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EXPERIMENTING WITH GGBS TO REPLACE FINE AGGREGATE.

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ABSTRACT

In the current work, the effect of the partial substitution of fine particles with ground granulated blast furnace slag (abbreviated as GGBS) and its effect on mechanical strength and durability qualities (acid attack) of conventional Portland cement concrete of grade (M20) were investigated. The purpose of this inquiry is to determine whether or not granulated blast furnace slag (GGBS) might be used in cement concrete in place of sand. This would help alleviate some of the environmental issues that are associated with the mining of fine aggregate and the disposal of slag waste. When a conventional w/c ratio of 0.4 is taken into consideration, the proportion of GGBS replacement ranges from 0 to 20 to 40 to 60 percent for natural sand. Research on the flow properties of the various mixes and the compressive strengths of those mixes at varying times is carried out as part of this. The use of natural sand in concrete is seeing steadily rising demand as each day passes.

We are conducting this experimental investigation in order to evaluate the impact that a portion of the fine aggregate being replaced with ground granulated blast furnace slag (GGBS) in concrete that also contains quarry dust as fine aggregate has. The production of steel results in a number of waste products, one of which being GGBS. In the sphere of building, the utilisation of industrial soil waste or secondary materials for the manufacturing of concrete is promoted because it contributes to lowering the consumption of natural resources. This is one of the reasons why this practise is supported. Through the process of exchanging the fine aggregate, we were able to investigate the concrete's strength, endurance, and resistance to corrosion. The substitution of fine aggregate with GGBS at several percentages, including 0% (no GGBS), 20%, 40%, and 60% respectively. The concrete mixtures were thoroughly mixed, tested, and analysed to determine the compressive, and the results were compared to those of standard concrete.

Keywords: Cement, Fine aggregates, Coarse aggregates, Water and GGBS.

1. INTRODUCTION

Concrete is a product of human industry that serves as the principal building material all over the world. It is also the material that is utilised the most in any and all forms of civil engineering work. Concrete, although being the most common and economically advantageous building material, is one of the primary contributors to the greenhouse gas effect. In the context of this research, ground granulated blast furnace slag, often known as GGBS, is a by-product of the blast furnaces that are utilised in the production of iron [1]. The temperature can be operated at and fed with the mixture of iron ore, coke, and limestone if care is used. The temperature is approximately 1500 degrees centigrade.

During this process, the iron ore is converted into iron, and the byproduct of this transformation is slag, which may be found floating on top of the iron. And regularly drawing off the molten slag as a liquid, which, before it can be employed in the production of GGBS, needs to be swiftly cooled off in vast amounts of water. The quenching process creates granules that have the consistency of coarse sand and optimizes the qualities of the cementation. After that, the granulated slag was dried and ground up into a fine powder [3]. In their fresh states, the properties of mortars and concrete are influenced by factors such as specific gravity, particle size distribution, form, and surface roughness. However, it has been discovered that some qualities of concrete, such as the mineralogical composition, toughness, elastic modulus, and degree of change of aggregates, can have an effect on the properties of concrete, particularly when it is in the hardened form. [2]In India, natural river sand can be defined as fine aggregate, which is traditionally utilised in mortars and concrete. This material is used in construction throughout the country.

However, increasing environmental constraints on the extraction of sand from riverbeds have led to the hunt for other sources of sand, particularly in close proximity to the more populous areas served by metro polytan districts. Because of this, the use of manufactured fine aggregates in cement concrete appears to be an appealing option to the use of natural fine aggregates.[4] The artificial sand has an uneven texture and a greater porosity. Grading will vary over a wide range, which will result in an increase in the amount of internal porosity and a decrease in the workability of mortar or concrete. The compressive strength of the manufactured sand was demonstrated to be comparable to or even greater than that of concrete. Providing lubrication for the aggregate system while not increasing the amount of water required by the mixture.

In the production of mortar and concrete, many forms of slags derived from the copper and steel industries are utilized. Other resources that can be used in place of aggregates include recycled aggregates, trash from quarries, and garbage from building and demolition. [5]In the manufacture of concrete, these aggregates have proven to be quite useful. 7.8 million metric tonnes of lag from blast furnaces are produced annually in India. Granulating all of the molten slag from the blast furnaces involves quenching the molten slag with a high-powered water jet, which results in 100% glassy slag granules. GGBS which is a by-product obtained to us from Here NBA instrument and Engineers Company, Chennai.

Fig1.Concrete

2. LITERATURE SUREY

Wangling We analysed the efficacy of GGBS on both freshly mixed concrete and concrete that had already been hardened. It has a good resistance to chemical corrosion, a low heat of hydration, and a high level of strength. GGBS concrete has these characteristics. Shariq The effect of the curing technique on the development of compressive strength in [3]cement mortar and concrete using ground granulated blast furnace slag was investigated in this study. Calculating the compressive strength development of cement mortar involves replacing 20, 40, and 60 percent of GGBFS[5] with various kinds of sand. These percentages are used in the calculation. In a similar manner, an investigation into the growth of concrete strength is conducted using GGBFS as a replacement for 20, 40, and 60 percent of two different grades of concrete. The findings of the tests reveal that increasing the proportion of GGBFS in the diet by 20% or 40% has a highly significant impact.

Md. Moinul Islam the outcomes of using slag as a partial replacement for cement in several amounts (ranging from 10% to 70%) were discussed. The compressive strength and tensile strength of mortar mixes with slag were evaluated at the ages of 3, 7, 14, 28, 60, 90, and 180 days. He discovered that these strengths decreased at early ages of curing (3 and 7 days).However, as time passes after treatment, the pace of decline slows down to a more manageable level. When compared to OPC mortar, slag has a compressive strength that is 19% higher and a tensile strength that is 25% higher. The optimal amount of slag to utilise in mortar is 40% of the cement's replacement. He came to the conclusion that the use of slag[4] lowers the quantity of cement content in a mortar mix in addition to the heat of hydration, which ultimately leads to a lesser risk of thermal cracking. In this way, the utilisation of slag concrete in the building industry becomes not only ecologically friendly but also economically viable.

3. METHODOLOGY

GGBS

Ground Granulated Blast Furnace Slag, also known as GGBS or GGBFS, is produced by first producing a glassy, granular product called GGBS or GGBFS by quenching molten iron slag, which is a by-product of the production of iron and steel, in water or steam from a blast furnace. This is followed by drying the product and grinding it into a fine powder. After coming into contact with water, ground granulated blast furnace slag transforms into calcium silicate hydrates (abbreviated as C-S-H), which acts as a latent hydraulic binder. It is a chemical that increases the strength of concrete while also boosting its durability. It plays a role as a component in metal urgic cement [2] (referred to as CEMIII in the European norm EN197).Its primary benefit is that it has a slower lease of hydration eat, which allows for the limitation of the temperature increase in enormous concrete components and structures during the setting of cement and the curing of concrete, or for the casting of concrete during the warm summer months.

Using GGBS as an alternative for fine gravel for concrete comes with a number of advantages, including the following:

- Improved durability: GGBS has a high content of amorphous silica, which enhances the durability of concrete. When used as a partial replacement for fine aggregate, it can help to reduce the permeability of concrete and improve its resistance to chemical attack and erosion.
- Reduced environmental impact: The use of GGBS in concrete reduces the demand for naturals and, which can help to reduce the environmental impact of sand mining. Additionally, GGBS is a by-product of industrial processes and using it in concrete provides as stainable way of disposing of this waste material.
- Improved workability: GGBS has a finer particle size distribution than sand, which can help to improve the work ability of concrete. This can make it easier to place and finish the concrete, especially in situations where high-strength or high-performance concrete is required.
- Cost Savings: The use of GGBS as a partial replacement for fine aggregate can reduce the amount of cement needed in concrete, which can help to lower the overall cost of the concrete mix.

Fig 2. GGBS

CASTING OF CUBES

When the sample has been thoroughly combined, the cube moulds should be immediately filled and the concrete should be compacted, either by hand or with the use of vibration.[3] If there is any air that gets trapped in the concrete, the cube's strength will be reduced. As a result, the cubes have to be completely crushed. However, caution is also required to avoid over-compacting the concrete, since this can lead to the aggregates and cement paste in the mix becoming separated. It is possible that this will also lower the final compressive strength.

Fig 3. Casted cubes

COMPACTION

Compaction is an essential step in the process of making concrete cubes. The purpose of compaction is to remove air voids from the concrete mixture, [4]ensuring that the concrete is dense, strong, and durable.

HAND COMPACTION

In the event that the concrete task at hand is of little importance or magnitude, hand compaction of the concrete is utilised. Sometimes, this procedure is also utilised in situations like these, where a substantial quantity of reinforcement is used that cannot ordinarily be compacted by mechanical means. This is because the reinforcement prevents regular mechanical compaction from occurring. Rodding, ramming, and tamping are the three methods that make up hand compaction. When hand compaction is used, the concrete's consistency is kept at a greater level than it would be using other methods. It is recommended that the layer of concrete not be any thicker than 15 to 20 centimetres. [4]To pack the concrete between there in for cement and sharp angles and edges, rodding consists of nothing more than poking the concrete with a rod that is around 2 metres long and 16 mm in diameter. Continuous rodding is carried out across the entirety of the space in order to achieve a proper packing of the concrete and expel any trapped air. Bamboo or cane may also be used for rodding purposes in addition to or in place of iron rods at times. When ramming, one ought to exercise caution. It's possible to get away with doing some light ramming in the foundation concrete of an unreinforced building or in ground floor construction. In the case of reinforced concrete or in the construction of upper floors, when concrete is laid in the form work supported on struts, ramming should not be allowed under any circumstances. When framing is used in the situation described above, the location of the reinforcement might be thrown off or the formwork might collapse, especially if a steel rammer was used.

When compacting materials for a roof, floor slab, or road, tamping is one of the more common procedures used. Pavements with a concrete thickness that is relatively less than that of other types and a surface that is to be finished smooth and level. The second step of tamping involves striking the top surface with a wooden crossbeam that is approximately 10 cm x 10 cm in section. Because it is sufficiently long, the tamping bar not only compacts the top surface but also levels it throughout the entire width of the area being worked.

Fig 4. compaction

Fig 5. Finishing of surface

PRECAUTIONS TO BE TAKEN WHILE MAKING OF CUBES

In the process of finishing off the surface of the concrete, if the mould is over full, the excess concrete should not be removed by scraping off the top surface. This is because doing so removes the cement paste that has come to the top and leaves the concrete deficient in cement. The proper technique entails using one of the corners of the trowel to excavate a representative sample of the concrete as a whole, followed by the completion of the surface by to welling.

After a specimen has been compacted, another specimen that is also being compacted should not be left standing on the same bench as the compacted specimen. If this is done, some of the vibration will be transferred to the first specimen, causing it to become more compressed than the other specimen. In extreme circumstances, some rearrangement of the particles and segregation of the particles will be the consequence.

CURING OF CUBES

Curing is the process of preserving wetness on the finished surface of the concrete (Say columns, beams, masonry walls before plastering and also after plastering, slabs etc.). This technique ends in increasing the material's strength while simultaneously reducing its permeability. Curing also plays an important role in minimising cracks in the concrete, which has a significant influence on its longevity. After adding water to the cement, the chemical reaction takes placed and the concrete[5] intended for hydration Due to chemical reaction heat is generated in the interior portion of the concrete, to overcome this situation there is a need for constant curing (or) curing may be done whenever the surface of the concrete becomes dry Concretes hall be kept continuously moist in case of slabs etc. The period of curing Portland cement should not be less than 14 days. The period of curing depends on type of cement and type of structure.

ADVANTAGES OF CURING

- The concrete gets we at hering resistance.
- The concrete becomes watertight (nonabsorbent of water) and it is water proofing.
- The concrete ensures high compressive strength.
- The concrete gets resistance to wear roads etc.
- The concrete gets better bond with reinforcement.

After the concrete cubes have been cast, they should be kept moist and protected from direct sunlight and wind to prevent rapid moisture loss. The cubes should be covered with Adam hessian cloth, burlap or polythene sheeting to retain moisture. During the time that the cubes are being aged, they need to be stored at a temperature that ranges from 20 to 25 degrees Celsius. For concrete with a defined compressive strength of 20 N/mm2 or less, the curing period should be at least 7 days long. For concrete with a required compressive strength of 20N/mm2 or more, the drying period must be at least 14 days long..[4] The cubes should be moistened regularly during the curing period to maintain the required moisture content. The moisture content of the cubes should be monitored regularly using a moisture meter or by weighing the cubes before and after drying in an oven. If the cubes are being cured in a laboratory, they should be stored in a curing tank filled with water to ensure that they remain fully submerged.

Fig 6. Curing of cubes

COMPRESSIVE STRENGTH OF CUBES

The compressive strength test of concrete cubes is a standard test method used to determine the compressive strength of concrete. The test involves the following procedure[3]: Sampling: The concrete cubes are sampled from the fresh concrete as per the relevant standard. Typically, cubes of size150mmx 150mm x 150mm are used for the test.

Preparation: After the curing period, the cubes are removed from the curing tank and any loose particles on the surface are removed.[2] The surfaces of the cubes are then ground flat using a grinding machine.

Testing: After that, the cubes are put through a compression test using an apparatus. The stress is exerted upon the cube at a constant rate of 140 kg/cm2 per minute right up until it gives way. The compressive strength is determined by using the following formula and recording the maximum load, which is equal to 5.

Compressive strength=Maximum load/Cross-sectional area of cube

The cross-sectional area of the cube is calculated by multiplying the length and width of the cube. The compressive strength is expressed in N/mm2 or MPa.

Reporting: The test results are recorded and reported as the average of three cubes. Any abnormal results are investigated, and the test may be repeated if necessary.

The compressive strength test of concrete cubes is a standard test method used to ensure that concrete meets the desired strength requirements for its intended use. It is important to note that the test result is affected by many factors, such as curing conditions,[5] mix design, and testing procedures. Therefore, the test should be conducted according to relevant standards and by trained personnel to ensure accurate and reliable results.

Fig 7. Compressive Testing Machine (CTM)

Fig 8. Work done during casting

4. RESULTS

Table 1. Compressive Strength Test Results

GGBS replacement	0%	20%	40%	60%
Compressive strength of cubes (N/mm2)				
14days2	19.06	24.71	27.24	21.24
8days	13.02	34.44	38.977	15.422

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Fig 9. A graph representation of 14 days compressive strength test results

Fig 10. A graph representation of 28 days compressive strength test results

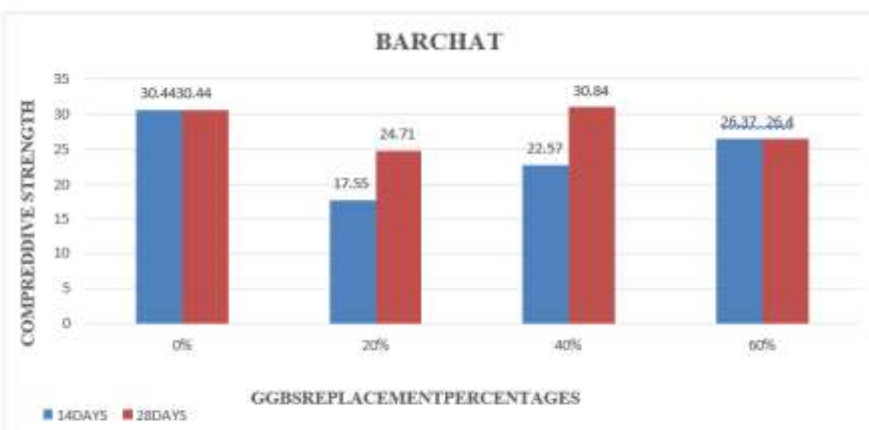

Fig 11. A graph comparing compressive strength test results of 14&28days

CONCLUSION

Demands of Fine aggregate in concrete is increasing day by day due to scarcity in availability and excessive cost of transportation. A study on alternate substitute of natural sand is becoming necessary. One such alternate replacement is GGBS (Ground Granulated Blast Furnace Slag) is one of the byproducts of steel manufacturing industry. The data obtained shows that the replacement of GGBS in concrete can produce high strength than the nominal concrete strength. However, for 100% replacement the strength decreases marginally compared to 100% natural sand. So, it is suggested that up to 40% replacement of GGBS can be done with natural sand which gives the best results like nominal concrete that is 30.84N/mm2 strength. On utilization of the industrial soil waste or secondary materials for the production of concrete is encouraged in field of construction because it contributes to reducing the consumption of natural resources.

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