International Journal of Application or Innovation in Engineering & Management (IJAIEM)
Web Site: www.ijaiem.org Email: editor@ijaiem.org
Volume 8, Issue 3, March 2019 **ISSN 2319 - 4847**

Experimental Study on Flyash and Lime With Gypsum in Concrete

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ABSTRACT

Conventional concrete is responsible for amount of carbon-dioxide emission to some Extent. So to reduce the emission, various types of concrete are developed using waste products from industries and agricultural use like blast furnace slag, silica fume, fly ash which requires low Amount of energy and also cause least harm to the environment. Falg concrete is a new technology developed now days to reduce the effect on environment by production of cement. Cement contains high amount of carbon-di-oxide which harms the environment drastically, so by replacing the cement by various materials which causes harm to the environment we not only reduce the problem of disposal of these materials but we reduce the emission of carbon-di-oxide from cement. This study concerns with the use of fly ash and lime to improve the strength of concrete. An experimental investigation has been carried out by replacing the cement with falg by 0%. 10% and 20% for M30 grade of concrete. The main aim of this project is to investigate the compressive strength, split tensile strength and water absorption of M30 grade of concrete.

Keywords: Concrete, Falg, M_{30} grade and Split tensile strength.

1. INTRODUCTION

Cement is the one of the major component of the concrete. The production of one ton of cement releases one ton of a CO_2 into the atmosphere. CO_2 is known to be greenhouse gas that contributes to the global warming. The reduction in CO_2 emission from a concrete can be achieved with a partial replacement of cement by the various supplementary cementitious materials. The use of these cementitious materials has resulted in an improvement of the properties of concrete. So to reduce this environmental impact green concrete plays a vital role. By using recycled materials or waste materials which are not harmful to the environment as a replacement of cement such as fly ash, silica flume, lime etc. we can reduce the CO_2 emission from concrete as well as it reduces the environmental impact on earth. Fly ash is a residual material of energy production using coal, which has been found to have numerous advantages for use in concrete. Some of the advantage include improved workability, reduced permeability, increased ultimate strength, reduced bleeding, better surface and reduced heat of hydration. Several types of fly ash are produced depending on the coal and coal combustion process. It is a pozzolanic material and has been classified into two classes Fly ash is one of the residues generated in combustion, 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 in the past, fly ash was generally released into the atmosphere, but pollution control equipment mandated in recent decades now require 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 percent is recycled, often used to supplement Portland cement in concrete production. In some cases, such as the burning of solid waste to create electricity the fly ash may contain higher levels of contaminants than the bottom ash and mixing the fly and bottom ash together brings the proportional levels of contaminants within the range to qualify as nonhazardous waste in a given state, whereas, unmixed, the fly ash would be within the range to qualify as hazardous waste. The industrial waste materials have aided the production of cement in construction works. The new products and waste materials are generate by different industries. Dumping and destruction of waste material is causes environmental and health problems. The recycling of waste material is used the construction field. And it is gives great potential in industry. For so many years by products such as flyash, silica flume and lime powder were consider waste

material. The concrete mix prepared with different materials as improvement in workability and durability compared with normal concrete. It has been used the construction of powder, chemical plants and under water structures and researchers study the decades, intensive in recently to all possible methods are reuse. The construction waste, blast furnace, steel slag, coal flyash and bottom ash has been use the replacement by aggregate in roads, pavements, building constructions, embankments and foundations.

Gypsum is one of the natural wastes evolved from the industries and leads to environmental pollution. As Gypsum has proved itself as a pozzolonic material it is used for replacement of cement in the concrete mix. The use of by-products is an environmental friendly method of disposal of large quantities of materials that would otherwise pollute land, water and air. The emission of carbon-dioxide into the environment can be reduced by reducing the use of ordinary Portland cement. Due to growing environment concerns and need to conserve energy and resources, efforts have been made to utilize the waste material of industrial and agro products in the construction industry as a pozzolonic mineral admixture to replace ordinary Portland cement. By considering all the above conditions, Gypsum which is a pozzolonic material is used for replacement of cement which reduces the percentage of cement in the concrete mix globally. The Gypsum concrete is made of fine aggregates, coarse aggregates, lime, flyash and gypsum. It is an eco-friendly product which controls the environmental pollution, reduces the cost of concrete and gives high strength concrete for construction.

2. METHODOLOGY

Figure 1 shows the methodology of the study.

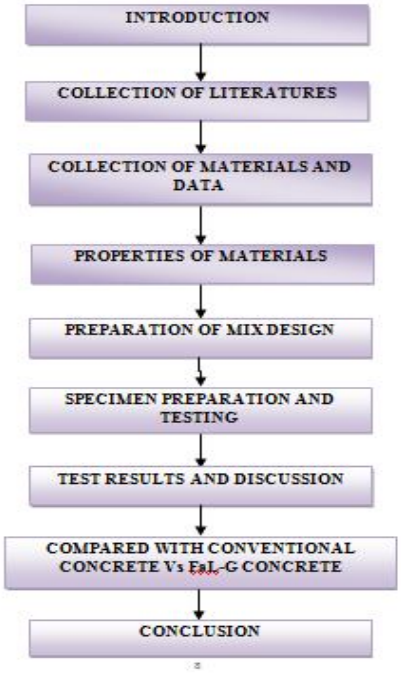

Figure 1 Methodology

3. MATERIAL COLLECTION

3.1 Cement

Many types of cements are available in market. When it comes to different grades of cement, the 53 Grade OPC Cement provides consistently higher strength compared to others. As per the Bureau of Indian Standards (BIS), the grade number of a cement highlights the minimum compressive strength that the cement is expected to attain within 28 days. For 53 Grade OPC Cement, the minimum compressive strength achieved by the cement at the end of the 28th day shouldn't be less than 53MPa or 530 kg/cm2. The color of OPC is grey color and by eliminating ferrous oxide during manufacturing process of cement we will get white cement.

Table 1 shows the properties of cement.

Table 1: Properties of cement

S.No	Properties	Test results
1	Normal consistency	0.32
2	Initial setting time	50min
3	Final setting time	320min
4	Specific gravity	3.14
5	Fineness	5%

3.2 Coarse Aggregate

Aggregates fractions larger than 4.75mm are termed as coarse aggregates. The fraction of aggregates used in the experimental work passed in 20mm sieve and retained on 10mm IS sieve comes under Zone II aggregates conforming to IS: 383-1970.

Table 2 shows the properties of coarse aggregates.

Table 2: Properties of Coarse aggregates

Properties	Coarse aggregate
Particle shape	Angular
Particle size	20mm
Specific gravity	2.75
Bulk density	1340 kg / m^3
Fineness modulus	4.18

3.3 Fine Aggregate

Sand is a natural granular material which is mainly composed of finely divided rocky material and mineral particles. The most common constituent of sand is silica(silicon dioxide, or SiO_2), usually in the form of quartz, because of its chemical inertness and considerable hardness, is the most common weathering resistant mineral. Hence, it is used as fine aggregate in concrete Fine aggregates are termed as "filler" which fills the voids in concrete. The reactions of aggregates less then4.75mm are known as fine aggregates. The river sand is used as fine aggregate conforming to requirements of IS:383-1970 comes under zone II.

Table 3 shows the properties of fine aggregates.

Table 3: Properties of Fine aggregates

Properties	Magnitude
Specific gravity	2.6
Bulk density ,kg/m^3	1830
Porosity,%	29.67
Grading zone	Zone II
Fineness modulus	3.13
Water absorption	1.02%

3.4 Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Since it helps to from the strength giving cement gel, the quantity and quality of water are required to be looked into very carefully.

3.5 Fly Ash

Fly Ash is a by-product of the combustion of pulverized coal in electric power generation plants. When the pulverized coal is ignited in the combustion chamber, the carbon and volatile materials are burned off. However, some of the mineral impurities of clay, shale, feldspars, etc., are fused in suspension and carried out of the combustion chamber in the exhaust gases. The size of the Fly Ash particles varies but tends to be similar to slightly larger than Type I Portland cement. The Fly Ash is collected from the exhaust gases by electrostatic precipitators or bag filters. Figure 2 shows the fly ash.

Figure 2 Flyash

3.5.2 Chemical Analysis (%)

Silicon dioxide (SiO_2) - 55.5
Aluminium oxide ($Al2O_3$) - 31.3
Ferric oxide (Fe_2O_3) - 6.4
Calcium oxide (CaO) - 1.02
Magnesium oxide (MgO) - 0.21
Titanium oxide (TiO_2) - 2.7
Sulphur trioxide (SO_3) - 0.44
Loss on ignition - 0.74

3.6 Lime Powder

Lime is one of the basic building materials used mainly as lime mortar in construction. Properties of building lime, advantages, and uses in construction are discussed. The broad category of lime is non-hydraulic and hydraulic lime. The non-hydraulic lime is called as quick lime, fat lime or white lime or as lump lime. Hydraulic lime sets under water and non-hydraulic lime do not set under water.
Figure 3 shows the lime powder.

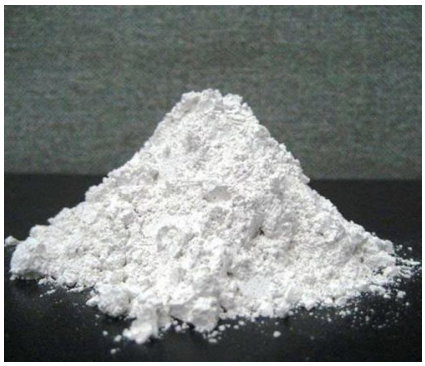

Figure 3 Lime powder

Table 4 shows the chemical composition of lime powder.

Table 4: Chemical composition of lime powder

Basic characteristics	The data sheet of lime
Physical appearance	White powder dries
CaO [%]	> 73.3
MgO [%]	< 0.5
Fe_2O_3 [%]	< 2
Al_2O_3 [%]	< 1.5
SiO_2 [%]	< 2.5
SO_3 [%]	< 0.5
Na_2O [%]	0.4 - 0.5
CO_2 [%]	< 5
$CaCO_3$ [%]	< 10
Specific density [g/cm^3]	2
More than 90 µm [%]	< 10
More than 630 µm [%]	0
Insoluble material[%]	< 1
Apparent density [g/l]	600-900

Table 5 shows the properties of lime powder.

Table 5: Properties of lime powder

Chemical name	Calcium hydroxide
Physical appearance	Dry white powder
Boiling temperature (^{0}C)	100
Heat of fusion(^{0}C)	580
Bulk density (kg/m^3)	Max. 500
Specific gravity	1.2–1.5
pH (25^{0}C)	12.4
$Ca(OH)_2$ (%)	80–86

3.7 Gypsum

Gypsum is a soft sulfate mineral composed of calcium sulfate dihydrate, with the chemical formula $CaSO_4 \cdot 2H_2O$. It is widely mined and is used as a fertilizer, and as the main constituent in many forms of plaster, blackboard chalk and wallboard. A massive fine-grained white or lightly tinted variety of gypsum, called alabaster, has been used for sculpture by many cultures including Ancient Egypt, Mesopotamia, Ancient Rome, the Byzantine Empire and the Nottingham alabasters of Medieval England. Mohs scale of mineral hardness, based on scratch hardness comparison, defines hardness value 2 as gypsum. It forms as an evaporite mineral and as a hydration product of anhydrite. Figure 4 shows the calcined gypsum.

Figure 4 Calcined Gypsum

4. MIX DESIGN

4.1 Mix Proportion for Normal Concrete

Table 6 shows the mix proportion.

Table 6: Mix Proportion

Cement (kg)	FA (kg)	CA (kg)	Water (liter)
330	603.48	1322.19	165

4.2 Mix Proportion for Replaced Concrete

Table 7 shows the mix proportion for replaced concrete.

Table 7: Mix Proportion for Replaced concrete

Cement (kg)	Fly ash (10%)in (kg)	Lime (10%) in (kg)	Gypsum(5%) in (kg)	FA (kg)	CA (kg)	Water (liter)
247.5	33	33	16.5	603.48	1322.19	165

5. TEST PROCEDURE

5.1 Compression Strength Test

Compressive strength of concrete cube test provides an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not. Concrete compressive strength for general construction varies from 15 MPa (2200 psi) to 30 MPa (4400 psi) and higher in commercial and industrial structures. Compressive strength of concrete depends on many factors such as water-cement ratio, cement strength, quality of concrete material, quality control during production of concrete etc. Figure 5 shows the cube mould.

Figure 5 Cube mould

Figure 6 shows the cube specimens.

Figure 6 Cube specimen

5.2 Split Tensile Strength Test

The tensile strength of concrete is one of the basic and important properties which greatly affect the extent and size of cracking in structures. Moreover, the concrete is very weak in tension due to its brittle nature. Hence. it is not expected to resist the direct tension. So, concrete develops cracks when tensile forces exceed its tensile strength. Therefore, it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack.

5.3 Water Absorption Test

One of the most important properties of a good quality concrete is low permeability, especially one resistant to freezing and thawing. Concrete with low permeability resists ingress of water and is not as susceptible to freezing and thawing. Water enter spores in the cement paste and even in the aggregate. The permeability of concrete is a measure of the rate at which a liquid pass through it.

6. TEST RESULTS

6.1 Compression and Split Tensile Test Result

Table 8 shows the test results of compression and split tensile test.

Table 8: Test results of compression and split tensile test

S.NO	NAME OF THE TEST	SPECIMEN	DAYS	DATE OF TESTING	LOAD IN (kN)		STRENGTH IN (N/mm^2)	
					CC	FaL-G Concrete	CC	FaL-G Concrete
1	COMPRESSION	CUBE	7	18/02/2019	346.5	387.0	15.4	17.2
			14	25/02/2019	506.2	576.2	22.5	25.6
			28	11/03/2019	591.7	645.7	26.3	28.7
2	SPLIT TENSILE	CYLINDER	7	18/02/2019	127.9	137.8	s	1.95
			14	25/02/2019	151.9	175.3	2.15	2.48
			28	11/03/2019	179.5	198.6	2.54	2.81

Figure 7 shows the compression strength test –bar chart.

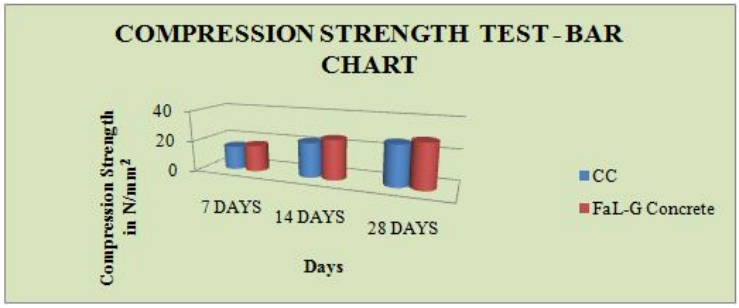

Figure 7 Compression strength test graph

Figure 8 shows the split tensile strength test – bar chart.

Figure 8 Split Tensile strength test graph

6.2 Water Absorption Test

Table 9 shows the water absorption test.

Table 9: Water absorption test

S.NO	% OF REPLACEMENT	INITIAL WEIGHT (KG)	OVEN DRY WEIGHT (W1)	WEIGHT AFTER IMMERSION (W2)	% OF WATER ABSORPTION
1	CC	8.41	8.30	8.55	3.01
2	FaL-G Concrete	8.32	8.11	8.51	4.93

7. CONCLUSION

After all the effort and present experiment work the following observation are made by partial replacement of cement with fly ash (10%), lime (10%) and gypsum (5%).

From the above observations we can conclude that,

- Having Fly ash, Lime and Gypsum in a concrete mix as a replacement of cement, increases its compressive strength due to their pozzolanic activity.
- The compressive strength of FaL-G concrete keeps increasing over a long time because the FaL-Gretards the hydration process of cement, whereas ordinary concrete reaches its maximum compressive strength after around 28 days.
- FaL-G (10%, 10% & 5% respectively)as replacement of cement has achieved the maximum compressive and split tensile strength.
- From the compressive strength test results, it is found that the, the strength of FaL-G concrete is increased up to 10%, compared to conventional concrete.
- Similarly, the split tensile strength of conventional concrete is less (2.54 N/mm^2) than FaL-G concrete (2.81N/mm^2)

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