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Experimental investigation on mechanical properties of geopolymer concrete with Magnetized water

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Abstract:

It is expected that in upcoming days, the community of civil engineering have to produce structures with the concept of sustainable development by using high-performance materials and new concept with low environmental impact, which are produced at a reasonable cost. However, with development of population pollution level and impact of pollution on human life and human health are also increasing. Cement production is one of the main components of pollution by releasing CO2 emissions in to the atmosphere. It is nearly 7% of the world's carbon oxide emission. Geopolymer concrete is one of the green building material in order to create the more sustainable world using industrial waste by replacing cement but also it maintain it state, workability and properties. As the Magnetic water concrete, synthesized from the normal materials used for manufacturing of concrete which provides increasing extra strength and workability to concrete, provides one route towards this objective. Good thing is normal water can easily replace with magnetic water and this additional strength by usage of magnetized water can be used to reduce the usage using of geoploymer materials. Using of geoplolymer materials by which quantity of cement in any concrete mix reduces and we can made as new Eco-friendly material of construction for future. The present research work is carried out to investigate the effect of magnetic water on the Compressive Strength, Split Tensile Strength and Flexural Strength properties of geoploymer concrete..

Keywords :compressive strength, split tensile strength, flexural strength geopolymer concrete etc,.

1. Introduction

Concrete is made of Portland cement, water, cement substitutes and aggregates. Portland cement is hydraulic cement that hardens in water to form a water-resistant compound. The hydration products act as binder to hold the aggregates together to form concrete. The setting and hardening of concrete are the outcome of chemical and physical developments that take place between Portland cement and water called hydration. This hydration reaction is an exothermic reaction, which liberates large quantity of heat, and this is to be dissolute for continuing hydration process. Many types of concrete are available, distinguished by the proportions of the main ingredients. In this way or by substitution for the cementitious and aggregate phases, the finished product can be tailored to its application. Strength, density, as well as chemical and thermal resistance are variables. Aggregate consists of large chunks of material in a concrete mix, generally a coarse gravel or crushed rocks such as limestone, or granite, along with finer materials such as sand. Cement, most commonly Portland cement, is associated with the general term "concrete.

Advantages of concrete

 Ingredients of concrete are easily available in most of the places.

 Concrete was manufactured to desired strength with an economy.

 The durability of concrete is very high.

 It can be cast to any desired shape.

Magnetic water concrete

One of the furthermost new main technologies to improve concrete workability and compressive strength is with magnetized water instead of normal water within concrete mixes. This technology Changes the main effective characteristics of water components of concrete mix. Water effective properties controlled within flowrate velocity, magnetic field strength and exposure time. The homogenous and workable concrete that mixes with magnetic water gave further property of maintaining equipment from hardening process through transportation of fresh concrete. no additives needs.

Geo-polymer concrete

Cement is one of the key element used for the manufacture of concrete and has no alternative in the civil construction industry. Unfortunately, production of cement involves release of large amounts of carbon-dioxide gas into the air, a major contributor for green- house effect and the global warming, hence it is necessary either to search for alternative material or partly substitute it by some other materialWorld cement production has grown steadily since the 1950s, with increased production in Asia and China in particular, accounting for the bulk of growth from the 1990s. Global cement production reached an estimated 2,557 million tons in2006.

Necessity of work

For several years, the problem of strength, workability and durability major topic of interest. 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. One Solution to overcome this problem is to switch over ordinary concreting methods to Geoploymer concrete.

Objective of present work

The main objective of the present work is to study the workability and mechanical properties of geopolymer concrete by replacing cement by adding fly ash, GGBS, Silica Fume and magnetic treated water instead of normal water.

2.Literature review

Much researches in recent years has been devoted to establish the fundamental and engineering properties of high-strength concrete, as well as the engineering characteristics of structural members made with the material.

The study of Wang & Zhao's (2008) shows the improvement of cement dough characteristics that made with magnetic water. In addition, magnetic treatment had gave positive results in compressive strength and porosity of concrete rock.

Su & Wu (2000) show that the compressive strength and workability of concrete containing fly ash and prepared with magnetic water increases by (9-19)%, (10-23)% respectively more than that prepared with normal water also he was found that magnetic water had increasing the rheology, amount of slump and concretehydration.

Weilin et al (1992) had got increasing in cement dough durability when he had treated it magnetically; also, he had observed improvement in other properties of cement dough such as compressive strength 54%, tension strength 39%, adhesion of dough 20% and decreasing in initial and final setting time about 39%, 31% respectively.

Davidovits (1988c; 1988d) worked with kaolinite source material with alkalis (NaOH, KOH) to produce geopolymers. The technology for making the geopolmers has been disclosed in various patents issued on the applications of the so-called "SILIFACE-Process".

3.Study on magnetic water and geopolymer concrete

In this chapter study of Magnetic Water and Geopolymer concrete and the application of are discussed using following research articles are presented.

Magnetic water

Magnetic water treatment is a controversial method of supposedly reducing the effects of hard water by passing it through a magnetic field, as a non-chemical alternative to water softening. After water passes through a magnetic field of a certain strength, it is called magnetic field treated water (MFTW).

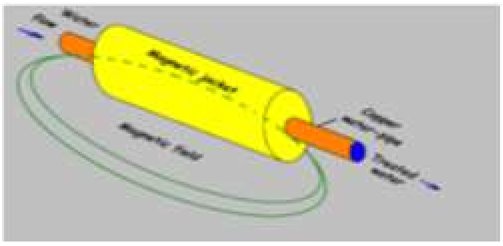


Figure 1: General arrangement of MWT apparatus

When fluid conductor (such as water) moving in one direction across a perpendicular magnetic field produces current around the same conductor, which creates a drift force perpendicular to the inductive magnetic field and also parallel to the direction of the fluid. This deflating electrical will occur positive pole through the fluid conductor.

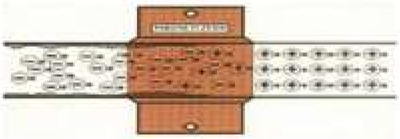


Figure 2: Effect of magnetic field on water polarization

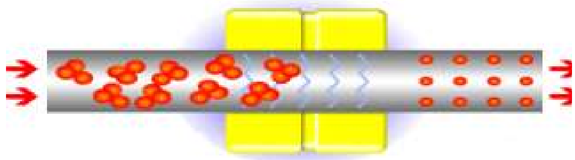


Figure 3: Difference between magnetized and normal water molecule

Magnetic field will decreasing the random contribute bonds especially in the molecule groups nuclides points, which form the precipitate layer. Thus, will making the minerals suspended in water without deposit. The molecule groups of magnetic water differ from molecule groups of ordinary water in having lower degree of consolidation, and the molecules volume is uniform.

Magnetic field effect on hydrogen bonds between water molecules and found some exchange, which happened in the properties of water such as light absorption, surface tension and pH.

Magnetic device

The type of magnet, which is used in many household appliances, automobiles, and industrial machines. This type of magnet can be used to produce a magnetic field and has the advantage control of the magnetic field strength by controlling the voltage of the electric current passed. 12 β = μo (N x I)/L

Where: β : magnetic field, measured in teslas. *μo* : magnetic constant (known as the permeability of vacuum has the exact value 4*π**10-7 N/A2, (Newton per ampere squared, or in henrys per meter) in SI units).

N : total number of rolls in the coil (nondimensional).

I : current in wire, measured in amperes.

L : length of the coil , measured in meter.

The strength of a magnet is given by its magnetic flux density, which is measured in unit of gauss, (1 gauss = 10-4 teslas = 100 microteslas (μT)), the strength of the magnet which is used in the present study was (1.2) Tesla, and in SI units of tesla, 1 T = 1 kg·s-2·A-1. An equivalent, but older, unit for 1 Tesla is Weber/m2. The magnetizer used in this study is made for domestic use.

Geopolymers

Geopolymers are new materials for fire- and heat-resistant coatings and adhesives, medicinal applications, high-temperature ceramics, new binders for fire-resistant fiber composites, toxic and radioactive waste encapsulation and new cements for concrete.

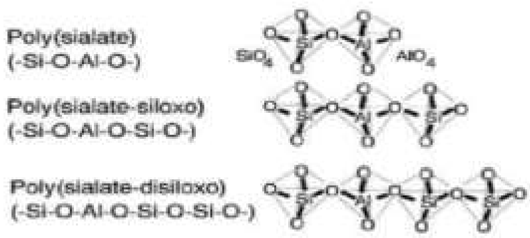
Terminology and Chemistry

'Davidovits' proposed in 1978 an alkaline liquid could be used to react with the silicon and aluminum in a source material of geological origin or in by-product materials such as fly ash and rice husk ash to produce binders. Because the chemical reaction that takes place, he coined the term 'Geopolymer' to represent these binders.

Geo-polymers are members of the family of inorganic polymers. The Polymerization process involves a chemical reaction under alkaline condition on Si-Al minerals that results in a 3-dimensional polymeric chain and ring structure. He also suggested the use of the term 'poly (sialate)' for the chemical designation of geopolymers based on silico-aluminate. Sialate is an abbreviation for silicon-oxo-aluminate. Poly(sialates) are chain and ring polymers with Si4+ and AL3+ in IV-fold coordination with oxygen and range from amorphous to semi-crystalline with the empirical formula:

$$M_n\,(-(SiO_2)_z\!-\!AlO_2)_n.\ wH_2O$$

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, namely the Poly(siala te) type (-Si-O-Al-O), the Poly(sialate-siloxo) type (-Si-O-Al-O-Si-O) and the Poly(sialate-disilo xo) type (-Si-O-Al-O-Si-O). The structure of these polysialates can be schematized.



Geopolymerization involves the chemical reaction of alumina-silicate oxides (Si2O5, Al2O2) with alkali polysilicates yielding polymeric Si – O – Al bonds. Polysilicates are generally sodium or potassium silicate supplied by chemical industry or manufactured fine silica powder as a by-product of ferro-silicon metallurgy.

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Source materials and alkaline liquids

There are two main constituents of geopolymers, namely the source materials and the alkaline liquids. The source materials for geopolymers based on alumino-silicate should be rich in silicon (Si) and aluminium (Al). These could be natural minerals such as kaolinite, clays, micas, andalousite, spinel, etc whose empirical formula contains Si, Al, and oxygen (O) (Davidovits, 1988c). Alternatively, by-product materials such as fly ash, silica fume, slag, ricehusk ash, red mud, etc could be used as source materials.

Types of Geopolymers

- Phosphate-based geopolymer
- Flyash based Geopolymers
- Silico-phosphate geopolymers
- Silicone
- Kerogen geopolymer

Fields of applications

According to Davidovits (1988b), geopolymeric materials have a wide range of applications in the field of industries such as in the automobile and aerospace, nonferrous foundries and metallurgy, civil engineering and plastic industries. The type of application of geopolymeric materials is determined by the chemical structure in terms of the atomic ratio Si:Al in the Polysilate.

Hydration of Cement

When cement and water are mixed, the hydration process begins and the concrete will gain strength and durability with time. Hydration process is driven by three elements water, temperature and the availability of unhydrated cement. In the hydration process, water is chemically combined with cement. When triple calcium silicates (Ca3SiO5) of cement comes in contact with water, it forms (Ca3SiO5OH3), Calcium Silicate Hydrate with the release of (Ca(OH)2) (Calcium hydroxide) from the surface of grains as the equation.

$$2Ca3SiO5 + 6H2O \rightarrow Ca3SiO5OH3 + 3\,Ca(OH)2 \quad \text{.......................} (1)$$

Rapid evolution of heat during this period (≈ 5 minutes). Then hydrolysis slows down (dormant period) and this stage is responsible for the plastic state of cement (2- 4 hours). Then (Ca3SiO5) again reacts. Nuclei forms and hydration products in equation begins to crystallize from solution (Acceleration period). (Ca(OH)2) crystallizes from solution & (Ca3SiO5OH3) develops at the surface of the (Ca3SiO5) grains ,developing a coating (4 -8 hours). Rate of reaction slows down as the coating of the (Ca3SiO5) hydrate layer flow through the barrier to reach the unhydrated (Ca3SiO5). Water reaches unhydrated (Ca3SiO5) through capillary action.

4.Materials and Methods

General

The physical and chemical properties of cement, fine aggregates, coarse aggregates, water, Mineral and Chemical Admixtures used in this investigation are analyzed based on standard experimental procedure laid down in standard codes like Indian standard code, ASTMC, and Bureau of Indian standard codes.

Materials

The materials used in present investigation include;

1. Cement-Ordinary Portland Cement (OPC)
2. Mineral Admixturesa. Fly-Ash b. GGBS c. Silica Fume
3. Fine aggregates
4. Coarse aggregates
5. Normal Water
6. Magnetic Field Treated Water
7. Alkaline Solution
8. Super Plasticizer

Cement

Ordinary Portland cement of 53 grades was selected for the experimental investigation. The compressive strength characteristics of cement were tested as per IS: 4031-1999 and IS: 12269-2013(9).The cement used in present study was bharati cement. The experiments such as standard consistency, initial setting time, final setting time and specific gravity of cement are conducted on ordinary Portland cement.

Figure 4: Cement Used for Concrete Mix

TABLE 1: physical properties of cement

S. No	Characteristic of cement	Value	Requirement as per IS : 12269 – 1987
1	Fineness of cement	3%	Less than 10%
2	Normal consistency	33%	--
3	Initial setting Time	40 minutes	>30
4	Final setting time	350 minutes	<600
5	Specific gravity	3.15	--
6	Compressive Strength	52.6	53 Mpa

Fly ash

For this project, Flyash taken from Thermal Power Station (VTPS), Vijayawada. NTPC has installed ESP for segregation and collection of fly ash into six different fields. As the field number increases the fineness of fly ash increases but the quantity

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decreases. Field-1 fly ash has coarse particles and is not suitable for concrete applications.

Figure 5: FlyAsh Used for Concrete Mix

GGBS (ground granulated blast furnace slag)

GGBS is obtained by quenching molten iron blast furnace slag in water or stream, to produce a glassy granular product that is then dried and ground into fine powder.

Figure 6: GGBS Used for Concrete Mix

Silica fume

Silica fume is a waste by-product of the production of silicon and silicon alloys. It is available in different forms, of which the most commonly used is in a dandified form. Silica fume used was conforming to IS: 1331(PART-1) 1992 and also ASTM C (1240-2000)..

o Low heat of hydration,

o Retarded alkali-aggregate reaction,

o Reduced freeze-thaw damage and water erosion,

o High strength,

Figure 7: Silica Fume Used in Concrete Mix

Fine aggregate

Sand is a naturally occurring material from Rock and Minerals by weathering and is composed of majorly sio2, and Calcium carbonate. The sand used throughout the experimental work was obtained from the Godavari River i.e. locally available. According to **IS 650:1966**, the sand used in cement concrete should confirm to the following specifications. Sand shall be of quartz, light gray or whitish variety. It shall be free from silt. The grains shall be angular.

Figure 8: Fine Aggregates

Coarse aggregate

Coarse aggregates used in this experiment was of two sizes 20mm and 12mm.The crushed aggregates was obtained from the local crushing plants. The physical properties of the coarse aggregate such as gradation, fitness modulus, specific gravity and bulk density are tested in accordance with IS:2386 – 1963 .

Figure 9: Coarse Aggregates

Water

Water used for drinking can also be used for mixing concrete. Impurities in the water may affect concrete, its setting time, and its Compressive strength and Split tensile strength. Water has two functions in a concrete mix. Firstly, it reacts chemically with the cement to form a cement paste in which the inert aggregates are held in suspension until the cement paste has hardened.The characteristics of water, to which various chemical and biological substances were spiked, are presented in the table below, were analysed according to the standard methods for the examination of water (APHA 1994) .

Magnetic water

This study aims to investigate the effect of using magnetized water on concrete properties. Therefore, prior to the proportion of each mix, water is prepared for that specific concrete mix. The water was simply treated by passing it through magnetic field (magnetizer). MW was prepared by passing it through magnetic field of 1.2 (Tesla), using an immerseable pump to circulate the water through the magnetic field .

Figure 10: Magnetic Field Treated Water

Table 2: characteristics of both normal and magnetized water

S.No	Tests Performed	Normal	Magnetized Water
1	pH	7.2	7.9
2	Turbidity	7	7
3	Alkalinity	20	20
4	Chlorides	28	28
5	Hardness	112	84

Alkaline solution

The most common alkaline liquid used in geopolymerisation is a combination of

1. Sodium Hydroxide (NaOH) and
2. Sodium Silicate (Na2Sio3,)

Super plasticizer

Admixtures are those ingredients in concrete other than Portland cement, water, and aggregates that are added to the mixture immediately before or during mixing. Concrete should be workable, finish able, strong, durable, watertight, and wear resistant. These qualities can often be obtained easily and economically by the selection of suitable materials rather than by resorting to admixtures.

Mix design for concrete

The material quantities obtained as per mix design method, (i.e., IS:10262-2009) arrived in trial mix are given in Tables as per mix proportion . The quantities of materials required per one cubic meter of concrete. The detailed mix design procedure of M 30 grade of concrete is given in Appendix.

TABLE 3: Concrete proportion quantities per 1m3 in kg's

Cement	Water	C.A :20mm	C.A :12.5 mm	F.A : Sand	Admixture
350	147	619	615	712	7
1.00	0.42	1.77	1.76	2.03	0.02

Mix design for geopolymer concrete

Since there is no codal recommendation for the design of GPC, the mix design was done by trial and error method. Mix proportion corresponding to a compressive strength of 30MPa was adopted from the trial mixes. Alkaline solution comprises a mixture 35% by mass of Binder content with sodium silicate solution to sodium hydroxide solution in the ratio of 2.5: 1, Sodium silicate solution with SiO_2 to Na_2O ratio of 2 (Na_2O=14.7%, SiO_2=29.4% and water=55.9%) by mass was used. Superplasticizers was also used to obtain workability for GPC.

Preparation of concrete

Production of quality concrete requires meticulous care exercised at every stage of manufacture of concrete. It is interesting no that the ingredients of good concrete and bad concrete are the same. The various stages of manufacture of concrete are:

a) Batching
b) Mixing
c) Placing
d) Compaction
e) Curing

5.Experimental procedure

The main objective of the present experimental investigations is to obtain specific experimental data, which helps to understand the Magnetic water concrete and its strength characteristics.

slump cone test

Slump cone test apparatus was made according to IS: 7320-1974 and used for calculating normal consistency of concrete Fresh concrete was filled in slump cone by tamping each layer for 25 times with a tamping rod. Later metal cone is raised slowly in a vertical direction. As soon as the settlement of concrete slump of the concrete measured by scale.

Fig4.3: Slump Cone Test

Above figure shows a Slump Factor of Fresh Concrete

compaction factor test

Place the concrete sample gently in the upper hopper to its brim using the hand scoop and level it. Cover the cylinder and Open the trapdoor at the bottom of the upper hopper so that concrete falls in to the lower hopper .Push the concrete sticking on its sides gently with the road. Open the trap door of the lower hopper and allow the concrete to fall in to the cylinder below.

Compaction Factor= (W1-W2 / W2-W)

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The different types of tests conducted on concrete are

- Compressive strength test
- Split tensile strength test
- Flexural strength test

Compressive strength test

Cubes with dimensions of 150mm×150mmx150mm Compressive Strength Testing Machine is used for the determination of compressive strength for cubes and cylinders. The specimens after subjected to curing drying for 1 day are loaded in compressive strength testing machine. It is able to provide compressive load up to 2000kN.

Fig4.5: Cube compressive strength test

Split tensile strength test

The test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of a compression testing machine and the load is applied until failure of the cylinder along the vertical diameter. When the load is applied along the generator an element on the vertical diameter of the cylinder is subjected to a vertical compressive stress

Split Tensile Strength = LOAD / AREA = 2P/ πDL

Where

P is the compressive load on the cylinder

L is the length of the cylinder

D is its diameter

Fig4.6: Split tensile test of cylinder

Flexural strength test

The ultimate flexural strength analysis presented in this paper is based on the based conventional compatibility and equilibrium conditions used for normal reinforced concrete except that the contribution of the fibers in the tension is recognized.

1. Plane sections remain plane after bending
2. The compressive forces equal the tensile forces.

$Fb = pl/bd^2$

When 'a' is greater than 20 cm for 15 cm specimen are greater than 13.3cm for a 1 m specimen or

$Fb = 3pa/bd^2$

When it is less than 20cm but greater then 17cm for 15cm specimens, are less than 13.3cm but greater than 11.0cm for a 10.0 cm specimen.

Where,

B = measure width in cm of the specimen

d = measure depth in cm of the specimen at thepoint failure

d = length in cm of the span on which the specimen was supported

p = maximum load in kg applied to the specimen

Fig4.7: Flexural strength test on beam. The above figure shows a universal testing machine

6 Results and discussion

Tests are conducted for M30 Grade Cement Concrete and geopolymer concrete made of replacement of cement with Fly Ash, GGBS, Silica Fume. The results of present investigation are presented both in tabulated and graphical forms. In order to facilitate the analysis, interpretation of results is carried out at each phase of experimental study.

compressive strength results

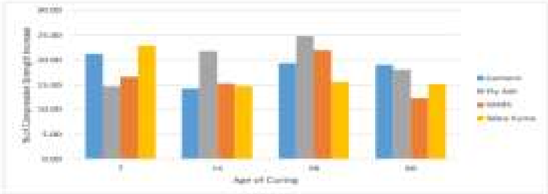
Concrete Cubes are casted for mix design M30 With cement and replacement of cement with FlyAsh, GGBS, Silica Fume. The compressive strength is tested for 7, 14, 28, 60 days age of curing, and obtained results are tabulated in the form of Table and Graph.

TABLE: 4 comparing percentage of Compressive strength increases using magnetic water with Cement, FlayAsh, GGBS, Silica Fume.

TABLE 19: AVERAGE INCREASING OF COMPRESSIVE STRENGTH (%)

S.no	Mix Type	% of Increase in Days			
		7	14	28	60
1	NWC	21.24	14.28	19.32	19.01
2	MWC				
3	NWFC	14.70	21.80	24.86	18.08
4	MWFC				
5	NWGC	16.66	15.29	21.99	12.29
6	MWGC				
7	NWSC	22.92	14.73	15.63	15.19
8	MWSC				

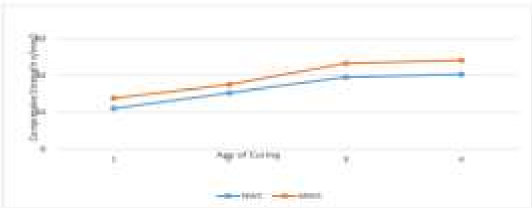
The results show that the concrete prepared with MW has a compressive strength higher than that of the mix with normal water, although the same mix proportions were used for all mixes



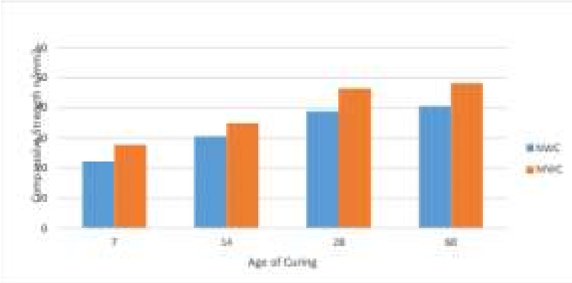
GRAPH 1: for comparing percentage of Compressive strength increases using magnetic water with Cement, FlayAsh, GGBS, Silica Fume

Table 5: Compressive Strength of Control Mix M30 with Normal Water(NWC) and Magnetized Water(MWC) in N/mm2

S.no	Days	NWC(N/mm²)	MWC(N/mm²)	% Increase
1	7	22.18	26.89	21.24
2	14	30.61	34.98	14.28
3	28	38.97	46.5	19.32
4	60	40.51	48.21	19.01



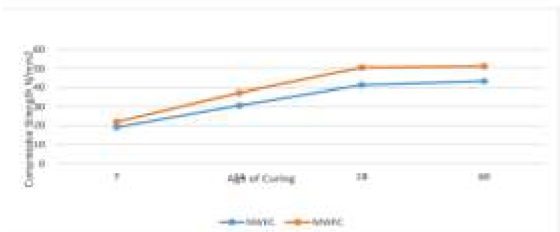
GRAPH 2:for Compressive Strength of Control Mix M30 with Normal Water(NWC) and Magnetized Water(MWC) in N/mm2



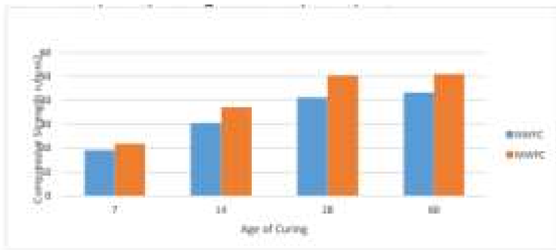
GRAPH 3: for comparing Compressive strength of Control Mix M30 with Normal Water(NWC) and Magnetized Water(MWC) in N/mm2

Table 6: Compressive Strength of Fly Ash based Geopolymer Concrete M30 with Normal Water (NWFC) and Magnetized Water(MWFC) in N/mm2

S.no	Days	NWFC(N/mm²)	MWFC(N/mm²)	% Increase
1	7	19.12	21.93	14.70
2	14	30.6	37.27	21.80
3	28	41.23	51.48	24.86
4	60	43.25	51.07	18.08



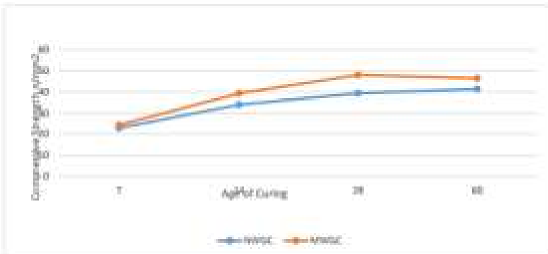
GRAPH 4: for Compressive Strength of Fly Ash based Geopolymer Concrete M30 with Normal Water(NWFC) and Magnetized Water(MWFC) in N/mm2



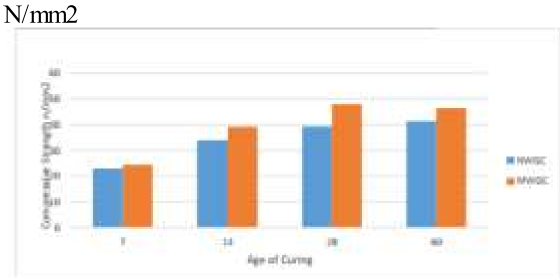
GRAPH 5: for comparing Compressive strength of Fly Ash based Geopolymer Concrete with Normal Water(NWFC) and Magnetized Water(MWFC) in N/mm2

Table 7: Compressive Strength of GGBS based Geopolymer Concrete M30 with Normal Water(NWGC) and Magnetized Water(MWGC) in N/mm2

S.no	Days	NWGC(N/mm²)	MWGC(N/mm²)	% Increase
1	7	20.95	24.44	16.66
2	14	34.08	39.29	15.29
3	28	39.39	48.05	21.99
4	60	41.35	46.43	12.29



GRAPH 6: for Compressive Strength of GGBS based Geopolymer Concrete M30 with Normal Water (NWGC) and Magnetized Water(MWGC) in N/mm2



GRAPH 7: for comparing Compressive strength of GGBS based Geopoly mer Concrete M30 with Normal Water (NWGC) and Magnetized Water (MWGC) in N/mm2

Table 8: Compressive Strength of Silica Fume based Geopolymer Concrete M30 with Normal Water (NWSC) and Magnetized Water (MWSC) in N/mm2

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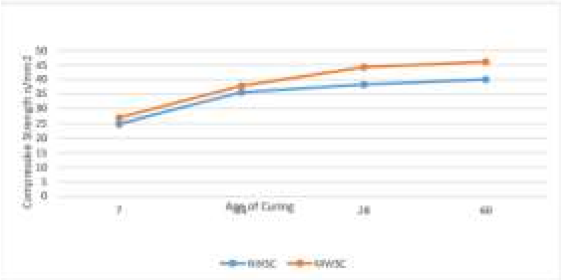
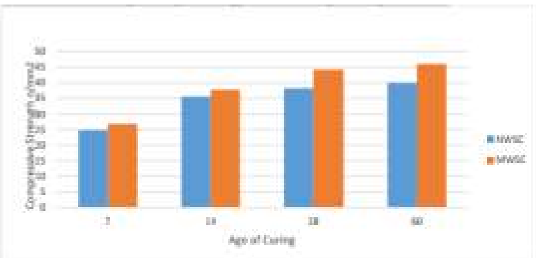
S.no	Days	NWSC(N/mm²)	MWSC(N/mm²)	% Increase
1	7	21.86	26.87	22.92
2	14	35.57	40.81	14.73
3	28	38.25	44.23	15.63
4	60	39.97	46.04	15.19



GRAPH 8: for Compressive Strength of Silica Fume based Geopolymer Concrete M30 with Normal Water (NWSC) and Magnetized Water(MWSC) in N/mm2



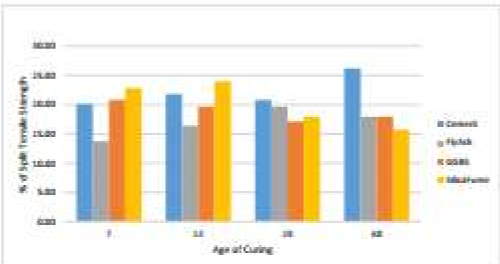
GRAPH 9: for comparing Compressive strength of Silica Fume based Geopolymer Concrete M30 with Normal Water (NWSC) and Magnetized Water(MWSC) in N/mm2

split tensile strength

The Split Tensile strength is tested for 7 days to 60 days age of curing and obtained results are tabulated in the form of Table and Graph show an increase of 14 to 26 % in the splitting tensile strength of all the concrete samples.

Table 9: Comparing percentage of Split Tensile strength increases using magnetic water with Cement, FlayAsh, GGBS, SilicaFume

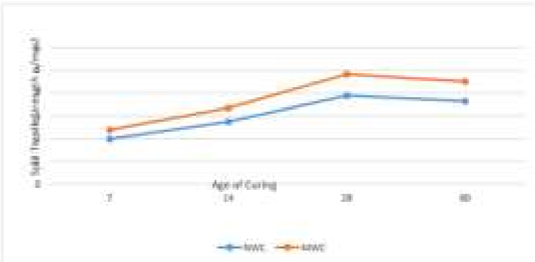
Average increase of Split Tensile Strength (%)					
S.no	Mix Type	% of Increase in Days			
		7	14	28	60
1	NWC	20.10	21.82	21.50	26.20
2	MWC				
3	NWFC	13.76	16.42	19.65	17.97
4	MWFC				
5	NWGC	20.82	19.65	17.12	17.97
6	MWGC				
7	NWSC	22.87	23.99	17.97	15.76
8	MWSC				



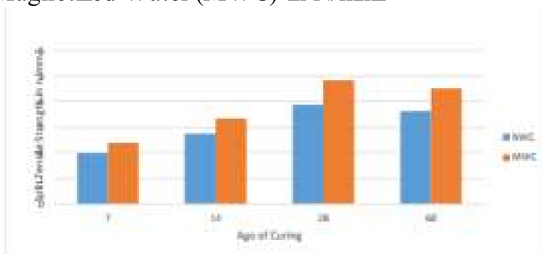
GRAPH 10: Graph for comparing percentage of Split Tensile strength increases using magnetic water with Cement, FlayAsh, GGBS, Silica Fume

Table 10: Split Tensile Strength of Control Mix M30 with Normal Water (NWC) and Magnetized Water (MWC) in N/mm2

S.no	Days	NWC(N/mm²)	MWC(N/mm²)	% of Increase
1	7	1.99	2.39	20.10
2	14	2.75	3.35	21.82
3	28	3.89	4.83	24.16
4	60	3.64	4.51	23.90



GRAPH 11: for Split Tensile Strength of Control Mix M30 with Normal Water (NWC) and Magnetized Water (MWC) in N/mm2

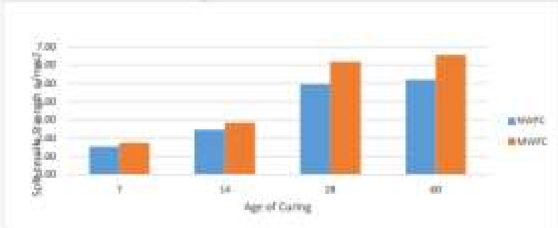


GRAPH 12: for comparing Split Tensile strength of Control Mix M30 with Normal Water(NWC) and Magnetized Water(MWC) in N/mm2

Table 11: Split Tensile Strength of FlyAsh based Geopolymer Concrete M30 with Normal Water (NWFC) and Magnetized Water (MWFC) in N/mm2

S.no	Days	NWFC(N/mm²)	MWFC(N/mm²)	% of Increase
1	7	1.53	1.74	13.76
2	14	2.45	2.85	16.42
3	28	4.95	6.18	24.91
4	60	5.19	6.55	26.20

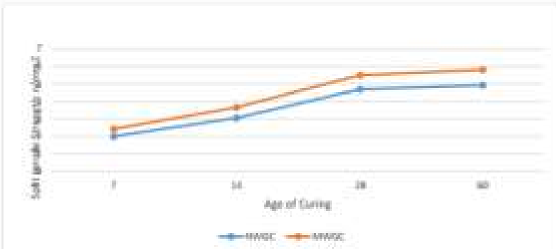
GRAPH 13: for Split Tensile Strength of FlyAsh based Geopolymer Concrete M30 with Normal Water(NWFC) and Magnetized Water(MWFC) in N/mm2



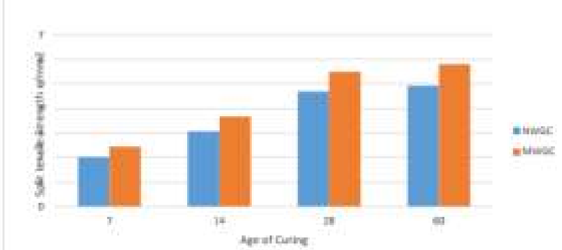
GRAPH 14: for comparing Split Tensile strength of FlyAsh based Geopolymer Concrete M30 with Normal Water(NWFC) and Magnetized Water(MWFC) in N/mm2

Table 12: Split Tensile Strength of GGBS based Geopolymer Concrete M30 with Normal Water (NWGC) and Magnetized Water (MWGC) in N/mm2

S.no	Days	NWGC(N/mm²)	MWGC(N/mm²)	% of Increase
1	7	1.84	2.24	21.50
2	14	3.07	3.67	19.65
3	28	4.69	5.49	17.12
4	60	4.92	5.8	17.97



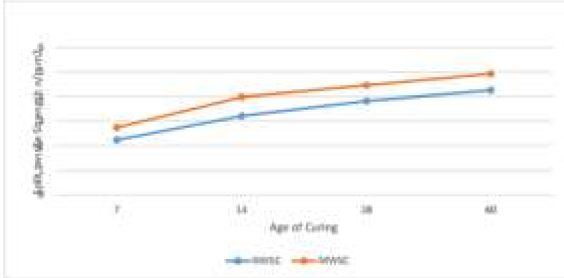
GRAPH 15: for Split Tensile Strength of GGBS based Geopolymer Concrete M30 with Normal Water (NWGC) and Magnetized Water (MWGC) in N/mm2



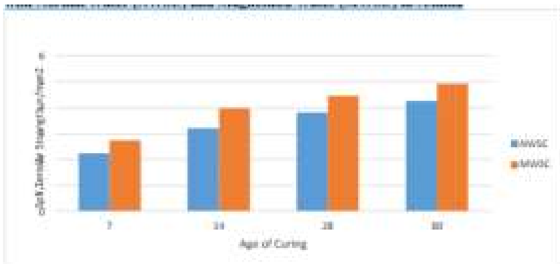
GRAPH 16: For comparing Split Tensile, strength of GGBS based Geopolymer Concrete M30 with Normal Water (NWGC) and Magnetized Water (MWGC) in N/mm2

Table 13: Split Tensile Strength of SilcaFume bsed Geopolymer Concrete M30 with Normal Water (NWSC) and Magnetized Water (MWSC) in N/mm2

S.no	Days	NWSC(N/mm²)	MWSC(N/mm²)	% of Increase
1	7	2.23	2.74	22.87
2	14	3.21	3.98	23.99
3	28	3.82	4.45	16.49
4	60	4.25	4.92	15.76



GRAPH 17: For Split Tensile Strength of SilcaFume based Geopolymer Concrete M30 with Normal Water (NWSC) and Magnetized Water (MWSC) in N/mm2



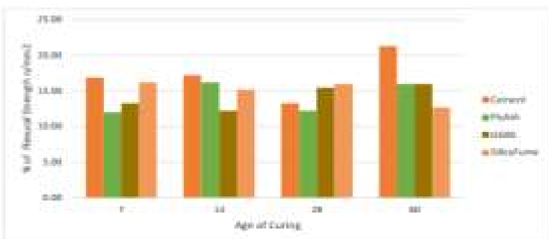
GRAPH 18: For comparing Split Tensile strength of SilcaFume based Geopolymer Concrete M30 with Normal Water (NWSC) and Magnetized Water(MWSC) in N/mm2

Flexural strength

Concrete Cubes are casted for mix design M30 With cement and replacement of cement with FlyAsh, GGBS, Silica Fume. The compressive strength is tested fot 7 days to 60 days age of curing and obtained results are tabulated in the form of Table and Graph, Concrete prepared with MW enhance the quality of concrete. The introduction of MW to concrete was found to increase its ability to resist flexural strength (12 to 21 %).

Table 14 Comparing percentage of Flexural Strength increases using magnetic water with Cement, FlyAsh, GGBS, Silica Fume.

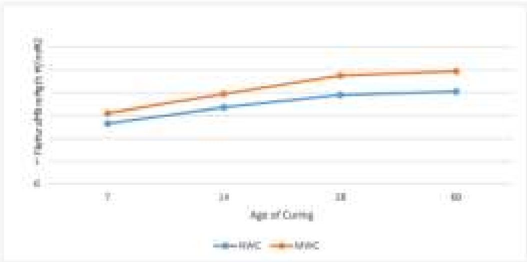
S.no	Mix Type	% of Increase in Days			
		7	14	28	60
1	NWC				
2	MWC	16.91	17.23	13.26	21.26
3	NWFC				
4	MWFC	12.00	16.23	12.20	16.00
5	NWGC				
6	MWGC	13.26	12.20	15.49	16.00
7	NWSC				
8	MWSC	16.22	15.21	16.00	12.68



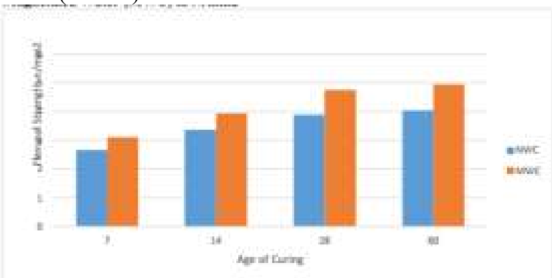
GRAPH 19: For comparing percentage of Flexural strength increases using magnetic water with Cement, FlyAsh, GGBS and Silica Fume

Table 15: Flexural Strength of Control Mix M30 with Normal Water (NWC) and Magnetized Water (MWC) in N/mm2

S.no	Days	NWC(N/mm²)	MWC(N/mm²)	% of Increase
1	7	2.66	3.11	16.91
2	14	3.37	3.95	17.23
3	28	3.90	4.75	21.95
4	60	4.05	4.94	22.04



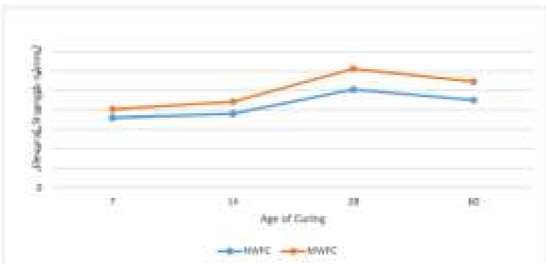
GRAPH 20: For Flexural Strength of Control Mix M30 with Normal Water (NWC) and Magnetized Water (MWC) in N/mm2



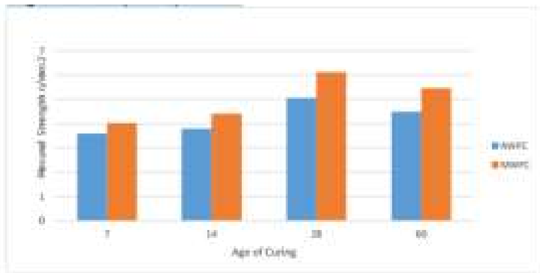
GRAPH 21: For Flexural strength of Control Mix M30 with Normal Water (NWC) and Magnetized Water (MWC) in N/mm2

Table 16: Flexural Strength of Control Mix M30 with Normal Water (NWFC) and Magnetized Water (MWFC) in N/mm2

S.no	Days	NWFC(N/mm²)	MWFC(N/mm²)	% of Increase
1	7	3.60	4.03	12.00
2	14	3.80	4.42	16.23
3	28	5.05	6.12	21.23
4	60	4.50	5.46	21.26



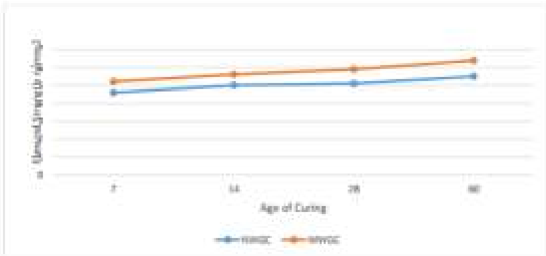
GRAPH 22: Flexural Strength of Control Mix M30 with Normal Water (NWFC) and Magnetized Water (MWFC) in N/mm2



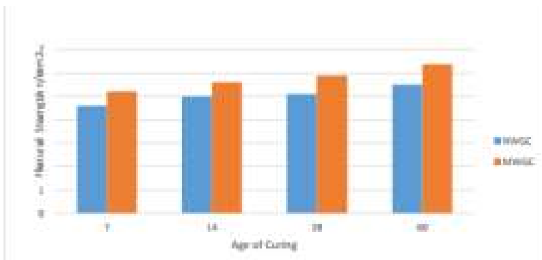
GRAPH 23: Flexural strength of Control Mix M30 with Normal Water (NWFC) and Magnetized Water (MWFC) in N/mm2

Table 17: Flexural Strength of Control Mix M30 with Normal Water (NWGC) and Magnetized Water (MWGC) in N/mm2

S.no	Days	NWGC(N/mm²)	MWGC(N/mm²)	% of Increase
1	7	4.60	5.21	13.26
2	14	5.00	5.61	12.20
3	28	5.10	5.89	15.49
4	60	5.50	6.38	16.00



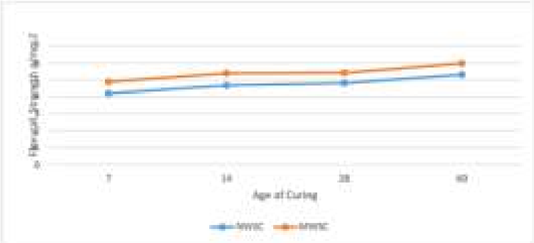
GRAPH 24: Flexural Strength of Control Mix M30 with Normal Water (NWGC) and Magnetized Water (MWGC) in N/mm2



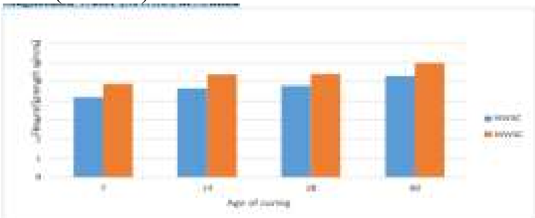
GRAPH 25: For Flexural strength of Control Mix M30 with Normal Water(NWGC) and Magnetized Water(MWGC) in N/mm2

Table 18: Flexural Strength of Control Mix M30 with Normal Water (NWSC) and Magnetized Water (MWSC) in N/mm2

S.no	Days	NWSC(N/mm²)	MWSC(N/mm²)	% of Increase
1	7	4.20	4.88	16.22
2	14	4.67	5.38	15.21
3	28	4.80	5.41	12.71
4	60	5.30	5.97	12.68



GRAPH 26: For Flexural Strength of Control Mix M30 with Normal Water (NWSC) and Magnetized Water (MWSC) in N/mm2



GRAPH 27: For comparing Flexural strength of Control Mix M30 with Normal Water(NWSC) and Magnetized Water(MWSC) in N/mm2

7Conclusion and future scope

Introduction

The need to study the role of supplementary Cementing materials like Fly Ash, GGBS, Silica Fume in concrete has been justified. Geopolymer concrete has excellent compressive strength when using magnetized water and is suitable for structural applications. The salient factors that influence the properties of the fresh concrete and the hardened concrete have been identified.

conclusion

Concrete mixes were prepared with using both Normal Water and Magnetized Water.

The following conclusions were found:

- The optimum replacement level of cement by fly ash, ggbs and silica in GPC carried out.
- The use of Magnetized Water increased the workability of concrete that eventually led
- to enhanced quality of concrete without adding water.
- The density of Concrete also increases 2% to 6% with magnetized water due to mineral admixtures.
- Geopolymer concrete is more environmental friendly and has the potential to replace ordinary cement concrete in many applications such as precast units.
- Geopolymer technology does not only contribute to the reduction of greenhouse gas emissions but also reduces disposal costs of industrial waste.
- Geopolymer concrete can be obtained in such a way, by adding and replacing of mineral admixtures and chemical admixtures, so that its compressive strength, split tensile strength and flexural strength are higher than those of normal mix .
- Chemical admixtures increases the bonding by developing smaller interface micro cracks and leads to better bonding between materials used and to an increase the Compressive strength, Tensile strength and Flexural Strength.
- Using magnetized water mechanical properties of concrete is increases its lead to reduce the consumption of materials used.
- The Compressive Strength of concrete cubes prepared with Magnetized water increased by 12% to 25 %.
- The Compressive Strength of cement concrete prepared with Magnetized water at 7,14,28,60 days were increases by 21%, 14%, 19% and 19 %.
- The Tensile Strength of GGBS based Geopolymer concrete prepared with Magnetized water at 7,14,28,60 days were increases by 22%, 20%, 17% and
- The Flexural Strength of Silica Fume based Geopolymer concrete prepared withMagnetized at 7,14,28,60 days were increases by 16%, 15%, 16% and 13 %.

Referred standards

IS 383-1970 Specification for coarse and fine aggregates from natural sources for concrete (second revision).

1. IS : 456-2000 Code of practice for plain and reinforced concrete (fourth revision).
2. IS : 516 1959 Method of test for strength of concrete (Reaffirmed 1999).
3. IS : 650-1991 Specification for standard sand for testing of cement (second revision).
4. IS : 3085- 1965 Method of test for permeability of cement mortar and concrete.

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Reffered books

1. "Properties of Concrete", by Neville. A. M – Pearson Education Asia Pte. Ltd,
2. Fourth Edition, First Indian reprint 2000.
3. "Concrete – Microstructure, Properties and Materials", by P.K. Mehta and Paulo
4. J.M Monteiro, Tata McGraw Hill Education Private Limited, Fourth reprint 2011.
5. "Design of Concrete Mixes", 4e, by N. Krishna Raju, CBS Publishers & Distributors, Delhi, 2010
6. Shetty M S, "Concrete technology (Theory and Practices)", 5thEdition, 2002, published by S. Chand and Company Ltd. Ram Nagar, New Delhi – 110055.
7. Advanced Concrete Technology, John Newman and Ban Seng Choo, Butterworth Heinemann Publications (Elsevier), UK, 2013