# PARAMETRIC STUDY ON DURABILITY OF BAGASSE ASH BLENDED CONCRETE

**Sandeep Kumar D. S[1], Abhishek M[2]**

[1]Assistant professor, Dept, of civil Engineering, PES college of Engineering, Mandya, Karnataka, India
[2]PG Student of PES College, Mandya, Karnataka, India

---***---

**Abstract –** The present study is aimed at utilizing sugarcane bagasse ash concrete, with partial replacement of cement in concrete and its strength and durability performance was checked. The concrete mix is designed for M 30 grade as per IS 10262:2009. The replacement is done at various percentages like 0%, 5%, 10%, 15% and 20% by weight and the concrete mix demands more amount of chemical admixture as the percentage replacement increases in order to attain the desired slump. At room temperature the compressive strength decreases with increase in percentage replacement and was found that at 10% replacement the desired strength of 30MPa is achieved.
Durability tests includes sulphuric acid resistance test, sulphate resistance test, Bulk diffusion test and water absorption test. Specimens are subjected to the particular chemical condition for a period of 90 days. From the result obtained from the above tests it showed that 10% replacement of Bagasse ash in concrete shows better result. Finally from the result it can said that sugarcane bagasse ash is a good pozzolonic material and it can be effectively used as a partial replacement of cement in concrete. Up to 10% SCBA in concrete can be considered as the optimum replacement.

***Key Words*: Sugarcane Bagasse Ash(SCBA), Blended concrete, Compressive strength, Durability.**

## 1. INTRODUCTION

Ordinary Portland cement is a controlled blend of calcium silicates, aluminates and ferrate, which is ground to a fine powder with gypsum and other materials. Ordinary Portland cement is the conventional building material that actually is responsible for about 5% - 8% of global CO2 emissions. This is the environmental problem will most likely be increased due to exponential demand of ordinary Portland cement.

Concrete is most widely used and very necessary material which is used in all types of construction works. Concrete consists of cement, aggregates, water and admixtures. Concrete uses is over 10 billion tons per year, concrete can present good mechanical strength, and also acceptable durability performance. Out of concern for the environment, and in support of sustainable development, cement industries are improving their production through a range of alternatives such as the use of alternative fuels or increasing the production of blended cements. All these aspects have been contributing to reduce CO2 emissions, which can reach up to 30% of diminishing according to the Danish Centre for Green Concrete.

Researchers all over the world are focusing on ways of utilizing industrial or agricultural waste, as a source of raw materials for industry. Industrial wastes, such as blast furnace slag, fly ash and silica fumes are being used as supplementary cement replacement materials. Sugarcane cane is one of the major crops grown in over 110 countries and its total production is over 1500 million tons. In India only, sugarcane production is over 300 million tons/year that cause about 10 million tons of sugarcane bagasse ash as an un-utilized and waste material. After the extraction of all economical sugar from sugarcane of about 40-45% fibrous residue is obtained, which is reused in the same industry as fuel in boilers for heat generation leaving behind 8-10% ash as waste material, known as sugarcane bagasse ash (SCBA). Sugarcane bagasse ash contains high amounts of unburnt matter, silicon, aluminum and calcium oxides. The ash, therefore becomes an industrial waste and possess disposal problems. A few studies have been carried out in the past on the utilization of bagasse ash obtained directly from the industries to study the pozzolonic activity and their suitability as binders by partially replacing cement. The experimental study examines the workability properties of fresh concrete such as slump and compaction factor and also compressive strength and split tensile strength with 5%, 10%, 15% and 20% replacement of cement with bagasse ash by volume.

The durability of the concrete is also an important information to prolong the service life of concrete as it is usually exposed to ground or water with some acidity or alkalinity conditions. This acid or alkali environment will shorten the concrete service life. The present study deals with the strength and durability of blended concrete with sugarcane bagasse ash(SCBA).

## 2. OBJECTIVES

The main objectives of this study,

i. The present study aims at mix design of M30 grade of concrete and to find the required constitutes of it.

ii. To study the effect of replacement of cement in concrete by pozzolonic material that is bagasse ash.

iii. To ascertain the effect of Bagasse Ash as alternative cementitious material with variable percentages by weight of cement in fresh properties of bagasse ash based on concrete to be compared with controlled concrete.

iv. To ascertain the effect of Bagasse Ash as alternative cementitious material with variable percentages by weight of cement in hardened properties like compressive strength and tensile strength of bagasse ash based on concrete to be compared with controlled concrete.

v. Various Durability tests are carried out in order to know the performance of bagasse ash blended concrete subjected to various exposure conditions..

## 3. MATERIALS AND METHODS

### 3.1 Cement

The Ordinary Portland cement is tested according to IS specification (IS:12269-2013) to determine its various properties. The grade of cement is 53 grade. The physical properties of cement are given below,

**Table-1:** Physical properties of Cement

| Sl.No | Tests | Values obtained | Requirement as per IS 269:2015 | IS Code |
|---|---|---|---|---|
| 1 | Specific Gravity | 3.09 | 3 to 4 | IS 4031 |
| 2 | Normal Consistency | 32% | | IS 4031 (Part 4):1988 |
| 3 | Setting Time Initial Setting Time Final Setting Time | 227mins<br>335mins | >30mins<br>< 600mins | IS 4031 (Part 5);1988 |
| 4 | Fineness | 5% | | IS 4031 |

### 3.2 Fine Aggregate

M sand is the alternative for the river sand produced by crushing the hard granite stones. The size of the manufactured sand is less than 4.75mm. The physical properties of fine aggregate are given below,

**Table-2:** Physical properties of Fine Aggregate

| Sl.No | Tests | Results | Requirementsas per IS 383:2016 | IS Code |
|---|---|---|---|---|
| 1 | Specific Gravity | 2.65 | 2.3 to 3 | IS:2386 (Part 3) |
| 2 | Fineness modulus | 2.34 | 2.2 to 3.2 | IS:2386 (Part 1) |
| 3 | Water absorption | 3% | | |
| 4 | Passing 75 micron | 1.5% | <15% | |

### 3.3 Coarse Aggregate

Locally available crushed granular aggregates of size less than 20 mm was used throughout the study and it was tested as per IS 383:2016. The physical properties of coarse aggregate are given below,

**Table-3** Physical properties of Coarse Aggregate

| Sl.No | Tests | Results | Requirements as per IS 383:2016 | Is Code |
|---|---|---|---|---|
| 1 | Specific gravity | 2.7 | 2.5 to 3 | IS 2386(Part 3)-1963 |
| 2 | Water Absorption | 0.50% | 0.6% | IS 2386(Part 3)-1963 |
| 3 | Fineness modulus | 7.06 | 5 to 8 | IS 2386(Part 1)-1963 |
| 4 | Angularity Number | 8.1 | 0 to 11 | IS 2386(Part 1)-1963 |

### 3.4 Water

Potable water available in the college campus has been used in the concrete mix design. PH value of the water used for concrete as per IS 456-2000 less than 7.

### 3.5 Sugar Cane Bagasse Ash

Source: NSL Sugars Ltd, Koppa.

Bagasse ash is an industrial waste or farming waste. It is a consequence which is obtained in sugarcane milling industries. Productivity of bagasse ash contains silica, aluminum, iron and calcium oxide. The bagasse ash used in the current study is obtained by burning the bagasse ash at a temperature of about 750-8500C for the purpose of generation of electricity in the factory. The ash so obtained from the discharge is sieved to obtain particles which are finer than 90µm in order to remove the unburnt particles present in the raw bagasse ash. The physical and chemical properties of the bagasse ash is obtained are given below.

**Table-4:** Physical Properties of Bagasse Ash

| Sl.No | Properties | Results |
|---|---|---|
| 1 | Specific Gravity | 2.17 |
| 2 | Color | Black |
| 3 | Bulk Density<br>Loose<br>Compacted | <br>520<br>648 |

**Table-5**: Chemical Properties of Bagasse Ash

| Sl.No | Properties | Percentage |
|---|---|---|
| 1 | Silica as $SiO_3$ | 76.32 |
| 2 | Aluminum as $Al_2O_3$ | 0.20 |
| 3 | Iron as $Fe_2O_3$ | 4.02 |
| 4 | Calcium as CaO | 3.68 |
| 5 | LOI | 6.67 |

### 3.5.1 X-Ray Diffraction Analysis

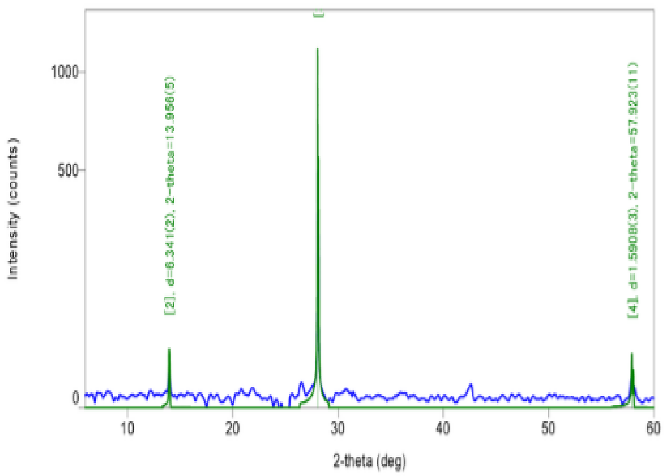


**Fig 1:** X – Ray Diffraction (XRD) Analysis of raw bagasse ash

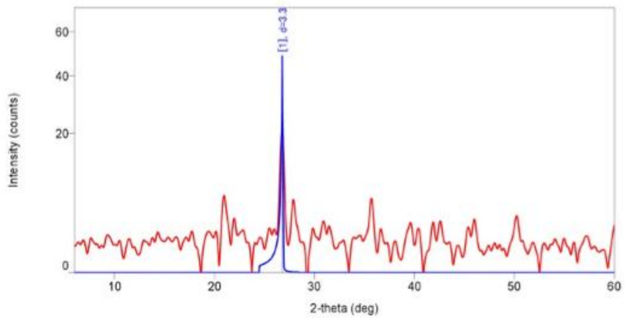


**Fig 2:** X – Ray Diffraction (XRD) Analysis of 90µm fine bagasse ash

The XRD pattern of raw bagasse ash and 90µm fine bagasse ash are shown in the fig 1 and fig 2 respectively. The XRD analysis was performed and the intensity was found for the angle of incidence 2 – theta varying from 0 to $60^0$. It is found that the peak intensity is obtained at an angle of incidence $26.7811^0$. in general, when the peaks are obtained between $15\text{-}40^0$, it indicates the presence of silica in form of quartz.

### 3.5.2 Scanning Electron Microscopic Analysis (SEM)

The SEM analysis is conducted in order to know the morphology of the bagasse ash sample.

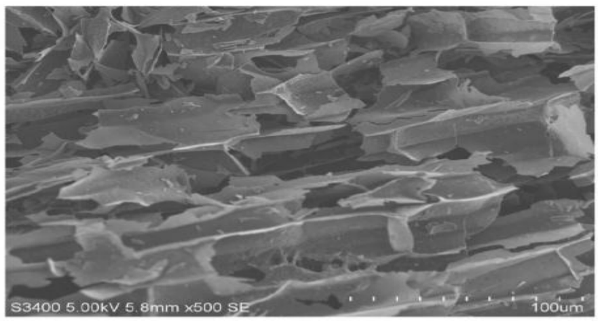


**Fig 3:** SEM analysis of raw bagasse ash at 100µm magnification

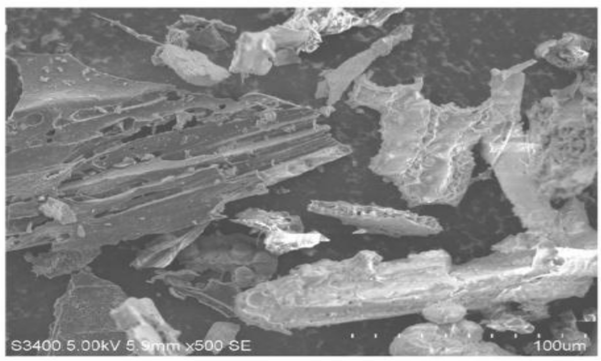


**Fig 4:** SEM analysis of 90µm fine bagasse ash at 100µm magnification

The microstructure of raw bagasse ash and 90 µm fine bagasse ash are as shown in fig 3 and 4 respectively. From the SEM analysis of SCBA sample it was found that they were composed of grains with different sizes and shapes. They contain prismatic particles consisting mainly of silica and oxides and spherical particles consisting of silica and oxides as well as some other minor compounds. Fiber particles contain only carbon at higher magnification small pores were observed on surface of the particles.

## 4. RESULTS AND DISCUSSIONS

### 4.1 Tests on Fresh Concrete

#### 4.1.1 Slump Test

Workability of the concrete is spotted by the slump test. The slump test values are obtained for each mixes are given in the table 6. Control mix value of slump is 100mm for designed M30 grade.

**Table-6:** Slump for various mix constituents

| Percentage Replacement | Slump(mm) | Chemical Admixture |
|---|---|---|
| 0% | 135 | 1% |
| 5% | 126 | 1% |
| 10% | 120 | 1% |
| 15% | 125 | 1.2% |
| 20% | 120 | 1.6% |

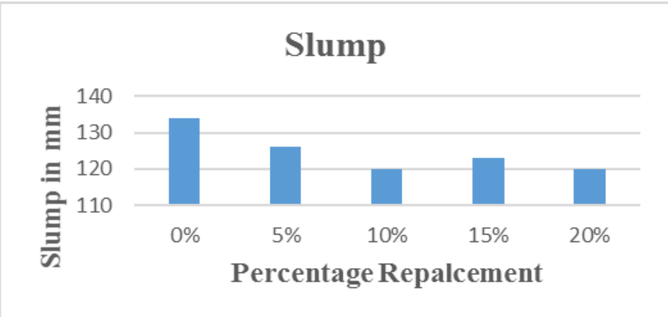


**Fig 5:** Variation of Slump with different percentage of SCBA

From the above graph indicates that the controlled concrete of M30 grade demands the chemical admixture of 1% to attain a slump of 100mm.Bagasse ash based concrete of M30 grade, as the bagasse ash is increased by 5%, 10%, 15% and 20% by the weight of cement demand of chemical admixture was also increased by 1%, 1%, 1.2% and 1.6% to attain a slump of 120-130 mm which is more than the desired slump of 100mm. Since the bagasse ash also have high loss on ignition (LOI) content which absorbs more water and demands more chemical admixture to attain desired slump value.

### 4.2 Tests on Hardened Concrete

#### 4.2.1 Compressive Strength

The compressive strength of bagasse ash blended concrete decreased with the replacement of 5%, 10%, 15% and 20% sugar cane bagasse ash by the weight of cement at 28 days of curing as shown in fig 6. At 28 days of curing, when compared with controlled mix, the compressive strengths of 5%, 10%, 15% and 20% bagasse ash blended concrete mixes were reduced by 9.28%,6.59%, 27.74% and 37.23%. The decrease in strength for the bagasse ash blended concrete mix prepared with bagasse ash was attributed to the pozzolonic effects of bagasse ash at later ages. In conclusion, the replacement of 10% bagasse ash by weight of cement is suitable for inducing the good compressive strength in bagasse ash blended concrete.

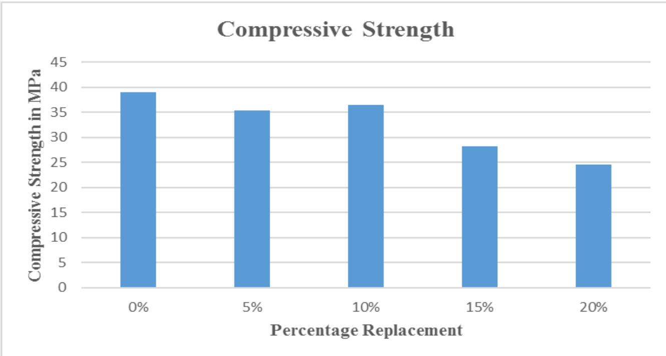


**Fig 6:** compressive strength at 28 days for different percentage replacements

#### 4.2.2 Split Tensile Strength

The tensile strength of bagasse ash blended concrete varied with replacements of 5%, 10%, 15% and 20% bagasse ash by the weight of cement at 28 days as shown in the fig 7. At 28 days of curing, when compared with the controlled mix, the tensile strength of 5%, 10%, 15% and 20% bagasse ash blended concrete mixes were reduced by 5.64%, 10.53%, 18.42% and 87%. The decrease in tensile strength for the bagasse ash blended concrete mix prepared with bagasse ash was also attributed to the pozzolonic effects of bagasse ash at later stages. In conclusion, the replacement of 10% bagasse ash by weight of cement is suitable for inducing the good tensile strength in bagasse ash blended concrete.

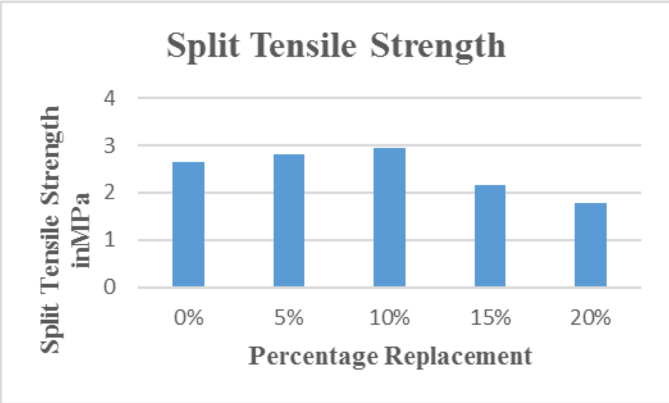


**Fig 7:** Split Tensile Strength for different percentage replacements

### 4.3 Sulphuric acid resistance test

. The specimen are cast and cured in mould for 24 hours, after 24 hours, all the specimen are demoulded and kept in curing tank for 28-days. After 28-days all specimens are kept in atmosphere for 2-days for constant weight, subsequently, the specimens are weighed and immersed in 3% sulphuric acid ($H_2SO_4$) solution for 90 days. The pH value of the acidic media was at 0.3. The pH value was periodically checked and maintained at 0.3. After 90 days of immersing in acid solution, the specimens are taken out and were washed in running water and kept in atmosphere for 2-day for constant weight. Subsequently the specimens are weighed and loss in weight and hence the percentage loss of weight and compressive strength loss was calculated. The rate of weight loss and strength loss was found to be minimum for 5% and 10 % replaced bagasse ash blended concrete for 90 days sulphuric acid exposure.

The fig 8 shows the variation of weight loss of different mixes immersed in sulphuric acid for 90 days

The fig 9 shows the variation of compressive strength loss of different mixes immersed in 90 days of water and 90 days of sulphuric acid

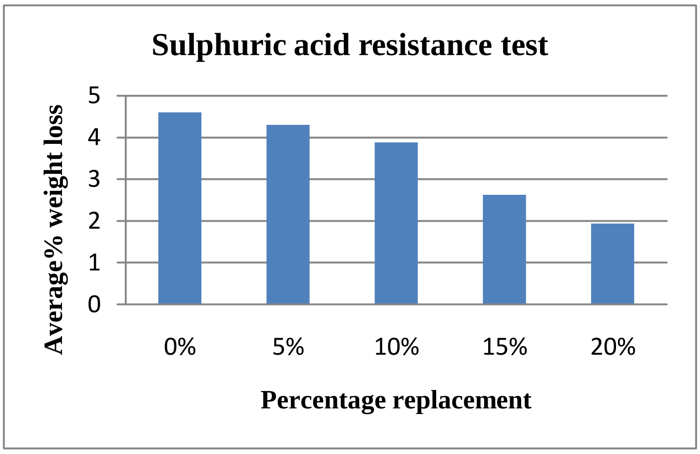


**Fig 8:** variation of weight loss of different mixes immersed in sulphuric acid for 90 days

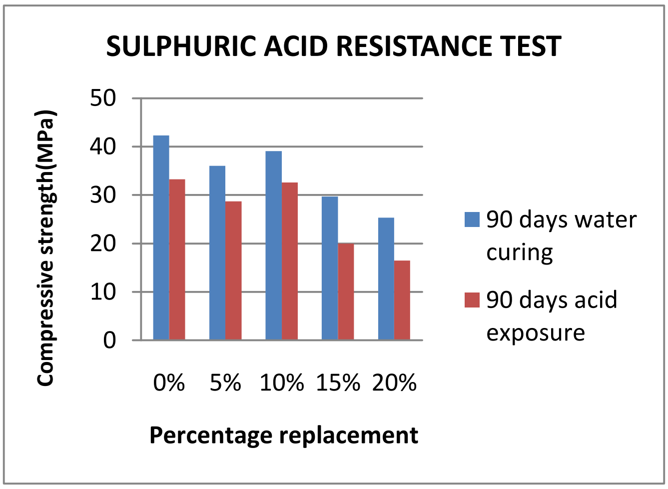


**Fig 9:** the variation of compressive strength loss of different mixes immersed in 90 days of water and 90 days of sulphuric acid

### 4.4 Sulpahate Resistance test

The specimen are cast and cured in mould for 24 hours, after 24 hours, all the specimen are demoulded and kept in curing tank for 28-days. After 28-days all specimens are kept in atmosphere for 2-days for constant weight, subsequently, the specimens are weighed and immersed in 3% sodium sulphate ($Na_2SO_4$) solution for 90 days. The pH value of the alkaline media was at 12.0. The pH value was periodically checked and maintained at 12.0. After 28 and 60- days of immersing in alkaline solution, the specimens are taken out and are washed in running water and kept in atmosphere for 2-day for constant weight. Subsequently, the specimens are weighed and loss in weight and compressive strength are checked and compared with the normal concrete The rate of weight loss and strength loss was found to be minimum for 5% and 10 % replaced bagasse ash blended concrete for 90 days sulphate exposure.

The fig 8 shows the variation of weight loss of different mixes immersed in sulphate solution for 90 days

The fig 9 shows the variation of compressive strength loss of different mixes immersed in 90 days of water and 90 days of sulphate solution

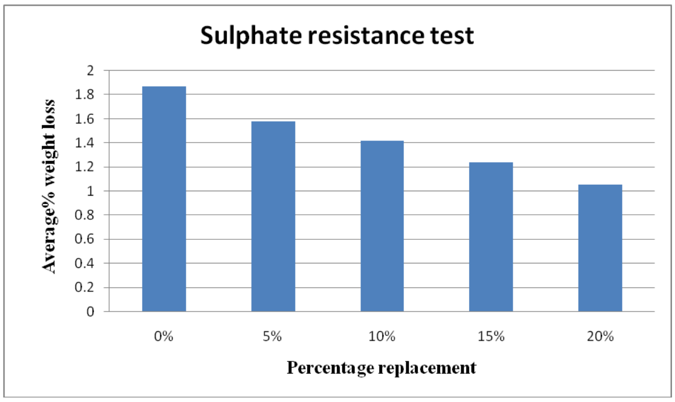


**Fig 10:** variation of weight loss of different mixes immersed in sulphuric acid for 90 days

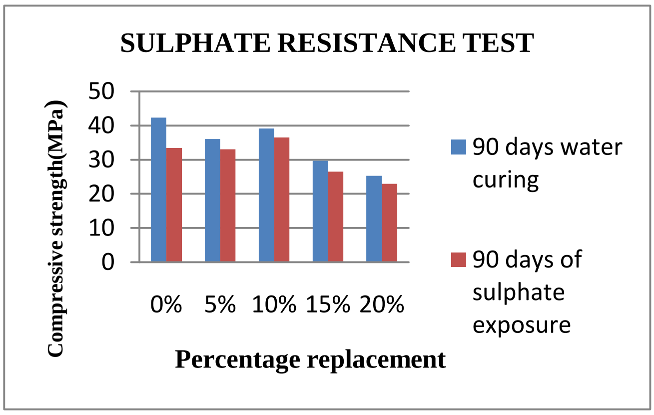


**Fig 11:** variation of weight loss of different mixes immersed in sulphuric acid for 90 days

### 4.5 Bulk Diffusion Test

The test proposes to assess the chloride attack on concrete specimen by measuring the depth of chloride penetration into the concrete specimen. In this test, cylinder of 150 mm diameter and 300 mm length was used as test specimen. After 28 days of water curing, the concrete specimens were exposed to 1.8 Molar NaCl solution for 90 days. After 90 days of exposure the specimens were split by applying splitting tensile force. To the split face, 0.1 Molar Silver Nitrate (AgNO3) solution was sprayed to observe the colour changes ie, up to the penetrated depth of chloride ion, a white precipitation will form and thus the depth of chloride ions can be found be found out.

From fig 12 it can be observed that The rate of depth of penetration of chloride ions was found to be minimum for 5% and 10 % replaced bagasse ash blended concrete for 90 days of chloride exposure

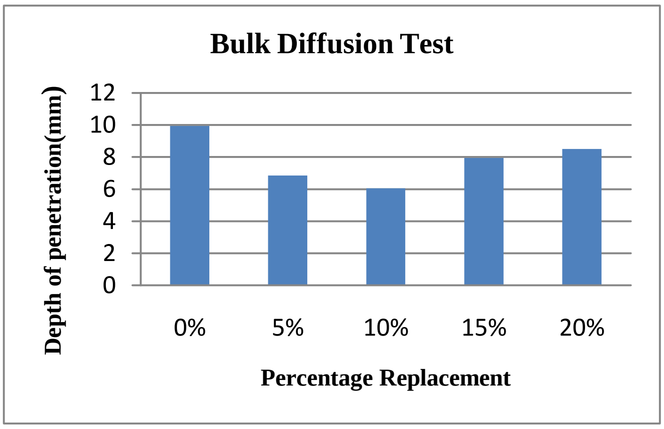


**Fig 12:** Variation of depth of penetration of chloride ions for various mixes

### 4.5 Water Absorption Test

Water absorption tests were carried out on bagasse ash-blended concrete cube specimens at the age of 28 days curing of bagasse ash-blended concrete is used to assess of the water absorption. The size of the specimen used for this test is 100mm cube. It represents, in saturated bagasse ash-blended concrete specimens, the amount of water which can be separated on drying. The formula used to calculate the water absortion.

$$\text{Water Absorption } (\%) = \frac{w_2 - w_1}{w_1} * 100$$

Where $W_1$ is mass of oven dry sample in air, $W_2$ is mass of surface dry sample in air after immersion

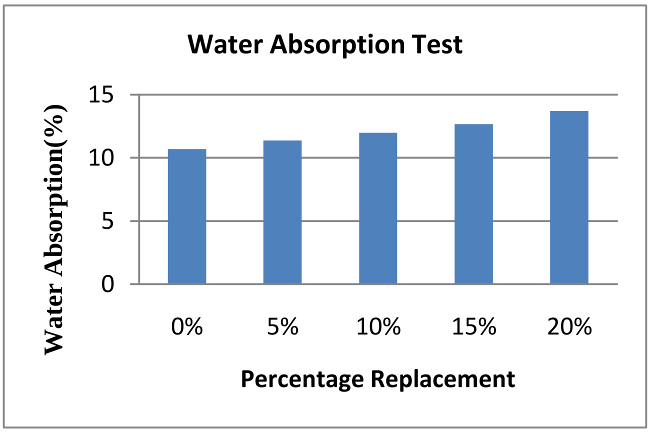


**Fig 13:** water absorption of concrete containing bagasse ash at 28 days.

The fig 13 shows the variation of water absorption of concrete containing bagasse ash. It can be observed that water absorption in normal mix is less when compared to bagasse ash blended concrete. Increase in water absorption in 5% and 10% is not much more than the normal mix.

## 5. CONCLUSIONS

The following conclusion shown below.

1. The utilization of bagasse ash in concrete and mortar solves the problem of its disposal thus keeping the environment free from pollution.
2. The increase in percentage of replacement of cement by SCBA resulted in higher standard consistency.
3. The increase in percentage of replacement of cement by SCBA resulted in delayed setting time.
4. The improvement in compressive strength of concrete by partially replacing cement by SCBA is due to filler effect and pozzolonic reaction between reactive SiO2 from SCBA and $Ca(OH)_2$ from cement hydration.
5. From the compressive strength results of cubes, it is found that on 10% of bagasse ash replacement with cement will yield better compressive strength as compared to controlled concrete.
6. From the split tensile strength results, it is found that on 10% of bagasse ash replacement with cement will yield better tensile strength as compared to controlled concrete.
7. From the total rate of percentage weight loss and compressive strength loss of the specimen subjected to acid exposure, 10% SCBA blended concrete shows less reduction in weight lost and compressive strength loss when compared to controlled concrete.
8. From the total rate of percentage weight loss and compressive strength loss of the specimen subjected to sulphate exposure, 10% SCBA blended concrete shows less reduction in weight lost and compressive strength loss when compared to controlled concrete.
9. The optimum replacement of cement by SCBA was found to be 10% taking into account the Bulk diffusion test as it showed the less depth of penetration of chloride as compared to the controlled concrete.
10. As the percentage of bagasse ash increases in concrete it resulted in increase of water absorption.
11. The study in turn is useful for various resource persons involved in using SCBA material to develop sustainable construction material.

## REFERENCES


1. Rattapon Soman, Chai jaturapitakkul, Amde M, "Effect of ground fly ash and ground bagasse ash on the durability of recycled aggregate concrete'", Construction and building materials, Elsevier Ltd 2012.
2. Vishnumaya L, Rekha ambi(2014), 'Strength and Durability of OPC – Fly ash Sugercane ash blended concrete', IJSER, volume 5, issue 7,July-2014 ISSN 2229-5518.
3. Aukkadet Rerkpiboon, Weerachart Tangchirapat, Chai Jaturapitakkul, "Strength, chloride resistance, and expansion of concretes containing ground bagasse ash", Elsevier Ltd 2015.
4. A. Bahurudeen, 'Performance Evaluation of Sugarcane Bagasse Ash Blended Cement in Concrete', of concretes containing ground bagasse ash", Elsevier Ltd 2015
5. Vinny Pushkaran, Manjula Unni, Nandana, 'The use of Sugarcane Bagasse ash as a cement replacement in concrete, IJRSET 2017.
6. Seyed Alireza Zareei, Farshad Ameri , Nasrollah Bahrami, 'Microstructure, strength, and durability of eco-friendly concretes containing sugarcane bagasse ash', Elsevier Ltd 2018.
7. A. Rajasekar, K. Arunachalam a, M. Kottaisamy, V. Saraswathy, 'Durability characteristics of Ultra High Strength Concrete with treated sugarcane bagasse ash' Elsevier Ltd 2018.