A STUDY ON CONCRETE WITH REPLACEMENT OF CEMENT BY FLYASH AND GBFS

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ABSTRACT

Utilization of industrial wastes and by-products has emerged as new scope for sustainable development of concrete along with combating the major issues as depletion of the natural resources, disposal issue of solid wastes and demand of fast growing population in the world. The present work experimentally investigated the influence of partially replacing fly ash (FA) as binder and granular blast furnace slag (GBFS) as fine aggregate separately and in combined form on the fresh and hardened properties of concrete. Eight series of concrete mixes were prepared as control mix, single blended mixes and combined blended mixes by weight batching. Single blended concrete mixes were prepared by different percentages of FA (20%, 30% and 40%) and 50% GBFS while combined blended concrete mixes by 50% GBFS with 20, 30 and 40% of FA respectively. Concrete mixes were evaluated for workability and compressive strength, split tensile strength and flexure strength after 7, 28 , 60 and 90 days, respectively.

1.INTRODUCTION

1.1 GENERAL

Concrete is a widely used construction material for various types of structures due to its structural stability and strength. The Ordinary Portland Cement (OPC) is one of the main ingredients used for the production of concrete and has no alternative in the civil construction industry. Regrettably, production of cement involves emission of large amounts of carbondioxide gas into the atmosphere, a major contributor for green house effect and the global warming. Hence it is inevitable either to search for another material or partly put back it by some other material. The search for any such material, which can be used as an alternative or as a supplementary for cement should lead to global sustainable development and lowest possible environmental impact.

In this thesis, the different admixtures were used to study their sole and combined effects on the resistance of concrete in addition to their effects on mechanical and stability properties by the replacement of cement by 10% fly ashand sand replacement 10%, 20%, 30% of slag, cement by 20% fly ash and sand replacement 10%, 20, 30% of slag, cement replacement of 30%fly ash and sand replacement 10%, 20%, 30% of slag.

The secondary materials used in our project are pozzolanic materials. The term pozzolana is a siliceous or a siliceous and aluminous material which itself possesses no cementitious value but in presence of water, chemically react with calcium hydroxide to form compounds possessing cementitious properties .The material which having the pozzolanic property known as pozzolanic material. The pozzolanic materials that are used in our project are

1. Fly ash
2. Granulated Blast Furnace Slag

1.1.1 Fly Ash: Fly ash also known as flue-ash is one of the residues generated in combustion coal and comprises the fine particles that rise with the flue gases. Ash which does not rise is termed bottom ash. In an industrial context, fly ash usually refers to ash produced during combustion of coal. Fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys of coal-fired power plants, and together with bottom ash removed from the bottom of the furnace is in this case jointly known as coal ash. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes considerable amounts of silicon dioxide (SiO_2) and calcium oxide (CaO).

In the past, fly ash was generally released into the atmosphere, but pollution control equipment mandated in recent decades now requires that it be captured prior to release. In the US, fly ash is generally stored at coal power plants or placed in landfills. About 43% is recycled,often used to increasePortland cement because fly ash is an low-cost replacement for Portland cement used in concrete, while it actually improves strength, separation, and ease of pumping of the concrete. Fly ash is also used as an ingredient in brick, block, paving, and structural fills. This waste is causing problems to human health and environmental pollution.

The challenge for the civil engineering population in the near future will be to realize projects in harmony with the concept of sustainable development, and this involves the use of high-performance materials and products manufactured at sensible cost with the lowest possible ecological impact. Concrete is the most widely used construction material worldwide. However, the production of Portland cement, an essential constituent of concrete, releases large amounts of CO_2 which is a major contributor to the greenhouse effect and the global warming of the planet and the developed countries are considering very severe regulations and limitations on CO_2 emissions. In this scenario, the use of supplementary cementing materials (SCMs), such fly ash, slag and silica fume, as a replacement for Portland cement in concrete presents one viable solution with multiple benefits for the sustainable development of the concrete industry. The most commonly available SCM worldwide is fly ash, a by-product from the combustion of pulverized coal in thermal power stations. Fly ash, if not utilized has to be disposed off in landfills, ponds or rejected in river systems, which may present serious environmental concerns since it is produced in large volumes.

1.2 EFFECTS OF DISPOSAL OF FLY ASH WASTE

Since coal contains trace levels of arsenic, barium, beryllium, boron, cadmium, chromium, thallium, selenium, molybdenum and mercury, its ash will continue to contain these traces and therefore cannot be dumped or stored where rainwater can leach the metals and move them to aquifers.

Fly ash contains trace concentrations of heavy metals and other substances that are known to be detrimental to health in sufficient quantities. Potentially toxic trace elements in coal include arsenic, beryllium, cadmium, barium, chromium, copper, lead, mercury, molybdenum, nickel, radium, selenium, thorium, uranium, vanadium, and zinc.

1.3 SCOPE AND OBJECTIVES

This research mainly focusing on studying the effect of fly ash and Slag on the properties of concrete mixtures as a partially replacement of cement and sand.The scope of this study, the main goal is to improve compressive and split tensile strength of concrete at different percentage of replacement of fly ash and slag. Fly ash and slag is the cheapest materials of all concrete constituents and is much less expensive than natural aggregate and sand as possible to save money. The main aim of the research is to study the effect of partially replacement of fly ash and slag in to the concrete. The main objectives are study in this theory is

- ❖ To study normal consistency, initial and final setting times, soundness and fineness of cement.
- ❖ To study specific gravity, water absorption of coarse aggregate.
- ❖ To study specific gravity, water absorption of fine aggregate of river sand and slag.
- ❖ To study the compressive strength of normal concrete and partially replacement of cement by fly ash and sand by GBFS.
- ❖ To study split tensile strength of normal concrete and partially replacement of cement by fly ash and sand by GBFS.

1.4 RESEARCH METHODOLOGY

The following are to be carried out in order to achieve the research objectives.

- To collect the fly ash from thermal power plant RTPP and collect the blast furnace slag from steel plant.
- Sieve the slag by using of 4.75mm sieve.
- To study about the fly ash and slag.
- To study about the strength of replacement of fly ash and slag in concrete.
- Study on acid attack in concrete

Analysis of experimental results to draw conclusions.

2. REVIEW OF LITERATURE

2.1 GENERAL

Extensive research work both at national and international level has been done on the use of various admixtures in mortars and concretes with common goal. The main objectives are:

- o To combat the environmental hazards from the industrial wastes.
- o To modify the properties of traditional concrete to the desired level suitable to the specific circumstances.
- o To conserve the natural resources used in the production of construction materials.
- o To bring down the increasing cost economics of cement, building blocks and high strength concretes.

In the last decades many experiments and researches have been done to investigate the effects of concrete influenced by the acidic attacks and the impact of chemicals on cementization. Literature relating to blended cements in concrete and the effect of curing regimes on this concrete are numerous. In this chapter, only literature concerning those aspects related to this particular research i. e. the mechanical and durability properties of hardened concrete incorporating fly ash and slag as a mineral admixtures added to concrete made with the Portland cement are discussed. This survey also includes the effect of curing conditions on the various properties of concrete.

2.2 MINERAL ADMIXTURES

Mineral admixtures refer to the finely divided materials which are added to obtain specific engineering properties of cement mortar and concrete. The other, equally important, objectives for using mineral admixtures in cement concrete include economic benefits and environmentally safe recycling of industrial and other waste by-products. Unlike chemical admixtures, they are used in relatively large amounts as replacement of cement and/or of fine aggregate in concrete. In the past, natural pozzolans such as volcanic earths, tuffs, trass, clays, and shales, in raw or calcined form, have been successfully used in building various types of structures such as aqueducts, monuments and water retaining structures. Natural pozzolans are still used in some parts of the world. However, in recent years, many industrial waste by-products such as fly ash, slag, silica fume, red mud, and rice husk ash and highly reactive metakaolin has recently become available as a very active pozzolanic material for use in concrete. Unlike fly ash, slag, or silica fume, this material is not a byproduct but is manufactured from a high-purity kaolin clay by calcination at temperatures in the region of 700 to 800°C are rapidly becoming the main source of mineral admixtures for use in cement and concrete.

2.3 TYPES OF MINERAL ADMIXTURE

Mineral admixtures can be classified in two groups: Pozzolanic materials and inert filler materials.Pozzolanic materials are mineral admixture contains reactive silica which when added to cement reacts with calcium hydroxide to form C-S-H such as volcanic ash, burnt clay, and fly ash. Using pozzolans lower the heat of hydration, increase later strength, and increase durability. Inert materials are mineral admixtures which do not affect the strength of concrete and used as workability aids such as hydrated lime, dust of normal weight aggregates, and colouring pigments.

2.4REVIEWS ON FLY ASH

2.4.1What is fly ash: Fly ash is one of the residues generated in coal combustion facilities, and comprises the fine particles that rise with the flue gases.

2.4.2 Where does fly ash come from: Fly ash is produced by coal-fired electric and steam generating plants. Typically, coal is pulverized and blown with air into the boiler's combustion chamber where it immediately gets ignites, generates heat and produces a molten mineral residue. Boiler tubes extract heat from the boiler, cool the flue gases and cause the molten mineral residue to harden and form ash. Coarse ash particles, called as bottom ash or slag, fall to the bottom of the combustion chamber, and the lighter fine ash particles, termed as fly ash, remain suspended in the flue gas. Before exhausting the flue gas, fly ash is removed by particulate emission control devices, such as filter fabric bag houses or electrostatic precipitators.

3. AND METHODS

3.1 MATERIALS:

The materials used in this present investigation are Ordinary Portland cement (53 grade), water, coarse aggregates, fine aggregates (sand, sag).In recent years, improvements in concrete properties have been achieved by blending cements with cementitious admixtures such as fly ash (FA),granulated blast furnace slag (GBFS). Incorporation of these materials in concrete mixes improves the durability concrete. The movement of aggressive substances such as chloride ions and carbon dioxide into concrete which are the main causes of deterioration of concrete structures that affect their integrity and long term serviceability life, is thus very much reduced. The deterioration of concrete is not a result of only aggressive agents, but the overall quality of concrete and also play a major role. In view of this problem, a growing number of concrete structures are constructed or under construction with the use of cement replacement materials. Therefore any attempt to alleviate the deterioration-risk implies producing good performance concrete capable of withstanding the harsh environmental conditions.

In this chapter, the materials and methods described together with their properties. In this the tests carried out on different concrete mixes, curing regimes, mix proportions and casting of specimens is discussed.

3.1.1 Fly Ash: The fly ash is collected from local waste scrapers. Fly ash is a pozzolana substance containing aluminous and siliceous material that forms cement in the presence of water. Cement is now partially replaced by its weight by fly ash at varying rates such as 10%, 20%,30%. The specific gravity of fly ash is taken as 2.0.The physical properties of fly ash are shown in the following table

3.1.2.1. Moisture content of fly ash: Moisture is an important property of coal because all coals are mined wet. Groundwater and other external moisture is known as adventitious moisture and is readily evaporated. Moisture which is held within the coal itself is known as inherent moisture and is analyzed quantitatively. Moisture may occur in four possible forms within coal:

- Surface moisture: water present on the surface of coal particles or minerals
- Hydroscopic moisture: water which is present by capillary action within the micro fractures of the coal
- Decomposition moisture: water which is held within the coal's decomposed organic compounds
- Mineral moisture: water which comprising part of the crystal structure of hydrous silicates such as clays.

Though fly ash is produced by combustion of coal still it contains some percentage of moisture.

Test procedure: About 1 gm of finely powdered of size (-212 micron) air-dried fly ash sample is weighed in a silica crucible and then placed it inside an electric hot air oven, where the temperature is maintained at $108^0 \pm 2^0$C. The crucible with the fly ash sample is allowed to remain in the oven for 1.5 hours and is then taken, cooled in desiccators for about 15 minutes and then weighed. The loss in weight is moisture (on % basis). Then calculation is done as per the following.

Percentage of moisture = Y−Z/Y−X

Where X= weight of empty crucible, gram

Y= weight of crucible + fly ash sample before heating, gram

Z= weight of crucible + fly ash sample after heating, gram Y−X= weight of fly ash sample, gram Y−Z= weight of moisture

Table: 1 moisture content of fly ash

Weight of empty crucible(gm)	Weight of fly ash (gm)	Weight of crucible and fly ash before heating (gm)	Weight of crucible and fly ash after heating (gm)	Moisture content (%)	Average moisture Content (%)
1	35.069	36.070	36.044	2.59	2.78
2	40.519	41.523	41.495	2.78	
3	43.852	44.856	44.826	2.98	

3.2.2 Cement: Cement may be described as a material with adhesive and cohesive properties that make it capable of bonding, mineral fragments into a compact whole. Most cement used today is Portland cement. This is carefully proportioned and specially processed combination of lime , silica, iron oxide and alumina. It is usually manufactured from limestone mixed with shale , clay. Properly proportioned raw materials are pulverized into kilns where they are heated to a temperature of 1300 to 1500˚C. The clinker is cooled and ground to fine powder with addition of about 3 to 5% of gypsum. The OPC (53 grade) used in the present work is of Zuari cement.

3.2.2.1Ordinary Portland Cement (53 grade): Ordinary Portland Cement (OPC) is one of several types of cement being manufactured throughout the world, are some of the more commonly used. OPC is the general purpose cement used in concrete constructions. OPC is a compound of lime (Cao), silica (SiO_2), alumina (AL_2O_3), iron (Fe_2O_3) and sulphur trioxide (SO_3), Magnesium (Mgo) is present in small quantities as an impurity associated with limestone. SO_3 is added at the grinding stage to retard the setting time of the finished cement. When cement raw materials containing the proper proportions of the essential oxides are ground to a suitable fineness and then burnt to incipient fusion in a kiln, chemical combination takes place, largely in the solid state resulting in a product aptly named clinker. This clinker, when ground to a suitable fineness, together with a small quantity of gypsum (SO_3) is Portland cement. In fact, cement powder is "nothing else" other than a combination of oxides of calcium, silicon, aluminum and iron. The cement used throughout the test programwas Ordinary Portland Cement (OPC) of 53 grade confirming to IS 4031:1988 was used in the present study. The specific gravity of cement is taken as 3.0. The chemical and physical properties of cement are presented in following tables.

4.RESULTS AND DISCUSSIONS

4.1 GENERAL

Concrete is the most widely used manufactured material in the construction industry. It's the most important property is durability which relates the performance of the material to its service life under various environmental conditions. The ability of concrete to withstand and satisfactorily and for long periods the effects of load, time, and environment depends very much on how the engineering properties of the material are constituted initially and how they are allowed to develop with age.

4.2 TESTS FOR WORKABILITY

Workability is the ability of fresh (plastic) concrete mix to fill the form/mould properly with the desired work (vibration) and without reducing the concrete's quality. Workability depends on water content, aggregate (shape and size distribution), cementitious content and age (level of hydration) and can be modified by adding chemical admixtures. Raising the water content or adding chemical admixtures will increase concrete workability. Excessive water will lead to increased bleeding and/or segregation of aggregates (when the cement and aggregates starts to separate), with the resulting concrete having reduced quality. The use of an aggregate with an undesirable gradation can result in a very harsh mix design with a very low slump, which cannot be readily made more workable by addition of reasonable amounts of water.

Workability is measured by performing the following tests:

4.2.1. Slump Cone Test: Slump test is the most commonly method for measuring the consistency of concrete which can be employed either in laboratory or at site of work. The internal surface of the mould is thoroughly cleaned and freed from moisture and adherence of any old set concrete before commencing the test. The mould is placed on a smooth, horizontal, rigid and non-absorbent surface. The mould is then filled in four layers, each approximately ¼ of the height of the mould. Each layer is tamped 25 times by the tamping rod taking care to distribute the strokes evenly over the cross section. After the top layer has been rodded, the concrete is struck off level with a trowel and tamping rod. The mould is removed from the concrete immediately by raising it slowly and carefully in a vertical direction. This allows the concrete to subside. This subsidence is referred as 'slump' of concrete. The difference in level between the height of the mould and that of the highest point of the subsided concrete is measured. The difference in height in 'mm' is taken as slump of concrete.

Fig.4.1 Slump Cone Apparatus

Fig4.2.Measuring Slump Fall

Test results

1. Slump in terms of millimeters to the nearest 5 mm = 49.5mm

2.Shape of the slump:SHEAR

3.Referring to the selection of data, we have a slump value within the Range (60 – 180 mm).

Table 4.1: Workability of concrete with replacement of fly ash and slag

S.NO	Details of Material	Slump in mm
1	90%cement +10%FA and 90%sand+10%slag	45
2	90%cement +10%FA and 80%sand+20%slag	47
3	90%cement +10%FA and 70%sand+30%slag	50
4	80%cement +20%FA and 90%sand+10%slag	53
5	80%cement +20%FA and 80%sand+20%slag	56
6	80%cement +20%FA+70%sand30%slag	58
7	70%cement +30%FA and 90%sand+10%slag	54
8	70%cement +30%FA and 80%sand+20%slag	57
9	70%cement +30%FA and 70%sand+30%slag	59

4.3 SOUNDNESS TEST

The expansion of cement specimen was less than 10 mm specified by IS 4031(Part 3)1988. This confirmed that the cement is agood additive material. Table 4.9 shows the values for soundness of 100% OPC

Table 4.2: Soundness of Ordinary Portland Cement

Test for Physical Requirement	Zuari O.P.C 53 Grade	IS 4031-1988
Lechatlier Method(mm)	1	<10

Soundness of cement with 10% replacement of fly ash:

Table 4.3:soundness of cement with 10%replacement of Fly Ash

Test of Physical requirement	ZUARI O.P.C 53 Grade	IS 4032 (part 3) :1987
Le chatlier method(mm)	2	<10mm

Soundness of cement with 20% replacement of fly ash:

Table 4.4: Soundness of cement with 20%replacement of Fly Ash

Test of Physical requirement	ZUARI O.P.C 53 Grade Cement	IS 4032 (part 3) :1987
Le-chatelier method(mm)	1	<10mm

Soundness of cement with 30% replacement of fly ash:

Table 4.5:soundness of cement with 30%replacement of Fly Ash

Test of Physical requirement	ZUARI O.P.C 53 Grade Cement	IS 4032 (part 3) :1987
Le-chattier method(mm)	2	<10mm

CONCLUSIONS

Fly Ash and GBFS is used in production of concrete cubes and cylinders replacement cement by fly ash dosage of 10% at replacement sand by slag dosage of 10%, 20%, 30%, replacement cement by fly ash dosage of 20% at replacement of sang by slag dosage of 10%, 20, 30%, replacement of cement by fly ash dosage of 30% at replacement of sand byslag dosage of 10%, 20%,30%.These cubes and cylinders were cured and tested for compressive strength and split tensile strength for 3days, 7days, 14days, 28days, 56days, 90days and results were noted. Based on experimental investigation conducted following conclusions are made.

- ✓ With increasing of fly ash and slag percentages in concrete then the workability should be increased gradually as compared to normal concrete.
- ✓ By using of fly ash and slag in concrete the water absorption quantity should be increased gradually because of slag absorbed more quantity of water.
- ✓ The most interesting finding was that Fly Ash retards the initial setting and accelerates the final setting of concrete mortar.

The experimental results show that the pozzolanic activity of fly ash and slag waste increases with increase of time.

REFERENCES

[1] Ganjian, E., Canpolat, F., Clasisse P, Naik T., 2015, "Special Issue on Sustainable Construction Materials," J. Mater. in Civil Eng., 27(7)

[2] Mohammed, S. I., Collette, C., Sean, M. K., 2012, "Trends and developments in green cement and concrete technology," Int. J. of Sustain. Built Env., 1, pp194-216

[3] Schneider, M., Romer M, Tschudin, M., Bolio H., 2011, " Sustainable cement production—present and future," Cem. Con. Res. 41(7), pp. 642-650

[4] Mehta, P.K., 2010, " Sustainable Cements and Concrete for the Climate Change Era – A Review," Proc. 2nd Int. Conf. Sustain. Constr. Mater. Tech..Ancona, Italy, June 28-30

[5] Khajuria, C., Siddique, R., 2014, " Use of iron slag as partial replacement of sand to concrete., Int. J. Sci. Eng. Technol. Res. 3 (6), pp.1877-1880

[6] Devi, V.S., Gnanavel, B.K., 2014, " Properties of concrete manufactured using steel slag," Procedia Eng., 97, pp. 95-104

[7] Madheswaran, C.K., Ambily, P.S., Dattatreya, J.K., Rajamane, N.P., 2014, " Studies on use of copper slag as replacement material for river sand in building constructions," J. Inst. Eng. India Ser. A, 95(3), pp.169-177

[8] Su, H., Yang, J., Ling, T.C., Ghataora G S., Dirar, S., 2015, " Properties of concrete prepared with waste tyre rubber particles of uniform and varying sizes," J. Clean. Prod., 91, pp.288-296

[9] Rafieizonooz, M., Mirza, J., Salim, M. R., Hussin, M.W., Khankhaje, E., 2016, "Investigation of coal bottom ash and fly ash in concrete as replacement for sand and cement,". Constr. Build. Mater., 116, pp.15- 24