Impact of Sugar Cane Molasses to Concrete Strength and Concrete Retardation

Algerico Jr. S. Odal [1]

[1] *Faculty of Civil Engineering, University of the East, Manila City, Philippines.*
algericoodal@gmail.com

Abstract: The impacts of sugar cane molasses to the strength and retardation of concrete was investigated in this study. A total of 15 concrete cylinder of size 150mm diameter x 300mm Height with a mix ratio of 1:2:4 were cast with different percentages of sugar cane molasses replacing some proportion of water in the concrete mix. The concrete cylinder was prepared by reducing water by 10-20% with sugar cane molasses in the following percentage, 0.3% by weight of cement of molasses, 0.6% of molasses, 1.2% of molasses and 1.5% of Molasses. The concrete cylinder was cured, tested and the physical properties of concrete were determined. The slump values of the concrete increased by 10mm when the percentage of molasses increases. A decrease in compressive strength was noticed when the percentage of molasses increases. The highest final setting time of 240 minutes occurred at 1.50% of molasses. The increased in retardation of concrete was noticed when the percentages of molasses increases.

Keywords: concrete retardation, percentage of sugar cane molasses, compressive strength, time setting of cement, concrete mix, slump test.

1. INTRODUCTION

In an on-going construction of a reinforced concrete structure, one of the major problems of the people responsible on the placement of concrete is the difficulty on transporting and handling concrete. This causes higher construction cost by additional expenses on transporting and handling concrete. Also, the difficulty on consolidation. placing and leveling of concrete is one of the problems, especially on those areas which are heavily reinforced. Workability of concrete is the main problem here. To improve it, addition of water is needed, but this procedure reduces the compressive strength and durability of concrete. To solve this problem without sacrificing the strength of concrete, people use admixture. Admixtures improve workability and strength of concrete.

Retarders are also used to: offset the accelerating effect of hot weather on the setting of concrete; delay the initial set of concrete or grout when difficult or unusual conditions of placement occur, such as placing concrete in large piers and foundations, cementing oil wells, or pumping grout or concrete over considerable distances; or delay the set for special finishing techniques, such as an exposed aggregate surface.

The main objective of this study is to investigate the sugar cane molasses on the retardation of the concrete.

Specifically, it sought to answer the following questions:

1. What are the physical properties of sugar cane molasses (SCM)?

2. What are the physical properties of concrete using SCM as retarder admixture?

3. What are the mechanical properties of concrete using SCM as retarder?

4. What is the amount of sugar cane molasses to improved retardation with respect to time setting?

2. METHODS

This research employed ASTM standard for the consistency of mixing and setting of cement, curing, and testing of concrete.

Experimental method was used in this study to investigate and evaluate the impact of sugar cane molasses when added to normal cement concrete in different percentage. There will be a series of trials to be conducted in this

research. Five different mixtures of sugar cane molasses were used to attain the objective of the study. Every mixture will have the same mix of cement, gravel and sand, the sugar cane molasses admixtures which is the independent variable in this research will be evaluated.

The Materials and Equipment used are Cement, Gravel (1" and ¾ ") aggregates, Fined aggregates (sand), Water and Sugar cane molasses.

While the Equipment are Small tools- shovels, steel brush, gloves, rubber mallet, Sieves, Pcynometer, Bucket, Sampling and Mixing pans, Tamping rod, Scales, Vicat apparatus for setting time, Moisture cabinet, Graduated Cylinder, Molds and Trial Mixer. The proper mix design for the designed concrete will be based on the results provided by the Material Testing done by the researchers; this includes the determination of the physical properties of cement and aggregates; such as Moisture Content, Specific Gravity, Absorption, Unit Weight and Abrasion.

The objective of including Material Testing into the experiment is to provide quality control among the specimens and thereby, decrease the errors that may be induced in it. Each concrete batch shall be prepared by the computed batch weights from the material tests. The samples were cured for 28 days before the compressive test is performed.

To achieve the objective of the study, the researchers' procedures for experiment is Compressive Test to determine the Strength of Concrete.

3. RESULTS

In this study, the researcher utilized the Sugar Cane Molasses as an admixture to the TYPE-1B PORTLAND CEMENT for it to have a retarding property that when mixed to concrete, it will create a better mixture. Secondly, the researcher checked if this procedure would affect the strength of the concrete after the mixture.

Material Properties and Characteristics

Table 1

SIEVE ANALYSIS				
SIEVE NO.	MASS RETAINED(g)	MASS PASSING (g)	% RETAINED	% PASSING
2 1/2	0	1200	0	100
2	0	1200	0	100
1 1/2	0	1200	0	100
1	0	1200	0	100
3/4	108	1092	9	91
1/2	792	408	66	34
3/8	1092	108	91	9
# 4	1176	24	98	2
# 200	1200	0	100	0

Table 2

SPECIFIC GRAVITY AND ABSORPTION		
1	Weight of Oven- Dry Sample, grams	2967.5
2	Weight of Saturated-Surface Dry (SSD), grams	3000
3	Apparent Weight of Saturated Sample in Water, grams	1943
4	Specific Gravity, (OD)	2.81
5	Specific Gravity, (SSD)	2.84
6	Apparent Specific Gravity, (SSD)	2.90
7	Absorption (%)	1.1

ANALYSIS:

Specific gravity is easily calculated by determining the densities by the displacement of water. All aggregates contain some porosity, and the specific gravity value depends on whether these pores are included in the measurement. There are two terms that are used to distinguish this measurement; absolute specific gravity and bulk specific gravity. Absolute specific gravity (ASG) refers to the solid material excluding the pores, and bulk specific gravity (BSG), sometimes called apparent specific gravity, includes the volume of the pores. For the purpose of mixture proportioning, it is important to know the space occupied by the aggregate particles, including the pores within the particles. The BSG of an aggregate is not directly related to its performance in concrete, although, the specification of BSG is often done to meet minimum density requirements.

Physical Properties of Sugar Cane Molasses

Table 3

Description	Specification	Method	ASTM Standard
Appearance	Black Strap	Visual Inspection	N/A
Brix	75.0% Min.	ICUMSA GS4/3/8-13 (2009)	N/A
Purity	45-60	ICUMSA GS4/7-1 (1994)	N/A
Reducing Sugars	20% Max	ICUMSA GS4/3-3 (2007)	N/A
Total Sugars as Invert	60.0-70.0%	ICUMSA GS4/2-4 (2007)	N/A
Conductivity Ash	15% Max	ICUMSA GS1/3/4/7/8-13(1994)	N/A
pH	4.8-5.2	IUCMSA GS 1/2/3/4/7/8/9-23 (2009)	7.0-7.3 (ASTM D 2110-96)
Specific Gravity	1.4-1.5	ICUMSA SPS-4	1.45 to 1.50 (ASTM Hydrometer No. 134H)

Analysis:

the pH value of Water content of Molasses and Specific Gravity passed the requirement of ASTM D 2110-96 for Standard Test Method for pH of Water Extractions of Halogenated Organic Solvents and Their Admixtures. ASTM D 2111-95 Standard Test Methods for Specific Gravity of Halogenated Organic Solvents and their Admixtures.

Table 4

Physical Properties of Concrete Using Sugar Cane Molasses as Retarder Admixture

MIX	BATCH WEIGHT	SLUMP TEST	AIR CONTENT
100% RC SUPERCON PLUS	38.98 kg	150mm	1.5%
80% RC SUPERCONPLUS AND 20% MOLASSES	39.04 kg	165mm	1.6%
60 % RC SUPERCONPLUS AND 40% MOLASSES	39.09 kg	175mm	1.65%
20% RC SUPERCONPLUS AND 80% MOLASSES	39.15 kg	175mm	1.75%
100% MOLASSES	39.23 kg	180mm	1.75%

Analysis:

100% RC SUPERCON PLUS has a slump of 150mm and Air content of 1.5%, while combining 80% RC SUPERCON PLUS and 20% MOLASSES behave a 165mm slump and Air content of 1.6%, when you reduce the RC SUPERCON PLUS BY 20% and adding 20% of molasses the Slump remain and Air content increase by .05%, Finally when 100% MOLASSES behave a 180mm Slump and the Air Content is 1.75%.

Mix 1: 1.11% RC Supercon plas Admixture

Table 5

MIX	COMPRESSIVE STRENGTH	LOAD APPLIED
MIX 1: 1.11% RC SUPERCON PLUS		
NO.1	23.5 MPA	414.5 KN
NO.2	24.5 MPA	430.6 KN
NO.3	25.6 MPA	448.28 KN

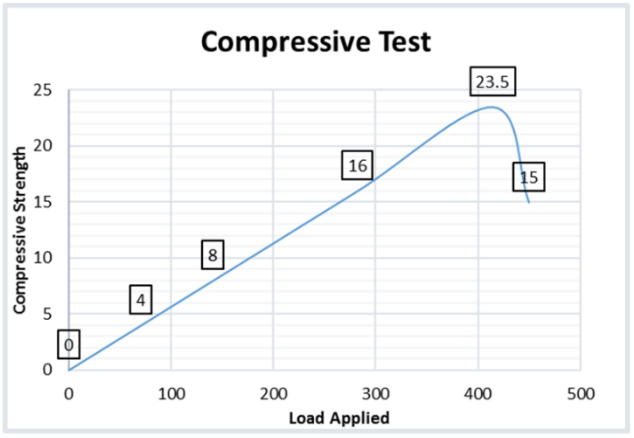

Figure 1. Mix 1- 1.11% RC Supercon plas-Sample No. 1

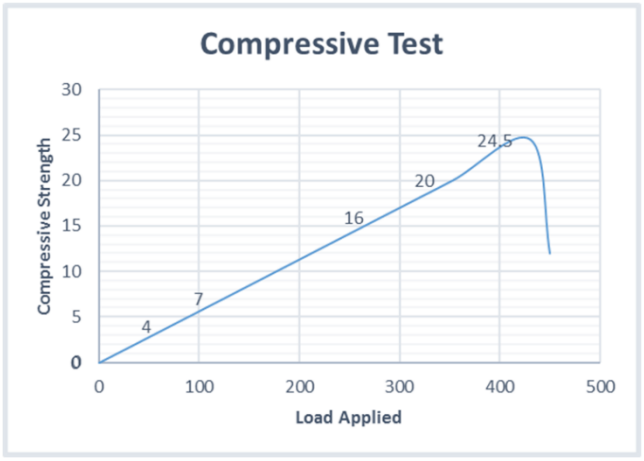

Figure 2. Mix 1- 1.11% RC Supercon plas-Sample No. 2

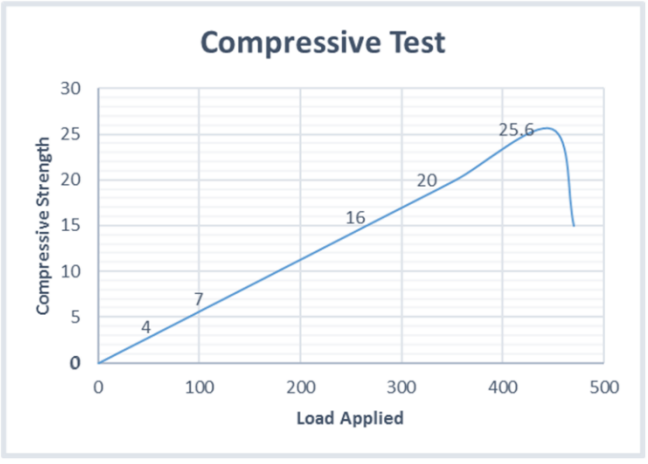

Figure 3. Mix 1- 1.11% RC Supercon plas-Sample No. 3

Mix 2: .952% RC Supercon plas and .3% Molasses

Table 6

MIX	COMPRESSIVE STRENGTH	LOAD APPLIED
MIX 2: .952% RC Supercon plas and .3% Molasses		
NO.1	26.35 MPA	465.6 KN
NO.2	26.82 MPA	473.9 KN
NO.3	16.32 MPA	288.5 KN

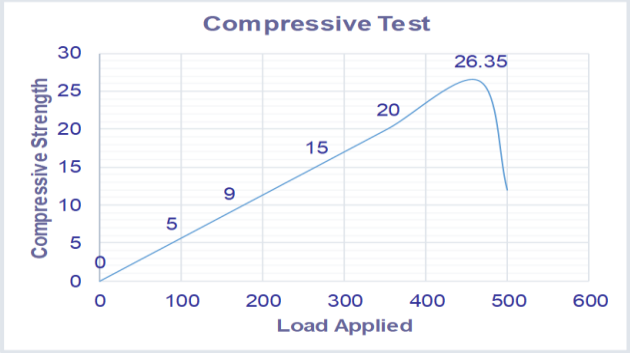

Figure 4 Mix 2-.952% RC Supercon plas and .3% Molasses- Sample No. 1

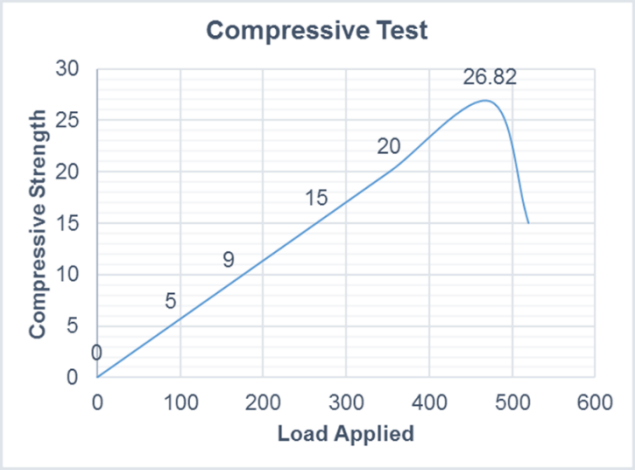

Figure 5. Mix 2-.952% RC Supercon plas and .3% Molasses- Sample No. 2

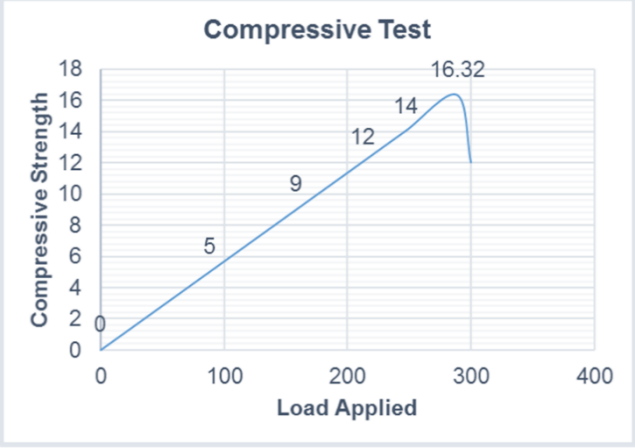

Figure 6. Mix 2-.952% RC Supercon plas and .3% Molasses- Sample No. 3

Mix 3: .714% RC Supercon plas and .6% Molasses

Table 7

MIX	COMPRESSIVE STRENGTH	LOAD APPLIED
MIX 3: 0.714% RC Supercon plas and .6% Molasses		
NO.1	26.82 MPA	473.9 KN
NO.2	19.33 MPA	341.5 KN
NO.3	22.97 MPA	406 KN

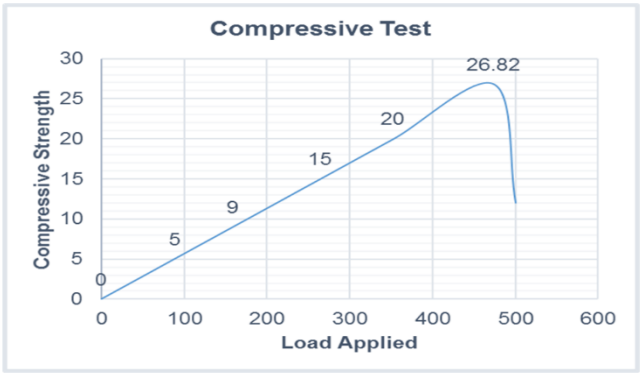

Figure 7. Mix 3-.714% RC Supercon plas and .6% Molasses- Sample No. 1

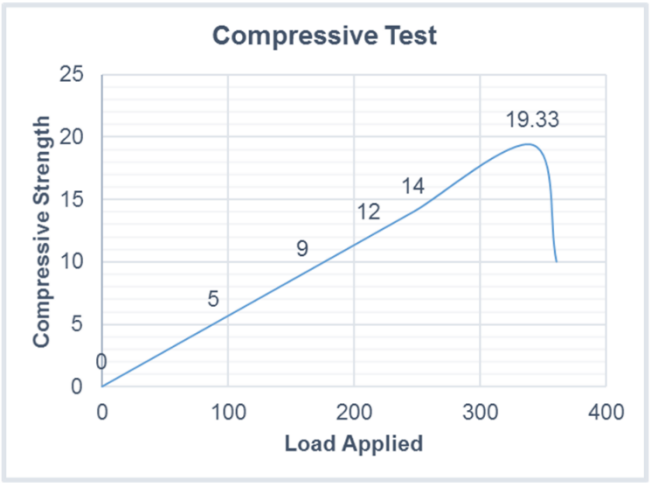

Figure 8. Mix 3-.714% RC Supercon plas and .6% Molasses- Sample No. 2

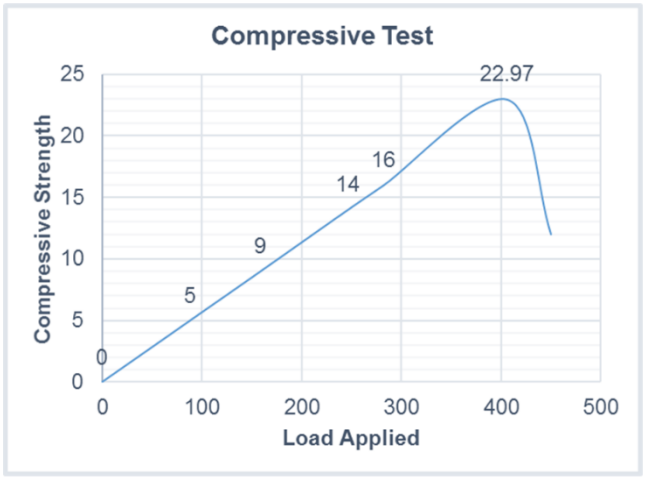

Figure 9. Mix 3-.714% RC Supercon plas and .6% Molasses- Sample No. 3

Mix 4: .236% RC Supercon plas and 1.2% Molasses

Table 8

MIX	COMPRESSIVE STRENGTH	LOAD APPLIED
MIX 4: .236% RC Supercon plas and 1.2% Molasses		
NO.1	12.25 MPA	216.5 KN
NO.2	17.47 MPA	307.7 KN
NO.3	16.29 MPA	287.9 KN

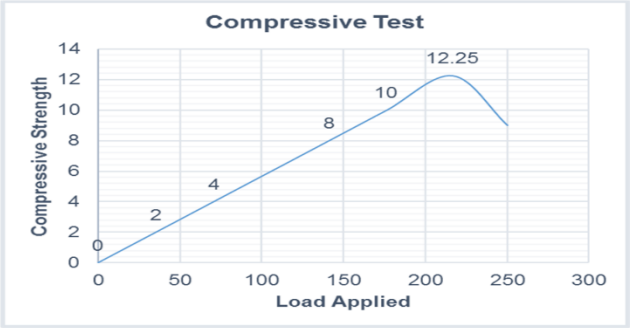

Figure 10. Mix 4-.236% RC Supercon plas and 1.2% Molasses-Sample No. 1

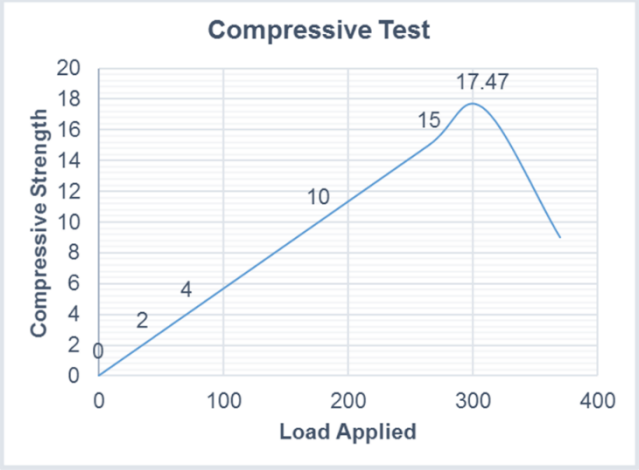

Figure 11. Mix 4-.236% RC Supercon plas and 1.2% Molasses-Sample No. 2

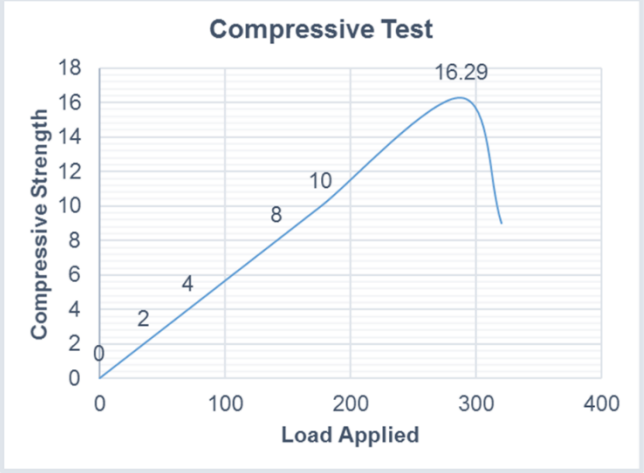

Figure 11. Mix 4-.236% RC Supercon plas and 1.2% Molasses-Sample No. 3

Mix 5: 1.5% Molasses

Table 9

MIX	COMPRESSIVE STRENGTH	LOAD APPLIED
MIX 5: 1.2% Molasses		
NO.1	3.18 MPA	56.2 KN
NO.2	2.15 MPA	45.2 KN
NO.3	3.16 MPA	63.8 KN

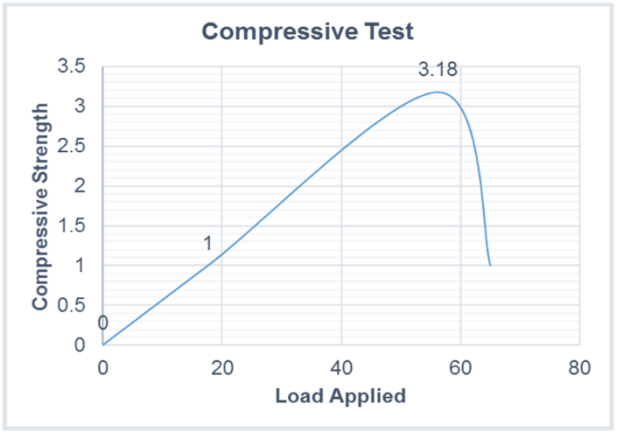

Figure 12. Mix 5- 1.5% Molasses-Sample No. 1

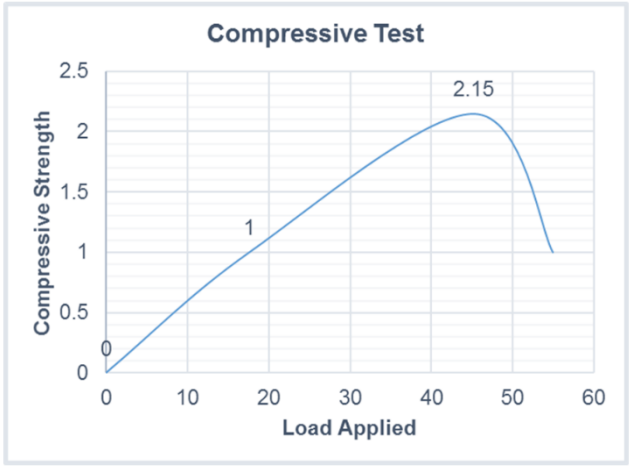

Figure 13. Mix 5- 1.5% Molasses-Sample No. 2

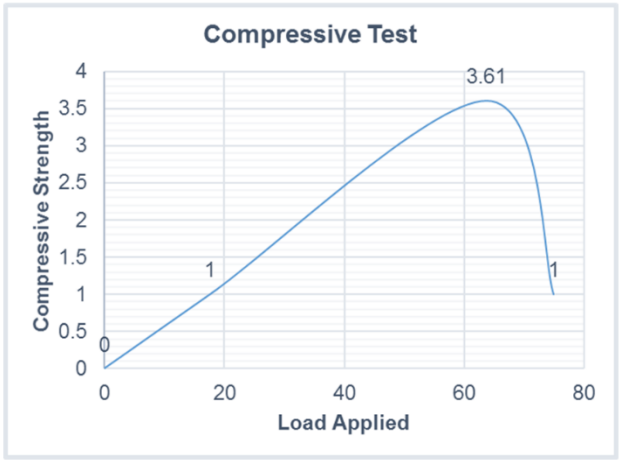

Figure 14. Mix 5- 1.5% Molasses-Sample No. 3

Analysis:

The test compressive strength result gives a confirmation that the sugar cane molasses has an effect on strength of concrete. The control has a strength average of 24.5Mpa, when you add sugar cane molasses about 20% of (1.5% of weight of cement) the strength has a slightly higher than the control, when the molasses increases the compressive strength of concrete must be weaker and weaker. It simply because the sugar cane molasses has a capacity to retard the concrete.

The small amount of sugar cane molasses can slightly improve the compressive strength of concrete while when too much molasses decreases the compressive strength of concrete.

Amount of Sugar Cane Molasses to improved retardation with respect to Time Setting

Mix 1: 1.19% RC Supercon Plus

Table 10

NORMAL CONSISTENCY & TIME SETTING ASTM C 187-98 / C 191-99 / C 109 / C 109M-99				
Cement Brand & Type :PORTLAND TYPE-1b			Date Commenced: April 02,2018	
Source / Supplier: REPUBLIC CEMENT			Date Completed : April 02,2018	
NORMAL CONSISTENCY TRIAL 1				
Wt. of Cement : 650 grams			Mixing Water Source : MWSS	
Wt. of Fly ash :			Admix Brand / Type: RC Supercon Plus	
F. A. Used (%):			Dosage(%): 1.19%	
Total Wt. : 650 grams			Temperature: 25degrees	
Trial	Water	Admixture(ml)	Penetration (mm)	w/c
1	160	7.735	9	0.23
II.PENETRATION RESISTANCE TIME MOLDED (H) : 10:30 am				
No.	Time		Penetration Reading (mm)	
	H	Min.		
1	15:36	15	40	INITIAL SETTING: **45 MIN.**
2	15:51	30	31	
3	11:30	45	25	FINAL SETTING: **135 MIN.**
4	11:45	60	22	
5	12:00	75	17	
6	12:15	90	4	
7	12:30	105	2	REMARKS: **PASSED**
8	12:45	120	1	
9	13:00	135	0	

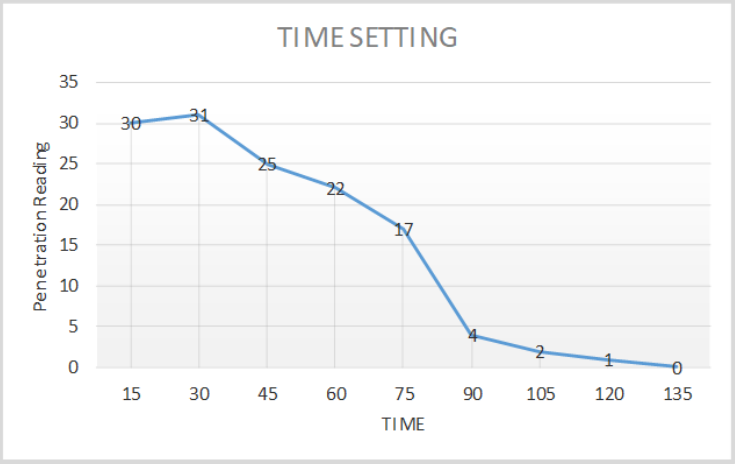

Figure 15. Mix 1: 1.19% RC Supercon Plus

Mix 2: 1.5% Molasses

Table 11

NORMAL CONSISTENCY & TIME SETTING ASTM C 187-98 / C 191-99 / C 109 / C 109M-99				
Cement Brand & Type :PORTLAND TYPE-1b			Date Commenced: April 03,2018	
Source / Supplier: REPUBLIC CEMENT			Date Completed : April 03,2018	
I. NORMAL CONSISTENCY TRIAL 2				
Wt. of Cement : 650 grams			Mixing Water Source : MWSS	
Wt. of Fly ash :			Admix Brand / Type: Molasses	
F. A. Used (%):			Dosage(%): 1.5%	
Total Wt. : 650 grams			Temperature: 25degrees	
Trial	Water	Admixture(ml.)	Penetration (mm)	w/c
1	145	9.75	10	0.23
II.PENETRATION RESISTANCE TIME MOLDED (H) : 10:30 am				
No.	Time		Penetration Reading (mm)	
	H	Min.		
1	10:30	30	40	INITIAL SETTING : 135 MINS.
2	10:45	45	40	
3	11:00	60	40	FINAL SETTING : 270 MINS.
4	11:15	75	37	
5	11:30	90	35	
6	11:45	105	32	
7	12:00	120	30	REMARKS: **PASSED**
8	12:15	135	25	
9	12:30	150	22	
10	12:45	165	20	
11	13:00	180	18	
12	13:15	195	15	
13	13:30	210	13	
14	13:45	225	10	
15	14:00	240	5	
16	14:15	255	2	
17	14:30	270	0	

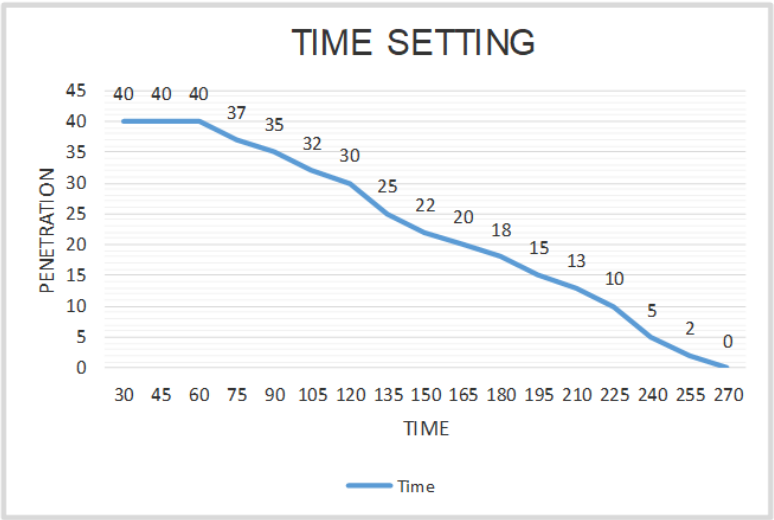

Figure 16. Mix 2: 1.5% Molasses

Mix 3: .95% RC Supercon Plus and 0.3% Molasses

Table 12

NORMAL CONSISTENCY & TIME SETTING ASTM C 187-98 / C 191-99 / C 109 / C 109M-99				
Cement Brand & Type :PORTLAND TYPE-1b			Date Commenced: April 03,2018	
Source / Supplier: REPUBLIC CEMENT			Date Completed : April 03,2018	
II. NORMAL CONSISTENCY TRIAL 3				
Wt. of Cement : 650 grams			Mixing Water Source : MWSS	
Wt. of Fly ash :			Admix Brand / Type: RC Supercon Plus	
F. A. Used (%):			Dosage(%): 0.952% RC Supercon and 0.3% Molasses	
Total Wt. : 650 grams			Temperature: 25degrees	
Trial	Water	Admixture(ml.)	Penetration (mm)	w/c
1	145	6.1925	9	0.23
II.PENETRATION RESISTANCE TIME MOLDED (H) : 10:30 am				
No.	Time		Penetration Reading (mm)	
	H	Min.		
1	15:37	0	40	INITIAL SETTING: **5 MIN.**
2	15:52	15	7	
3	16:07	30	2	FINAL SETTING: **60 MIN.**
4	16:22	45	1	
5	16:37	60	0	
				REMARKS: **FAILED**

Figure 17. Mix 3: .95% RC Supercon Plus and 0.3% Molasses

Mix 4: 0.238% RC Supercon Plus and 1.2% Molasses

Table 13

NORMAL CONSISTENCY & TIME SETTING				
Cement Brand & Type :PORTLAND TYPE-1b			Date Commenced: April 03,2018	
Source / Supplier: REPUBLIC CEMENT			Date Completed : April 03,2018	
III. NORMAL CONSISTENCY TRIAL 4				
Wt. of Cement : 650 grams			Mixing Water Source : MWSS	
Wt. of Fly ash :			Admix Brand / Type: RC Supercon Plus and Molasses	
F. A. Used (%):			Dosage(%): 0.238% of RC Supercon and 1.2% Molasses	
Total Wt. : 650 grams			Temperature: 25degrees	
Trial	Water	Admixture(ml.)	Penetration (mm)	w/c
1	150	9.347	9	0.23
II.PENETRATION RESISTANCE TIME MOLDED (H) : 10:30 am				
No.	Time		Penetration Readin g (mm)	
	H	Min.		
1	15:00	0	40	INITIAL SETTING : 1 MIN.
2	15:15	15	3	
3	15:30	30	0	FINAL SETTING : 30 MIN.
				REMARKS: **FAILED**

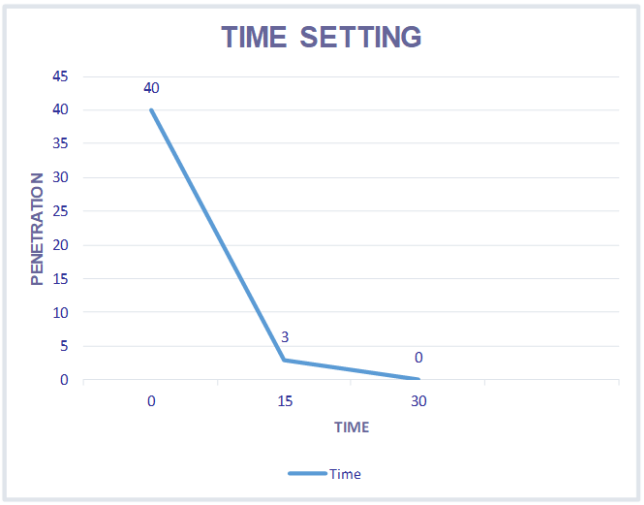

Figure 18. Mix 4: 0.238% RC Supercon Plus and 1.2% Molasses

0.714% RC Supercon Plus and 0.6% Molasses

Table 14

NORMAL CONSISTENCY & TIME SETTING OF HYDRAULIC CEMENT ASTM C 187-98 / C 191-99 / C 109 / C 109M-99				
Cement Brand & Type :PORTLAND TYPE-1b			Date Commenced: April 02,2018	
Source / Supplier: REPUBLIC CEMENT			Date Completed : April 02,2018	
IV. NORMAL CONSISTENCY TRIAL 1				
Wt. of Cement : 650 grams			Mixing Water Source : MWSS	
Wt. of Fly ash :			Admix Brand / Type: RC Supercon Plus and Molasses	
F. A. Used (%):			Dosage(%): 0.714% of RC Supercon and 0.6% Molasses	
Total Wt. : 650 grams			Temperature: 25degrees	
Trial	Water	Admixture(ml.)	Penetration (mm)	w/c
1	145	8.541	9	0.23
II.PENETRATION RESISTANCE TIME MOLDED (H) : 10:30 am				
No.	Time		Penetration Readin g (mm)	
	H	Min.		
1	10:41	0	40	INITIAL SETTING : 4 MIN.
2	10:56	15	6	
3	11:11	30	1	FINAL SETTING : 45 MIN.
4	11:26	45	0	
				REMARKS: **FAILED**

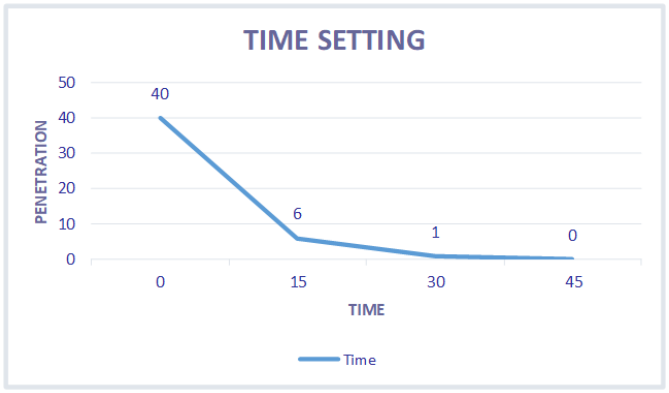

Figure 19. Mix 5-12 0.714% RC Supercon Plus and 0.6% Molasses

Analysis

The result of time setting indicates that the sugar cane molasses improve the retardation of concrete. The Control has a final setting of 135 min. it passed the requirement of ASTM standard. When you combined the molasses and RC Supercon plus it has an effect on Cement paste, the result of .952% RC Supercon Plus and 0.3% Molasses the Final Setting become lower, but when you test the 1.5% Molasses only the retardation become higher. It means too much addition of sugar cane molasses the time setting of cement paste become higher.

4. DISCUSSION

The salient findings of the study are as follow:

a. What are the properties of Sugar Cane Molasses (SCM)?

a.1. Specific Gravity of Sugar Cane Molasses ranging from 1.4 to 1.5, it passed the ASTM Standard

a.2. The PH Value of Sugar Cane Molasses ranging from 4.5 to 5.2, it passed the requirement of ASTM.

b. What are the physical properties of concrete using SCM as retarder admixture?

b.1 Slump Test, the percentage of sugar cane increases the Slump value slightly increases by 10mm. The 1.5% molasses have a minimum slump of 180 mm.

b.2 Air Content, the percentage of sugar cane increases the Air content value slightly increases by .05%. The 1.5% molasses have a maximum Air content of 1.75%.

c. What is the mechanical properties of concrete using SCM as retarder?

The control has has value of 25.6 Mpa, when you added small percentage of sugarcane molasses the concrete strength slightly increased. The 1.2% of Molasses has 15.3367 not passed the requirement of concrete strength of 21 Mpa for low rise Building. When the percentage of sugar cane molasses increases up to 1.5% Molasses the impact of this the compressive strength weaker and weaker.

d. What is the amount of sugar cane molasses to improved retardation of concrete in terms of Time Setting?

1.5% of Molasses with an initial setting time of 135mins and final setting time of 270mins improved the retardation of concrete. When the percentage of Molasses increases the retardation of concrete it also increases.

5. CONCLUSION

Based on the findings in the study, the following conclusions are drawn:

1. The researcher concludes that the physical properties of sugar cane molasses in terms of Specific Gravity and pH value passed he requirement of ASTM standard.
2. Based on the physical properties of concrete using SCM as retarder admixture, we concluded that increasing the percentage of molasses to the mix, the workability of concrete increases. The air content result signifies as increasing the dosage of sugar cane molasses to the mix, the air content slight increases.
3. The researcher concludes that increasing the percentage of sugar cane molasses, it has a positive and negative impact to the concrete mix. Based on the result on the compressive test, 15 sample tested on different percentage of molasses. Small amount of Molasses added to the concrete mix has a slight increase the strength of concrete. Increasing the percentage of molasses by 1.5% of weight of cement the effect on compressive strength of concrete become weaker or decreases.
4. The researcher concludes that the impacts of adding sugar cane molasses as admixtures on the cement as retarder varied – positively and negatively, depending with the dosage of sugar cane molasses to be introduced. With 0 % dosage of sugar cane molasses, cement reached its final setting at an average of 135 min with a flexural strength of 23.5Mpa. With .3% dosage of Sugar Cane Molasses, final time setting of 60min with a compressive strength of 26.35Mpa. With 1.5 % dosage of sugar cane molasses, cement reached its final setting time of 270min with a flexural strength of 2.98Mpa.

6. RECOMMENDATION

Based on the findings and conclusions presented, the following recommendations are suggested:

1. The researcher recommends further studies regarding the other physical properties of sugar cane molasses that will use to improve the study.
2. The researcher recommends small percentage of sugar cane molasses, to determine the workability and air content of concrete.
3. The researcher recommends small amount of sugar cane molasses to determine the increase of compressive strength of concrete, when too much the amount of sugar cane molasses the strength become weaker and decreases and it failed to pass the desired strength.
4. The researcher recommends small amount of sugar cane molasses admixture with no commercial admixture added to the concrete to determine the time setting.

7. REFERENCES

[1] ASTM. C 29/C 29M-97. Standard Test Method for Bulk Density (“Unit Weight”) and Voids in Aggregate
[2] ASTM. C 33-99a. Standard Specification for Concrete Aggregates
[3] ASTM. C 39/C 39M-99 Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
[4] ASTM C 494/C 494M-99a Standard Specification for Chemical Admixtures for Concrete
[5] Bazid Khan and Bulent Baradan, “The Effect of Sugar on Setting Time of Various type of Cements”, Science Vision,2002, pp 71-78
[6] http://www.cement.org retrieved on December 16, 2018
[7] http://www.ijesird.com retrieved on November 12, 2017
[8] Neville, A.M. (2006). “Properties of concrete fourth edition”

DOI: https://doi.org/10.15379/ijmst.v10i2.2974

This is an open access article licensed under the terms of the Creative Commons Attribution Non-Commercial License (http://creativecommons.org/licenses/by-nc/3.0/), which permits unrestricted, non-commercial use, distribution and reproduction in any medium, provided the work is properly cited.