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Effect of Sugar Waste on Cement Concrete

Shiv Kumar[1], Manu Chaudhary[2], Anil[3], Kapil Bhutani[4], Arun Bhardwaj[5]
[1, 2, 3]Student, [4]HOD, [5]Assistant Professor, Department of Civil Engineering, NNSS' Samalkha Group of Institutions, Samalkha – Kurukshetra University, Kurukshetra, Haryana, India.

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 upto 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.

Keywords: Air-entraining admixture, organic materials, microscopic bubbles, cohesion, durability, cavities

I. INTRODUCTION

Molasses also acts as air-entraining admixture. The air-entraining admixtures are organic materials normally in soluble form (as molasses), which when added to the gauging water of a concrete mix, entrain a controlled quantity of air in the form of uniformly dispensed microscopic bubbles. This type of air should not be confused with entrapped air, which is often present in concrete in the form of irregularly shaped cavities and which can be due to inadequate compaction or flaky aggregates.

There are three main reasons for the intensionally entrapped air into concrete.

A. Durability

These admixtures are used to improve the durability of concrete exposed to a combination of injurious salts and cycles of freezing and thawing and to improve the resistance of concrete to surface scaling due to ice removal. In the fresh state, these admixtures improve the workability of concrete also.

B. Cohesion

Concrete which is produced using fine aggregates deficient at the fine end of the grading, e.g. sea dredged aggregates, exhibit a tendency to bleed and segregate. The presence of a small amount of entrained air (2 to 4 percent by volume) leads to an improvement in cohesion, or mix stability. Alternatively, with mixes which are adequate in this respect, a reduction in sand content can be made when air is entrained without loss of cohesion. The amount that can be removed is approximately equal on a volume basis and leads to a reduction in water/cement ratio to minimise the effect of entrained air on compressive strength.

C. Density

Durability and cohesion are normally associated with minor quantities (less than 8 percent by volume) of entrained air. But using different chemical types of materials, much larger quantities (upto 30 percent by volume) can be entrained to lower the density, enhance the thermal insulation properties or to produce light weight concrete in conjunction with light weight aggregates.

Due to air entrainment, there are a number of side effects which need to be considered.

1) The presence of microscopic air bubbles acts as a 'lubricant' and increases the workability and this allows reduction in water/cement ratio.
2) The compressive and tensile strength decreases with increasing air content when the mix design is unchanged.
3) The yield of the concrete is increased for a given weight of mix ingredients.

The air-entraining water-reducing admixtures

These agents possess the ability to entrain microscopic air bubbles into the cement paste, while allowing a reduction in the water-cement ratio greater than that which • would be obtained by the air entrainment itself.

They are available in the normal and retarding form and also fall into two types depending on the level of air entrainments. The first type entrains only about 1 to 2 percent of additional air and is normally used to increase the internal surface of the concrete to redress any deficiencies in fine aggregate grading. The second type results in concrete containing 3 to 6 percent of air and is used to enhance the durability of the concrete to freeze-thaw condition.

There are so many Sugar Industries in India. The effect of waste coming out from the sugar industries on the concrete can be studied at different levels.

II. CONTENT

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 cemen.t-concrete. The Molasses were taken from ISGEC (Indian Sugar and General Engg. Corporation) Paniapt, whose main constituents are listed in Table 1 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 :

1) The standard consistency, initial setting time andfinal 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.
2) 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.
3) The air-content of freshly mixed concrete by pressure method were determined at different dosages of Molasses.
4) 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.
5) Split tensile strength and flexural strength of concrete at varying dosages of molasses were determined, while the mix and workability were kept same.

III. MATERIALS

A. Molasses

The molasses were collected from ISGEC (Indian Sugar and General Engg. Corporation)Haryana. This type of molasses can be obtained for commercial purposes. Its commercial designation and main constituents are listed in Table 1. The molasses samples were mixed homogeneously mixed in specified quantity of water and that water was used for the work.

Table1 Physical Properties and Main Sugar Constituents of Molaasses

Physical properties of molasses		
a.	Colour	Dark Brown
b.	State	Liquid
c.	Brix	80^0
d.	Specific Gravity	1.333
Main sugar Constituents		
a.	Reducing Sugar(Glucose)	19 %
b.	Sugar content(Surcose)	24 – 26 %
c.	Total sugar content	43 – 45 %

B. 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. The properties of cement are shown in Table 2. Same type of cement was used throughout the work. The cement was stored properly and used within 6 months.

Table – 2 Physical properties of cement

Sr. No.	Characterstics	Test Result	IS : 269-1976 Requirements
1	Colour of cement	Deep grey	-
2	Standard consistency	27 %	-
3	Specific gravity	3.043	3.14 – 3.15
4	Setting time in minutes		
	Initial setting time	105 min.	30 min
	Final setting time	215 min.	600 min
5	Compressive strength (Mpa) on 1:3 cement . Standard – sand mortar		
	3 – day	20.6 Mpa	16 Mpa
	7 –day	3.1 Mpa	22 Mpa
6	Soundness – By Lechateliers method	2 mm	10 mm
7	Fineness (By sieve analysis residue on IS : Sieve No. 9)	6.5 %	10 %

C. 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). The properties of the sand are oven in the Table 3.

1) Sieve Analysis of Fine Aggregates

Weight of Sample = 1000 gms.

Table - 3 Sieve Analysis and Physical Properties of Fine Aggregate

IS Sieve Designation	Result			
	Weight Retained(gm)	Percentage weight retained	Commulative percentage retained	Commulative percentage passing
IS: 480 (4.75mm)	0	0	0	100
IS:240 (2.36mm)	49	4.9	4.9	95.1
IS:120(1.18mm)	115	11.5	16.4	83.6
IS:60(600 micron)	215	21.5	37.9	62.1
IS:30(300 micron)	308	30.8	68.7	31.3
IS:15(150 micron)	221	22.1	90.8	9.2
Pan	92	9.2	-	-
Total 1000	218.7			

2) Fineness Modulus = 218.7/100 = 2.19

3) Specific gravity = 2.69

D. Coarse Aggregate

Locally available crushed coarse aggregates were used in the mix. The sieve analysis of coarse aggregate has presented in Table 4. The Fineness Modulus of Coarse Aggregate was found as 6.99 and its specific gravity as 2.65.
Sieve Analysis of Coarse Aggregate
Weight of Sample = 10000 gms

Table - 4 Sieve Analysis and Physical Properties of Coarse Aggregate

IS Sieve Designation	Result			
	Weight Retained(gm)	Percentage weight retained	Commulative percentage retained	Commulative percentage passing
40 mm	0	0	-	100.00
20 mm	1098	10.98	10.98	89.02
10 mm	7872	78.72	89.70	10.30
4.75mm(IS: 480)	0868	08.68	98.38	1.62
2.36mm (IS:240)		1.06	99.44	0.56
1.18mm (IS:120)	56	0.56	100	0.0
600 micron (IS:60)	-	-	100.00	0.0
300 micron (IS:30)	-	-	100.00	0.0
150 micron(IS:15)	-	-	100.00	0.0
Total 10000			698.50	

1) Fineness modulus = 698.50/100 =6.99
2) Specific gravity = 2.65

E. Water

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

1) *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.

Figure 1 Testing for Standard Consistency and Setting time of Cement

2) Testing for Mortar

Mixing Mortar

The mixing of mortar was done according to the clause 9 of "IS:4031-1968, Indian standard Methods of Physical Tests for Hydraulic Cement"

Cube Moulds

The 50 mm size cube moulds were used according to the specifications in clause 9.3.2(3) for the testing.

3) *Preparation of Mortar:* Maintaining the room temperature as per laboratory conditions, the mix was prepared. The proportions of cement and sand was taken 1:3, 1:4 and 1:5 by weight for different mixes of mortar. The amount of water was adjusted to get the flow of 110 + 5 percent (3). The flow value was determined according to the clause 9.5.3.

Figure 2 Mixing of cement sand mortar

IV. MOULDING, CURING AND TESTING

Moulding, storage, curing and testing of specimens were done according to the clauses 9.6, 9.7 and 9.8(3) respectively. Similar tests were repeated for the dosages of 0.10, 0.25 and 0.50 (Percent by weight of cement) of Molasses.

A. 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.

Figure 3 Compressive strength test on concrete

B. Testing for Air Content of Freshly Mixed Concrete

M5 concrete mix was prepared. The air content of freshly mixed concrete at different dosages of 0, 0.10, 0.25 and 0.50 (Percent by weight of cement) of molasses were determine according to clause 8 of Is:1199-1952(7).

Figure 4 Flow table test for mortar

C. 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. The cylinder of size 150 mm diameter and 300 mm height were prepared. Storage, curing and testing were done as per Indian Standard specification IS: 5816-1970(13) for Split strength of concrete.

Split tensile strength = $2p/\pi$ dl

where P = load

d= diameter

l = length

D. Testing for Flexural Strength of Concrete

Same type of mix of concrete at different dosages 0, 0.10, 0.25 am 0.50 (Percent by weight of cement) of molasses were used, maintaining the constant compaction factor 0.80, 0.05 as per IS specification (5).

The beam of size 100 mm x 100 mm x 500 mm were prepared. Storage, curing and testing were done as per Indian standard specification for flexural strength of concrete.

Figure 5 Flexural strength test on Beam Specimen

For calculation of flexural strength

Maximum B.M. = M =PI/6

Section Modulus = Z = $Bd^2/6$

Flexural Strength = f_b = M/Z

$$= \frac{pl/6}{Bd^2/6}$$

$$= pl/bd^2$$

Where L = specimen span

B = width of beam

D = depth of beam

V. 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.

A. The molasses contains about 20 to 25 percent sugar.
B. Molasses acts as accelerating agent at lower dosage level 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 upto 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.
C. 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.
D. 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.
E. 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.
F. 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.
G. 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.
H. 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.
I. For concrete mixes the compressive strength at early age is not favourable but at later age it is favourable.
J. The 7-day compressive strength is almost same upto dose 0010 percent and decreases with an increase in the dosage level. The 28-day compressive strength is favourable.
K. Upto 0.25 dose and then decreases. The 56-day and 91-day compressive strength is favourableupto 0.50 percent dose and most favourable dose for all mixes is 0.25 percent dose by weight of cement.
L. 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.
M. 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.
N. 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.
O. 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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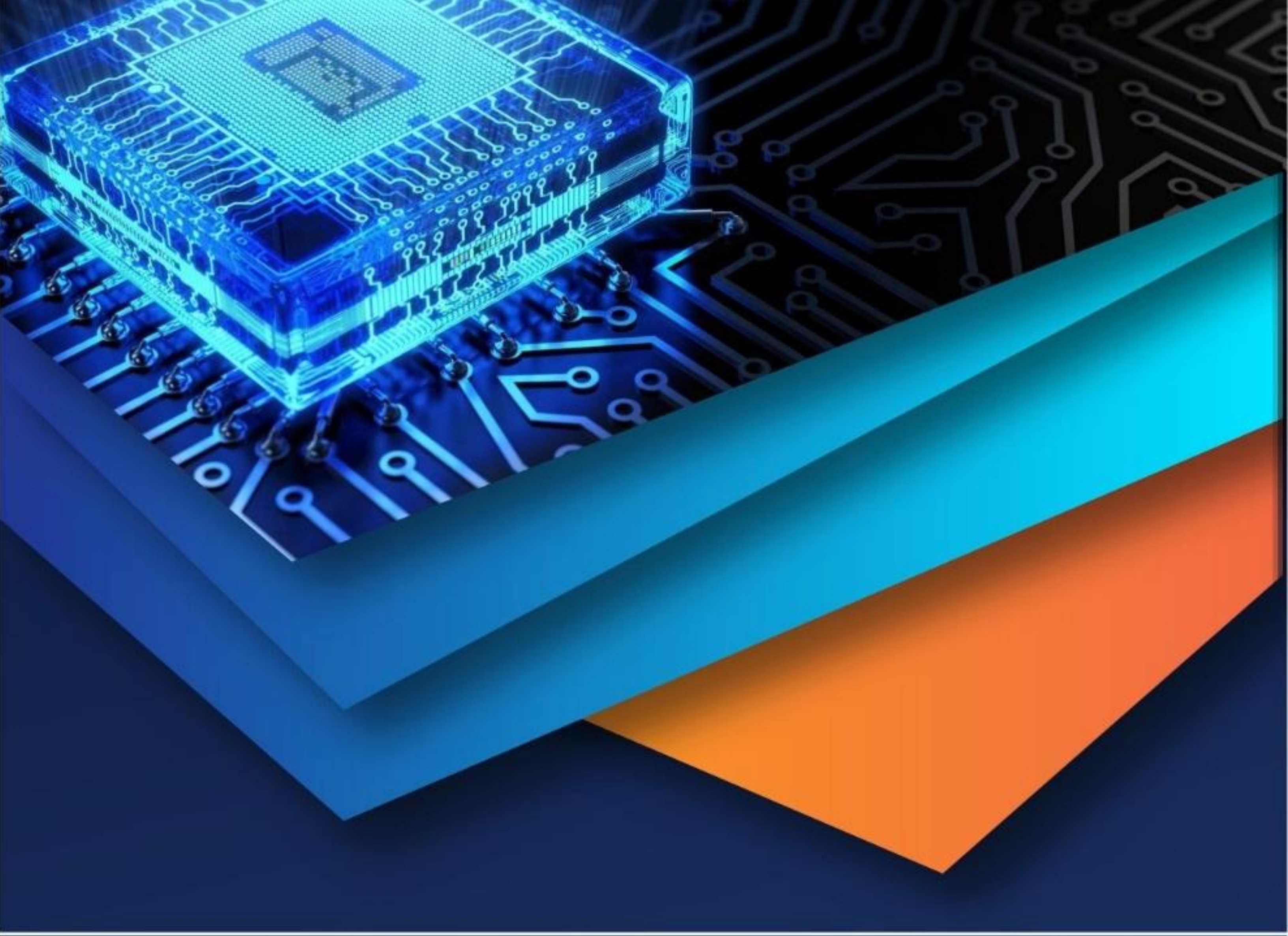

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