EXPERIMENTAL STUDY ON PARTIAL AND FULLY REPLACEMENT OF OPC WITH GGBS, FA AND SILICA FUME IN CONCRETE

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Abstract: The production of 1 tonne of cement liberates 755 kg of carbon-dioxide this leads to increase in global warming, the usage of cement is keep on increasing due to the construction of structures, which is necessary for a country to improve its infrastructures. The usage of cement should be reduced by replacing it, now a day's industries are developing in a rapid manner and the by- products from it are disposing as a waste in dumping yards. Mainly three major mineral admixtures fly ash, blast furnace slag, silica fume are treated as a waste products. Fly ash has been using in construction field for replacement of cement up to 35%. This project is to increase that percentage of replacement by a suitable waste material. To achieve this all the three by products mentioned above are mixed in a proportion of 60%, 30%, 10% of blast furnace slag, fly ash, silica fume respectively. This combination will give better properties like standard cement then the individual replacement of by-products. Then the cement manufacturing process is adapted for mixture by heating the mixture at a temperature of 1400ºC, the clinker will form then the clinker is crushed and grained to get the fineness of cement. The mixture is tested for standard cement tests like specific gravity, consistency, initial and final setting time, loss on ignition, and chemical composition. The cement in concrete is replaced by obtained mixture by increment of 20% up to 100%. Then the concrete is tested for compression, split tensile, flexural strength test to find the performance of mixture in concrete.

(Keywords: GGBS, Flyash, silica fume)

I.Introduction

Concrete is composite material composed of coarse aggregate bonded together with fluid cement which hardened over time. Most concrete used are lime based concretes such as Portland cement concrete or concrete made with other hydraulic cements. In Portland cement concrete (and other hydraulic cement concretes) when the aggregate is mixed together with the dry cement and water. They forms a fluid mass that is easily molded into any shapes. The cement reacts chemically with the water and the other ingredients to forma hard matrix which binds all the materials together into a durable stone like materials that has many uses. Often additives such as pozzolanas or super plasticizers are included in the mixture to improve the physical properties of the wet mix or the finished material.Most concrete is poured with reinforcing material (such as rebar). Embedded to provide tensile strength, yielding reinforced concrete. Today, large concrete structures such as Dams, Multi storied car parks are usually made with reinforced concrete.

II.REVIEW OF LITERATURE

Christison.J.A, (2013) has conducted an experimental study about fly ash in concrete .Nearly about 67% of the total energy consumption in the country is fulfilled by coal as it is one of the primary sources of energy. Most of the country‟s total installed power generation capacity is thermal. Coal-based generation is 90%. Thermal power stations, besides several captive power plants use coal and produce large quantities of fly ash. High ash content (30% - 50%) coal contributes to these large volumes of fly ash. The country‟s dependence on coal for power generation is increasing and so the production of fly ash will be more. Fly ash causes air, water and soil pollution when it is exposed to environment. This project report is an attempt to find a suitable utilization for a particular fly ash sample depending upon its geotechnical properties. In this project various geotechnical experiments were carried out on fly ash samples. Some of them are Tensile strength study, Unconfined compressive strength study etc. Based on the results obtained from these experiments, a suitable use for the fly ash is ascertained. The main constituents of the composite are: 1. Fly ash 2. Lime Compressive and tensile strength were determined from the FCMs after 7, 14, 21 days of curing time. Different samples were taken with different percentages of lime (i.e. 5, 10, and 15 %) with fly ash and their properties were studied. The results from these above experiments helped in determining the potential of the fly ash for use, in manufacture of bricks, in highway embankments, as an aggregate material in Portland cement, filling of low lying and mine void areas etc. Based on the different strength of composites it can be used in various geotechnical applications like construction of roads, embankment, dams and reservoirs and mine filling.

Dhruvkumar Patel, (2014), has conducted an experimental study in the field of Concrete with GGBS as a replacement material in cement at Gandhi nagar, India. The utilization of supplementary cementation materials is well accepted, since it leads to several possible improvements in the concrete composites, as well as the overall economy. The present paper is an effort to quantify the strength of ground granulated blast furnace slag (GGBS) at various replacement levels and evaluate its efficiencies in concrete. Cement with GGBS replacement has emerged as a major alternative to conventional concrete and has rapidly drawn the concrete industry attention due to its cement savings, energy savings, and cost savings, environmental and socio-economic benefits. This research evaluates the strength and strength efficiency factors of hardened concrete, by partially replacing cement by various percentages of ground granulated blast furnace slag for M35 grade of concrete at different ages. From this study, it can be concluded that, since the grain size of GGBS is less than that of Ordinary Portland Cement, its strength at early ages is low, but it continues to gain strength over a long period. The optimum GGBS replacement as cementation material is characterized by high compressive strength, low heat of hydration, resistance to chemical attack, better workability, good durability and cost-effectiveness.

Sujata D. nandagawali Dr. N. R. Dhamge(2014):

Due to growing environmental awareness, as well as stricter regulations on managing industrial waste, the world is increasingly turning to researching properties of industrial waste and finding solutions on using its valuable component parts so that those might be used as secondary raw material in other industrial branches. Although iron and steel slag is still today considered waste and is categorized in industrial waste catalogues in most countries in the world, it is most definitely not waste, neither by its physical and chemical properties nor according to data on its use as valuable material for different purposes. Considering the specificity of physical and chemical properties of metallurgical slags and a series of possibilities for their use in other industrial branches and in the field of civil constructions, this report demonstrates the possibilities of using iron slag as partial replacement of sand in concrete. Iron and steel making slag are by products of the iron making and steelmaking processes. To date, these types of slag have been widely used in cement and as aggregate for civil works. The report presents an investigation of mechanical and durability properties of concrete by adding iron slag as replacement of sand in various percentages.

Tapeshwar Kalra &Ravi Rana (2014):

Fly ash concrete has economical and environmental advantages. It also makes concrete sustainable. In India presently less than 50% of fly ash produced is consumed. Infrastructural Development is at its peak all over the world and is a symbol of growth for any country. The most popular construction material, involves use of cement which is responsible for 7% of total world's carbon dioxide emissions. Carbon dioxide is the main threat in causing global warming of the environment. The attempts have been made to reduce CO2emissions in environment by all possible ways, but cement has not found a suitable replacement for it till date. Fly ash Concrete is an effort in reducing cement content of construction. The paper aims at discussing the use of fly ash concrete in construction as a solution to address two environmental problems - one, disposal of huge amounts of fly ash, by production of thermal power plants, environmental degradation through large areas of landfills and two, high percentage of carbon dioxide emissions in atmosphere from cement industry.

III. METHODOLOGY

Finding out the by products from industries

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Finding the material having properties similar to cement properties

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Comparison and proportioning of materials

Testing of mixture such as consistency, initial and final setting time etc,..

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Casting of cubes, beams and cylinder for compression ,tension and flexural

Testing of samples for 7, 14 and 28 days along with conventional samples

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Comparison of results with conventional concrete

VI. PRELIMINARY TEST ON MATERIALS

i. cement: Ordinary Portland cement of 53grade [IS: 12269 – 1987] specifications for 53 grade OPC is used.Table 1

Physical Properties	Test Results
Specific Gravity(G)	3.19
Consistency	28%
Initial Setting time	30min
Final Setting time	600min

ii.Flyash: Low calcium fly ash samples taken from ennore thermal power plant.

Table 2:

Physical Properties	
Specific Gravity(G)	2.51
Consistency	35%

iii. *GGBS (Ground Granulated Blast Furnace Slag):* It is a glassy granular material formed in the process of producing iron in a blast furnace and is formed by rapidly chilling or quenching the molten material and subsequently grinding it to a fine powder.

Table 3:

Physical Properties	
Specific Gravity(G)	2.9
Colour	off-white
Fineness	3.12

iv. fine aggregate: River sand belongs to zone II. Table 4:

Properties	
Specific Gravity(G)	2.51
Water absorption%	0.98
Fine particles	10-12

V.Coarse aggregate: Table 5

Properties	
Specific Gravity(G)	2.65
Impact Value(%)	16.67
Water absorption%	0.8

VI.Mix Design and Batching:

Designed a mix for M20 grade concrete for the following datas.

a) Grade designation : M20
b) Type of cement : OPC 53 grade
c) Cement content : 300kg/m^3
d) Water cement ratio : 0.40
e) Method of Placing : Manual
f) Degree of supervision : good
g) Type of aggregate : fine

vii. Fresh concrete Tests:

i.slump cone test:

This test measures the consistency of fresh concrete and also check the workability of the freshconcrete. Slump value for cement mixed concrete is 84mm and mixture mixed concrete is 79mm. Hence it is good workable condition for beams and columns.

ii.Compaction factor test:

Compacting factor of fresh concrete is done to determine the workability of fresh concrete by compacting factor test as per IS: 1199 – 1959.Compaction factor value is 0.98.The degree of workability of fresh concrete is medium.

viii. Tests on Harden concrete:

i.Compression Test:

The strength compressive strength of concrete cubes were tested of size 150mmx150mmx150mm for different proportion of replacement. And at the end of tests the results were compared with conventional concrete to check the strength obtained. Table 6:

Trials	7 days (N/mm^2)	14 days (N/mm^2)	28 days (N/mm^2)
M1	15.30	22.44	25.00
M2	15.10	22.21	25.00
M3	15.10	22.20	24.80
M4	14.40	21.80	24.22
M5	12.20	18.00	20.00
M6	9.78	14.20	16.67

ii. split-tensile test:

The split tensile test is conducted to find the strength of concrete in tension. For the testing of concrete, samples of different proportions are casted of 10cm in diameter and 20cm in length of a cylinder. Table 7:

Trials	7 days (N/mm^2)	14 days (N/mm^2)	28 days (N/mm^2)
M1	1.43	2.07	2.39
M2	1.43	2.00	2.22
M3	1.27	1.91	2.20
M4	1.23	1.75	2.07
M5	0.79	1.11	1.27
M6	0.64	0.79	1.00

iii. Flexural strength test:

The Flexural Strength for the Concrete is determined by using Loading Frame. The hydraulic jack loaded the beam and the load is measure by using the proving ring. Table 8:

Trials	7 days (N/mm^2)	14 days (N/mm^2)	28 days (N/mm^2)
M1	0.138	0.225	0.265
M2	0.134	0.220	0.250
M3	0.130	0.218	0.245
M4	0.125	0.2.13	0.238
M5	0.113	0.200	0.225
M6	0.100	0.181	0.213

VI. Durability test:

1.Acid Attack (H_2SO_4)
2.Chloride Attack (NaCl)
3.Sulphate Attack ($MgSO_4$)

Weight reduction after acid attack.
Table 9:

Samples	Initial weight (kg)	Weight after acid attack (kg)	Weight reduction (%)
M1	7.88	7.45	5.55
M2	7.84	7.34	6.34
M3	7.96	7.30	8.29
M4	7.90	7.15	9.49
M5	7.94	7.10	10.57
M6	7.87	7.00	11.05

Weight reduction after chloride attack
Table 10

Samples	Initial weight (kg)	Weight after chloride attack (kg)	Weight reduction (%)
M1	7.86	7.85	0.12
M2	7.83	7.82	0.14
M3	7.80	7.78	0.24
M4	7.90	7.82	0.99
M5	7.93	7.83	1.30
M6	7.91	7.79	1.49

Weight reduction after sulphate attack
Table 11

Samples	Initial weight (kg)	Weight after sulphate attack (kg)	Weight reduction (%)
M1	7.89	7.88	0.12
M2	7.86	7.85	0.13
M3	7.92	7.90	0.20
M4	7.89	7.87	1.02
M5	7.84	7.74	1.32
M6	7.88	7.76	1.50

IX. Conclusion

According to our experimental study, strength of concrete in compression, tension, and flexure will keep on increasing by increase in replacement percentage up to 60% after that it loses its strength gradually. So we can use the mixture in concrete by an optimum replacement of 60%. Since M1, M2, M3 and M4 mixes have similar strength it can be used for any RC works. Its shows that the cost towards the purchasing of cement can be reduced up to 60% without any compromises in strength. We can use the 60% replacement of cement by mixture in any reinforced concrete section without any loss in strength. Since the M5 mix have 20% lesser strength when compared to conventional or up to M4 mix it can be used for any single storied or comparatively lesser loads bearing structures. But 81-100% of mixture is not suitable for reinforced concrete section where the section has to carry more loads. For the replacements 81% to 100% is suggests for plain concrete structures like concrete wall, compound wall, etc. And the same replacement can be used for floor slabs, flooring works, and as a mortar for plastering. And coming to the flexural strength of concrete it shows the same results up to M4 mix. And the deviations of M5 & M6 mix from the conventional concrete are gradually increased which indicates that‟s the flexural strength is decreasing keep on increasing in replacement above 80%. So that this experimental study suggests that the replacement of cement shall be increased up to 60% to achieve the same strength of conventional concrete with reduction in cost.

X. References

[1] Christison, J.A. (1995), 'Behavior of concrete containing fly ash ', ACI SP-155, Vol-12, No.2, pp.105-110.

[2] Dhruvkumar patel. (2014), 'Ground granulated blast furnace slag as a replacement of cement, magazine of concrete research, Vol-44, No.5, pp160-168.

[3] Qing wang. (2014), 'silica in the field of concrete', advances in cement research, Vol-32, No.6, pp 232-239.

[4] Ravindra, K. (2015), ' Hypo sludge as a replacement for cement', international concrete research institute, Vol-52, No-253,

[5] Xianyu Jin, and Zongjin Li (2003). ―Effects of Mineral Admixture on Properties of Young Concrete.‖ ASCE Mat. J(15) 435-442.

[6] David B. McDonald, A. S. AI-Gahtani, Rasheeduzzafar, A. A. AI-Mussallam, Yacoub M. Najjar, and Imad A. Basbeer (1996). ―Discussion of Resistance of Silica-Fume Concrete to Corrosion-Related Damages.‖ ASCE Mat. J(8) 177-178.

[7] Safwan A. Khedr, and Ahmed F. Idriss (1995). ―Resistance of Silica-Fume Concrete to Corrosion-Related Damage‖. ASCE Mat. J.(7). 102-107.

[8] Mohammad Shamim Khan, and Michael E. Ayers (1995). ―Minimum Length of Curing of Silica Fume Concrete.‖ ASCE Mat. J(7) 134-139.

[9] Martin O'Connell, Ciaran McNally, and Mark G.Richardson. (2012). "Performance of Concrete Incorporating GGBS in Aggressive WastewaterEnvironments". Construction and Building Materials, 27 (1), 368-374.

[10] Mojtaba Valinejad Shoubi, Azin Shakiba Barough, and Omidreza Amirsoleimani. (2013). "Assessment of the Roles of Various Cement Replacements in Achieving Sustainable and High Performance Concrete".International Journal of Advances in Engineering and Technology, 6 (1): 68-77.

[11] Peter W.C. Leung, and Wong, H.D. (2010). "Final Report on Durability and Strength Development of Ground Granulated Blast Furnace Slag Concrete". Geotechnical Engineering Office, Civil Engineering and Development Department, The Government of Hong Kong.