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Experimental Study on Strength Characteristics of Cement Concrete by Adding Sugar Waste

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ABSTRACT

This investigation deals with the effects of the sugar- waste (Molasses) on the cement concrete. Studies were carried out on a cement paste , the types of different mortar mixes and five types of different concrete mixes, with and without the use of molasses. Molasses is one among the four types of sugar waste and it contains 40-60 percent of total sugar content depending upon types of molasses. While other sugar waste are Bassage, pressed mud and Discharging water containing mud. Among these wastes first two contains 3 percent of sugar and three contains negligible percent of sugar. In the present work molasses was collected sugar mill name. The effects of different dosage level 0, 0.1, 0.25, 0.50, 0.75, 1.00, 2.00, 3.00, 4.00, 5.00 percent of the molasses by weight of cement were studied for standard consistency, setting time, water – reduction behavior and air – entrainment in fresh concrete. The studies were also carried out for 7-day and 28-day compressive strength of the mortar, 7-day, 28-day, 56-day and 91-day compressive strength for five types of concrete mixes, 14-day tensile strength and flexural strength of concrete for the dosage levels 0, 0.10, 0.25, 0.50 percent of molasses by weight of cement. This test results indicates that molasses acts as accelerator up to 0.50 percent dose and then becomes retarder. Also it is slightly a water reducer and air entraining agent. The compressive strength of mortar, concrete, flexural strength and tensile strength of concrete get increased on using 0- 0.50 percent dose of molasses but the most favourable dose is 0.25 percent of molasses by weight of cement.

INTRODUCTION

The years of great Engineering development and the anticipated demand of future societies have necessitated the need to utilize the industrial waste and by-products in order to achieve high economy. Side by side one or another means of safe disposal of such a material which can cause environmental pollution is discovered.

Realising that the waste and by-product of sugar industry may found a suitable admixture with cement and other binding materials. It can prove itself in the field of construction material investigation particularly for the leading sugar producing nations of third world like India, Ghana etc. In such countries sugar industries are widely distributed throughout the length and breadth making the raw material easily available.

Recognising the need, a series of experiments were conducted to study the effect of Molasses on concrete, which is one of the four types of waste of sugar industry.

There are four types of sugar-waste coming out from the sugar industry. Among these two are liquids and other two are solids. They are as follows:

a) Molasses
b) Bagasse
c) Pressed Mud
d) Discharging water containing mud

Molasses will be discussed later. Solid bagasse contains about 3 percent sugar content and is used in paper mill industry.

Pressed mud contains about 3 percent sugar content and creates a disposal problem. It can be used in the filling of depressed ground only. Effluent water contains mud and negligible percent of sugar content. The disposal of this water is also a problem for sugar industry. This water can be used for construction purpose if it contains acceptable amount of mud and molasses.

Sampling of Waste Molasses from Sugar Industry

Sample must be taken from the discharge pipe leading to the weighing or measuring tanks and not from the gutter behind the centrifugal machines. The samples taken should be referred to each pan-strike. A sample may be taken from the storage tank by hand at every 4 hours and composited for analysis. A small sub-sample i.e. 100 gm. of every daily sample is weighed out and transferred into a second collecting bottle. These sub-samples are mixed and served for the total analysis, which is made once a week or a fortnight.

Molasses-Composition and Specifications

The history of the word 'molasses' ('Melasse' in German and Dutch) is not mentioned in Etymological dictionaries since it is quite definitely and clearly derived from the Romanic languages. The term 'molasses' is applied to the final effluent obtained in the preparation of sugar by repeated crystallization. The amount of molasses obtained and its quality .provide information about the nature of the sugar-cane and the processing in the sugar factor, such as the efficiency of the juice clarification, the method of crystallization during boiling and the separation of the sugar crystals from the low-grade massecuite.

Chemical Composition

Theoretically the final molasses is a mixture of sugar, non sugars and water, from which no sucrose crystallizes under any conceivable physical and technically optimum conditions, with no regard to time. The objective of the sugar industry is to produce molasses whose purity is as low as possible.

Types of Molasses

Molasses is effluent obtained from the centrifugals on purging or spinning a massecuite and also distinguished as A, B and C etc. The discharge, before washing begins, is termed as heavy molasses and when diluted with wash water it is called light molasses. This molasses eventually removed from the process is called waste are final molasses. Although the main objective of the sugar industry is to produce a final molasses, whose purity and total sugar content is as low as possible, yet the final molasses comes out as waste from the sugar industry having no uniform brix and total sugar content.

Cement Concrete

Cement concrete is the most widely used construction material now-a-days and is being extensively used in greater quantities than any other man made material of construction in the field of Civil Engineering. Due to its property that it can be cast in any required shape, it has not only replaced the old construction techniques of stone and brick masonry construction, but also has made it possible to cast intricate structures. The annual rate of production of cement is nearly constant but its demand increases day by day. That's why there is great demand to save cement and the cost. By slightly charging the composition of concrete e.g. adding admixture, we can improve much the quality of concrete and at the same time can save cement, other constructional material and the total cost of structure. Thus the use of controlled cement concrete definitely results in an improved quality job and that also at lower cost. Quality control thus aims at reducing the above variations inherent in the mixing of cement concrete and in producing a uniform material with requisite properties. The actual work In-Situ production of cement concrete requires very careful attention in their proportioning, mixing, placing, compacting, finishing and other required operations.

LITERATURE REVIEW

The use of chemical admixtures in India has not gained the degree of acceptance observed in the most other major concrete producing countries, despite the many similarities in other respects, such as concreting materials, practice and standards. There are many reasons for this and some of these are inadequate facilities for researchers, inadequate admixture industry and little political motivation towards this. In this chapter, a brief account of the work which has already been done is presented. Molasses is a mixture of chemicals and chemical compounds. But its main constituent is sugar i.e. carbohydrates. But it contains little percentages of chlorides also. That's why its behaviour is very confusing. At some percentage it acts as accelerating admixture and at other percentage it acts as retarding admixture.

Sugar has a retarding action. The effect of sugar depends greatly on the quantity used, and conflicting results have been reported in past. It seems that, used in a care- fully controlled manner, a small quantity of sugar (about0.05 percent of the weight of cement) will act as an acceptable retarder, the delay in-setting of concrete is about 4 hours. However, the exact effects of sugar depend greatly on the chemical composition of cement. For this reason the performance of sugar, and indeed of any retarder, should be determined by trial mixes with the actual cement which is to be used in construction. A large quantity of sugar, say 0.2 to 1 percent ‘of the weight of cement, will virtually prevent the setting of cement such quantities of sugar can therefore be used as an inexpensive "Kill", for instance when a mixer or an agitator has broken down and cannot be discharged.

When sugar is used as a controlled set retarder, the early strength of concrete is severally reduced. But beyond about 7 days there is an increase in strength of several percent compared with non-retarded mix. This is probably due to the fact that delayed setting produces a denser gel. It is interesting that retarders tend to increase the plastic shrinkage because the duration of the plastic stage is extended but drying shrinkage is not affected. The mechanism of action of retarders has not been established with certainty. We know that they modify the crystal growth or morphology and this results in a more effective barrier to further hydration than is the case without admixture. The admixtures are finally removed from solution by being incorporated into the hydrated material but this does not necessarily mean the formation of different complex hydrates. This is also the case with water-reducing and retarding admixtures (Such as ligno-sulphonates). Khaliland Ward (15) showed that the linear relation between the heat of hydration and weight of non-evaporable water is unaffected by the addition of water.

Molasses as Water-Reducing Admixture

Molasses is also a water-reducing admixture. Since molasses acts as retarder and accelerator both, we have to see the characteristics of all three types of water reducing admixtures i.e.

a) Normal water-reducing admixtures
b) The accelerating water-reducing admixtures
c) The retarding water-reducing admixtures.

a) Normal Water-Reducing Admixtures

(i) By the addition of the admixture, a reduction in water-cement ratio results and thus a concrete having the same workability as that of the control concrete can be obtained, with unconfined compressive strength at all ages exceeding that of the control concrete.
(ii) If the admixture is added directly to a concrete as part of gauging water with no other changes to the mix proportions, a concrete possessing similar strength development characteristics is obtained, yet having a greater workability than the control concrete.
(iii) A concrete with similar workability and strength development characteristics can be obtained at lower cement content and water than a control concrete without adversely affecting the durability or engineering properties of concrete.

Corresponding Mixes are, therefore, concrete mixes having the same workability and 28 day strength characteristics, but the mix containing the water-reducing admixture will have a lower cement content than the other mix.

It is more difficult to obtain higher strength and workability by further increasing the cement content. It is in this area that the hydroxy-Carboxylic acid water-reducing admixtures are particularly beneficial, enabling considerable increase in strength to be obtained without the additional cost and undesirable side effects of large cement increments.

b) The accelerating Water-Reducing Admixtures

These types of admixtures give higher strength during the earlier hydration period, which is particularly useful at lower temperature.

c) The Retarding Water-Reducing Admixtures

These types of admixtures behave in a similar manner to the normal materials and are often of similar chemical composition at higher dosages level. But they extend the period of time when the concrete is in the workable state. This means, that the time available for transport, handling and placing is increased. The retarders are actually 'retarding water-reducing admixtures.

EXPERIMENTAL PROGRAMME

The experiments were conducted in laboratory of Royal Institute of Management and Technology, Sonipat. Experimentation was made as intensive and broad based as possible considering the various objectives of the study consistent with the available facilities. Testing of materials, casting and curing of specimens and conducting tests at the prescribed age formed a major part of the study.

The aim of present investigation was to study the effect of Sugar-Waste (Molasses) on the various properties of cement, cement-mortar and cement-concrete. The Molasses were taken from ISGEC (Indian Sugar and General Engg. Corporation) Panipat, whose main constituents are listed By varying the dosage level of molasses the tests were performed on cement and different mixes of the cement-mortar and the cement-concrete.

The practical work of trials, casting and testing was carried out as follows:

a) The standard consistency, initial setting time and final setting time was compared with and without the use of Molasses. The effect of Molasses on these properties of cement was compared with the effect of sugar on these properties of cement.
b) The water-reducing effect in different mixes of cement-sand mortar (1:3, 1:4 and 1:5) has been worked out for different dosages of Molasses. The workability of the mortar was kept same i.e. flow value = 110± 5 percent. Using 50 mm size cube specimens the 7-day and 28-day compressive strength were determined.
c) The air-content of freshly mixed concrete by pressure method were determined at different dosages of Molasses.
d) Water-reducing effect in five different concrete mixes has been worked out for different dosages of molasses. The compaction factor was kept the same i.e. 0.80 + 0.05. Using 150 mm size cube specimens the 7-day, 28-day, 56-day and 91-day compressive strength were determined.
e) Split tensile strength and flexural strength of concrete at varying dosages of molasses were determined, while the mix and workability were kept same.

Materials

Molasses
The molasses were collected from ISGEC (Indian Sugar and General Engg. corporation) Haryana.

Cement
The cement used for the project was ordinary portland cement (OPC) with trade name JK. The cement was tested as per IS: 4031-1969 and satisfied the requirements of IS: 269-1976.

Fine Aggregate
Locally available Yamuna river sand was used as fine aggregate in the mix. The sand passed through 4.75 mm 15(4801 and 90.9% was retained on IS:15 Sieve (150 micron Size).

Coarse Aggregate
Locally available crushed coarse aggregates were used in the mix. The Fineness Modulus of Coarse Aggregate was found as 6.99 and its specific gravity as 2.65.

Water
Tap water, used for drinking purposes available in the laboratory was used for mixing and curing purposes.

Testing for Standard Consistency and Setting time of Cement
The investigations were done with the help of vicat apparatus conforming to "IS:5513-1969". All the tests followed the clause 7 of "IS:4031-1968, Indian Standard Methods of Physical Tests for Hydraulic Cement" (3). Same procedure was adopted for the dosage levels of 0.10, 0.25and 0.50 (Percent by weight of cement) of Molasses and Sugars

Testing for Concrete
Five mixes M1, M2, M3, M4 and M5 with aggregate-cement ratios of 2.8, 4.0, 4.5, 5.0 and 6.0 and with water-cement ratios of 0.35, 0.40, 0.45, 0.50 and 0.55 respectively were designed for a compacting factor of 0.30 + 0.05 as per Indian Standard Specification (5,6). The same mixes were used for maintaining the compacting factor 0.80 + 0.05 y using different dosages of molasses. The test specimens were 150 mm size cube which were tested for 7-day, 28-day, 56-day and 91-day compressive strength. The tests were carried out as per relevant Indian standard Specifications.

Testing for Split Tensile Strength of Concrete

Same type of mix of concrete at different dosages of 0, 0.10, 0.25 and 0.50 (Percent by weight of cement) of molasses were used, maintaining the constant compacting factor 0.80, 0.05 as per IS specification.

Testing for Split Tensile Strength of Concrete

Same type of mix of concrete at different dosages of 0, 0.10, 0.25 and 0.50 (Percent by weight of cement) of molasses were used, maintaining the constant compacting factor 0.80, 0.05 as per IS specification.

RESULTS AND DISCUSSION OF RESULTS

Observations and Calculations

The observations based on the experimental programme are listed in the following tables.

Table 1 Effect of Molasses on Standard Consistency and Setting Time

Sr.No.	Dose of Molasses(percent by wt. of cement)	Standard consistency	Setting times (Minutes)	
			Initial	Final
1	0.0	27.00	105	215
2	0.050	27.00	101	208
3	0.075	27.00	60	174
4	0.100	27.00	45	111
5	0.150	27.00	40	96
6	0.200	26.75	38	91
7	0.250	26.75	60	137
8	0.500	26.75	89	188
9	0.750	26.75	112	231
10	1.000	26.50	132	289
11	2.000	26.00	173	358
12	3.000	25.50	107	241
13	4.000	25.25	128	291
14	5.000	25.00	148	326

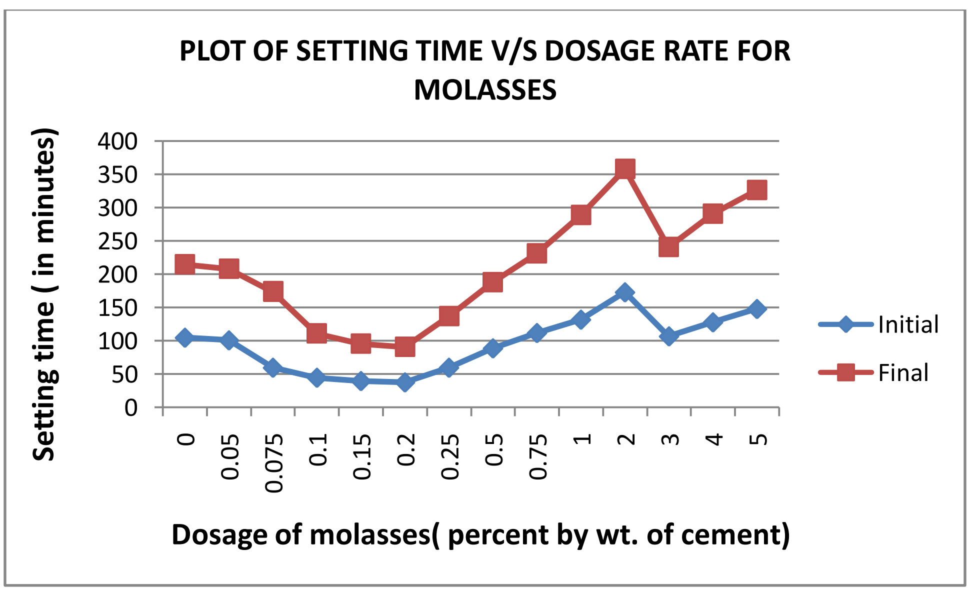

Fig. 1 Plot of Setting Time v/s Dosage Rate for Molasses

Table 2 Effect of Sugar on Setting Time

Sr.No.	Dose of sugar (percent by wt. of cement)	Standard consistency	Setting times (Minutes)	
			Initial	Final
1	0.0	27.00	105	215
2	0.025	27.00	103	211
3	0.050	27.00	34	151
4	0.075	27.00	41	156
5	0.100	27.00	52	165
6	0.150	27.00	76	204
7	0.200	27.00	154	266
8	0.250	26.75	204	309
9	0.300	26.75	198	267
10	0.400	26.75	174	241
11	0.500	26.75	156	237
12	0.750	26.75	143	229
13	1.000	26.75	123	218
14	1.125	26.75	140	226

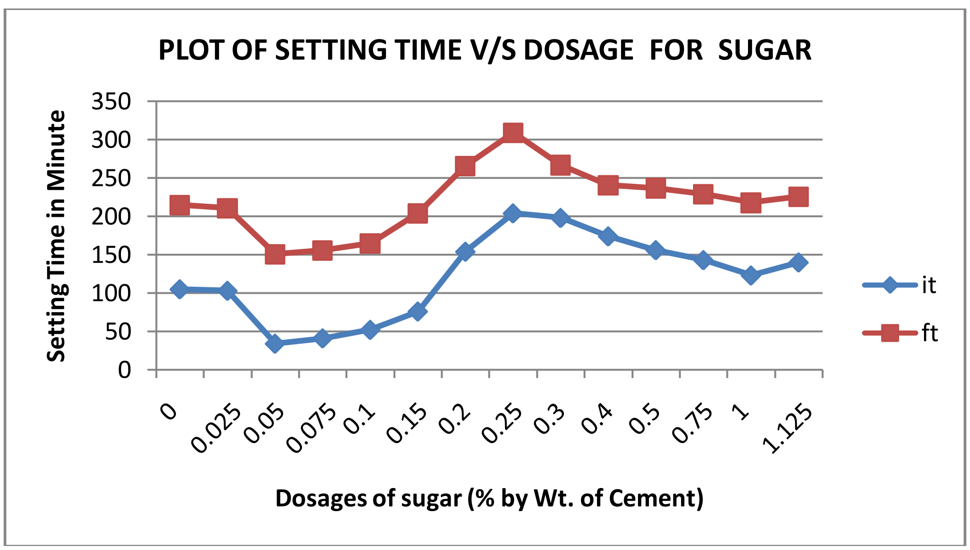

Fig. 2 Plot of Setting Time v/s Dosage for Sugar

Effect of Molasses on Spilt tensile strength of concrete
Cylinder specimen size dia = 150 mm
Length = 300 mm
Aggregate/cement = 6.0

Table 3 Constant compaction factor = 0.80±0.05

Sr. No.	Dose(percent by wt. of cement)	Water/cement ratio	Average Load(t) (P)	Split tensile strength	Increase in strength (%)
1	0.00	0.550	7.75	1.096	-
2	0.10	0.550	8.75	1.238	12.96
3	0.25	0.547	10.75	1.521	38.78
4	0.50	0.543	9.75	1.379	25.82

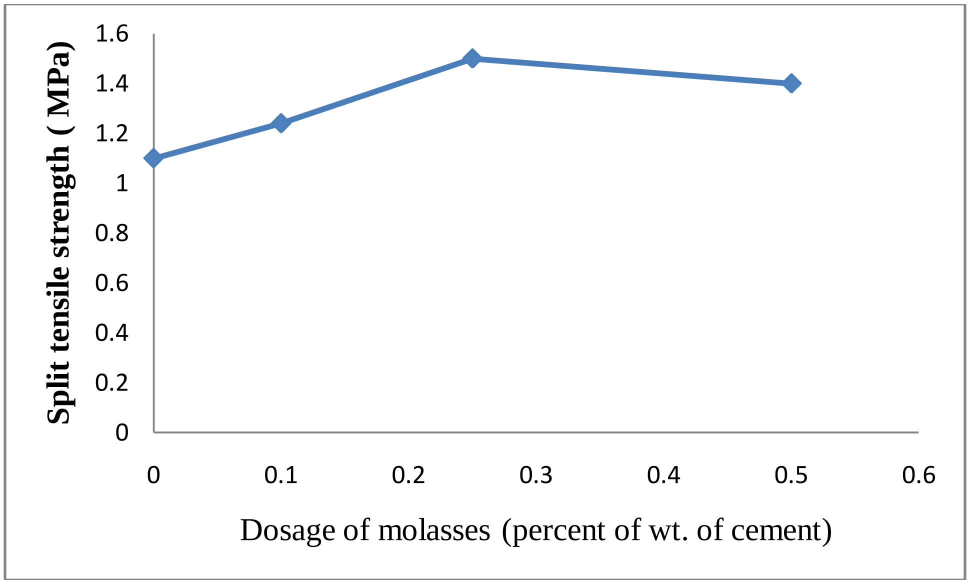

Fig. 3 Effect of molasses on split tensile strength of concrete at 14th days

Effect of Molasses on Flexural Strength of Concrete
Beam Specimen Size = 100mm x 100mm x 500mm
Aggregate/Cement = 6.0

Table 4 Constant compaction factor = 0.80±0.05

Sr. No.	Dose(percent by wt. of cement)	Water/ cement ratio	Average deflection Load (t) mm		Flexural Strength	Increase in flexural strength (%)
1	0.00	0.55	0.076	0.671	2.686	-
2	0.10	0.55	0.087	0.769	3.074	14.48
3	0.25	0.55	0.98	0.866	3.463	28.94
4	0.50	0.54	0.079	0.698	2.792	3.950

CONCLUSION

Based on the experimental results obtained in the present study, the following conclusions are drawn tentatively for the cement, cement-sand mortar and cement concrete as effected by different percentages of molasses.

- The molasses contains about 20 to 25 percent sugar.
- Molasses acts as accelerating agent at lower dosage level an as retarding agent at higher dosage level. Thus initial setting time and final setting time of cement-paste with molasses has too much variation. Out up to 0.5 percent dose it acts as accelerating agent. From 0.75 percent to5.0 percent dose it acts as retarding agent. The trend shows that at higher percentage it will act as retarding agent.
- The cement mortar with a dose more than 0.75 percent did not set within 24 hours and the proper bond strength between cement and sand did not develop also.
- The molasses is a water reducing agent. It is capable of reducing water by 12 percent by adding 5 percent molasses by weight of cement.
- The relationship between dosage levels of the molasses and the percentage of water-reduction for the same workability is almost linear in the range of 0 to 5 percent of dosage level.

- The rate of water reduction is different for the different mixes, when they were studied with the use of the molasses. It is maximum for poor mix and minimum for richer mix.
- Molasses act as air entraining agent. By addition of 5 percent molasses, the air content of freshly mixed concrete has increased by 20 percent. The relationship between increase in air content (in percent) and dosage of molasses is almost linear in the range of 0 to 5 percent of dosage level.
- For mortar the 7-day compressive strength decreases with an increase in the dosage level. Rut 28-day compressive strength of mortar is favourable in the range of 0 to 0.5 percent of dosage level. But the most favourable dose is 0.25 percent.
- For concrete mixes the compressive strength at early age is not favourable but at later age it is favourable.
- The 7-day compressive strength is almost same up to dose 0010 percent and decreases with an increase in the dosage level. The 28-day compressive strength is favourable.
- upto 0.25 dose and then decreases. The 56-day and 91-day compressive strength is favourable up to 0.50 percent dose and most favourable dose for all mixes is 0.25 percent dose by weight of cement.
- The split tensile strength of concrete mix is favourable in the range of 0 to 0.50 percent dose of molasses. But the most favourable dose is 0.25 percent by weight of cement.
- The flexural strength of concrete mix with molasses has the favourable result in the range of 0 to 0.50 percent dose of molasses and the most favourable dose is again 0:25 percent by weight of cement.
- The compressive strength, split tensile strength and flexural strength of the rich mixes have lesser effect of the molasses as compared to the poor mixes. At 0.25 percent dose, strength increase 10 to 30 percent at 91 days depending on type of mixes.
- The compressive strength of mortar and the compressive strength, split tensile strength and flexural strength of the concrete mixes are maximum at 0.25 percent dose by weight of cement Hence in general the most favourable dose of molasses is 0.25 percent dose, but it can be used safely in the range of 0 to 0.50 percent by weight of cement.

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