

Effect of Sugar on Various Properties of Concrete

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ABSTRACT: Construction activities are accomplished through laid down procedures and parameters such as temperature and humidity. Concreting in hot weather above 100°F accelerates the early hydration of cement and procedure concrete with high strength at early ages but later, the strength is reduced considerably. The rapid evaporation of water causes plastic shrinkage in concrete and subsequent cooling causes tensile stresses and cracking. The study seek to investigate the impact of sugar on setting –time of ordinary Portland cement(OPC) paste and compressive strength of concrete. Sugar used for experiment was sucrose crystals (C₁₂H₂₂O₁₁); it was dissolved in required amount of water. The sugar was used at concentrations of 0, 0.4, 0.06, 0.08, 0.10, by weight of cement. In addition, the compressive strength of the concrete was investigated at 3, 7, and 28 days. Sugar crystals (C₁₂H₂₂O₁₁) were weighed and dissolved in the required 0.6 volume of water before mixing. The materials was batched by weight and mixed manually. The increase in initial and final setting times were apparent to sugar content of 0.06. Higher long-term compressive strength can be achieved in concrete by the use of sugar as admixture. The study recommends that sugar should be used as retarder but when it is used in excessive amount it reverse its property. The quantity of the sugar and other related quantity of the sugar and other related quantities must be adequately metered in the production process.

KEYWORDS: Concrete, Compressive Strength, Ordinary Portland cement, Sugar and Setting-Time

I.INTRODUCTION

Concrete is a composite construction material, composed of cement (commonly Portland cement) and other cementation materials such as fly ash and slag cement, aggregates (generally a coarse aggregate made of gravels or crushed rocks as limestone, or granite, plus a fine aggregate such as sand), water and chemical admixtures. Concrete solidifies and hardens after mixing with water and placement due to chemical process known as hydration. Water reacts with cement, which bonds with other components together, eventually creating a robust stone like material. Concrete is used to make pavements, pipe, architectural structures, foundations, motorways/roads, bridges/overpass, parking structure, brick/block walls and footings for gates, fences and poles.

Concrete is used more than any other man material in the world. As of 2006, about 7.5 cubic kilometers of concrete are made each year-more than one cubic meter for every person on earth.

Concrete powers US\$ 35 Billion industry, employing more than two million workers in United States alone. More than 55,000 miles (89,000 km) of highways in US are paved with this material. Reinforced concrete, prestressed concrete and precast concrete are most widely used types of concrete functional extensions in modern days.

Properties of concrete:

Property of concrete are divided into two major groups:

1. Properties of fresh concrete.
2. Properties of hardened concrete.

1) Fresh Concrete:

Fresh concrete is that stage of concrete in which concrete can be molded and it is in plastic stage. This is also called green concrete. Another term used to describe state of fresh concrete is consistence, which is ease with which concrete will flow.

Properties of Fresh Concrete

Following are the important properties of fresh concrete:

- A. Settling of concrete
- B. Workability

C. Bleeding and Segregation

- Bleeding
- Segregation

D. Hydration

E. Air Entrainment

A. **Settling of Concrete:**

The hardening of concrete before its hydration is known as settling of concrete or the hardening of concrete before it gains strength. OR The transition process of changing of concrete from plastic state to hardened state. Settling of concrete is based or related to the settling of cement paste. Thus cement properties greatly affect the settling time.

B. **Workability of Concrete:**

Workability is often referred to as the ease with which a concrete can be transported, placed and consolidated without excessive bleeding and segregation.

The internal work done required to overcome the frictional forces between concrete ingredients for full compaction. It is obvious that no single test can evaluate all these factors. In fact, most of these cannot be easily assessed even through some standard tests have been established to evaluate them under specific conditions.

In the case of concrete, consistency is sometime taken to mean the degree of wetness; within limits, wet concretes are more workable than dry concrete, but concrete of same consistency may vary in workability because the strength of concrete is adversely and significantly affected by the presence of voids in the compacted mass, it is vital to achieve a maximum possible density. This requires sufficient workability for virtually full compaction to be possible using a reasonable amount of work under the given conditions. Presence of voids in concrete reduces the density and greatly reduces the density and greatly reduces the strength 5% of the voids can be lower the strength by as much as 30%.

Factor Affecting Concrete Workability:

- Water-Cement ratio
- Amount and type of Aggregate
- Amount and type of Cement
- Weather Condition
 - Temperature
 - Wind
- Chemical Admixtures
- Sand to Aggregate Ratio

C. **BLEEDING AND SEGREGATION:**

1. **CONCRETE BLEEDING:**

Bleeding in concrete is sometimes referred as water gain. It is particular form of segregation, in which some of the water from the concrete comes out to the surface of the concrete, being of the lowest specific gravity among all the ingredients of concrete. Bleeding is predominantly observed in the highly wet mix, badly proportioned and insufficiently mixed concrete. In thin members like roof slab or road slabs and when concrete is placed in sunny weather show excessive bleeding.

Due to bleeding, water come up and accumulates at the surface. Sometimes, along with this water, certain quantity cement also come to the surface. When the surface is worked up with the trowel the aggregates goes down and the cement and water come up to the surface. This formation of cement paste at the surface is known as "Laitance". In such an case, the top surface of the slabs and pavements will not having good wearing quality. The laitance formed on the roads produces dust in summer and mud in the rainy season.

2. **SEGREGATION IN CONCRETE:**

Segregation can be defined as the separation of constituent materials of concrete. A good concrete is one in which all the ingredients are properly distributed to make a homogeneous mixture. There are considerable differences in the sizes and specific gravities of the constituent ingredients of concrete. Therefore, it is natural that the materials show a tendency to fall apart.

SEGREGATION MAY BE OF THREE TYPES:

- Coarse aggregate separating out or settling down from the rest of the matrix.
- Paste separating away from aggregate.

- Water separating out from the rest of the material being the material of lowest specific gravity.

D. HYDRATION IN CONCRETE:

Concrete derive its strength by the hydration of cement particles. The hydration of cement is not a momentary action but a process continuing for long time. Of course, the rate of hydration is fast to start with, but continues over a long time at the decreasing rate. In the field and in actual work, even the higher cement/water ratio is used, since the concrete is open to the atmosphere, the water used in the concrete evaporates and the water available in the concrete will not be sufficient for effective hydration to take place particularly in the top layer if the hydration is to be continuous, extra water must be added to refill the losses of water in account to absorption and evaporation. Therefore, curing can be considered as creation of a favorable environment during the early period for uninterrupted hydration. The desirable conditions are suitable temperature and moisture.

Concrete, while hydration release high heat of hydration. This heat is harmful from the point of view of volume stability.

E. AIR ENTRAINMENT:

Air entrainment reduces the density of concrete and consequently reduces the strength. Air entrainment are used to produce a number of effects in both the plastic and the hardened concrete.

This include:

1. Resistance to freeze the thaw action in the hardened concrete.
2. Compaction of low workability mixes including semi-dry.
3. Hardened concrete properties.

Following are the properties of hardened cement:

- Strength of concrete
- Concrete creep
- Shrinkage
- Modulus of elasticity
- Water tightness(impermeability)
- Rate of strength gain of concrete

II.LITERATURE REVIEW

Bazid khan (2004) - He added sugar as admixtures in cement paste into three different type of cements. The test result shows that the effect of sugar on setting time of cement paste depends upon the dosages and different type of cement used. According to his investigation the one type of cement it accelerated the initial setting time when dosages higher than 0.25% were used.

G.L Oyekan (2007) - Successfully worked on improving the compressive strength of concrete block by the addition of sugar. 0.1% sugar content (by weight of cement) increase the compressive strengths of the block by nearly 0.2% sugar content (by weight of cement) the 28 day strength of the blocks was increased by only 9% but the 14-day strengths of the blocks was increased by 56.6%.

Akogu Elijah Abalak (2011)- A successful work on sugar at concentration of 0.05% by weight of sugar content were taken on the cement paste with C33 concrete curing at 3,7, 14, and 28, days was investigated by uses of ordinary Portland cement. The compressive strength test results show some marginal strength gain at all ages but peaks at 11.84% at 3 days at 0.05% sugar content.

Bazid khan and Ulla Mohammad (2004)- In this study they added variable percentage of sugar in different types of cement and came to the conclusion that in same type of cement the sugar act as retarder and in some case act as accelerator.

Giridhar.V (2003)- Based on the test results, as percentage of admixtures increases from 0 to 0.1% that compressive strength of concrete also increased. Maximum strength of concretes was related on workability of concrete and it can be achieved by high of workability. The compressive strength of concrete measured for both admixtures after 7 and 28 days. After 28 days, the percentage of variation between the ordinary concrete and concrete with 0.1% of sugar added as admixtures was 12.0%.

Erdogen (1997)- Reported that retarding admixtures are mainly based on having lignosulfonic acids and their salts, hydroxyl carboxyl acids and their salts, and their derivatives and inorganic salts such as borates, phosphates, zinc, and lead salts.



III.MATERIAL AND METHODOLOGY

MATERIAL USED:

1. Cement: Portland cement is hydraulic cement that hardens in water to form a water-resistant compound. The hydration products act as binder to hold the aggregates together to form concrete. Cement of OPC43 Grade was used in the experiment.
2. Fine Aggregate: The fine aggregate is locally available. And size of fine aggregate is below 4.75mm.
3. Coarse Aggregate: Coarse aggregate consists of natural occurring stones (crushed, uncrushed or broken). It should be hard, strong, dense, durable, and clean.
4. Water: The water used in the manufacturing of concrete masonry units shall be free from matter harmful to concrete or drinking water should to be used to provide adequate strength and generally the water-cement ratio is taken 0.45 in whole experiments.
5. Admixture: Sugar was used in the concrete production. A white crystalline solid easily soluble in water and easily available in market and used in the experiment works. Sugar was added in concrete mix with three different dosages as 0.0%, 0.04%, 0.06%, 0.08%, 0.1%, by weight of cement.

IV.METHODOLOGY

43 grade OPC cement was taken to perform the test. Sugar used to perform the test. Sugar used to perform the experiment was Sucrose (C₁₂H₂₂O₁₁), it was dissolved in required amount of water. In order to determine the Consistency and setting time of cement past vicat apparatus, conforming to IS: 5513-1976, was used. The test was performed conforming to IS. The standard consistency of a cement paste was recorded as amount of water added that permits 5 to 7 mm penetration of vicat plunger from the bottom of the vice mold (IS:4031(Part 4)1988). Similarly setting time was measured as per IS: 4031(Part 5), 1988- initial setting time as the period elapsed between the time of adding water to the cement to the time when needle fails to pierce the mold by 5±0.5mm; final setting time as period elapsed between the time of adding water to the cement to the time when the annular rings fails to make the impression on the mold as the final setting time. The test was conducted at a temperature of 27±2°C.

Procedure for Determination Setting Time:

1. Unless otherwise specified this test shall be conducted at a temperature of 27+20°C and 65 + 5% of relative humidity of the laboratory.
2. Prepare a paste of 300 grams of cement with 0.85 times the water required to a give a paste of standard consistency IS: 4031(Part 4) 1988.
3. The time of gauging in any case shall not be less than 3 minutes not more than 5 minutes and the gauging shall be completed before any sign of setting occurs.
4. Count the time of gauging from the time of adding water to the dry cement until commencing to fill the mold.
5. Fil the vicat mold with this paste making it level with the top of the mold.
6. Slightly shake the mold to expel the air.
7. In filling the mold the operator hands and the blade the gauging trowel shall only be used.

Workability Test:

1. Clean the internal surface of the mold and apply oil.
2. Place the mold on a smooth horizontal non- porous base plate.
3. Fill the mold with the prepared concrete mix in 4 approximately equal layers.
4. Tamp each layer 25 strokes of the rounded end of the tamping rod in a uniform manner over the cross section. For the subsequent layers, the tamping should penetrate into the underlying layer.
5. Remove the excess concrete and level the surface with a trowel.
6. Clean away the mortar or water leaked out between the mold and the base plate.

7. Raise the mold from the concrete immediately and slowly in vertical direction. Measure the slump as the difference between the height of the mold and that of height point of specimen being tested.

Procedure for the Determination of Compressive Strength:

PREPARATION OF CUBES:

Concrete cubes are made on site to check that the strength of the concrete is above the minimum strength which has been specified. Making, curing and testing should be carried out in the correct manner. Even small deviations from the standard procedures will usually lead to compressive strength results which are lower than the true strength of the concrete. For example, for each 1% air entrapped there will be a 4 to 5% loss of strength.

CUBE MOULDS:

The standard of cube is 150mm.

Cubes of 100mm size are not suitable for concrete having a nominal maximum aggregate size exceeding 40mm.

PREPARING THE MOULDS:

Before assembling the molds, make sure that there is no hardened mortar or dirt on the faces of the flange that prevent the sections from fitting together closely.

These faces must be thinly coated with mold oil prevent leakage during filling, and a similar oil film should be provided between that contact surfaces of the bottom of the mold and the base.

COMPACTION:

FILLING THE CUBE MOLD AND COMPACTING THE CONCRETE:

After the sample has been mixed, immediately fill the cube molds and compact the concrete, either by hand or by vibration. Any air trapped in the concrete will reduce the strength of the cube. Hence, the cubes must be compacted.

COMPACTING WITH COMPACTING BAR:

150mm molds should be filled in three approximately equal layers (50mm deep). A compacting bar is provided for compacting the concrete. It is a 380mm long steel bar, weighs 1.8 kg and has a 25mm square end for ramming.

During the compacting of each layer with the compacting bar, the strokes should be distributed in a uniform manner over the surface of the concrete and each layer should be compacted to its full depth. The minimum number of strokes per layer required to produce full compaction will depend upon the workability of the concrete, but at least 35 strokes will be necessary except in the case of very high workability concrete.

CURING AND DE-MOLDING: INITIAL CURING OF CONCRETE CUBES:

Immediately after curing the cubes should be covered with damp matting or other suitable damp material and then polythene or similar impervious sheeting and stored in a place where the temperature can be kept at 27°C for approximately 16 to 24 hrs.

DE-MOULDING THE TEST CUBES:

Test cubes be de-molded 16 and 24 hours after they have been made. If after this period of time the concrete has not achieved sufficient strength to enable de-molding without damaging the cube that demolding should be delayed for a further 24 hours. Take care not to damage the cube because, if any cracking is caused, the compressive strength may be reduced. After the de-molding, each cube should be marked with a legible identification on the top or bottom using crayon or ink.

CURING OF THE CUBE:

Cubes must be cured before they are tested. Unless required for the test at 24 hours, the cube should be placed immediately after de-molding in the curing tank or mist room. The curing temperature of the water in the curing tank should be maintained at 27-30°C. If the curing is in a mist room, the relative humidity should be maintained at no less than 95%. Curing should be continued as long as possible up to time of testing.



CRUSHING OF CUBES:

Specimen is centrally placed on the testing machine, then we apply load on the specimen at the rate of 4tm till the specimen reaches the failure. Due to compression load the cube undergoes lateral expansion swing to the passion’s ratio effect. This induces the tangential force between the end surfaces of the concrete specimen and the adjacent steel plates of the testing machine. It has been found that lateral strain in the plates is only 0.4 of the lateral strain in the concrete.

V.RESULTS

SETTING TIME:

Table 1 show the variation of initial setting time with change in percentage of sugar as follow-

1. On no addition of sugar in concrete the initial setting time was recorded as 35 minutes.
2. On addition of 0.04% of sugar in concrete the initial setting time was increased to 40 minutes.
3. On addition of 0.06% of sugar in concrete the initial setting was recorded to 55 minutes.
4. On addition of 0.08% of sugar in concrete the initial setting time was recorded to 70 minutes.
5. Concrete the initial setting time was on addition of 0.10% of sugar in increased to 85 minutes.

PERCENTAGE OF SUGAR	INITIAL SETTING TIME
0%	35 Minutes
0.04%	40 Minutes
0.06%	55 Minutes
0.08%	70 Minutes
0.10%	85 Minutes

Table 1: Initial Setting Time

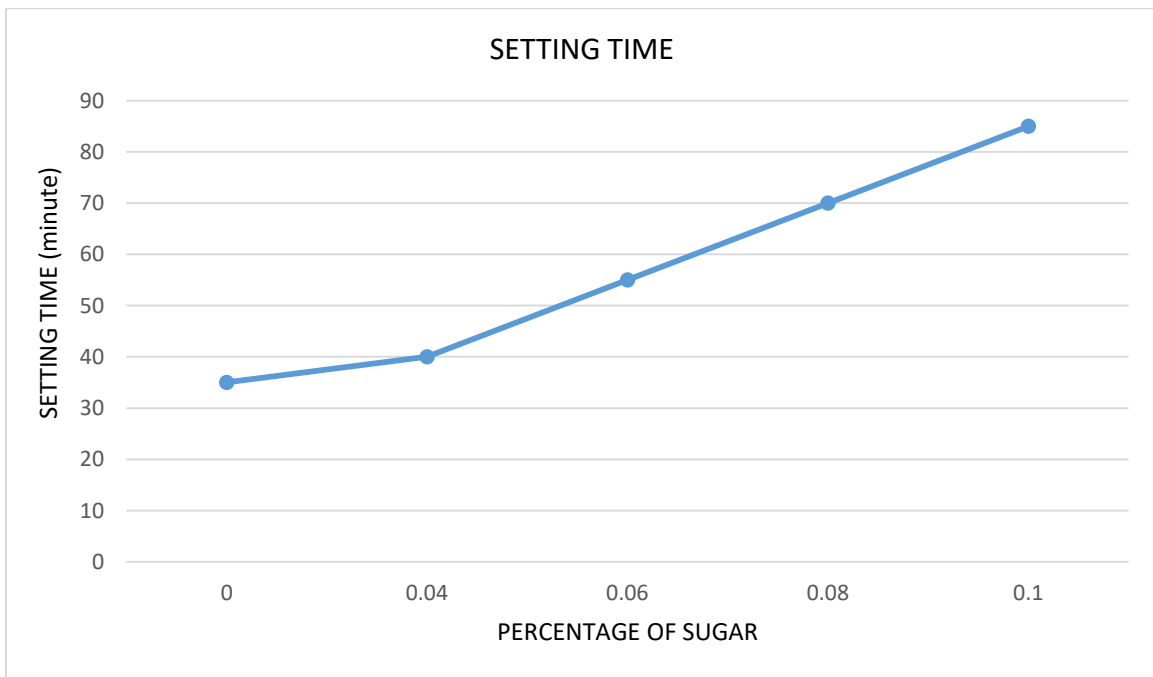


Fig 1: Variation on Setting Time with Variation in Percentage of Sugar



WORKABILITY OF CONCRETE:

Table 2 shows the variation of concrete with change in percentage of sugar as follow-

1. On no addition of sugar in concrete the slump value was recorded as 110mm.
2. On addition of 0.04% of sugar in concrete the slump value was recorded as 135mm.
3. On addition of 0.065 of sugar in concrete the slump value was recorded as 150mm.
4. On addition of 0.08% of sugar in concrete the slump value was recorded as 165mm.
5. On addition of 0.10% of sugar in concrete the slump value was recorded as 190mm.

PERCENTAGE OF SUGAR	SLUMP VALUE
0%	110 mm
0.04%	135 mm
0.06%	150 mm
0.08%	165 mm
0.10%	190 mm

TABLE 2: Slump Value of Concrete

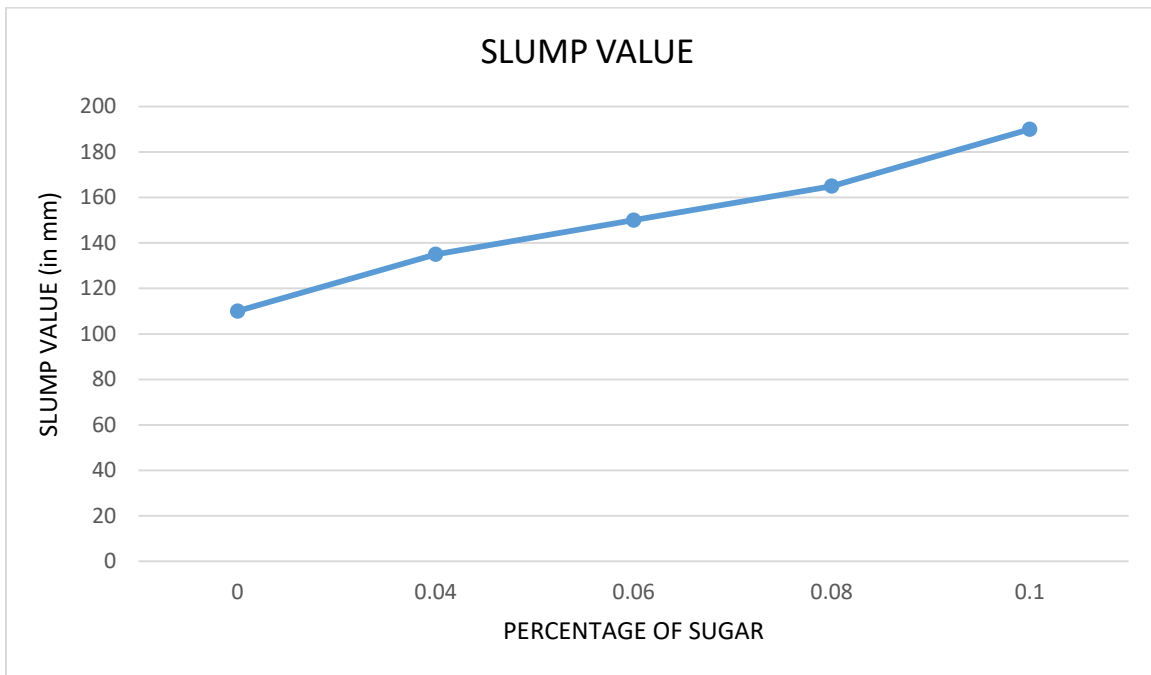


FIGURE 2: Variation of Slump Value with Variation of Percentage of Sugar

COMPRESSIVE STRENGTH OF CONCRETE:

Table 3 shows the variation of compressive strength of the concrete at various percentage of sugar at 7 days, 14 days, 28days, as follows-

1. On no addition of sugar in compressive strength on 7 days, 14 days, 28 days, was recorded as 15.14, 20.95 and 23.28 N/mm² respectively.
2. On addition of 0.04% of sugar in concrete the compressive strength for 7 days, 14 days, and 28 days, was increased to 16.36, 22.67 and 25.88 N/mm² respectively.



3. On addition of 0.06% of sugar in concrete the compressive strength for 7 days, 14 days and 28days was increased by 17.56, 24.33 and 27.02 N/mm² respectively.
4. On addition of 0.08% of sugar in concrete the compressive strength of concrete was increased by 18.09, 25.49 and 28.17 N/mm² respectively.
5. On addition of 0.10% of sugar in concrete the compressive strength of concrete increased by 19.34, 26.47 and 29.34N/mm² respectively.

PERCENTAGE OF SUGAR	7 DAYS (COMPRESSIVE STRENGTH)	14 DAYS (COMPRESSIVE STRENGTH)	28 DAYS (COMPRESSIVE STRENGTH)
0%	15.14	20.95	23.28
0.04%	16.36	22.67	25.88
0.06%	17.56	24.33	27.02
0.08%	18.09	25.49	28.17
0.10%	19.34	26.47	29.32

TABLE 3: Compressive Strength of Concrete

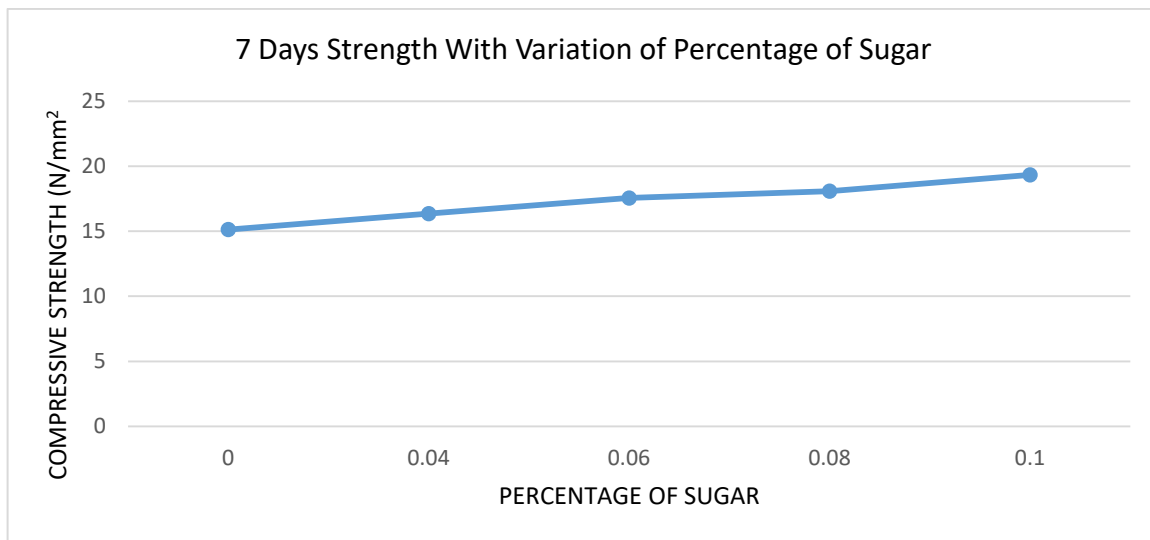


FIGURE 3: Strength after 7 Days

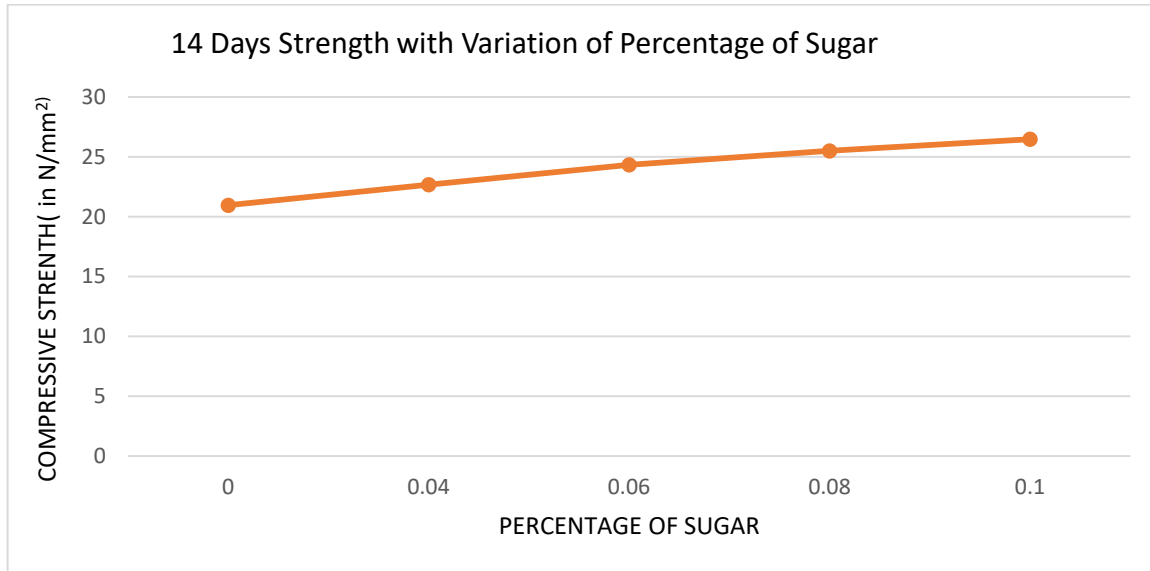


FIGURE 4: Strength after 14 Days

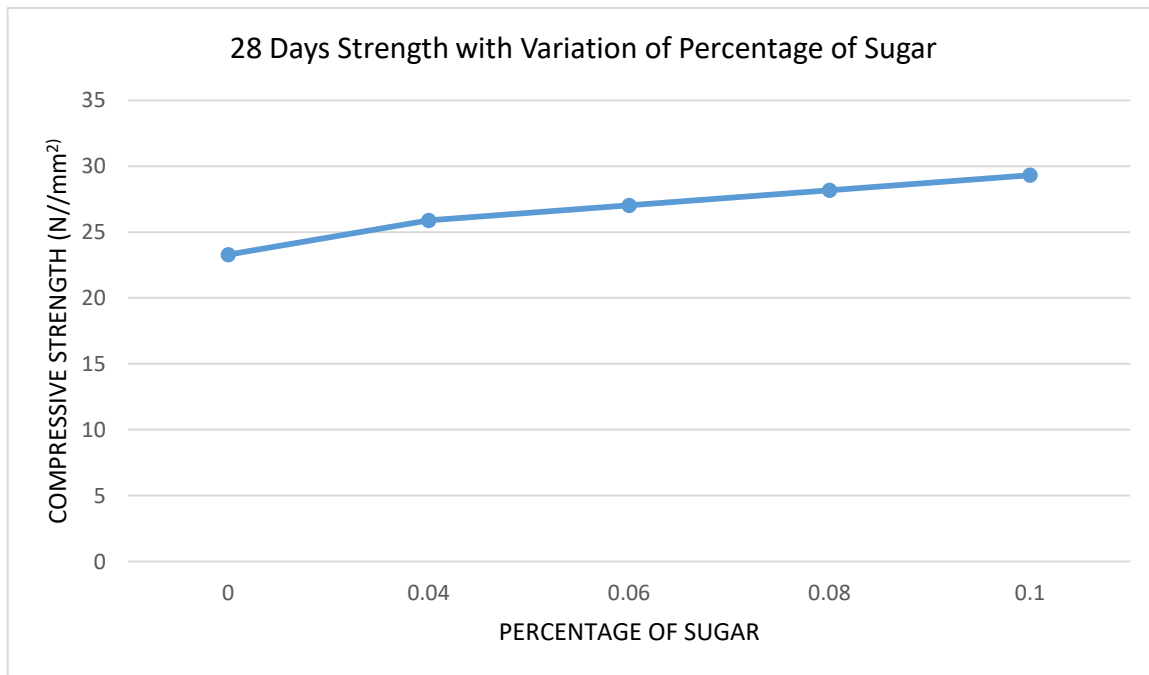


FIGURE 5: Strength after 28 Days

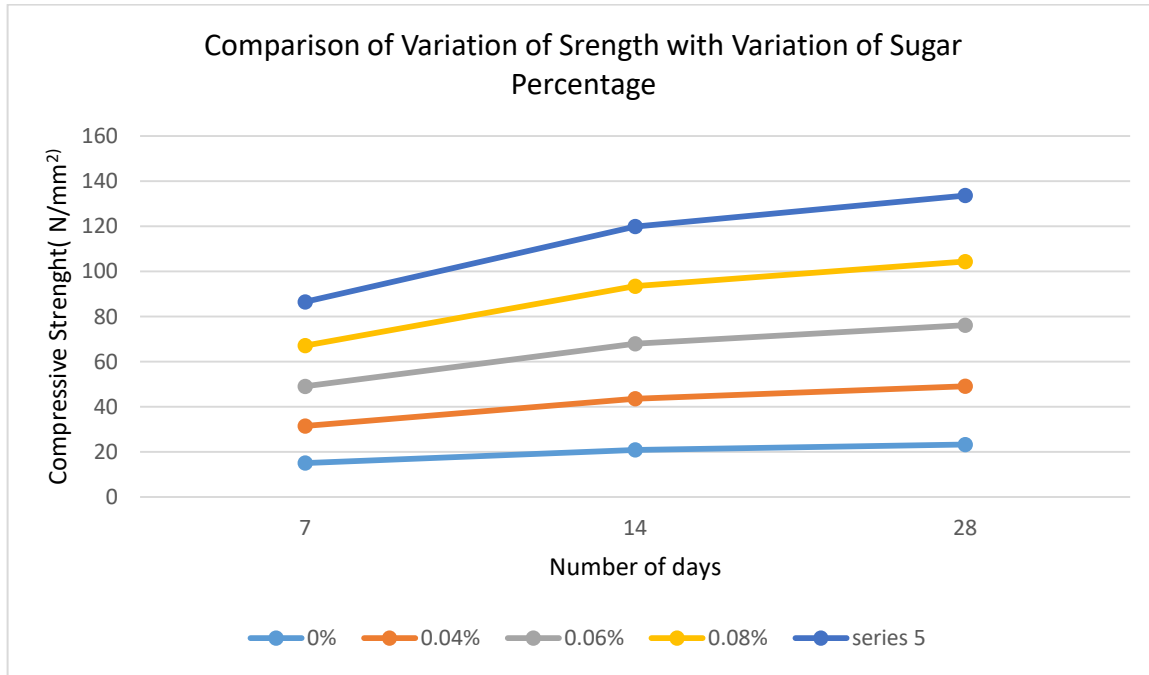


FIGURE 6: Comparison of Variation of Compressive Strength with Variation of Sugar

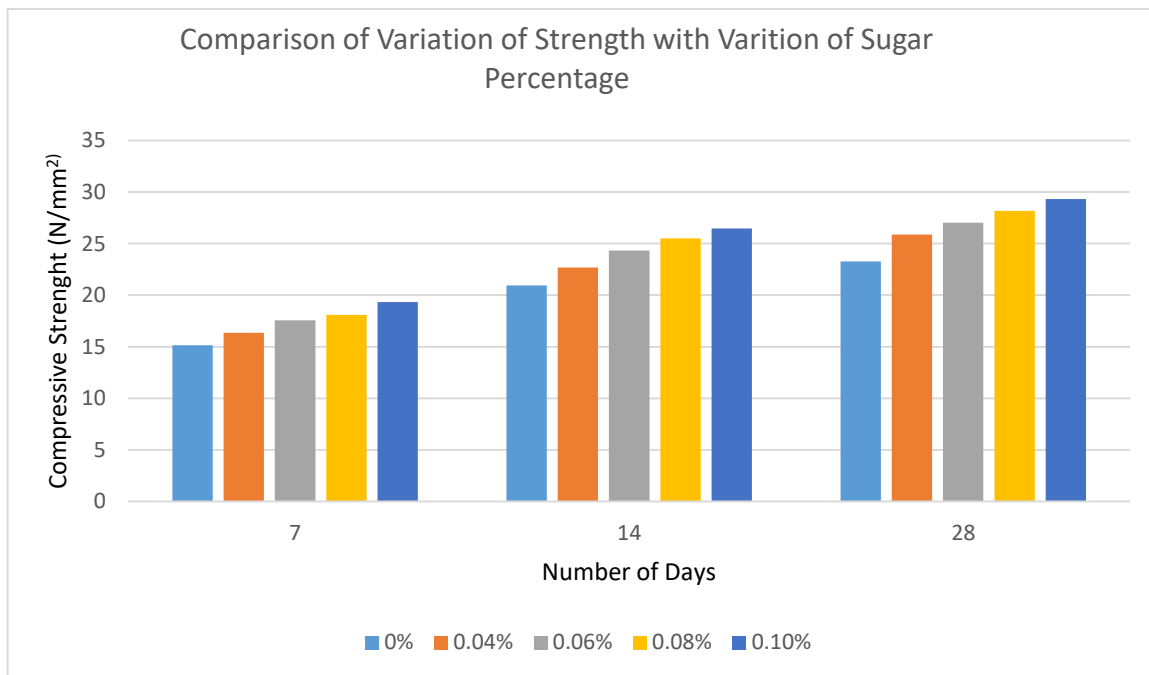


FIGURE 7: Comparison of Variation of Compressive Strength with Variation of Sugar

VI.CONCLUSION

From the result it is clear that a change in the properties of concrete take place. When sugar is mixed with concrete.

1. The setting time of cement increase in the percentage of sugar. The delay in initial setting time was 0.10% of sugar is 50 minutes.



2. The workability of concrete increases with increase the percentage of sugar. The slump value of the concrete having 0.10% of sugar is increased by 80mm.
3. The compressive strength increases as compared to ordinary concrete. The 28 days compressive strength is increased by 6.04N/mm².

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