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Experimental investigation on partial replacement of Cement with GGBFS and Sand with Bottom Ash in concrete

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Abstract

Nowadays Cement is major constituent material in construction industry and Lime and Silica producesthe Cement.Without these natural materials production of cement is very tedious task.Moreover the emission of Carbondioxide(CO_2) is more in the production of Cement.It causes environmental pollution globally.Sand is also naturally available material ,it gives good strength to the concrete.But environmental degradation happened by scarcity of natural sand.The main motto of this work is to find alternate materials for partial replacement of Cement and sand in concrete to obtain required strength as well as to minimize degradation of natural materials.In this work Cement is partially replaced by Ground GranulatedBlast Furnace slag(GGBFS) and sand is Bottom Ash(BA) to achieve required compressive strength.By this investigation,replacement of 10% Cement and 10% sand in concrete with and without adding of admixture gave sufficient characterstic compressive strength of concrete for 28 days curing period.

Key words

Charactersticcompressive strength

GroundGranulatedBlast Furnace slag(GGBFS)

Bottom Ash(BA)

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1. Introduction

Concrete is made by the mix of ingredients like cement, both fine and coarse aggregate and water. In ever construction concrete plays a vital role to give good strength and a perfect shape of any structure. Concrete's durability and relatively low cost make it famous worldwide. Manufacturing of one ton of Portland cement requires querying 1.5 tons of Limestone and Clay (Civil and Marine, 2007).Continues excavation of sand and extraction of natural rock strata and other ores causes an imbalance of geological phenomena, it may lead to manual disaster. So researchers and manufacturing industries are trying to find out alternative replacement materials for manufacturing of concrete.GGBFS is one of the industry waste produced by steel plants. The main components of GGBFS are Cao, Sio2, Al2O3 and Mgo.These contents lead to good compressive strength in concrete with limited percentage replacement of cement in that.From previous studies it was proved that GGBFS replacement enhances lower heat of hydration, higher durability and higher resistance to sulphate and chloride attack when compared with normal ordinary concrete. Bottom Ash is also

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one of the waste disposal material came from coal fired thermal power plants. As per Central Electrical Authority, India report (2014) about 57.63% of coal ash produced by coal-fired thermal power plants.

Objectives of the work

- To find the optimum percentage of replacement ofcement with GGBS and natural sand with Bottom Ash at which the maximum strength is obtained.
- Provide safeguard to the environment by utilizing waste material and minimize the emission of carbon dioxide (CO_2).

2. Methodology

The present investigation study has been undertaken to replacement of cement with GGBS and replacement of sand with Bottom Ash in preparation of concrete.GGBFS and Bottom Ash were replaced at percentages of10%, 20% and 30%.M30 grade of concrete mix was done as per 10262-2009 and water cement ratio was maintained 0.45.Based on the design mix the concrete mix prepared, slump cone test & compaction factor test was conducted on fresh concrete for knowing workability of concrete. The cube specimens were prepared as the size of 150mmX150mmX150mm with manual compaction. All the cubes casted will be cured for 3, 7& 28 days with placing an identify mark on each cube for identify in curing tank separate normal water.The following procedure has been adopted for casting of concrete test specimens. Coarse aggregates passing through 20mm sieve and retained on 4.75mm sieve were used. Sand is passing through 2.36mm IS sieve and retained on 150µ IS sieve was used. Bottom Ash used in partial replacement of sand in passing through 4.75mm IS sieve and retained on150µ.OPC 53 grade cement wasused in the preparation of concrete and experimental investigation was made with partial replacement of cement and sand with 10%, 20% and 30% ofGGBS and BA respectively used in concrete. Available tap water used for both mixing of concrete and curing specimens.The mix proportions are prepared as

Mix	Cement (%)	GGBS (%)	Sand (%)	Bottom Ash (%)	Coarse Aggregate (%)	Water Cement Ratio
M1	90%	10%	90%	10%	100	0.45
M2	80%	20%	80%	20%	100	0.45
M3	70%	30%	70%	30%	100	0.45

3. Materials

A. Cement

Ordinary Portland cement (OPC)53 grade conforming to IS 12269-2013 standards has been procured and following tests have been carried out of physical properties.

Table 1 Physical properties of Cement

Property	**OPC 53**
Fineness (Sp. Surface)	303 m^2/Kg
Specific Gravity	3.1
Soundness (Le-Chatlier Exp.)	10mm
Initial setting time	30 minutes
Final setting time	600minutes

Ordinary Portland cement (OPC) 53 grade of the ACC cement Branch conforming to ISI standards has been procured, and following chemical properties.

Table 2 Chemical properties of cement

Chemical composition	**Percentage**
Al_2O_3	6.19
Fe_2O_3	2.45
Mgo	3.55
Cao	60.29
SiO_2	18.24
SO_3	2.38

B.GGBS

Ground-granulated blast-furnace slag (GGBS or GGBFS) is a by-product of iron and steel-making .It came from blast furnace then it became dried and makes it finepowder. In this present study GGBS was collected from vizag steel plant, Visakhapatnam, Andhrapradesh,India.

Table 3 Physical properties of GGBS

Property	**GGBFS**
Physical Form	Off white powder
Specific gravity	2.78
Specific surface area	400-600m^2/Kg
Bulk density(loose)	1000-1100 Kg/m^3

When tested in accordance with the methods given in IS 4032-1985 the composition of granulated slag shall comply with the following chemical requirements

Table 4 Chemical properties GGBS

Chemical composition	**Percentage Max.**
Mgo	5.5
Mno_2	17.0
Sulphide sulphur	2.0

C.Bottom Ash

Bottom ash is the coarser material, constitute about 20% of gross ash content of the coal fed in the boilers. Raw bottom ash is a granular material that consists of a mix of inert materials such as sand, stone, glass, porcelain, metals and ash from burnt materials. In this present study bottom ash was collected from vizag steel plant, Visakhapatnam, Andhrapradesh,India.

Table 5 Physical properties of Bottom Ash

Property	**Specification**
Specific gravity	2.1-2.7 KN/m^3
Dry unit weight	7.07-15.72 KN/m^3
Plasticity	None
Absorption	0.8 – 2.0%

Table 6 Chemical properties ofBottom Ash

Chemical composition	**Percentages**
Sio_2	38.64
Al_2o_3	21.15
Fe_2o_3	11.96
Cao	13.80
Mgo	2.75
So_3	0.61
N_2o	0.90
K_2o	2.06

D. Fine Aggregates (F.A)

Locally available river sand which is free from organic impurities is used. Sand passing through sieve is 4.75mm and retaining on IS sieve 150µ is used in the investigation.

Table 7 Physical properties of F.A

Property	**Specification**
Fineness of modulus	2.70
Specific Gravity	2.55
Grading	ZONE-II

E. Coarse Aggregate (C.A)

The coarse aggregate used here with having maximum size is 20mm. We used the IS 383:1970 to find out the proportion of mix of coarse aggregate, with 60% 10mm size and 40% 20mm.

Table 6 Physical properties of C.A

Property	Specification
Fineness of modulus	3.0
Specific Gravity	2.79

F.Super Plasticizer

Super plasticizer CONPLAST SP 430, based on Sulphonated naphthalene polymers, complies with IS 9103-1999 and ASTM C-494 was used.

4. Results and Discussion

The compressive strength test was carried out on 150mm x150mm x150mm size cubes, as per IS: 516-1959. The 3,7 and 28 days test results were given below

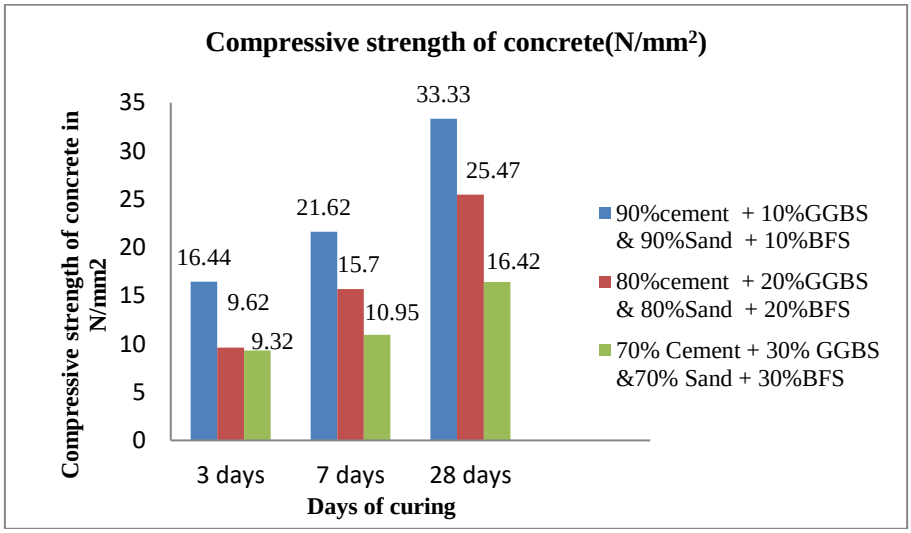

Figure 1 Compressive strength of concrete with replacement of 10%, 20%&30% of Cement &Sandwithout adding admixture

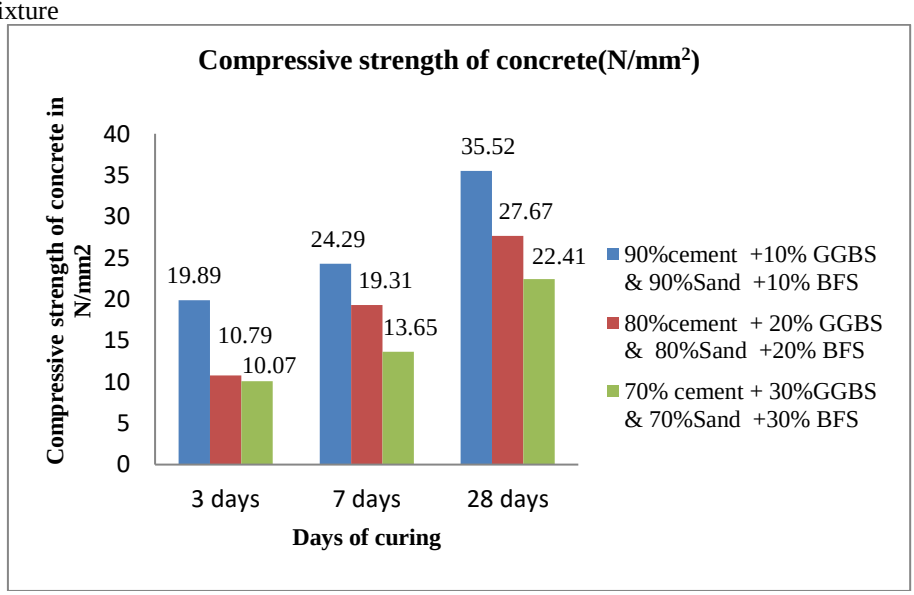

Figure 2 Compressive strength of concrete with replacement of 10%, 20%&30% of Cement &Sand with adding admixture

Discussion

- The compressive strength of M30 grade concrete for 3, 7,and 28 days was increased up to 10% replacement of cement and sand and after that the compressive strength decreased at 20% and 30% replacement with and without adding admixture .
- Concrete containing GGBS has a higher proportion of the strength-enhancing calcium silicate hydrates (CSH) than concrete made with Portland cement hencethe 28 days compressive strength is increased
- The porous structure, angular and rough texture of Bottom ash affected its specific gravity and particle density. The usage of Bottom ash in concrete reduces workability due to the increase in water demand.
- The percentage replacement increment of both GGBFS and Bottom ash not helped in gaining required strength in concrete but byadding of admixture the strength increases 36%.

5. Conclusion

From the experimental results it isconcluded that thereplacement of cement with10% GGBSand sand with 10% BottomAsh give good characterstic compressive strength to the concrete.Added admixture is lead to an additional benefit for obtaining more strength.Experimental tests on durability of this modified concrete will helps us how much of this modified concrete is more economical and safe.

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