MODIFICATION OF UHPC USING INDUSTRIAL WASTE AND OTHER TYPES OF MINERALS ADMIXTURES WITH THE HELP OF STEEL FIBRES

PARIXIT PANDEY[1], ANKUR KUMAR SAHU[2]

[1]Research Scholar, [2]Asst. Prof. Department of Civil Engineering, RRIMT LUCKNOW

Abstract- The Ultra-High-Performance Fibre-Reinforced Concrete is a relatively new type of Construction material, which is a combination of various types of admixtures, industrial waste and steel fibers. The compressive strength of UHPC reaches beyond 150 MPa, which help to allows the construction of sustainable and economic structures with an extraordinarily slim design. The aim herein is to develop a concrete mix incorporating silica fume, nano silica, rice husk ash and ground granulated blast furnace slag (GGBS), with the addition of different percentages of steel fibers, which provides for high performance, durability and better serviceability in addition to overall economy in the long run. In this study, the compressive strength of UHPFRC is studied closely for different percentages of steel fibers with three w/b ratios (0.22, 0.20, and 0.18). The purpose is to have such proportions of materials, including cement replacement materials like silica fume, nana-silica, GGBS etc., which on mixing would be able to provide compressive strengths in the range of 125 to 150 MPa at 28 days. The compressive strength studies were carried at after 7 and 28 days after curing of concrete. The workability of the different mixtures was constantly maintained by optimum usage of super plasticizers. The results showed that with the increase in the percentage of steel fibers the compressive strength of the matrix increased. The maximum strength of UHPFRC, which was achieved under laboratory conditions, was 158 MPa, after 28 days of curing. This strength was achieved for the mix wherein the overall binder content included 8% silica fume, 2% nano silica, 10% GGBS (with remaining 80% as cement content) along with the addition of 1.5% steel fibers. UHPC does not contain the capillary pores of traditional precast or glass-reinforced concrete, it does not absorb water and degrade in demanding freeze/thaw or marine conditions.

Keywords- GGBS, UHPC, UHPFRC, Aspect Ratio etc.

1. Introduction

Concrete as a building material has become inseparable part of modern construction industry right from its inception into it. The usage of concrete gained tremendous popularity due to easy availability of natural raw materials present in abundant quantity and the strength it possesses. The concrete also possesses high durability compared to other materials used for construction. One such material that may be used as a partial replacement to cement is Ground coarse furnace slag (GGBS) that may be a by-product from iron and industry. Among the many replacement materials that are presently used, GGBS that is fine powdery material containing calcium and Mg oxides as its major elements is that the most generally used one. GGBS employed in the present work is factory-made by rapid quenching of Fe scum which ends in kindation of glassy substance that is then fine-grained to get its original powder like form. The chemical composition of GGBS is comparable to those of the glass because of presence of silicates and aluminates [4] and therefore they convey higher strength compared to different admixtures. The modulus of elasticity of GGBS concrete varies slightly to it of Portland cement concrete. The mechanical strength of concrete depends upon the constituents additional to that. whereas the strength numerous in proportion to the grade of concrete, the addition of fibres greatly enhances them. Many hundred forms of fibres are out there naturally that might be utilized in concrete however the foremost normally most popular are unnaturally created fibres like glass fibres, steel fibres, carbon fibres, etc. Fibres are threaded like linear distinct materials that are attenuated into smaller individual parts. As a result, they need larger extent to weight quantitative relation compared to traditional reinforcements. These fibres offer extra tensile and flexural strength to the concrete. Fibres that are heavily distorted afford higher post-crack strength. The usage of fibres in concrete keeps on increasing to satisfy the necessities of advanced contemporary construction. Sudden failure of concrete is eliminated considerably as a result of the fibres still support load even when incidence of crack. The fibre concrete provides larger abrasion resistance similarly as high impact load capability because of their high ratio and uniform cross section. The fibres are typically another within the vary of 0.1% to 1.5% by volume of concrete. The objective of this study is to seek out the best proportion of GGBS replacement to cement from partial GGBS replacement levels of 40%, 50%, and 60% to cement and use that optimum combine for fibre addition. The mix is then tested for varied mechanical properties (compressive strength, strength, flexural strength) and durability property (acid attack) at hardening age of 14, 28 and 56 days. Further, reinforced concrete beams of every mixer tested for flexure.

2. Experimental Investigations

2.1 Materials Used:

The Cement used is of OPC 53 Grade that is usually offered within the market confirms to IS 12269-1987.The specific gravity of cement was found to be three.14 whereas the initial setting and final setting time were found to be forty five minutes and three hundred minutes severally. GGBS is primarily employed in concrete structures together with cement and/or different pozzolanic materials to create it extremely sturdy. GGBS may be a by-product from industry that is far finer than cement and as a result provides a far better binding medium in concrete. GGBS used satisfies the specifications mentioned in IS 12089:1987. The particle size of GGBS employed in the present work is 45 microns. The area as nominal by manufacturer is 350 m2/kg and the glass content is 92. Silicon dioxide fumeis an amorphous type of silicon oxide. It a by-product from industry and consists of particles with a mean diameter of 150 named having particle size but one µm. Particles is spherical in form. The individual particle size of silicon dioxide fume is very small that is roughly concerning 1/100th of individual cement particle. The area is 20000 m2/kg and therefore the bulk density is300 kg/m3. Locally accessible stream sand of zone II class as per IS 383-1970 has been used. The fine aggregate used had coarse texture to that. Solely those aggregates that passed through 12mm sieve and retained on 10mm sieve were used as coarse aggregates for the work and it confirms to IS 383:1970 standards. Potable water used for drinking that is accessible within the experimental laboratory has been used for the whole work. Commercially accessible naphthalene-based super plasticiser having solid content 400th is employed. The most objective of adding super plasticizer is to cut back water content whereas increasing workability.

Hooked end steel fibres of 30mm length and aspect ratio 50 are used. The durability of the fibres as given by manufacturer is larger than 1450 MPa. The strain at failure is a smaller amount than 4-dimensional.The glass fibres utilized in this project are of S-type. The density is about 1140 kg/m3 and flexural strength 69 MPa. The Charpy notched impact strength of the fibres getting used is 29.52 KJ/m2.

Table 1- Mixtures proportions of GGBS and Steel fibers blended concrete

Sample	Cement	GGBS	Steel fiber	Coarse Aggregate	Fine Aggregate	Water
0SF0GGBS0	380	0	0	1283	711	160
79SF0.5GGBS10	342	38	1.9	1283	711	160
79SF1.0 GGBS20	304	76	3.8	1283	711	160
79SF1.5GGBS30	266	114	3.8	1283	711	160
55SF0.5GGBS10	342	38	1.9	1283	711	160
55SF1.0GGBS20	304	76	5.7	1283	711	160
55SF1.5GGBS30	266	114	5.7	1283	711	160

2.2 Results and Discussions

2.2.1 Initial testing results:

In order to seek out optimum GGBS replacement levels, three mixes of various GGBS replacement levels of 40%, 50% and 60% were taken and tested for compressive strength at 28 days. The strength enhanced with increase in GGBS replacement unto 40% and reduced on more replacement. the {mix the combination the combo} containing 40% GGBS was found to possess the highest compressive strength of 63 N/mm2 whereas mix containing 60% GGBS replacement had least strength of about 58 N/mm2. Hence, the optimum mixture of 40% GGBS is additional taken for the addition of fibres.

2.2.2 Workability Test:

This test was conducted to find out the degree of workability of GGBS steel fiber based concrete. Below shows that with increase in GGBS percentage, workability of concrete increases' It was observed that as percentage of fiber increases workability reduces. The reduction in workability is due to more water required to lubricate more amount of fiber' As amount of fiber increases less space is availablee for movement of fiber.

Table- 2 Slump Test Result

Sample	Slump, mm
0SF0GGBS0	58
79SF0.5GGBS10	54
79SF1.0 GGBS20	44
79SF1.5GGBS30	39
55SF0.5GGBS10	35
55SF1.0GGBS20	33
55SF1.5GGBS30	30

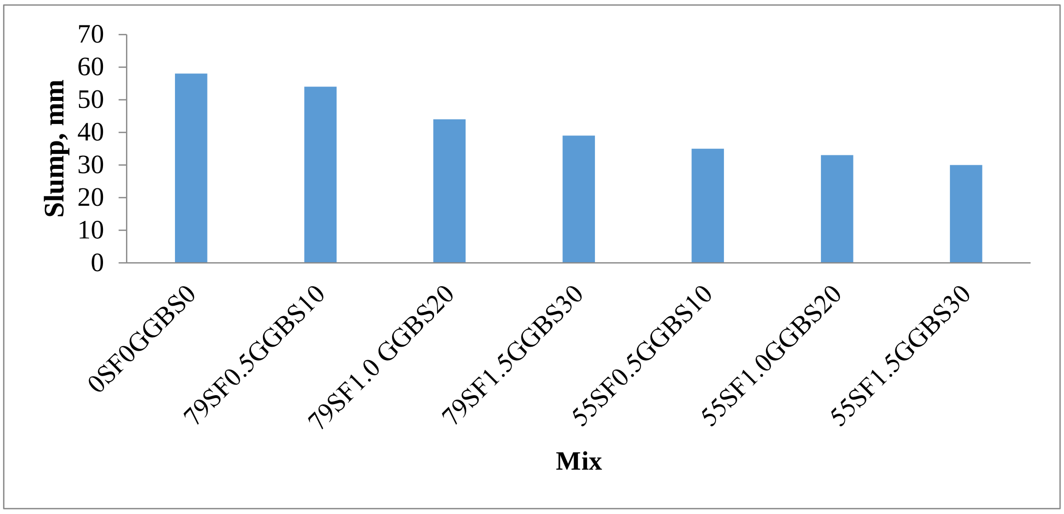

Fig 1- Slump test result

2.2.3 Compression test results

For conducting compressive strength test, cubes specimens of dimensions 150 mms x 150 mm x150 mm were cast. It was conducted as per IS 516-1959 to obtain compressive strength for M30s grades of concretes. The compressive strength of concrete with ordinary Portland cement and ground granulated blast furnace slag concrete at the age of 7days, 21 days and 28days are conducted. Maximum compressive load taken by cube and causes resistance per unit area is compressive strength of cubes. The failure load was noted. For each sample, cubes were tested and failure loads is noted.

Fig 2- Compressive strength test conducted in lab

Table- 3 Compressive Strength at 7 days

Sample	Compressive Strength, (MPa)
0SF0GGBS0	70.65
79SF0.5GGBS10	72.42
79SF1.0GGBS20	73.53
79SF1.5GGBS30	73.79
55SF0.5GGBS10	72.56
55SF1.0GGBS20	72.14
55SF1.5GGBS30	71.32

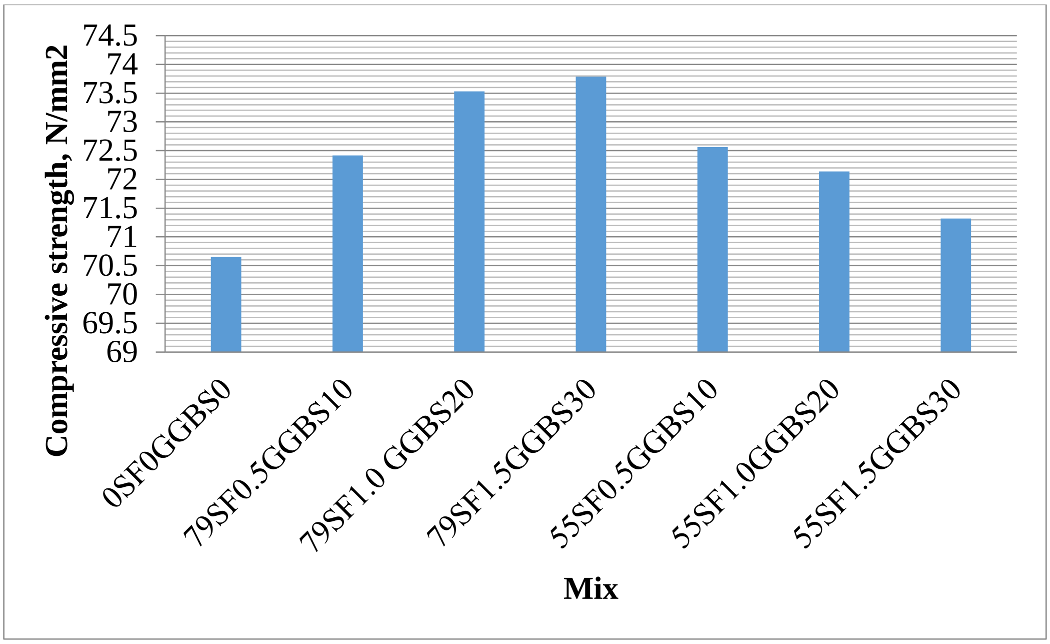

Fig 3- Compressive Strength at 7 days

Table 4- Compressive Strength at 28 days

Sample	Compressive Strength, (MPa)
0SF0GGBS0	85.27
79SF0.5GGBS10	85.89
79SF1.0GGBS20	86.31
79SF1.5GGBS30	87.64
55SF0.5GGBS10	86.56
55SF1.0GGBS20	85.14
55SF1.5GGBS30	84.32

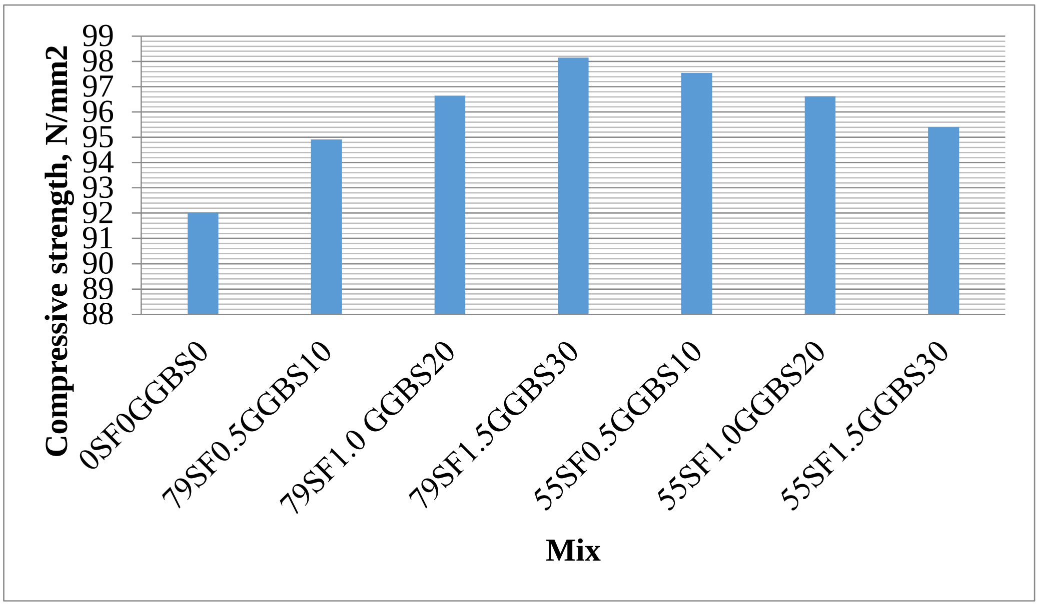

Fig -4 Compressive Strength at 28 days

2.2.4 Flexural strength test results

Flexural strength test was conducted on beam specimens under two point loading as per I.S.516-1959. The average ultimate flexural tensile stress was determined from the failure flexural loads. Beam specimens of dimension 100mm x100mm x 500 mm were made after 28 days curing period. The load is gradually increased and when cracking of beam specimen occurred, failure load is noted. The flexural strength was found out by formula given below.

Flexural strength (MPa) = $(P \times L) / (b \times d^2)$ Where, P is the Failure load, L is the Centre to centre distance between the support which is taken as 400 mm, b is the width of Specimen which is 100 mm, d is the depth of specimen which is taken as 100 mm.

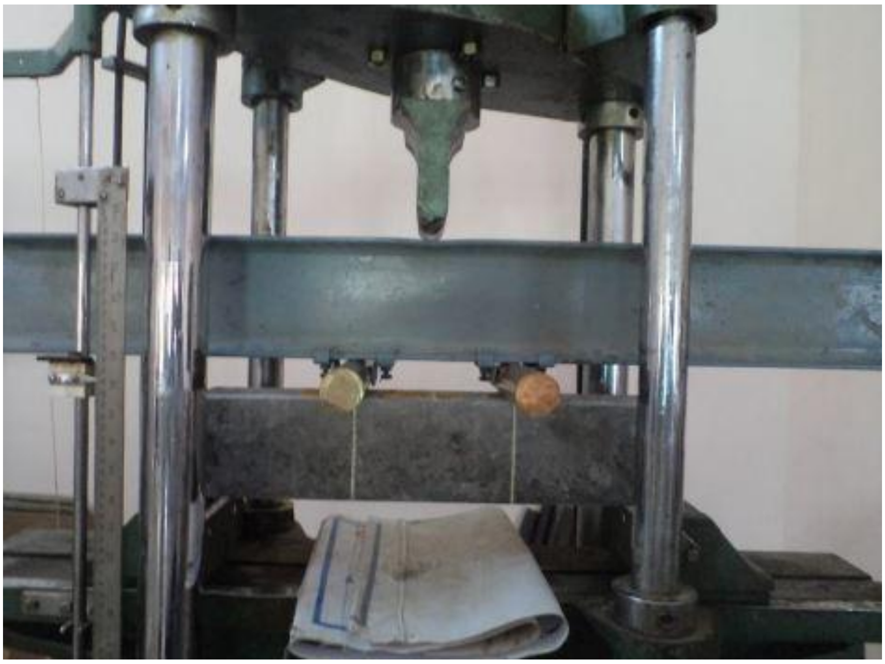

Fig 3- Specimen loading for flexural strength test

Table 5- Flexural strength of M30 at 28 days

Sample	Flexural Strength, (MPa)
0SF0GGBS0	4.98
79SF0.5GGBS10	5.25
79SF1.0GGBS20	6.08
79SF1.5GGBS30	8.23
55SF0.5GGBS10	5.43
55SF1.0GGBS20	6.51
55SF1.5GGBS30	7.79

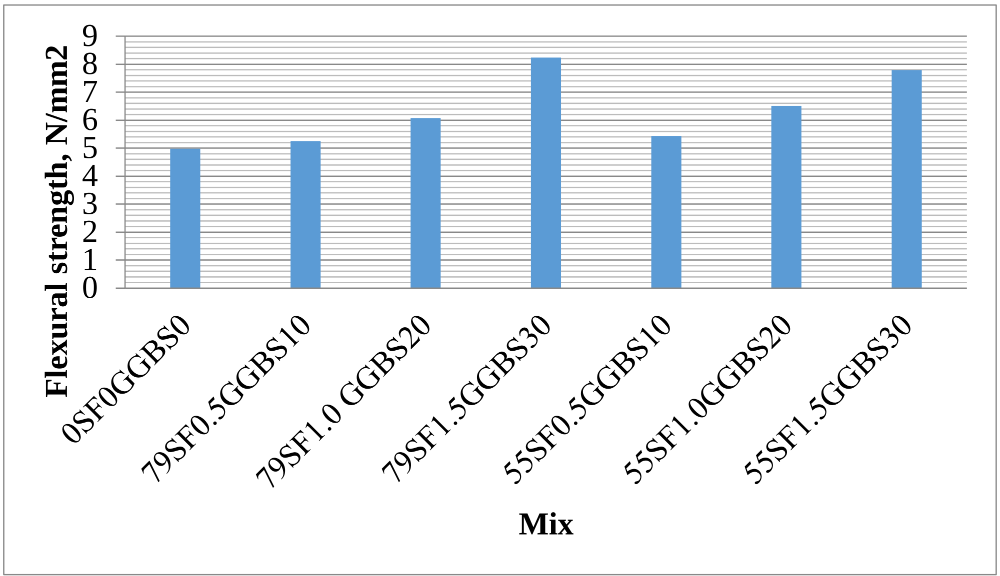

Fig 4- Flexural strength of M30 at 28 days

2.2.5 Split tensile strength results

The split tensile strength is the indirect measurement to determine the strength of concrete. For this test various cylinders having 150mm diameter and 300mm height were casted for various percentages of GGBS and steel fiber. The test results shows that there is an increase in the strength only up to 10% GGBS and 1.5 % fiber with aspect ratio 79 beyond the strength decreases and it was also observed that the strength showed increased only after 28 days of curing period.

Table 6- Split tensile strength test at 28 days

Sample	Split Tensile Strength, (MPa)
0SF0GGBS0	3.12
79SF0.5GGBS10	3.64
79SF1.0GGBS20	5.55
79SF1.5GGBS30	6.90
55SF0.5GGBS10	5.36
55SF1.0GGBS20	4.23
55SF1.5GGBS30	3.42

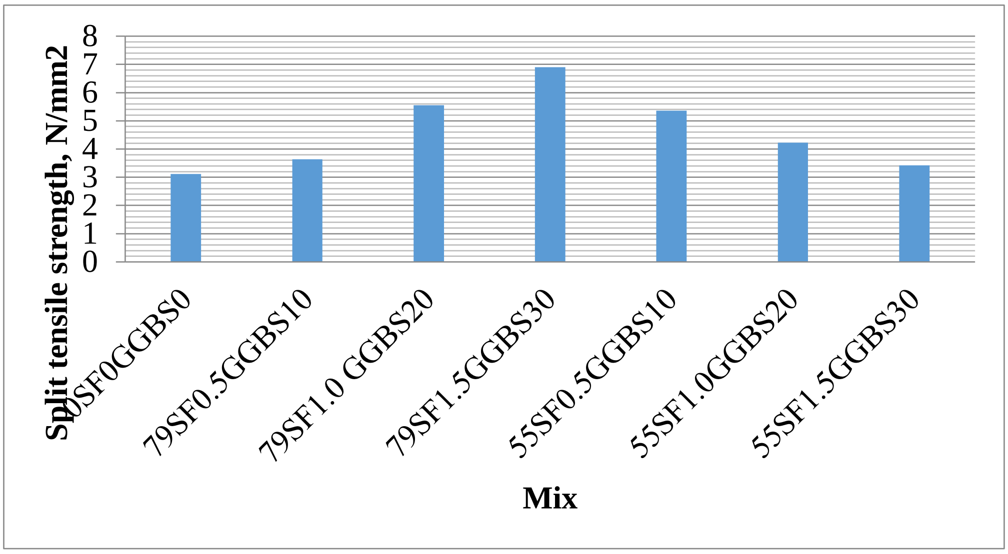

Fig 5- Spli tensile strength at 28 days

3. Conclusion

The addition of fibres to concrete improves the strength distribution. Take a look at results showed a rise in strength across all parameters of testing. Slump cone test shows that with increase in GGBS content, the workability increases but addition of steel fiber in concrete decreases the slump value. Use of GGBS as cement replacement increases consistency. Increment of GGBS and steel fiber content up to 10 % and 1.5 % showsworthy results in terms of compressive, split tensile and flexural strength.Concrete ductility developed by the accumulation of steel fibers. Also in this study we noticed that compressive strength, split tensile strength and flexural strength of concrete improves with the addition of fibers. Also with the addition of steel fibers, it reduces bleeding and it advances the surface integrity of concrete. Hence the probability of cracks greatly reduced. This experimental investigation helps to know the properties and behaviour of steel fiber reinforced concrete. From the mechanical properties, the optimum replacement by GGBS and steel fiber was found to be 10 %& 1.5 %with aspect ratio 79 and beyond all the strength values decreased when compared to normal concrete. With increase in amount of fibers, flexural strength increases while flexural deflection decreases with increase in addition of steel fiber as compared to the normal concrete. Advantage of addition of GGBS in cement is that it sets faster than it is made with OPC, it also gain strength continuously with a longer curing period. It also offers high resistance against corrosion attack and provides protection against sulphate attack hence used in effluent and sewage treatment plant (to avoid sulphate attack), in marine work and many more.

4. References

[1] Pooja, Shreenivas Reddy Shahapur, Maneeth PD, Brijbhushan S, “Evaluation of Effect of Steel Fibres on M45 grade of Concrete by Partial Replacement of Cement with Fly ash and GGBS”, International Journal for Research in Applied Science & Engineering Technology, Vol. 5, Issue 8, PP: 1949-1956.

[2] T. Subbulakshmi, B. Vidivelli, K. Nivetha, "Strength Behaviour of High Performance Concrete using Fibres and Industrial by Products", International Journal of Engineering Research & Technology, Vol. 3, Issue 8, PP: 1219-1224.

[3] SuchitaHirde, Pravin Gorse, "Effect of Addition of Ground Granulated Blast FurnaceSlag (GGBS) on Mechanical Properties of Fiber Reinforced Concrete", International Journal of Current Engineering and Technology, Vol. 5, Issue 3, PP: 1677-1682.

[4] Nandhini.J, Kalingarani.K, "Effect of Hybrid Fibres on Flexural Behaviour of Reinforced Concrete Beams with Blended Cement", International Journal of Research in Advent Technology, Vol.4, Issue 6, PP: 70-73.

[5] A.M. Shende; A.M. Pande, M. GulfamPathan, "Experimental Study on Steel Fiber Reinforced Concrete for M-40 Grade", International Refereed Journal of Engineering and Science, Volume 1, Issue 1, PP: 43-48.

[6] S.P.Sangeetha, Dr.P.S.Joanna, "Flexural Behaviour Of Reinforced Concrete Beams With GGBS", International Journal Of Civil Engineering And Technology, Volume 5, Issue 3, PP: 124-131.

[7] Christina Mary V, Kishore CH, "Experimental Investigation On Strength And Durability Characteristics of High Performance Concrete Using GGBS And Msand", ARPN Journal of Engineering and Applied Sciences, Vol. 10, Issue 11, PP: 4852-4856.

[8] Sowmya. S.M, PremanandKumbar, R. Amar, "An Experimental Investigation on Strength Properties of Concrete by Replacing Cement with GGBS and Silica Fume", International Journal of Research, Vol. 1, Issue 8, PP: 148-152.

[9] Sujit V. Patil, N. J. Pathak, "The Experimental Study on Compressive Strength of Concrete using AR Glass Fibers and Partial Replacement of Cement with GGBS with Effect of Magnetic Water", International Journal of Engineering Technology, Management and Applied Sciences, Vol.4, Issue 8, PP: 21-29.

[10] Prashant Y.Pawade, Nagarnaik P.B., Pande A.M, "Performance of steel fiber on standard strength concrete in compression", International Journal of Civil and Structural Engineering Volume 2, No 2, PP: 483-488.

[11] Nikhil A. Gadge, S. S. Vidhale, "Mix Design of Fiber Reinforced Concrete (FRC) Using Slag & Steel Fiber", International Journal of Modern Engineering Research, Vol. 3, Issue. 6, PP: 3863-3871.

[12] T. Subbulakshmi, B. Vidivelli, "Experimental Investigation on the Effect of Industrial byproducts on the Strength Properties of High Performance Concrete", Journal of Mechanical and Civil Engineering, Volume 13, Issue 3, PP: 13-21.

[13] RoopaSaira Thomas, Jebitta Fancy Rajaselvi .P, "An Experimental Investigation on the Effects of Concrete by Replacing Cement with GGBS and Rice Husk Ash with the Addition of Steel Fibers",International Journal of Science and Research, Volume 5, Issue 2, PP: 2104-2109.

[14] Vijay MadhavraoTakekar, G. R. Patil, "Experimental Study of Properties of Fiber Reinforced Concrete using GGBS", International Journal of Engineering Technology, Management and Applied Sciences, Volume 3, Issue 3, PP: 589-594.

[15] AnushaSuvarna, P.J. Salunke, T.N.Narkehde, "Strength Evaluation of Fiber Reinforced Concrete Using Pozzolanas", International Journal of Engineering Sciences & Research Technology, Vol. 4, Issue 10, PP: 196-201.

[16] NamaniSaikrishna, Syed Moizuddin, "Strength Properties of Steel Fiber Concrete by Partial Replacement of Silica Fume", International Journal of Research in Advanced Engineering Technology, Volume 6, Issue 1, Jan 2017, PP: 120-124.

[17] DasariVenkateswara Reddy, Prashant Y.Pawade, "Combine Effect Of Silica Fume And Steel Fiber On Mechanical Properties On Standard Grade Of Concrete And Their Interrelations", International Journal of Advanced Engineering Technology, Vol.3, Issue I, January, 2012, PP: 361-366.

[18] K.Vidhya, T.Palanisamy, R.ThamaraiSelvan, "An Experimental Study On Behaviour Of Steel Fibre Reinforced Concrete Beams", International Journal of Advanced Research Methodology in Engineering & Technology, Volume 1, Issue 2, March 2017, PP: 178-183.

[19] Mohammad Panjehpour, Abang Abdullah Abang Ali, RamazanDemirboga, "A Review For Characterization Of Silica Fume and Its Effects On Concrete Properties", International Journal of Sustainable Construction Engineering & Technology, Vol 2, Issue 2, December 2011, PP: 1-7.

[20] Vijay M. Mhaske, Rahul D. Pandit, A. P. Wadekar, "Study on Behaviour on High Strength Crimped Steel Fibre Reinforced Concrete for Grade M90", Journal of Ceramics and Concrete Sciences, Vol. 1, Issue 3, PP: 1-12.

[21] SubhashMitra, Pramod K. Gupta and Suresh C. Sharma, "Time- dependant strength gain in mass concrete using mineral admixtures", Indian Concrete Journal, Vol. 1, Issue 3, November, 2012, PP: 15-22.

[22] A. Annadurai, A. Ravichandran, "Flexural Behaviour of Hybrid Fiber Reinforced High Strength Concrete", Indian Journal of Science and Technology, Vol 9, Issue 1, Jan 2016, PP: 116-122.

[23] Ram Kumar, Jitender Dhaka, "Review Paper on Partial Replacement Of Cement With Silica Fume And Its Effects on Concrete Properties", International Journal For Technological Research In Engineering Volume 4, Issue 1, September-2016, PP: 83-85.

[24] Neeraja, "Experimental investigation of Strength Characteristics of Steel Fiber Reinforced Concrete", International Journal of Scientific &Engg. Research, Vol-4, Issue-2, PP: 89-94.

[25] Vikrant S. Variegate, Kavita S. Kene (2012), "Introduction to Steel Fiber Reinforced Concrete on Engineering Performance of Concrete" International Journal of Scientific & Technology Research Volume 1, Issue 4, PP: 54-61.

[26] M. V. Mohod, "Performance of steel fiber reinforced concrete" International Journal of Engineering and Science, Vol. 1, issue 5, PP. 01 – 04.

[27] ISO 901:20089, "International Organisation for Standard".

[28] ASTM A-820, "Standard Specification for steel fiberreinforce concrete", 2011.

[29] M.S.shetty {Book},"concrete technology (theory and practice)", 2011.