International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 11, Issue 02, February 2022)

An Investigational Study of GGBS and Silica Fume to Improve Strength Properties of M30 Grade of Concrete

Kamal Kishor Gupta[1], Kamlesh Kumar Choudhary[2]

[1]M.Tech Scholar, [2]Professor, Saraswati Institute of Engineering & Technology, Jabalpur, India

***Abstract*--This paper provides a contemporary review of the The Ordinary Portland cement is most widely used material in the production of concrete. Construction industry consumes a vast volume of cement every year. There is no alternative material used in construction industry. However, the manufacture and consumption of cement causes pollution to the environment due to the emissions of large amount of Carbon dioxide gas in the environment and reduction of raw material (limestone). Use of GGBS(Ground Granulated Blast Furnace Slag) and silica fumes as cement replacement will simultaneously reduce cost of concrete and help to reduce rate of cement consumption. In this research we present found on to investigate the strength properties of GGBS and silica fumes. The partial replacement of GGBS and silica fumes with cement is performed in this experiment. GGBS is the waste product attained from steel manufacturing industry, is formed by the partition of molten steel from impurities. M30 grade of concrete is used in this experiment and 10% of silica fumes was used as an cement replacement. The specimens for testing were prepared, the cube, cylinders are cured for 7 & 28 days. All the properties were determined by performing different tests like split tensile strength, flexural strength and compressive strength and. The cement are substituted by GGBS by 20%, 30%, 40% and then compared with that of cement and the ideal percentage of GGBS is obtained. At last, workability, setting time, compressive strength is investigated. The maximum strength for the concrete specimen is obtained when 30% of GGBS is replaced with cement.**

***Keywords*-- Ground Granulated Blast-Furnace Slag; Silica-Fume; Compressive Strength; Flexural Strength**

I. INTRODUCTION

Sustainability was a major problem and concern in making a development. This is because sustainable development has become a key issue in society, economy and development. Sustainable development must meet the needs of the present without compromising the ability of future generations to meet their own needs. It also shows that the development will be done to sustain the planet's resources, using them effectively without unnecessary waste. The cement industry is responsible for major portion of the carbon dioxide emissions. Production of one ton of cement Portland approximately emits several tons of carbon dioxide gas into the atmosphere.

The use of Ground granulated blast furnace slag (GGBS) and silica fume to replace cement, can be considered as sustainable approach, because the production of the cement is emits carbon dioxide gas to atmosphere. Carbon dioxide emissions will increase the effect of global warming due to greenhouse effect. Among the greenhouse gases, carbon dioxide contributes about 65% of global warming.

Ground Granulated Blast Furnace Slag

Ground granulated blast furnace slag (GGBS) is a recyclable material created when the molten slag from iron ore is quickly quenched and then ground into a powder. This material has properties and cement has been used as a substitute for cement for over 100 years. Recently, Wisconsin began to use it in some of its road projects. Wisconsin has experienced several problems with GGBS, including slow gain strength and decrease in surface quality. Combating these problems, GGBS concrete has higher resistance and lower permeability. This project investigates these GGBS features and has several objectives. Ground granulated blast furnace slag (GGBS) is a by-product of the steel industry. Blast-furnace slag is defined as "non- metallic product consisting essentially of calcium silicates and other bases that is developed in a molten simultaneously with iron condition in a furnace". In the production of iron, the blast furnaces are loaded iron ore, fluxes and coke. When the iron ore, which is constituted by iron oxides, silica and alumina, comes together with fluxing agents, iron and molten slag are produced. The molten slag then passes through a specific process, depending on the type of slag that will be. GGBS is produced when the molten slag is rapidly quenched using water jets, which produces a glassy granular aggregate.

Production Of Ggbs

GGBS is a non-metallic byproduct of the steel produced simultaneously with iron in the blast furnace steel mills industry, which consists essentially of silicates and alumino silicates of calcium and other bases. Iron ore, limestone and coke are ground and mixed in a blend that constitutes the raw material for iron which is produced in a blast furnace ± 2,700 ° F. The residual molten slag is quenched by immersion in water for glazing material in glassy sand -like substance.

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 11, Issue 02, February 2022)

This substance is then dried and ground into a very fine powder with at least 80 percent less than 45 microns in size.

Silica Fume

Silica fume, also known as micro- silica, is a (no crystalline) amorphous silicon dioxide polymorph of silica. It is an ultrafine powder collected as a byproduct of the production of silicon and ferrosilicon alloy and consists of spherical particles with an average diameter of 150 nm particle. The main application field is as pozzolanic material for high-performance concrete. It is often confused with fumed silica. However, the process of production, characteristics of particles and fumed silica fields of application are all different from those of silica fume.

Production Of Silica Fume

Silica fume is a by-product of high purity quartz carbothermic reduction with carbonaceous materials like coal, coke, wood chips, in electric furnaces in the production of silicon and ferrosilicon alloys. The main source of silica fume is produced as a by-product during the extraction of iron ore.

II. Objective Of The Study

The main objective of the study is to investigate the change in characteristics strength properties and workability of concrete mixed with different percentage of steel slag with concrete. Following are objectives of the study.

- To find out the effect of Ground-granulated blast-furnace slag (GGBS or GGBFS) on strength when mixed with concrete sample. To study the workability of concrete on variation in different percentage of steel slag when mixed with concrete.
- To find out the change in slump value.
- To perform the sieve analysis and specific gravity of aggregate used Reduce the maintenance cost.
- Increase the economy of the construction with using the cheaper material as a replacement of the cement**.**

Table 1:
Chemical Composition of GGBS and Silica Fume

Oxides (%)	GBBS	Silica fume
CaO	29 – 43.7	0 – 0.8
SiO_2	30 – 40	>85
AL_2O_3	06 – 19.3	0 – 1.1
Fe_2O_3	0.1 – 2.5	0 – 2
MgO	0.0 – 19	0 – 4.5
K_2O	0.3 – 0.5	0 – 1.3
Na_2O	0.0 – 1.2	0 – 1.3
SO_3	1.0 – 4.0	0 – 1.3
LOI	0.1 – 1.7	0 – 2.8

III. Literature View

M.D.V.S.Sravani1 |Avvaru Pradeep |J.ManikantaVamsi |S.V.Ganesh | A. Sai Kumar (JUNE 2021) High performance concrete (HPC) is a concrete meeting special combinations of performance and uniformity requirements. This leads to examination of the various admixtures to improve the performance of the concrete. The usage of mineral admixtures in the concrete not only enhances its strength properties but also durability. To study the role of silica fume and ground granulated blast furnace slag (GGBS) on concrete strength characteristics of a high-strength test program has been planned. Different concrete mixtures were prepared and tested with different levels of cement replacement (0 %, 10 %, 20 %, 30% and 40 %) of GGBS with active silica fume as addition (0 %, 5 %, 10 % and 15 % by weight of cement). The main objective of this study is to determine the optimal replacement percentages that can be appropriately used in Indian conditions. To find the optimal replacement GGBS with the addition of silica fume in M60 grade concrete with maintaining water cement ratio of 0.32. This experiment is planned to compare 7days and 28days the strength parameters of concrete i.e., compressive strength, split tensile strength and flexural strength. And also workability and durability characteristics were examined. Key Words: GGBS, Silica fume, super plasticizer, compressive strength, split tensile strength, flexural strength and High performance concrete.

B. Rajalakshmi (2020) performed the experiment on “Experimental Study on Optimization of Cement by Using Ground Granulated Blast Furnace Slag (GGBS) and Sand in High Performance Concrete” in this research the OPC partially replaced with GGBS and the properties were observed using M50 concrete with various percentages of cement viz.. 40%, 45%, 50%, 55%, 60%, 65% & 70% as per Cl 18.4. of IRC 112.2011. Since River sand is becoming scarce nowadays, the use of manufactured stone (M-Sand) in concrete has become unavailable. The 7th and 28th day test results point out that the workability of concrete viz 40%, 45%, 50%, 55%, 60%, 65% & 70% substitution of cement by GGBS were excellent in High Performance Concrete (M50) and it is increased from 25 % to 68% compared to conventional concrete. It achieved maximum Compressive strength when there is partial replacement of 45% GGBS with 100% M-Sand. But the target mean strength as specified by IRC is satisfied at the partial replacement of 50% GGBS. So the optimum percentage of replacement of GGBS is 50%.

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 11, Issue 02, February 2022)

P.K. Prasanna (2019) perform the experiment on "Compressive Strength Assessment using GGBS and Randomly Distributed Fibers in Concrete" in this experiment GGBS is used as a replacement material of cement to understand its compressive strength and long term behavior. 100x100x100 mm size cubes were cast in six numbers and GGBS is replaced by cement by 20%,30%,40%,50%,60%,80% and cured for 3,7,28,56,90 and 180days and then compressive strength is determined. It has been found that GGBS can be efficiently replaced by cement up to 60% without compromising the strength of GGBS based concrete in comparison with OPC concrete. It was also observed that with an increase in the fiber content from 0.5% to 1.5%, there is a marginal increase in the strength of approximately 5% to 12% at 28 days to 180 days.

Pratap Singh (2019) has carried out the experiment on "An Experimental Study on Effect of Concrete Performance in Addition of GGBS and Partial Replacement of Cement by Glass Fiber" in this experiment he replaces few percentage of cement with Ground granulated blast-furnace slag which varies from 0% to 25% at interval of 5% for concrete mixes of M35 and then compressive strength, split tensile strength and flexure strength is calculated for 7 and 28 days. Compressive Strength increased initially upto when addition of Ground granular blast furnace and OPC replacement by glass fiber increased upto 5% and 0.2% respectively. However, it started decreasing as additional alterations made in the same ratio and finally achieved similar values as starting. Due to partial replacement of OPC by glass fiber, tensile strength increased 32% having 3.27 N/mm2. Initially it increased slowly but as partial replacement and addition GGBS ratio increased, tensile strength increased immediately.

IV. Problem Statements

From the above literature review the following conclusions can be drawn:

1. Up till the maximum value the characteristics strength of concrete increases and after the optimum value the characterize strength decreases.
2. The split tensile strength and flexural strength also increases while there is decrease in water absorption capacity.
3. Using of self-compacting concrete in place of normal mix slightly increases the shear capacity of beams.
4. When the cement was replaced with GGBS and Silica Fume at various proportions then there is slight increase in the percentage of the characteristics strengths.

V. Experimental View

To fulfill our study, we adopted the research methodology are as follows:

We performed compressive, flexural and shear strength test to find out the increase in strength of concrete. To find the optimum value of the fiber added percentage we have read out many of the research papers. The cubes and beams are casted for finding out the strength of conventional concrete and fiber added concrete with M30, grade are as follows

- To determine the compression strength test we had casted the 6 cubes of 100x100x100mm
- To determine the flexural strength test we had casted the 6 beams of 500x100x100mm
- To determine the split tensile strength test we had casted the 6 cylinders of 200x100mm

VI. Results And Discussions

In this research we present found on to investigate the strength properties of GGBS and silica fumes. The partial replacement of GGBS and silica fumes with cement is performed in this experiment. GGBS is the waste product attained from steel manufacturing industry, is formed by the partition of molten steel from impurities. M30 grade of concrete is used in this experiment and 10% of silica fumes was used as an cement replacement. The specimens for testing were prepared, the cube, cylinders are cured for 7& 28 days. All the properties were determined by performing different tests like split tensile strength, flexural strength and compressive strength and. The cement are substituted by GGBS by 10%, 20%, 30% and then compared with that of cement and the ideal percentage of GGBS is obtained. At last, workability, setting time, compressive strength is investigated. The maximum strength for the concrete specimen is obtained when 30% of GGBS is replaced with cement.

Compressive Strength

Out of many tests applied to the concrete, this is the outmost important which gives an idea about all the characteristics of concrete. By this single test one judge that whether concreting has been done properly or not. For cube test two types of specimens either cube of 15cm x 15cm x 15cm depending upon the size of aggregate are used. For most of the works cubical moulds of size 15cm x 15cm x 15cm are commonly used.

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 11, Issue 02, February 2022)

Table 2
Comparison of strength at 7 days and 28 days for different percentages of GGBS

Mix Code	7 day compressive strength for cube(N/mm^2)	28 day compressive strength for cube(N/mm^2)
M30	24.53	45.33
M-1	26.05	44.88
M-2	29.53	50.33
M-3	23.95	42.58

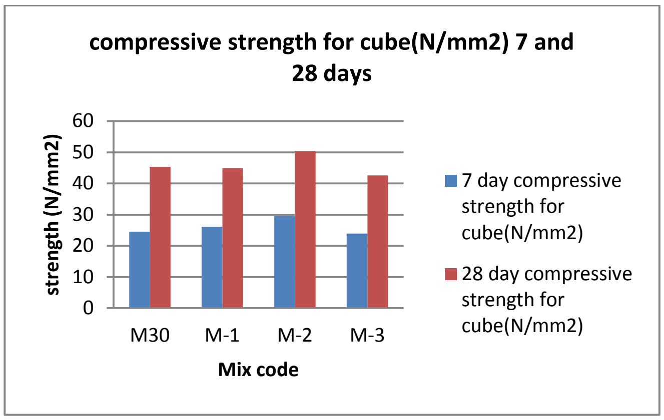

Fig 1 7 & 28 Days Compressive Strength of Concrete

Spilt Tensile Strength

The Spilt tensile strength of concrete obtained using cylinder specimens of size 150mm*300mm. Calculation of splitting tensile strength of each sample was calculated by the Equation

$$T = 2P/\pi LD$$

Where
T = split tensile strength in psi.
P= maximum load applied in pounds.
L= average sample length in inches.
D = sample diameter in inches

Table 3
7 days and 28 days split tensile strength of cylinder

Mix Code	Spilt tensile strength (N/mm2) 7 days	Spilt tensile strength (N/mm2) 28 days
M30	4.30	4.53
M-1	3.95	4.49
M-2	4.21	4.61
M-3	4.02	4.43

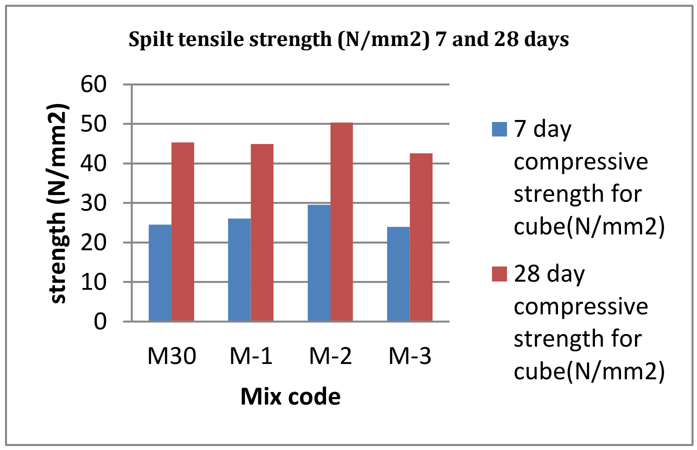

Fig 2 7 & 28 days split tensile strength of concrete

Flexural Strength Test

Flexural strength is a measure of tensile strength of concrete prisms of size 750mm x100mm x 100mm was used. It is 12-20 % of compressive strength. The flexural strength testing conducts on the prism for 7 days and 28 days respectively and the comparison of the results are shown in the Fig. From the results it is observed that the result 15% increments in mix when replaced by 30% of GGBS and 10 % of silica fume when compared with control mix.

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 11, Issue 02, February 2022)

Table 4
7 days and 28 days' Flexural strength of cylinder

Mix Code	Flexural strength (N/mm^2) 7 days	Flexural strength (N/mm^2) 28 days
M30	6.83	7.54
M-1	5.68	7.32
M-2	5.08	7.16
M-3	6.14	7.79

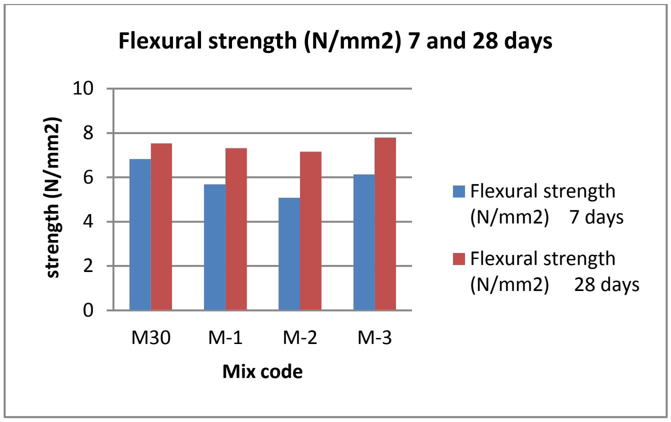

Fig 3 7 & 28 days Flexural Tensile Strength of Concrete

VII. CONCLUSION

The following conclusions can be drawn from the experimental investigations conducted on the behavior of concretes with GGBS and silica fume as partial replacements for cement

1. As GGBS and silica fume is partially replaced with the cement, the consumption of the cement is reduced and also the cost of construction is reduced.
2. Thus the workability is improved by the partial replacement of the GGBS and silica fume with cement.
3. The use of GGBS and silica fume as a replacement of cement helps to reduce the Energy consumption in the manufacturing of cement.
4. We find that there is increase in the strength of concrete that compressive strength is 50.33N/mm2 ,split tensile strength is 4.610N/mm2 and flexural strength is 7.79 N/mm2
5. We get the maximum strength at 30% replacement of GGBS and silica fume with cement.

VIII. FUTURE SCOPE

The following recommendations for future work are suggested to study the behavior of GGBS and silica fume concrete.

- GGBS and silica fume will be used to performance of concrete under marine.
- GGBS and silica fume will be used to performance of concrete for acidic environment.
- To the performance of concrete under temperature effect for same GGBS and silica fume concrete.
- To the performance of concrete under creep and shrinkage for same GGBS and silica fume concrete.

REFERENCES

[1] M.D.V.S.Sravani |Avvaru Pradeep |J.ManikantaVamsi |S.V.Ganesh | A. Sai Kumar "Study on Engineering Properties of GGBS and Silica Fume Admixed High Performance Concrete" Received: 18 May 2021; Accepted: 25 June 2021; Published: 30 June 2021International Journal for Modern Trends in Science and Technology, ISSN : 2455-3778

[2] P.K. Prasanna (2019) "Compressive Strength Assessment using GGBS and Randomly Distributed Fibers in Concrete" International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-9 Issue-2, December 2019

[3] S.k.Sirajuddin (2019) "Experimental Investigation on Properties of Concrete by Partial Replacement of Cement with GGBS and Fine Aggregate with Quarry Dust" International Conference on Advances in Civil Engineering (ICACE-2019) | 21-23 March 2019

[4] Pratap Singh (2019) "An Experimental Study on Effect of Concrete Performance in Addition of GGBS and Partial Replacement of Cement by Glass Fiber" International Journal on Recent and Innovation Trends in Computing and Communication ISSN: 2321-8169 Volume: 7 Issue: 5

[5] Anas (2018) "A Review on Ground Granulated Blast-Furnace Slag as a Cement replacing material" International Research Journal of Engineering and Technology (IRJET) ISSN: 2395-0056 Volume: 05 Issue: 04 | Apr-2018

[6] Shanmuganathan.N (2018) "Ground Granulated Blast Furnace Slag (Ggbs or Ggbfs) and Fly Ash (Fa) in Concrete – A Study Report" SSRG International Journal of Civil Engineering (SSRG - IJCE) - Volume 5 Issue 3 – March 2018

[7] Vaishak K (2018) "Study on Strength and Durability Properties of GGBS-Fly Ash based Concrete" IOSR Journal of Engineering (IOSRJEN) ISSN (e): 2250-3021, ISSN (p): 2278-8719 Vol. 08, Issue 6 (June. 2018)

[8] Sunil Bhagwan Yamgar (2018) "Study and Analysis of Strength of GGBS Concrete" International Journal of Engineering and Management Research ISSN (ONLINE): 2250-0758, ISSN (PRINT): 2394-6962 Volume-8, Issue-6, December 2018

[9] B K Varun (2018) "EFFECT OF ADDITION OF FLYASH AND GGBS ON CEMENT CONCRETE IN FRESH AND HARDENED STATE" International Journal of Advance Engineering and Research Development Volume 5, Issue 02, February -2018

[10] Chalamcharla Venu Gopal (2017) "Partial Replacement of Cement with GGBS in Concrete" International Journal of Advance Research, Ideas and Innovations in Technology

[11] Amunuri Sravan Kumar (2017) "Strength Development of Concrete by Replacing Cement with Ground Granulated Blast Furnace Slag (Ggbs)"

[12] B.Kaviya.R (2017) "STUDY ON PARTIAL REPLACEMENT OF CEMENT BY GROUND GRANULATED BLAST FURNACE SLAG (GGBS)" International Journal of Pure and Applied Mathematics

[13] Quaid JoharBhattiwala (2016) "Effect of Cementitious Waste Material (GGBS) on concrete as a Replacement in Cement" International journal of science technology & Engineering" ISSN (online): 2349-784X Volume 2, Issue 11, May 2016

[14] Shetty M.S. "Concrete Technology" Chand S. and Co. Ltd.,India (2004).

[15] IS:456-2000, "Plain and Reinforced Concrete - Code of Practice "Bureau of Indian Standards.

[16] IS:456-2000, "Plain and Reinforced Concrete - Code of Practice "Bureau of Indian Standards.

[17] IS: 2386-1963 (Part I to Part III), "Indian Standards Method of Test for Aggregate for Concrete", Bureau of Indian Standards, New Delhi, India

[18] IS: 383-1970, "Indian Standard Specification for coarse and fine aggregates from Natural Source for Concrete", Bureau of Indian Standards, New Delhi, India.

[19] IS: 8112-1989, "Specifications for 43-Grade Portland Cement", Bureau of Indian Standards, New Delhi, India.

[20] IS: 10262-1982," Guidelines for Concrete Mix Design",Bureau of Indian Standards, New Delhi, India

[21] IS: 516-1959, "Indian Standard Code of Practice-Methods of Test for Strength of Concrete", Bureau of Indian Standards, New Delhi, India.

[22] IS: 5816-1999, "Method of Test Splitting Tensile Strength of Concrete", Bureau of Indian Standards, New Delhi, India.

[23] IS: 9103-1999, "Specification for Concrete Admixtures" Bureau of Indian Standards, New Delhi.

.