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AN EXPERIMENTAL STUDY ON MECHANICAL STRENGTH PROPERTIES OF CONCRETE BY PARTIAL REPLACEMENT OF CEMENT BY FLYASH AND GBFS

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ABSTRACT

Concrete is mainly classified into three types based on the density. Concrete containing natural sand and gravel or crushed- rock aggregate and water, when placed in the skeleton of form and allowed to cure, becomes hard like stone. Generally weighing about 2400kg/m 3 is called "normal-weight concrete" and it is the most commonly used concrete for structural purposes. For applications where a higher strength-to-weight ratio is desired, it is possible to reduce the unit weight of concrete by using natural aggregate with lower bulk density. The term lightweight concrete is used for concrete that weightless than 1800 kg/m 3 . Heavy weight concrete used for radiation shielding, is a concrete produced from high density aggregate and generally weigh more than 3200kg/m 3 .

Our aim it is to study the properties of concrete by partially replacing cement by fly ash and fine aggregate (sand) by granulated blast furnace slag. In this study, Cement was partially replaced by Fly Ash and Fine aggregate were partially replaced by Granulated Blast Furnace Slag in concrete. A mix design was done for M 20 grade of concrete by using IS method. The utilization of fly-ash and blast furnace slag in concrete as partial replacement of cement and fine aggregate (sand) is gaining immense importance in today's concrete works, mainly on account of the improvement in long term durability along with ecological benefits. Three grades of ordinary port land cement (OPC) namely: 33, 43 and 53 as classified by bureau of Indian Standard (BIS) or commonly used in construction industry. Now in this project only 53 grade of cement is used.

This paper reports comparative study on effects of concrete properties by partially replacement of OPC of 53 grades with fly ash and sand were partially replaced by blast furnace slag. The main variable investigated in the study of variation of fly ash dosage of 10% and slag dosage of 10%, 20%, 30%, fly ash dosage of 20% and slag dosage of 10%, 20,30%, fly ash dosage of 30% and slag dosage of 10%, 20%, and 30%. The compressive strength and split tensile strength & acid attack of concrete were mainly studied. Test results shows that, inclusion of fly ash and GBFS generally improves the concrete properties up-to certain percentage of replacement in53 grade of cement.

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 carbon dioxide 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 ash and 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 increase Portland 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.

Far to be considered as a “Misuse” product, research and development has shown that fly ash actually represents a highly valuable concrete material. In order to significantly increase the utilization of fly ash as replacement for cement, such concrete must meet engineering performance requirements that are comparable to those for conventional Portland cement concrete, and be cost effective. This is a principally important issue for India, which currently produces over 100 million tons of Portland cement and 100 million tons of fly ash annually. Disposal of fly ash is a growing problem in India, only about fifteen percent of this amount is currently used; the remainder goes to landfill. The World Bank has reported that by 2015, disposal of fly ash will require 1,000 square kilometers, or 1 square meter of land per person. The Indian government has begun to take positive steps in the utilization of fly ash in construction, such as mandating the use of fly ash in road and building construction projects within a 100 km radius of a coal fired power plant.

Environmental impacts of fly ash

The World Bank has cautioned India that by 2015, disposal of coal ash would require 1000 sq. km. of land. Since coal currently accounts for 70% of power generation in the country, there is a need of new and innovative methods for reducing impacts on the environment. The problem with fly ash lies in the fact that not only does its disposal require large quantities of land, water and energy, its fine particles, if not managed well, can become airborne. Currently more than 120 million tones of fly ash are being generated annually in India, with 65000 acres of land being occupied by ash ponds. Such a huge quantity does pose challenging problems, in the form of land use, health hazards and environmental damages.

1.1.2Granulated Blast Furnace Slag:

Granulated Blast Furnace Slag is a by-product of the steel industry. Granulated Blast furnace slag is defined as "the non-metallic product consisting essentially of calcium silicates and other bases that is developed in a molten condition simultaneously with iron in a blast furnace." In the production of iron, blast furnaces are loaded with iron ore, fluxing agents, and coke. When the iron ore, which is made up of iron oxides, silica, and alumina, comes together with the fluxing agents, molten slag and iron are produced. The molten slag then goes through a particular process depending on what type of slag it will become. Air-cooled slag has a rough finish and larger surface area when compared to aggregates of that volume which allows it to bind well with Portland cements as well as asphalt mixtures. GBFS is produced when molten slag is quenched rapidly using water jets, which produces a granular glassy aggregate. This glassy aggregate with little fines used as sand replacement in the present investigation.

GBFS has a positive effect on both the flexural and compressive strength of concrete after 28 days. In the first 7 days the compressive strength is generally slightly higher than pure 100% Portland cement mixtures. In the 7 to 14 day range, the compressive strength is about equal to the strength of concrete without slag. The real gain in strength is noticed after the 28 days.

So to reduce the environmental pollution we used fly ash waste as a cement replacement and slag as a sand replacement in different percentages and we have determined the compressive strength of concrete.

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.

Analysis of experimental results to draw conclusions.

1.5 OUR PROPOSAL

The main objective of using this fly ash and slag waste to reduce environmental pollutions like water pollution, air pollution and disposal problems on agricultural lands. To overcome all above effects we are using the fly ash waste as a cement replacement and slag waste as a sand replacement in different proportions and also we can reduced the cost of the project.

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:

To combat the environmental hazards from the industrial wastes.

To modify the properties of traditional concrete to the desired level suitable to the specific circumstances.

To conserve the natural resources used in the production of construction materials.

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.

2.4 REVIEWS 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. MATERIALS 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 cementious 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

Table: 4 Physical properties of fly ash

S.NO	DESCRIPTION	
1	Specific Gravity	2.0
2	Physical Form	Powder
3	Color	Dark grey

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.

3.2.2.1 Ordinary 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 program was 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.

3.2.2.2 Chemical composition O.P.C:

Although Portland cement consists essentially composed of four major oxides: lime (Cao), silica (SiO_2), alumina (Al_2O_3), and iron (Fe_2O_3) and also Portland cement contains small amount of magnesia (Mgo),alkalies(Na2O and K2O), and sulfuric anhydrite (SO3).

Table 6: Chemical composition Limits of Oxides in Portland cement are given below

S.NO	Oxide Composition	Percent Content
1	Lime, Cao	63
2	Silica,SiO_2	20
3	Alumina,Al_2O_3	6
4	Iron oxide,Fe_2O_3	3
5	Magnesia, Mgo	1.5
6	Sulphur trioxide, SO_3	2
7	Potassium oxide,K_2O	1
8	Sodium oxide,Na_2O	1
9	Tricalcium silicate,C_3S	54.1
10	Dicalcium silicate,C_2S	16.6
11	Tricalcium aluminate,C_3A	10.8
12	Tetra calcium aluminoferrite,C_4AF	9.1

3.1.3 AGGREGATES: The material which is combined with cement and water to make concrete is called aggregate. Aggregate makes 60 to 80 percent of concrete volume. It increases the strength of concrete, reducing the shrinking tendencies of cement and is used as economical filler. Aggregates are divided into fine and coarse categories.

3.1.3.1Fine Aggregates

3.1.3.1.1. Sand:

Naturally available sand is used as fine aggregate in the present work. The most common constituent of sand is silica, usually in the form of quartz, which is chemical inert and hard. The sand is free from clayey matter, silt and organic impurities etc. Hence used as a fine aggregate in concrete. The size of sand is that passing through 4.75 and retained on 150 micron IS sieve. The specific gravity of Sand is taken as 2.62. Sand is tested for specific gravity, in accordance with IS: 2386-1963.

3.1.3.1.2Grain Size Distribution of Fine Aggregate-Sand

Table 7: Specification of Fine Aggregates Grading

Sieve size	%passing for Grading Zone			
	I	II	III	IV
10mm	100	100	100	100
4.75mm	90-100	90-100	90-100	95-100
2.36mm	60-95	75-100	85-100	95-100
1.18mm	30-70	55-90	75-100	90-100
600μm	15-34	35-59	60-79	80-100
300μm	5-2	8-30	12-40	15-50
150μm	0-10	0-10	0-10	0-15

Table 8: Sieve analysis of Fine Aggregate - Sand

S.NO.	Sieve Size	Wt. retained in gm	Percentage wt. retained	Cumulative % wt. retained(F)	Percentage passing (100-F)
1	4.75mm	12	1.2	1.2	98.5
2	2.36mm	103	10.3	11.5	88.5
3	1.18mm	316	31.6	43.1	56.9
4	600μm	205.5	20.5	63.65	36.35
5	300μm	296.5	29.6	93.3	6.7
6	150μm	6.2	0.62	99.5	0.5
7	Pan	2	0.2	100	0

Calculation

Fineness modulus = $S \frac{F}{100} = \frac{312.25}{100} = 3.12$

Sand is conforming to zone II.

3.2 METHODS

Parameters tested in this study

Normal consistency,

Initial setting & Final setting time

Workability

Compressive strength

Split tensile strength

3.2.1 TESTS ON CEMENT

3.2.1.1 Fineness of Cement by Dry Sieving Method:

The degree of fineness of cement is a measure of the mean size of grains in cement. The finer cement has quicker action with water and gains early strength through its ultimate strength remains unaffected. However, the shrinkage and cracking cement will increase with the fineness of cement. Apparatus used to determine the sieve analysis are I.S. Sieve No. 9 (90 Microns), Weighing Balance capacity 5 kg as per IS: 4031(part 1)1996.Weigh 100 grams of the given cement and sift it continuously for 15 minutes on IS. Sieve 9 no air set lumps may be broken down by fingers but nothing should be rubbed on the sieves. Find the weight of residue of the sieved after the sifting is over and report the values as a percent of the original sample taken.

3.2.1.2 Normal Consistency:

About 400g of cement was initially mixed with 30 percent mixing of water. The paste was filled in the mould of Vicat's apparatus and care was taken such that the cement paste was not pressed forcibly in the mould and the surface of filled paste was smoothened and leveled. A square needle 1mm×1mm of size is to be attached to the plunger and then lowered gently on to the surface of the cement paste and is released quickly. As plunger pierces the cement paste, reading on scale was recorded. The experiment was performed carefully away from vibrators and the other disturbances. The test procedure was repeated by increasing the percentage of mixing water at 0.5% increment until the needle reaches 5 to 7 mm from the bottom of the mould. When this condition is fulfilled, the amount of water added was taken as the correct percentage of water for normal consistency. The entire test was completed within 3 to 5 minutes, if the time taken to complete the experiments exceeds 5 minutes, the sample was rejected and fresh sample was taken and the operation was repeated again. Fresh cement was taken for each repetition of the experiment. The plunger was cleaned each time the experiment is done.

3.2.1.3 Initial and Final Setting Time:

Cement paste was prepared by mixing cement with 0.85 times appropriate mixing water required to give a paste of standard consistency. The stop watch was started at the instant the mixing water was added to the cement. After half-a-minute, the paste was thoroughly mixed with fingers for one minute. The mould resting on a nonporous plate was filled completely with cement paste and the surface of filled paste was leveled smooth with the top of the mould. The test was conducted at room temperature of 27 ± 2^0C at a relative humidity of 60%. The mould with the cement paste was placed in the Vicat's apparatus and the needle was lowered gently to make contact with the test block and was then quickly released. The needle thus penetrates the block and the reading on the graduated scale of Vicat's apparatus was recorded. The procedure was repeated until the needle fails to pierce the block by about 5 to 7 mm measured from the bottom of the mould. The stop button of stop watch was pushed down and the time was recorded which give the initial setting time. The cement paste was considered finally set when upon applying the needle gently to the surface of test block, the needle makes an immersion, but fails to penetrate and the time was noted which gives the final setting time. The needle was cleaned after every repetition and also care was taken such that there could not any vibrations.

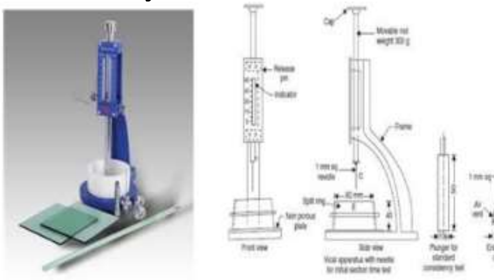


Figure: 3.1: Vicat apparatus with dimensions

3.2.1.4 Soundness:

It consists of a small split cylinder of spring brass of 0.5mm thickness, forming a mould with 30mm internal diameter and 30mm high. On either side of the split are attached two indicators are attached with pointed ends AA, the distance from these ends to the Centre of cylinder being 165mm. the mould was placed on a glass sheet and was filled with cement paste formed by gauging 100g of cement with 0.78 times the mixing water required to give a paste of standard consistency. The mould was covered with a glass sheet and a small weight was placed on its top. The mould was then submerged in the water at a temperature of 27 ± 2^0C. After 24hours, the mould was taken out and the distance separating the indicators points was measured. The mould was again submerged in water. Using the water heaters the water was brought to boiling point within 25 to35 minutes and the specimen was kept for 3 hours at a boiling point. The mould was removed from water and was allowed to cool down to 27^0C. The distance between the indicator points was measured again. The difference between the two measurements represents the unsoundness of cement. For each concentration of mixing water, three samples were tested and the mean value was taken as the unsoundness of cement sample.

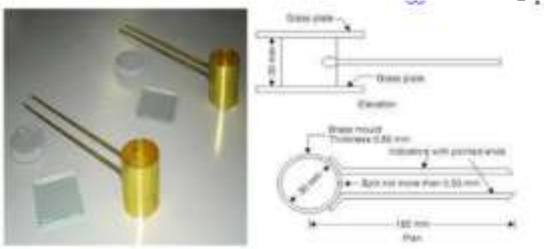


Figure: 3.2: Le Chatelier Apparatus with dimensions

3.2.1.5 Specific Gravity Cement:

Specific gravity of cement is defined as, the ratio of dry weight of cement to the weight of equal volume of kerosene added. This test is conducted by Le-Chatliers apparatus this property very important in the mix design. Note down the weight of empty density bottle (W_1). Take a one third of cement in bottle and weigh the bottle (W_2) then fill the bottle with kerosene fully and weigh the bottle with cement and kerosene (W_3). Then clean the bottle and fill the kerosene in the bottle and weigh the bottle with kerosene (W_4).

Note down the readings and determine the specific gravity of cement.

Specific Gravity of Cement $= (W_2-W_1)/((W_2-W_1)-(W_3-W_4))$

Figure 3.3: Specific gravity apparatus (Density bottle)

3.2.2.2 Specific Gravity of Coarse and fine aggregate:

Obtain approximately 1000 g of aggregate material passing the (4.75 mm) sieve. Prepare the material. Dry the material until it maintains a constant mass. This indicates that all the water has left the sample. Drying should occur in an oven regulated at 230°F (110°C).Cool the aggregate to a comfortable handling temperature. Immerse the aggregate in water at room temperature for a period of 15 to 19 hours. Dry the sample to a saturated surface dry (SSD) condition. Spread sample on a flat, non-absorbent surface and stir it occasionally to assist in homogeneous drying. A current of warm air may be used to assist drying procedure .The air current (typically from a blow dryer) should not blow the sample off the non-absorbent surface. Throughout this drying process, the aggregate should be repeatedly tested for a SSD condition using the Cone Test as follows: Fill a cone-shaped metal mould to overflowing with drying aggregate. Lightly tamp the aggregate into the mould with 25 light drops of a small metal tamper Remove loose aggregate from the outside of the mould and carefully lift the mould vertically. If surface moisture is still present, the fine aggregate will retain its moulded shape. When thea ggregate achieves an SSD condition, it will slump slightly. Upon the first test where slumping occurs, record the weight of the aggregate as SSD mass.

Figure 3.5: Specific gravity of fine and coarse aggregates apparatus

3.4 TESTS ON CONCRETE

3.4.1 Compressive Strength Test:

Remove the specimen from water after specified curing time and wipe out excess water from the surface. Take the dimension of the specimen to the nearest 0.2m. Clean the bearing surface of the testing machine. Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast. Align the specimen centrally on the base plate of the machine. Rotate the movable portion gently by hand so that it touches the top surface of the specimen. Apply the load gradually without shock and continuously at the rate of 140kg/cm2/minute till the specimen fails. Record the maximum load and note any unusual features in the type of failure.

Figure 3.8: Compressive testing machine

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.

The use of cementitious and pozzolanic siliceous industrial by-products as mineral admixtures-in concrete can bring improvements in engineering properties of concrete (strength, impermeability and general durability). Normal pozzolan additives due to their low surface area and reactivity are not generally able to improve the early strength which is crucial to the strength and stability of structural concrete applications and durability of concrete. The problem, though, could be solved by using a mixture of normal (such as fly ash and slag) and a highly reactive pozzolan, to produce a durable concrete which does not suffer from low early strength. Also the durability of concrete during its service life may be significantly affected by the environmental conditions to which it is exposed, and in order to produce a concrete of high quality, the placing of an appropriate mix must be followed by a planned curing system in a suitable environment during the early stages of hardening.

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 13: 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

4.3.2 Compaction factor:

The compaction factor test is mainly use within the laboratory conditions however currently it is using even within the field conditions. It represents a far better measurement of workability of concrete than slump test and this test best suitable for controlling the production of low slump concrete mixes. The degree of compaction known as "compacting factor", is measured by the density magnitude relation, which may be described as the magnitude relation of the density actually gained in the test to the density of same concrete when it is completely compacted. This method of workability test describes than the degree of fresh concrete mix will be compact by itself when proceed it to fall freely by its gravitational force and without any other external forces. The apparatus of compaction factor test was shown in the following figure.

The compacting factor was determined from the following equation:

$$\text{Compacting factor} = \frac{\text{mass of partially compacted concrete (W 1)}}{\text{mass of fully compacted concrete (W 2)}}$$

Figure 4.7:apparatus of compaction factor test

4.4 TESTS ON CEMENT

S.NO	TEST NAME	VALUE
1	Specific Gravity of Cement	3.0
2	Standard Consistency of Cement	34%
3	Initial and Final Setting Time	40min , 380min
4	Fineness of cement	3%

4.7 TEST RESULTS ON CONCRETE

Compression test is the most common test conducted on hardened concrete, partly because it is easy test to perform and partly because most of desirable characteristic properties of concrete are qualitatively related to its compressive strength. Compression test is carried out on specimens of cubical shape. The size of specimen is 15×15×15 cm.

Moulds:

Metal moulds made of cast iron, thick enough to prevent distortion are required. The internal faces are required to be accurate within the following limits. The height of mould and distance between the opposite faces are of specified size plus or minus 0.2mm. The angle between adjacent internal faces and between internal faces and top and bottom planes of the mould is required to be 900 ± 0.50. The interior faces of mould are plane surfaces with a permissible variation of 0.03mm. Each mould is provided with a base plate having a plane surface, the base plate is of dimensions to support the mould during filling without leakage and attach the mould by sprigs or a screws. Joints between the sections of mould are thinly coated with mould oil applied between the contact surface of the bottom of the mould and the base plate in order to ensure that no water escapes during filling. The interior surfaces of the assembled mould are also required to be thinly coated with mould oil to prevent adhesion of the concrete.

Curing:

The mould is kept at a temperature of 27±20C in atmosphere of at least 90^0 relative humidity for 24hrs after completion of vibration. At the end of that period they are removed from mould and immediately submerged in clean water and kept there until taken out just prior to breaking. The water in which the cubes are submerged renewed every 7days and shall be maintained at a temperature of 27± 20C. After they have been taken out, until they are broken the cubes shall not allowed becoming dry.

4.7.1COMPRESSIVE STRENGTH RESULTS

COMPRESSIVE STRENGTH WITHOUT REPLACEMENT:

S.No.	Days	Compressive strength in N/mm^2
1	3	15.82
2	7	18.74
3	14	23.54
4	28	29.25
5	56	35.47
6	90	37.54

Table : Normal concrete compressive strength

The below graph shows compressive strength V_s no of days .the horizontal axis represents the compressive strength and vertical axis represents days.

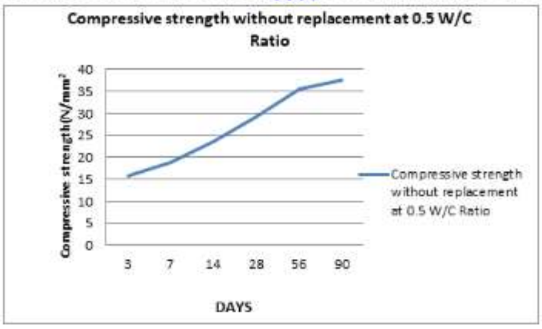


Fig (a).

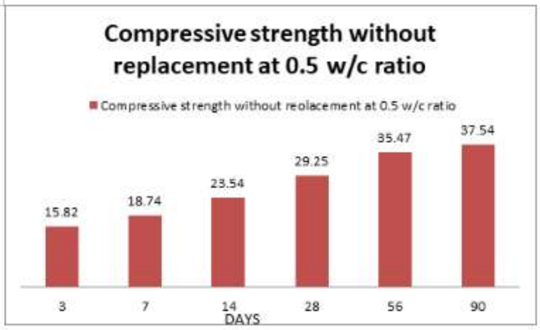


Fig (b).

Figures4.17(a)&(b): Compressive strength graph

Compressive Strength AT fly ash dosage of 10% and slag dosage of 10%, 20%, 30%:

Table36: compressive strength for cubes at10% fly ash and 10%,20%,30% of slag

S. No.	Days	10%FA+10%GBFS in N/mm^2	10%FA+20%GBFS in N/mm^2	10%FA+30%GBFS in N/mm^2
1	3	20.66	20.88	19.33
2	7	32.66	23.55	20.66
3	14	33.33	24.22	20.44
4	28	36.88	25.99	22.88
5	56	39.77	32.22	25.15
6	90	42.55	35.55	28.66

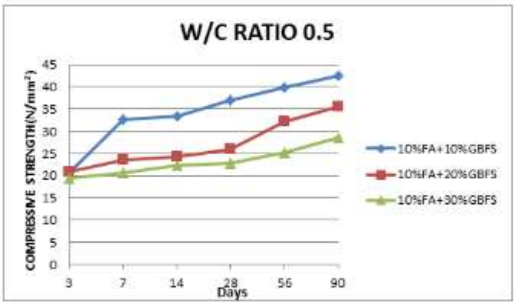


Fig (a).

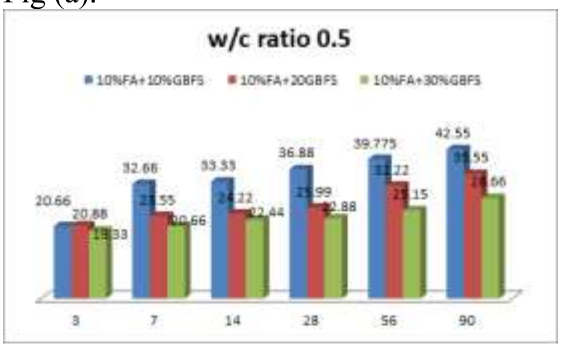


Fig (b).

Figure 4.18(a)&(b): Compressive strength graph at replacement 10% of fly ash and 10%,20%,30% of Slag

The graph is drawn between compressive strength Vs. days at fly ash dosage of 10% and slag dosage of 10%, 20%, 30%,.The horizontal axis represents the days and compressive strength shown in vertical axis. From graph as compared to the normal concrete (0% fly ash and 0% slag), the 3,7 14,28,56,90 days compressive strength is increased at fly ash dosage of 10% and slag dosage of 10%, 20%, 30%.

The Compressive strength of concrete for 10% FA and 10% GBFS is more compared to that for 10% FA and 20% GBFS and 10% FA and 30% GBFS.

Compressive Strength AT fly ash dosage of 20% and slag dosage of 10%, 20%, 30%:

Table37: Compressive strength for cubes at20% fly ash and 10%,20%,30% of Slag

S. No.	Days	20%FA+10%GBFS	20%FA+20%GBFS	20%FA+30%GBFS
1	3	23.77	18.88	14.22
2	7	26.44	20.44	19.11
3	14	26.22	23.77	21.77
4	28	31.32	29.99	24.88
5	56	33.11	31.11	26.21
6	90	35.11	32.66	27.77

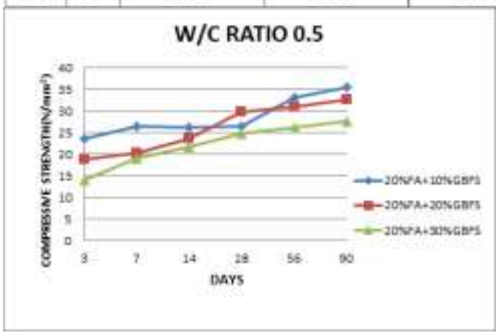
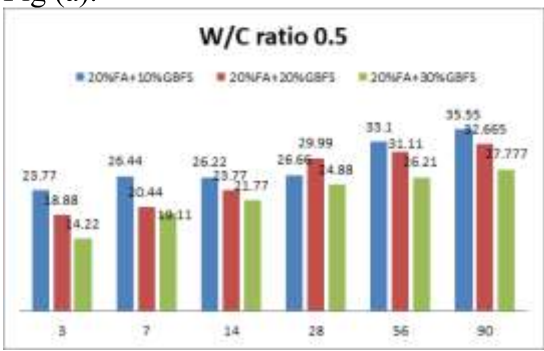


Fig (a).



Fig(b).

Figure4.19(a)&(b): Compressive strength at 20% replacement of fly ash and 10%,20%,30% replacement of GBFS

The graph is drawn between compressive strength Vs. days at fly ash dosage of 20% and slag dosage of 10%, 20%, 30%,.The horizontal axis represents the days and compressive strength shown in vertical axis. From graph as compared to the normal concrete (0% fly ash and 0% slag), the 3,7 14,28,56,90 days compressive strength is increased at fly ash dosage of 20% and slag dosage of 10%, 20%, 30%.

Compressive Strength AT fly ash dosage of 30% and slag dosage of 10%, 20%, 30%:

Table38: Compressive strength for cubes replacement of 30% of fly ash and 10%,20%,30% of GBFS

S.No	Days	30%FA+10%GBFS in N/mm^2	30%FA+20%GBFS in N/mm^2	30%FA+30%GBFS in N/mm^2
1	3	14.44	13.77	11.77
2	7	20.66	19.77	17.22
3	14	21.11	20.55	18.22
4	28	23.33	21.33	18.99
5	56	28.22	27.55	23.55
6	90	30.22	29.33	27.66

Fig (a).

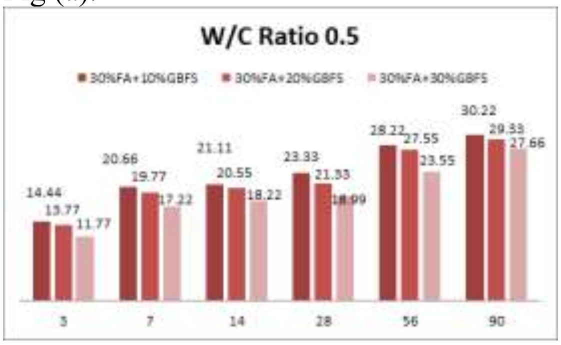


Fig (b)

Figure 4.20 (a)&(b): Compressive strength graph strength at 30% replacement of fly ash and 10%,20%,30% replacement of GBFS

4.7.2 SPLIT TENSILE TEST:

Fly ash and Blast furnace slag replaced as cement sand in concrete to determine the split tensile strength for 3, 7, 14, 28 days curing of the concrete cylinders by using compressive strength testing machine. At room temperature these cubes were cured. The water cement ratios were taken as 0.50. Two cubes were casted for each sample because the average values of the two cubes test results are taken for the exact results. By conduct the split tensile test the cylinder is placed horizontally on the compressive testing machine and two parallel plates are kept in top and bottom of the cylinder because of the reason is the load is uniformly distributed on the cylinder. Then the load is applied on the specimen and to observe the crushing load values and they are recorded. After knowing the crushing load values by using split tensile strength formula and to calculate the split tensile test values they are shown in below table.

SPLIT TENSILE STRENGTH WITHOUT REPLACEMENT:

Cement by Fly ash and sand by slag replaced in concrete to determine the split tensile strength for 3, 7, 14, 28 days. The curing of concrete cylinders by using compressive strength testing machine. At room temperature these cubes were cured. The water cement ratio was taken as 0.50. By conduct the split tensile test the cylinders is placed horizontally on the compressive testing machine and two parallel plates are kept in top and bottom of the cylinder because of the reason is the load is uniformly distributed on the cylinder. Then the load is applied on the specimen and to observe the crushing load values and they are recorded. After knowing the crushing load values by using split tensile formula and to calculate the split tensile values they are shown in below tables

Table 40: Normal concrete split tensile strength

S. No.	Days	Split tensile strength in N/mm^2
1	3	2.55
2	7	2.68
3	14	2.41
4	28	2.68

Normal concrete Split tensile strength graph:

Fig (a).

Fig (b).

Figure4.21(a)&(b): shows split tensile strength of normal concrete

A).Split tensile Strength AT fly ash dosage of 10% and slag dosage of 10%, 20%, 30%:

Table41: Split tensile strength for cylinders at replacement of 10%fly ash and 10%,20%,30% of Slag split tensile strength graph:

S.No.	Days	10%FA+10%GBFS in N/mm²	10%FA+20%GBFS in N/mm²	10%FA+30%GBFS in N/mm²
1	3	2.05	1.50	2.12
2	7	1.76	1.32	1.41
3	14	2.05	2.90	1.98
4	28	2.97	2.61	2.05

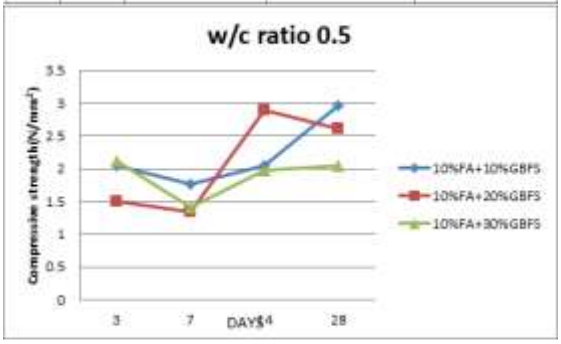


Fig (a).

Fig (b).

Figure 4.22(a)&(b): Split tensile strength at replacement of 10%fly ash and 10%,20%,30% GBFS

B). Split tensile Strength AT fly ash dosage of 20% and slag dosage of 10%, 20%, 30%:

Table42: Spilt tensile strength at replacement of 20% fly ash and 10%,20%,30% GBFS

S. No.	Days	20%FA+10%GBFS in N/mm²	20%FA+20%GBFS in N/mm²	20%FA+30%GBFS in N/mm²
1	3	1.76	1.20	1.13
2	7	2.05	1.14	1.20
3	14	2.47	2.90	2.68
4	28	2.54	1.98	1.76

SPLIT TENSILE STRENGTH GRAPH:

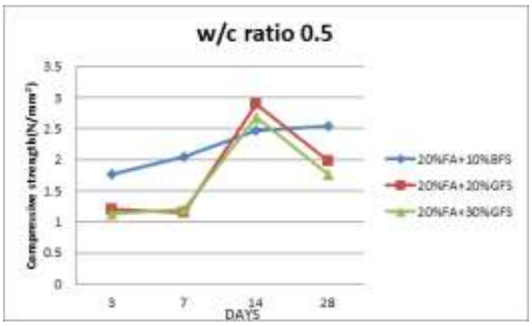


Fig (a).

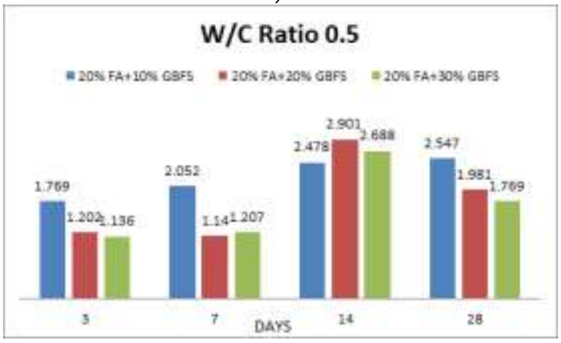


Fig (b).

Figure 4.23(a)&(b): Split tensile strength at replacement of 20%fly ash and 10%, 20%, 30% GBFS

5. 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 by slag 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.

The physical properties of cement with the replacement of fly ash and slag were found to be increase with the increasing of the percentages of admixtures.

The Compressive strength of concrete for 10% FA and 10% GBFS is more compared to that for 10% FA and 20% GBFS and 10% FA and 30% GBFS.

The Compressive strength of concrete for 20% FA and 10% GBFS is more compared to that for 20% FA and 20% GBFS and 20% FA and 30% GBFS.

The Compressive strength of concrete for 30% FA and 10% GBFS is more compared to that for 30% FA and 20% GBFS and 30% FA and 30% GBFS.

The maximum strength had attained 39.59% increased at 10 % FA and 10% GBFS replacement when compared to controlled concrete.

The split tensile strength values were found to be gradually decreased while the combination of percentage replacement of admixtures is increased.'

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