iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 **Issue:** III **Month of publication:** March 2024

DOI: https://doi.org/10.22214/ijraset.2024.59138

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue III Mar 2024- Available at www.ijraset.com

Study on the Performance of Concrete Using Waste Glass and Sugarcane Bagasse Ash

S. Naga Sai Kumar[1], Dr. K. Naga Sreenivasa Rao[2]
[1]*PG Scholar,* [2]*Professor & HOD, Department of Civil Engineering, Chalapathi Institute of Technology, Mothadaka, Andhra Pradesh, India, 522016*

Abstract: During cement production, the emission of CO_2 has significant impact on environment. Apart from this, the extraction of natural aggregates and generation of industrial, agricultural and domestic waste also leads to environment degradation. The use of these waste materials not only helps to reduce the use of natural resources also helps to mitigate the environment pollution. The basic objective of this research is to investigate the effect of Waste Glass (WG) as partial replacement of fine aggregates and Sugarcane Bagasse Ash (SCBA) as partial replacement of cement in concrete. This study primarily deals with the characteristics of concrete, including compressive strength, workability and thermal stability of all concrete mixes at elevated temperature. Twenty-five mixes of concrete were prepared at different replacement levels of WG (0%, 10%, 20%, 30% & 40%) with fine aggregates and SCBA (0%, 5%, 10%, 15% & 20%) with cement. The water/cement ratio in all the mixes was kept at 0.55. The workability of concrete was tested immediately after preparing the concrete whereas the compressive strength of concrete was tested after 14, 28 and 60 days of curing. Based on the test results, a combination of 10% WG and 10% SCBA is the most significant for high strength and economical concrete. This research also indicates that the contribution of WG and SCBA doesn't change the thermal properties of concrete.
Keywords: Waste Glass (WG), Sugarcane Bagasse Ash (SCBA), Compressive Strength

I. INTRODUCTION

Concrete has become an essential component of the construction industry due to the mechanical and long-lasting properties that it has. The industry's dependence on concrete was directly responsible for this transition, which took place as a direct result. In terms of the quantity of natural resources that are needed to make a single unit of a completed product, the manufacture of concrete is one of the top five industries in terms of the amount of resources that are necessary. The rising usage of concrete components like cement and aggregates is ultimately responsible for the expansion of unfavorable consequences for the natural environment that is all around us. Examples of these components are aggregates and cement. Cement, water, and aggregates are the three major components that are required for the production of concrete. Concrete cannot be made without their presence. The substance known as concrete is a composite. A few decades ago, acquiring these resources was hardly the most difficult thing to do. On the other hand, there is now a negative effect that is associated with the use of these resources. In the past, this was not the situation at all. A few decades ago, this was not at all the case. The burning of a variety of industrial and fuel sources leads to the release of a considerable amount of the greenhouse gas carbon dioxide (CO2) (OPC) during the manufacturing of typical Portland cement. This is because of the chemical reaction that takes place. The reason for this is because carbon dioxide is a greenhouse gas, and this transpires as a consequence. The release of greenhouse gases into the atmosphere occurs as a result of the heating of limestone (CaCO3) in the course of an industrial operation that results in the production of calcium oxide. These gases are a contributor to the warming of the planet. The production of cement involves a number of factors, one of which is the combustion of fossil fuels, which results in an additional emission of five percent more carbon dioxide. The proportion of this emission is what is being measured. (2010) According to Fairbairn et al. Because of these emissions, there has been a discernible rise in the temperature that is generally accepted to be the norm throughout the whole world. This, in turn, has resulted in the phenomenon that is now often referred to as global warming. Because of its role in the production of fine aggregate, natural sand is considered an essential component of concrete. This is because it is utilized in the process of making concrete. Therefore, the removal of sand from its natural source has an effect on the natural resources that are now available to be used. Additionally, the use of river sand as a fine aggregate is a contributor to the extraction of riches from river beds, the modest fall in water levels, the erosion of land in close proximity to rivers, and the damage that is caused to bridge structures. The rise in the nation's population that cannot be maintained is a result of all of these causes, which contribute to the problem. This has resulted in the search for alternatives to natural aggregates and cement taking on a greater sense of relevance and urgency as a consequence of the fact that it has taken on a bigger sense of significance.

A. Objective of the Project

1) The purpose of this research is to conduct an analysis of the concrete strength that was created by partly substituting fine particles with ash derived from sugarcane bagasse and Waste Glass (as a partial replacement of cement).
2) The purpose of this research is to establish whether a concrete mix that consists of ash derived from sugarcane bagasse and WASTE GLASS can be efficiently worked.
3) The purpose of this investigation is to investigate the impact that higher temperatures have on the strength of concrete that was made using ash derived from sugarcane bagasse and Waste Glass.

II. PROPERTIES OF MATERIALS

A. Cement

The powdered substance known as cement is produced when lime and clay are subjected to the calcination process. In the procedure, cement is produced as a byproduct. The term "cement" is often used to refer to cement. Cement manufacture requires the use of a large variety of different minerals, some of which include limestone, shells, chalk or marl, shale, clay, slate, blast furnace slag, silica sand, and iron ore, amongst others. In addition to this, the production of cement requires the utilization of a wide range of minerals.

Table1: Properties of ordinary Portland cement

Sr. No.	Characterizing	Value Obtained experimentally	Values specified byBIS: 8112-2013
1.	Specific Gravity	3.15	-
2.	Standard consistency	31%	-
3.	Initial Setting time	135 minutes	30 minutes (minimum)
4.	Final Setting time	220 minutes	560 minutes (maximum)
5.	Compressive Strength3 days 7 days 28 days	25.54 N/mm^2 36.12 N/mm^2 49.53 N/mm^2	23 N/mm^2 33 N/mm^2 43 N/mm^2

B. Coarse Aggregates

Forty millimeters, twenty millimeters, sixteen millimeters, and ten millimeters are the nominal sizes of the individual pieces that are used to split the coarse aggregate into subcategories. These subcategories are based on the characteristics of the individual particles. These sizes range from the smallest to the largest, with the smallest being the smallest. Spherical aggregates, on the other hand, have a propensity to improve flow because of the significantly increased strength they possess.

Table 2: Properties of coarse aggregates

Colour	Grey
Shape	Angular
Maximum Size	20 mm
Specific Gravity	2.65
Water Absorption (%)	0.61
Fineness Modulus	6.61

C. Fine Aggregates

1) *Natural Sand:* Particulate matter of varying sizes that was formed as a consequence of the natural disintegration of rock and was later deposited by glaciers or flowing water. This material was produced as a result of the natural process of rock breaking down.
2) *Crushed Stone Sand:* Stone that has been reduced in size during the crushing process in order to produce fine aggregates.
3) *Crushed Gravel Sand:* Fine aggregates produced by crushing natural gravel.The aggregates' degree of harshness, medium fineness is defined by the average size of their fine particles. Coarse aggregates have larger fine particles than medium aggregates.

D. Sugarcane Bagasse Ash

India's main industry that contributes to the GDP of the nation is agriculture (GDP). Sugarcane farming, one of the most profitable agricultural products, is widespread throughout the country. According to the Food and Agriculture Organization (FAO), Brazil is the world's greatest producer of sugarcane, with India coming in second.

E. Waste Glass

The substance commonly known as glass is a non-living material that exhibits a wide range of morphological properties. This material cannot be recycled because waste glass (WG) cannot be recycled in its entirety. This is due to the impracticality of recycling used glass. The use of this waste material is crucial to creating an environment that is kind to the environment. This is a result of the previously mentioned factors. The WG was collected during the study project from a variety of dispersed sites across the city.

Table 3: Physical properties of WG

Color	Mixed color
Particles shape and texture	Angular and irregular
Specific Gravity	2.65

F. Water

Since it acts as a catalyst for the chemical process that occurs when cement and water are mixed to create concrete, water is a crucial component of this material. Since water is essential to the creation of concrete, it is also a significant component of this material. The water used for mixing and curing should not include any unwanted organic components or inorganic elements in excess due to the significance of these operations.

G. Design Mix

One of the areas covered by this inquiry is the creation of a concrete mix suitable for M20-grade concrete. To standardize the process of creating concrete mixtures, guidelines included in the codes BIS: 10262-2009 and BIS: 456-2000 have been implemented. This was carried out to guarantee that the procedure yields reliable outcomes.

Table 4: Proportion of different materials

Water	Cement	Fine aggregates	Coarse aggregates
186 liters	338.18 kg	747.23 kg	1142.87 kg
0.55	1	2.21	3.38

III. RESULTS AND DISCUSSION

A. Workability of Concrete

Based on the information that was provided, it was found that an increase in the percentage of SCBA resulted in a reduction in the workability of concrete, but an increase in the percentage of WG resulted in a significant improvement in workability. The comparison of the two situations led to the discovery of these conclusions from the analysis. When the percentage of SCBA replaced by cement rises from 0% to 40%, the slump value drops from 110 millimeters to 91 millimeters. This is due to the fact that SCBA partials have a rough and angular form.

The reason for this is because SCBA partials have a surface that is rough and angular. When the proportion of WG was raised from 0% to 40%, on the other hand, the slump values climbed quite quickly, rising from 110 mm to 133 mm. This was the case when the percentage of WG was increased.

After doing research, it was discovered that the combination of 0% SCBA replacement and 40% WG produced the highest slump value. It is around 133 millimeters. The majority of the blame for this situation may be placed on the fact that the WG does not possess a structure that is permeable.

Table 5: Test results for workability of concrete

Mix	SCBA (%)	WG (%)	Slump(mm)
S1	0	0	110
S2	5		107
S3	10		103
S4	15		95
S5	20		91
S6	0	10	112
S7	5		104
S8	10		101
S9	15		95
S10	20		90
S11	0	20	117
S12	5		111
S13	10		108
S14	15		99
S15	20		97
S16	0	30	127
S17	5		119
S18	10		114
S19	15		105
S20	20		103
S21	0	40	133
S22	5		132
S23	10		123
S24	15		121
S25	20		119

B. *Compressive Strength of Concrete*

The compressive strength of each mix was measured at 14, 28, and 56 days. The findings were compared to each other based on the different amounts of WG that were replaced with fine aggregates and SCBA that were replaced with cement. The fact that the WG and SCBA were present in varying amounts served as the foundation for the findings. The results of these tests were examined in connection with each other. There are three different possibilities for curing times: 14 days, 28 days, and 56 days. Data on average compressive strength and percentage of loss are shown in Tables 4.19 and 4.20, respectively. These tables provide the data corresponding to the different degrees of replacement for SCBA (0%, 5%, 10%, 15%, and 20%) and WG (0%, 10%, 20%, 30%, and 40%) at the conclusion of each of these time periods. Figures 4.2 through 4.4 demonstrate how both waste products affected the material's compressive strength after 14, 28, and 56 days of curing, respectively. This persisted throughout the duration of the cure procedure. These figures demonstrate the magnitude of the influence that these waste products have.

Table 6: Test results for average compressive strength of concrete

Mix	SCBA (%)	WG (%)	Average compressive strength (N/mm²) of concrete for different curing days		
			14 days	28 days	56 days
S1	0	0	23.01	27.35	32.10
S2	5		23.63	28.41	33.44
S3	10		24.06	29.01	33..99
S4	15		23.33	27.86	32.42
S5	20		22.84	26.93	31.81
S6	0	10	22.87	27.10	31.93
S7	5		23.51	28.17	33.28
S8	10		23.92	28.79	33.86
S9	15		23.21	27.65	32.32
S10	20		22.71	26.74	31.61
S11	0	20	22.43	26.55	31.23
S12	5		23.05	27.59	32.64
S13	10		23.53	28.19	33.15
S14	15		22.73	27.11	31.42
S15	20		22.29	26.11	30.84
S16	0	30	21.65	25.79	30.14
S17	5		22.25	26.83	31.45
S18	10		22.68	27.21	32.00
S19	15		21.99	26.28	30.49
S20	20		21.46	25.68	30.10
S21	0	40	21.14	24.80	29.17
S22	5		21.79	25.84	30.49
S23	10		22.23	26.50	31.04
S24	15		21.44	25.27	29.56
S25	20		20.96	24.36	29.30

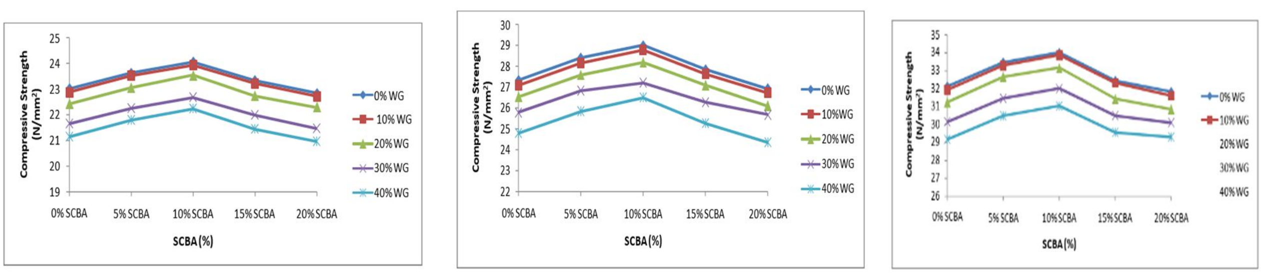

Figure 1: Compressive strength of concrete with different replacement levels ofcement with SCBA and fine aggregates with WG at 14, 28 and 56 days

C. Compressive Strength of Concrete at Elevated Temperature

Throughout the experiment, the compressive strength was tested at two different temperatures: room temperature and a temperature higher than that in intensity. The compressive strength was measured at both temperatures. It remains unchanged no matter what sort of concrete mix is used, both at room temperature and after boiling at 150, 300, and 560 degrees Celsius, respectively. No matter what sort of concrete mix is being utilized, this is true. The strength of concrete with 0% substitution of SCBA and WG was 81.0%, 84.0%, and 39.1% of its non-heated counterpart when heated to 150 degrees Celsius, 300 degrees Celsius, and 560 degrees Celsius, respectively.

This was the state of affairs when the concrete was heated. The concrete mixes from SCBA and WG both showed a trend that was virtually the same. This feature revealed the two-fold basic difference. The material's compressive strength declined less when heated to 1500 degrees than when heated to other temperature ranges, in comparison to the amount that was lost when the material was heated to other temperature ranges. The degree of replacement when 20% of the WG and 20% of the SCBA were replaced caused the most reduction in strength. This was the moment when the substitution took place. This was the state observed in relation to the different levels of replacement.

Table 7: Residual compressive strength of concrete mixes at different temperature

Mix	SCBA (%)	WG(%)	Residual compressive strength (N/mm²) at different temperature ranges			
			Room Temperature(R.T.)	150°C	300°C	560°C
S1	0	0	29.35	26.71	24.66	11.45
S2	5		30.26	26.93	25.11	12.41
S3	10		31.38	28.86	26.36	13.18
S4	15		30.22	26.59	24.78	12.09
S5	20		29.02	26.12	24.09	11.32
S6	0	10	29.14	26.19	23.63	11.30
S7	5		30.08	26.10	25.17	12.12
S8	10		31.14	27.12	26.25	13.01
S9	15		29.99	26.66	24.62	11.96
S10	20		28.79	25.73	24.03	11.17
S11	0	20	28.64	25.86	23.34	10.88
S12	5		29.61	26.20	25.67	11.99
S13	10		30.64	27.91	25.82	12.74
S14	15		29.52	25.94	23.94	12.57
S15	20		28.29	24.44	23.70	11.40
S16	0	30	27.58	24.24	23.33	10.97
S17	5		28.46	25.18	23.28	11.12
S18	10		29.29	26.21	23.75	11.80
S19	15		28.44	25.68	23.40	10.77
S20	20		27.32	24.12	22.97	10.40
S21	0	40	26.91	23.62	22.01	10.62
S22	5		27.85	24.20	22.92	11.50
S23	10		28.99	25.16	24.20	12.20
S24	15		27.73	24.43	23.37	11.42
S25	20		26.53	23.79	22.04	10.58

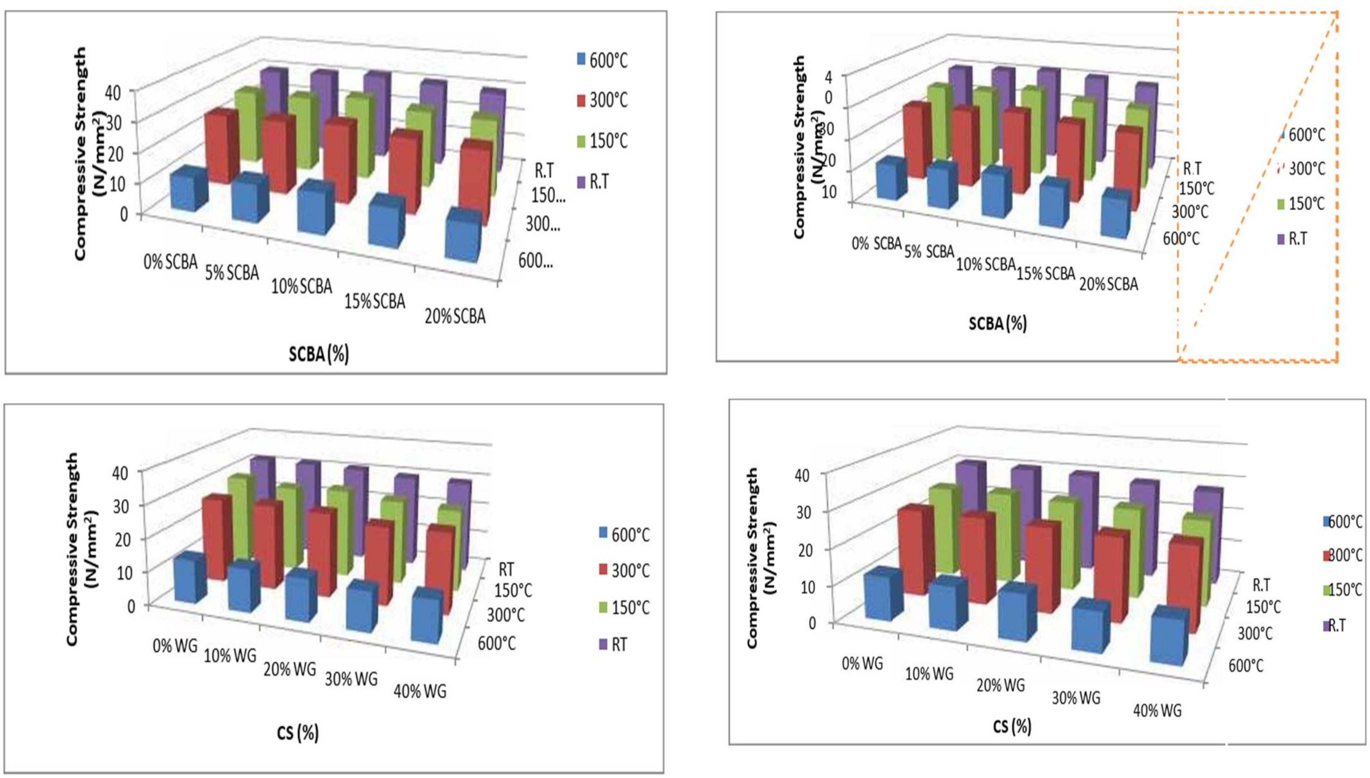

Figure 2: Compressive strength of concrete at different temperature ranges withdifferent replacement levels of fine aggregates and cement with WG and SCBA.

IV. CONCLUSIONS

There are three characteristics of concrete that are explored in this study: the workability characteristic WG, the strength characteristic WG, and the thermal stability of concrete, which includes SCBA and WG. One of the factors that determines how easily concrete can be worked with is the degree to which it can be shaped into different shapes..

1) It is more difficult to deal with concrete that has a higher proportion of SCBA than concrete that does not. This is because increasing that amount makes the concrete harder to deal with. Alternatively, if more WG is being replaced at the same time, the slump value will also grow. Slump values are used to describe this phenomenon, which is sometimes referred to as an increase in workability. Because of this, the slump will have a higher value.
2) The slump values dropped from 110 millimeters to 91 millimeters when the SCBA ratio grew from 0% to 20%. This was a notable decline. On the other hand, when the amount of WG is increased from 0% to 40%, workability begins to improve, and measures increase from 110 to 133 millimeters during this period. This is a result of the measurements growing as WG increases.
3) At every curing age, the concrete's compressive strength increases in proportion to the amount of SCBA present in the mixture. There is a correlation between the two, which explains why this link occurs. It has been shown that a 10% SCBA increases compressive strength the most; however, strength begins to decrease when this point is reached. Should twenty percent of the SCBA be removed, there will be a discernible decrease in the material's compressive strength.
4) The concrete's overall compressive strength decreases as finer particles are added to the mixture in lieu of coarse aggregates. The replacement is the cause of this. The reason this is the case is because fine particles are less dense than coarse aggregates. The total strength of each replacement level decreases with the number of children in a population with special needs (WG). This is a result of the growing population of kids with special needs.
5) It has been shown that integrating 10% SCBA and 20% WG improves results over the complete curing age range without noticeably lowering aggregate strength. The fact that the results were more appropriate serves to illustrate this. The fact that the compressive strength value is around 28.19 after 28 days serves as an example of this.
6) To provide superior strength and acceptable workability, the most necessary combination is 10% SCBA and 10% WG. Additionally, this combination saves costs by 5.7%. The reason for this is that it maintains the same level of workability while reaching a stronger degree than the mix that served as a reference. This is the cause of the current state of affairs.
7) Raising the temperature will not enhance the thermal characteristics of concrete in any manner for either WG or SCBA. This occurs as a result of the already-high temperature. The results show that there is a significant drop in the material's compressive strength as the temperature is elevated.
8) Even after being heated to a very high temperature of 1500 degrees Celsius, the material's strength is only marginally diminished. Even after the material has been heated, this remains the case. This means that the percentage might be anything from 8.0 to 13.6% of the total. After the concrete was heated to a temperature of 300 degrees Celsius, its size was seen to have decreased.
9) The same as around 18.9% of the whole amount The strength of concrete with internal fractures begins to decrease when the temperature reaches 560 degrees Celsius. Concrete that is left in the water for a lengthy period of time will lose around 56% of its strength.

REFERENCES

[1] Behnood A and Ghandehari M (2009) Comparison of compressive and splitting tensilestrength of high-strength concrete with and without polypropylene fibers heated to high temperatures. Fire Saf J 44:1015-22.
[2] BIS: 10262-2009: Recommended guidelines for concrete mix design, Bureau of Indian Standard, New Delhi-2004.
[3] BIS: 1199-1959 (Reaffirmed 2004): Methods of Sampling and Analysis of Concrete, Bureau of Indian Standard, New Delhi-1999.
[4] BIS: 2386 (Part I)-1963(Reaffirmed 2002): Methods of Test for Aggregates for Concrete, Bureau of Indian Standard, New Delhi-1963.
[5] BIS: 383-1970 (Reaffirmed 2002): Specification for Coarse and Fine Aggregates from Natural Sources for Concrete, Bureau of Indian Standard, New Delhi-1997.
[6] BIS: 4031 (Part 4, 5&6)-1988: Methods of Physical Tests for Hydraulic Cement, Bureau of Indian Standard, New Delhi-1988.
[7] BIS: 456-2000(Reaffirmed 2005): Code of practice- plain and reinforced concrete, Bureau of Indian Standard, New Delhi-2000.
[8] BIS: 516-1959 (Reaffirmed 2004): Methods of tests for strength of concrete, Bureau of IndianStandard, New Delhi-2004.
[9] BIS: 8112-2013: Specification for 43 grade Ordinary Portland Cement, Bureau of Indian Standard, New Delhi-2005.
[10] Bishr H A M (2008) Effect of Elevated Temperature on the Concrete Compressive Strength. Int Confe Constr Build Technol. Pp 217-20. Kuala Lumpur, Malaysia.
[11] Chusilp N, Jaturapitakkul C and Kiattikomol K (2009) Utilization of bagasse ash as a 84pozzolanic material in concrete. Constr Build Mater **23**:3352–58.
[12] Cordeiro G C, Filho R D T and Fairbairn E M R (2010) Ultrafine sugarcane bagasse ash: High potential pozzolanic material for tropical countries. IBRACON Struct Mater **3**(1):50-67.

[13] Cordeiro G C, Filho R D T, Tavares L M and Fairbairn E M R (2008) Pozzolanic activity and filler effect of sugar cane bagasse ash in Portland cement and lime mortars. Cem Concr Compos **30**: 410–18.
[14] Fairbairn E M R, Cordeiro G C, Toledo Filho R D, Silvoso M M, Paula T P and Americano BB (2010) Durability of concretes containing sugar cane bagasse ash http://www.rilem.org/gene/main.php?base=500218&id_publication=70&id_papier=7851 (accessed on 22 July 2014).
[15] Fairbairn E M R, Cordeiro G C, Toledo Filho R D, Silvoso M M, Paula T P and Americano BB (2012) Evaluation of partial clinker replacement by sugar cane bagasse ash: CO_2 emission reductions and potential for carbon credits. IBRACON Struct Mater J **5**(2):229-51
[16] Ganesan K, Rajagopal K and Thangavel K (2007) Evaluation of bagasse ash assupplementary cementitious material. Cem Concr Compos **29**:515–24.
[17] Ghazi O M (2013) The Effect of Elevated Temperature of Compressive Strength of SteelFiber Concrete. J Babylon Univ Eng Sci **21**(3):1006-12.
[18] Husem M (2006) The effects of high temperature on compressive and flexural strengths of ordinary and high-performance concrete. Fire Saf J **41:**155-63.
[19] Ismail M, Ismail M E and Muhammad B (2011) Influence of elevated temperatures on physical and compressive strength properties of concrete containing palm oil fuel ash Constr Build Mater **25**:2358–64.
[20] Janjaturaphan S and Wansom S(2010) Pozzolanic activity of industrial sugarcane bagasseash. Suranaree J Sci Technol **17**(4):349-57.
[21] Srikanth N, Experimental Investigation on Strength and Toughness Properties of Self Compacting Concrete Mineral Admixtures, Test Engineering Management, March - April 2020 ISSN: 0193-4120 Page No. 17246 – 17253.
[22] Srikanth N, et.al, Mechanical and Durability Properties of Flyash Geopolymer Concrete Using Granite Waste, The International journal of analytical and experimental modal analysis, ISSN NO:0886-9367, Volume XII, Issue VII, July/2020, Page No:2223-2230.
[23] N.Srikanth, et.al, Experimental Study on Self Healing Concrete, The International journal of analytical and experimental modal analysis, ISSN NO: 0886-9367, Volume XIV, Issue VI, June/2022, Page No : 1288-1296.
[24] Dr. K Naga Sreenivasa Rao, et.al, Utilization of fly ash and Baggage ash in light weight concrete, The International journal of Analytical and experimental modal analysis, ISSN 0886-9367, volume XV, Issue VI, June/2023
[25] Dr. K Naga Sreenivasa Rao, et.al, Experimental Investigation on partial replacement of fine aggregate with stone dust in concrete, The International journal of Analytical and experimental modal analysis, ISSN 0886-9367, volume XV, Issue VI, June/2023
[26] Dr. K Naga Sreenivasa Rao, et.al, An investigational work on mechanical properties of low calcium flyash based geopolymer concrete with GGBS, IJAEM, Volume 5, Issue 4, 2023, ISSN 2395-5252, PP 1103-1112.
[27] Dr. K Naga Sreenivasa Rao, et.al, Experimental study on strength of concrete by using sand stone dust, IRJET, Volume 09, Issue 12, ISSN 2395-005, Dec-2022, PP-754-760, PP 583-588.
[28] K Naga Sreenivasa Rao, et.al, Strength Peremenation and nano studies an flyash based magnetic water concrete, ISJER, Volume 7, Issue 6 PP 1088-1093, 2018, ISSN 2319-8885
[29] K Naga Sreenivasa Rao, et.al, Impact of strength properties on concrete by relatively replacement of cement with clay and flyash, IJITR, Volume 5, Issue 3, ISSN 2320-5547, PP 6376-6379, 2017
[30] K Naga Sreenivasa Rao, et.al, Experimental investigation on the strength properties of eco-friendly concrete, JICR, Volume 12, Issue 7, ISSN 0022-1945, PP 1171-1175
[31] N. Srikanth, et.al, Study on Different Internal Curing Agents on Properties Self-Compacting Concrete, The International journal of analytical and experimental modal analysis, ISSN NO: 0886-9367, Volume XV, Issue VI, June/2023, Page No: 254-262
[32] Raju, B. G., & Rao, K. N. S. (2015). Characterization of fibre reinforced bituminous mixes. International Journal of Science and Research (IJSR), 4(12), 802-806.
[33] Kiranmai, Y., & Rao, K. N. S. (2018). Strength permeation and nano studies on fly ash based magnetic water concrete. International Journal of Scientific Engineering and Technology Research, 7(6), 1088-1093.
[34] Pandey, S., Singh, N. K., Rao, K. N. S., Yadav, T. C., Sanghavi, G., Yadav, M., ... & Nayak, J. (2020). Bacterial production of organic acids and subsequent metabolism. Engineering of Microbial Biosynthetic Pathways, 153-173.
[35] KUMAR, M. C. N., & RAO, K. N. S. Moderate Density Fly Ash Blend to Erect Geopolymer Binders.
[36] PRASAD, U., & RAO, K. N. S. AN EXPERIMENTAL INVESTIGATION ON UTILIZATION OF LOW DENSITY TESLON WASTE IN THE MANUFACTURING OF PAVER BRICK.
[37] GOPI, G. V., & RAO, K. N. S. STUDY OF STRENGTH PROPERTIES OF CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH SILICAFUME, METAKAOLIN AND GGBS.
[38] Saikrishna, P., & Rao, K. N. S. An Investigational Work on Mechanical Properties of Low Calcium Fly Ash Based Geopolymer Concrete with GGBS.
[39] Srikanth N, Experimental Investigation on Strength and Toughness Properties of Self Compacting Concrete Mineral Admixtures, Test Engineering Management, March - April 2020 ISSN: 0193-4120 Page No. 17246 – 17253.