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# Effect of sugar on Strength and Durability Characteristics of HVFAC Pavements

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***Abstract*** **- Concrete is the most important material in the construction industry. Since it is available widely and of its low cost, it can also be used in the construction of rigid pavement. The effect of sugar at concentrations of 1%, 0.8%, 0.6%, 0.4%, 0.1%, 0.05%, 0.02% by weight of cement was considered and the optimum dosage of 0.02% by weight of cement was adopted for the design based on the setting time of cement. In this study, M40 concrete mix design was considered and two mixes, one with SP 430 as an admixture and the other with sugar solution were casted and the same is repeated for a mix design containing 40% of fly ash. The effect of these admixtures on workability, strength and durability was observed. 7 day, 14 days and 28 days of strength parameters were note down. It was concluded that concrete mix with sugar solution as an admixture showed enhanced strength compared to other mix which is of SP 430 as an admixture. The durability of concrete was also checked by immersing the cubes in acid solution (HCl). Concrete with sugar as additive showed less percentage of weight loss and less loss in strength.**

***Key Words:*** ***OPC- Ordinary Portland Cement, setting time, Durability, Compressive Strength***

## 1. INTRODUCTION

Concrete is heterogenous mixture mainly composed of cement, sand, aggregate and water. In addition to this, concrete can also contain various admixtures that are added in the form of powder or solutions to enhance various properties of concrete. Common admixtures are accelerators, retarders, plasticizers, superplasticizers, air entraining agents etc., and some mineral admixture are fly ash, ground granulated blast furnace slag (GGBS), silica fumes, carbon nanofibers etc.,

### *1.1 Fly Ash*

Use of fly ash will benefit in both fresh and hardened states of concrete. The workability of concrete is improved in fresh state due to the spherical particle form property of fly ash. And because of this spherical shape, the workability of concrete is also improved. This improved workability allows for lower water cement ratios. And in hardened state, the various properties of concrete like strength and durability were increased.

### *1.2 Sugar as admixture*

While on the other hand sugar can be used as both retarder and accelerator depending on the dosages of sugar. Researches showed that sugar of less dosage in the range 0.0%1 to 0.05% by weight of cement acts as retarder and 0.4% to 2% of sugar by weight of cement acts as accelerator. After all it was concluded that use of sugar as admixture can enhance various properties of concrete both in fresh state as well as hardened state.

## 2. LITERATURE REVIEW

Kalyan et al. (2018) analyzed the use of fly ash for the construction of rigid pavements and the properties of the same concrete were studied. M40 mix design with water-cement ratio of 0.4 was adopted. Concrete cubes of 0%, 20%, 30%, 40%, 50% and 60% fly ash by replacement of cement were casted. The compressive strength of cubes with 0% fly ash showed 56.55N/mm2 for 28 days whereas for 30% fly ash it was found to be 72.40N/mm2. Hence, they concluded that 30% fly ash replacement by weight of cement was recommended.

Aggarwal et al. (2010) tested the durability of high-volume fly ash concrete and compared it with the high-performance concrete and high strength concrete. They observed that fly ash reduces its compressive strength at early ages and drastic increase of its strength in the later stages. The authors also concluded that concrete with less than 40% replacement of cement with fly ash showed greater strength compared to 40% replacement of cement but gained better strength at 90 days.

Chand & Dhyani (2015) evaluated the effect of sugar on the compressive strength of concrete. OPC (ACC cement) of 43 grades is used for the cube casting. The cubes having sugar dosages of 0%, 0.06%, 0.08% by weight of cement were casted and the compressive strength of cubes for 7 days, 21 days and 28 days were tested by the authors. They observed that setting time of concrete increased with the increase in dosage of sugar and also the workability of concrete increased. They also reported that there was the increase in the compressive strength of about 16.02% at 28 days compared to ordinary cube.

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## 3. METHODS AND METHODOLOGY

*3.1 Materials used:*

Cement: Ordinary Portland cement of 53Grade was used with specific gravity of 3.1.

Fine Aggregate: M sand of specific gravity 2.6 and conforming to IS-383 Zone 2 was used.

Coarse Aggregate: Locally available 20mm down and 12mm down aggregates were used

Water: Portable drinking water used.

Fly ash: Class F fly ash from Raichur thermal power plant

Sugar: Sugar crystals available in the market was used it was dissolved in the water to make it as solution.

*3.2 Methodology:*

53 grade OPC cement sample was taken to perform the test. Sugar used to perform the experiment was sugar crystals; it was dissolved in required amount of water. In order to determine the Consistency and setting time of cement paste vicat apparatus, conforming to IS: 5513-1976, was used. M40 grade of concrete is considered for the mix design. Four mixes M1, M2, M3 and M4 were prepared. M1 refers to OPC, M2= OPC+Sugar, M3= HVFAC, M4=HVFAC+Sugar. M1, M3 concrete with SP430 admixture and M2, M4 concrete with sugar solution as admixture were casted. The water-cement ratio of 0.4 for M1, M2 and 0.364 for M3, M4 was adopted. SP-430 of 0.5% by weight of cement for M1 concrete and 0.02% of sugar solution for M2 concrete were used. 40% of HVFA is considered. The mix proportions were arrived at 1: 1.8:3.2 for M1, 1:1.77:3.2 for M2, 1:0.66:2.53:4.66 for M3 and 1:0.66:2.55:4.71 for M4. The 7 days, 14 days and 28 days strength parameters were noted.

*3.21 Compressive strength*

Concrete cubes of standard size 100*100*100mm for M1 and M2 induced M40 Grade concrete cubes were casted. The Compressive strength of the concrete cubes at 7 days, 14 days and 28 days were determined, as shown in Table 2.

Figure 1: Compressive strength testing

*3.22 Flexural strength*

Beam specimens of size 100*100*500mm for M1,M2, M3 and M4 were casted and the results were shown in Table 3.


Figure 2: Flexural testing

*3.23 Split tensile strength*

Cylinders of size 100mm diameter and 200mm height were casted. Split tensile strength at 7 days, 14 days and 28 days were determined, as shown in Table 4.

**3.3 Durability**

Acid Attack

Durability of concrete is conducted immersing concrete specimens that contain acid solution of 2% of hydrochloric acid solution to the 98% of water for 28 days. Test was conducted for both M1 and M2 mixes.

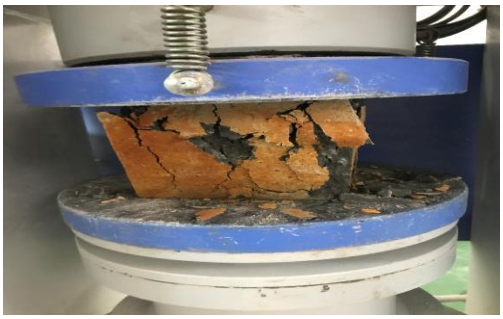

Figure 3: Compressive strength test after acid attack

## 4. RESULTS

Table 1: Initial and final setting time

| Sl. No | % of Sugar | Initial Setting Time in minutes | Final setting time in minutes |
|---|---|---|---|
| 1 | 1 % | 179 | 550 |
| 2 | 0.8 % | 174 | 488 |
| 3 | 0.6 % | 112 | 349 |
| 4 | 0.2 % | 97 | 410 |
| 5 | 0.05 % | 84 | 497 |
| 6 | 0.02 % | 55 | 316 |

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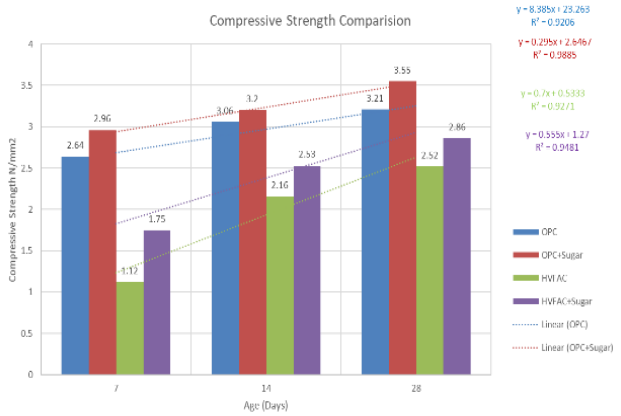
Table 2: Compressive strength of concrete

| Type of mix | 7 days | 14 days | 28 days |
|---|---|---|---|
| **M1** | 33.07 | 37.19 | 51.24 |
| **M2** | 33.3 | 39.7 | 54.81 |
| **M3** | 27.71 | 33.18 | 42.16 |
| **M4** | 28.69 | 36.45 | 47.79 |




Graph 1: Compressive strength comparison

Table 3: Flexural strength of concrete

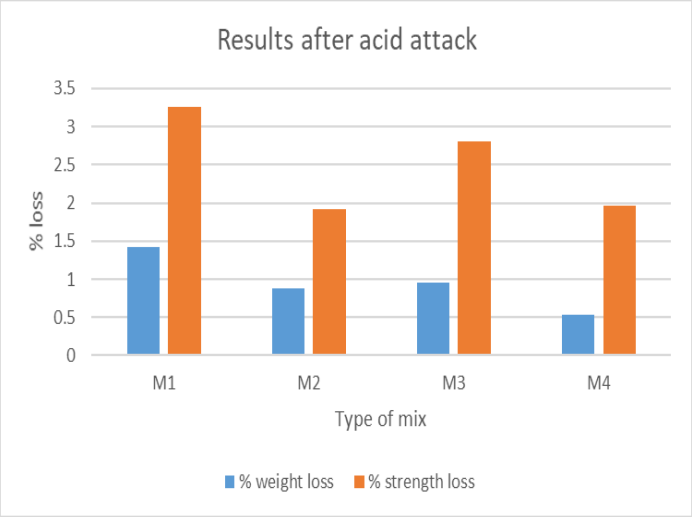
| Type of mix | 7 days | 14 days | 28 days |
|---|---|---|---|
| **M1** | 2.9 | 4.8 | 5.2 |
| **M2** | 3.2 | 5.3 | 57 |
| **M3** | 2.6 | 3.92 | 4.8 |
| **M4** | 3.03 | 4.4 | 5.3 |

Table 4: Split Tensile strength

| Type of mix | 7 days | 14 days | 28 days |
|---|---|---|---|
| **M1** | 2.64 | 3.06 | 3.21 |
| **M2** | 2.96 | 3.20 | 3.55 |
| **M3** | 1.12 | 2.16 | 2.52 |
| **M4** | 1.75 | 2.53 | 2.86 |

Table 5: Results after acid attack

| Type of mix | % Weight loss | % Strength loss |
|---|---|---|
| **M1** | 1.42 | 3.26 |
| **M2** | 0.88 | 1.92 |
| **M3** | 0.95 | 2.8 |
| **M4** | 0.54 | 197 |




Graph 2: Loss in weight and strength

## 5. VALIDATION USING SOFTWARE

ANSYS Mechanical APDL is used for the analysis of beams

Based on the data of Young`s Modulus, Poison`s Ratio and Density of concrete for M1, M2, M3 and M4, stress analysis was carried out for beam.

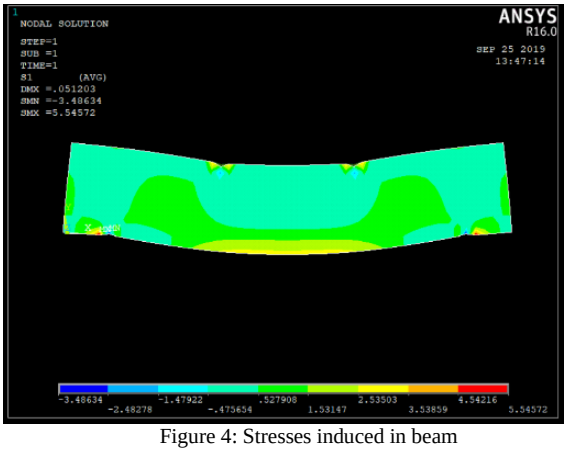



Figure 4: Stresses induced in beam

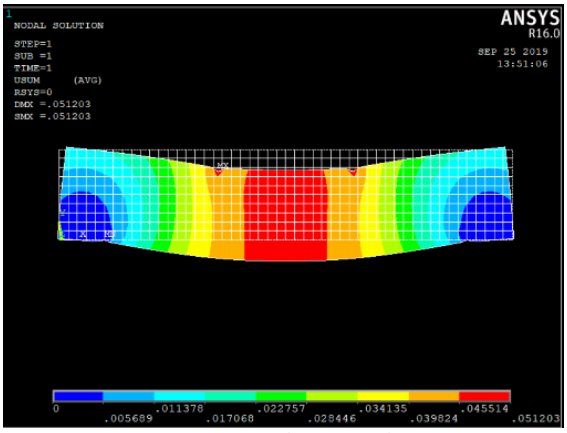



Figure 5: Deformation of beam

Table 6: Validation of stress results

| Type of mix | Experimental results | ANSYS results |
|---|---|---|
| **M1** | 5.2 | 5.54 |
| **M2** | 5.7 | 5.98 |
| **M3** | 4.8 | 5.12 |
| **M4** | 5.3 | 5.64 |

## 6. CONCLUSION

- It is observed from studies that addition of Sugar increases workability of concrete in compaction factor test.
- 0.02% of sugar solution is optimum dosage which increases the compressive strength of concrete.
- Addition of Sugar increases 6.8%, 9.4%, and 11.88% in compressive strength, Flexural and split tensile strength of HVFA concrete with sugar when compare to HVFA concrete without sugar
- Addition of Sugar increases the density of concrete, so Sugar induced concrete can be less permeable concrete.
- Concrete with Sugar as additive showed more resistance to acid attack.

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