Use of Industrial and Agricultural Solid Wastes As Source of Supplementary Cementitious Materials To Produce Eco-Efficient Concrete

CH. Krupanidhi[1], B. Ganesh[2]
[1]Dept of Civil Engineering
[2]Assistant Professor, Dept of Civil Engineering
[1, 2] Lenora College of Engineering, Rampachodavaram

Abstract- *The making of Ordinary Portland Cement involves enormous size of energy consumption, leading to mammoth discharge of carbon dioxide to the air. This is being great task to the sustainable advance. Cement being the major constituent in building construction, contributes about 7-8% to the emission of green house gases. The environmental impact of carbon dioxide emission due to production of Portland cement can be reduced by partial replacement of cement with supplementary cementitious materials. Sugarcane bagasse ash (SCBA) and ground granulated blast-furnace slag (GGBS) are waste materials comprising pozzolanic properties but their disposal is causing acute environmental setbacks. The utilization of industrial and agricultural waste product in concrete has been a major step on waste reduction. Ceramic waste and Sugarcane bagasse ash can by effectively used in concrete as partial replacement of Cement because of their high content of silica and pozzolanic properties which plays an important role in achieving high strength and durability in concrete. This Study describes the feasibility of using the ceramic Waste powder and GGBS in concrete production as partial replacement of cement to reduce disposal and pollution problems and detecting workability, compressive strength and tensile strength on comparison with conventional concrete.*

Keywords**-** Sugarcane Bagasse ash (SCBA), GGBS, compressive strength, split tensile strength test, water absorption test.

I. INTRODUCTION

Cement is the most important ingredient of the concrete which produces carbon dioxide which is May harmful. So it is a main concern to reduce the usage of cement. The increase in cost of the cement not only increases the budget of a construction but also poses a serious threat to the country's development. It is identified that some industrial waste products like Bagasse Ash are having some cementitious and siliceous properties. So the use of the industrial and agricultural wastages in concrete partly as cement replacement, reduce the cost of making concrete, also causes improvement in the properties of concrete and reduce environmental pollution.

Sugarcane Bagasse ash is a byproduct of the sugar factories found after burning sugarcane Bagasse which itself is found after the extraction of all economical sugar from sugarcane. The disposal of this material is already causing environmental problems around the sugar factories. Due to the boost of the construction activity in the country, a huge shortage is created in most of the construction materials especially cement, resulting in steady increase of price.

Ground Granulated Blast Furnace Slag (GGBS) is a byproduct of the steel industry. Blast furnace slag is defined as "the non-metallic product consisting essentially of calcium silicates and other bases that is developed in a molten condition simultaneously with iron in a blast furnace." In the production of iron, blast furnaces are loaded with iron ore, fluxing agents, and coke. When the iron ore, which is made up of iron oxides, silica, and alumina, comes together with the fluxing agents, molten slag and iron are produced. The molten slag then goes through a particular process depending on what type of slag it will become. Air cooled slag has a rough finish and larger surface area when compared to aggregates of that volume which allows it to bind well with portland cements as well as asphalt mixtures. GGBS is produced when molten slag is quenched rapidly using water jets, which produces a granular glassy aggregate.

The Fibre Reinforced Concrete (FRC) is a composite material essentially consisting of concrete reinforced by random placement of short discontinuous and discrete fine fibers of specific geometry. It is now well established that the addition of short, discontinuous fibers plays an important role in the improvement of the mechanical properties of concrete. In the FRC, the fibers help to transfer load to the internal micro cracks. In the recent past, many developments have been made in the fiber reinforced concrete. Also it has been recognized that addition of small, closely spaced and uniformly dispersed fibers to concrete would act as crack arrester and would substantially improve the properties and can cause a change in the failure mode under compressive deformation from brittle to pseudo-ductile, thereby imparting a degree of toughness to concrete. GGBS can be used as partial replacement of cement for better performance and it helps in producing high strength concrete because of the total participation in hardening process. Fibres are generally used to resist cracking and to assist in strengthening of concrete.

This Study describes the feasibility of using the ceramic Waste powder and GGBS in concrete production as partial replacement of cement to reduce disposal and pollution problems and detecting workability, compressive strength, and tensile strength on comparison with conventional concrete.

II. REVIEW OF LITERATURE

The beneficial reuse of waste products from industrial and agriculture seems to be the new trend now. Baggase is the by-product of sugar cane milling. About 33% of the baggage produced supplies the fuel for the generation of steam (Bilba et al 2003). According to ahmad and sheikh (1992), the physical and chemical properties of sugar cane baggage ash as found to satisfactory requirements for pozzolana. This makes it good for replacing by cement partially. Researchers has said that the usage of sugar cane baggage ash as a partial replacement of cement. A lot of work has been done to explore the benefits of using pozzolanic materials in making and enhancing the properties of concrete. Literature review of Bagasse ash and GGBS is presented in the following sections.

Mr. U.R. Kawade et al., had studied on “Effect of use of Bagasse ash on Strength of Concrete” they had Chemically and Physically Characterized and partial replaced in the ratio of 0%, 10%, 15%, 20%, 25% and 30% by weight of cement in concrete. The results show that the SCBA concrete had significantly higher compressive strength compared to that of the concrete without SCBA. It is found that the cement could be advantageously replaced with SCBA up to maximum limit of 15%. Although the optimal level of SCBA content was achieved with 15% replacement. Partial replacement of cement by SCBA increases workability of fresh concrete, therefore use of Super Plasticizer is not essential.

Urooj Masood et al., studied the behaviour of mixed fibre reinforced concrete exposed to acids. A mixture 75% glass and 25% steel fibres were used in mixed fibre reinforced concrete and cubes were casted and cured for 30, 60, 90, 120 and 180 days in acids and sodium sulphate. Test specimens were tested for weight loss and denseness of concrete of exposed and unexposed specimens at all the ages and compressive strength at 180 days. They concluded that the resistance towards the sulphuric acid attack was maximum when 100% steel fibres was used when compared to other fibres and without any fibres. Mixed fibre reinforced specimens and 100% steel fibre reinforced specimens exhibited more resistance towards the attack of sulphuric acid.

Sangeetha,P.S.Joanna (2014) studied the structural behavior of RC beams with GGBS concrete. The results obtained from experiments states that the ultimate moment capacity of GGBS was less than the controlled beam when tested at 28 days, but it increases by 21% at 56 day. The measured crack width at service load ranged between 0.17 to 0.20mm and is within the limits (IS456-2000). The structural behavior of RC beam with GGBS resulted the typical behavior of RCC beams and there increase in load carrying capacity of GGBS beams with age. The structural behavior of Reinforced concrete beams with GGBS resembles the typical behavior of Reinforced cement concrete beams and there is increase in load carrying capacity of GGBS beams with age. Hence results of this investigation suggest that concrete with 40% GGBS replacement for cement could be used for RC beams. Having cementing properties, which can be added in cement concrete as partial replacement of cement, without compromising on its strength and durability, which will result in decrease of cement production thus reduction in emission in green house gases, in addition to sustainable management of waste

III. MATERIALS AND METHODS

The experimental investigation work is started with various tests on the constituent materials. The constituent materials are given below.

1. Cement
2. Coarse aggregate
3. Water
4. Bagasse ash
5. Ground granulated blast furnace slag.

Cement

Ordinary Portland Cement (OPC) was used in the experimental work which is conforming to I.S 4031-1988.The O.P.C is classified into three grades, those are 33grade, 43grade and 53 grade, depending upon the strength of the cement in this experiment 43grade cement is used.

Fine Aggregate

Fractions from 4.75 mm to 150 microns are termed as fine aggregate. Locally available river sand passed through 4.75mm IS sieve is applied as fine aggregate conforming to the requirements of IS 383:1970.

Coarse Aggregate

The crushed aggregates used were of 20mm nominal maximum size. Aggregate most of which is retained on 4.75-mm IS Sieve and containing only so much finer material as is permitted for the various types described in this standard.

Bagasse ash

In this project sugarcane bagasse ash was collected from Divili in East Godavari district. The combustion yields ashes containing high amounts of unburned matter, silicon and aluminum oxides as essential elements. These sugarcane bagasse ashes (SCBA) have been chemically, physically and mineralogical characterized, in order to evaluate the possibility of their use as a cement-replacing material in the concrete industry.

GGBS

Concrete made with ground granulated blast furnace slag cement sets more slowly than concrete made with ordinary Portland cement, depending on the amount of ground granulated blast furnace slag in the cementitious material. For the present study the GGBS was brought from the Visakhapatnam steel plant by using wet bags

IV. MIX DESIGN

The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible, is termed the concrete mix design. The proportioning of ingredient of concrete is governed by the required performance of concrete in two states, namely the plastic and the hardened states. If the plastic concrete is not workable, it cannot be properly placed and compacted. The property of workability, therefore, becomes of vital importance. Percentage dosage of super plasticizer was fixed as per the mix design method described in IS 10262- 2009. Mix proportion was arrived through various trial mixes. The grade of concrete prepared for the experimental study was M35.

TABLE 4.1 shows the materials proportion

Water	Cement	Fine Aggregate	Coarse Aggregate
192	330.00kg	693.43kg	1232.78kg
0.40	1.0	2.10	3.73

The result of the experimental investigation on sugar cane bagasse ash and GGBS concrete where Sugar cane bagasse ash and GGBS has been used as partial replacement of cement in concrete mixes. On replacing cement with different percentages of SCBA the workability, compressive strength is studied and then to the optimum percentage of sugar cane bagasse ash ,keeping SCBA constant the Ground granulated blast furnace slag is replaced and studied the compressive strength, flexural strength for different mixes and then studied the tensile strength with addition of steel fibres of various percentages..

V. TESTS ON FRESH CONCRETE

5.1 WORKABILITY OF CONCRETE

Workability of concrete is a composite property which depends on many parameters of the components of the concrete. Workability for the fresh concrete was tested by slump cone test method. The following are the results of fresh concrete using slump cone test for various percentages of replacement of cement by SCBA. Since the controlled concrete (M 35) is designed for 75 mm average value of slump value .Therefore a deviation of ±10 % in Slump value is allowed while fixing the slump value in individual samples accordingly i.e. slump value lies between 68- 83mm.However to obtain 75 mm (average) slump value changes were made in w/c ratio for concrete mixes with specified cement replacements.

5.1.1 Variation of slump values for percentage replacement of bagasse ash

Slump test was carried out to measure the workability of various mixes. The workability of various mixes was assessed as per the IS 1199:1959 specification.

Figure 5.1, Table 5.1 shows that the variation of slump values with different percentage replacement of bagasse ash. Slump Value is get increases with increases with increase in replacement of bagasse ash.

TABLE 5.1 shows the Variation of Slump Values

Sample designation	% Replacement of SCBA in cement	Slump(mm)
MIX 0	0	75
MIX 1	5	80
MIX 2	10	83
MIX 3	15	87
MIX 4	20	98
MIX 5	25	110

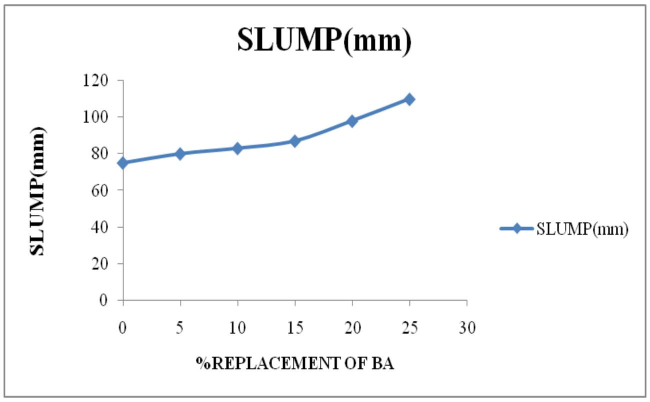

Fig 5.1: Plot shows the Variation of Slump Values for % replacement of BA.

VI. TESTS ON HARDENED CONCRETE

6.1 VARIATION OF COMPRESSIVE STRENGTH FOR DIFFERENT MIXES

Compressive strength of concrete replaced with bagasse ash for curing period of 7-days, 14-days and 28-days respectively and TABLE 6.1 shows the summarized Compressive strength Results for different curing periods–M35 grade.

Table 6.1: Evaluating the optimum % of bagasse ash

BA (%)	7 days	14 days	28 days
0	25.63	34	37.49
5	23.67	35.46	39.08
10	22.81	37.08	40.21
15	21.45	34.13	37.15
20	19.82	27.43	32.08

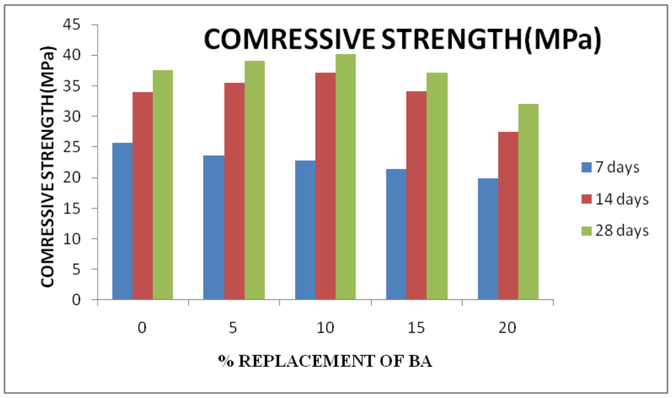

Fig 6.1: Plot shows the Variation in Compressive Strength for % Replacement of BA

The strength of 10% sugarcane bagasse ash concrete is more than 5% sugar cane bagasse ash concrete and strength of 5% sugar cane bagasse ash concrete is more than normal concrete. This shows that till 10% sugarcane bagasse ash concrete the strength increases while percentage of sugarcane bagasse ash increases. The strength of cubes having 10% sugar cane bagasse ash is almost equal to 15% sugar cane bagasse ash concrete.

6.2 VARIATION OF COMPRESSIVE STRENGTH FOR ADDITION OF GGBS TO OPTIMUM PERCENTAGE OF BAGASSE ASH

Compressive strength of concrete keeping 10% bagasse ash as constant and with different percentages of GGBS for curing period of 7-days, 14-days and 28-days respectively and TABLE 6.2 shows the summarized Compressive strength Results for different curing periods–M35 grade.

Table 6.2 shows the summarized Compressive strength Results for GGBS to optimum percentage of bagasse ash for curing periods

BAGASSE ASH + GGBS	7 days	14 days	28 days
10%BA+0%GGBS	22.81	37.08	40.21
10%BA+10%GGBS	24.81	39.61	42.5
10%BA+20%GGBS	26.64	40.5	43.91
10%BA+30%GGBS	28.7	41.91	45.12

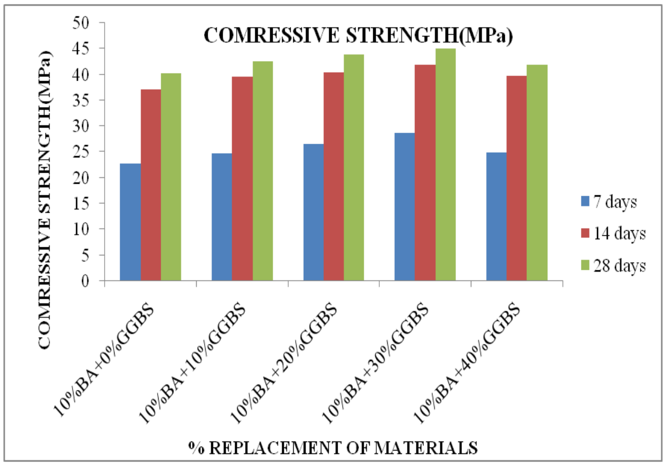

Fig 6.2: Shows the Variation in Compressive Strength for % Replacement of GGBS

6.3 EFFECT OF STEEL FIBER ON COMPRESSIVE STRENGTH USING BAGASSE ASH AND GGBS

Compressive strength of concrete keeping 10% bagasse ash and 30% GGBS as constant and with different percentages of steel fibre for curing period of 7-days, 14-days and 28-days respectively and TABLE 6.3 shows the summarized Compressive strength Results for different curing periods– M35 grade.

Table 6.3: Evaluation of optimum percentage of Steel fiber to the optimum percentage of bagasse ash and GGBS

BA+GGBS+SF	7 days	14 days	28 days
10%BA+30%GGBS+0%SF	28.7	41.91	45.12
10%BA+30%GGBS+1%SF	29.5	42.6	46.7
10%BA+30%GGBS+1.5%SF	31.2	43.2	48.1
10%BA+30%GGBS+2%SF	28.9	42.1	45.97

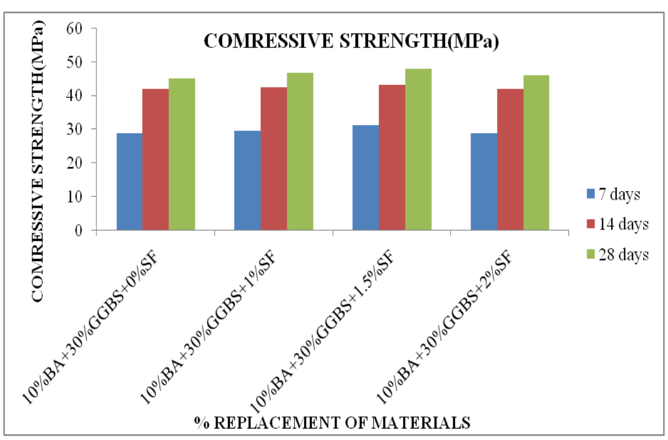

Fig 6.3 Plot shows the Variation in Compressive Strength for different percentages of steel fibres

6.4 EFFECT OF STEEL FIBER ON SPLITTING TENSILE STRENGTH USING BAGASSE ASH AND GGBS

The Split Tensile strength of the concrete mix for M-35 with partial replacement of cement by SCBA and GGBS respectively showed higher Strength against splitting after 7 , 14 and 28 days.

Split tensile strength of concrete keeping 10% bagasse ash and 30% GGBS as constant and with different percentages of steel fibre for curing period of 7-days, 14-days and 28-days respectively and TABLE 6.4 shows the summarized Split tensile strength Results for different curing periods– M35 grade.

Table 6.4 shows the effect of steel fiber on splitting tensile strength using bagasse ash and GGBS

BA+GGBS+SF	7 days	14 days	28 days
10%BA+30%GGBS+0%SF	2.1	2.79	3.8
10%BA+30%GGBS+1%SF	3.7	4.42	4.95
10%BA+30%GGBS+1.5%SF	4.1	4.91	5.63
10%BA+30%GGBS+2%SF	3.5	3.81	4.12

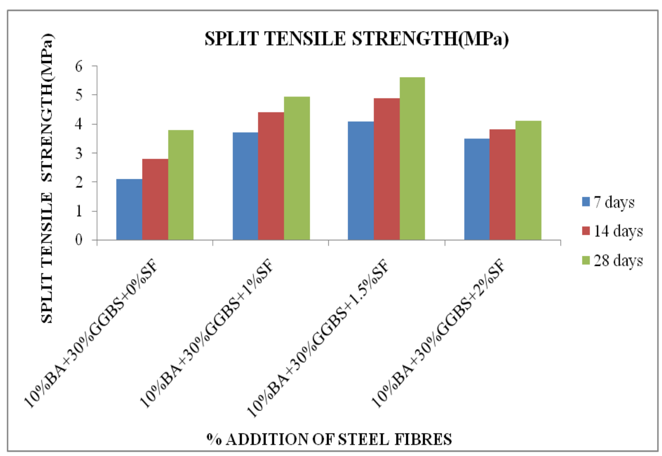

Fig 6.4: Plot shows the Variation in Split Tensile strength for different percentages of steel fibres

6.5 EFFECT OF STEEL FIBER ON FLEXURAL STRENGTH USING BAGASSE ASH AND GGBS

Flexural strength of concrete keeping 10% bagasse ash and 30% GGBS as constant and with different percentages of steel fibre for curing period of 7-days, 14-days and 28-days respectively and TABLE 6.5 shows the summarized Split tensile strength Results for different curing periods– M35 grade.

The Flexural strength of the concrete mix for M-35 with partial replacement of cement by SCBA and GGBS respectively showed higher Flexural Strength after 7 and 28 days. The 7 days and 28 days Flexural strength of mix with 10% partial replacement of Bagasse ash, 30 % replacement of GGBS and 1.5% of steel fibre showed higher strength compared to other mixes.

Table 6.5 shows the effect of steel fiber on splitting tensile strength using bagasse ash and GGBS

BA+GGBS+SF	7 days	14 days	28 days
10%BA+30%GGBS+0%SF	28.7	41.91	45.12
10%BA+30%GGBS+1%SF	29.5	42.5	46.12
10%BA+30%GGBS+1.5%SF	30.6	43.1	47.23
10%BA+30%GGBS+2%SF	29.3	42.3	45.6

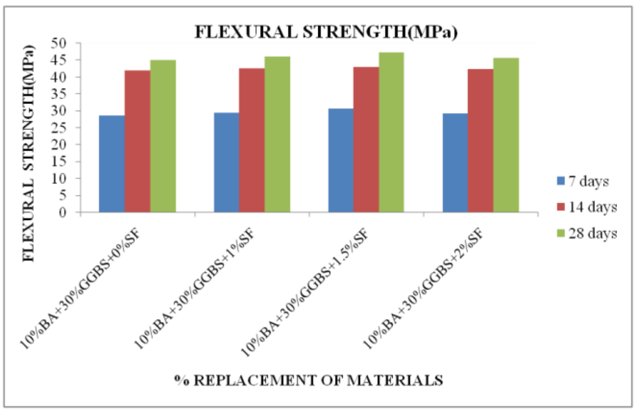

Fig 6.5: Plot shows the Variation in flexural strength for different percentages of steel fibres

From the results it is evident that with the increase of fibre content the tensile nature of the concrete also increases results in higher values compared to that of Plain concrete. It is concluded that the percentage increase in strength increases with the increase in percentage of fiber content. Also, from the results it is evident that compressive and flexural strength also increases with the increase of fiber content.

VII. CONCLUSIONS

The Conclusions and Recommendations that could be drawn from the results of this project and experiments are summarized and the use of Bagasse ash and GGBS as a cement replacing material in concrete production was studied and after the research work is done, the following conclusions were made:

- It has been observed that by the incorporation of SCBA & GGBS as partial replacement to cement in fresh and plain concrete increases workability when compared to the workability with reference to concrete made without SCBA & GGBS.
- SCBA concrete performed better when compared to ordinary concrete up to 10% replacement of sugar cane bagasse ash.
- The bond strength exhibited improvement with bagasse ash replacement level. A 7.2% increase in the strength was observed when compared with conventional concrete for 28 days. Increase of strength is mainly to presence of high amount of Silica in bagasse ash.
- The mix with replacement of cement with 10% SCBA and 30% GGBS has shown good strength properties like compressive and tensile and flexural strength. This may be due to the fact that the CSH gel formed at this percentage is of good quality and have better composition.
- The highest compressive strength value i.e. 45.12 MPa, was obtained for a mix having 10% bagasse ash and 30% GGBS.
- It is evident from the present investigation that the addition of steel fibers to concrete improve compressive strength, split tensile strength, flexural strength etc. of the mix.
- There was a 6.5% increase in the compressive strength and 48% increase in the tensile strength because of the high elastic modulus of steel fiber. Due to the high stiffness of Steel fibres, resulted in a significant enhancement in split tensile strength.
- The use of SCBA and GGBS combined is economic when compared to cement in concrete. Likewise saves a great deal of waste disposal problems and reduces the cement price rise and intensities of CO_2 release by the cement production. Also these materials make the concrete more sustainable, light weight and low energy emitting which is noble.

REFERENCES

[1] IS 456 (2000): Plain and Reinforced Concrete - Code of Practice .

[2] IS 10262 (2009): Guidelines for concrete mix design proportioning .

[3] K. Ganesan, K. Rajagopal, et al, “Evaluation of bagasse ash as supplementary cementitious material” Cement & Concrete Composites 29 515–524| March 2007.

[4] D. Suresh, K. Nagaraju, et al, “Ground Granulated Blast Slag (GGBS) In Concrete – A Review” IOSR Journal of Mechanical and Civil Engineering (IOSRJMCE),e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 12, Issue 4 Ver. VI | Aug. 2015.

[5] Shamila Habeeb,et al, “Strength and Durability Studies on Ternary Blended Concrete containing GGBS and Bagasse

ash" International Journal of Scientific & Engineering Research, Volume 5, Issue 7, ISSN 2229-5518| July-2014.

[6] Christina Mary V., et al, "Experimental investigation on strength and durability characteristics of high performance concrete using ggbs and msand" ARPN Journal of Engineering and Applied Sciences ISSN 1819-6608, Vol. 10, No. 11| June 2015.

[7] Dr. P. Srinivasa Rao et al., "Durability studies on steel fibre reinforced metakaolin blended concrete".

[8] P.N.Rao (2010) "High performance of concrete with GGBS" published in International journal of engineering, science & technology.

[9] S.P.Sangeetha, P.S.Joanna "flexural behavior of RC beam with partial replacement of GGBS, American journal of engineering research, volume 03, Issue No 01, 2014.