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Mixing of Sugar in Concrete of M20 Grade

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Abstract

The objective of this paper is to experimentally study the effect of sugar doses on the physical properties of concrete. Effect of sugar at concentrations of 0,0.5.0.75, and 1% by weight of cement-on-cement paste and M20 grade of concrete cured at 3,7,14, and 28 days was studied using Portland cement in the laboratory. The main function of sugar is it is used as an admixture to increase the initial setting time of concrete. After the study, it was concluded that the workability and compressive strength of concrete get enhanced when admixture like sugar is added into the concrete mix.

Keywords

sugar, Admixtures, setting time, workability, compressive strength

1. Introduction

Cementing materials carry a history of as long as that of engineering construction. In early times, it is believed that burning of gypsum was used as cementing material. India stands at second place after China in the world in second largest producer of cement [4]. Mostly every work related to civil engineering is basically on concreting in hot weather. The early cement hydration is promoted by hot weather condition and thus helps in producing high strength at early ages, but this set a drawback of reduced latter strength. Plastic shrinkage in concrete is developed due to quickly water evaporation and whereas tensile stresses and cracking is caused by subsequent cooling. Therefore, to maintain the equilibrium between such condition's admixtures are used. For increase in hydration induction period, Retarders are used, that helps in increasing the setting time and vice versa for accelerators. The properties of ingredients, proportion of mix, placing, compaction and curing plays a major role for Strength, Durability and other characteristics of concrete. Weather and sessions changes play a great role in variation in setting time initial of the concrete. Therefore, retarders and accelerators are used to alter the initial setting time of increasing and decreasing respectively [5]. Increase in winters and decrease in summers. Admixtures used such as Retarders: Sugar and Gypsum and accelerators: Calcium chloride, etc.

2. Literature Review

I got this project idea from internet while I saw and read few research papers. Firstly, "SOME INVESTIGATIONS INTO THE USE OF SUGAR AS AN ADMIXTURE TO CONCRETE" by Robert Ashworth, B.Eng., A.M.I.C.E. Lecturer in Civil Engineering, University of Liverpool. In which he has performed tests with mixing Sugar in concrete. He added of about 0.25% of sugar to the weight of cement. And performed various test on concrete with different water cement ratios such as 0.36 and 0.44.
Secondly, "Effect of Sugar on Setting-Time and Compressive Strength of Concrete" ARPANA BEERANNA DEVAKATE, ACHARYA V T AND KEERTHI GOWDA B S from VTU-PG Center, Mysuru, Karnataka, India and SLN College of Engineering, Raichur, Karnataka, India. In their research they have mixed sugar in 0.02, 0.04,0.06% of sugar to the weight of cement. They have also varied the water cement ratio as 0.36, 0.45 and 0.50. Therefore, I decided to perform the test with 0.5, 0.75 and 1 % of sugar to that of weight of cement and I will be making concrete with water cement ratio as 0.40. I will be performing Initial setting time test on Vicat's Apparatus and Compressive strength test on cubes of 150mm*150mm*150mm by using universal testing machine [1-8].

3. Objectives

This project deals with the changes observed in the properties of concrete and cement when sugar is mixed in different ratios. This project contains different ratios of sugar i.e., 0%, 0.5%, 0.75% and 1% of sugar to the weight of cement. The main objective of this project is to notice and perform tests of setting time test on cement and compressive strength test on hardened and properly cured concrete. Tests that are performed in this project are:
Initial setting time test on VICAT'S Apparatus
Compressive strength test on Universal Testing Machine.

4. Materials and Its Properties

4.1. Cement

A dry powdered chemical that when mixed with water, reacts slowly to form a new solid hard compound is known as Cement. The raw materials used for the manufacturing of cement consist mainly of silica, lime, alumina and iron oxide mixed in different proportions. The interaction between these oxides at a very high temperature in the kiln results to form more complex compounds [1].

Table 1. Approximate oxide content

Oxides	Percent Content
Cao	60-67
Sio_2	17-25
Al_2O_3	3.0-8.0
Fe_2O_3	0.5-6.0
MgO	0.1-4.0
Alkalies	0.4-1.3
SO_3	1.3-3.0

Apart from the mentioned above there are four more major compounds in cement. They are:

A) Tricalcium Silicate (C3S): its approximate composition is of about 45-55%. It is mainly responsible for early strength that is developed in 1-7 days.

B) Dicalcium Silicate (C2S): Its approximate composition is of about 20-30%. It is mainly responsible for later strength developed that is 7 days and beyond.

C) Tricalcium Aluminate (C3A): its approximate composition is of about 6-10%. It is mainly responsible for increase in rate of hydration of C3S. It has a very low contribution to strength.

D) Tetracalcium Aluminoferrite (C4AF): its approximate composition is of about 15-20%. Its main responsibility is to hydrate rapidly whereas its contribution to strength is very less.

The chemical reactions that take place between cement and water is referred as hydration of cement.

4.2. Physical Characteristics of Cement

A) Fineness: Fineness of cement plays a major role on the rate of hydration and therefore on the rate of gain of strength. More surface area offers more area for hydration and hence faster development of strength, therefore finer cement is most appropriate. It is expressed in Blaine (m2/kg).

B) Setting time: This generally refers to stiffing of cement. There are two types of setting time 1) Initial setting time: this time is regarded as in which the paste remains in plastic condition and can be moulded. This time should be more that the time required for mixing, transportation, placing and compaction. 2) Final Setting time: this time starts when cement has lost its plasticity. The cement should not be disturbed now as there is gradual increase in strength.

C) Soundness: This refers to dimensional stability of cement. There should be no change in volume of cement paste once it is set.

D) Compressive Strength: This is the most important property. According to the type and class of cement, there should be result in 3,7 and 28 days.

4.3. Aggregate

The most important constituent of concrete is Aggregate. They are responsible for to give body to concrete. Aggregates occupy 70-80% of volume of concrete. Aggregates can be classifying into various types under various headings [4].

A) Classification: Aggregates are classified as normal weight, light weight and heavy weight aggregates.

B) Source: this category deals on the formation of aggregates. This is also distributed into 3 categories: Aggregates from Igneous Rocks, Aggregates from Sedimentary Rocks and Aggregates from Metamorphic Rocks...

C) Size: this is most important classification of aggregate. In this it is divided into two major categories: **FINE AGGREGATES:** Aggregates with size less than that of 4.75mm are considered as fine aggregates. **COARSE AGGREGATES:** Aggregates ranging with size from 4.75mm to 80mm (maximum used in concreting) are considered as coarse aggregates.

D) Shape: this category plays a major role in workability of concrete. It is divided as: Rounded, Irregular or Partly rounded, Angular and flaky.

4.4. Water

Water is an important constituent of concrete as it actively participates in the chemical reaction with cement to form concrete. Water used for experiments and construction places should be of good quality as it helps to form the strength giving cement gel.

There are few guidelines that need to be followed:

i. It should not take more that 5ml of 0.02 normal NaOH, to neutralize 100ml of water using phenolphthalein as an indicator.

ii. It should not take more that 25ml of 0.02 normal H2SO4, to neutralize 100ml of water using mixed indicator.

4.5. Admixture

Admixture is a material apart from cement, aggregate and water. It is an ingredient that is added to the mix during mixing. Admixture is added to enhance the property of ordinary concrete and modify its property to make it suitable for designed situation [2].

Admixtures can be classified as:

a) Plasticizers: to provide workability without adding excess water
b) Retarders: to reduce the setting time
c) Accelerators: to increase the setting time
d) Curing Admixtures: to self-cure the component after setting.
e) Super plasticizers: to reduce high amount of water content without decreasing its workability.
f) Colouring admixtures
g) Corrosion inhibiting
h) Alkali aggregate Inhibiting admixtures
i) Grouting admixtures

Admixture used in this project is Sugar. A white crystalline solid easily available in market and easily dissolvable in water is used in experiment. It is mixed in different ratio dosage to cement. For eg: 0.02%, 0.04%, 0.06%, etc by weight of cement.

4.6. Concrete

A mixture of cement blended with water, coarse aggregate and fine aggregate and with admixture is known as Concrete. There are various stages that are involved in the production of concrete:

- **Batching**: measurement of different ingredients is known as batching. It can be done by two methods weigh batching and volume batching.
- **Mixing**: mixing of different ingredients to form as homogenous mixture. It can be done by hand mixing and machine mixing.
- **Transportation**: transporting of mixed concrete to place of concreting. It can be done by mortar pan, crane, pump and pipeline, transit mixer, truck mixers and dumpers.
- **Placing**: after the initial's steps taken, it is most important to place the concrete at correct place and in correct manner. Proper form work should be made for proper placement.
- **Compaction**: after placing, compaction of concrete is most important, to remove voids from between. It can be done by hand compaction, by mechanical vibration such as needle, table, platform, etc.
- **Fining**: to remove the form work and proving repairing if required is defined as finishing.
- **Curing**: this is last step, curing for 28days is required, it can be done manually or by adding curing compounds. Its main purpose is to keep concrete moist and worm for hydration of cement to continue.

Concrete is also divided as fresh and hardened concrete.

4.7. Main Property of Fresh Concrete

4.7.1 Workability

The ease of flow of concrete is defined as workability of concrete. It depends upon

- Water content: higher the water content greater is the workability
- Mix proportions: higher aggregate cement ratio, the leaner is the concrete
- Size of aggregate: bigger size of aggregate will give high workability nut upto certain extent only

- Shape of aggregate: angular, elongated and flaky will result in harsh concrete whereas rounded will increase workability
- Surface texture of aggregate: rough surface will show poor workability whereas smooth and glassy will give better workability.
- Grading of aggregate: the well graded aggregate will have less voids and higher workability.
- Use of admixture: Plasticizers and super plasticizers will result in good workability in many times.

Measurement of workability is done by

- Slump Test
- K-Slump test
- Compacting factor test
- Vee bee consistometer test

4.7.2 Bleeding

It is referred to as water gain. In this some water comes out of the surface of concrete because water has the least specific gravity as compared to other ingredients.

4.8. Main Property of Hard Concrete

4.8.1 Compressive Strength

This is generally done by making of cube or cylinders and doing test on them. The load is applied and then it is divided by the area of cross section on which load is applied. This test is usually happened on Universal testing machine [2].

5. Methodology & Calculations

For all the experiment procedures Portland pozzolana cement was used. Supplementary cement material used for the enhancement of the strength and durability of the cement is called as pozzolana. PPC cement is more durable in aggressive weather as compared to OPC cement. OPC cement is expensive compared to PPC cement. Therefore, PPC is preferred. Sugar used for the experiments is Sucrose ($C_{12}H_{22}O_{11}$). The concrete was prepared with a ratio of 1: 1.5: 3 where, 1 is the ratio of cement, 1.5 portions of fine aggregate and 3 portions of course aggregate. The water cement ratio was kept ranging from 0.4 to 0.6, which means 0.4 to 0.6 liter of water was added per kilogram of cement. Sugar is mixed in water and then it is added to cement in different ratios to form cement and concrete paste. To determine the consistency and setting time of cement paste, vicat apparatus was used. The standard consistency of the cement pastes which allows the penetration of vicats plunger from the bottom of the mould in Vicats apparatus by 5mm to 7mm was recorded as the amount of water added [6]. After the preparation of samples of cement paste and concrete mix the following tests were performed keeping IS guidelines in mind, such as:

a. **Setting Time Test:** this test was perfectly performed on cement paste to find the settling time both final and initial. The vicats apparatus was used for this testing.
b. **Compressive Strength Test:** This test was performed on hardened concrete. After 7 and 28 days of cured concrete the test was performed. For this test Universal testing machine was used.

5.1. Calculations Made for Material Content to be Used in Project

Ratio of cement, fine aggregate and coarse aggregate for M20 is 1:1.5:3
Volume of 1 cube= 150mm*-150mm*150mm
Volume of 3 cube= 0.01m^3

Total Volume =1+1.5+3= 5.5
Volume of dry concrete =1.57 * volume of wet concrete

5.2. Calculation for 0.01m^3

5.2.1. Volume of Cement = 1/5.5 *1.57* 0.01 = 2.87*10^-3 m3

1 m3 of cement = 1440kg
2.87*10^-3 m3 of cement =1440 * 2.87*10^-3 = 4.111kg

5.2.2. Volume of Fine Aggregate = 1.5/5.5 *1.57* 0.01 = 4.28*10^-3 m3

1 m3 of Fine aggregate = 1600kg
4.28*10^-3 m3 of cement =1600 * 4.28*10^-3 m3 = 6.851 kg

5.2.3. Volume of Coarse Aggregate = 3/5.5 *1.57* 0.01 = 8.56*10^-3 m3

1 m3 of coarse aggregate = 1500kg
8.56*10^-3 m3 of cement =1500 * 8.56*10^-3 m3 =12.845kg

5.2.4. Water Cement Ratio = 0.40

5.2.5. Water Content = 0.40*4.111 = 1.64 lit

5.2.6. Sugar Content to the Weight of Cement

0.5% = 21gms
0.75% = 31gms
1% =41gms

6.Results and Discussion

6.1. Test 1 (Setting time of cement test)

6.1.1. Objective

To find the initial and final setting time of the cement paste
Initial setting time is the time when first drop of water is added to cement, the paste starts losing its plasticity
Final setting time is the time from when water is added to the cement, the paste completely loses its plasticity and attained its complete firmness.

6.1.2. Apparatus

i. Vicats apparatus
ii. Weight balance
iii. Stopwatch

6.1.3. Procedure for Initial Setting Time

i. Preparation of mould with freshly prepared test block of apparatus.
ii. The test block is made with water, cement and different ratios of sugar respectively.

iii. Then place the test block on the apparatus under the rod bearing the needle, then lower the needle such that is just touched the surface of the block, then release the needle allowing the needle to penetrate in the mould freely.
iv. Try the steps till the needle penetrate only till 5mm+0.5mm.
v. Note this time this is regarded as the initial setting time of the paste.

6.1.4. Procedure for Final Setting Time

i. Replace the needle with annular attachment.
ii. The cement is considered to be finally set, when the needle makes an impression thereon, while the attachment fails to do so.
iii. The time from when the water is mixed till the time needle makes the impression thereon and the attachment fails to do so is said as Final setting time.

6.1.5. Observation

Weight of the sample: 400 gm
Consistency at Percentage: 33%
Water for Consistency: 132ml

Table 2. Initial Setting Time (mins)

S. No.	Sugar content as % weight of cement	Weight of Sugar (in grams)	Weight of water 0.85P (ml)	Initial setting time (mins)
01	0%	0.0	112	39.30
02	0.5%	2.0	112	49.30
03	0.75%	3.0	112	55.30
04	1%	4.0	112	59.45

6.1.6. Results

Figure 1. Vicat's Apparatus mould

Figure 2. Vicat's Apparatus

The initial and final setting time of the cement was found to be increasing with increase of sugar content. Hence, we can conclude by saying *SUGAR ACTS AS A RETARDER***.**

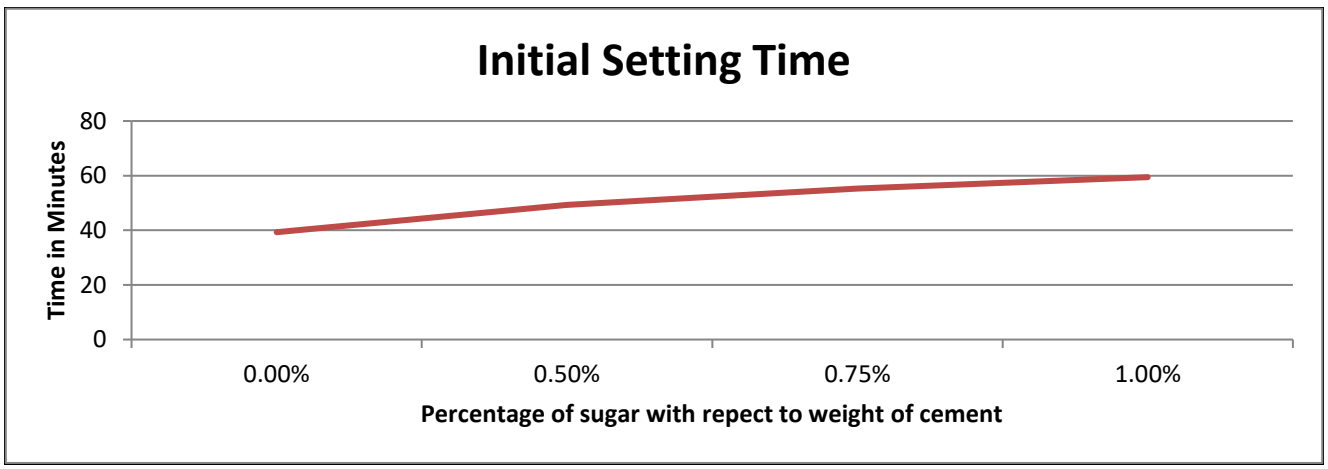

Figure 3. Graph has been made with percentage of sugar to the weight of cement on x-axis and time on y-axis.

The result after testing is quite clear that Sugar can be used as a *RETARDER***.**

6.2. TEST 2 (Compressive strength test)

6.2.1 Objective

To find compressive strength value of concrete cubes.

6.2.2. Apparatus

i. Concrete mixture
ii. Vibrating table or vibration machine
iii. Cube mould
iv. Compression testing machine
v. Balance

6.2.3. Procedure

i. Preparation of test specimen: Clean the mould properly. the mould is filled with concrete with 25 tamping after every layer so that no air is trapped. Then, put the cube mould over the vibrating table so that the slurry can come on top and can be removed and then it is rested for a while and then the marking is made on the cube.
ii. Curing: the mould is covered with red gunny bag for 24 hrs. Then the specimen is submerged under fresh water for 7 and 28 days. The specimen is removed from water 30 minutes before the test so that it is in a dry condition while testing. The cube weight should not be less than 8.1kgs.
iii. Testing: placing the cube in the machine centrally. Then the load is applied to the specimen axially. Slowly the load is applied at the rate of 140kg/cm^2 per minute till the cube collapse. The maximum value at which the load breaks is taken as compressive load.

6.2.4. Calculation

The compressive strength is measured of the cubes will be calculated by dividing the maximum axial load applied to the cubes during the test by the area of cross section, the mean dimensions of the section are used for calculation and shall be expressed to the nearest 0.5 N/mm2

Figure 4. concrete cubes

Figure 5. Curing of concrete cubes

Table.3 Curing Condition

Sr. No	Percentage Of Sugar	Indentification Mark	Age Of Specimen	Curing Condition
1	0%	A1	28days	Good
2	0%	A2	28days	Good
3	0%	A3	28days	Good
4	0.5%	B1	28days	Good
5	0.5%	B2	28days	Failed
6	0.5%	B3	28days	Failed
7	0.75%	C1	28days	Good
8	0.75%	C2	28days	Good
9	0.75%	C3	28days	Failed
10	1%	D1	28days	Good
11	1%	D2	28days	Good
12	1%	D3	28days	Good

Figure 6. Compressive strength

Table 4. Average Compressive Strength N/mm^2

Sr. No	Cross Sectional Area (mm*mm)	Maximum Load In (KN)	Compressive Strength N/mm^2	Average Compressive Strength N/mm^2
1	150*150	466.6	20.7	20.69
2	150*150	476	21.15	
3	150*150	455	20.22	
4	150*150	468	20.8	20.8
5	150*150	Failed	Failed	
6	150*150	Failed	Failed	
7	150*150	455	20.22	20.11
8	150*150	450	20	
9	150*150	Failed	Failed	
10	150*150	466	20.7	20.31
11	150*150	470	20.89	
12	150*150	435	19.33	

Figure 7. Tested concrete cube

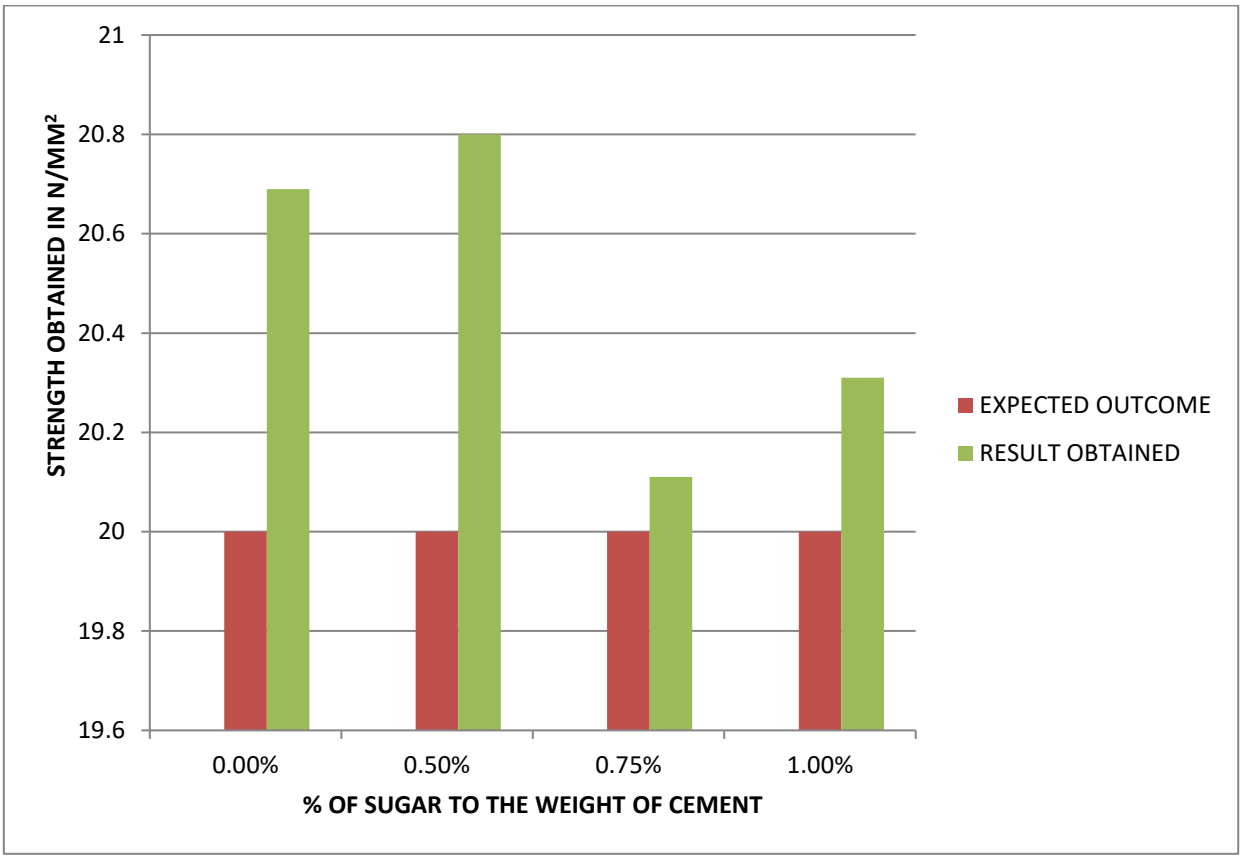

Figure 8. Compressive Strength and Percentage of Sugar Content

6.2.5. Result

The average compressive strength of the sample of cement after 28 days is found to be

i. 0.0% is 20.69N/mm^2
ii. 0.5% is 20.80N/mm^2
iii. 0.75% is 20.11N/mm^2
iv. 1% is 20.31N/mm^2
v. The compressive strength for all the 3 ratios and nominal mix is noted to be above 20N/mm^2.
vi. Therefore, Sugar can be used as a Retarder as it does not make any effect on the compressive strength of concrete.

7. Conclusion

Sugar delays the setting time of cement by up to 1.33 hours at a dosage level of 1% by weight of cement. There was no effect on the workability and compaction using sugar as an admixture in concrete. The compressive strength for all the 3 ratios and nominal mix is noted to be above 20N/mm^2.Therefore, Sugar can be used as a Retarder as it does not make any effect on the compressive strength of concrete. The optimum dosage level of sugar as a set-retarding admixture is 1% by weight of cement. Consequently, sugar performs satisfactorily as a set-retarding admixture in concrete.

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