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Examining The Impact of Carbon Dioxide Emissions While Utilizing Ground-Granulated Blast Furnace Slag as A Partial Cement Replacement

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Abstract
Concrete has become an essential component of our life, and its use is growing rapidly. Portland cement is one of the primary ingredients of concrete. Significant amounts of CO_2 are released throughout the cement making process. As a result, scientists have begun looking for substitutes for cement in part. This paper's primary focus is on examining the behavior of M80 concrete when ground granulated blast furnace slag (GGBS) is used in place of some of the cement. Molten iron slag, a by-product of creating iron and steel, is quenched in water or steam in a blast furnace to create ground-granulated blast-furnace slag (GGBS), a glassy, granular substance that is subsequently dried and ground into a fine powder. GGBS is used in conjunction with regular Portland cement and/or other pozzolanic ingredients to create long-lasting concrete buildings. After seven and twenty-eight days of curing, the compressive and split tensile strengths of cubes and cylinders are tested. Flexure strength is also tested at 28 days.zero, ten , twenty, Thirty, forty, and fifty percent of the cement is replaced by GGBS. In this work, a water-to-cement ratio of 0.4 was used. According to the results of the experimental studies, for M80 grade cement, the ideal substitution of ground granulated blast furnace slag is 20%.
***Keywords**: ground granulated blast furnace slag, . Molten iron slag, pozzolanic ingredients*

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I.INTRODUCTION

Concrete has become an essential component of our lives in the modern world. The use of concrete is growing at an extremely rapid rate every day. Portland cement is one of the primary ingredients of concrete. Cement production and use have skyrocketed in parallel with the growing use of concrete.

Despite cement's remarkable binding qualities and suitability for use in concrete, the production of cement releases a significant quantity of CO_2. As a result, scientists are now looking for cost-effective and environmentally friendly cement substitutes. One of the various substitutes is ground granulated blast furnace slag, an industrial byproduct that replaces cement in concrete and gives it superior binding qualities. Supplementary cementious materials (SCMs) are the common term for this substitute [1-4]. Aggregates and fluid cement are bonded together to create concrete, a composite material that solidifies over time. For every ton of cement produced, an estimated 0.9 tons of carbon dioxide are discharged into the atmosphere. When iron is made, GGBS is a by-product, and the amounts of slag and iron that are produced are comparable. At a temperature of roughly 1500°C to 1600°C, the molten slag that results from feeding iron ore, coke, and limestone into the furnace floats above the molten iron. The remaining molten slag, which is primarily siliceous and aluminous residue, is quickly water-quenched once the molten iron is tapped off, forming a glassy granulate. GGBS is a glassy granulate that has been dried and ground to the necessary size.

1.1 OBJECTIVE

The primary goals of this research are

- To assess the performance of concrete by substituting ground granulated blast furnace slag in 10%, 20%, 30%, 40%, and 50% variations for some of the cement.

- to ascertain the concrete's split tensile and compressive strengths after seven and twenty-eight days of curing. Flexure strength at 28 days.

- The goal is to identify the best concrete mix based on GGBS.

II. LITERATURE REVIEW

Arvind Singh Gaur et al(2017) The purpose of this study is to assess the effectiveness of using marble slurry, a mineral additive, in concrete to partially substitute cement (OPC-43 grade) with ground-granulated blast-furnace slag and fine aggregate. Molten iron slag is quenched in steam or water to create GGBS, which is a glassy, granular substance that is subsequently dried and crushed into a fine powder. Additionally, one of the global environmental issues is marble slurry, a waste product from the marble industry. In this investigation, GGBS replaced up to 20% of the total weight of OPC (43-grade) and marble slurry replaced up to 40% of the fine aggregates. This study examines the concrete mixture's performance over seven and twenty-eight days in terms of the cube's compressive strength, the beam's flexural strength, and the cylinder's splitting strength. [5-7].

S.P. Kanniyappan et al (2016) Because of its natural cementing qualities, ground granulated blast furnace slag (GGBS), a waste product from the iron manufacturing sector, can be used in concrete in place of some of the cement. The design of self-compaction GGBS concretes based on the efficiency principle is attempted to be presented in this research. The technique was effectively acquired, and a suitable experimental study on self-compacting slag concretes was conducted to assess their strength and self-compatibility properties in both reinforced and unreinforced concrete. The purpose of this study is to experimentally examine the strength characteristics of Self-Compacting Concrete (SCC) made using OPC for a mixture of M40 grade concrete in which 40%, 50%, and 60% of the GGBS is replaced with OPC to ascertain the ideal replacement % that yields the highest compressive strength. The findings show that the suggested approach is for mixing mixtures with the greatest amount of GGBS substituted for cement. [8-10].

Table 1. Test Results on Cement

S. No.	Type Of Test	Values Obtained	Is Specifications
1.	Sieve analysis category	Zone I	IS 383 – 1970
2.	Specific Gravity	2.64	IS 2386 - 1963

Rajith M et al (2015) By using more industrial byproducts in our construction industry, we can lessen the environmental impact of pollution. This study examines how M30 concrete behaves when ground granulated blast furnace slag (GGBS) and granulated blast furnace slag (GBS) are used in place of some of the cement and fine aggregate. After 28 days of curing, the compressive, split tensile, and flexural strengths of cubes, cylinders, and beams are evaluated. The velocity of the ultrasonic pulse is determined using cubes. Cement and fine aggregate replacement percentages by GGBS and GBS are 20, 25, 30, and 25, 50, 75, respectively. This work uses a water-to-cement ratio of 0.45. It has been discovered that, in comparison to regular mix concrete, the strength of concrete can be increased by partially substituting GGBS for cement and GBS for sand. [11-14].

III. PRELIMINARY TEST RESULTS

A. **Tests on Cement**

Table 2. Test Results On Fine Aggregate

S. No.	Type of Test	Values Obtained	IS SPECIFICATIO NS
1.	Fineness Testby Sieving	97.2%	IS 269 – 1976
2.	Normal Consistencyof cement	33%	IS 4031
3.	Initial Setting time	36 Minutes	IS 4031
4.	Specific Gravity	3.15	IS 4031

B. **Test on Fine Aggregate**

Sand, the fine aggregate used in HPC, is graded appropriately to provide the lowest possible void ratio. Fineness of river sand that complies with IS: 383 zone I. Sand was examined using IS: 2386.

C. **Tests on GGBS**

In this work, GGBS of 120 Grade, which complies with IS 12089-1987, was used.

Table 3. Test Results on Ggbs

S. No.	Type of Test	Values Obtained	IS SPECIFICATIONS
1.	Specific Gravity	2.85	IS 1727 – 1967

D. **Tests on Coarse Aggregate**

The maximum aggregate size for concrete is 20 mm because larger particles concentrate stresses around them since the aggregate and paste have different elastic moduli, which reduces the concrete's strength. The aggregate has a crushing strength at least 1.5 times that of concrete and is devoid of harmful substances. [15-18]

Table 4. Test Results On Coarse Aggregate

S. No.	Type of Test	Values Obtained	IS SPECIFICATIONS
1.	Crushing Value	24.36	IS 2386 - 1963
2.	Impact Value	17	IS 2386 - 1963
3.	Specific Gravity	2.63	IS 2386 - 1963

E. **Slump Cone test**

According to IS: 1199, the concrete slump test evaluates the workability of freshly mixed concrete and, consequently, the ease of concrete flow by measuring the consistency of the material before it sets. [19-21].

Table 5. Slump Cone Test

S. No.	GGBS CONTENT	Slump in mm
1.	NM	100
2.	30 %	80
3.	40 %	110
4.	50 %	130

F. **Compaction Factor Test**

In accordance with IS: 1199-1959, the compacting factor test is used to assess the workability of fresh concrete.

G. **Mix Design**

This study employed M80 mix proportion with a 0.4 water cement ratio and a 0.7% super plasticizer.

Target mean strength of concrete= f_{ck}+1.65 x standard deviation

= 80+1.65*5

=88.25 MPa

IV. RESULTS AND DISCUSSION

The test results are shown in the figures below.

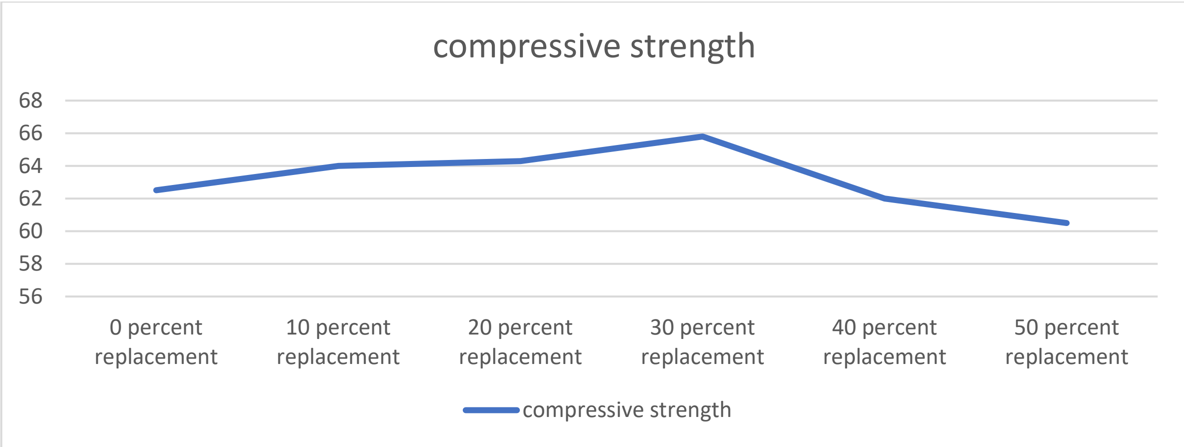
A. Compressive Strength at 7 days

The ability of a material or structure to bear loads that tend to reduce size is known as compressive strength.

Sr no		Compressive strength after 7 days MPa
1	0% replacement	62.5
2	10% replacement	64.0
3	20% replacement	64.3
4	30% replacement	65.8
5	40% replacement	62.0
6	50% replacement	60.5

Table 6 compressive strength at 7 days

The 7 day mean compressive strength was tested and best performance is found at 30 % that is 65.8 .Significant variation was observed between the results, in the equivalent cubes. Uneven stress distribution on the cube surface appeared to be the major cause of this variant compressive behaviour. This was also reflected in the tensile strength development of the standard cured.



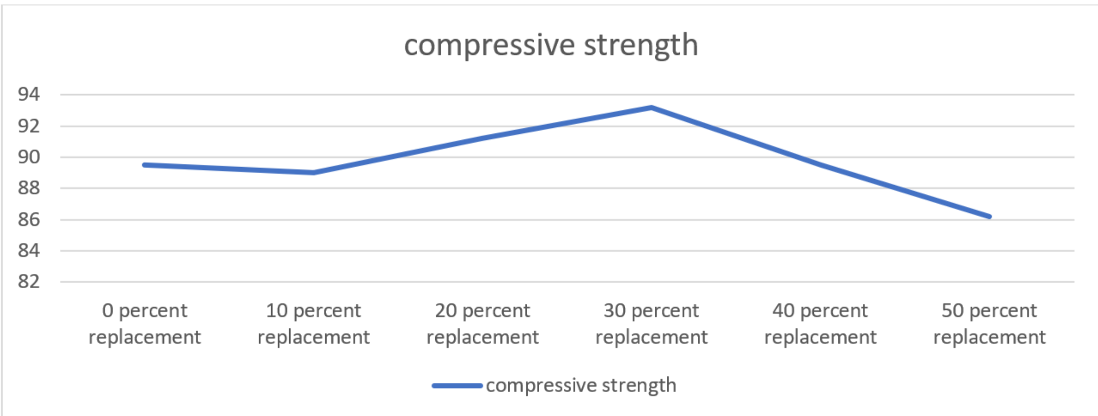
Graph 1. Compressive strength at 7days

B. Compressive Strength at 28 days

Sr no		Compressive strength after 28 days MPa
1	0% replacement	89.5
2	10% replacement	89.0
3	20% replacement	91.2
4	30% replacement	93.2
5	40% replacement	89.5
6	50% replacement	86.2

Table 7 compressive strength at 28 days

The 28 day mean compressive strength was tested and best performance is found at 30 % that is 93.2.Significant variation was observed between the results, in the equivalent cubes. Uneven stress distribution on the cube surface appeared to be the major cause of this variant compressive behaviour. This was also reflected in the tensile strength development of the standard cured



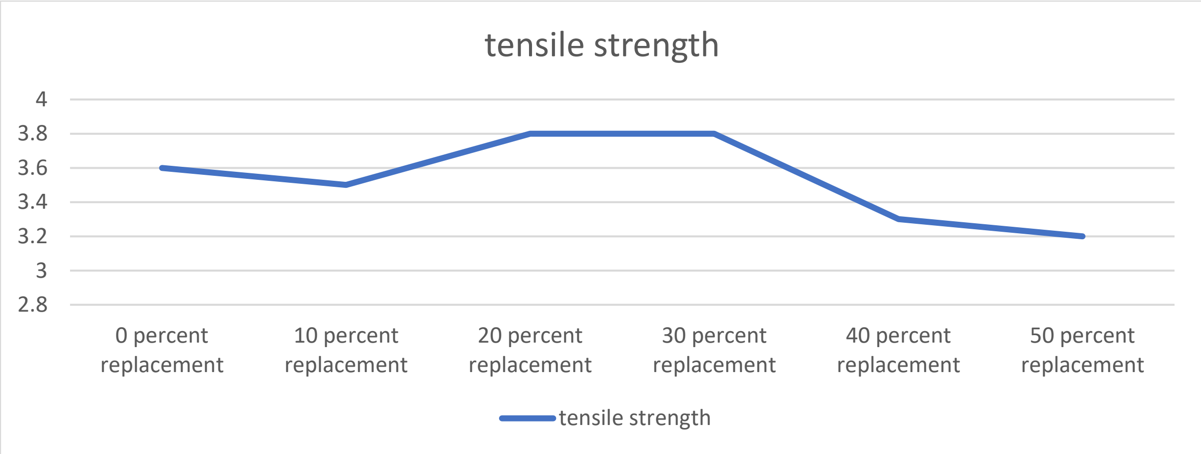
Graph 2. Compressive strength at 28 days

C. Split Tensile Strength at 7days

One of the fundamental and significant characteristics of concrete is its tensile strength. One way to ascertain the tensile strength of concrete is to perform a splitting tensile strength test on a concrete cylinder. Because it is brittle, the concrete is exceedingly weak under tension and is not supposed to withstand direct tension.

Sr no		Split tensile strength after 7 days MPa
1	0% replacement	3.6
2	10% replacement	3.5
3	20% replacement	3.8
4	30% replacement	3.8
5	40% replacement	3.3
6	50% replacement	3.2

Table 8 Split Tensile strength at 7 days



Graph.3 Split tensile strength at 7 days

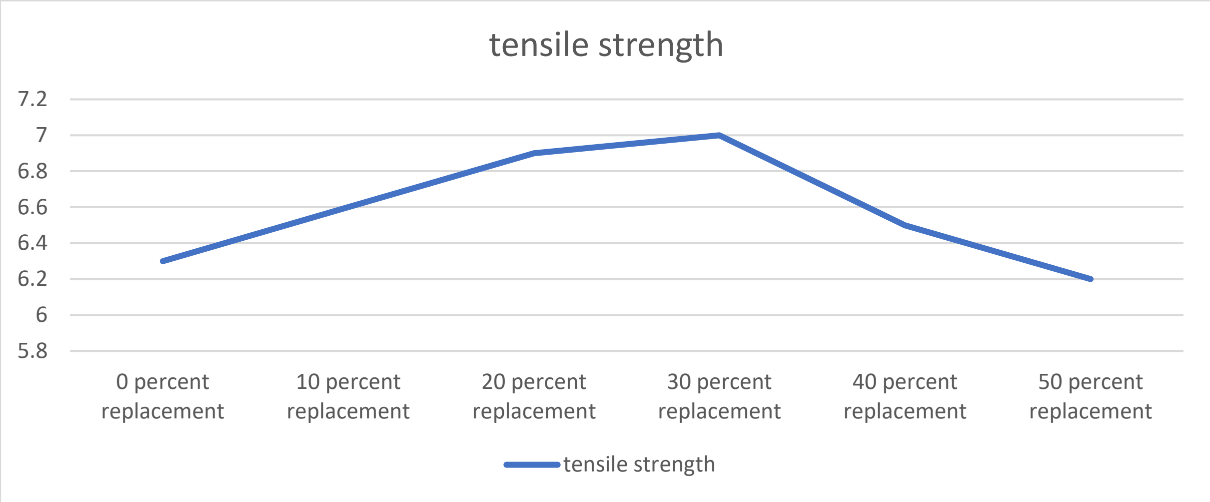
The 7 day mean cylinder tensile strength was tested and best performance is found at 30 % and 20% both that is 3.8 .Significant variation was observed between the results, in the equivalent cubes. Uneven stress distribution on the cube surface appeared to be the major cause of this variant compressive behaviour. This was also reflected in the tensile strength development of the standard cured.

D. Split Tensile Strength at 28 days

Sr no		Split Tensile strength after 28 days MPa
1	0% replacement	6.3
2	10% replacement	6.6
3	20% replacement	6.9
4	30% replacement	7.0
5	40% replacement	6.5
6	50% replacement	6.2

Table 9 Split Tensile Strentgth at 28 days

The 28 day mean cylinder tensile strength was tested and best performance is found at 30 % that is 7.0 .Significant variation was observed between the results, in the equivalent cubes. Uneven stress distribution on the cube surface appeared to be the major cause of this variant compressive behaviour. This was also reflected in the tensile strength development of the standard cured.

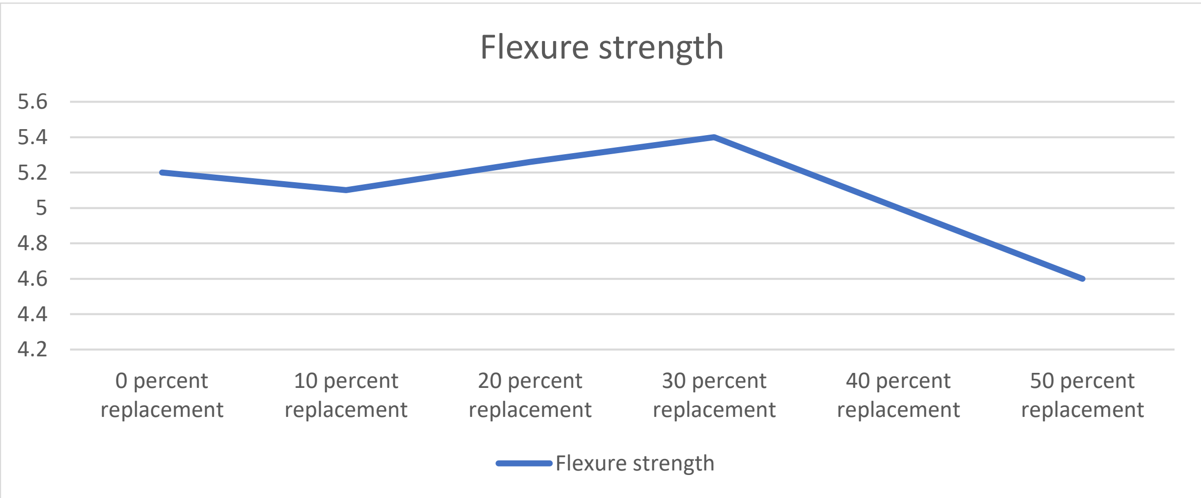


Graph 4. Split tensile strength at 28 days

E. Flexure Strength at 28 days

Sr no		Flexure Strength after 28 days MPa
1	0% replacement	5.2
2	10% replacement	5.1
3	20% replacement	5.26
4	30% replacement	5.40
5	40% replacement	5.0
6	50% replacement	4.6

Table 10 Flexure strength at 28 days



The 28 day mean beam flexure strength was tested the best performance of flexure is on 30% percent of replacement .Significant variation was observed between the results, in the equivalent cubes. Uneven stress distribution on the cube surface appeared to be the major cause of this variant compressive behaviour. This was also reflected in the tensile strength development of the standard cured.

V. CONCLUSIONS

The experimental investigation's findings support the following conclusions:
At 7 and 28 days, it has been noted that GGBS-based concrete has increased in strength when 30% of the cement is replaced.
In addition to increasing compressive strength, using GGBS in place of cement lowers cement content, which lowers CO_2 emissions.
According to the concrete's compressive and split tensile strengths, the best GGBS-based concrete mix is 30%. Nevertheless, strength declines after 40% replacement.

In terms of price, GGBS is three times less expensive than OPC in the market, including packaging and shipping.

Thus, using GGBS in place of some of the OPC in concrete is not only cost-effective but also makes it easier to dispose of waste slag, which is produced in large amounts by the iron and steel industries, in an environmentally responsible manner.

REFERENCES

[1]. Brindha G., Emerging trends of telemedicine in India, Indian Journal of Science and Technology, vi-SUPPL5, pp-4572-4578, 2013.
[2]. Vijayalatha S., Brindha G., Emerging employee retention strategies in it industry, International Journal of Pharmacy and Technology, v 12218, 2016.
[3]. Karthik A., Brindha G., Green revolution conversion of offline education to online education, International Journal of Pharmacy and Technology, v-8, i-3, pp-15393-15407, 2016.
[4]. Padminii K., Venkatramaraju D., Brindha G., A Study on Quality of Women Employees in Medical Transcription, Journal of Health Management, v-18, i-1, pp-13-20, 2016.
[5]. Gunaraja T.M., Venkatramaraju D., Brindha G., Organizational climate-pharmaceutical professional, International Journal of Pharmacy and Technology, v-7, i-2, pp-8924-8929, 2015.
[6]. Padminii K., Brindha G., Venkatramaraju D., Quality work life â€" In medical field, International Journal of Pharmacy and Technology, v-7, i-1, pp-8437- 8446, 2015.
[7]. Gopalakrishnan K., Prem Jeya Kumar M., Sundeep Aanand J., Udayakumar R., Analysis of static and dynamic load on hydrostatic bearing with variable viscosity and pressure, Indian Journal of Science and Technology, v-6, i-SUPPL.6, pp-4783-4788, 2013.
[8]. Prem Jeya Kumar M., Sandeep Anand J., Gopalakrishnan K., Satheesh B., Anbazhagan R., Computer modelling of a vehicle system, Indian Journal of Science and Technology, v-6, i-SUPPL5, pp-4620- 4628, 2013.
[9]. Prem Jeya Kumar M., Gopalakrishnan K., Srinivasan V., Anbazhagan R., Sundeep Aanan J., PC modeling and simulation of car suspension system, Indian Journal of Science and Technology, v-6, i- SUPPL5, pp-4629-4632, 2013.
[10]. Jeykar K., Srinivasan V., Performance characteristics of twin cylinder Di diesel engine operated with three different non edible vegetable oil blends with diesel, International Journal of Applied Engineering Research, v-9, i-22, pp-7601-7607, 2014.
[11]. Srinivasan K., Gopikrishnan M., Analysis of a reduced switch three phase BLDC drive, International Journal of Applied Engineering Research, v-9, i-22, pp- 6633-6637, 2014.
[12]. Venkatesan N., Srinivasan V., Fabrication and mechanical properties of natural composite materials, International Journal of Applied Engineering Research, v-9, i-22, pp-7743-7748, 2014.
[13]. Mustafa Kamal Basha M., Srinivasan V., Fabrication of AlSic Mmc and analysis of its mechanical properties, International Journal of Applied Engineering Research, v-9, i-22, pp-7621-7626, 2014.
[14]. Selvam M.D., Srinivasan V., Sekar C.B., An attempt to minimize lubricants in various metal cutting processes, International Journal of Applied Engineering Research, v-9, i-22, pp-7688-7692, 2014.
[15]. Valentina D.S., Ilayaraja K., Ambica A., Spatial distribution of groundwater in Selaiyur village, Chennai, India, Ecology, Environment and Conservation, v-20, i-, pp-S173-S179, 2014.
[16]. Ambica A., Tamizharasan V., Venkatraman K., Treatment of domestic waste water by electrochemical method, International Journal of Applied Engineering Research, v-9, i-22, pp-5537-5542, 2014.
[17]. Gokul V., Ambica A., An experimental study on high strength concrete with replacement of fine aggregate using welding slag, International Journal of Applied Engineering Research, v-9, i-22, pp-5570-5575, 2014.
[18]. Divyaa K., Venkatraman K., Design of flexible pavement for an engineering college, International Journal of Applied Engineering Research, v-9, i-22, pp-5576-5581, 2014.
[19]. Venkatraman S., Sathish Kumar K., Effect of glass powder on performance of concrete subjected to sulphate attack, International Journal of Applied Engineering Research, v-9, i-22, pp-5636-5659, 2014.
[20]. Iyappan L., Maria Subashini L., Landuse change detection in namakkal taluk using remote sensing, International Journal of Applied Engineering Research, v-9, i-22, pp-5699-5707, 2014.
[21]. Ajona M., Maria Subashini L., Eco-friendly concrete with rice husk ash, International Journal of Applied Engineering Research, v-9, i-22, pp-5471-5489, 2014.