International Journal of Advance Research in Science and Engineering
Vol. No.9, Issue No. 03, March 2020
www.ijarse.com
IJARSE
ISSN 2319 - 8354

STRENGTH STUDIES ON GEO-POLYMER CONCRETE BY USING FLY ASH,BOTTOM ASH AND QUARRY DUST

Dr.R.Shanmugam M.E.Ph.D [1] S.Sasikumar. [2]R.Sivakumar. [3]R.Raghu [4]

1.AssociateProfessor, Department Of Civil Engineering,Tamil nadu, India
Sengunthar Engineering College, Tiruchengode.
2. B.E Civil Engineering–FinalYear, Sengunthar Engineering College, Tiruchengode Tamil nadu,
3.B.E Civil Engineering–FinalYear, Sengunthar Engineering College, Tiruchengode Tamil nadu,
4. B.E Civil Engineering–FinalYear, Sengunthar Engineering College, Tiruchengode, Tamil nadu,
Corresponding Author: R.Shanmugam[1]

ABSTRACT

The major problem the world is facing today is environmental pollution. In the construction industry mainly the production of Portland cement will cause the emission of pollutants results in environmental pollution. We can reduce the pollution effect on the environment, by increasing the usage of industrial by-products in our construction industry. Geopolymer concrete is such a one and in the present study, to produce the geo-polymer concrete the Portland cement is fully replaced with fly ash and the fine aggregate is replaced with quarry dust and bottom ash and alkaline liquids are used for the binding of materials. The alkaline liquids used in this study for the polymerization are the solutions of Sodium hydroxide (NaOH) and sodium silicate (Na_2Sio_3). Different molarities of sodium hydroxide solution i.e. 8M, 10M and 12M are taken to prepare different mixes.

And the compressive strength is calculated for each of the mix. The cube specimens are taken of size 150mm x 150mm x 150mm.The Geopolymer concrete specimens are tested for their compressive strength at the age of 7days, mixes of varying sodium hydroxide molarities i.e.8M,10M and 12M are prepared and they are cured by direct sun-light and strengths are calculated for 7 days. The result shows that the strength of Geopolymer concrete is increasing with the increase of the molarity of sodium hydroxide.

Key words: bottom ash compressive strength Geo-polymer concrete, m-sand, quarry dust

INTRODUCTION

1.1 GENERAL

For the construction of any structure, Concrete is the main material. Concrete usage around the world is second only to water. The main ingredient to produce concrete is Portland cement.

On the other side global warming and environmental pollution are the biggest menace to the human race on this planet today. The production of cement means the production of pollution because of the emission of CO_2 during its production. There are two different sources of CO_2 emission during cement production. Combustion of fossil fuels to operate the rotary kiln is the largest source and other one is the chemical process of calcining limestone into lime in the cement kiln also produces CO_2.In India about 2,069,738 thousands of metric tons of CO_2 is emitted in the year of 2010. The cement industry contributes about 5% of total global carbon dioxide emissions. And also, the cement is manufactured by using the raw materials such as limestone, clay and other minerals. Quarrying of these raw materials also causes environmental degradation. To produce 1 ton of cement, about 1.6 tons of raw materials are required and the time taken to form the limestone is much longer than the rate at which humans use it. But the demand of concrete is increasing day by day for its ease of preparing and fabricating in all sorts of convenient shapes. So to overcome this problem, the concrete to be used should be environmental friendly.

1.2 NEED OF GEOPOLYMER CONCRETE

To produce environmentally friendly concrete, we have to replace the cement with some other binders which should not create any bad effect on the environment. The use of industrial by products as binders can reduce the problem. In this respect, the new technology geo-polymer concrete is a promising technique. In terms of reducing global warming, the geo-polymer technology could reduce the CO_2 emission to the atmosphere caused by cement and aggregates industries by about 80% (Davidovits, 1994c). And also the proper usage of industrial wastes can reduce the problem of disposing the waste products into the atmosphere.

1.3 GEOPOLYMER

1.3.1 TERMINOLOGY AND CHEMISTRY

The term geo-polymer was first coined by Davidovits in 1978 to represent a broad range of materials characterized by chains or networks of inorganic molecules. Geo-polymers are chains or networks of mineral molecules linked with covalent bonds. Geopolymer is produced by a polymeric reaction of alkaline liquid with source material of geological origin or by product material such as fly ash, rice husk ash, GGBS etc. Because the chemical reaction that takes place in this case is a polymerization process, Davidovitscoined the term 'Geopolymer' to represent these binders.Geo-polymers have the chemical composition similar to Zeolites but they can be formed an amorphous structure. He also suggested the use of the term 'poly(sialate)' for the chemical designation of geopolymers based onsilico-aluminate. Sialate is an abbreviation for siliconoxo-aluminate.

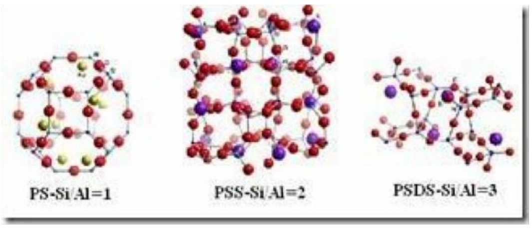


Figure-1.1. General Polymeric structures from polymerization of monomers.

Poly(sialates) are chain and ring polymers with Si^{4+} and AL^{3+} in IV-fold coordination with oxygen and range from amorphous to semi-crystalline with the empirical formula:

$$Mn\ (-(SiO_2)\ z–AlO_2)n.\ wH_2O$$

Where "z" is 1, 2 or 3 or higher up to 32; M is a monovalent cation such as potassium or sodium, and "n" is a degree of polycondensation (Davidovits, 1984, 1988b, 1994b, 1999).

Davidovits (1988b; 1991; 1994b; 1999) has also distinguished 3 types of polysialates,

International Journal of Advance Research in Science and Engineering
Vol. No.9, Issue No. 03, March 2020
www.ijarse.com
IJARSE
ISSN 2319 - 8354

namely the Poly(sialate) type (-Si-O-Al-O), the Poly (sialate-siloxo) type (-Si-O-Al-O-Si-O) and the Poly(sialate-disiloxo) type (-Si-O-Al-O-SiO).

The structures of these polysialates can be schematized as in Figure 1.1.

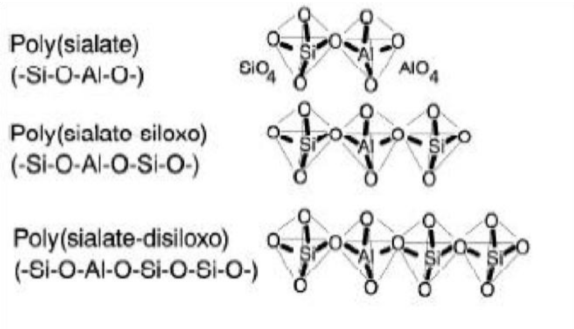
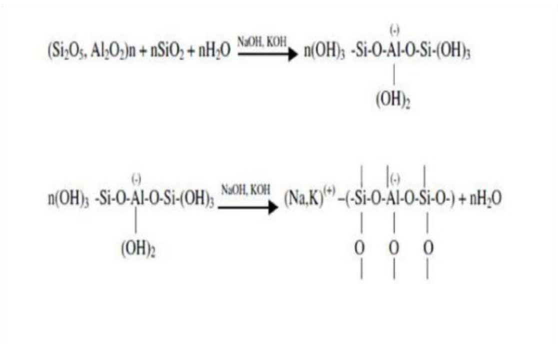


Fig 1.2 Chemical Structures of Polysialates

Geopolymerization involves the chemical reaction of alumino-silicate oxides (Si_2O_5, Al_2O_2) with alkali polysilicates yielding polymeric Si–O–Al bonds. The most common alkaline polysilicates used in the geo-polymerization is the combination of Sodium hydroxide/ Potassium hydroxide and Sodium silicate/ Potassium silicate. This combination increases the rate of reaction. Among 15 Alumino-silicate minerals, all the Al-Si minerals are more soluble in NaOH solution than in KoH solution.



Equation 1.2 shows an example of polycondensation by alkali into poly (sialatesiloxo). The last term of Equation 1.2 indicates that water is released during the chemical reaction that occurs in the formation of geo-polymers. This water, expelled from the geopolymer matrix during the curing and further drying periods, leaves behind discontinuous nano-pores in the matrix, which provide benefits to the performance of geopolymers. The water in a geopolymer mixture, therefore, plays no role in the chemical reaction that takes place; it merely provides the workability to the mixture during handling. This is in contrast to the chemical reaction of water in a Portland cement mixture during the hydration process.

Unlike ordinary Portland / pozzolanic cements, geo-polymers do not form calcium silicate- hydrates (C-S-H) for matrix formation and strength, but utilise the polycondensation of silica and alumina precursors and a high alkali content to attain structural strength. Therefore, geo-polymers are sometimes referred to as alkali activated aluminosilicate binders (Davidovits, 1994a; Palomo et. al., 1999; Roy, 1999; van Jaarsveld et. al., 2002a). However, Davidovits stated that using the term 'alkali-activated' could create significant confusion and generate false granted ideas about geopolymer concrete

1.4.1 FLY ASH

Fly ash is manufactured by the burning of coal in an electrostatic precipitator, a by-product of industrial coal. The cementitious properties of fly ash were discovered in the late 19th century and it has been widely used in cement manufacture for over 100 years. In the UK , fly ash is supplied as a separate component for concrete and is added to the concrete at the mixer. It generally replaces between 20 and 80 percent of the normal Portland cement.

1.4.2 PRODUCTION AND CLASSIFICATION OF FLY ASH

A thermal station is a power plant in which the prime movers steam driven. Water is heated, turns into steam and spins a steam turbine which drives an electrical generator. After it passes through the turbine, the steam is condensed in a condenser and recycled to where it was heated; this is known as a Rankine cycle. The greatest variation

IJARSE
ISSN 2319 - 8354

in the design of thermal power stations is due to the different fossil fuel resources generally used to heat the water. Some prefer to use the term energy center because such facilities convert forms of heat energy into electrical energy. Certain thermal power plants also are designed to produce heat energy for industrial purposes of district heating , or desalination of water, in addition to generating electrical power. Globally, fossil fueled thermal power plants produce a large part of man-made CO_2 emissions to the atmosphere, and efforts to reduce these are varied and widespread.

Two types of fly ash are commonly used in concrete: Class C and Class F. Class C are often high calcium fly ashes with carbon content less than 2%; whereas, Class F are generally low-calcium fly ashes with carbon contents less than 5% but sometimes as high as 10%. In general, Class C ashes are produced from burning sub-bituminous or lignite coals and Class F ashes bituminous or anthracite coals. Performance properties between Class C and F ashes vary depending on the chemical and physical properties of the ash and how the ash interacts with cement in the concrete. Many Class C ashes when exposed to water will react and become hard just like cement, but not Class F ashes.

1.5 QUARRY DUST

Now-a-days the natural river sand has become scarce and very costly. Hence we are forced to think of alternative materials. The Quarry dust may be used in the place of river sand fully. The worldwide consumption of fine aggregate in concrete production is very high, and several developing countries have encountered difficulties in meeting the supply of natural fine aggregate in order to satisfy the increasing needs of infrastructural development in recent years. To overcome the stress and demand for river fine aggregate, researchers and practitioners in the construction industries have identified some alternative materials such as fly ash, slag, limestone powder and siliceous stone powder. In India attempts have been made to replace river sand with quarry dust. The successful utilization of quarry dust as a fine aggregate would turn this waste material that causes disposal problems into a valuable resource. The utilisation will also reduce the strain on supply of natural fine aggregate, which will also reduce the cost of concrete.

A comparatively good strength is expected when sand is replaced fully with or without concrete admixtures. It is proposed to study the possibility of replacing sand with locally available crusher waste without sacrificing the strength and workability of concrete.

Coarse aggregate of 20mm maximum size is used in Reinforced cement concrete work of all types of structures. This is obtained by crushing the stone boulders of size 100 to 150mm in the stone crushers. Then it is sieved and the particles passing through 20 mm and retained on 10mm sieve known as coarse aggregate. The particles passing through 4.75mm sieve are called as quarry dust. The quarry dust is used to sprinkle over the newly laid bituminous road as filler between the bitumen and coarse aggregate and manufacturing of hollow blocks. Based on this experimental investigations, it is found that quarry dust can be used as an alternative material to the natural river sand. The physical and chemical properties of quarry dust satisfy the requirements of fine aggregate. It is found that quarry dust improves its mechanical property of concrete if used along with super plasticizer. Usage of quarry dust, it will also reduce the cost of concrete.

1.6 BOTTOM ASH

Bottom ash is part of the non-combustible residue of combustion in a power plant, boiler, furnace or incinerator. In an industrial context, it has traditionally referred to coal combustion and comprises traces of combustibles embedded in forming clinkers and sticking to hot side walls of a coal-burning furnace during its operation.The portion of the ash that escapes up the chimney or stack is, however, referred to as fly ash. The clinkers fall by themselves into the bottom hopper of a coal-burning furnace and are cooled. The above portion of the ash is also referred to as bottom ash. Most bottom ash generated at U.S. power plants is stored in ash ponds, which can cause serious environmental damage if there are structural failures of the ponds. Bottom ash also makes a useful construction material. The European Coal Combustion Products Association estimates the use of bottom ash in the construction industry at 46% and the use of fly ash at 43%. Bottom ash applications include filler material for structural applications and embankments, aggregate in road bases, sub-bases, pavement, and lightweight concrete products, as feedstock in the production of cement

1.7 OBJECTIVE OF THE STUDY

Our aim is to have an alternative binder instead of Cement in Concrete. The reason is during the production of cement, higher amounts of Carbon dioxide is released into the atmosphere and causes global warming. In this respect Geopolymer concrete is produced by replacing cement with Geopolymer binder which consists of Fly Ash and alkaline liquid.Sand also fine aggregate is replaced with quarry dust because it is more economical than fine aggregate.

REVIEW OF LITERATURE

2.1 GENERAL

There is a wide range of research undergoing for the use of Geo-polymer Concrete. For our investigation, some important publications were reviewed to have a broad idea about Geo-polymer Concrete and they have been listed in the references at the end of the report.

2.2 LITERATURE REVIEW

DjwantoroHardjito, Steenie E Wallah, Dody M.J. Sumajouw, and B.V. Rangan (1992) describes the effects of several factors on the properties of fly ash based Geopolymer concrete, especially the compressive strength. The test variables included were the age of concrete, curing time, curing temperature, quantity geo-polymer of superplasticizer, the rest period prior to curing, and the water content of the mix. They concluded that compressive strength of concrete does not vary with age, and curing the concrete specimens at higher temperature and longer curing period will result in higher compressive strength. They also concluded Naphthalene-based superplasticizer improves the workability of fresh geo-polymer concrete.

D. M. J. Sumajouw D. Hardjito S. E. Wallah B. V. Rangan (2007) presents the results of experimental study and analysis on the behaviour and the strength of reinforced Geopolymer concrete slender columns. They concluded that heat-cured low-calcium fly ash-based geopolymer concrete has excellent potential for applications in the precast industry. The products currently produced by this industry can be manufactured using geopolymer concrete. The design provisions contained in the current standards and codes can be used in the case of geopolymer concrete products.

Zhu Pan, Jay G. Sanjayan , B. V. Rangan(2009) they concluded that the ductility of the mortars has a major correlation to this strength gain/loss behaviour. They prepared the specimens with two different fly ashes, with strengths ranging from 5 to 60 MPa, were investigated. They concluded that the strength losses decrease with increasing ductility, with even strength gains at high levels of ductility. This correlation is attributed to the fact that mortars with high ductility have high capacity to accommodate thermal incompatibilities. It is believed that the two opposing processes occur in mortars: (1) further geo-polymerisation and/or sintering at elevated temperatures leading to strength gain; (2) the damage to the mortar because of thermal incompatibility arising from non-uniform temperature distribution. The strength gain or loss occurs depending on the dominant process.

XiaoluGuo ,Huisheng Shi , Warren A. Dick(2009) they studied the compressive strength and micro structural characteristics of a class C fly ash geopolymer (CFAG) were studied. They concluded that a high compressive strength was obtained when the class C fly ash (CFA) was activated by the mixed alkali activator (sodium hydroxide and sodium silicate solution) with the optimum modulus viz., molar ratio of SiO_2/Na_2O of 1.5. When CFA is alkali activated the sphere

International Journal of Advance Research in Science and Engineering
Vol. No.9, Issue No. 03, March 2020
www.ijarse.com
IJARSE
ISSN 2319 - 8354

seems to be attacked and broken due to the dissolution of alumino-silicate in the high pH alkali solution. Utilization of this fly ash in geo-polymer materials is a resource and energy saving process and it also indirectly reduces the emission of greenhouse gas CO2 released from cement manufacturing. This is beneficial for resource conservation and environmental protection.

N A Lloyd and B V Rangan (2010) concluded based on the tests conducted on various short-term and long-term properties of the geo-polymer concrete and the results of the tests conducted on large-scale reinforced geo-polymer concrete members show that geo-polymer concrete is well-suited to manufacture precast concrete products that can be used in infrastructure developments. In this paper a simple method to design geo-polymer concrete mixtures has also been described and illustrated by an example. The paper also includes brief details of some recent applications of geopolymer concrete.

PROPERTIES OF MATERIALS USED FOR THE STUDY

3.1 QUARRY DUST:

To produce geo-polymer concrete mix, the quarry dust is used as a fine aggregate and it was taken from local quarries. It has the following properties.

Table 3.1.1physical Properties of quarry dust

Property	**Quarry rock dust**	**Test method**
Specific gravity	2.60	IS 2386 (PartIII) 1963
Bulk relative density(kg/m3)	1700	IS 2386 (PartIII) 1963
Absorption (%)	1.30	IS 2386 (Part III) 1963
Moisture Content(%)	Nil	IS 2386 (Part III) 1963
Fine Particles less than 0.075mm (%)	14	IS 2386 (PartI)1963
Sieve Analysis	Zone III	IS 383-1970

Table3.1.2 chemical composition of quarry dust

Constituent	**Quarry Rock Dust (%)**	**Test method**
SiO2	62.48	IS: 4032-1968
Al2O3	18.72	
Fe2O3	06.54	
Cao	04.83	
Mgo	02.56	
Na2O	Nil	
K2O	03.18	

International Journal of Advance Research in Science and Engineering
Vol. No.9, Issue No. 03, March 2020
www.ijarse.com
IJARSE
ISSN 2319 - 8354

3.2 COARSE AGGREGATE:

Coarse aggregates of sizes 12mm and 20mm having following properties taken from a local supplier are used in the present study.

Table3.2 Properties of Coarse Aggregate

Property	Coarse Aggregate	
	20mm	**12mm**
Fineness Modulus	8.14	8.14
Specific gravity	2.87	2.83
Bulk Density	1533.33 kg/m3	1517 kg/m3
Percentage of voids	45.24%	47.14%

3.3 FLY ASH:

Fly Ash is taken from METTUR POWER PLANT in Mettur .

Table3.3Properties of FLY ASH

Oxide composition (%by mass)	fly ash
Sio2	59.2
Al2O3	38.02
CaO	0.94
MgO	0.28
Na_2O_3	0.47
K_2O	0.22
Loss of ignition	1.05

IJARSE
ISSN 2319 - 8354

3.4 BOTTOM ASH

Grading of Bottom ash

TABLE3.4. Grading of Bottom ash

IS Sieve	Weight retained (gm)	Cumulative Weight retained (gm)	% Cumulative Weight retained	% Passing
4.75 mm	106	106	10.6	89.4
2.36 mm	112	218	21.8	78.2
1.18 mm	178	396	39.6	60.4
600 micron	345	741	74.1	25.9
300 micron	167	907	90.7	9.3
150 micron	79	987	98.7	1.3
Pan	13	1000	100	0

3.5 ALKALINE SOLUTIONS

The solutions of Sodium hydroxide and Sodium Silicate are used as alkaline solutions in the present study.

Sodium hydroxide is available in market in various forms as flakes, pellets and in powder forms. In the study, Commercial grade Sodium Hydroxide in flakes form (97%-100% purity) is used.

Sodium silicate is available in powder form. By using sodium silicate we may prepare a solution of required molarity. In this study, sodium silicate used in solution form having the following chemical proportion is used.

Na_2O -7.5%-8.5%

Sio_2 -25% -28%

Water -67.5%-63.5%.

3.6 SUPER PLASTICIZER

In order to improve the workability of fresh concrete, Super plasticizer Conplast SP 430, of colour brown based on sulphonated naphthalene polymers, complies with IS 9103-1999, BS:5075 part 3 and ASTM C-494, Type F was used.

ADVANTAGES

- Reduction in water-cement ratio of the Order of 20-25 % .
- Flowing, pumpable concrete.
- Excellent workability and retention even in extreme temperatures.

International Journal of Advance Research in Science and Engineering
Vol. No.9, Issue No. 03, March 2020
www.ijarse.com
IJARSE
ISSN 2319 - 8354

4. EXPERIMENTAL WORK

4.1 GENERAL

This Chapter describes the experimental work. First, Mix design of geo-polymer concrete, manufacturing and curing of the test specimens are explained. This is then followed by description of types of specimens used, test parameters, and test procedures.

4.2 MIX DESIGN

The mix design in the case of geo-polymer concrete is based on conventional concrete with some modification. In the case of conventional concrete the material proportion can be found out for the required strength using the code, but in the case of geo-polymer concrete there is no design method or codal provisions. Here by means of trial and error method optimized mixes are being produced.

The mix proportions given by **N A Lloyd and B V Rangan (2010)** is taken as a reference one, several trial mixes are prepared with fly ash and constant molarity of NaOH as 2M. The mix which gives high workability is taken as the final one and the project continues with the final one. The trial mixes are as follows.

The trial mixture proportion is as follows: combined aggregates = 1848 kg/m3, GGBS = 408 kg/m^3, sodium silicate solution = 103 kg /m^3, and sodium hydroxide solution = 41 kg/m^3 (2M solution). 20 mm aggregates = 910 kg/m^3,12 mm aggregates = 390 kg/m^3, fine sand = 554 kg/m^3 . The geo-polymer concrete is wet-mixed for four minutes and cured at 60^{o}C for 24 hours in a hot air oven after casting. Commercially available super plasticizer of about 0.75% of mass of Bottom ash, i.e. 5 kg/m^3 is added to the mixture to facilitate ease of placement of fresh concrete. In this manner, by changing the quantities of aggregates and by increasing the fines in the mixture the final mix is as follows. The total volume occupied by the aggregates (Coarse and fine aggregates) is assumed to be 65%. The alkaline liquid to bottom ash ratio is taken as 0.30. The quantities of all ingredients are kept constant as given in table-4.1 except the molarity of NaOH is changed in each mix.

Assume the density of geo-polymer concrete as 2500 kg/m3. Assume the volume of combined aggregates occupied 70% of the mass of concrete, i.e. 0.70x2500= 1750 kg/m^3.

In this,

The mass of fine aggregates + coarse aggregates= 1750kg/m^3.

Coarse Aggregate= 60% of 1750

= 1050 kg/m

Quarry dust= 20% of 1750

= 350 kg/m

Bottom ash = 20% of 1750

= 350 kg/m

Mass of Alkaline liquid and Fly ash

=2500-1750

= 750 kg/m

Assume,

Mass of fly ash= 60% of 750

= 450 kg/m

Mass of alkaline liquid = 40% of 750

= 300 kg/m

mass of sodium hydroxide solution =100kg/m^3;

The mass of sodium silicate solution =200 kg/m3;

The mass of super plasticizer = 0.75X450

=3.375 kg/m3

The final mix proportion is shown in table 4.

Table-4.1 Mixing proportions of the geo-polymer concrete

Name of the Mixture	Fly ash (kg/m^3)	Quarry dust (kg/m^3)	Bottom ash (kg/m^3)	Coarse Aggregate (kg/m^3)		Sodium silicate solution (kg/m^3)	Sodium hydroxide solution (kg/m^3)	Super-Plasticizer (kg/m^3)
				20 mm	12 mm			
GP1	450	350	350	400	650	200	100(8M)	3.375
GP2	450	350	350	400	650	200	100(10M)	3.375
GP3	450	350	350	400	650	200	100(12M)	3.375

4.3 PREPARATION OF ALKALINE LIQUIDS

NOTE: Molarity = moles of solute/litre of solution

In this paper the compressive strength of geo-polymer concrete is examined for the mixes of varying molarities of Sodium hydroxide (8M, 10M, and 12M). The molecular weight of sodium hydroxide is 40. To prepare 8M i.e. 8 molar sodium hydroxide solution, 320g of sodium hydroxide flakes are weighed and they can be dissolved in distilled water to form 1 litre solution. For this, a volumetric flask of 1 litre capacity is taken, sodium hydroxide flakes are added slowly to distilled water to prepare 1liter solution. The weights to be added to get required molarity are given in Table.4.2

Table.4.2 Weights of NaOH flakes

Required Molarity	Weight in g. of Sodium hydroxide flakes
8M	320
10M	400
12M	480

The sodium silicate solution and the sodium hydroxide solution were mixed together at least one day prior to use to prepare the alkaline liquid. On the day of casting of the specimens, the alkaline liquid was mixed together with the super plasticizer and the extra water (if any) to prepare the liquid component of the mixture.

Fig 4.1 sodium hydroxide in pellets form

Fig 4.2 sodium hydroxide in flakes form

4.4 MANUFACTURING AND CASTING OF GEO-POLYMER CONCRETE

The conventional method used in the making of normal concrete is adopted to prepare geo-polymer concrete. First, the quarry dust, coarse aggregate and Fly ash are mixed in dry condition for 3-4 minutes and then the alkaline solution which is a combination of Sodium hydroxide solution and Sodium silicate solution with super-plasticizer is added to the dry mix. The mixing is done about 6-8 minutes for proper bonding of all the materials. After the mixing, the cubes are casted with the mixes GP1 toGP3 by giving proper compaction. The sizes of the cubes used are of size 150mmX150mmX150mm.

International Journal of Advance Research in Science and Engineering
Vol. No.9, Issue No. 03, March 2020
www.ijarse.com
IJARSE
ISSN 2319 - 8354

Fig 4.3 Adding sodium silicate solution to dry mix

Fig 4.4 Fresh geo-polymer concrete

Fig 4.5 Casting of geo-polymer concrete cubes

4.5 CURING OF GEO-POLYMER CONCRETE

For the curing of geo-polymer concrete cubes, the cubes are placed in direct sun-light. For the sunlight curing, the cubes are demoulded after 1 day of casting and they are placed in the direct sunlight for 7 days.

4.6 COMPRESSIVE STRENGTH

Compressive strength is the capacity of a material or structure to withstand axially directed pushing forces. Cubes of 150mm×150mm×150mm were casted and a compressive strength test was conducted on specimens at 7 days. To conduct the test the specimens are placed in a compression testing machine and the load is applied to the cube and the load at failure is noted as failure load. The compressive strength is calculated by using the formula given in 4.1. The results in tables 5.1.1.

$F_{ck}=P_c/A$

Where, P_c=load at failure in N

A=loaded area of cube in mm^2

Fig 4.6-polymer concrete cubes after compression test

RESULTS AND DISCUSSIONS

5.1 GENERAL

The results of the tests which are specified in chapter 4 are given in the following tables with their corresponding graphs.

5.2 RESULTS OF STRENGTH TESTS

5.2 .1COMPRESSIVE STRENGTH

Table 5.1.1 Compressive strength

Name of the mix	Compressive strength in N/mm^2 of specimens Cured by		
	7days	14days	28days
CC	18.6	23.4	27
GP1	19.23	23.6	27.5
GP2	20.26	24.2	28.2
GP3	21	25.2	29.4

International Journal of Advance Research in Science and Engineering
Vol. No.9, Issue No. 03, March 2020
www.ijarse.com
IJARSE
ISSN 2319 - 8354

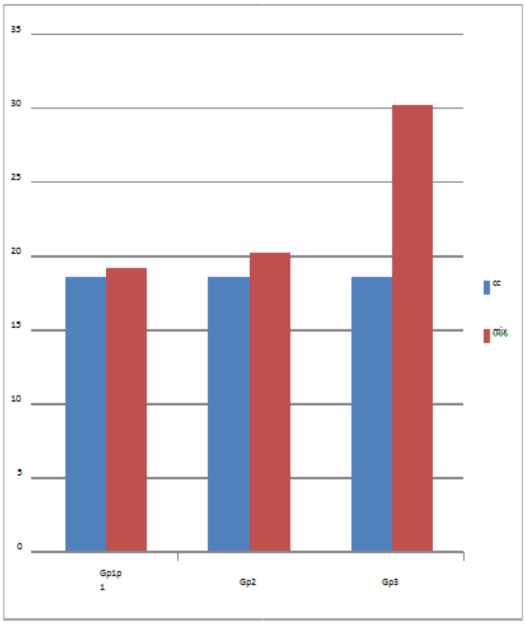


Figure 5.1 Compressive strength of specimens at the age of 7 days

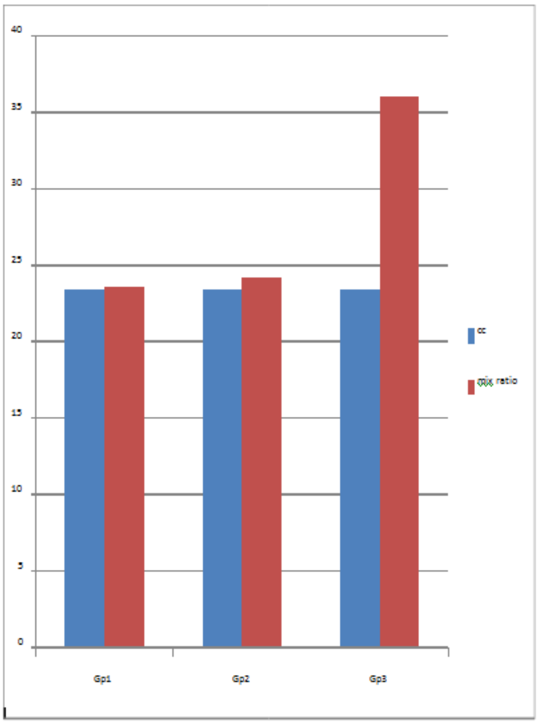
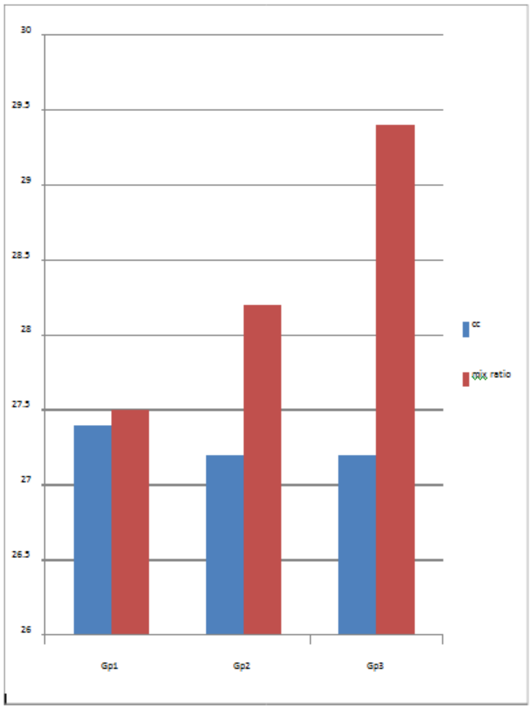


Figure 5.2 Compressive strength of specimens at the age of 14 days

Figure 5.3 Compressive strength of specimens at the age of 28 days



By showing the above graph the compressive strength increases the strength by 40% in 7days.The other one shows the increase of the strength by 60% it reflects that by increasing the days limit the strength of the mixture can be increased .The last one shows the increase of the strength by 75%.

Table 5.3 Split Tensile Test

Name of the mix	Split Tensile Test in N/mm^2 of specimens Cured by		
	7days	14days	28days
CC	1.7	2.25	2.87
GP1	1.9	2.34	2.74
GP2	2.2	2.47	2.85
GP3	2.3	2.52	2.96

IJARSE
ISSN 2319 - 8354

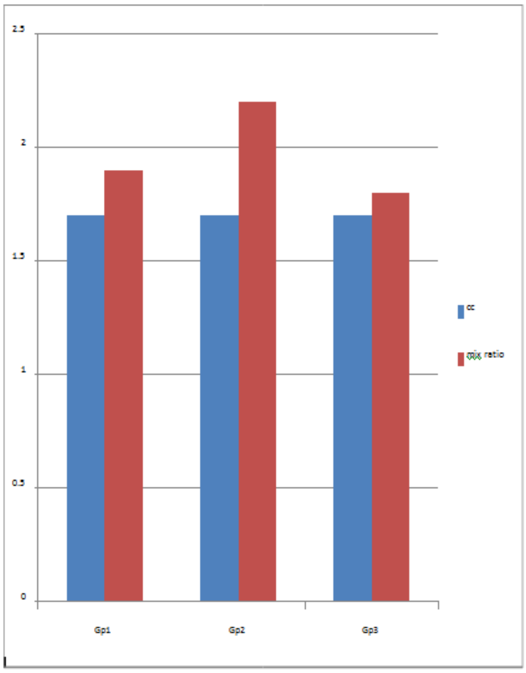


Figure 5.4 Split Tensile Test of specimens at the age of 7 days

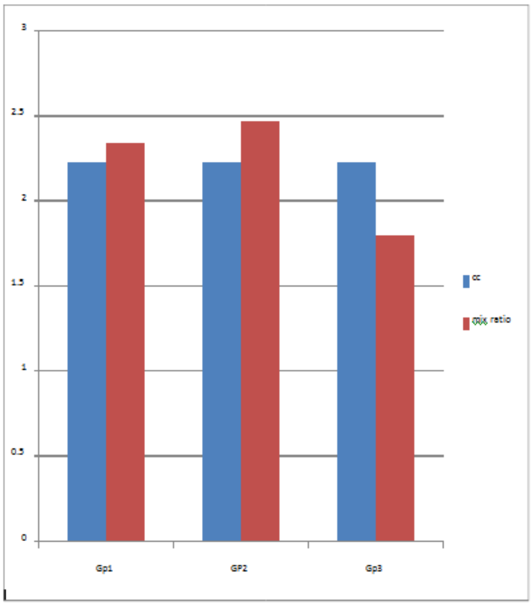


Figure 5.5 Split Tensile Test of specimens at the age of 14 days

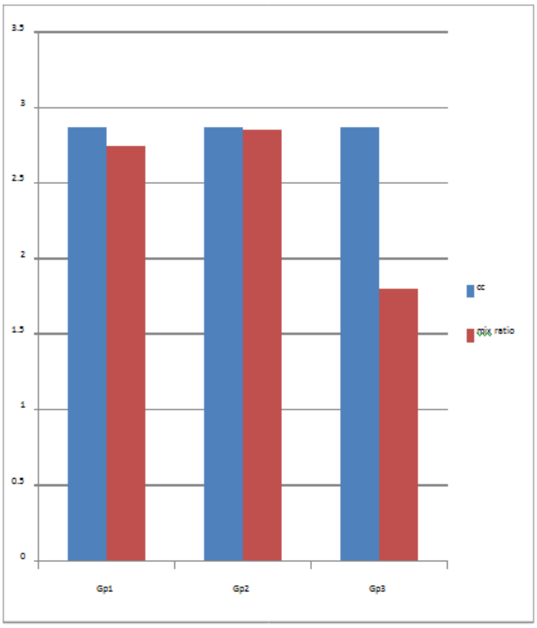


Figure 5.6 Split Tensile Test of specimens at the age of 28 days

In case of considering the split tensile test the strength can be varied as it compares with the compressive strength. The only difference we can observe is the mixing ratio of the quantity .The graph shows an increase of composition by 40% to 80 %.

Table 5.4 Workability Test

S.NO	Name of the Mix	Workability in mm
1	cc	65
2	Gp1	75
3	Gp2	82
4	Gp3	92

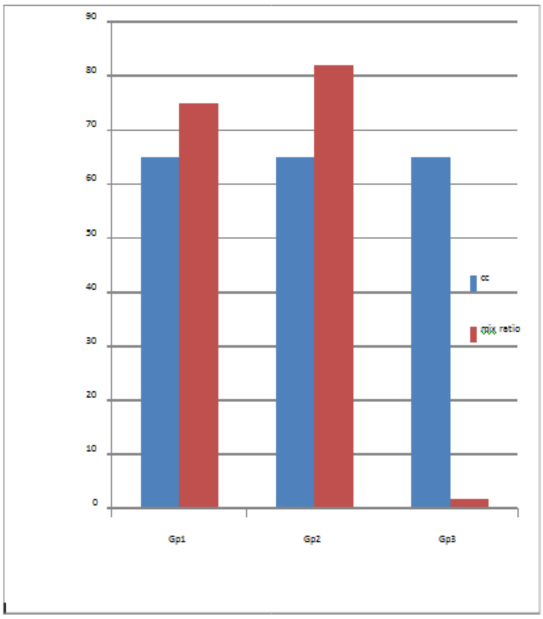


Figure 5.7 Workability Test of specimen

6. CONCLUSIONS

Based on the experimental work reported in this study, the following conclusions are drawn.

- Higher concentration (in terms of molar) of sodium hydroxide solution results in higher compressive strength of fly ash & quarry dust based geo-polymer concrete.
- Longer curing time, in the range of 4 to 96 hours (4 days), produces higher compressive strength of fly ash & quarry dust based geo-polymer concrete. However, the increase in strength beyond 24 hours is not significant.
- The fresh fly ash-based geo-polymer concrete is easily handled up to 120 minutes without any sign of setting and without any degradation in the compressive strength.
- The mix GP3 gives higher compressive strength, as it has high molarity of NaOH
- We observe that the compressive strength is increased with the increase in the molarity of the sodium hydroxide
- After three days of curing the increase the compressive strength is not sufficient
- The geo-polymer concrete shall be effectively used for the beam column junction of the reinforced concrete structure
- Geo-polymer concrete shall also be used in the Infrastructure works.
- In addition to that fly ash shall be effectively used and hence no landfills are required to dump the fly ash.

7. SCOPE FOR FUTURE WORK

7.1 SCOPE FOR FUTURE WORK

As geo-polymer concrete technology is a new one, there is a lot of scope to work on this topic. In the present study we used fly ash as a binder instead of cement. We recommended to extend this topic by using by products like rice husk ash, GGBS, pulverized fuel ash etc .And also, investigation of Long term properties like durability, creep, drying shrinkage may also gives the suitability of geo-polymer concrete in the field. To implementing such a method the durability can be increased and strength of the material can also be increased .The most important thing is that cement can be made to increase the striking property of the materials can be increased in proper quantity.

To provide a most Economical Concrete

- It should be easily adopted in the field.
- To reduce the cost of construction.
- To promote low cost housing for the people.
- To find the optimum strength of the partial replacement of concrete.
- To make the maximum usage of locally available materials.

. REFERENCES

[1]. Zhu Pan , Jay G. Sanjayan , B. V. Rangan,(2007) “An investigation of themechanisms for strength gain or loss of geopolymer mortar after exposure to elevated

temperature" , published in *J Matera Science (2009) 44:1873–1880.*

[2]. Davidovits, J. (1988b). Geopolymer Chemistry and Properties. Paper presented at the *Geopolymer '88, First European Conference on Soft Mineralurgy, Compiegne, France.*

[3]. XiaoluGuo, HuishengShi , Warren A. Dick (2009) "Compressive strength and microstructural characteristics of class C fly ash Geopolymer" published in *Elsevier .Ltd, Cement & Concrete Composites 32 (2010) 142–147 www.elsevier.com/locate/cemconcomp*.

[4]. Smith Songpiriyakij, TeinsakKuprasit , ChaiJaturapitakkul , PrinyaChindaprasirt(2010) "Compressive strength and degree of reaction of biomass- and fly ash-based Geopolymer" published in *Elsevier .Ltd, Construction and Building Materials 24 (2010) 236–240.*

[5]. Shuguang Hu, Hongxi Wang, GaozhanZhang ,Qingjun Ding(2007) "Bonding and abrasion resistance of geopolymeric repair material made with steel slag" published in *Elsevier .Ltd ,Cement & Concrete Composites 30 (2007) 239–244*.

[6]. Christina K. Yip, Grant C. Lukey, John L. Provis, Jannie S.J. van Deventer (2008), "Effect of calcium silicate sources on geopolymerisation" published *in Elsevier .Ltd, Cement and Concrete Research 38 (2008) 554–564*.

[7]. C.A. Hendriks1, "Emission Reduction of Greenhouse Gases from the Cement Industry" Greenhouse gas control technologies conference paper.

[8]. Ernst Worrell. Lynn Price, et al. "CO2 emission from the global cement industry", *Annual review of energy and the environment. Vol 26: p-303-329.*

[9]. M.F.Nuruddin, Sobia Quazi, N. Shafiq, A. Kusbiantoro, "Compressive strength P& Micro structure of polymeric concrete incorporating fly ash and silica fume", *Canadian journal on civil engineering Vol.1, No.1, feb-2010.*

[10]. Warner, R. F., Rangan, B. V., Hall, A. S.,&Faulkes, K. A. (1998).*ConcreteStructures. Melbourne: Longman.*

[11]. Wee, T. H., Suryavanshi, A. K., Wong, S. F., N Rahman, A. K. M. A. (2000) Sulfate Resistance of Concrete Containing *Mineral Admixtures.ACIMaterials Journal, 97(5), 536-549.*

[12]. Xu, H., & Deventer, J. S. J. V. (1999). The Geopolymerisation of Natural Alumino-Silicates.Paper presented at the *Geopolymer '99 International Conference,Saint-Quentin, France.*

[14]. Xu, H., & Deventer, J. S. J. V. (2000). The geopolymerisation of alumino-silicateminerals.*International Journal of Mineral Processing, 59(3), 247-266.*

[15]. D.M.J. Sumajouw, D. Hardjito, S. Wallah, and B.V. Rangan, ".Behavior of Geopolymer Concrete Columns under Equal Load Eccentricities".