

# Experimental Study on Concrete with Bottom Ash and GGBS

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**ABSTRACT:** Concrete is the most extensively used construction material in the world. Concrete is normally prepared by using coarse aggregate, fine aggregate, cement and water measured by weight in a required proportion. These materials are obtained from natural resource. Continuous use of these materials on a large scale leads to their depletion causing strain on the environment. Large quantities of waste materials are produced from the manufacturing industry, service industry and municipal solid waste incinerators. The waste materials are gaining attention to use the materials as a substitute to natural aggregates or cement in concrete. In this research, this project focused on the effects of varies percentage of bottom ash and GGBS replacement on the concrete and also study compressive strength, tensile strength and flexural strength of concrete containing bottom ash as fine aggregate and GGBS as cement replacement. The strength are analysed 7days and 28days. The strength for 15-25% replacement of bottom ash with fine aggregate and 15-25% replacement of GGBS with cement is higher or equal to conventional concrete.

**KEYWORDS:** Bottom ash, and ground granulated blast furnace slag (GGBFS), cement, fine aggregate, coarse aggregate, strength

## I.INTRODUCTION

Concrete is a widely used construction material for various types of structures due to its structural stability and strength. Cement concrete is the most extensively used construction material in the world and is the second to water as the most heavily consumed substance with about six billion tons produced every year. It has emerged as the dominant construction material for the infrastructure needs of the 21<sup>st</sup> century. The challenge for civil engineers in the future is to design the project using high performance materials within reasonable cost and lower impact on environment. Large quantities of waste materials are produced from the manufacturing industry, service industry and municipal solid waste incinerators. The waste materials are gaining attention to use the materials as a substitute to natural aggregates or cement in concrete. The increasing demand for electricity resulted in construction of coal fired power plants. As the consumption of coal increases, the production of coal and it's by-products also increased. The ash has to be disposed off either dry or wet to an open area near the plant or by mixing both the fly ash and bottom ash with water and pumping into artificial lagoon or dumping yards. The disposal of such large quantity of ash has occupied thousands hectares of land which includes agricultural and forest land and causes pollution of water bodies too. If these combustion by-products are not utilized properly, there will be no enough space and the disposal of these by-products will be a problem. To minimize all these effects, a best alternative is to promote large-scale utilization of coal ash. The utilization of large quantity of bottom ash can mitigate or solve the disposal and environmental problems associated to it. Coal ash is a residue resulting from combustion of pulverized coal or lignite in Thermal Power Plants and these residues or by-products are commonly known as Coal Combustion products or CCPs. In a dry bottom boiler, about 80 percent of the unburned material or coal ash is entrained in the combustion gases and is captured as fly ash. The remaining 20 percent of the ash is dry bottom ash collected at the bottom of the furnace. This study shows the effect of mechanical properties of concrete in which the fine aggregates are partially replaced with varying percentages. Blast furnace slag is a by-product of iron manufacturing industry. Iron ore, coke and limestone are fed into the furnace, and the resulting molten slag floats above the molten iron at a temperature of about 1500°C to 1600 °C. The molten slag has a composition of 30% to 40% silicon dioxide (SiO<sub>2</sub>) and approximately 40% CaO, which is close to the chemical composition of Portland cement. After the molten iron is tapped off, the remaining molten slag, which mainly consists of siliceous and aluminous residues is then rapidly water- quenched, resulting in the formation of a glassy granulate. This glassy

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granulate is dried and ground to the required size which is known as ground granulated blast furnace slag (GGBFS). The production of GGBFS requires little additional energy compared with the energy required for the production of Portland cement. The replacement of Portland cement with GGBFS will lead to a significant reduction of carbon dioxide gas emission and environmentally friendly construction material. It can be used to replace as much as 50% of the Portland cement when used in concrete. GGBFS concrete has better water impermeability characteristics as well as improved resistance to corrosion and sulphate attack. As a result, the service life of a structure is enhanced and the maintenance cost reduced. High volume eco-friendly replacement slag leads to the development of concrete which not only utilizes the industrial wastes but also saves significant natural resources and energy. This in turn reduces the consumption of cement.

### 1.1. OBJECTIVE

- To determine the durability of concrete by partial replacement of bottom ash and ground granulated blast furnace slag (GGBFS).
- Tons of waste is being produced in thermal power plants and iron manufacturing industry they aren't recycled. But by using them in construction field, wastes can be reused, which will lead to a eco-friendly environment.

### 1.2. SCOPE

- Concrete with good workability.
- Concrete with high compressive and tensile strength.
- Cost effective because of the usage of the waste materials

## II.MATERIALS

### 2.1 MATERIALS USED

- Cement
- Fine aggregate
- Coarse aggregate
- Water
- Bottom Ash
- GGBS

Cement used in the experimental work is ORDINARY PORTLAND CEMENT conforming to IS:12269-1987. The cement for the whole work was procured in a single consignment and properly stored.

Fine aggregate was purchased which satisfied the required properties of fine aggregate required for experimental work and the sand conforms to zone III.

Crushed stone of 20mm maximum size has been used as coarse aggregate. The sieve analysis of combined aggregates confirms to the specifications of IS 383:1970 for graded aggregates.

Tap water was used in this experiment. The properties are assumed to be same as that of normal water.



Fig 2.1 Image of GGBS



Fig 2.2 Image of Bottom Ash

## 2.2 EFFECT OF BOTTOM ASH AND GGBS

GGBS is used to make durable concrete structures in combination with ordinary Portland cement and/or other pozzolanic materials. GGBS has been widely used in Europe, and increasingly in the United States and in Asia (particularly in Japan and Singapore) for its superiority in concrete durability, extending the lifespan of buildings from fifty years to a hundred years. Two major uses of GGBS [2] are in the production of quality-improved slag cement, namely Portland Blast furnace cement (PBFC) and high-slag blast-furnace cement (HSBFC), with GGBS content ranging typically from 30 to 70% and in the production of ready-mixed or site-batched durable concrete. Concrete made with GGBS cement sets more slowly than concrete made with ordinary Portland cement, depending on the amount of GGBS in the cementitious material, but also continues to gain strength over a longer period in production conditions. This results in lower heat of hydration and lower temperature rises, and makes avoiding cold joints easier, but may also affect construction schedules where quick setting is required. The workability of bottom ash concrete decreased on use of coal bottom ash in partial replacement of fine aggregate in concrete. When micro silica was added to bottom ash concrete workability again decreases. Compressive strength reduced marginally on the inclusion of bottom ash in concrete. Splitting tensile strength of concrete improved on use of coal bottom ash as fine aggregate in partial replacement of sand and also when micro silica was added to the optimum mix. The flexural strength of concrete almost linearly decreased as the replacement level of bottom ash was increased. Water absorption of bottom ash concrete at 28 days curing age also increased approximately linearly with the increase in replacement levels of fine aggregate with bottom ash in concrete.

## III. MIX DESIGN

Mix design is taken as the conventional mix M25 grade of concrete. The proportion of cement, fine aggregate and coarse aggregate are 1:1:2 with a addition of bottom ash and GGBS at (15%, 20% & 25%) respectively. The cement, fine aggregates and coarse aggregates were mixed manually in a concrete mixer and then the bottom ash and GGBS was added to the concrete at respective % to prepare the concrete. This prepared concrete was placed in 150mm cube moulds, cylindrical moulds and prism mould in three layers and each layer was compacted by giving 25 blows with a 25mm tamping rod. Totally 3 different percentages of bottom ash and GGBS at (15%, 20% & 25%) respectively.

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Table2.1 Material Quantity

Materials	Mix 1	Mix 2	Mix 3
Cement	21.78Kg	20.91Kg	19.56Kg
Fine aggregate	19.56 Kg	20.91 Kg	21.78 Kg
Coarse aggregate	54.15Kg	54.15Kg	54.15Kg
Bottom ash	6.78 Kg	5.43 Kg	4.07 Kg
GGBS	4.07 Kg	5.43 Kg	6.78 Kg
Water cement ratio	10.89L	10.21L	9.78L

#### IV.RESULTS AND DISCUSSION

##### 4.1 GENERAL

This chapter deals with the results obtained from the various experiments conducted to access mechanical properties. The aim of the study is to determine the compressive strength, flexural strength and split tensile strength. so the results of test specimens are presented. The discussion on the results also presented in this chapter.

##### 4.2 MECHANICAL PROPERTIES

The mechanical properties of concrete such as compressive strength, flexural strength and split tensile strength are determined from the standard experiments. They are as follows.

##### 4.2.1 Compressive Strength

Comparing the result of compression from the three types of specimen it is typically found that the mix containing 15% addition of bottom ash and 25% addition of GGBS has relatively high strength compared with that of the conventional one and other percentages of bottom ash and GGBS.

Table 4.1 Compressive strength

Compressive strength (N/mm <sup>2</sup> )			
% of Bottom ash and GGBS	7 days	14 days	28 days
M <sub>25</sub>	23.11	26.67	32
25% & 15%	30.22	28.44	30.22
20% & 20%	24	30.22	31.11
15% & 25%	24.89	27.11	38.68

#### 4.2.2 FLEXURAL STRENGTH

There is no considerable increase of flexural strength attained by this concrete.

Table 4.2 Flexural strength

Flexural strength (N/mm <sup>2</sup> )			
% of Bottom ash and GGBS	7 days	14 days	28 days
M <sub>25</sub>	3.11	2.27	3.48
25% & 15%	1.725	1.24	2.1
20% & 20%	2.1	1.35	2.52
15% & 25%	1.425	2.05	2.87

#### 4.2.3 SPLIT TENSILE STRENGTH

Comparing the result of split tensile strength there is no specific increase in the strength of the concrete. But the highest strength was attained by the 15% addition of bottom ash and 25% addition of GGBS .

Table 4.3 Split Tensile strength

Split tensile strength (N/mm <sup>2</sup> )			
% of Bottom ash and GGBS	7 days	14 days	28 days
M <sub>25</sub>	2.55	2.83	3.40
25% & 15%	2.55	2.26	2.69
20% & 20%	2.12	2.40	3.54
15% & 25%	2.26	2.97	3.62

## V. CONCLUSION

From the Exhaustive experimental study presented in the present project, the following conclusions can be made: This experimental study on has proved to be better way in providing strong and durable concrete. It also giving solution to disposal problem of bottom ash and ground granulate blast furnace slag. Due to the scarcity of building material we have to search for alternative materials. So by using these different kinds of materials we can make a great change in our construction field and we can environmental to the great extant. It's our responsibility to save our country from pollution and lots of money can be saved by using these materials and also by following these techniques.

1. Use of bottom ash and GGBS is effective, economical and eco-friendly.
2. The increasing demand of sand will be decreased and thus helps to keep the natural resource.
3. Replacement of sand with bottom ash up to 50% and cement with GGBFS up to 25% is beneficial.

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