An Investigation of the Impact of a Mineral Additive on Geopolymer Concrete

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***Abstract*— The usage of concrete is increasing day by day. Concrete, being material of choice in construction industry could be composed of naturally available materials. Cement in concrete is a binding material which produced by making use of natural materials leading natural materials to deplete. The new generation concrete has been developed such as geopolymer concrete. Thus, using the alternative materials which are waste products such as Ground Granulated Blast Furnace slag, Granite powder and Marble Powder without using cement along with some chemicals such as Sodium Silicate and Sodium Hydroxide to bind the concrete ingredients together to produce geopolymer concrete. An attempt has been made to find out an optimum mix for the geopolymer concrete by replacing Ground** Granulated Blast Furnace slag with Granite powder and Marble powder

***Index Terms*— GGBS, Marble powder, Granite powder, Sodium silicate (Na2SiO3), Sodium hydroxide (NaOH).**

1 INTRODUCTION

1.1GENERAL

Environmental pollution is a major issue in now-a-days. As far as construction industry hasconcerned, the production of cement leads mostly in polluting the environment. Geopolymer concrete could be an alternative material for normal concrete since it uses the waste products in place of cement which reduces the pollution also. In general, polymer concrete uses polymers to bind the concrete ingredients unlike the normal concrete, thus usage of water will also be very less. The polymers in this study were obtained from the manufacturers and the marble powder was taken from the marble powder stock yard at Puttur and Granite powder was taken from the granite cutter at Tadipatri. The Ground Granulated Blast Furnace Slag gets reacted in presence of alkaline solution and makes all other materials in concrete to stick together to form a strong material which can resist against forces on it. Because of this sticky nature it can be moulded into any shape like normal concrete.

HISTORY OF CONCRETE:

600 BC-Rome: Although the ancient romans weren't the first to create concrete, they werefirst to utilize this material widespread. By 200 BC, the romans successfully implemented the use of concrete in the majority of their construction. They were used to a mixture of volcanic ash, lime, and sea water to form the mix. The time period during which concrete was first invented depends on how one interprets the term concrete. Ancient materials werecrude cements made by crushing and burning gypsum or limestone. Lime also refers to crushed, burned limestone. When sand and water were added to these cements, they became mortar, which was a plaster like material used to adhere stones to each other.

Today's concrete is made using Portland cement, coarse and fine aggregates of stone and sand, water. Admixtures are chemicals added to the concrete mix to control its setting properties and are used primarily when placing concrete during environmental extremes, such as high are low temperatures, windy conditions, etc.

EARLY USE OF CONCRETE:

The first concrete like structures were built by the Nabataea traders or Bedouins who occupied and controlled series of a oases and developed a small empire in the regions of southern Syria and northern Jordan in around 6500 BC.

In making concrete, the Nabataea understood the need to keep the mix as dry or low slumpas possible, as excess water introduces voids and weaknesses into the

concrete.Their building practices included tamping the freshly placed concrete with special tools.

NEED OF THE PRESENT INVESTIGATION

Introduction

Concrete is the most commonly used construction material; Its usage by the communities across the globe is second only to water. Cement production is also highly energy intensive, after steel and aluminum the other hand, coal burning power generation plants produce huge quantities of GGBS and some of the materials which byproducts. Present prepare of geo polymer concrete adding of GGBS, Granite powder, Marble powder, Sodium silicate, Sodium hydroxide polymers. The geo polymer concrete preparestotally wastage of industrial material. These materials are cheaply, nearly available. The main content of geopolymer concrete is reduce to CO_2 compares to normal concrete, geopolymer concrete gives to good and early increasing strength. Its early setting time compares to normal concrete. But the geopolymer concrete is no usage to RCC, Constructions, other works. Because this is very costly and early setting.

PRESENT MATERIALS AND ITS RESOURCES

GRANITE POWDER:

Granite powder, this is the waste material from the granite polishing industry, is a promisingmaterial for use in concrete similar to those of pozzolanic materials such as silica fume, flyash and others. This is freely available material to wastage of granite cutter machines. If placing of granite stone to machine after start to machine and releasing of water in granite stone. It will be coming wastage of granite stones.

ADVANTAGES OF GRANITE POWDER

1.Granite powder can be used as filler in concrete and paving material and helps to reducetotal void content in concrete

2.Granite powder can be used as an admixture in concrete, so that strength can be increased

3.We can reduce the environmental pollution by utilizing this granite powder

4.Granite powder used as a construction purpose

5.Granite powder is cheaper as compared to cement

6.Binding property of granite slurry is very good

GROUND GRANULATED BLAST FURNACE SLAG:

Ground granulated blast furnace slag is a by-product, a mineral admixture which does not have cementations properties but when mixed in concrete produces compounds which Skins to cement. It is a non-eco-friendly material which cannot be stored in environment and not desirable to leave on to the ground. The blast furnace slag is mainly used in India for manufacturing slag cement. There are two types of methods for making blast furnace slag cement. In the first method blast furnace slag is interground with the cement clinker along with gypsum. In the second method blast furnace slag is separately ground mix with cement.

ADVANTAGES OF GGBS:

The incorporation of ground granulated blast furnace slag (GGBS) in concrete manufacturegains:

1) Ground granulated blast furnace slag is concrete increases the strength and durability ofthe concrete structure.
2) It reduces voids in concrete hence decreasing permeability
3) These make the concrete more chemically stable
4) Gives a good surface finish and improves aesthetics
5) The color is more even and light.

2 LITERATURE REVIEW

PARAS S. PITHADIYA, ABHAY V. NAKUM (2015) has examined the experimental study on geo-polymer concrete by using GGBS as a replacement of fly ash upto 100%. The fresh and hardened properties of concrete were examined. Results showed that replacement of fly ash increases the strength gradually. It has been observed that geo- polymer concrete requires oven curing about 100% and concluded that GGBS makes significant impact on mechanical properties of geo-polymer concrete.

Ajay Takekar, GR Palli (2017) has studied by Experimental study on mechanical properties of fly ash and GGBS based on Geopolymer concrete. The present investigation aims at studying the mechanical properties of fly ash and GGBS based on GPM. In this study fly ash replaced (0%, 25%, 50%, 100%) by GGBS. The compressive strength, split tensile strength, flexural strength 3, 7, 28, days compared to with normal OPC M25 grade of concrete and oven

curing studied. Geopolymer concrete shows better results than normal conventional concrete. This Geopolymer concrete is more advantageous, economical and eco-friendly.

E. Rabia, R.A.S. Mohammed (2020) Studied by developing geopolymer concrete by using nano materials and steel fibers. The geo polymer concrete was prepared by with and withoutnano materials (nano silica) of 0, 2%, 4%, 6%, and 8% from GGBS used. Nano silica and nano metakaolin mixes individually were compared GPC mixes. The tensile strength of the concrete samples accompanied by 0.5,1, and1.5% hooked end steel fibers demonstrated anincrease of 8.14, 14.8, 11.11% respectively. The flexural strength of the various concrete mixes was enhanced because of addition of 4% of NS,6%NMK,1% of crimped steel fiber values of 30.43%, 24%, 22, 15.22 respectively, compared to GPC control sample (NS; Nano silica, NMK; Nano metakaolin).

3.MATERIALS

GROUND GRANULATED BLAST FURNACES SLAG(GGBS):

Ground granulated blast furnace slag is off white colour and is a by-product, a mineral admixture which does not have cementations properties but when mixed in concrete produces compounds which Skins to cement. The specific gravity of GGBS is 2.9 and fineness is greater than 350kg/m^2. Ground granulated impact heater slag (GGBS) is gotten by extinguishing liquid iron slag (a side effect of iron and steel production) from a shoot heater in water are steam, to deliver a lustrous, granular item that is then dried and ground into a fine powder. These works at a temperature of around 1500 degrees centigrade and are encouraged with a deliberately controlled blend of iron mineral, coke and limestone.

The compound chemical synthesis of a slag changes significantly relying upon the creation of the crude materials in the iron generation process. To acquire a decent slag are reactivity or hydraulicity, the slag soften should be quickly cooled or extinguished beneath 800 degrees of centigrade keeping in mind the end goal to keep the crystallization of melilite. The principal segments of impact heater slag are CaO (30-half), SiO_2 (Silicon di oxide 28- 38%), MgO (magnesium oxide 1-18%). When all is said in done expanding the Cao substance of the slag brings about raised slag basicity and an expansion in compressive quality. The MgO and Al2O3 content demonstrate a similar pattern up to separately 10- 12% and 14%, past which no further change can be observed. GGBS is utilized toinfluence of strong solid structure in mix with customary Portland to concrete and additionally other pozzolanic materials.

Fig 3.1. GGBS

Granite powder:

Granite belongs to igneous rock of family. This is totally dust and waste of material. This is used to main thing of replacement of sand this is available to granite cutting machines (tadipatri, ongole) and the density of granite is 2.65 to 2.75 g/cm3, specific gravity of granite powder is 2.53 and fineness modulus was approximately 2.4 particle size <90 micron

Fig. 3.2 Granite powder

Table3. 2: Physical properties of Granite powder

S NO	CHARECTERISTICS	VALUE
1	Density of granite powder	2.65 to2.75
2	Specific gravity of granite powder	2.53
3	Fineness	2.4

Casting:

Preparing/casting of concrete cubes, Cylinders were finished. The test molds are kept prepared before setting up the mix. Tighten the bolts of moulds carefully because if bolts ofthe moulds are not kept tight the concrete slurry coming out of the mould when vibration oftakes place. Then the moulds are cleaned and oiled to all of surfaces of the moulds and initially the constituent materials were weighted and dry mixing was carried out for cement, sand, coarse aggregate, polymers. The mix thoroughly 2-5 minutes and then the water and polymers were added as per the mix proportion. The mixing was carried out for 3-5 minutesduration. Then the mix poured into the moulds and then compacted manually using tampingrod. The polymer concrete is curing: The cubes are demolded after 1 day of casting and then kept in respective solutions for curing at room temperature with a relative humidity of 85%the cubes are taken out from curing after 14days,28 days.

Preparation of Geo polymer concrete:

GEO means materials available in nature. In this geopolymer concrete the addition of GGBS, Granite powder, Marble powder and polymers were sodium silicate and sodium hydroxide and little bit of water added to this geopolymer concrete. Three binder contents (360,420,450 kg/m³)with four Alkaline to Binder ratios (0.3,0.32,0.4 and 0.45) wereconsidered along with 50-50,60-40,70-30,80-20,90-10,100-0 as different combination of M.P,G.P and GGBS.

Fig.3.9 Mixing of material before polymer

Fig. 3.9.1 Mixing of material after polymer

4 EXPERIMENTAL INVESTIGATION

INTRODUCTION:

Preparing/casting of concrete Cubes, Cylinders, Beams is done were finished. The test molds are kept prepared before setting up the mix. Tighten the bolts of moulds carefullybecause if bolts of the moulds are not kept tight the concrete slurry coming out of the mould when vibration of takes place. Then the moulds are cleaned and oiled to all of surfaces of the moulds and initially the constituent materials were weighted and dry mixing was carriedout for cement, sand, coarse aggregate, polymers. The mix thoroughly 2-5 minutes and thenthe water and polymers were added as per the mix proportion. The mixing was carried out for3-5 minutes duration. Then the mix poured into the moulds and then compacted manuallyusing tamping rod. The polymer concrete is curing: The cubes are demoulded after 1 day of casting and then kept in respective solutions for curing at room temperature with a relative humidity of 85% the cubes are taken out from curing after 14days,28 days of testing.

The following are the strength tests which was conducted in the project:

- Compressive strength test
- Split tensile strength test
- Flexural strength test
- RCPT (Rapid chloride permeability test)
- Rebound hammer test

COMPRESSIVE STRENGTH TEST:

Concrete cubes of sizes 150mm x150mm x150mm were tested for crushing strength. Compressive strength depends on loads of factor such as w/c ratio, cement strength, excellence of concrete material and

excellence control manufacture of concrete.

These cubes are tested by compression testing machine after 14 days,28 days air curing. Thesample is placed centrally on the base plate of machine and the load have to be apply gradually at the rate of 140kg/cm^2 per minute till the specimen fails. Load at the failure separated by area of sample gives the compressive strength of concrete. The sample to increased load breaks down and no greater load greater load can be constant. The maximumload applied to specimen shall then be recorded and any unusual value noted at the time of failure brought out in the report.

The cube compressive strength, then f_c=P/A N/mm^2

Where "P" is an ultimate load in N, "A" is across sectional area of cube in mm^2

Split tensile strength test:

The tensile strength of concrete is one of the basic and important properties. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. The concrete is very weak in tension due to its brittle nature and is not expected to resists the direct tension.

Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. Split tensile strength test was conducted by using the method prescribed by IS5816-1999.Cylynders of 150mm x150mm x300mm were used for this test. The specimens were tested for 14 days,28 days the cylinders specimens were placed in horizontal direction on the testing machine.

The splitting of cylinder is shown in figure. The following relation is used to find out the split tensile strength of cylinder

- $Ft=2P/\pi DL$

Where "Ft" is split tensile strength"P" is Ultimate load in KN

"L" is Length of the cylinders in mm "D" is Diameter of the cylinder in mm

Flexure strength test:

Flexure strength test on polymer concrete beam to determine the strength of polymer concrete. Flexural strength test was conducted by using the method prescribed by IS516-1959.Beams of dimensions 700mm x150mm x 150mm were used for this test, the test specimen is placed in the machine at the bearing surfaces of the supporting and loading rollers. So that the load shall be without shock and increasing continuously at a stress increase at approximately 7kg/sq mm that is at a rate of loading 400 kg/min for the 150 mm specimens. The load shall be increased until the specimen fails, and the maximumload applied to the specimen during the test shall be recorded.

Modulus of rupture; $f = PL/BD^2$

Where, "P" is the load in KN.

"L", "B" is the length and breadth in mm."D" is the depth in mm.

"F" is the flexure strength in N/mm^2

RCPT (Rapid chloride permeability test):

The RCPT is performed by monitoring the amount of electrical current that passes througha sample 50 mm thick by 100mm in diameter in 6 hours see schematic. This sample is typically cut as a slice of a core or cylinder. A volt age of 60 v dc is maintained across the ends of the sample throughout the test. The test has low inherent repeatability and reproducibility characteristics' precision statement in ASTM c1202-97 indicates that a single operator will have a coefficient of variation of 12.3%. Thus, the results from two properly conducted tests on the same material by the same operator could vary by the same operator could vary by as much as 42%.

Total charge passed (in coulombs)

QC=900(I0+2(I30+I60+I90+I120+I150+I180+I210+I240+I270+I300+I330) +I360)

Fig 4.5.1 Testing of RCPT moulds

5 EXPERIMENTAL RESULTS AND DISCUSSION

This chapter explains the mechanical strength properties like compression, split tensile strength and flexural strength tests of concrete with respective percentages.

The results completed in the present investigation are reported in the form of tables and graphs for various percentages, in the present experimental investigation of GGBS, Granite powder, Marble powder and polymers by weight.

: Compression Strength Test Results

The cubes were cast in the concrete technology laboratory and were tested on 14,28 days and the results obtained were as follows

Table:5.1.1Compressive Strength Test Results(N/mm²) @ GGBS+G.P

Mix Proportions	14 days	28 days
Convectional concrete	24.5	36.8
GGBS 100%	37.77	62.95
GGBS90%+G.P10%	37.59	62.65
GGBS 80%+G.P 20%	32.97	54.95
GGBS 70%+G.P 30%	34.77	57.95
GGBS 60%+G.P 40%	26.43	44.05
GGBS 50%+G.P 50%	29.52	49.2

NOTE: Geopolymer concrete of proportion GGBS100% gives high strength than conventional concrete with 54% increase in 14 days. Similarly for 28 days up to 71% increases value.

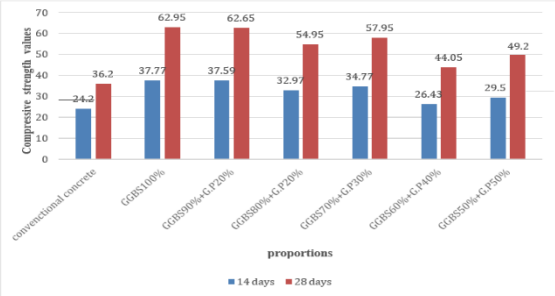


Fig 5.1.1Compressive Strength Test Results

Table :5.1.2 Compressive Strength Test Results(N/mm²) @ GGBS+M.P

Mix Proportions	14 days	28 days
GGBS100%	37.77	62.95
GGBS 90%+M.P 10%	38.64	64.4
GGBS 80%+M.P 20%	37.05	61.75
GGBS 70%+M.P 30%	26.37	43.95
GGBS 60%+M.P 40%	25.05	41.75
GGBS 50%+M.P 50%	17.01	28.35
Conventional concrete	24.5	36.8

DURABILITY PROPERTIES

The durability of cement concrete is defined as its ability to resist weathering action, chemical attack, abrasion, or any other process of deterioration. Durable concrete will retain its original form, quality, and serviceability when exposed to its environment. concrete was considered to be very durable material requiringa little or no maintenance. The assumption is largely true, except when it is subjected to highly aggressive environments. We build concrete structures in highly polluted urban and industrial areas, aggressive marine environments, harmful sub-soil water in coastal area and many other hostile conditions where other materialsof construction are found to be non-durable. Since the use of concrete in recent years, have spread to highly harsh and hostile conditions, the earlier impression that concrete is a very durable material is being threatened, particularly on account of premature failures of number of structures in the recent past.

5.COMPRESSION TEST RESULTS

The cubes were casted in the concrete technology laboratory and were tested on 56 days and the results obtained were as follows the following tests are conducted for the calculation of compressivestrength

- ACID RESISTANCE TEST
- SULPHATE ATTACK TEST
- ALKALINITY TEST

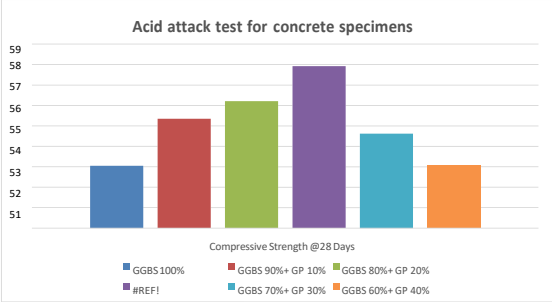
Acid Attack Test

The concrete cube specimens of various concrete mixtures of size 150 mm were cast and after28 days of air curing, the specimens were removed. The weights of concrete cube specimen were taken. The acid attack test on concrete cube was conducted by immersing the cubes in the acid water for 28 days of curing. Hydrochloric acid (HCL) with pH of about 2 at 5% weight of water was added to water in which the concrete cubes were stored.The pH was maintained throughout the period of28 days. After 28 days of immersion, the concrete cubes were taken out of acid water. Then, the specimens were tested for compressive strength.

Table: ACID attack

Mix	Compressive strength @ 28 Days
GGBS 100%	53.00
GGBS 90%+M.P 10%	55.2
GGBS 80%+M.P 20%	56.1
GGBS 70%+M.P 30%	57.9

GGBS 60%+M.P 40%	54.6
GGBS 50%+M.P 50%	53.0



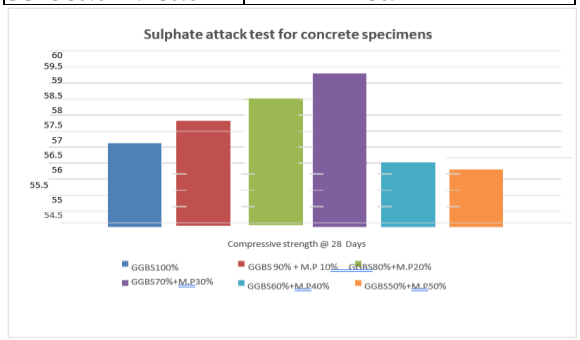
Graph 1: Acid attack test for concrete specimens

Sulphate Attack Test:

The resistance of concrete to sulphate attacks was studied by determining the loss of compressive strength or variation in compressive strength of concrete cubes immersed in sulphate water having 5% of sodium sulphate (Na2SO4) and 5% of magnesium sulphate (MgSO4) by weight of water and those which are not immersed in sulphate water. The concrete cubes of 150mm size after 28days of air curing and were immersed in 5% Na2SO4 and 5% MgSO4 added water for 56 days. The concentration of sulphate water was maintained throughout the period. After 28 days immersion period, the concrete cubes were removed from the sulphate waters and after wiping out the water and girt from the surface of cubes tested for compressive strength following the procedure prescribed in IS:516-1959. This type of accelerated test of finding out the loss of compressive strength for assessing sulphate resistance of concrete Mehta and Burrows (2001).

Table: Sulphate Attack

Mix	Compressive strength @ 28 Days
GGBS 100%	57.3
GGBS 90%+M.P 10%	57.8
GGBS 80%+M.P 20%	58.5
GGBS 70%+M.P 30%	59.3
GGBS 60%+M.P 40%	56.5
GGBS 50%+M.P 50%	56.1



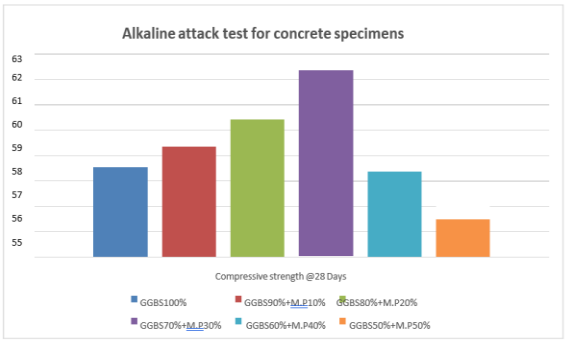
Graph 2: Sulphate attack test for concrete specimens

Alkaline Attack Test:

To determine the resistance of various concrete mixtures to alkaline attack, the residual compressive strength of concrete mixtures of cubes immersed in alkaline water having 5% of sodium hydroxide (NaOH) by weight of water was found. The concrete cubes which were cured under air for28 days. The weights of concrete cube specimen were taken. Then the cubes were immersed in alkaline water continuously for 28 days. The alkalinity of water was maintained same throughout the test period. After 28 days of immersion, the concrete cubes were taken out of alkaline water. Then, the specimens were tested for compressive strength.

Table: Alkaline Attack

MIX	COMPRESSIVE STRENGTH @ 28DAYS
GGBS 100%	58.5
GGBS 90%+M.P 10%	59.2
GGBS 80%+M.P 20%	60.7
GGBS 70%+M.P 30%	62.4
GGBS 60%+M.P 40%	58.3
GGBS 50%+M.P 50%	56.5



Graph 3: Alkaline attack test for concrete specimens

6 CONCLUSION

COMPRESSIVE STRENGTH TEST:

1) Geopolymer concrete of proportion GGBS100% gives high strength than conventional concrete with 54% increase in 14 days. Similarly for 28 days up to 71% increases value.
2) Geopolymer concrete of proportion GGBS 90%+M. P10% gives high strength than conventional concrete with 57%increase in 14 days. Similarly for 28 days up to 19% increases value.
3) Geopolymer concrete of proportion GGBS 60%+G.P20%+M.P20% gives high strength

than conventional concrete with 18%increase in 14 days. Similarly for 28 days up to 31% increases value.

4) Geopolymer concrete of proportion GGBS 70%+M.P20%+G.P10% gives high strength than conventional concrete with 20%increase in 14 days. Similarly for 28 days up to 33% increases value.

SPLIT TENSILE STRENGTH TEST:

1) Geopolymer concrete of proportion GGBS60%+G.P20%+M.P20% gives higher Strength then conventional concrete with 3% increase in 14 days. Similarly for 28 days up to 26% increases
2) Geopolymer concrete of proportion GGBS50%+G.P20%+M.P30% gives higher strength then conventional concrete with 8% increase in 14 days. Similarly for 28 days up to 19% increases.

FLEXURE STRENGTH TEST:

1) Geopolymer concrete of proportion GGBS 100% gives higher strength in beams than conventional concrete with 5% increases in 28 days. Similarly for 56 days up to1% increases.
2) Geopolymer concrete of proportion GGBS 100% gives higher strength in beams than conventional concrete with 5% increases in 28 days. Similarly for 56 days upto 2% increases.
3) Geopolymer concrete of proportion GGBS70%+G.P20%+M.P10% gives higher strength than conventional concrete with 10% increases in 28 days. Similarly for 56 days up to 2% increases
4) Geopolymer concrete of proportion GGBS70%+M.P20%+G.P10% gives higher strength than conventional concrete with 8% increases in 28 days. Similarly for 56days up to 1% increase.

RCPT (Rapid Chloride Permeability Test):

1) Geopolymer concrete of proportion GGBS+G.P20%(c)+M.P gives the chargepassed (coulombs) total values are below 1000-2000,which satisfies the Low permeability conditions.
2) Geopolymer concrete of proportion GGBS+M.P20 %(c)+G.P gives the chargepassed (coulombs) total values are below 1000-2000,which satisfies the Low permeability conditions.

DURABILITY TEST:

A). Acid Attack Test

1.Geopolymer concrete of proportion GGBS 70%+M.P 30% gives highstrength than conventional concrete with 57% increase in 28 days.

B). Sulphate Attack Test

1) Geopolymer concrete of proportion GGBS 70%+M.P 30% gives high strength than conventional concrete with 61% increase in 28 days.

C). Alkaline Attack Test

1) Geopolymer concrete of proportion GGBS 70%+M.P 30% gives high strength than conventional concrete with 69% increase in 28 days.

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