

## Experimental Investigation of Sugarcane Bagasse ash and Glass Powder as partial replacement of Cement in Concrete.

Shetty Ashish Vishwanath<sup>1</sup>, R. Mahadeva Swamy<sup>2</sup>

<sup>1</sup>Department of Civil Engineering, Shivajirao Jondhale College of Engineering and Technology, Asangaon, Maharashtra, India

<sup>2</sup>Department of Civil Engineering, Shivajirao Jondhale College of Engineering and Technology, Asangaon, Maharashtra, India

**Abstract** — Agricultural and industrial by-products are commonly used in concrete production as cement replacement material as mineral admixtures to enhance both fresh and hardened properties of concrete as well as to save the environment from the negative effects caused by their disposal. Utilization of these waste products in the industry has been the focus of Research for economic, environmental, and technical reasons. Sugarcane Bagasse Ash (SCBA) and glass powder is one of the promising material, with its potential proved to be used as a partial replacement of cement as well as mineral admixtures for producing concrete; properties of such concrete depend on the chemical composition, fineness, specific surface area of SCBA and glass powder. This report aims to study the present Scenario of Sugarcane and SCBA production all over the world and in India to understand the potential of SCBA and its use in cementitious system. The present study deals with effect of use of as received SCBA and burnt and ground SCBA as cement replacement material on properties of cement and cement mortar. Therefore, this study attempts to make use of the bagasse ash produced in India mainly in state of Maharashtra as a pozzolanic material to replace cement. Chemical and physical composition of SCBA is found out. An experimental investigation was carried out to examine the impact of replacing cement by bagasse ash and glass powder to the mechanical and physical properties of pastes and mortars, fresh and hardened concrete such as consistency, setting time and workability, compressive strength. Sugarcane Bagasse Ash and waste glass powder used by replacing OPC at 5%, 10% 15%, 20%, 25% and 30%. It's found that the strength increases with addition of Sugarcane Bagasse Ash and waste glass powder at 5%, 10% 15% and 20% after that declines at 25% and 30%.

**Keywords-** Sugarcane Bagasse ash, Glass powder, Concrete.

### I. INTRODUCTION

Concrete is a composite material composed of aggregate bonded together with a fluid cement which hardens over time. Most use of the term "concrete" refers to Portland cement concrete or to concretes made with other hydraulic cements, such as cement fond. However, road surfaces are also a type of concrete, "asphaltic concrete", where the cement material is bitumen. In Portland cement concrete (and other hydraulic cement concretes), when the aggregate is mixed together with the dry cement and water, they form a fluid mass that is easily molded into shape. The cement reacts chemically with the water and other ingredients to form a hard matrix which binds all the materials together into a durable stone-like material that has many uses. Often, additives (such as pozzolans or super plasticizers) are included in the mixture to improve the physical properties of the wet mix or the finished material. Most concrete is poured with reinforcing materials (such as rebar) embedded to provide tensile strength, yielding reinforced concrete. Famous concrete structures include the Hoover Dam, the Panama Canal and the Roman Pantheon. The earliest large-scale users of concrete technology were the ancient Romans, and concrete was widely used in the Roman Empire. The Colosseum in Rome was built largely of concrete, and the concrete dome of the Pantheon is the world's largest unreinforced concrete dome. Today, large concrete structures (for example, dams and multi-storey car parks) are usually made with reinforced concrete.

### II. LITERATURE REVIEW

Utilization of industrial and agricultural waste products in the industry has been the focus of research for economic, environmental, and technical reasons. Sugar-cane bagasse is a fibrous waste-product of the sugar refining industry, along with ethanol vapor. This waste-product is already causing serious environmental pollution which calls for urgent ways of handling the waste. Since last few years tremendous efforts have been made to increase the use of cement replacement materials in concrete production because the cement production consumes high energy and is responsible for 5% of global anthropogenic CO<sub>2</sub> emission (each ton of cement produces about one ton of CO<sub>2</sub>) and their use can also improve the properties of concrete. Sugar cane bagasse ash is recently accepted as a pozzolanic material, study of using bagasse ash, glass powder as a pozzolanic material is not well-known and its uses are limited and most of bagasse ash and glass is disposed in the landfills and "only a few studies have been reported on the use of bagasse ash and glass powder as a pozzolanic material in respect of the cement paste".

Utilization of such agro-industrial by-products as cement replacement material, as pozzolana etc. In concrete will not only save the environment; but also will reduce the cement production and consequently the high energy consumption,

reduce the CO<sub>2</sub> emission, improve the mechanical properties and durability of the produced concrete and reduce the cost of concrete.

### III. PROBLEM DEFINITION

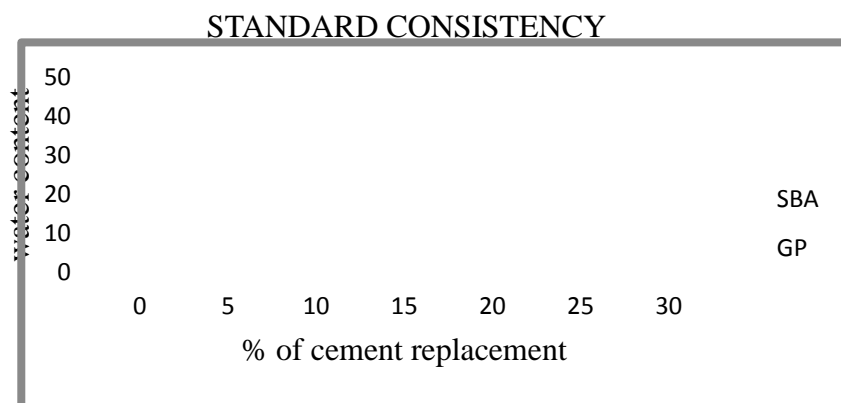
The amount of waste glass powder and sugarcane bagasse ash that is generating in Mumbai city itself is increasing at an alarming rate. The waste glass powder being a non-biodegradable material is not environmentally safe to dispose it into the landfills. The alarming increase in the rate of production of the waste glass powder and sugarcane bagasse ash has increased concerns on the environmental and health issues of the public. Hence various studies have been made to utilize this waste to transform it into best use. One of such studies conducted is to study the potential of waste glass and sugarcane bagasse ash to be used as construction industry to reduce the waste glass powder and sugarcane bagasse ash disposal in landfills. Based on the limited research done on waste glass and sugarcane bagasse ash as cement replacement this research focuses on the utilization of waste glass powder and sugarcane bagasse ash to cement in concrete.

### IV. METHODOLOGY

In the experimental program, three basic tests for mechanical properties of concrete were conducted i.e. tests for compressive strength, flexural strength and split tensile strength. The mechanical properties of concrete were tested at the ages of 7 days, 28 days. The compressive strength was tested on concrete cubes of 150 x 150 x 150 mm after water curing for 7 days, 28 days. The flexural strength was tested using concrete beams with dimension of 150 x 150 x 700 mm after curing in the water for 7 days, 28 days. The split tensile strength was tested using concrete cylinders with dimension  $\phi 150$  mm x 300 mm after curing in the water for 7 days, 28 days.

#### 4.1. Standard Consistency Test

The objective of conducting this test is to find out the amount of water to be added to the cement to get a paste of normal consistency. 500 grams of cement was taken and made into a paste with a weighed quantity of water (% by weight of cement) for the first trial. The paste was prepared in a standard manner and filled into the vicat mould plunger, 10mm diameter, 50mm long and was attached and brought down to touch the surface of the paste in the test block and quickly released allowing it to sink into the paste by its own weight. The depth of penetration of the plunger was noted. Similarly trials were conducted with higher water cement ratios till such time the plunger penetrates for a depth of 33-35mm from the top. That particular percentage of water which allows the plunger to penetrate only to a depth of 33-35mm from the top is known as the percentage of water required to produce a cement paste of standard consistency. From above results we conclude that the standard consistency increase with increase in the proportion of sugarcane baggash ash and waste glass powder. Standard consistency increased from 30% for normal OPC cement to 45% for mix with 30% replacement of cement with sugarcane baggash ash. Standard consistency increased from 30% for normal OPC cement to 37% for mix with 30% replacement of cement with waste glass powder. This shows that requirement of water increases as the percentage of glass powder increases.



*Figure 4 Standard Consistency of cement with partially Sugarcane Bagasse Ash vs Glass Powder Replacements*

#### 4.2 Setting Time of Cement Paste

For convenience, initial setting time is regarded as the time elapsed between the moments that the water is added to the cement, to the time that the paste starts losing its plasticity. The final setting time is the time elapsed between the moment the water is added to the cement, and the time when the paste has completely lost its plasticity and has attained sufficient firmness to resist certain definite pressure. From above results we conclude that the setting time initial and final both increase with increase in the proportion of sugarcane baggash ash and waste glass powder.

Initial setting time increased from 180 min for normal OPC cement to 297min for mix with 30% replacement of cement with sugarcane baggash ash. Initial setting time increased from 180 min for normal OPC cement to 356 min for mix with 30% replacement of cement with waste glass powder.

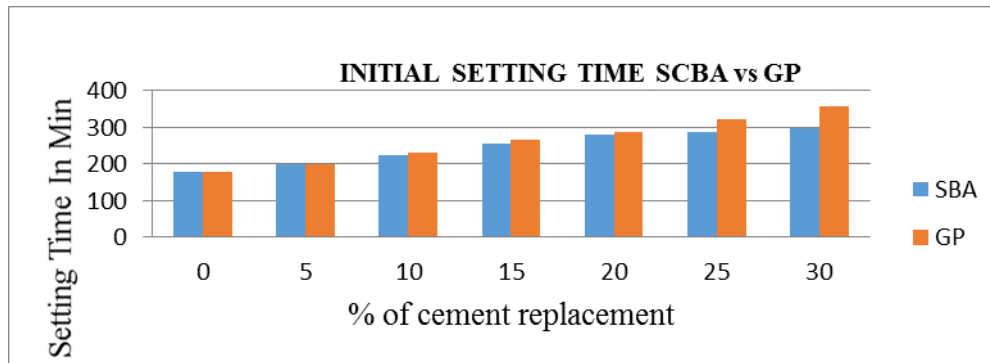


Figure 5 Initial setting time of cement with partially Sugarcane Bagasse Ash vs Glass Powder Replacements

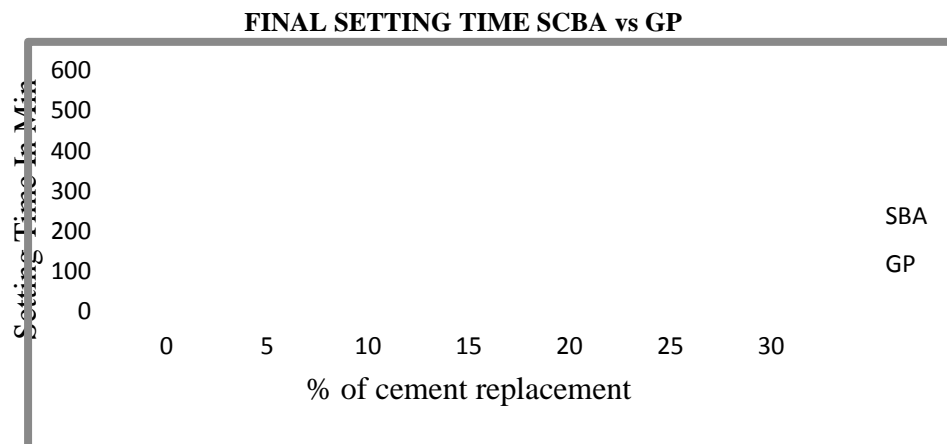


Figure 6 Final setting time of cement with partially Sugarcane Bagasse Ash vs Glass Powder Replacements

#### 4.3 Workability Test

The workability of concrete is one of the functions of the relative magnitudes of various concrete mix constituents. Slump Test is one of the tests which measure the parameters close to workability and provide useful information about it. It is the most commonly used method of measuring consistency of concrete which can be employed either in lab or at the site. From this test, slump is deduced by measuring the drop from the top of the slumped fresh concrete. Additional information on workability of concrete can be obtained by observing the shape of the slump in concrete. From above results it is concluded that the workability decrease with increase in the percentage of sugarcane baggash ash and waste glass powder used as partially replacement of cement. Slump value decreased from 92mm for normal OPC cement to 54 mm for mix with 30% replacement of cement with Sugarcane Bagasse Ash. Slump value decreased from 92mm for normal OPC cement to 58 mm for mix with 30% replacement of cement with waste glass powder.

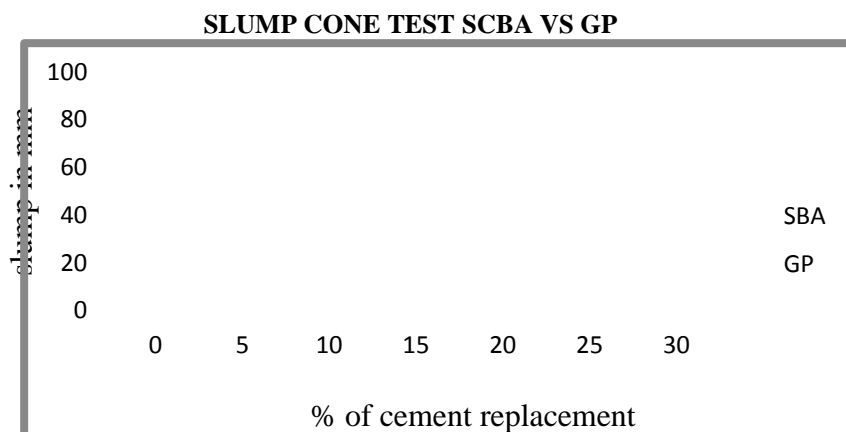
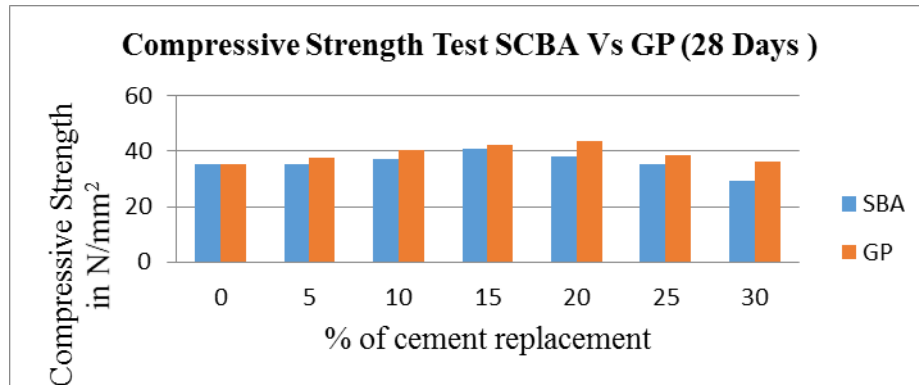


Figure 7 Workability of concrete, with partially Sugarcane Bagasse Ash vs Glass Powder Replacements

#### 4.4 Compressive Strength of Concrete

The test method covers determination of compressive strength of cubic concrete specimens. It consists of applying a compressive axial load to molded cubes at a rate which is within a prescribed range until failure occurs. For each mix cubes of 150mm x 150mm x 150mm size, three cylinders of 150mm diameter and 300mm height were cast using steel molds. The caste specimens were kept in ambient temperature for 24 hours. After 24 hours they were demolded and

placed in water for curing. Cubes were used to determine the compressive strength of concrete for 7 days and 28 days. Thus, there is improvement in compressive strength because of continuous increase of Sugarcane Bagasse Ash and waste glass powder. The strength increases with addition of Sugarcane Bagasse Ash and waste glass powder at 5%, 10% 15% and 20% after that declines at 25% and 30% gradually because of more alkali silica reaction freed during hydration of cement.



**Figure 8 Compressive Strength Test Sugarcane Bagasse Ash vs Glass Powder Replacements at 28 day**

#### 4.5 SPLIT TENSILE TEST

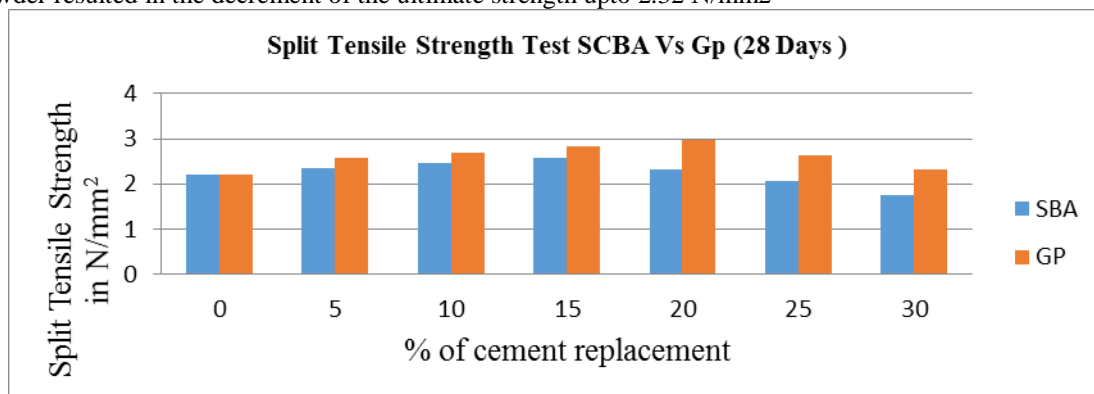
SFRC cylinders of size 15cm (dia) x 30cm (height) are casted. The test is carried out by placing a cylindrical specimen horizontally between the loading surface of a compression testing machine and the load is applied until the failure of the cylinder, along the vertical diameter. When the load is applied along the generatrix, an element on the vertical diameter of the cylinder is subjected to a horizontal stress of  $2P/\pi ld$ .

Where, P is the compressive load on the cylinder

l is the length of the cylinder

d is diameter of the cylinder.

Replacement of Sugarcane Bagasse Ash in cement by 15% will increase the split tensile strength upto 2.58 N/mm<sup>2</sup> compared to conventional concrete and further increase within the proportion of Sugarcane Bagasse Ash resulted in the decrement of the ultimate strength upto 1.76 N/mm<sup>2</sup>. Replacement of glass powder in cement by 15% will increase the split tensile strength upto 2.82 N/mm<sup>2</sup> compared to conventional concrete and further increase within the proportion of glass powder resulted in the decrement of the ultimate strength upto 2.32 N/mm<sup>2</sup>



**Figure 9 Split Tensile Strength Test Sugarcane Bagasse Ash vs Glass Powder Replacements at 28day**

#### 4.6 Flexural Test

SFRC beams of size 150x150x700mm are tested using a flexure testing machine. The specimen is simply supported on the two rollers of the machine which are 600mm apart, with a bearing of 50mm from each support. The load shall be applied on the beam from two rollers which are placed above the beam with a spacing of 200mm. The load is applied at a uniform rate such that the extreme fibers stress increases at 0.7N/mm<sup>2</sup>/min i.e., the rate of loading shall be 4 KN/min. The load is increased till the specimen fails. The maximum value of the load applied is noted down. The appearance of the fracture faces of concrete and any unique features are noted.

The modulus of rupture is calculated using the formula.

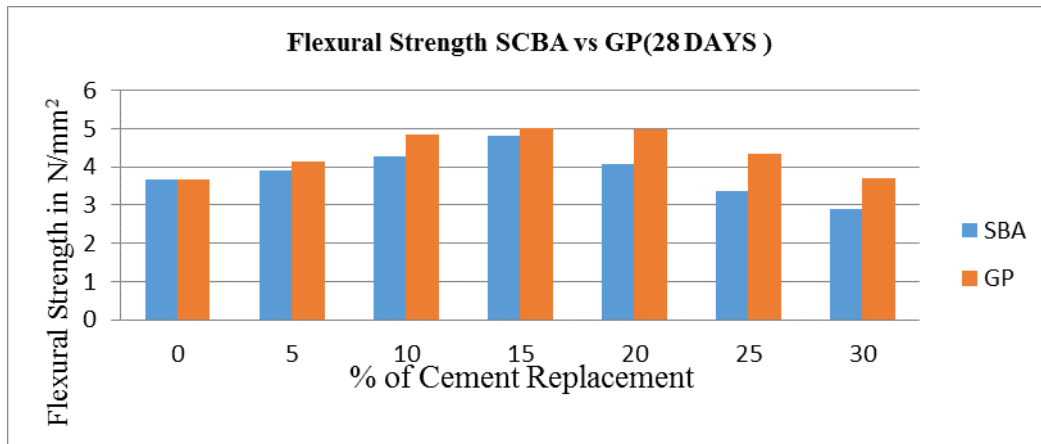
$\sigma_s = Pl/bd^2$ , where,

P = load in N applied to the specimen

l = length in mm of the span on which the specimen is supported (600)

b = measured width in mm of the specimen

d = measured depth in mm of the specimen at point of failure.



**Figure 10 Flexural Strength Test Sugarcane Bagasse Ash vs. Glass Powder Replacements at 28 day**

Replacement of Sugarcane Bagasse Ash in cement by 15% will increase the flexure strength upto 4.83 N/mm<sup>2</sup> compared to conventional concrete and further increase within the proportion of glass powder resulted in the decrement of the ultimate strength upto 2.89 N/mm<sup>2</sup>. Replacement of glass powder in cement by 15% will increase the flexure strength upto 5.03 N/mm<sup>2</sup> compared to conventional concrete and further increase within the proportion of glass powder resulted in the decrement of the ultimate strength upto 3.72 N/mm<sup>2</sup>

## V. CONCLUSION

Experimental investigation following conclusions are made

- For consistency, compare with control mix it increases upto 50 % for SCBA and 23% for GP, when replaced upto 30% of cement.
- For initial setting time , compare with control mix it increases upto 65 % for SCBA and 97% for GP, when replaced upto 30% of cement. Similarly final setting time, compare with control mix increases upto 16 % for SCBA and 29% for GP, when replaced upto 30% of cement.
- For workability, compare with control mix it reduces upto 58% for SCBA and 63% for GP, when replaced upto 30% of cement. Another comparison between SCBA and GP, then workability of SCBA reduces 8% more than GP, when replaced upto 30% of cement.
- For compressive strength compare with control mix, increases upto 11% for SCBA at 15% replacement of OPC. At the same time strength of GP mix also increase upto 42% at 20% replacement, for 7 days strength. For 28 days strength also follows same pattern of strength gain, 15% for SCBA at 15% replacement of OPC, and 22% increase in strength for GP at 20% replacement. Again there is comparison between SCBA and GP, compressive strength of GP mixes increases 14% more than SCBA, when replaced upto 20% of cement.
- For split tensile strength compare with control mix, increases upto 28% for SCBA at 15% replacement of OPC. At the same time strength of GP mix also increase upto 37% at 15% replacement, for 7 days strength. For 28 days strength also follows same pattern of strength gain, 31% for SCBA at 15% replacement of OPC, and 37% increase in strength for GP at 15% replacement. Again there is comparison between SCBA and GP, compressive strength of GP mixes increases 4% more than SCBA, when replaced upto 15% of cement.
- For flexural strength compare with control mix, increases upto 6% for SCBA at 15% replacement of OPC. At the same time strength of GP mix also increase upto 12% at 15% replacement, for 7 days strength. For 28 days strength also follows same pattern of strength gain, 17% for SCBA at 15% replacement of OPC, and 28% increase in strength for GP at 15% replacement. Again there is comparison between SCBA and GP, compressive strength of GP mixes increases 9% more than SCBA, when replaced upto 15% of cement.
- It is clearly seen that cost of cement can be save with better strength than control concrete.
- The test result indicate that the strength of concrete increase up to 20% SCBA replacement with cement.
- Compared to SCBA concrete, finer glass powder concrete had slightly higher early strength as well as late strength.
- The smaller particle size of the Sugarcane Bagasse Ash and glass powder has higher activity with lime resulting in higher compressive strength in the concrete mix.
- Workability decrease with increase in the percentage of Sugarcane Bagasse Ash waste glass powder used as partially replacement of cement.
- The strength increases with addition of Sugarcane Bagasse Ash and waste glass powder at 5%, 10% 15% and 20% after that declines at 25% and 30%.
- Flexural and split tensile strength of concrete also increase as compared to control mix upto 15% replacement but after that strength starts reduces.



- As compared to SCBA and GP, overall performance of glass powder is better than SCBA in all manners like workability, and all the strength.
- So finally it conclude that upto 20% replacement of cement is possible without any effect on concrete.

## REFERENCES

- [1]Almir Sales, Sofia Araújo Lima, "Use of Brazilian sugarcane bagasse ash in concrete as sand replacement", Waste Management 30 (2010), pp.1114–1122
- [2] Anurag Shrivastava, Devansh Jain, Rajesh Joshi, "Application of Different Waste in Concrete as a Partial Replacement of Cement", International Journal of Science Technology & Engineering, Vol. 2, Issue 3, Sept. 2015, pp89-107
- [3] B.Naga Niranjan Kumar, M.Ashok Kumar, "Influence of Glass Powder on the Properties of Concrete", Journal of Mechanical and Civil Engineering, Vol.2, Issue.4, April. 2016, pp 35-44
- [4] Dhanaraj Mohan Patil, Keshav K. Sangle, "Experimental Investigation of Waste Glass Powder as Partial Replacement of Cement in Concrete", International Journal of Advanced Technology in Civil Engineering, Vol.2, Issue1, 2013, pp112-117
- [5] G.M. Sadiqul Islam, M.H. Rahman, Nayem Kazi, "Waste glass powder as partial replacement of cement for sustainable concrete practice", International Journal of Sustainable Built Environment, 2016, pp1-8
- [6] G.Vijayakumar, Ms H. Vishalini, D. Govindarajulu, "Studies on Glass Powder as Partial Replacement of Cement in Concrete Production", International Journal of Emerging Technology and Advanced Engineering Vol. 3, Issue 2, Feb.2013, pp153-157
- [7] Gunalaan Vasudeva, Seri Ganis Kanapathy pillay, "Performance of Using Waste Glass Powder in Concrete as Replacement of Cement", American Journal of Engineering Research, Vol. 02, Issue.12, pp-175-181
- [8] Hongjian Du, Kiang Hwee Tan, "Properties of high volume glass powder concrete", Cement and Concrete Composites, Dec2016, pp. 22-29
- [9] Hongjian Du and Kiang Hwee Tan, "Waste Glass Powder as Cement Replacement in Concrete", Journal of Advanced Concrete Technology Vol. 12, Nov 2014, pp 468-477
- [10] Ismail Ansari, Sheetal Sahare, "Utilization of Glass Powder as A Partial Replacement of Cement and Its Effect on Concrete Strength – A Review", Proceedings of 45th IRF International Conference, 13th December 2015, Pune, India, pp.1-5
- [11]Mohammad Zakir, Syed Iqbal Qadri, Rohit Siwach, "Experimental Evaluation of Waste Glass Powder as A Partial Replacement of Cement in Concrete", International Journal of Recent Innovation in Engineering and Research, Vol.01 Issue 08, Dec. 2016, pp 71-76
- [12] Jayminkumar A. Patel, D. B. Rajjiwala, "Use of Sugar Cane Bagasse Ash as Partial Replacement of Cement in Concrete – An Experimental Study", Global Journal of Researches in Engineering: J General Engineering, Vol.15, Issue 5, Year 2015, pp13-18
- [13] K. Kiran, I. Siva Kishore, "An Experimental Study on Partial Replacement of Cement With Bagasse Ash in Concrete Mix", International Journal of Civil Engineering and Technology Vol.8, Issue 1, Jan.2017, pp. 452–455
- [14] M.Vijaya Sekhar Reddy, K.Ashalatha, M.Madhuri, P.Sumalatha, "Utilization of Sugarcane Bagasse Ash (SCBA) in Concrete by Partial Replacement of Cement", IOSR Journal of Mechanical and Civil Engineering, Vol. 12, Issue 6, Nov. - Dec. 2015, pp 12-16
- [15] Noor-ul Amin, "Use of Bagasse Ash in Concrete and Its Impact on the Strength and Chloride Resistivity", Journal of Materials in Civil Engineering, May 2011, pp.717-720
- [16] Prashant O Modania, M R Vyawahareb, "Chemical Utilization of Bagasse Ash as a Partial Replacement of Fine Aggregate in Concrete", Civil and Mechanical Engineering Tracks of 3rd Nirma University International Conference on Engineering (2013), pp 25 – 29
- [17]R.Srinivasan, K.Sathiya, "Experimental Study on Bagasse Ash in Concrete", International Journal for Service Learning in Engineering, Vol. 5, No. 2, pp. 60-66,
- [18] Shilpa Raju, P. R. Kumar, "Effect of Using Glass Powder in Concrete", International Conference on Innovations & Advances In Science, Engineering And Technology Vol. 3, Special Issue 5, July 2014, pp421-427
- [19] Sombir, Parveen Berwal, "A Laboratory Study on Use of Waste Glass Powder as Partial Replacement of Cement in Concrete Production", International Journal of Advance Research, Ideas and Innovations in Technology, Vol.3, Issue1, 2017,pp143-151
- [20] Veena V. Bhat, N. Bhavanishankar Rao, "Influence of Glass Powder on the Properties of Concrete", International Journal of Engineering Trends and Technology, Vol. 16, Oct 2014, pp196-199
- [21] Shao, Y., Lefort, T., Moras, S. and Rodriguez, D., "Studies on concrete containing ground waste glass." Cement and Concrete Research, 2000, 30(1), pp.91-100.
- [22] C Mryer, N Egosi, C Andela, "Concrete with waste glass as aggregate" in "Recycling and Re-use of glass cullet", Proceeding of the International Symposium concrete technology unit of ASCE and university of Dundee, March 19-20, 2001
- [23] IS 10086-1982: Specification for moulds using test of cement and concrete
- [24] IS: 1199-1959: Methods of sampling and analysis of concrete

- [25] IS: 516 - 1959: Methods of tests for strength of concrete
- [26] IS 10262-2009: Concrete mix proportioning – guidelines
- [27] IS: 5513-1976: Vicat apparatus – specification
- [28] IS: 4031 (Pat 4) - 1988: Methods of physical tests for hydraulic cement Determination of consistency of standard of cement paste
- [29] IS: 4031 (Pat 5) - 1988: Methods of physical tests for hydraulic cement, determination of initial and final setting times
- [30] IS: 7320-1974: Specification for concrete slump test apparatus
- [31] IS 456-2000: Plain and reinforced concrete -Code of practice
- [32] SP: 23-1982: Handbook on concrete mixes
- [33] ASTM C441: Standard test method for effectiveness of pozzolans or Ground Blast Furnaces slag in preventing excessive expansion of concrete due to Alkali- Silica reaction
- [34] ASTM C1260: Standard test method for potential Alkali reactivity of aggregate.
- [35] M. S. Shetty, “Concrete technology – theory and practice”, S. Chand and company LTD.