STRENGTHENING OF CONCRETE BEAMS USING TERNARY BLEND WITH SUGARCANE BAGASSE ASH AND PROSOPIS JULIFORA ASH

S Raaj nivas [1] and K J Jegidha [2]

[1] Department of Civil Engineering, Adhiyamaan College of Engineering, Hosur
[2] Assistant Professor, Department of Civil Engineering, Adhiyamaan College of Engineering, Hosur

Abstract

Concrete is one of the most versatile and flexible building materials. Owing to concerns regarding environmental impacts of mining, various researches have been conducted on feasibility of using different non-conventional materials as partial replacement for cement. However, the strength of resulting concrete by partial replacement of cement by non-conventional materials is required to be same, if not higher in comparison to that of conventional concrete in order for the partially replaced concrete to be used efficiently and economically. Hence, this demand for higher strength of construction materials can be satisfied by use of a mixture of ash from sugarcane bagasse and prosopis juliflora both of which are waste byproducts that can be used to improve the strength properties of concrete.

Keywords: concrete, pozzolana, prosopis juliflora, sugarcane bagasse.

1. INTRODUCTION

One of the waste materials that can be used to partially replace cement is a mixture of ashes of sugarcane bagasse and *prosopis juliflora*. The use of this ash mixture is aimed to increase the strength of concrete and decrease the quantity of cement used, in turn facilitating economic and more environmental friendly concrete.

This paper discusses the materials used and the methodology involved in the casting and testing of concrete made with cement partially replaced by mixture of sugarcane bagasse ash and *prosopis juliflora* ash.

2. OBJECTIVES

1. To determine the optimal percentage of sugarcane bagasse ash and *prosopis julifora* ash that can be added to cement to strengthen the concrete.

2. To compare the structural behavior of conventional concrete beams with that of ash blended concrete beams.

3. LITERATURE REVIEW

- **Parthiban kathirvel, George Amal Anik, Saravana raja, Saravana Raja Kaliyaperumal** tested and published **"Effects of Partial replacement of *prosopis julifora* ash on the strength and microstructural characters of cement concrete", ScienceDirect, Construction and Building Materials, 2019**. *prosopis julifora* ash constituting a chemical composition of Calcium oxide –59.45%, Silicon dioxide – 1.19%, Magnesium oxide – 1.70%, Sulfur trioxide – 4.44%, Ferric oxide– 0.57%, Sodium oxide – 0.84%, Potassium oxide – 23.85%, was utilized as a partial replacement of OPC in this study. From the experimental investigation, it was observed that *prosopis julifora* ash can be effectively used up to 20% replacement level of cement in the production of concrete. It was concluded *prosopis julifora* ash cannot be used as a replacement for cement at higher levels due to the higher amount of alkalies present in *prosopis juliflora* ash which exceeds the limitation of IS standards.

- **Pratiksha Patnaik, Tasneem Abbasi and S. A. Abbasi** published **"Prosopis (*prosopis julifora*): blessing and bane", International Society for Tropical Ecology Tropical Ecology 58(3): 455–483, 2017**. It is shown that *prosopis juliflora* is a major boon when growing in its native habitat desert lands making the desert environment more habitable and providing fuel, food, feed, bio pesticides, medicines, cosmetics, gum, and activated carbon. But when taken to exotic environments, the same attributes of *prosopis juliflora* which enable it to survive and thrive in forbidding territories, make it a very aggressive invader and colonizer. It becomes a major monopoliser of natural resources and a destroyer of biodiversity. It also poses serious risk to humans, livestock, and wildlife.

- **A.Durai Murugan, M.Muthuraja** performed experiments on concrete using *prosopis julifora* ash in 0%, 10%, 20%, 30%

and 40% as replacement of cement and published **"Experimental Investigation on *prosopis julifora* Ash as a Partial Replacement of Cement in Conventional Concrete", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 6, Issue 5, May 2017.** Compression test on cubes for compressive strength, split tensile test on cylinders for tensile strength and flexural test on beams for flexural strength of concrete were carried out at 7 and 28 days of curing respectively to determine the properties of concrete. The compressive strength of M20 grade concrete by replacement of 30% of concrete by *prosopis julifora* ash was 18.33N/mm^2 on day 7 and 28.2 N/mm^2 on day 28. Split Tensile strength was calculated as 1.9 N/mm^2 on day 7 and 2.455 N/mm^2 on day 28 for 30% replacement of cement by *prosopis juliflora* ash. The flexural strength was calculated as 8.10 N/mm^2 on day 28 for replacement of 30% of concrete by *prosopis julifora* ash.

- **George Amal Anik S, Parthiban Kathirvel, Murali G** studied the effects of using *prosopis julifora* as partial replacement of cement and published **"Effect of Utilizing *prosopis julifora* Ash as Cementitious Material", International Journal of Engineering & Technology 7 (3.12) (2018) 218-284.** The results of consistency test showed that the optimum water content required for cement paste is 35% upto 20% of replacement of cement with *prosopis julifora* ash. For 30% and 40% the optimum water content for the required consistency is increased to 37.5%. This may be due to the hygroscopic character and increased surface area of *prosopis julifora* ash which leads to increase the water demand. The setting time of cement paste increases with the increase in percentage of *prosopis julifora* ash as replacement of cement. Initial setting time of cement paste at room temperature increases from 32 to 50 min, when replaced by 40%. This is mainly due to the water holding characteristics of *prosopis julifora* ash and loss of tri-calcium aluminate from cement which delays the hydration process and increases duration of setting. The variation in expansion of cement paste when cement replaced with *prosopis julifora* ash shows that with the increase in percentage of replacement of cement with *prosopis julifora* ash expansion of cement paste reduces. This is mainly due to the presence of MgO in *prosopis julifora* ash. The limit of acceptable soundness as per IS4031 is10 mm and the tested results showed that all the mixes were inside the acceptable range.

- **M. Kamesh, T. Karthik, M. Ramakrishnan, S. Sanjay Kumar, P. Suresh Kumar** conducted experiments on cement concrete with partial replacement of cement by 0%, 5%, 10% and 20% *prosopis julifora* ash and published **"Experimental Project on Concrete - Partial Replacement of Cement by *prosopis julifora* Ash", International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-6 Issue-1, March 2017**. The compressive strength of M20 concrete on day 7, day 14 and day 28 respectively found to be 20.65N/mm^2, 22.84N/mm^2 and 24.5N/mm^2 for 15% replacement of cement by *prosopis julifora* ash. The split tensile strength of M20 concrete on day 7, day 14 and day 28 respectively found to be 1.74 N/mm^2, 2.24 N/mm^2 and 2.24 N/mm^2 for 15% replacement of cement by *prosopis julifora* ash. The flexural strength of M20 concrete on day 7, day 14 and day 28 respectively found to be 3.01 N/mm^2, 3.53 N/mm^2 and 4.95 N/mm^2 for 15% replacement of cement by *prosopis julifora* ash.

- **P. Manisha sri, M. Nithya, P.Poornima** tested effects of *prosopis juliflora* ash in cement in paver blocks and published **"An Experimental Investigation On *prosopis julifora* Ash As A Partial Replacement Of Cement In Paver Block", International Journal of Creative Research Thoughts (IJCRT) Volume 6, Issue 2 April 2018, ISSN: 2320-2882.** On increasing the fineness of the *prosopis juliflora* ash the strength of the paver block was retained. On adding of 5% of ash the strength obtained was 32.22 N/mm^2 and adding 20% of ash the strength obtained was 44.7 N/mm^2. By not adding any ash content the strength is 25 N/mm^2.

- **P. Sarala, S. Bhanu Sai Krishna Reddy, T.V. Ravi Teja, T. Revanth Kumar, Y. Masthan** conducted research on *prosopis julifora* ash replaced concrete and published **"Experimental Study of Partially Replacement of Cement by *prosopis julifora*", Volume: 06 Issue: 03 Mar 2019.** Based on the experimental investigation on concrete with cement was partially replaced by *prosopis julifora* as 5%, 10%, 15% on 7, 14 and 28 days and conclusion that compressive strength of concrete increases with the amount of *prosopis julifora* by 10 % on various days of curing respectively. After that strength gradually decreased while increasing the percentage of *prosopis julifora*. The replacement of cement with *prosopis julifora* upto 15% is desirable, as it is cost effective. As a result, the research work concluded that more than 15% of *prosopis julifora* is not a suitable material for cement replacement in concrete.

- **R. Dharmaraj, B. SivaKumar** conducted a study and published **"A feasibility study on cement with addition of *prosopis julifora* ash as in concrete", International Conference on Newer Trends and Innovation in Mechanical Engineering: Material Science, Proceedings 37, 2021.** It was found that *prosopis julifora* ash also acts as self-retarder parameter to increase the Setting time as well.

- **S.Saranya, A.Faizuneesa, S.P.Kanniyappan** published **"Experimental Study On Partial Replacement Of Cement By *prosopis julifora* In Concrete", Journal of Applied Science and Computations Volume VI, Issue V, May/2019 ISSN NO: 1076-5131.** As a result of the experiments, the research work concluded that more than 15% of *prosopis julifora* is not a suitable material for cement replacement in concrete as it is cost effective. Compressive strength of concrete increased with the amount of *prosopis julifora* by 15 % on various days of curing respectively.

- **Sajjad Ali Mangi , Jamaluddin N , Wan Ibrahim M H , Abd Halid Abdullah, A S M Abdul Awal, Samiullah Sohu and Nizakat** Ali studied sugarcane bagasse ash replaced concrete and published "**Utilization of sugarcane bagasse ash in concrete as partial replacement of cement**", **IOP Conference Series: Materials Science and Engineering 271 (2017) 012001**. Sugar cane Bagasse ash in concrete gives the higher compressive strength as compared to the normal strength concrete, hence optimal results were found at the 5% replacement of cement with sugar cane bagasse ash. The usage of sugarcane bagasse ash in concrete is not only a waste-minimizing technique, also it saves the amount of cement. The replacement of cement with sugarcane bagasse ash increases the workability of fresh concrete; therefore, use of super-plasticizer is not essential.

- **V.S. Sethuraman, L. K. Rex, Gomathi Nagajothy** experimented on pozzolanic material from *prosopis juliflora* and published **"Burnt ash from Hazardous *prosopis julifora* Plant as a Pozzolanic replacement Material in Cement", International Journal of Advanced Science and Technology Vol. 29, No. 6, (2020), pp. 4216 – 4224** and experimentally concluded that the percentage increase in compressive strength was a maximum of 6.01% for 5% replacement of cement by plant ash. The percentage increase in split tensile strength was a maximum of 148.77%for 5% replacement of cement by plant ash. The percentage increase in flexural strength was a maximum of 104.37 % for 5% replacement of cement by plant ash. From the experimental investigations, it can be concluded that the *prosopis julifora* plant ash performed well as a partial replacement of cement in all aspects. Hence, it can be highly recommended for use as a pozzolanic material for blended cements.

- **R.Srinivasan, K.Sathiya** published **"Experimental Study on Bagasse Ash in Concrete", International Journal for Service Learning in Engineering Vol. 5, No. 2, pp. 60-66, Fall 2010.** The sugarcane bagasse consisted of approximately 50% of cellulose, 25% of hemicellulose and 25% of lignin. Each ton of sugarcane generates approximately 26% of bagasse (at a moisture content of 50%) and 0.62% of residual ash. The residue after combustion presents a chemical composition dominates by silicon dioxide (SiO2). It was found that the cement could be advantageously replaced with sugarcane bagasse ash up to maximum limit of 10%. Partial replacement of cement by sugarcane bagasse ash increases workability of fresh concrete; therefore, use of super plasticizer is not substantial. The density of concrete decreases with increase in sugarcane bagasse ash content, low weight concrete produced in the society with waste materials.

- **Qing Xu, Tao Ji, San-Ji Gao, Zhengxian Yang and Nengsen Wu** studied and published **"Characteristics and Applications of Sugar Cane Bagasse Ash Waste in Cementitious Materials", Multidisciplinary Digital Publishing Institute Materials 2019, 12, 39; doi:10.3390/ma12010039** It was reported that sugar cane bagasse ash is conventionally used as fertilizer or is disposed of in landfills, both of which are not sustainable from the standpoint of environmental and health concerns. Utilization of sugarcane bagasse ash in construction materials offers a promising solution for superior recycling and management of sugarcane bagasse ash wastes. In general, sugarcane bagasse ash concrete shows an excellent performance when sugarcane bagasse ash partially replaces cement. There are two main reasons, the high amorphous silica content in sugarcane bagasse ash triggers pozzolanic reactivity and the ultrafine particle sizes of the sugarcane bagasse ash significantly improve the microstructure, leading to a high early strength.

- **José da Silva Andrade Neto, Mavisson Júlio Santos de França, Nilson Santana de Amorim Júnior, Daniel Véras Ribeiro** experimented on and published **"Effects of adding sugarcane bagasse ash on the properties and durability of concrete", Construction and Building Materials, 226(2021) 120959** and inferred that , the addition of sugarcane bagasse ash resulted in a higher lifetime against the penetration of chlorine ions. The larger the sugarcane bagasse ash content, the higher the estimated lifetime, increasing by up to 95.7% for the concrete containing 15% sugarcane bagasse ash. Concrete containing sugarcane bagasse ash showed a higher carbonation rate owing to the reduction in the alkaline reserve (consumption of portlandite), reducing its lifetime. However, except for the concrete specimen with 15% sugarcane bagasse ash exposed to the industrial environment, all specimens had a lifetime of more than 50 yrs in all environments considered. The addition of 5% sugarcane bagasse ash mitigated the ASR because of the pozzolanic reaction that leads to higher C-S-H formation and pore refinement. However, for larger sugarcane bagasse ash amounts (10% and 15%), there was a gradual increase in ASR owing to the increasing alkali content of the added sugarcane bagasse ash.

- **Sales, A; Lima, S.A** experimented and published an article **"Use of Brazilian sugarcane bagasse ash in concrete as sand replacement", Waste Manage. 2010, 30, 1114–1122.** Upon analysis of various samples of Sugarcane Bagasse Ash, it was found that all the ash samples presented silica contents of more than 75% (SiO2). All the sugarcane bagasse ash samples analyzed here were classified as ''Non-hazardous waste – Class II A – Non-inert". Wastes with this classification can have properties of biodegradability, combustibility or water solubility. Based on this finding, it is suggested that SBA not be used as an aid in fertilizing sugarcane plantations, which is the current practice.

- **Sayan Sarkar** conducted a study on sugar industries and published **"Problems of Sugar Industry Management System in India" Volume: 06 Issue: 08 Aug 2019**. It was reported that an important problem of sugar industry is the fuller utilization of by-products specially bagasse and molasses. At one time bagasse was used as fuel ,while sugar factories did not know what to do with the accumulating molasses ,a health hazard. Presently, small paper plants are coming up to make paper and paper board, packing paper etc through using bagasse.

- **Shruthi H R, Dr.H Eramma, Yashwanth M K, Keerthi gowda BS** studied plain cement concrete with sugarcane bagasse ash and published **"A Study On Bagasse Ash Replaced Plain Cement Concrete", Volume No.02, Issue No. 08, August 2014.** It was observed that the experimental result for the 10% replacement of bagasse ash to OPC has increase in strength in comparison with 0% and 5% replacement. Beyond 10% replacement of bagasse ash, the strength decreased. The analytical results obtained are not much varied compared to experimental results. It gives very near values to the experimental values so the developed equations of this present study an be used for the calculation of values compressive strength, split tensile strength and flexural strength for bagasse ash replacement with OPC up to 20% replacement.

- **Siva Kishore, Ch.Mallika Chowdary, T.N.Seshu Babu, K.P.Nandini** published **"A Case Study on Waste Utilization of sugar cane bagasse ash in Concrete Mix", International Journal of Engineering Trends and Technology (IJETT) – Volume 25 Number 3- July 2015.** From investigations, it was observed that structural properties like compressive strength, flexural strength, split tensile strength of concrete with the replacement of cement by sugar cane bagasse ash, which is close to the strength of conventional concrete. Test results indicated that the strength results of conventional mix close to the strength of concrete which is replace by 10% sugar cane bagasse ash in cement. It was concluded that 10% sugar cane bagasse ash can be replaced in cement which give results equal to the normal concrete.

- **Riccardo Maddalena, Kefei Li, Philip A. Chater, Stefan Michalik, Andrea Hamilton** attempted synthesis of cement using calcium hydroxide and Nano silica and published **"Direct synthesis of a solid calcium-silicate-hydrate (C-S-H)", Construction and Building Materials, 223 (2019), 554-565.** C-S-H was prepared by mixing a dry source of calcium and aqueous nano silica suspension with deionized and decarbonated water, manually and without further chemical processing, providing a simple, relatively fast and inexpensive method for producing solid C-S-H.

6. SUMMARY OF LITERATURE REVIEW

- It was found that sugarcane bagasse ash consists of more than 75% Silicon Dioxide (SiO2).

- It was found that *prosopis julifora* ash constitutes of about 59.45% Calcium Oxide(CaO).

- Various tests conducted by different people, as stated above, concluded that the use of sugarcane bagasse ash and *prosopis juliflora* ash separately improved the strength properties of concrete.

- Sugarcane bagasse ash and *prosopis julifora* ash are both waste materials that can be used as partial replacement of cement as a means for waste management and saving cement material.

5. MATERIALS USED

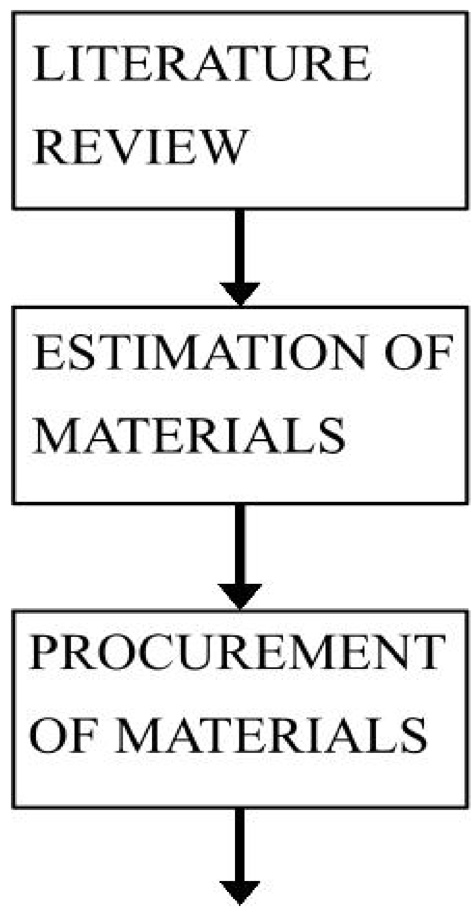
5.1 Sugarcane bagasse ash

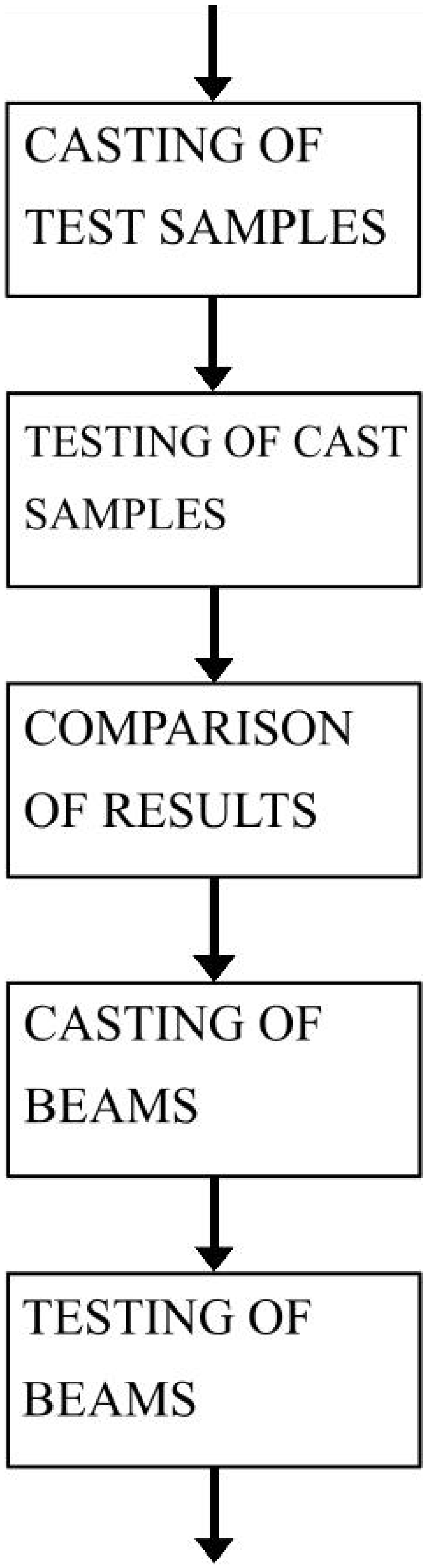
Sugarcane bagasse ash is a waste product of sugar and jaggery industries that use dried sugarcane bagasse as fuel for boiling. It consists of over 75% of Silicon dioxide that is a determining factor of initial setting time of cement and helps improving strength.

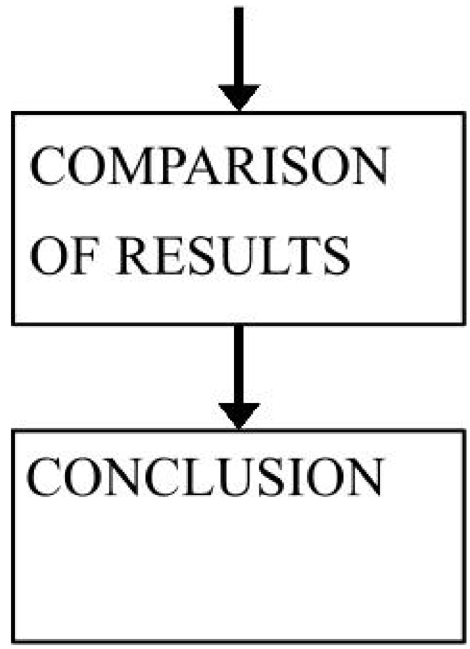
5.2 *prosopis juliflora* ash

A small tree *prosopis juliflora,* is commonly used as firewood in India. The ash of *prosopis julifora* is composed of about 60% Calcium oxide whose presence is crucial for formation of calcium silicates and aluminates in concrete.

6. METHODOLOGY







6.1 Literature review

Various literatures on this topic have been collected, reviewed and summarized.

6.2 Estimation of materials

The quantity of constituent materials of conventional concrete along with ash from sugarcane bagasse ash and *prosopis juliflora* ash that are required for casting of samples is estimated. The quantities of materials used are measured in weight.

6.3 Procurement of materials

Ash from *prosopis juliflora* can be collected from brick factories and hotels with wood stoves that use timber from *prosopis juliflora* as firewood. Sugarcane bagasse ash can be obtained from local jaggery industries that use dried sugarcane bagasse as burning fuel for their boiling pans. The conventional materials namely cement and aggregates are readily available.

6.4 Casting of test samples

The samples are cast with 0%, 5% and 10% of sugarcane bagasse ash and prosopis juliflora ash respectively. For testing compressive strength of concrete cubes of 150mm x 150mm x 150mm height, breadth and width respectively are cast. Clean the standard cube molds 6 Nos thoroughly and tight all nuts-bolts properly. Apply oil to all contract surface of mold. Fill the concrete in cubes in 3 layers. Compact each layer with 35 Nos of stroke by tamping rod. Finish the top surface by trowel after completion of last layer. Submerge the specimen in clean fresh water till the time of testing.

6.5 Testing of cast samples

The samples are tested at 7 and 28 days for strength properties. The samples are checked for defects and wiped clean. The dimensions of the sample are measured. The molds are placed in the testing machine and a load is applied at a slow rate. The load is applied until the sample fails and the load at which the sample fails is noted as the ultimate bearing of the respective concrete sample. The compressive strength f_c is calculated using the following formula:

$$f_c = P/A$$

Where:

f_c = Compressive strength of concrete (in N/mm²)

P = Maximum load applied to the cube (in N)

A = Cross-sectional area of the cube (in mm²)

6.6 Casting of beams

The samples are cast with 0%, 5% and 10% of sugarcane bagasse ash and prosopis juliflora ash respectively. For testing flexural strength, beams of size 100mm x 100mm x 500mm are cast. Clean the standard cube molds 6 Nos thoroughly and tight all nuts-bolts properly. Apply oil to all contract surface of mold. Fill the concrete in cubes in 3 layers. Compact each layer with 35 Nos of stroke by tamping rod. Finish the top surface by trowel after completion of last layer. Submerge the specimen in clean fresh water till the time of testing.

6.7 Testing of beams

The samples are tested at 7 and 28 days for strength properties. The samples are checked for defects and wiped clean. The dimensions of the sample are measured. The molds are placed in the testing machine and a load is applied at a slow rate. The load is applied until the sample fails and the load at which the sample fails is noted as the ultimate bearing of the respective concrete sample. The flexural strength f_{cr} or modulus of rupture is calculated using the following formula:

$$f_{cr} = (P_{max} \times L) / (b \times d^2)$$

Where:

f_{cr} = Flexural strength (in N/mm²)

P_{max} = Maximum load applied at failure (in N)

L = Length of the beam between supports (in mm)

b = Width of the beam (in mm)

d = Depth (height) of the beam (in mm)

6.8 Comparison of results

The results of Test for Compressive strength of Concrete are as follows.

SAMP- -LE	SUGAR- -CANE BAGASSE ASH	PROSOP- -IS JULI- FLORA ASH	STRENGTH (N/mm²)	
			DAY 7	DAY 28
A	0%	0%	14.06	25.11
B	5%	10%	16.80	28.11
C	10%	5%	15.04	26.40

The results of Test for Flexural Strength of Concrete are as follows.

SAMP- -LE	SUGAR- -CANE BAGASSE ASH	PROSOPIS JULI- -FLORA ASH	STRENGTH (N/mm²) DAY 28
A	0%	0%	3.48
B	5%	10%	3.74
C	10%	5%	3.57

6.9 Conclusion

As per the test results the compressive strength of concrete increases by 10% and 5% for addition of 5% Sugarcane Bagasse Ash and 10% Prosopis Juliflora ash and 10% Sugarcane Bagasse Ash and 5% Prosopis juliflora ash respectively. Similarly, the flexural strength of concrete increases by 10% and 5% for addition of 5% Sugarcane Bagasse Ash and 10% Prosopis Juliflora ash and 10% Sugarcane Bagasse Ash and 5% Prosopis juliflora ash respectively. Therefore, an optimal amount of 5% Sugarcane Bagasse Ash and 10% Prosopis Juliflora Ash can be added to cement to increase the strength of Concrete.

7. REFERENCES

[1].Parthiban kathirvel, George Amal Anik, Saravana raja, Saravana Raja Kaliyaperumal tested, "Effects of Partial replacement of *prosopis julifora* ash on the strength and microstructural characters of cement concrete", ScienceDirect, Construction and Building Materials, 2019.

[2].Pratiksha Patnaik, Tasneem Abbasi and S. A. Abbasi published "Prosopis (*prosopis julifora*): blessing and bane", International Society for Tropical Ecology Tropical Ecology 58(3): 455–483, 2017.

[3].A.Durai Murugan, M.Muthuraja, "Experimental Investigation on *prosopis julifora* Ash as a Partial Replacement of Cement in Conventional Concrete", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 6, Issue 5, May 2017.

[4].George Amal Anik S, Parthiban Kathirvel, Murali G, "Effect of Utilizing *prosopis julifora* Ash as Cementitious Material", International Journal of Engineering & Technology 2018.

[5].L.S. Kalaiselvan and B. Manibalu published "Experimental Investigation of Concrete by Partial Replacement of Cement Using Mesquite", International Journal of Advanced Research in Science, Communication and Technology (IJARSCT) Volume 4, Issue 2, April 2021.

[6].M. Kamesh, T. Karthik, M. Ramakrishnan, S. Sanjay Kumar, P. Suresh Kumar, "Experimental Project on Concrete - Partial Replacement of Cement by *prosopis julifora* Ash", International Journal of Recent Technology and Engineering (IJRTE), Volume-6 Issue-1, March 2017.

[7].P. Manisha sri, M. Nithya, P.Poornima, "An Experimental Investigation On *prosopis julifora* Ash As A Partial Replacement Of Cement In Paver Block", International Journal of Creative Research Thoughts (IJCRT) Volume 6, Issue 2 April 2018.

[8].P. Sarala, S. Bhanu Sai Krishna Reddy, T.V. Ravi Teja, T. Revanth Kumar, Y. Masthan conducted research on *prosopis julifora* ash replaced concrete and published "Experimental Study of Partially Replacement of Cement by *prosopis julifora*", Volume: 06 Issue: 03 Mar 2019.

[9].R. Dharmaraj, B. SivaKumar , "A feasibility study on cement with addition of *prosopis julifora* ash as in concrete", International Conference on Newer Trends and Innovation in Mechanical Engineering: Material Science, Proceedings 37, 2021.

[10]. S.Saranya, A.Faizuneesa, S.P.Kanniyappan, "Experimental Study On Partial Replacement Of Cement By *prosopis julifora* In Concrete", Journal of Applied Science and Computations Volume VI, Issue V, May/2019.

[11]. Sajjad Ali Mangi , Jamaluddin N , Wan Ibrahim M H , Abd Halid Abdullah, A S M Abdul Awal, Samiullah Sohu and Nizakat Ali, "Utilization of sugarcane bagasse ash in concrete as partial replacement of cement", IOP Conference Series: Materials Science and Engineering 271 (2017) 012001.

[12]. V.S. Sethuraman, L. K. Rex, Gomathi Nagajothy, "Burnt ash from Hazardous *prosopis julifora* Plant as a Pozzolanic replacement Material in Cement", International Journal of Advanced Science and Technology Vol. 29, No. 6, (2020), pp. 4216 – 4224.

[13]. 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, Fall 2010.

[14]. Qing Xu, Tao Ji, San-Ji Gao, Zhengxian Yang and Nengsen Wu, "Characteristics and Applications of Sugar Cane Bagasse Ash Waste in Cementitious Materials", Multidisciplinary Digital Publishing Institute Materials 2019.

[15]. José da Silva Andrade Neto, Mavisson Júlio Santos de França, Nilson Santana de Amorim Júnior, Daniel Véras "Effects of adding sugarcane bagasse ash on the properties and durability of concrete", Construction and Building Materials, 2021.

[16]. Sales A; Lima, S.A, "Use of Brazilian sugarcane bagasse ash in concrete as sand replacement", Waste Manage. 2010. 30, 1114–1122.

[17]. Sayan Sarkar, "Problems of Sugar Industry Management System in India" Volume: 06 Issue: 08 Aug 2019.

[18]. Shruthi H R, Dr.H Eramma, Yashwanth M K, Keerthi gowda BS, "A Study On Bagasse Ash Replaced Plain Cement Concrete", Volume No.02, Issue No. 08, August 2014.

[19]. Siva Kishore, Ch.Mallika Chowdary, T.N.Seshu Babu, K.P.Nandini, "A Case Study on Waste Utilization of sugar cane bagasse ash in Concrete Mix", International Journal of Engineering Trends and Technology (IJETT) – Volume 25 Number 3- July 2015.

[20]. Riccardo Maddalena, Kefei Li, Philip A. Chater, Stefan Michalik, Andrea Hamilton, "Direct synthesis of a solid calcium-silicate-hydrate (C-S-H)", Construction and Building Materials, 223 (2019), 554-565.