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Improving Strength of Concrete by Partial Replacement of Cement with Ground Granulated Blast Furnace Slag and Sand with Robo Sand

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ABSTRACT: Concrete is the most undisputable and indispensable material being used in infrastructures development throughout the world. Ground Granulated Blast Furnace Slag has been constantly in use as cementitious replacement for sustainable infrastructure. It helps for the utilization of large quantity of concrete. High Performance Concrete (HPC) is a concrete meeting special combinations of performance and uniformity requirements that cannot be always achieved routinely by using conventional constituents and normal mixing. This leads to examine the admixtures to improve the performance of the concrete. On the other side, cost of concrete is attributed to the cost of its ingredients which is scarce and expensive, this leading to usage of economically alternative materials in its production.

This requirement is drawn the attention to explore new replacements of ingredients of concrete. Present focuses on the characteristics of M30 concrete with partial replacement of cement with Ground Granulated Blast Furnace Slag (GGBS), sand with ROBO sand and Synthetic resin compound is used for self-curing. Realization on the increasing demand for river sand supply in construction sector has inspired the current research to find alternative material to reduce the use of natural sand in concrete. The cubes and cylinders are tested for both compressive and tensile strengths. This usage of GGBS serves as replacement to already depleting conventional building material and the recent years also as being a byproduct, it serves as an Eco-friendly way of utilizing the product without dumping it on ground. It is found that by the partial replacement of cement with GGBS and sand with ROBO sand helped in improving the strength of the concrete substantially compared to normal mix concrete. The cement has been replaced by GGBS accordingly in the range of 0%, 5%, 10%, 15%, 20%, and 25% by weight of cement. And River sand has been replaced by Robo sand accordingly in the range of 0%, 10%, 20%, 25%, & 30% by weight of Sand for every replacement of GGBS for M30 grade mix. Concrete cubes were casted and tested after 7 days and 28 days curing for compressive strength and compared with Compressive strength of control cubes specimen. So that optimum percentage of GGBS and Robo sand is to be determined.

KEYWORDS: Robo sand, High performance concrete, Ground granulated blast furnace slag,

I. INTRODUCTION

Concrete is the most famous and extensively used building material, owes to its advantageous properties, production and maintenance over steel and timber. Concrete is a matrix consists of basic ingredients namely binding material, fine aggregate, coarse aggregates and water. Conventional binding material cement has now become expensive and its production involves undesirable environmental consequences such as heavy production of Carbon dioxide (CO₂). Conventional fine Aggregate, River sand has become scarce and its excessive use causes degradation of river bed and reduction in ground water recharge. To offset with these two challenges, an attempt has been made to produce concrete with supplementary and alternative materials.

Ground Granulated Blast Furnace Slag which is byproduct of steel production has been used to partially replace the cement. It is supplementary cementitious material which partially replaces the cement in concrete. GGBS unit price is almost half of the price of cement. Its replacement has considerable advantages in properties of concrete in fresh and hardened state. A study is required to assess the effects of combination of GGBS and quarry stone dust in fresh and hardened state of concrete. Quarry stone dust, a by-product from crushing process during quarrying activities has been used as an alternative fine aggregate that completely replaces the river sand which is far superior to river sand in all aspects. Various combinations have been made with different proportions of Cement, Ground Granulated Blast Furnace Slag, Quarry stone dust, Coarse aggregate and Water. Properties of concrete have been studied in fresh and hardened state for all combinations made and deduced the conclusions. High performance concrete meeting special combination of performance and uniformity requirement that cannot always be achieved routinely using conventional constituents and normal mixing, placing, and curing practices. High performance concrete (HPC) is concrete that has been designed to be more durable and, if necessary, stronger than conventional concrete. HPC mixtures are composed of essentially the same material as conventional concrete mixtures. But the proportions are designed or engineered to provide the strength and durability needed for the structural and environmental requirement of the project. High performance concrete is defined as having a specified compression strength of 4350 psi (30 MPa) or greater. The value of 4350 psi (30 MPa) was selected because it represented a strength level at which special care is required for production and testing of the concrete and at which special structural design requirements may be needed. Concrete is very weak in tension and is brittle. Idea of using GGBS and quarry stone dust for improving the properties of building materials is very old. First applications include the addition of clay bricks reinforced horsehair plaster and asbestos reinforced ceramics. With the development and strengthening of reinforced concrete there is increase in the strength and ductility, but requires careful and intelligent placement of concrete. Ingredients of concrete now became scarce and expensive. Production and excessive use of some conventional ingredients of concrete causes undesirable environmental consequences. Natural River sand is one of the constituents used in the production of concrete has become expensive and scarce.

Hence there is a large demand for alternative building materials that replace the river sand without sacrificing desired properties of concrete in fresh and hardened states. The crusher dust produced from granite crushers is one of such alternative building materials that replaces the river sand and named as quarry stone dust. It is popularly known by several names such as Crushed sand, Rock dust, green sand, Robo sand, Poads sand, Barmac sand, and Pozzolana sand. This Robo sand is far superior to conventional river sand and its unit price is little less or near to river sand. Conventional binding material in concrete is cement which has now become expensive and its production is not an eco-friendly activity. Hence there is great demand for alternative and supplementary cementitious materials. Ground Granulated Blast Furnace Slag (GGBS) is by-product from iron manufacturing process. Alternatively, use of fibres in reinforced or unreinforced concrete can provide good results. Latest development of fibre-reinforced concrete was started in the early sixties. Addition of fibers in the concrete can make it more homogeneous, consistent and isotropic material. When concrete cracks, randomly oriented fibres begin to work, stop the crack formation and propagation, and thus to improve the strength and ductility. The failure modes are either broken bond between the fibers and the matrix or hardware failure.

This report sets state-of-the-art fiber concrete was investigated and reported results of surgical tests carried out on the properties of fiber-reinforced concrete with local materials. It is supplementary cementitious material which partially replaces the cement in concrete. GGBS unit price is almost half of the price of cement. Its replacement has considerable advantages in properties of concrete in fresh and hardened state. A study is required to assess the effects of combination of GGBS and quarry stone dust in fresh and hardened state of concrete.

The global consumption of natural sand is very high, due to the extensive use of concrete or mortar. In general, the demand of natural sand is quite high in developing countries to satisfy the rapid infrastructure growth, in this situation developing country like India facing shortage in good quality natural sand. Particularly in India, natural sand deposits are being depleted and causing serious threat to environment as well as the society.

The most- commonly used fine aggregate is a natural river sand or pit sand. Fine and coarse aggregate constitute about 75% of total volume. Therefore, important to obtain right type and good quality aggregate at site, because the aggregate forms the main matrix of concrete or mortar.

The production of cement is an energy intensive process resulting in emission of green- house gases which adversely impact on the environment. At the same the cost of production of cement is increasing at alarming rate and natural

resources giving raw material for its manufacturing are depleting. The use of waste material having cementitious properties as a replacement of cement in cement concrete has become the thrust area for construction material experts and researchers

II. RELATED WORK

The Experiments were carried out on cement and aggregates and then later on the resulting concrete, in order to evaluate various parameters of the materials and the concrete, to determine whether the materials and the concrete give the expected results. To determine the fineness of cement by dry sieving as per IS: 4031 (Part 1) –1996. The principle of this is that we determine the proportion of cement. The apparatus used are 90 μ m IS Sieve, Balance capable of weighing 10g to the nearest 10mg, A nylon or pure bristle brush, preferably with 25 to 40mm, bristle, for cleaning the sieve. Sieve shown in pic below is not the actual 90 μ m sieve. Its just for reference.[1] Weigh approximately 10g of cement to the nearest 0.01g and place it on the sieve.[2]Agitate the sieve by swirling, planetary and linear movements, until no more fine material through it.[3]Weigh the residue and express its mass as a percentage R1, of the quantity first placed on the sieve to the nearest 0.1 percent.[4]Gently brush all the fine material off the base of the sieve.[5]Repeat the whole procedure using a fresh 10g sample to obtain R2. Then calculate R as the mean of R1 and R2 as a percentage, expressed to the nearest 0.1 percent. When the results differ by more than 1 percent absolute, carry out a third sieving and calculate the mean of the three values. Then the Report the value of R, to the nearest 0.1 percent, as the residue on the 90 μ m sieve.

The basic aim is to find out the water content required to produce a cement paste of standard consistency as specified by the IS: 4031 (Part 4) – 1988. The principle is that standard consistency of cement is that consistency at which the Vicat plunger penetrates to a point 5-7mm from the bottom of Vicat mould.[1]Weigh approximately 400g of cement and mix it with a weighed quantity of water. The time of gauging should be between 3 to 5 minutes.[2]Fill the Vicat mould with paste and level it with a trowel.[3]Lower the plunger gently till it touches the cement surface.[4]Release the plunger allowing it to sink into the paste.[5]Note the reading on the gauge.[6]Repeat the above procedure taking fresh samples of cement and different quantities of water until the reading on the gauge is 5 to 7mm. We need to calculate the initial and final setting time as per IS: 4031 (Part 5) – 1988. To do so we need Vicat apparatus conforming to IS: 5513 – 1976, Balance, whose permissible variation at a load of 1000g should be +1.0g, Gauging trowel conforming to IS: 10086 – 1982.[1] Prepare a cement paste by gauging the cement with 0.85 times the water required to give a paste of standard consistency.[2]Start a stopwatch, the moment water is added to the cement.[3]Fill the Vicat mould completely with the cement paste gauged as above, the mould resting on a non-porous plate and smooth off the surface of the paste making it level with the top of the mould. The cement block thus prepared in the mould is the test block. And the specific gravity test of cement is the Weigh a clean and dry Le Chatelier flask with its stopper (W1). Place a sample of cement up to half of the flask and weight with its stopper (W2). Add kerosene to cement in flask till it is about half full. Mix thoroughly with glass rod to remove entrapped air. Continue stirring and add more kerosene till it is flush with the graduated mark. Dry the outside and weigh (W3). Entrapped air may be removed by vacuum pump, if available. Empty the flask, clean it refills with clean kerosene flush with the graduated mark wipe dry the outside and weigh (W4).

The fineness modulus of fine aggregate is the Fineness modulus of fine aggregate is an index number which represents the mean size of the particles in sand. It is calculated by performing sieve analysis with standard sieves. The cumulative percentage retained on each sieve is added and divided by 100 gives the value of fineness modulus of fine aggregate. Fine aggregate means the aggregate which passes through 4.75mm sieve. To find the fineness modulus of fine aggregate we need sieve sizes of 4.75mm, 2.36mm, 1.18mm, 0.6mm, 0.3mm and 0.15mm. Fineness modulus of finer aggregate is lower than fineness modulus of coarse aggregate. The apparatus used are standard sieves, dry oven and digital weight scale.

III. METHODOLOGY

In this method of research and design mix have been described for various percentages of replacement of GGBS and quarry stone dust with cement and sand respectively. Concrete specimens were casted using 0%, 10%, 20% and 30% of replacement of cement by GGBS and fine aggregate with stone dust. Cubes of standard size 150mm were casted and tested for 7-28 days compressive strength. Standard cylinders of size 100mm x 200mm (diameter x height) were casted and tested for 7 and 28 days for split tensile strength. Also, standard prisms of size 500mm x 100mm x 100mm (length

x width x height) were cast and tested for 28 days for flexural strength and observed the percentage of water absorption in both quarry Stone dust and Natural sand.

In this methodology we are adopted is the [1] First preliminary we are collect the raw materials and tests are conducted to fine aggregate, coarse aggregate, GGBS and cement.[2] then The tests include particle size distribution of fine aggregate and coarse aggregate, specific gravity of cement, etc.[3] The concrete mix design is designed by appropriate proportions and then, [4] The set of cubes were casted with different proportions and tested for compressive strength, tensile strength at 7, 28 days.[5] This process is repeated until optimum mix proportion is obtained for M30 grade concrete. In that way we are doing this experiment by above methodology used.

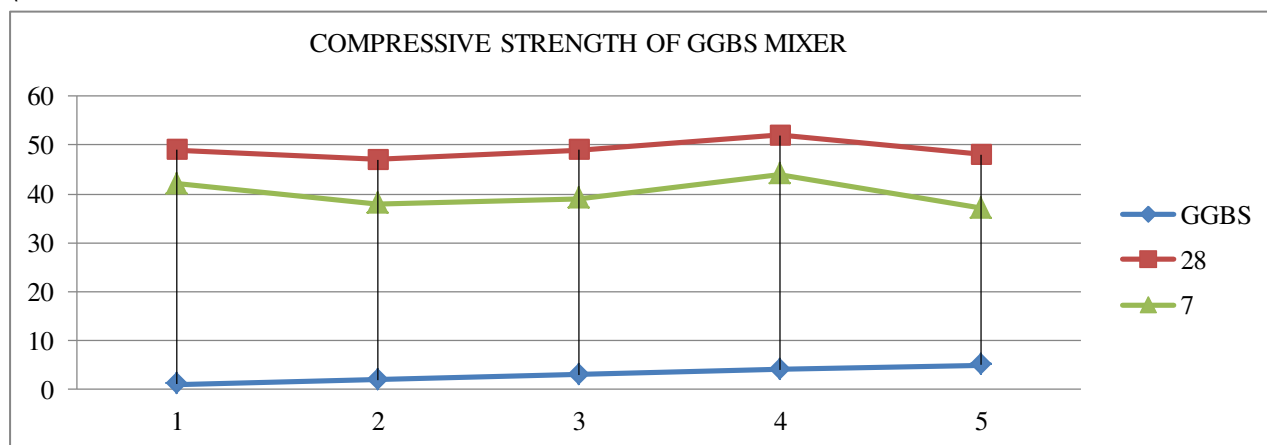
IV. EXPERIMENTAL RESULTS

In this the experimental results the compressive strength test at 7 and 28 days are is to calculated, then the values are get , by showing below table.

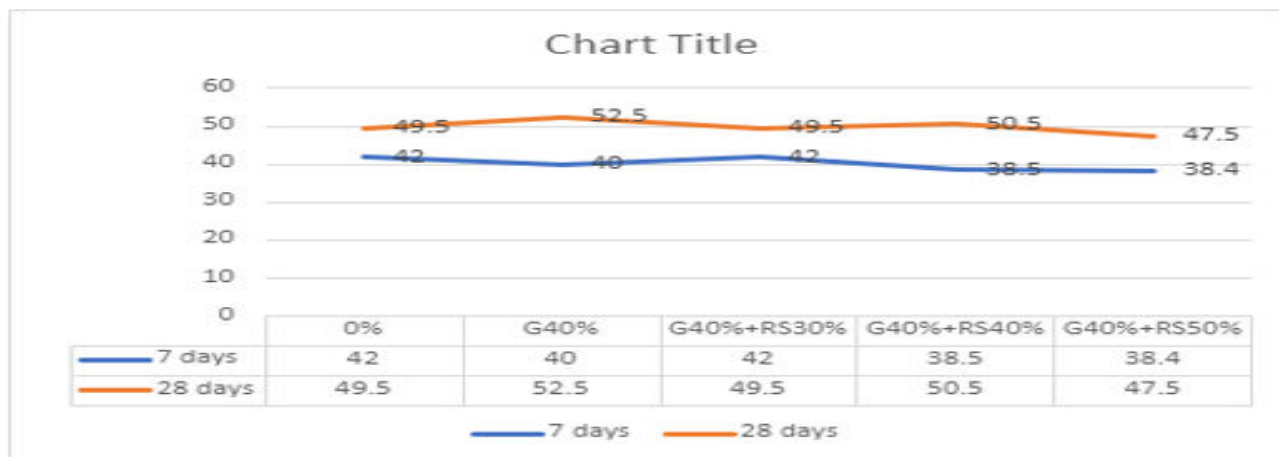
S. NO	Mix	7 days(N/mm ²)	28 days(N/mm ²)
1.	Normal concrete (without replacement)	19.12	28.76
2.	Concrete with 20 GGBS and 10% Robo sand	16.38	27.71
3.	Concrete with 30% GGBS and 20% Robo sand	18.09	29.36
4.	Concrete with 40% GGBS and 30% Robo sand	17.89	28.26

Table 1 compression test results

The compressive strength of GGBS mixer values are represented given below graph .



(a) compressive strength of GGBS mixer



(b) compressive strength of GGBS with variation of robo sand.

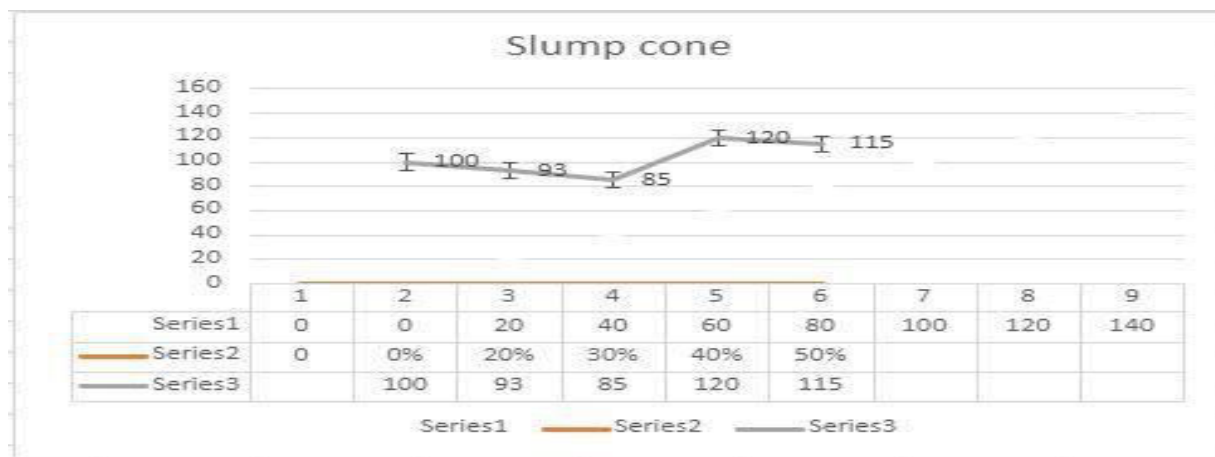
The following graph are the compression strength of GGBS with variation of robo sand

Table 2 slump test results

S.NO	Mix	Slump (mm)
1.	Normal concrete (without replacement)	80
2.	Concrete with 20% GGBS and 10% Robo sand	79
3.	Concrete with 30% GGBS and 20% Robo sand	77
4.	Concrete with 40% GGBS and 30% Robo sand	74

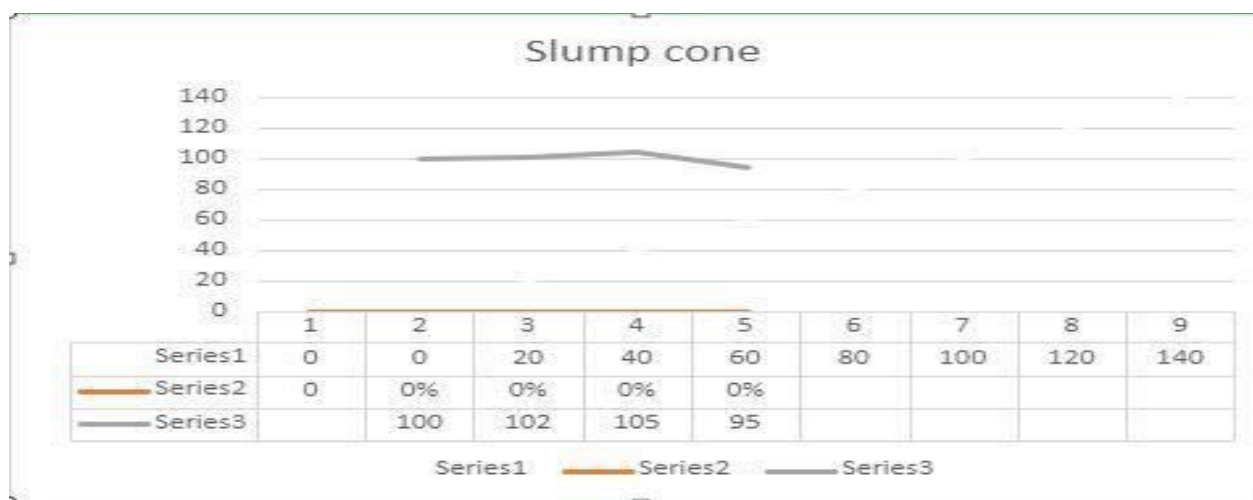
Table 2 :The slump test is we are conducted and in that test the normal concrete without replacement and after that 20%GGBS and 10% robo sand is taken the slump is 80 mm are occurred and each sample we can increased by 10% of the GGBS and robo sand then we get the values are the 79,77,74 respectively .

The Workability of GGBS concrete mix



(c)slump cone test results graph

Workability of GGBS variation with the various of Robo sand is represented the graph is below



(d)slump cone test results graph

Table 3 is The split tensile test are is to conducted in this experiment at normal concrete and concrete with 20% of the GGBS and 10% of the robo sand the values is at 28 days are 3.21 N/mm²,and remaining values are is represented on the following table

S. no	Mix	7 days(N/mm ²)	28 days(N/mm ²)
1.	Normal concrete (without replacement)	3.07	3.63
2.	Concrete with 20% GGBS and 10% Robo sand	2.93	3.21

3.	Concrete with 30 % GGBS and 20% Robo sand	3.16	3.97
4.	Concrete with 40% GGBS and 30% Robo sand	2.56	3.09

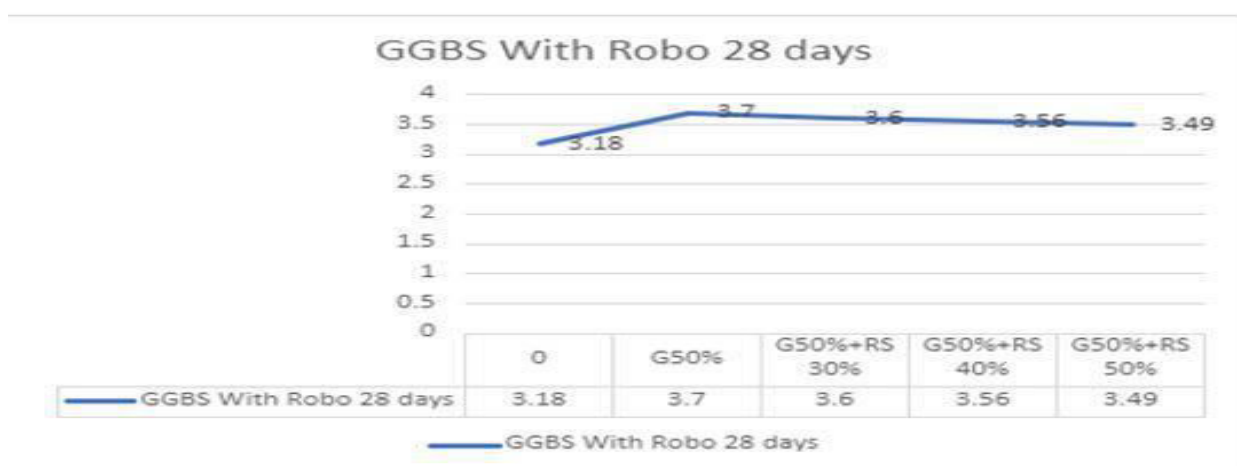
Table 3split Tensile test

The Split tensile strength of GGBS variation represented in graph shows



(e) split tensile test at variation of GGBS

The Split tensile strength of GGBS with variation of Robo sand is



(e) split tensile strength of GGBS at variation of robo sand graph



V. CONCLUSION

In this report, an attempt has been made to study the effects of GGBS as an alternative to cement and quarry stone dust as an alternative to fine aggregate on concrete properties. Combinations of quarry stone dust and GGBS were prepared and effects of these combinations on concrete properties have been studied. The non-availability of river sand has led to the search of an alternate material for the fine aggregates that can replace the river sand. Quarry stone dust more economical was found to be best alternative of fine aggregate to River sand which satisfied all technical specification specified in the Indian Standard Codes and it contained no impurities. The GGBS which is also a waste generated by the industry proves to be a replacement of cement in concrete thus to reduce the emission of the CO₂ from the cement production. The effects of M30 design mix (1: 1.6: 2.6) with water cement ratio as 0.45 have been studied. The comparison of results was done with 0% replacement. The slump was found to be decreased on increasing the percentage of the quarry stone dust. This is due to the reason that the quarry stone dust has high initial water absorption. Based on the results, it is understood that the Portivity for Control Mix, mix 1, Mix 2, and Mix 3 are low when compared to Mix 4 and Mix 5. The rate of water absorption is maximum at the bottom of the concrete samples for Mix 4 and Mix 5. It is understood that there is slight decrease in compressive strength of all the mixes after acid curing for 30 days. The M1 mix is enhanced resistance to chloride attack. The compressive strength of concrete incorporating 10% GGBS and 50% MSAND is reduced only by 3.55% as compared with the reduction of strength of control mix specimen by 4.38%. The 28 days compressive strength of 15% GGBS and 20% quarry stone dust was found to be increased. The split tensile strength also shows the increase at 15% GGBS and 20% quarry stone dust. The flexure strength of 28 days was found to be increased by replacing 15% of cement by GGBS and 20% of river sand by quarry stone dust. Hence using Ground- granulated blast furnace slag and quarry stone dust in concrete mix proved to be useful to solve environmental problems and reduce some extent the need of cement in large quantity. Therefore, it is recommended to reuse these wastes in concrete to move towards sustainable development in construction industry.

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