

## Manufacturing of Concrete with Retarders

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### Abstract

*The concrete is one of the most important composite materials in construction industry. This paper deals with the study of concrete in hot weather condition and aims to induce the performance of concrete and its durability. For the improvement of workability & maintain the w/c ratio the paper suggests to use the chemical admixture called Gypsum which seems to be better for concreting in hot weather condition. The properties of the mentioned admixture were studied carefully and then it will allow mixing with concrete. The heat of hydration is get slow down by the appropriate addition of gypsum with concrete and then the state of workability also increased.*

*The thesis also studies the properties and reaction of another retarding agent called sugar and compare those two retarders. Further the nominal tests are proposed to conduct to found the optimum percentage level of retarders on the basis of setting time and Compressive strength.*

**Keywords:** Concrete, Gypsum, Sugar, Admixtures, Concrete Retarders

### Introduction

#### Concrete

**Concrete** is a composite material composed of coarse granular material (the aggregate or filler) embedded in a hard matrix of material (the cement or binder) that fills the space among the aggregate particles and glues them together. Concrete is used in large quantities almost everywhere mankind has a need for infrastructure. The amount of concrete used worldwide, ton for ton, is twice that of steel, wood, plastics, and aluminum combined. Concrete's use in the modern world is exceeded only by that of naturally occurring water.

Concrete is also the basis of a large commercial industry. Globally, the ready-mix concrete industry, the largest segment of the concrete market, is projected to exceed \$100 billion in revenue by 2015.

#### Initial & Final Setting Time

Initial time of cement is the time required by the cement for its early setting. Cement must be applied to the place of its use before its initial setting so it is necessary to find out the initial setting time. Generally the initial setting time of cement (OPC) is 30min. Similarly, for the final setting time we have to use the third needle which has a enlarged 5mm hollow cylindrical base.

The final setting time is the time from the mixing of the water to the time when this needle just makes the impression on the surface of the cement but do not penetrate into it. Generally the final setting time of cement (OPC) is 10hrs to 12hrs.

### **Set-Retarding Admixtures**

Retarding admixtures are those compounds which are used to slow down the chemical process of hydration due to which the concrete remains plastic and workable for a longer time than normal concrete without changing its mechanical properties. It is also used to overcome the accelerating effect of hot weather on setting time of concrete. The most commonly used retarders are Calcium Sulfate (Gypsum), Common Sugar, Lignosulfonic acids.

### **Mechanism**

There are many theories which are put forward to explain the mechanism of retarding admixtures such as:

- Adsorption of retarding compound on the nuclei of Calcium Hydroxide which defers the growth which is necessary for the hydration process.
- The retarding admixtures tend to form a film around the cement particles thereby preventing these materials to react with water and thickness of film indicates the retardation process.

### **Effects on Properties of Concrete**

1. It improves workability of concrete and helps in better placement and handling.
2. It delays the setting time of concrete in order to give time for it to be placed.
3. Due to the retarding action, the 1-day strength is reduced but the ultimate strength of concrete is improved.
4. The appearance of the concrete is greatly improved and finished concrete has better texturing.
5. The rates of drying shrinkage and creep increase due to the addition of retarding admixtures which can cause cracks and long-term failure.
6. The addition of retarding admixtures also causes some air to be entrained in the concrete

### **ASTM Specifications**

- The admixture which is used should be tested before use and also should be the same category which is approved.
- The retarders can be used with water-reducers but care should be taken while curing to avoid cracks and bleeding.
- The dosage of retarders should be within limits and the dosages also depend on the water-cement ratio, amount of C3A and also cement content.

## Advantages

- Improves workability, cohesion and extends setting time, provides protection against delays and stoppages and facilitates keeping workable concrete for extended period
- In the large construction, good workability of the concrete throughout the placing period and prevention of cold joints is ensured by adding retarders in the concrete
- Extended setting time minimize risks of long distance delivery in hot weather, improves pumpability of concrete by extended setting period and improved workability of concrete
- Reduces bleeding and segregation where poor sand grading are unavoidable.
- Reduces adverse environmental effects of various nature on concrete and embedded steel by considerable reduction in permeability

## Gypsum

Calcium Sulfate is commonly known as “Natural Gypsum”, is found in different forms mainly as dihydrate ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ) and anhydrate ( $\text{CaSO}_4$ ). Gypsum renders workability to mortar or concrete by keeping the cement in plastic state at early age of hydration. This is achieved by changing the course of hydration of calcium aluminate that manifests as retardation in cement hydration. This is how gypsum is identified as a set regulator or retarder, as known popularly. Nevertheless, gypsum also contributes for strength acceleration in the early stages of hydration.

Commonest of the sulphate minerals, Gypsum is found in marine evaporites, in caves where the air is dry enough to allow it to be deposited and remain, at fumaroles, and in the oxidized zones of sulfide deposits on occasion

## Properties

- It is a high-strength retarder that is effective at low dosages.
- Purified material with no offensive odors.
- Dose-response is linear, making the determination of effective dosage easy.
- Can be used in cement-gypsum blends.
- Effective over wide range of pH.
- Efficacy does not diminish during storage

## Sugar

Sugar interferes with the cement binding process in the concrete. Note that concrete and cement are not the same. Concrete is made by combining cement, water and a filler material called an “aggregate,” like gravel or sand. Most cement is made from limestone and clay. It reacts with water to form a hardening paste that binds the aggregate together to produce hard concrete. This hardening process is called hydration.

One theory suggests that when the concrete mixture contains sugar, the sugar molecules attach themselves to the hydrating cement and inhibit the chemical reactions involved in stiffening.

A different theory, called the “precipitation theory,” suggests that the addition of sugar increases the concentrations of calcium, aluminum and iron in concrete. The sugar molecules combine with these metals to form insoluble chemical complexes that coat the cement grains. Several key chemical processes that harden the concrete are then impeded. Hydration slows down the process and the concrete takes longer to set. For this reason, sugar is known as a retarder. Retarders increase the setting time of concrete. Refined white sugar is one of the best retarders.

### Mix Design of M25

The mix design ratio for the concrete having the grade of M25 was calibrated using the method of IS. The proportion of ingredients plays a vital role in concrete behavior. With the respective calculation the proportion for the grade of concrete M25 is mentioned below:

#### Mix Design for M25

<i>Water</i>	<i>Cement</i>	<i>Fine Aggregate</i>	<i>Coarse Aggregate</i>
191.6	480kg	520kg	1130kg
0.40	: 1	: 1.08	: 2.30

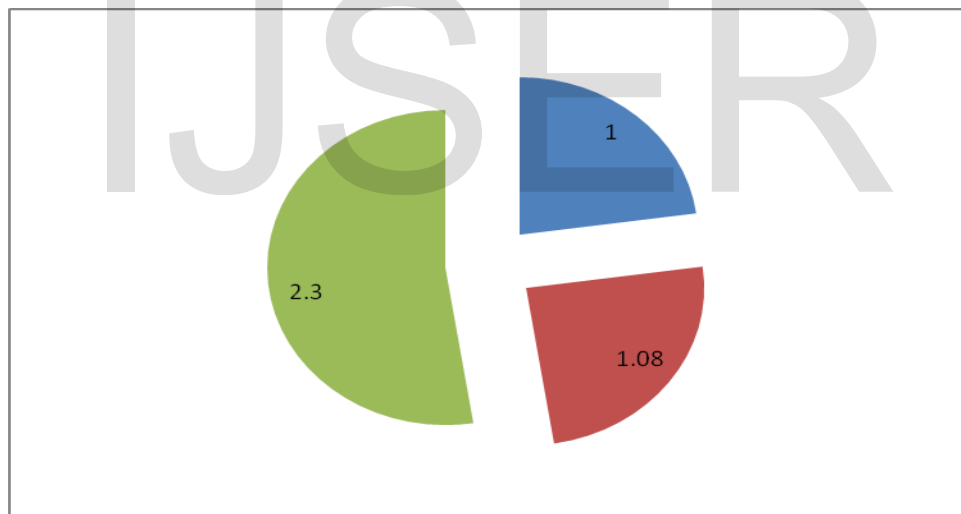


Fig 1. Mix Proportion of M25 Concrete

### Tests and Results

The following are the tests conducted to find out the setting time and compressive strength of concrete:

- Vicat's Apparatus Test
- Cube Test

## Vicat's Apparatus Test

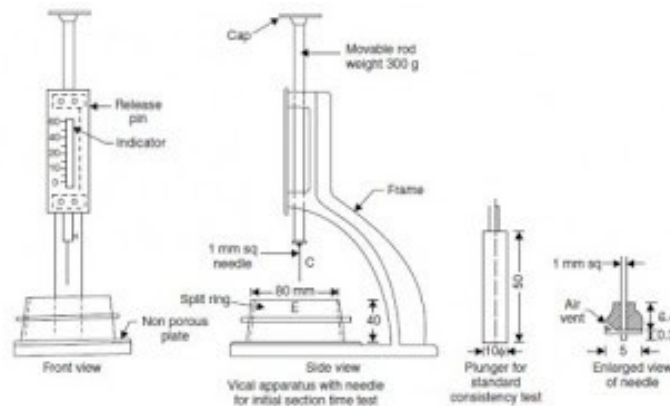


Fig. 1.5. Vicat apparatus

It is used to find out the consistency, initial & final setting time of the cement. It consists of an arrangement to hold the plunger of 10mm diameter and two other needles which are made to freely fall into a mould filled with the cement paste and the amount of penetration of the needles of plunger can be noted using the vertical graduations from 0mm to 50mm.

The nominal initial setting time of concrete is 30min and the initial setting time of concrete with Gypsum and Sugar was calibrated using Vicat's Apparatus.

### For Gypsum:

The level of gypsum was taken as 2%, 2.5% and 3% to weight of cement and it was mixed along with the concrete mix. The obtained initial setting time was tabulated and graphically represented below:

Sl.no	Gypsum in %	Initial setting time in min	Penetration of Needle in 'mm'
1	2	30	0
		60	0
		135	33
2	2.50	30	0
		60	0
		180	35
3	3	30	0
		60	0
		240	37

Table.1. Initial Setting Time vs Penetration of Needle

### For Sugar:

The retarding agent sugar was taken as 0.02%, 0.04% and 0.05% to the weight of the cement taken. The corresponding values obtained for initial setting time was tabulated and graphically represented below:

Sl.no	Sugar in %	Initial setting time in min
1	0.02	170
2	0.04	177
3	0.05	260

Table.2. Initial Setting Time for mix with Sugar

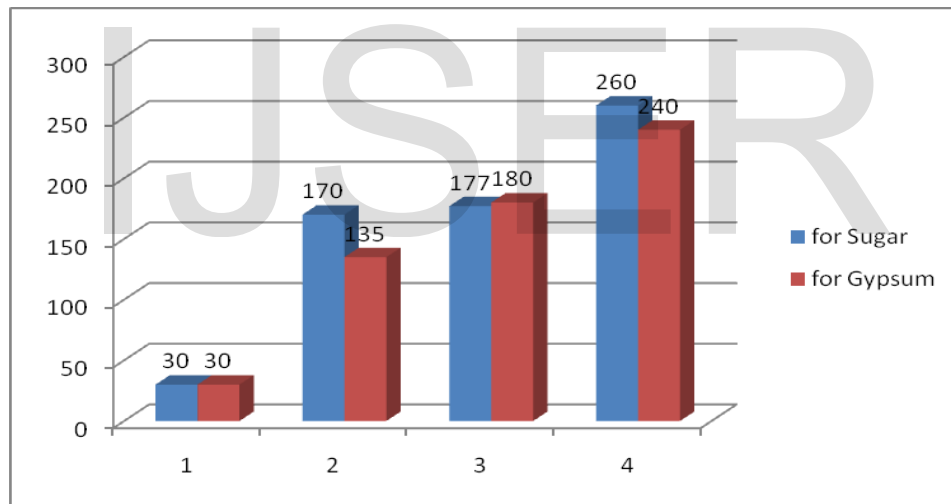


Fig.2. Comparison of Initial Setting Time with Sugar & Gypsum

### Compressive Strength Test

The concrete compressive strength was finding out by casting the cubes of 150x150x150mm in the ratio of 1:1:2. Totally 27nos of cubes are casted and distributed as 6nos for every level of gypsum and Sugar. Using Compression Testing Machine, the early strength and the final compressive strength was calibrated with the curing of 7&28 days.

The following table shows that the strength of M25 concrete with different level of gypsum and sugar:

% of Gypsum	Compressive Strength at 28 days Curing (N/mm <sup>2</sup> )	% of Sugar	Compressive Strength at 28 days Curing (N/mm <sup>2</sup> )
0%	27.92	0.02%	26.72
2%	36.44	0.04%	34.30
2.50%	23	0.05%	32.55

Table.3.Comparison of Compressive Strength

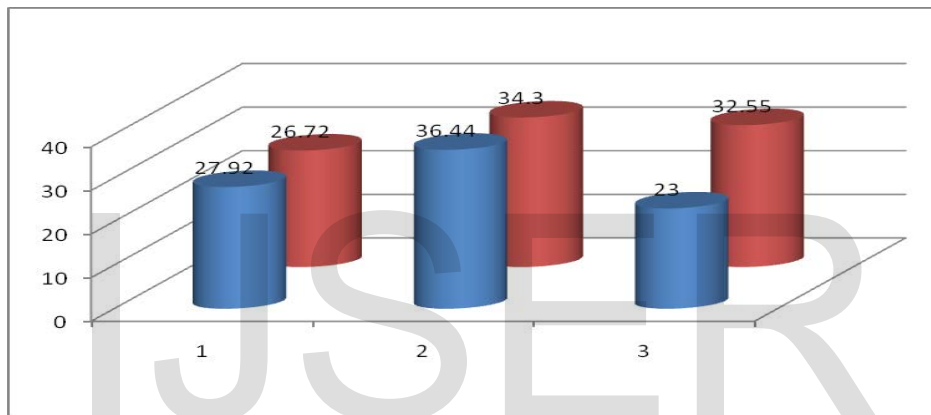


Fig.3. Compressive Strength

### Discussions

The result showing that the Gypsum was succeed as retarder in concreting by extending the initial setting time and by increasing the compressive strength. The over dosage of 3% makes a collapse to the structure so the test was carried and compared between 2 and 2.5% for gypsum and 0.02 to 0.05% for sugar.

The 2% of gypsum and 0.04% of sugar is giving the better result than other levels and the optimum results attained are listed as below:

Gypsum in %	Initial Setting Time in Min	Compressive Strength	
		7 days	28 days
2	135	8.22	36.44

Table.4. Results of 2% Gypsum in Concrete

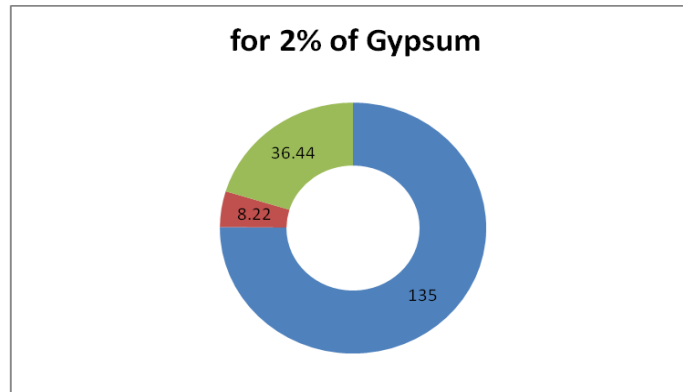


Fig.4. Results for 2% level of Gypsum

**For 0.04% of Sugar**

Sugar in %	Initial Setting Time in Min	Compressive Strength	
		7 days	28 days
0.04	177	8.20	34.30

Table.5 Results of 0.04% of Sugar

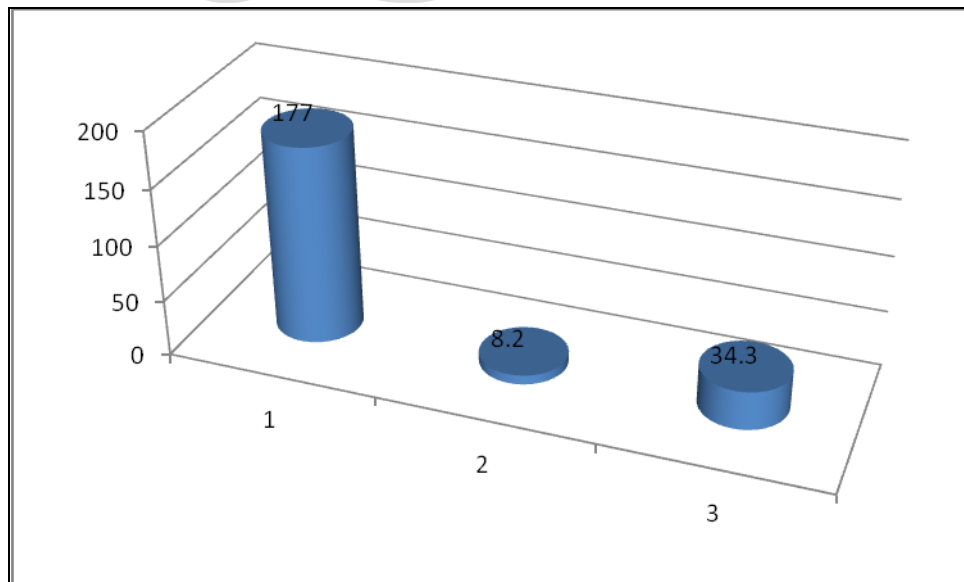


Fig.5. Results for 0.04% level of Sugar



## Conclusion

Thus the project was concluded with the following points:

- The need of admixture is unavoidable in certain conditions regarding purpose or environment.
- The retarder was used as an admixture in concrete at hot weather condition to extend the initial setting time of concrete.
- This thesis was carried out by using the gypsum and sugar as a considerable retarders to retarding the hydration of cement.
- The properties and specifications are studied carefully to manufacturing the concrete with retarding admixtures.
- The concrete was casted in the region of Pudukkottai, Tamil Nadu having a temperature around 45°.
- The initial setting time was extended and the improvement in compressive strength was also achieved at an appropriate level of using the gypsum and Sugar.
- Thus the 2% of Gypsum and 0.04% of Sugar is adoptable for succeeding the strength and initial setting time.
- The over dosage of admixtures was results in the total collapse of concrete.

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