were workability (slump), setting time and compressive strength of concrete. The findings of this investigation provides an important contribution towards the knowledge on the effect of molasses as water reducing and retarding admixture.According to the observed test results, the addition of 0.1%, 0.2%, 0.3%, 0.4%,0.5%,0.6%, and 0.7% of molasses increases the workability of the fresh concrete and setting time with an increasing dosage of molasses. So that, the results of this study lead to the following Conclusions:

- The slump value of the concrete is directly proportional to the dosage of molasses. As the dosage of molasses increased, the slump of the concrete also increased. The slump value of concrete increased from 25mm to 120mm when 0.7% of molasses by weight of cement added to the mixture.
- Molasses has a significant effect on Setting time of the concrete. When the amount of molasses increases in the cement paste, the initial and final setting time of the paste is prolonged due to the retarding effect of molasses.
- The Compressive strength of concrete with molasses at early age is lower than the concrete with zero molasses. But, the compressive strength at later age i.e. at 28 days is higher than the Compressive strength of concretegroup. Therefore, the concrete prepared with molasses show a slight increase in compressive strength at later ages.
- 12.48% and 13.54% increase in compressive strength was observed for 0.3% of molasses at 14 days and 28day curing age respectively when compared with the control sample of zero molasses.
- As the dosage of molasses increased, the early compressive strength of concrete at 3day age was decreased.
- The cost of the Concrete can be reduced by using easily available sugar cane by product which is molasses as a water reducing and retarding admixture up to 0.3% by weight of cement.

1.2. Recommendation

Based on the conclusion above, the following recommendation are forwarded.

- According to the result of this study, it is possible touse molasses as a water reducing and retarding admixture in replacing the chemical admixture wherever required.
- In order to produce quality concrete and to minimize the cost of concrete, the recommended dosage of molasses is in the range of 0.1% to 0.3% by weight of cement.
- The result of this research suggests that when beyond 0.6 % molasses by weight of cement is used in concrete mix, the mix shows difficulty in demolding after 24hr so that it is recommended to increase the demolding period.
- The chemical admixtures company has to do further research on molasses in order to fulfill the demand of the admixture in construction industries and to reduce cost of concrete.
- In our country local contractor and consultant do not give attention on admixtures in order to improve the properties of concrete, therefore the researcher recommends to these stakeholders in order to use locally available waste material from sugar factories which is molasses as water reducing and retarding admixtures to improve the properties of concrete and to reduce the cost of concrete and mortar production.
- Further research should be carried out to compare the effects of molasses on concrete with other retarding admixtures
- Further research should be conducted to assess the durability of concrete properties made with molasses as an admixture.
- Further researches should be conducted by using molasses on grades above 25Mpa.

References

Aalm, A.,& Singh, P. (2016, july). *experimental study on strength characteristics of cement concrete by adding sugar waste*. International journal of enhanced research in science,technolgy and engineering, 5(7).

Abalaka,A.E.(2011b).*Comparative effect of cassava starch and simple suger in cement mortar and concrete*. ATBU journal of Enviromental technology; 4(1).

American Concrete Institute (ACI).(1999). *Guide to the selection and use of hydraulic cement.*

AFCA.(2005)."*Retarding admixtures"*. United Kingdom: European Federation of Concrete Admixtures Association.

ASTM C403.(1999)."*Standard test for time of setting concrete mixtures by penetration resistance"*.

ASTMC494.(2013).*"Standard Specification for Chemical Admixtures for Concrete"*,. ASTM Intrnational.

Canbaz,M.A.(2011)."*usage of molasses as water reducing admixture*".8th national concrete congress proceeding book, (pp. 583-594).

Dinku, A. (2002). "*Construction Materials labratory manual* . addis ababa : Addis Ababa University Instituteof Technology.

Duggal,S.(2008). *building materials(3rd edition).* Indian: new age International publishers.

Elzamzami, M. A. (2000). *The Effect of Molasses And Vz4 Additions on The Properties of Cement Paste and Concrete*. *Journal of Building and Road Research,3*(1), 25-32.

Gao, X., Yang, Y., & Deng, H. (2011). *Utilization of beet molasses as a grinding aid in blended*. *Construction and Building Materials, 25(9).*

Greesan, R.P.(2014). *Manufacturing Of Concrete With Retarders.*International Journal of Scientific & Engineering Research, 5(4).

Gupta, B.L and Gupta Amit (2004). *Concrete Technology*, A. K. Jain, Standard Publishers Distributor. Delhi ,121-290.

Jumadurdiyev A, O. M. (2005). *The Utilization Of Beet Molasses As Retarding And Water Reducing Admixture For Concrete*. cement and cocrete research.*3(5).*

Juneja, A. S. (2017, July). *To Study Accerating And Retarding Behaviors Of Molassses In Cement Mortar And Concrete*. *International Research Journal of Engineering and technology(IRJET), 4*(7).

Khan , B..& Ullah, M. (2004). *Effect of Retarding Admixture on the setting time of Cement pastes in hot weather*. *International journal of Engineering science and technology*, 15(1): 63- 79.

Khan, B., & Baradan, B. (2002). *The Effect of Sugar On Setting-Time of Various Types of Cements*. *Science Vision, 8*(1).Izmir, Turkey, 71-78.

Kosmatka,S.K.,Kerkhoff, B., and Panarese, W.C.(2003)."*design and control of concrete mixtures*,14th Ed".,. In Skokie, *portland cement association.* Skokie.

Kumar, D.(2015). *Sugarcane Molasses in Concrete as a Water Reducing-Retarding*. *SRG International Journal of Civil Enigineering (SSRG-IJCE).*

Li.Z. (2011). *Advance Concrete Technology*.Hoboken, New Jersey: John Wiley and sons. Inc., 7-135.

Liu et al. (2009). *the progress of research on treating molasses waste water and resources.* china.

Mandal, A. (2006). Modeling the Compressive strength of molasses-cement sand system using design of experments abd back propagation neutral network. *J.Mater.process.technol.*, 180,167-173.

Mehta,P.K.,& Monteiro, P. J. M. (2001). Concrete Microstructure,properties and materials.

M'Ndegwa,J.K. (2016). diversifying the use of molasses towards improving infrastructure and economy of kenya., *8.* kenya.

Muhammed, Sh. K.,Navaneeth, A.P.,Bhavia, K.K.,Harikrishna, A.S. Mohammed A,P.P. (2016). *Pulp Black Liquor- An Admixture in Concrete*. *SSRG International Journal of Civil Engineering (SSRG – IJCE), 3*(3).

Neville, A.M & Brooks,J.J. (2010). *Properties of Concrete Technology*. United kingdom: logman Scientific and Technical,4thedition.

Neville, A.M. (2006). *properties of concrete* (Fourth ed.). India: Pitman publishing corporation.

Oladiran, A. O. (2012). *Effect Of A Locally Sourced Water Reducing/ Retarding Admixture On Concrete*. *Journal of civil engineering and Urbanism, 2*(5), 170-175.

Olbrich, H. (1963). *The Molasses.* Germany.

Pathan,S.B.(2017,November).*Using Molasses in Concrete As A Time Retarding Admixture*. *International journal of engineering research and technology(IJERT), 6*(11).

Peter, R. V. (2007). *Cane sugar engineering.* Berlin.

Rathi,V.R.,and Kolase,P. K.(2013). *Effect of Cold Joint on Concrete*. *Journal of Innovative Research in Science,, 63*.

Salahaldein, A. (2013). *Effect of super plasticising and retarding admixture on property ofconcrete*.,international conference on innovation in Engineering and technology(ICIET)). Bangkok.

Shantanu et al. (2017, July). *Effect of sugarcane molasses on compressive strength and workability of fly ash mixed concrete.International Journal of enhanced research in science,Technology and Engineering*.

Shetty, M.S. (2009). *Concrete Technology*. In *Theory and Practice, S. chad and company Ltd.* India.

Somawanshi,S.P.,Ansari, U.S. and karale, S. A. (2016, September). *Effect of molasses as a water reducing and time retarding Admixture*. *International Journal of recent Scientific research, 7*(9).

Taye, B. (2015). *stablization of expansive soil with suger cane molasses*.

Yildirim, H., & Altun, B.(2012). *Usage of molasses in concrete as a water reducing and retarding . Indian Journal of Engineering and Materials Science, 4 19*(6), 421–426.

Appendices

Annex 1: Mix Design Procedures and Calculations

- ✓ Normal Strength Concrete(C-25)

The mix design for C-25 non air entrained normal strength concrete is done as per ACI 211.1.

The data from test results, which are important for mix design, are:

- ✓ **Properties of fine aggregate**
  - ➢ Unit weight =1520 kg/m3
  - ➢ Fineness modulus =3.0
  - ➢ Specific gravity =2.51
  - ➢ Absorption =1.28%
  - ➢ Free moisture content =1.03%
- ✓ **Properties of coarse aggregate**
  - ➢ Maximum size =20mm
  - ➢ Unit weight =1567 kg/m3
  - ➢ Specific gravity =2.64
  - ➢ Absorption =1%
  - ➢ Free moisture content =0.9%
- ✓ **Specific gr. Of Cement (O.P.C**) = 3.15

Step 1: Slump

30mm -50mm (minimum slump possible) is selected.

Step 2: Maximum size of aggregate

Maximum size is fixed to be 20mm.

Step 3: Target mean strength calculation

When no test data is available, 8.5MPa shall be added to get mean strength.

FM = 25+8.5=33.5Mpa

Step 4: W/C ratio

From ACI Table, for 30MPa W/C ratio is 0.55 and for 35MPa W/C ratio is 0.48. The W/C ratio can be found by interpolation as follows:

Average compressive Strength at 28 days (MPa)		Effective water –cement ratio (by mass)	
		Non air –Entrained concrete	Air-Entrained concrete
45		0.38	-
40		0.43	-
35	Target mean Strength=33.3	**0.48**	0.40
30		**0.55**	0.48
25		0.62	0.53
20		0.70	0.61
15		0.80	0.71

$$\frac{\mathbf{W}}{\mathbf{C}} = \frac{\mathbf{0.55-0.48}}{\mathbf{30-35}}\mathbf{(33.3\text{-}30) + 0.55 = 0.5}$$

Step 5: Mixing water amount

For maximum size of aggregate of 20mm, slump 30 to 50mm (minimum range) and non-air entrained concrete the mixing water requirement according to ACI table.3.8 seen below.

Table 3-8 Approximate requirement for mixing water and air content for different workabilities and nominal maximum sizes of aggregates according to ACI 211.1-81

Workability or Air Content	Water Content (kg/m^3) of Concrete for Indicated Maximum Aggregate Size in mm							
	10	12.5	20	25	40	50	70	150
	Non-air-entrained concrete							
Slump								
30–50 mm	205	200	185	180	160	155	145	125
80–100 mm	225	215	200	195	175	170	160	140
150–180 mm	240	230	210	205	185	180	170	—
Approximate entrapped air	3	2.5	2	1.5	1	0.5	0.3	0.2

Mixing water amount = 185 Kg/M3

Entrapped air=2%

Step 6: Cement Amount

Cement content = **185/0.50 = 370 kg/m3**

Step 7: Coarse aggregate amount

For maximum size aggregate=20mm and sand fineness modulus of 3.0 the dry bulk volume max. The unit weight of the dry rodded coarse aggregates is 1567Kg/m3. From the table the percentage by interpolation as follows from table 3.11 of ACI 211.1.81:

The weight of coarse aggregate = 0.6x1567Kg/m^3 = 940.2 Kg/m^3

Table 3-11 Dry bulk volume of coarse aggregate per unit volume of concrete as given by ACI 211.1-81

Maximum Size of Aggregate (mm)	Dry Bulk Volume of Rodded Coarse Aggregate Per Unit Volume of Concrete for Different Fineness Modulus of Sand			
	2.40	2.60	2.80	3.00
10	0.50	0.48	0.46	0.44
12.5	0.59	0.57	0.55	0.53
20	0.66	0.64	0.62	0.60
25	0.71	0.69	0.67	0.65
40	0.75	0.73	0.71	0.69
50	0.78	0.76	0.74	0.72
70	0.82	0.80	0.78	0.76
150	0.87	0.85	0.83	0.81

Step 8: Fine aggregate amount

$$U_m = 10G_a\left(100-\overline{A}\right)+C_m\left(1-\frac{G_a}{G_c}\right)-W_m\left(G_a-1\right)\left[kg/m^3\right]$$

$$=10(2.51)(100-2)+370\left(1-\frac{2.51}{3.15}\right)-185(2.51-1)=2255.63kg/m^3$$

Weight of fine Aggregate = 2255-(185+370+940.2 Kg/m^3) = **760.6 Kg/m^3**

Step 9: mix Proportions

	Cement (Kg/M3)	Water (Kg/M3)	Fine Aggregate (Kg/M3)	Coarse Aggregate (Kg/M3)	Total (Kg/M3)
Quantity per m3	370	185	760.6	940.2	2255.80
Moisture Content (%)			1.03	0.9	
Absorption Capacity (%)			1.28		
Adjustment		9.74-7.83-8.46= -6.55	7.83-9.74=-1.91	8.46	
Adjusted	370	178.45	758.69	948.7	2255.80

Annex 2:Material Properties Test Result

I. **Fine Aggregate (Sand)**

A. **Moisture content(ASTMC-70)**

sample	Sample 1	Sample 2	Sample 3
mass of sand (M1) in kg	500	500	500
Oven dried mass (M2)	497	495	493
Percentage of moisture=((M1-M2)/M2)*100	0.6	1.8	1.5
average moisture content	**1.03**		

B. **specific gravity of sand** (ASTM218)

sample	Sample 1	Sample 2	Sample 3
A = weight of oven-dry sample in air, [g]	493.5	494.5	493
B = weight of pycnometer filled with water, [g]	1554	1554	1554
C = weight of pycnometer with sample and water to calibration mark, [g]	1852.5	1855.5	1856
Bulk specific gravity(oven dry basis) =(A)/ (B+500-C)	2.45	2.49	2.49
average oven dry specific gravity	**2.48**		
Bulk Specific Gravity(Saturated-Surface-Dry Basis) =500/(B+500-C)	2.48	2.52	2.53
average SSD specific gravity	**2.51**		
Apparent Specific Gravity =A/(B+A-C)	2.53	2.56	2.58
average apparent specific gravity	**2.56**		
Absorption (%) = (500-A)* 100 /A	1.32	1.11	1.42
average Absorption	**1.28**		

C. Silt content (Field method) (ES)

sample	Sample 1	Sample 2	Sample 3
Volume 1 in ml	50	50	50
Volume 2 in ml	2.1	1.1	1.5
% silt= (V2/V1)*100	4.2	2.2	3
average %silt content	**3.13**		

D. Silt content (Laboratory method) (ASTM 117)

sample	Sample 1	Sample 2	Sample 3
mass of sand(M1) in gr(M1)	1000	1000	1000
Oven dried mass (M2)	981.5	985	988.5
Percentage of silt=((M1-M2)/M2)*100	1.88	1.52	1.16
average silt content	**1.52**		

E. sieve analysis of fine aggregate

Sieve size (mm)	mass retained(g)	% of retained	% cum. retained	percentage Passing(%)	ASTM C33-03(%)	
					min	max
9.5	0	0	0	100	100	100
4.75	91	4.56	4.56	95.44	95	100
2.36	240	12.02	16.57	83.43	80	100
1.18	360	18.03	34.60	65.40	50	85
600	600	30.05	64.65	35.35	25	60
300	356	17.83	82.47	17.53	5	30
150	310	15.52	98.00	2.00	2	10
pan	40	2.00	100.00	0	0	0
	1997		300.85			
Fineness Modulus			3.01			

$$fineness\ Moduluss = \frac{\sum \text{Cumulative Retained}}{100} = \frac{300.85}{100}$$

II. **Coarse Aggregate property**

A. Unit Weight

sample	Sample 1	Sample 2	Sample 3
Mass of Container (M1)	1680	1680	1680
Mass of Aggregate and Container(M2)	17362	17375	17314
Mass of aggregate (M3)=M2-M1	15682	15695	15634
Volume of container in m3	10	10	10
Unit weight = M3/V	1568	1569	1563
average unit weight of coarse aggregate	1567.00		

B. Moisture Content

sample	Sample 1	Sample 2	Sample 3
mass of aggregate (M1) in kg	2	2	2
Oven dried mass (M2)	1.981	1.982	1.983
Percentage of moisture=M1-M2*100/M1	0.95	0.95	0.85
average moisture content	0.9		

C. Specific Gravity of Coarse Aggregate

sample	Sample 1	Sample 2	Sample 3
Mass of oven dry aggregate(MD)	1986	1988.5	1986.5
Mass of saturated surface dry aggregate in air (MssD)	2008.5	2001	2011
Mass of aggregate in water(MW)	1254.5	1265	1217.5
Bulk specific gravity(oven dry basis) = (MD)/(MssD -MW)	2.63	2.70	2.50
Mean specific gravity at oven dry	**2.61**		
Bulk Specific Gravity (Saturated-Surface-Dry Basis)=(MssD)/(MssD-MW)	2.66	2.72	2.53
Mean specific gravity at SSD	**2.64**		
Apparent Specific Gravity =(MD)/(MD-MW)	2.71	2.75	2.58
Mean specific gravity at apparent state	**2.68**		
Absorption (%) = (MssD-MD)/(MD)* 100	1.13	0.63	1.23
average Absorption	**1.00**		

Annex 3: Experimental Results

The Effect of Molasses on Concrete Properties

Table -1 Effect of Molasses on workability for C-25 grade of concrete.

Slump test result		
Sample	**% of Molasses added**	**Measured (mm)**
1	0.0%	25
2	0.1%	35
3	0.2%	40
4	0.3%	45
5	0.4%	65
6	0.5%	75
7	0.6%	100
8	0.7%	120

Table -2 Effect of Molasses on setting time of cement paste

Molasses dosage (%)	Initial setting time(min)	Final setting time(min)
0%	**190**	318
0.1%	320	474
0.2%	385	552
0.3%	430	606
0.4%	495	684
0.5%	540	738
0.6%	620	834
0.7%	669	892

Table -3 Effect of molasses on Workability and Compressive Strength for C-25 Concrete.

computation of workability & compressive strength for C-25 concrete										
for zero % of molasses (control group)										
No	test age (days)	dimension (cm)			slump (mm)	weight (gm)	volume (cm3)	failure load(kn)	compressive strength (mpa)	unit weight (gm/cm3)
		L	W	H						
1	3rd day	15	15	15	25	7997.5	3375	329.83	14.64	2.37
2		15	15	15		8052	3375	335.75	14.81	2.39
3		15	15	15		8158	3375	332.65	14.89	2.42
mean						**8069.17**	**3375**	**332.74**	**14.78**	**2.39**
1	7	15	15	15		7884	3375	399.83	17.77	2.34
2		15	15	15		8275	3375	454.94	20.22	2.45
3		15	15	15		7719	3375	449.78	19.99	2.29
mean						**7959.33**	**3375**	**434.85**	**19.33**	**2.36**
1	14	15	15	15		8021	3375	504.78	22.41	2.38
2		15	15	15		7944	3375	445.77	19.79	2.35
3		15	15	15		8122	3375	516.27	22.96	2.41
mean						**8029.00**	**3375**	**488.94**	**21.72**	**2.38**
1	28	15	15	15		8142	3375	631.67	28.07	2.41
2		15	15	15		7997	3375	691.14	30.74	2.37
3		15	15	15		8095	3375	706.73	31.41	2.40
mean						**8078.00**	**3375**	**676.51**	**30.07**	**2.39**

computation of workability & compressive strength for C-25 concrete										
for 0.1% of molasses by weight of cement										
No	test age (days)	dimension (cm)			slump (mm)	weight (gm)	volume (cm3)	failure load(kn)	compressive strength (mpa)	unit weight (gm/cm3)
		L	W	H						
1	3rd day	15	15	15	35	8299.0	3375	328.72	14.60	2.46
2		15	15	15		8112.0	3375	313.26	13.92	2.40
3		15	15	15		8000.5	3375	324.16	14.41	2.37
mean						**8137.2**	**3375**	**322.05**	**14.31**	**2.41**
1	7	15	15	15		8044.0	3375	471.38	20.95	2.38
2		15	15	15		8480.0	3375	467.80	20.78	2.51
3		15	15	15		7948.5	3375	400.72	17.8	2.36
mean						**8157.5**	**3375**	**446.63**	**19.84**	**2.42**
1	14	15	15	15		8065.0	3375	519.4	23.09	2.39
2		15	15	15		8060.5	3375	515.23	22.89	2.39
3		15	15	15		8122.0	3375	515.70	22.92	2.41
mean						**8082.5**	**3375**	**516.78**	**22.97**	**2.39**
1	28	15	15	15		8127.0	3375	749.98	33.3	2.41
2		15	15	15		8038.5	3375	756.04	33.64	2.38
3		15	15	15		8141.2	3375	665.23	29.57	2.41
mean						**8102.2**	**3375**	**723.75**	**32.17**	**2.40**

computation of workability & compressive strength for C-25 concrete										
for 0.2 % of molasses										
No	test age (days)	dimension (cm)			slump (mm)	weight (gm)	volume (cm3)	failure load(kn)	compressive strength (mpa)	unit weight (gm/cm3)
		L	W	H						
1	3rd day	15	15	15	40	7971.5	3375	318.33	14.15	2.36
2		15	15	15		7721.0	3375	265.16	11.79	2.29
3		15	15	15		7676.0	3375	278.15	12.36	2.27
mean						**7789.5**	**3375**	**287.21**	**12.77**	**2.31**
1	7	15	15	15		8153.0	3375	459.44	20.42	2.42
2		15	15	15		8062.0	3375	491.17	21.83	2.39
3		15	15	15		8083.0	3375	445.95	19.82	2.39
mean						**8099.3**	**3375**	**465.52**	**20.69**	**2.40**
1	14	15	15	15		8062.0	3375	536.17	23.83	2.39
2		15	15	15		8327.0	3375	512.44	22.76	2.47
3		15	15	15		7925.0	3375	566.16	25.16	2.35
mean						**8105**	**3375**	**538.26**	**23.92**	**2.40**
1	28	15	15	15		8135.0	3375	690.15	30.68	2.41
2		15	15	15		8267.0	3375	738.12	35.81	2.45
3		15	15	15		7967.0	3375	750.22	33.35	2.36
mean						**8123.0**	**3375**	**726.16**	**33.28**	**2.41**

computation of workability & compressive strength for C-25 concrete										
for 0.3 % of molasses										
No	test age (days)	dimension (cm)			slump (mm)	weight (gm)	volume (cm3)	failure load(kn)	compressive strength (mpa)	unit weight (gm/cm3)
		L	W	H						
1	3rd day	15	15	15	45	7955.0	3375	266.875	11.85	2.36
2		15	15	15		7893.5	3375	257.2	11.43	2.34
3		15	15	15		7950.0	3375	262.03	11.66	2.36
mean						**7932.8**	**3375**	**262.04**	**11.65**	**2.35**
1	7	15	15	15		8382.0	3375	467.15	20.76	2.48
2		15	15	15		8364.0	3375	465.18	20.67	2.48
3		15	15	15		8024.0	3375	429.87	19.11	2.38
mean						**8256.7**	**3375**	**454.07**	**20.18**	**2.45**
1	14	15	15	15		8127.0	3375	551.93	24.53	2.41
2		15	15	15		8060.5	3375	536.18	23.83	2.39
3		15	15	15		8262.0	3375	560.7	24.92	2.45
mean						**8149.8**	**3375**	**549.60**	**24.43**	**2.41**
1	28	15	15	15		8527.0	3375	767.25	34.12	2.53
2		15	15	15		8338.5	3375	796.5	35.40	2.47
3		15	15	15		8341.2	3375	740.27	32.89	2.47
mean						**8402.2**	**3375**	**768.01**	**34.14**	**2.49**

computation of workability & compressive strength for C-25 concrete										
for 0.4 % of molasses										
No	test age (days)	dimension (cm)			slump (mm)	weight (gm)	volume (cm3)	failure load(kn)	compressive strength (mpa)	unit weight (gm/cm3)
		L	W	H						
1	3rd day	15	15	15	65	7959.00	3375	**252.2**	11.21	2.36
2		15	15	15		8152.00	3375	**250.05**	11.11	2.42
3		15	15	15		8330.00	3375	**251.32**	11.17	2.47
mean						**8147.00**	**3375.0**	**251.19**	**11.16**	**2.41**
1	7	15	15	15		7942.00	3375	**437.67**	19.45	2.35
2		15	15	15		7985.00	3375	**432.24**	19.21	2.37
3		15	15	15		7812.50	3375	**450.18**	20.03	2.31
mean						**7913.17**	**3375**	**440.03**	**19.56**	**2.34**
1	14	15	15	15		8021.00	3375	**547.11**	24.32	2.38
2		15	15	15		8117.00	3375	**485.16**	21.57	2.41
3		15	15	15		8311.00	3375	**521.18**	23.16	2.46
mean						**8149.67**	**3375**	**517.82**	**23.02**	**2.41**

1	**28**	15	15	15		7834.00	3375	**694.92**	30.89	2.32
2		15	15	15		8135.00	3375	**754.32**	33.53	2.41
3		15	15	15		8562.00	3375	**694.92**	32.91	2.54
mean						**8177.00**	**3375**	**714.72**	**32.44**	**2.42**

computation of workability& compressive strength for C-25 concrete										
for 0.5 % of molasses										
No	**test age (days)**	**dimension (mm)**			**slump (mm)**	**weight (gm)**	**volume (cm3)**	**failure load(kn)**	**compressive strength (mpa)**	**unit weight (gm/cm3)**
		L	**W**	**H**						
1	**3rd day**	15	15	15	**75**	8224	3375	220.73	9.81	2.44
2		15	15	15		8200.5	3375	235.13	10.45	2.43
3		15	15	15		7987.5	3375	202.5	9.00	2.37
mean						**8137**	**3375**	**219.45**	**9.75**	**2.41**
1	**7**	15	15	15		8013	3375	422.25	18.78	2.37
2		15	15	15		8318	3375	404.12	17.96	2.46
3		15	15	15		8002	3375	389.20	17.29	2.37
mean						**8111.0**	**3375**	**405.19**	**18.01**	**2.40**
1	**14**	15	15	15		8400	3375	511.42	22.75	2.49
2		15	15	15		8375	3375	426.15	18.93	2.48
3		15	15	15		8140.5	3375	443.03	19.69	2.41
mean						**8305**	**3375**	**460.20**	**20.46**	**2.46**
1	**28**	15	15	15		8200.5	3375	740.35	32.89	2.43
2		15	15	15		8183.5	3375	659.98	29.31	2.42
3		15	15	15		8240.5	3375	708.11	31.48	2.44
mean						**8208.17**	**3375**	**702.81**	**31.23**	**2.43**

computation of workability& compressive strength for C-25 concrete										
for 0.6 % of molasses										
No	**test age (days)**	**dimension (cm)**			**slump (mm)**	**weight (gm)**	**volume (cm3)**	**failure load(kn)**	**compressive strength (mpa)**	**unit weight (gm/cm3)**
		L	**W**	**H**						
1	**3rd day**	15	15	15	**100**	8400	3375	151.47	6.75	2.49
2		15	15	15		8182.5	3375	170.10	7.56	2.42
3		15	15	15		8048.5	3375	175.85	7.86	2.38
mean						**8210**	**3375**	**165.81**	**7.39**	**2.43**
1	**7**	15	15	15		8073	3375	331.62	14.75	2.39
2		15	15	15		8014	3375	376.84	16.74	2.37
3		15	15	15		8084	3375	362.98	16.11	2.40
mean						**8057**	**3375**	**357.15**	**15.87**	**2.39**
1	**14**	15	15	15		8194	3375	407.7	18.12	2.43
2		15	15	15		8082.5	3375	458.1	20.36	2.39
3		15	15	15		8342	3375	454.37	20.21	2.47
mean						**8206**	**3375**	**440.06**	**19.56**	**2.43**
1	**28**	15	15	15		8284	3375	627.51	27.84	2.45
2		15	15	15		8212	3375	709.88	31.55	2.43
3		15	15	15		8012	3375	742.35	33.01	2.37
mean						**8169.33**	**3375**	**693.25**	**30.80**	**2.42**

computation of workability & compressive strength for C-25 concrete										
for 0.7 % of molasses										
No	**test age (days)**	**dimension (cm)**			**slump (mm)**	**weight (gm)**	**volume (cm3)**	**failure load(kn)**	**compressive strength (mpa)**	**unit weight (gm/cm3)**
		L	**W**	**H**						
1	**3rd day**	15	15	15	**120**	8407	3375	109.8	4.85	2.49
2		15	15	15		8082.5	3375	97.2	4.32	2.39
3		15	15	15		8148.5	3375	102.55	4.55	2.41
mean						**8213**	**3375**	**103.18**	**4.57**	**2.43**
1	**7**	15	15	15		7755	3375	286.15	12.74	2.30
2		15	15	15		8121	3375	345.06	15.36	2.41
3		15	15	15		8083	3375	281.48	12.51	2.39
mean						**7986**	**3375**	**304.23**	**13.54**	**2.37**
1	**14**	15	15	15		7971	3375	416.03	18.49	2.36
2		15	15	15		8352	3375	419.78	18.66	2.47
3		15	15	15		8258	3375	423.9	18.84	2.45
mean						**8194**	**3375**	**419.90**	**18.66**	**2.43**
1	**28**	15	15	15		8000.5	3375	708.08	31.48	2.37
2		15	15	15		7983.5	3375	719.49	31.97	2.37
3		15	15	15		7940.5	3375	623.02	27.69	2.35
mean						**7974.83**	**3375**	**683.53**	**30.38**	**2.36**

Annex 4: Photo Gallery During Photos Taken During the Study

Figure 1 collecting molasses sample from Arjo Didessa sugar factory.

Figure 2 test for constituent of molasses

Figure 3 Aggregates sample collection

Figure 4 washing of sand to make free of silt and clay

Figure 5 sun drying of washed sand

Figure 6 specific gravity test and silt content test of fine aggregate

Figure 7 washing of coarse aggregate to make free of clay lump

Figure 8 Sieve analysis and unit weight test of coarse aggregate

Figure 9 specific gravity of coarse aggregate

Figure 10 coating molds with oil and cleaning concrete mixer

Figure 11 measuring concrete ingredient

Figure 12 Concrete Mixing Process

Figure 13 Slump test

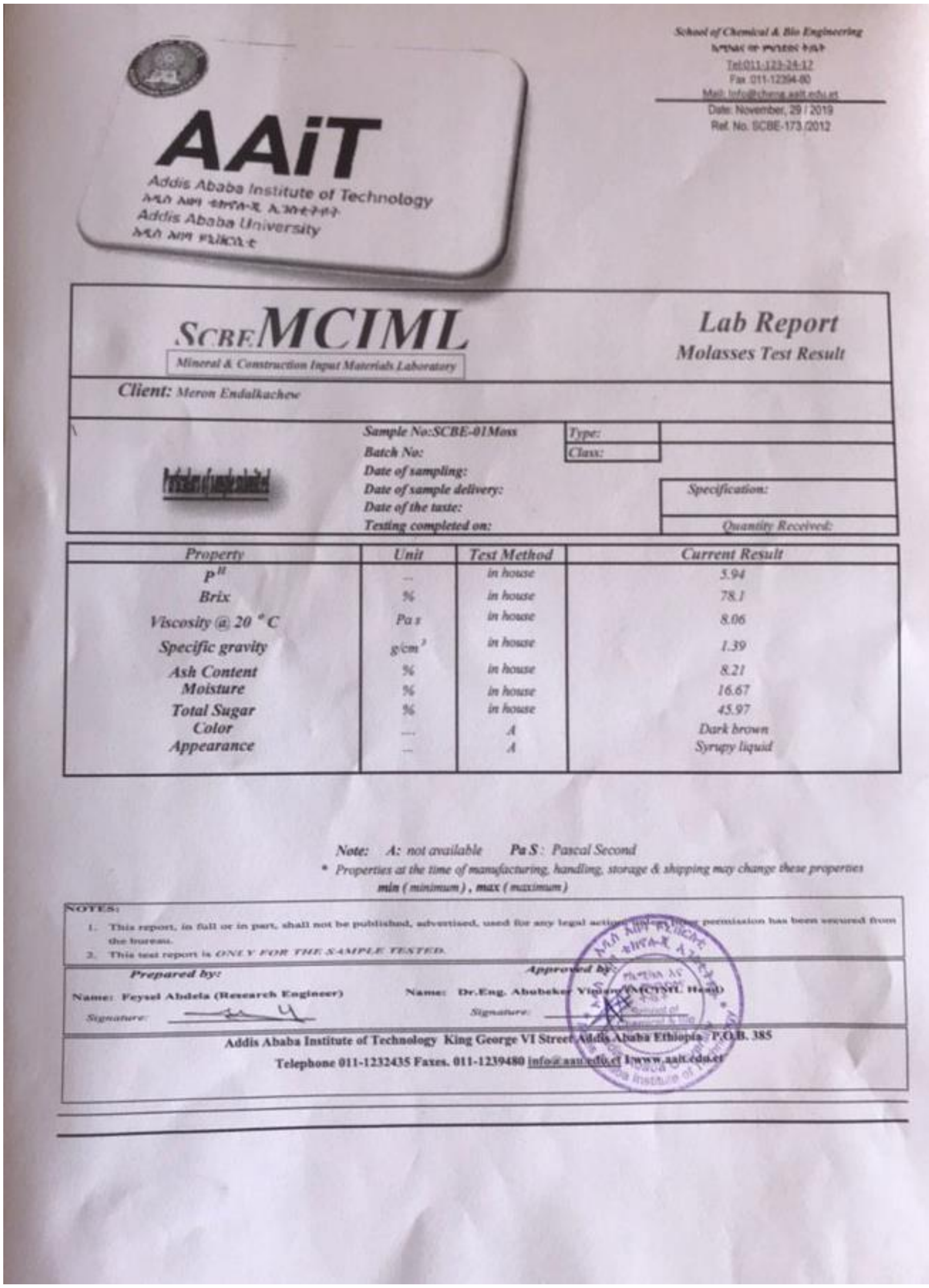
Figure 14 Casting of Concrete

Figure 15 Concrete curing

Figure 16 Surface drying of concrete mold

Figure 17 Weighing and crushing of concrete cubes

Physical and Chemical properties of molasses samples



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AAiT
Addis Ababa Institute of Technology
Addis Ababa University

SCBE MCIML
Mineral & Construction Input Materials Laboratory

Lab Report
Molasses Test Result

Client: Meron Endalkachew

Sample No: SCBE-01Moss
Batch No:
Date of sampling:
Date of sample delivery:
Date of the taste:
Testing completed on:
Type:
Class:
Specification:
Quantity Received:

Property	Unit	Test Method	Current Result
P^H	---	in house	5.94
Brix	%	in house	78.1
Viscosity @ 20 °C	Pa s	in house	8.06
Specific gravity	g/cm³	in house	1.39
Ash Content	%	in house	8.21
Moisture	%	in house	16.67
Total Sugar	%	in house	45.97
Color	---	A	Dark brown
Appearance	---	A	Syrupy liquid

Note: A: not available Pa S: Pascal Second
* Properties at the time of manufacturing, handling, storage & shipping may change these properties
min (minimum), max (maximum)

NOTES:
1. This report, in full or in part, shall not be published, advertised, used for any legal action unless prior permission has been secured from the bureau.
2. This test report is ONLY FOR THE SAMPLE TESTED.

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