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# Effect of Molasses on the Strength and Workability of Concrete with Cement Partially Replaced by Saw Dust Ash (SDA)

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**ABSTRACT**

This study aimed at investigating the effect of molasses on the workability of concrete with Saw Dust Ash (SDA) as partial replacement of Ordinary Portland Cement (OPC) in normal strength concrete of C25/30. Concrete samples with varying percentages of SDA, Molasses by weight of cement was made, cured at 28 days and tested for workability and strength. Results of the study indicated that the slump values increased linearly with increase in percentage of molasses from 0.1% to 0.20% respectively. The 0.15% of molasses added to 10% replacement of cement with SDA gave a slump of 110 mm along with the highest Cylinder strength result of 30.2 Mpa at 28days. From the study, it was seen that the slump values remained in the range of 100-110mm for 0.10% and 0.15% of molasses added and this implied that molasses can maintain acceptable workability of concrete up to 0.15% by mass of cement.

## 1. Introduction

Saw Dust is a waste material from the timber industry. It is produced as timber is sawn into planks at saw mills located in virtually all major towns of the country (Uganda). This process is a daily activity causing heaps of saw dust to be generated after each day and it adds on to the total solid waste generated in the country. Solid waste management has become one of the major environmental issues in developing countries of which Uganda is among the countries where the wastes generated are continually increasing both in rural and urban areas (Tan, 2012). Continuous generation of wastes arising from industrial by-products and agricultural residue, create acute environmental problems both in terms of their treatment and disposal. The construction industry has been identified as the one that absorbs the majority of such materials as filler in concrete (Antiohos et al., 2005). If these fillers have pozzolanic properties, they impart technical advantages to the resulting concrete and also enable larger quantities of cement replacement to be achieved (Hossain, 2003). As part of the sustainable waste management strategy, saw dust ash was identified in different studies as one of the materials that can be used

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to partially replace cement during concrete production while cutting the cost of cement during concrete production.

The cost of conventional building materials in Uganda have continued to increase as the majority of the population continues to fall below the poverty line and therefore there is a need to search for local materials as alternatives for the construction of functional but low-cost buildings in both the rural and urban areas. Efforts have been made by different researchers in identifying the local materials like saw dust ash that can be used as a partial replacement for cement in the concrete production and their results are considered promising results for cement mixtures in general, however there is still need for detailed studies to assure the efficient use of saw dust ash as a partial replacement for cement in concrete production. Past studies showed that the workability of concrete greatly reduce with increased addition of saw dust ash to concrete mix. There has been a significant increase in the prices of cement in Uganda between the years 2009 to 2018 from Ush 24,000 to Ush 34,000 respectively (Fig 1) and the need for affordable building materials in providing adequate housing for the teaming populace of the world has been a significant challenge. The study conducted by A.A Raheem (2012) on Saw Dust Ash as partial replacement for Cement in Concrete showed that the slump and compacting factor decrease with increased SDA content indicating that concrete becomes less workable as the SDA content increases and the compressive strength decrease with increasing SDA replacement. Thus, the core aim of this study was to investigate the effect of molasses on the strength and workability of concrete with Saw Dust Ash as partial replacement of cement.

### 1.1. Molasses

Molasses is a by-product of sugar production. 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 which not only improves concrete fluidity but also improves hardening of cement paste (Khuram Rashid, 2009) and also the incorporation of Saw Dust Ash and Molasses, was seen to cut down the production costs of concrete while improving its physical and mechanical properties such as workability and compressive strength. Therefore the need to investigate the influence this waste product molasses on physical and mechanical properties of concrete with sawdust ash as partial replacement for cement was the focus of this study.

According to the world data atlas, Molasses - production of Uganda increased from 75,500 tons in 1969 to 200,000 tons in 2018 growing at an average annual rate of 14.15%.

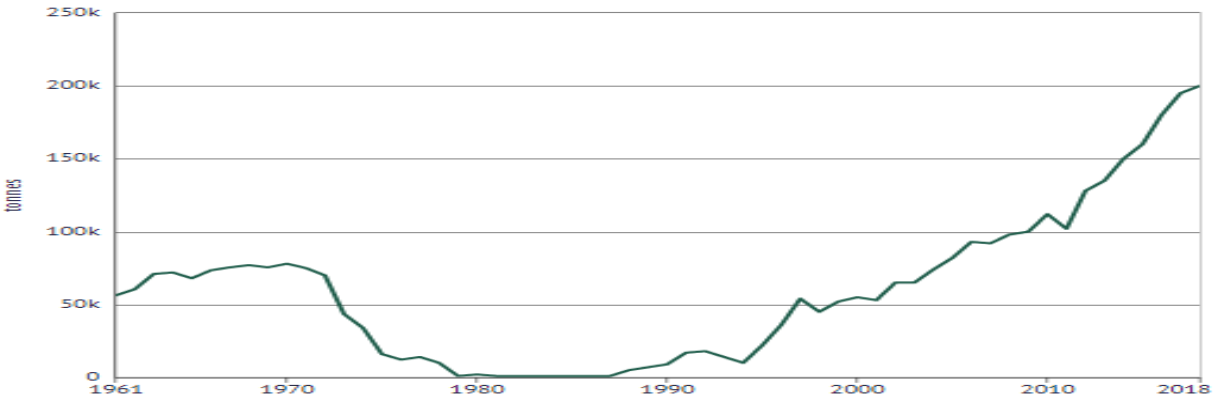



*Figure 1.* Molasses production statistics for Uganda

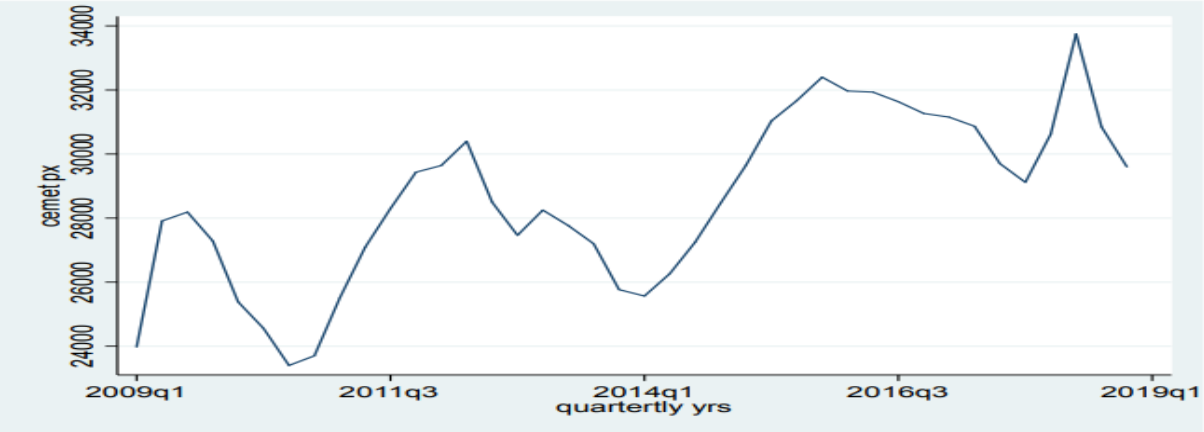



*Figure 2.* A trend showing the price of a 50kg bag of cement in Uganda overtime [1]

### 1.2. Purpose of the Study

Concrete is the major construction material used on most building projects in Uganda and cement is the most expensive of the materials used to make concrete. This means that there is a need to minimize on the quantity of cement used in the production of concrete while maintaining the strength and workability standards. Saw dust ash was identified as one of the waste materials that can be used as a partial replacement for cement but it has a problem of reducing the workability of concrete. Hence the principal purpose of this study was to investigate the effect of molasses on the strength and workability of concrete with Saw Dust Ash as partial replacement of cement.

## 2. Literature

The construction industry in Uganda and all over the world has seen quite several technological advancements over the years in cement and concrete technology. These include use of mineral and chemical admixtures in concrete production added during mixing in order to enhance the properties of the concrete. Some of the best advancements include studies into replacement of cement by using by-product materials to contain environmental impact of cement production and the economical aspect. Different materials that have been found to have properties that enable them to be used as cement replacements include fly ash, rice husk ash, saw dust ash and granulated ground blast furnace slag among others. [2].

The study conducted by Yohannes Kassa (2019) on the use of cane molasses as concrete retarder admixture indicated that the addition of molasses into cement paste has the capability to delay the setting time of cement paste with a minimum of 380 min and a maximum of 990 min and at the same time it increases the concrete compressive strength at the 28th days with a range of 4.5–16.52%. [3].

The results of the study conducted by A.A Raheem (2012) on Saw Dust Ash as Partial Replacement for Cement in Concrete showed that SDA is a good pozzolan with combined SiO2, Al2O3 and Fe2O3 of 73.07%. The slump and compacting factor decreased as the SDA content increased indicating that concrete becomes less workable as the SDA content increased and the compressive strength decreased with increasing SDA replacement [4].

C.Marthong (2012) conducted a research to investigate the use of saw dust ash (SDA) as partial replacement of cement in India and in this research, Saw dust was burnt and the ash sieved using a 90 micron sieve before being used for the mix. Percentage replacement of OPC with SDA was 0, 10, 20, 30 and 40% respectively. The results of the study showed that, inclusion

of SDA cause little expansion due to low calcium content and early cube strength development was observed to be about 50-60% of their 28 days strength [5].

The results of the study conducted by Shahidkha pathan and Dr v.v. Singh (2018) on the effect of using molasses in concrete as a time retarding admixture showed that addition of molasses to fresh concrete causes considerable increase in both initial and final setting time and it was also found that it has no harmful effect on the strength although the strength near about same slight increase, workability test was carried out and it was found that as the percentage of admixtures increased consequently slump also increased [6]

The results of the study conducted by Raheem, Olasunkanmi and Folorunso (2016) to investigate the physical properties and chemical composition of saw dust ash (SDA) as well as the workability, and compressive strength properties of the concrete produced by replacing 5%, 10%, 15%, 20% and 25% by weight of ordinary Portland cement with SDA showed that the slump and compacting factor decreases as the SDA content increase indicating that concrete becomes less workable as the SDA content increases [7].

Somawanshi, S. P., Ansari, U.S and karale, S. A (2016) studied the effect of molasses in concrete as a water reducing and time retarding admixture. In this study the molasses were determined from sugar production factories. Setting times of concrete prepared with molasses at three different dosage (0.40, 0.60, and 0.80 wt. % of cement content) were determined and it was found that molasses addition causes a considerable increase in both initial and final setting time. Also treated waste water used in concrete with different dosages of molasses (0.40, .60, and 0.80 wt. % of cement content) were determined and it was found that no harmful effect on the strength although the strength near about same slight increase. High performance concrete is prepared with molasses of different dosage (0.4, 0.6, and 0.8 wt. % of cement content) in this case also found that molasses of addition cause a considerable increase in both initial and final setting times. Workability test was carried out on fresh concrete prepared with three molasses. Compressive strength test are carried on (7, 14, and 28 days) prepared block and on hardening concrete (28 days) flexural, split test carried out. The strength of concrete with molasses showed slight increase at all ages, except early age, with respect to the control mix [8].

Prof. Mahesh Yelbhar, Saurabh Palande, Sangram Pawar and Rohan Jawale (2020) conducted a study on the effective utilization of molasses for improvement of workability of concrete and in this study the molasses were determined from sugar production factories. Setting times of concrete prepared with molasses at three different dosage (0.40, 0.60, and 0.80 wt. % of cement content) were determined and it was found that molasses addition causes a considerable increase in both initial and final setting time. Also treated waste water used in concrete with different dosages of molasses (0.40, .60, and 0.80 wt. % of cement content) were determined and it was found that no harmful effect on the strength although the strength near about same slight increase. High performance concrete was prepared with molasses of different dosage (0.4, 0.6, and 0.8 wt. % of cement content) in this case it was also found that addition of molasses cause a considerable increase in both initial and final setting times. Workability test was carried out on fresh concrete prepared with three molasses. Compressive strength test are carried on (7, 14, and 28 days) prepared block and on hardening concrete (28 days) flexural, split test carried out. The strength of concrete with molasses showed slight increase at all ages, except early age, with respect to the control mix [9].

The study conducted by A. Megahed Ahmed, Mohamed M. A, Omar A, F. and Shawky M. H. for improvement of the concrete characteristics by using sugar industry wastes (vinasse) in Egypt indicated that the (VSW 2016) solution improves the consistency characteristics and compressive strength of concrete, In this experimental study, three different normal – strength

concrete mixes were used. Trial mixes were conducted to reach the target cubic compressive strength of 20, 30 and 35 MPa after 28 days [10].

The results of the study conducted by Shahidkha b pathan and Dr v.v. Singh (2018) to using molasses in concrete as a time retarding admixture indicated that molasses addition causes considerable increase in both initial and final setting time of concrete. In this study the molasses were determined from sugar production factories. Setting times of concrete prepared with molasses at three different dosage (0.40, 0.60, and 0.80 wt. % of cement content) were determined.

The treated waste water used in concrete with different dosages of molasses (0.40, .60, and 0.80 wt. % of cement content) were determined and it was found that no harmful effect on the strength although the strength near about same slight increase [11].
The study conducted by Weifeng, Suhua , & Zhang (2014) for the Physical and chemical studies on cement containing sugarcane molasses indicated that a small amount of sugarcane molasses retards the setting and hardening of cement paste and increases the fluidity of cement mortar, while excess molasses accelerates the setting and hardening. Molasses improves significantly the compressive strength at 3d due to the decrease of porosity. The addition of 1.0 % molasses accelerates the formation of ettringite, prevents the second hydration of aluminate phase and delays the hydration of C3S [12].

The study conducted by N.H.M. K. Serker, R. U. Hafiz, A.H.M. A. Rahman and M. Ashikuzzaman (2021) on the showed that the compressive strength of concrete increases at 5% replacement of cement by sugarcane bagasse ash. It was also found that workability rises with the increasing percentage of sugarcane bagasse ash, and setting time decreases with time. In this study, 5%, 10%, 15%, 20% and 25% of cement was replaced by sugarcane bagasse ash by weight in concrete. The slump increased linearly from 9mm at 0% sugarcane bagasse ash to 63mm at 25% sugarcane bagasse ash [13].

In the study conducted by Mohammad Iqbal Malik, Syed Rumysa Jan, Junaid Ahmad Peer,Syed Azhar Nazir, Khubbab Fa and Mohammad in 2015 for the partial replacement of cement by Saw Dust Ash in Concrete as a sustainable approach. Cement was replaced by Saw Dust Ash as 5%, 10%, 15% and 20% by weight for M-25 mix. The concrete specimens were tested for compressive strength, durability (water absorption) and density at 28 days of age and the results obtained were compared with those of normal concrete. The results of the study indicated that SDA is a suitable material for use as a pozzolan since it satisfied the requirement for such a material by having a combined (Sio2+Al2O3+Fe2O3) of more than 70%. The study further indicated that Concrete becomes more workable as the SDA percentage increases meaning that less water is required to make the mixes more workable .This means that SDA concrete has lower water demand and the compressive strength generally increases with curing period and decreases with increased amount of SDA. Only 10% substitution is allowed at maximum and 5% substitution is adequate to enjoy maximum benefit of strength gain. The results concluded the permissibility of using Saw Dust Ash as partial replacement of cement up to 10% by weight for particle size of range 90micron [14].

A Study was conducted by Shantanu, et al in 2017 to investigate the effect of Sugarcane Molasses on Compressive Strength and Workability of Fly Ash Mixed Concrete. In this study, effect of molasses with concentrations of 0.1%, 0.15%, 0.2% and 0.25% by weight of cement, cured at 7, 28 and 56 days were examined and the compressive strength test results showed significant strength gain at all ages for 0.15% dosage molasses but peaks at 43.89% at 28 days. However, there was no significant increase in strength from 28 to 56 days which peaks 4.8% for 0.15% dosage. The slump values were measured at time intervals of 30, 45 and 60 minutes

after preparation of the mix respectively and the slump values were observed to increase linearly with increase in dosage of molasses from 0.1% to 0.25% respectively [15].

Babar Ali, el.al (2019) studied the effect of molasses and water–cement ratio on properties of recycled aggregate concrete. In this study, the influence of four different concentrations of molasses (0%, 0.25%, 0.50% and 1% by weight of cement) on the properties of RAC was investigated using three different water–cement (W/C) ratios (0.45, 0.50 and 0.55) and the Workability, fresh density, compressive strength, water absorption and chloride penetrations were investigated**.** The results encouraged the use of 0.25–0.50% molasses in RAC for maximum strength and durability. Blank and molasses-added mixes showed maximum strength and durability at 0.55 and 0.50 W/C ratios, respectively [16].

Aster Taye Serte (2019) of Addis Ababa Science and Technology University conducted a research on the impact of sugarcane molasses in concrete as time retarding and water reducing admixture. In this study, the Slump test, compressive strength test and split tensile test of concrete was conducted at 0%, 0.2%, 0.3%, 0.4%, and 0.6% of sugarcane molasses by weight of cement. The total samples of 180 concrete cubes of size 150mm× 150mm × 150mm and cylinder of size 300mm×150mm were produced. From these samples 90 cubes were used for compressive strength test and 90 cylinders used for split tensile strengths test at 7 and 28 days curing periods for both. The results showed that Sugarcane molasses acted as accelerating admixture up to 0.4% dosage of molasses, and above 0.4% as a retarding admixture, the slump test value of the three concrete grades C25, C30 and C40 were increased due to the dosage level increment of sugarcane molasses, After 28 days curing periods, the compressive strength and tensile strength of concrete were increased up to 0.4% dosage of molasses and at higher percentage of molasses, the strength were reduced. The 7 days curing period's tensile strength was decrease with an increased percentage of molasses except 0.3% of dosage of molasses. These results revealed that 0.3% addition of sugar cane molasses gave the best results in compressive and tensile strengths tests of the concrete specimens made with concrete grade C25,C30 and C40 and therefore 0.3% proved to be the optimum dosage [17].

Vijay Bahadur and Dr. Preeti Agarwal (2022) studied the effect of Addition of Sugarcane Molasses in Structural Concrete. In this study, the effects of different dosage level like 0.1, 0.2, 0.3, 0.4, 0.5, 0.6% of the molasses by weight of the cement were analyzed for the consistency, setting time, water reduction and workability. The test were performed for workability and compressive strength by adding dosage level like from 0.1% to 0.6% respectively of the molasses by weight of cement of the design mix M20, M30 and M35 for 3 day, 7 day and 28 day. The test results stipulate that molasses behave like as accelerators up to 0.5 % of dose and after that retarder. The compressive and split tensile strength of structural concrete for 3 day and 7 day with molasses indicated a decline in strength. The compressive strength of structural concrete and mortar increased by adding 0.5 % of molasses by weight of cement for 28 day and therefore the most favorable dosage level was 0.3 % of the molasses by weight of cement [18].

Yohannes Kassa (2019) conducted a study on the application of cane molasses as concrete retarder admixture. This study tried to establish a different mix ratio of molasses as a retarder for the concrete mix, while at the same time, the properties of C-25 Concrete were determined. It was found out that the presence of molasses in concrete had significantly extended the setting time and reduce the rate of strength development at early ages but enhance the compressive strength at the later ages. During the study, it became evident that the addition of molasses into cement paste has the capability to delay the setting time of cement paste with a minimum of 380 min and a maximum of 990 min and at the same time it increases the concrete compressive

strength at the 28th days with a range of 4.5–16.52%. Therefore the study concluded that molasses could be used as a conventional retarder admixture for concrete [19]

## 3. Methods and Materials

**Cement - Saw Dust Ash:** The cement used was replaced by 10% of SDA by mass as per the results obtained by a fellow research student. Cement type I (Grade 42.5 N) was used from Tororo Cement conforming to EN 197-1:2011. The Saw Dust Ash used was sourced from ERIMU Company Limited prepared by uncontrolled burning.

**Molasses:** Specimens with varying percentages (0, 0.1, 0.15 and 0.20) % of molasses were prepared and appropriate laboratory tests carried out to determine the percentage of molasses that produces optimum workability of concrete with Saw Dust Ash as partial replacement of cement. The 0 – 0.20% range was chosen based on previous research work about usage of molasses in concrete production since optimum percentages lied with in this range. In addition, the chemical composition of molasses was determined and finally the compressive strength of the resultant concrete was determined.

**Coarse Aggregates:** The granite course aggregates of size 5-20 mm sourced from the quarry at Mbalala- Mukono was used, conforming to EN 12620 aggregates for concrete.

**Fine Aggregates:** Sand used for this research work was lake sand sourced from Lwera Masaka.

**Water:** The water used for the study was potable tap water supplied by National Water and Sewerage Corporation, clean and free from any visible impurities, conforming to EN 1008:2002.

### 3.1. Mix Proportions

Given the class of concrete (C25/30), the number of cubes for every percentage and the water – cement ratio, the mix quantities were automatically generated by a Department of Environment mix design spreadsheet template. The Cement-Saw Dust Ash and w/c ratio were the same for all concrete mixtures and was 14.9kg and 0.55 respectively with a constant 10% by mass of Saw Dust Ash partially replacing cement. Specified proportions of each material consisting of fine aggregates of maximum size 5 mm and coarse aggregates of size 5-20mm, using a mix design ratio of (1:2.4:3.2) for a target strength of 25N/mm$^2$. The molasses was used as a plasticizer in percentages of 0, 0.1, 0.15 and 0.20. **Table 1** below gives the different mix proportions used.

Table 1.
*Mix Proportions of Concrete*

| No. Mixes | Molasses (%) | Molasses (g) | Cement (kgs) | SDA (kgs) | Fine Aggt (kgs) | Coarse Aggt (kgs) | Water W/C=0.55 (kgs) |
|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 13.41 | 1.49 | 36.3 | 48.1 | 8.2 |
| 2 | 0.10 | 14.9 | 13.41 | 1.49 | 36.3 | 48.1 | 8.2 |
| 3 | 0.15 | 22.35 | 13.41 | 1.49 | 36.3 | 48.1 | 8.2 |
| 4 | 0.20 | 29.8 | 13.41 | 1.49 | 36.3 | 48.1 | 8.2 |

Batching of materials was done by weight. The percentage replacement of cement by SDA was 10% constant and the dosage of molasses was varied as 0.1%, 0.15% and 0.20%. The 0% was to serve as a control mix for other samples.

Water, Cement – SDA were thoroughly blended and then the aggregates added and mixed followed by gradual addition of water and mixing. Wet mixing was done until a mixture of uniform color and consistency achieved. Mixing of ingredients was done using a revolving drum mixer. Before casting the specimens, workability of the mixes were determined by 4the slump test with different percentage molasses.

### 3.2. Workability Tests

The workability of each concrete mix was measured by performing slump cone test. The test was carried out in accordance with the requirements of BS 1881: Part 102(1983) for slump test.

### 3.3. Compressive Strength Test

This was done in accordance to BS1881: Part 116:1983. After 28 days of normal curing, a total of 3 cubes for each mix with (0%, 0.10%, 0.15%, and 0.20%) of molasses were removed from the curing tank and compressive strength test performed on them.

The compressive strength test was performed on the cube samples using a universal compressive testing machine. The cubes were subjected to compression load at a constant rate while the maximum load at failure recorded. The compressive strength was determined by dividing the load (force) with the area of the tested cubes.

## 4. Results, Analysis and Discussion

### 4.1. Chemical Composition of Molasses

**1) PH:** PH of 5.6 was obtained from the PH test implying absence of bases or acids in the molasses. The molasses were therefore considered neutral hence posing no threats to the aggregates in the concrete.
**2) Moisture Content:** The chemical analysis of the molasses showed moisture content of 62.4%.
**3) Total Reducing Sugars:** An amount of total reducing Sugars of 41.92% was obtained. The existence of sugars in molasses facilitated the process of coating the cement particles and delaying of the hydration of cement thus prolonging setting time this is what improved the workability of concrete.
**4) Inorganic compounds:** The X-ray fluorescent spectrometer was used to determine the extent of inorganic elements and elements such as Si, and Ca, had an effect on the compressive strength of concrete.
The 10g of molasses was used to analyze the inorganic compounds.

Table 2.
*The organic compounds of molasses tested*

| No | Parameter | Result |
|---|---|---|
| 1 | PH | 5.6 |
| 2 | Moisture Content | 62.4% |
| 3 | Total Reducing Sugars ( TRS) | 41.92% |

Table 3.
*The major Inorganic compounds of molasses tested of initial mass 10g.*

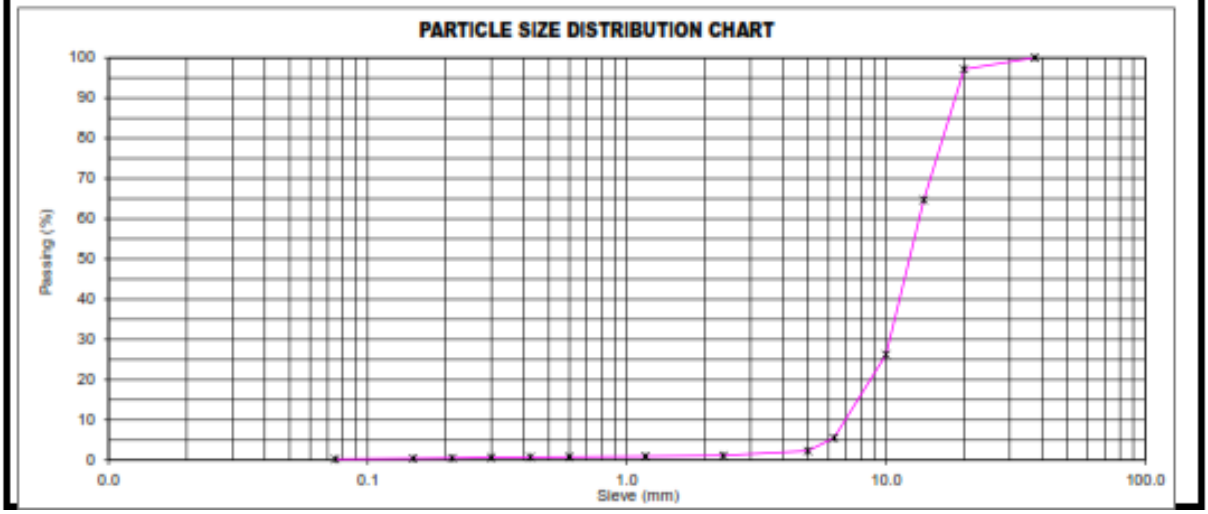
| No | Parameter | Result | At optimum 0.15% (22.35g) |
|---|---|---|---|
| 1 | Si (Silicon) | 0.126% | 0.282% |
| 2 | P (Phosphorous) | 0.183% | 0.409% |
| 3 | S (Sulphur) | 0.320% | 0.715% |
| 4 | K (Potassium) | 7.410% | 16.561% |
| 5 | Ca ( Calcium) | 5.226% | 11.680% |
| 6 | Fe ( Iron) | 0.259% | 0.579% |
| 7 | Cl ( Chloride) | 0.719% | 1.607% |

## 4.2. Coarse Aggregates Gradation results

From the graph below the aggregates used were well graded thus contained fewer voids

Table 4.
*Particle size distribution of coarse aggregates*

| Sample Description | | CRUSHED AGGREGATES | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | Moisture Content(%) | | | |
| Dry wt | | 1528.9 | | | | | |
| | | | | Initial Dry Weight | | 1528.9 | |
| Sieve, mm | Apparture Size Used (mm) | Partial Retained | Cumulative Retained | Cumulative | % Passing | Grading Limits (%) | |
| | | Mass(g) | Mass (g) | (%) | (%) | LL | UL |
| 37.5 | 37.5 | 0.0 | 0.0 | 0.00 | 100.0 | | |
| 20.0 | 20.0 | 43.6 | 43.6 | 2.85 | 97.1 | | |
| 14.0 | 14.0 | 496.0 | 539.6 | 32.44 | 64.7 | | |
| 10.0 | 10.0 | 587.5 | 1127.1 | 38.43 | 26.3 | | |
| 6.3 | 6.3 | 316.7 | 1443.8 | 20.71 | 5.6 | | |
| 5.0 | 5.00 | 49.5 | 1493.3 | 3.24 | 2.3 | | |
| 2.4 | 2.36 | 17.7 | 1511 | 1.16 | 1.2 | | |
| 1.18 | 1.18 | 2.9 | 1513.9 | 0.19 | 1.0 | | |
| 0.60 | 0.60 | 1.9 | 1515.8 | 0.12 | 0.9 | | |
| 0.425 | 0.425 | 0.9 | 1516.7 | 0.07 | 0.8 | | |
| 0.300 | 0.300 | 1.2 | 1517.9 | 0.08 | 0.7 | | |
| 0.212 | 0.212 | 2.0 | 1519.9 | 0.13 | 0.6 | | |
| 0.150 | 0.150 | 1.6 | 1521.5 | 0.10 | 0.5 | | |
| 0.075 | 0.075 | 2.8 | 1524.3 | 0.18 | 0.3 | | |
| PAN | | 4.6 | 1528.9 | 0.3 | 0.0 | | |



### 4.3. Flakiness Index

The flakiness index of 14% was obtained indicating that aggregates were not flaky since 14 %< 35%, thus they were good to work with. The results of flakiness index are shown in the **Table 5** below.

Table 5.
*Flakiness index value of the coarse aggregates*

| FLAKINESS OF AGGGREGATES (BS 812 Part 105:1990) | | | | | | |
|---|---|---|---|---|---|---|
| FI= 14% | BS GAUGE | PASS GAUGE Wt (g) | RET. GAUGE Wt. (g) | Wt. (g) per Fraction | Individual Flakiness % | Reported Flakiness Result % |
| | 50.0-37.5 | | | | | |
| | 37.5-28.0 | 0 | | 0.0 | | |
| | 28.0-20.0 | 107.0 | 310.0 | 417.0 | | |
| | 20.0-14.0 | 130.0 | 1052.5 | 1182.5 | | |
| FI=Total Mass Passing / Total Mass Retained * 100 | 14.0-10.0 | 89.0 | 649.0 | 738.0 | | |
| | 10.0-6.3 | 115.0 | 697.5 | 812.5 | | |
| TOTAL | | **441.0** | 2709.0 | **3150.0** | | |
| | | | | | | |
| Student | Technician | | | | | |

### 4.4. The workability test

The workability of concrete was measured by the slump cone test and it was observed from **Figure 3** that as the percentage of molasses increased, the slump values also increased. This effect was attributed to the plasticizing property of molasses.

According to **Table 6**, the slumps remained in the range of (90-110) mm for percentages 0.10% and 0.15%.

Table 6.
*Slump values with different dosage of molasses*

| MOLASSES (%) | SLUMP (mm) |
|---|---|
| 0 | 90 |
| 0.1 | 100 |
| 0.15 | 110 |
| 0.2 | 130 |

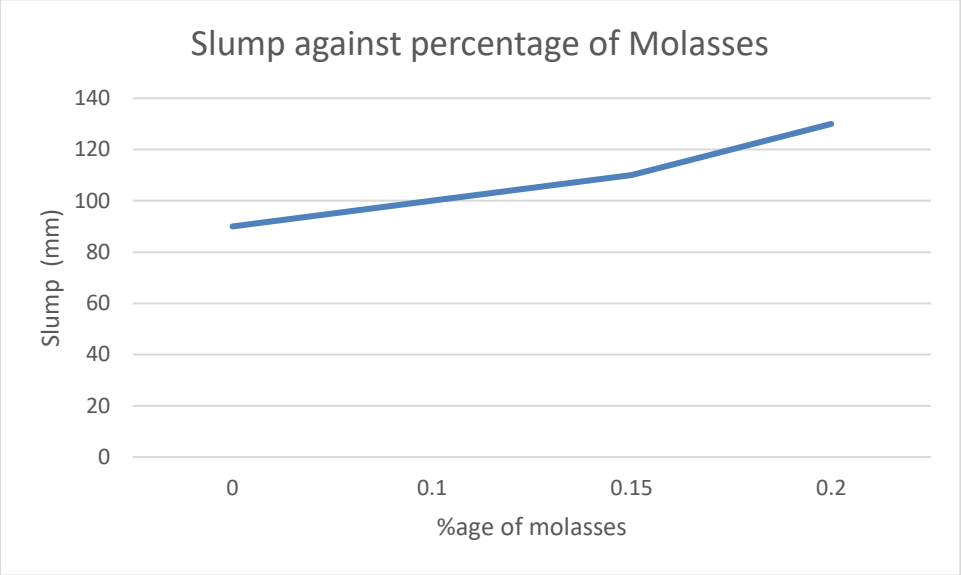



*Figure 3.* A graph of slump against molasses percentages

## 4.5. The Compressive Strength

The compressive strength results of concrete cubes with different percentages of molasses are presented in **Table 7.** The results revealed that, the compressive strength did not vary linearly with the percentage of molasses added. For example, for 0.15% dosage, the compressive strength increased to 30.2Mpa compared to the concrete without molasses at the same age of 28 days. As shown in **Table 7** below it was observed that the results obtained the 0.15% percentage of molasses gave the optimum value. The results of compressive strength was obtained using cubes and later converted to cylinder strength as show below. Source EN 206- 1:2000.

Table 7.
*Shows Compressive Strength at different ages*

| **Compressive strength class** | **Molasses (%)** | **Slump (mm)** | **Cube strength(Mpa)** | **Cylinder strength (Mpa)** |
|---|---|---|---|---|
| C25/30 | 0 | 90 | 32.7 | 26.2 |
| C25/30 | 0.10 | 100 | 33.5 | 26.8 |
| C25/30 | 0.15 | 110 | 37.8 | 30.2 |
| C25/30 | 0.20 | 130 | 25.1 | 20.1 |

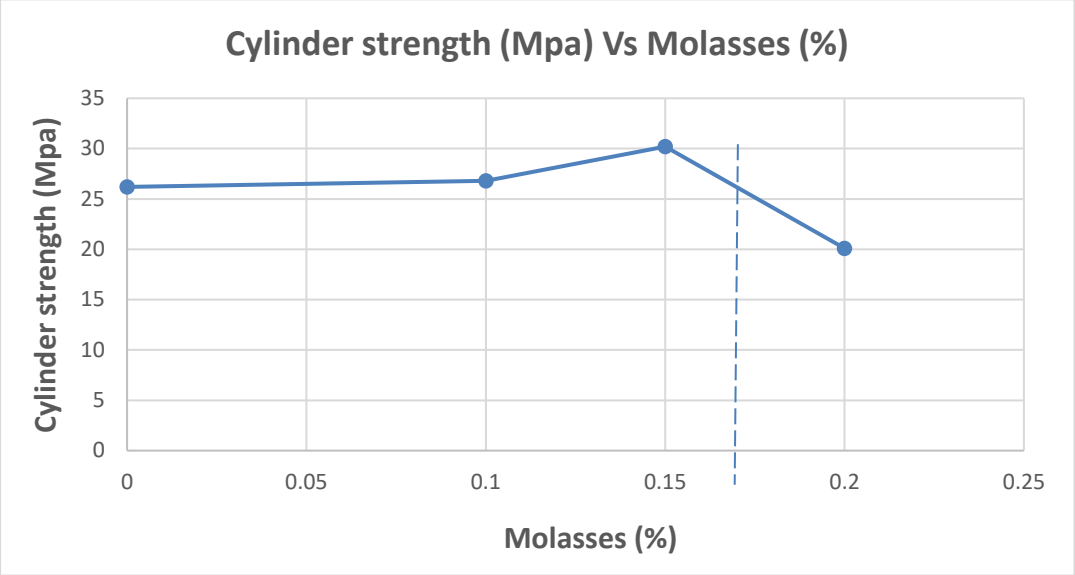



*Figure 4.* A graph of Compressive Strength against Molasses

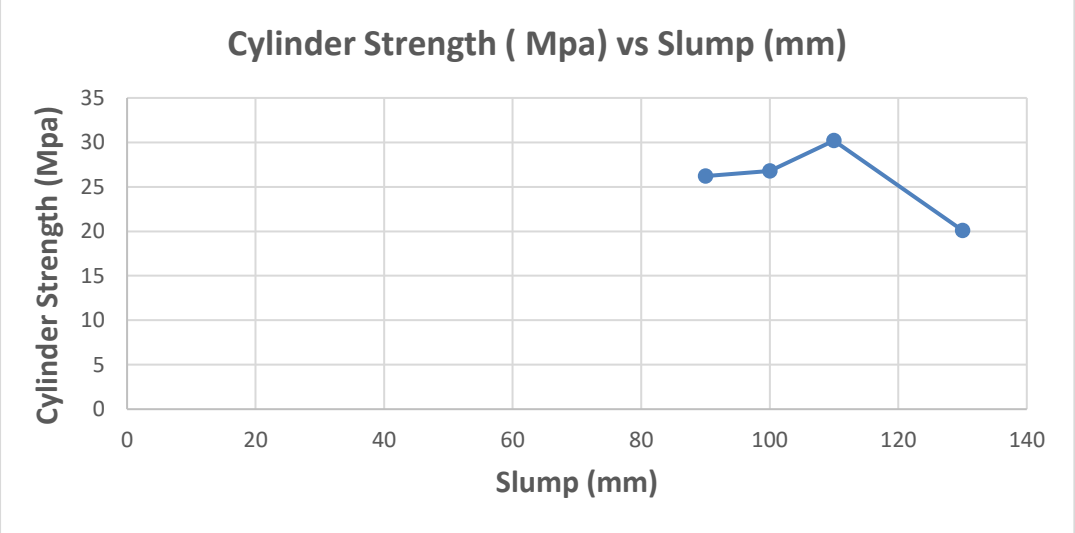



*Figure 5.* A graph of Compressive Strength against Slump (mm)

The following conclusions were drawn from the experimental study carried out using molasses in preparation of concrete with Cement - SDA.

As the percentage of molasses increased, the slump value increased which indicated higher workability. Molasses containing 41.92% TRS greatly increased the workability of concrete. The slump values remained in the range of 100-110mm for 0.10% and 0.15% of molasses added. Therefore, molasses can maintain acceptable workability of concrete up to 0.15% by mass of cement.

The concrete prepared with 0.15% of molasses showed a maximum cylinder strength of 30.2Mpa at 28days with Organic and inorganic constituents maintained as indicated in **Table 2** and **3**.

For 0.20% dosage at 28 days the strength decreased. Thus, increase in the percentage of molasses beyond 0.15% was undesirable.

Considering the parameters of workability and compressive strength, it can be concluded that 0.15% molasses was the optimum percentage.

## 5. Recommendations

The following are recommended from this research study:

- The constituent reducing sugars in the molasses should be studied more critically to identify the individual sugars present as these contribute differently to the workability of concrete.
- The use of local materials like SDA, molasses should be encouraged in concrete production because they result in stronger concrete that is more workable and has a longer setting time for proper placing and molding.
- The cubes should be tested at 2 days to monitor the strength development and at 28 days as what EN 197-1: 2000 recommends and after the strength results obtained be compared with cylinder strength at the same dates and finally durability studies of concrete made with molasses and Cement -SDA should be carried out.

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