JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

COMPARITIVE STUDY ON MECHANICAL PROPERTIES OF GGBS BASED GEOPOLYMER CONCRETE AND CONVENTIONAL CONCRETE

1 Deepa Pundir, [2]Mr. Mahendra Kumar Singar, [3]Dr. Ravi Kant Pareek
[1]M. Tech scholar, [2]Assistant Professor, [3]Associate Professor, Department of Civil engineering, Vivekananda Global University, Jaipur

ABSTRACT

Paver blocks are often used in alternative functions, such as those in the street as well as other areas of building. This work is mainly focused on the use of GGBS in Geo-polymer concrete (GPC) and using it as a paver block and compare its performance with conventional concrete of grade M30. In this study, compressive tests were performed on the cube specimens at the ages of 7,14 or 28 days. It was observed that the strength of geopolymer concrete is more than strength of conventional concrete at the age of 7 days because of the very fine pozzolana material present in the GGBS which enhance the binding property of the concrete. But the strength of the geopolymer concrete at the age of 28 days is slightly less than that of conventional concrete as in GPC there is polymerization process in which water comes out or reduces the strength of GPC. In conventional concrete strength gain is much at the age of 28 days because hydration of the concrete is completed significantly, or 99% strength of conventional concrete is achieved. Finally, it is found that Geopolymer concrete is a promising construction material due to its low carbon dioxide emission and higher early strength or fire resistance (due to their low levels of chemically bound water) make in better in usage than conventional concrete. As the density of Geopolymer concrete is less than conventional concrete makes the structural weight lesser because the water absorption capacity or porosity of Geopolymer concrete is lower than conventional concrete.

Keywords*: *Paver block, Geo-polymer concrete, GGBS, Conventional concrete, Strength.

1 INTRODUCTION

Geopolymer concrete has emerged as a possible another to Portland cement concrete. The word Geopolymer was initially presented by Davidov in an (1978). These binders can be formed by reaction of alkaline solutions with silicon or aluminium in foundation of ingredients of ecological origin and through manufactured materials such by means of, metakaolin, Blast furnace slag, red mud. It has been found that the ancient building like the Egyptian pyramids and the Romen Coliseum were built from the concrete which resembles the Geopolymer concrete of today. In recent years there has been a dramatic improvement in understanding the reaction mechanism and property development of Geopolymer concrete and it can be used in many construction applications.

Concrete, the mostly utilized construction material in the world has selected up its popularity because of its different advantages like generally minimum cost of production, simplicity of taking care of, ability to be formed into wanted shape, achievement of wanted quality extending from low to extremely high, functionality and durability. The key ingredient of concrete will be cement, for the most part Portland Cement (OPC) which acts as binder and holds total aggregates intact. But sadly, OPC is seen as related with some unfavourable consequences for environment condition. The manufacture of OPC is highly intensive energy or discharges high amount CO_2 into air which contributes fundamentally to the 'Green House' effect. The manufacturer, one ton of cement consumes almost around 1.5 huge amounts earth minerals and furthermore one ton of CO_2 is discharged into environment. The raw ingredients necessary for cement production are non-renewable or are reducing at a fast speed. And yet, various industrial or Argo wastes with inborn cementitious things are production in large quantities. But they are typically put into landfills. Using such by products as interchanges for cement takes different advantages with preservation environment, sustainability of properties or solving a removal issue of by-products. Especially in India, with the consistently developing interest for concrete to provide the quick production developments and foundation extends, the effect made by OPC on the environment is considerable. Consequently, there is a quick need to control the utilization of OPC by production possible alternates for it. In that background, broad investigations are being done the world over in investigating the possible outcomes of utilizing substitute materials for OPC Concrete. One such option is 'geopolymer cement' (GPC) which eliminates OPC in its production.

1.1 Objective of Paper

1. To use by-products by replacing cement to increase sustainability.
2. To control the utilization of OPC by production.
3. To provide the quick production developments and foundation extend.
4. To provide the different advantages with preservation environment, sustainability of properties or solving a removal issue of by-products.
5. To examine the properties of Geopolymer based paver hinders for person on foot applications.
6. To examine the Mechanical properties of Geopolymer and Conventional concrete based paver blocks.

II MATERIALS AND METHODS

2.1 MATERIALS

1. **Granulated Blast furnace slag:** Blast furnace slag is non-metallic coproduct formed in manner. That one contains mainly silicate, alumina silicates, or calcium-alumina-silicates. A melted slag, which engages greatly sulphur as of charge, includes around 20 percent in mass of iron construction.

Fig.-1 Granulated Blast furnace Slag

Table-1 Chemical composition of Granulated Furnace Slag

NAME OF CHEMICAL	SYMBOL	% BY WEIGHT
CALCIUM OXIDE	CaO	34-43
SILICA	SiO_2	27-38
ALUMINA	Al_2O_3	7-15
FERRIC OXIDE	Fe_2O_3	0.2-1.6
MANGANESE OXIDE	MnO	0.15-0.76
SULPHUR TRIOXIDE	SO_3	Up to 0.07
POTASSIUM OXIDE	K_2O	0.08-1.83
SODIUM OXIDE	Na_2O	0.20-0.48
LOSS ON IGNITION	-	0.20-0.85

Table-2 Physical Properties of Blast Furnace Slag

COLOUR	OFF WHITE
SPECIFIC GRAVITY	2.9
BULK DENSITY	1000 - 1100 KG/M3 (LOOSE) 1200 - 1300 KG/M3 (VIBRATED)
FINENESS	>350 M2 /KG

2. ALKALINE SOLUTIONS:

Now the present research, sodium created alkaline solutions stands used. Activators also NaOH or sodium silicate only not far in effect as obviously seen as of past research. Thus, mixture of sodium hydroxide or

Concrete made by GGBS using recycled sodium silicate solutions. It has been shown that enhanced knowledge of sodium hydroxide or sodium silicate solutions in combination with a new mix that has a higher viscosity causes geo. concrete's compressive strength to improve. The concrete becomes more breakable and has enhanced compression strength as the molarity (M) of the sodium hydroxide solution grows. Then either the research is highly caustic or the rate of sodium hydroxide solid is large. Additional water is needed in order to obtain the desired level of workability, which ultimately lowers sodium hydroxide solution concentration. The mass-based sodium silicate-to-sodium hydroxide ratio was kept at 1, which either caused cubes to set within 24 hours of casting or produced results for compression strength that are suitably respectable.

Fig-2 Sodium - Hydroxide (NaOH) Pellets

Table-3 Chemical properties of Sodium Hydroxide (NaOH)

MOLAR MASS	40g/mol
CHEMICAL FORMULA	NaOH
APPEARANCE	White solids in form of Pellets
DENSITY	2.12gr/cc
MELTING TEMPERATURE	318^0 C
BOILING TEMPERATURE	1390^0 C
STORAGE	Air fitted container
AMOUNT OF HEAT PRODUCED	266cal/gr

Table-4 Chemical properties of Sodium Silicate (Na_2Sio_3)

MOLECULAR MASS	122.6g/mol
CHEMICAL FORMULA	$Na_2O_xSiO_2$
SODIUM OXIDE	14.65%
SILICON DIOXIDE	29.48%
WATER	55.97%
APPEARANCE	Liquid (Gel)
BOILING POINT	1020 C
SPECIFIC GRAVITY	1.66

3. **WATER:**

Thus, the lowest amount of water essential succeed preferred workability is certain on origin degree of workability, fineness GGBS or classifying of fine aggregate. When the chemical reaction first started, it was discovered that water emerged from the mixture during the polymerization process.

4. **ALCCOFINE:**

It is 1 type super - pozzolanic goods, helps in decreasing the perviousness of concrete or creates solid filling in concrete; thus, decreases the water contented or ultimately rises the strength of compression in concrete. Alccofine is a mineral admixture which is highly reactive, consists of high glass content as slag and is obtained through the process of controlled granulation having a specific surface area of more than 12000 cm^2 /gm.

Fig.3 Alccofine

Table-5 Chemical and Physical properties of Alccofine

Fineness (cm^2/gm	**Specific Gravity**	**Bulk Density (Kg/m^3)**	**Particle Size Distribution**		
			D10	D50	D90
>12000	2.9	700-900	1.5 micron	5 microns	9 microns
CHEMICAL PROPERTIES					
CaO	SO_3	SiO_2	Al_2O_3	Fe_2O_3	MgO
61-64 %	2-2.4 %	21-23 %	5-5.6 %	3.8-4.4 %	0.8-1.4 %

5. AGGREGATES:

In order to reduce water use, a fine aggregate would have round, level particles. It is suggested that classifying should be on the coarser side of the parameters, with a fineness modulus of 3.0 or higher recommended, to lessen the requirement for water and enhance the workability of these paste-rich combinations. Coarse aggregate units must be hardy for concrete.

Table-6 The Properties of Fine -Aggregate

S.No.	**CHARACTERISTICS**	**VALUES**
1.	SP. GRAVITY	2.65
2.	WATER ABSO.	0.8%
3.	SIEVE ANALYSIS	II Zone

Table-7 Physical properties of Aggregates

CHARACTERISTICS	**VALUES**	
COLOUR	BLACKISH GREY	
SHAPE	THIN ANGULAR	
SIZE	20 mm	10 mm
SPEC. GRAVITY	2.648	2.165
WATER ABSO.	4.3%	4.5 %

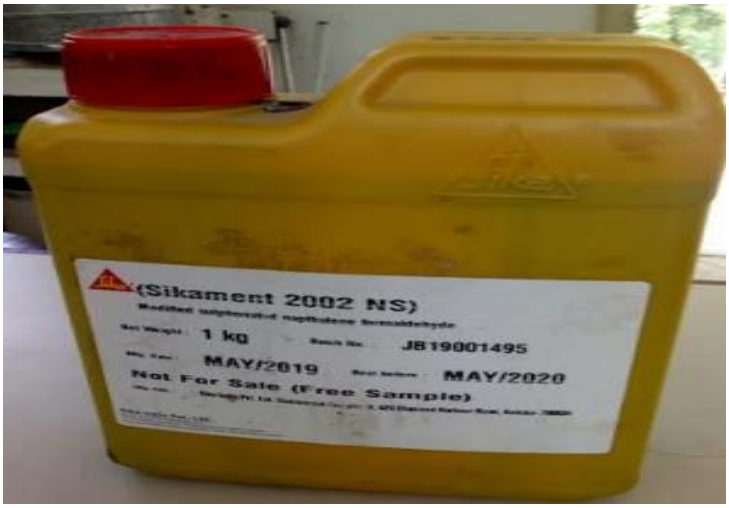


Fig-4 Superplasticizer

2.2 TESTS USED:

1. Compression strength Test

Mix Title	Compression Strength (N/mm^2)		
	7 Days	14 Days	28 Days
CC	26.93	34.94	43.6
GPC	27.73	36.72	41.8

2. Flexural strength Test

3. Split tensile strength Test

4. Durability test of cubes

5. Chloride Test

6. Sulphate Test

III RESULT AND DISCUSSION

For testing of the compression strength, geopolymer or conventional concrete cube sizes (150mm x 150mm x 150mm) and grade M35 be present arranged. After preparing the cubes, they were left for curing i.e., conventional concrete cubes in the water and geopolymer concrete cubes in the room temperature at 27^0 C for the 28 days.

3.1 Compression strength Test: -

Table: - 8 Results of Compressive Strength

Fig.-5: Compressive testing machine

Graph 1-Comparison of compression strength of geopolymer concrete and conventional concrete.

4.2 Result of Flexural strength Test: -

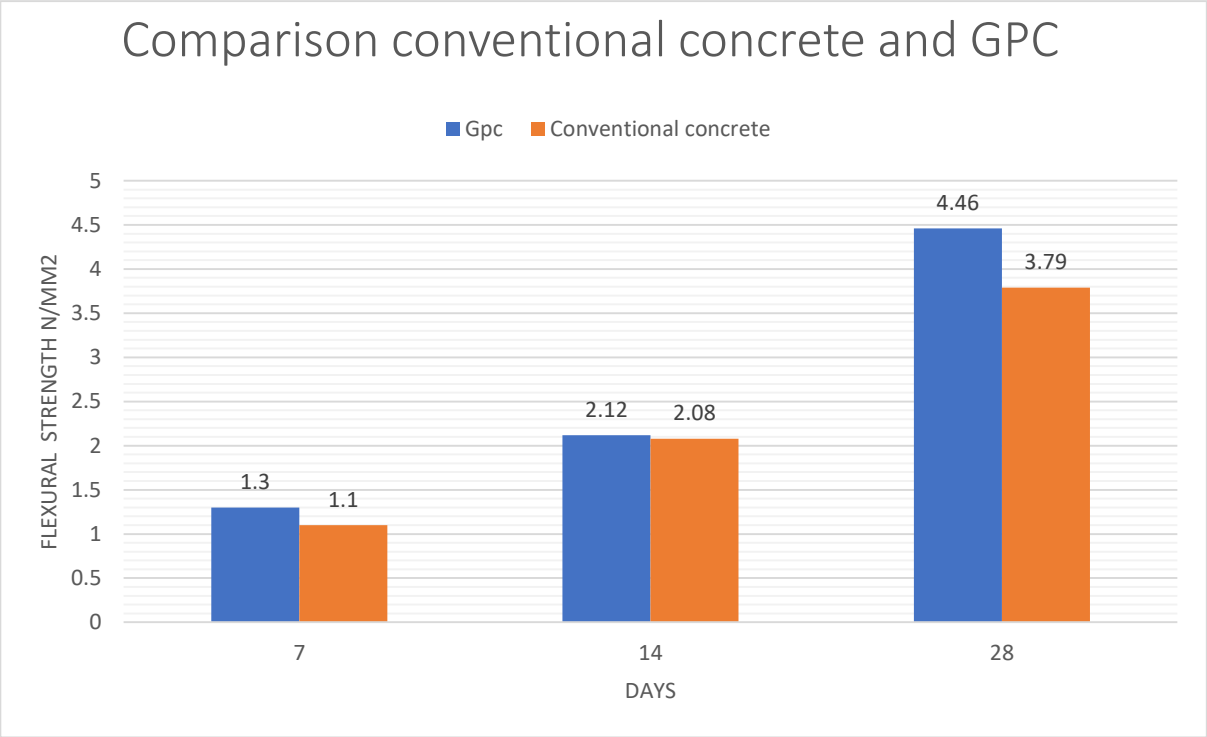
Flexural strength = P L/bd^2 (MPa)

For concrete cube with specific dimensions: P is maximum load in N.

L = 150mm, b = 150 mm, d = 150mm.

Table: - 9 Results of Flexural Strength

Mix Title	Flexural Strength (N/mm^2)		
	7 Days	14 Days	28 Days
CC	1.1	2.08	3.79
GPC	1.3	2.12	4.46



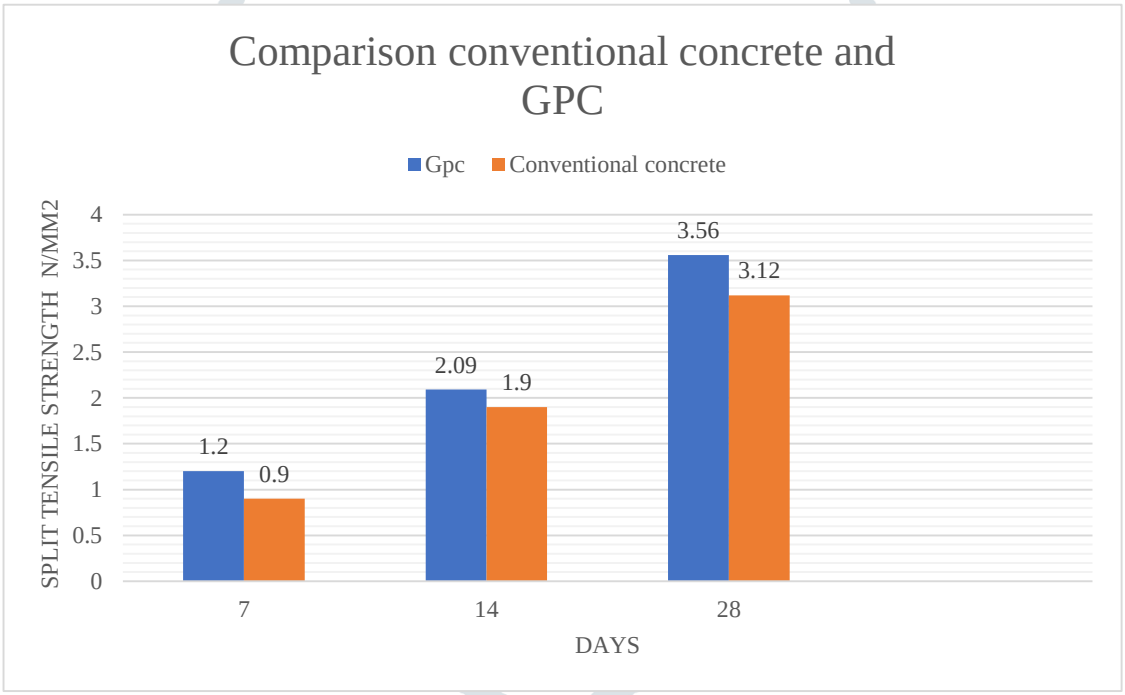
Graph 2 Comparison of Flexural strength of geopolymer concrete and conventional concrete.

4.3 Split tensile strength Test: -

To determine the split tensile strength of geopolymer concrete, cubes measuring 150 x150 x 150 mm were employed. The cubes underwent initial oven curing for one day at a consistent temperature of 70◦C, followed by subsequent sunlight curing for durations of 7, 14, and 28 days. The split tensile strength values of Conventional concrete and Geopolymer concrete under these various curing conditions are presented in the next Figure.

Table: - 10 Results of Split tensile Strength

Mix Title	Split tensile Strength (N/mm^2)		
	7 Days	14 Days	28 Days
CC	0.9	1.9	3.12
GPC	1.2	2.09	3.56



Graph 3 -Comparison of Split tensile strength of geopolymer concrete and conventional concrete.

4.4 Durability test of cubes

It is realized that the solid structure is viewed as sufficient, on the off chance that it acts as per its proposed degree of function ability or workableness over a normal or anticipated life cycle. As concrete is a permeable material, dampness development can happen by stream, dissemination, or adsorption.

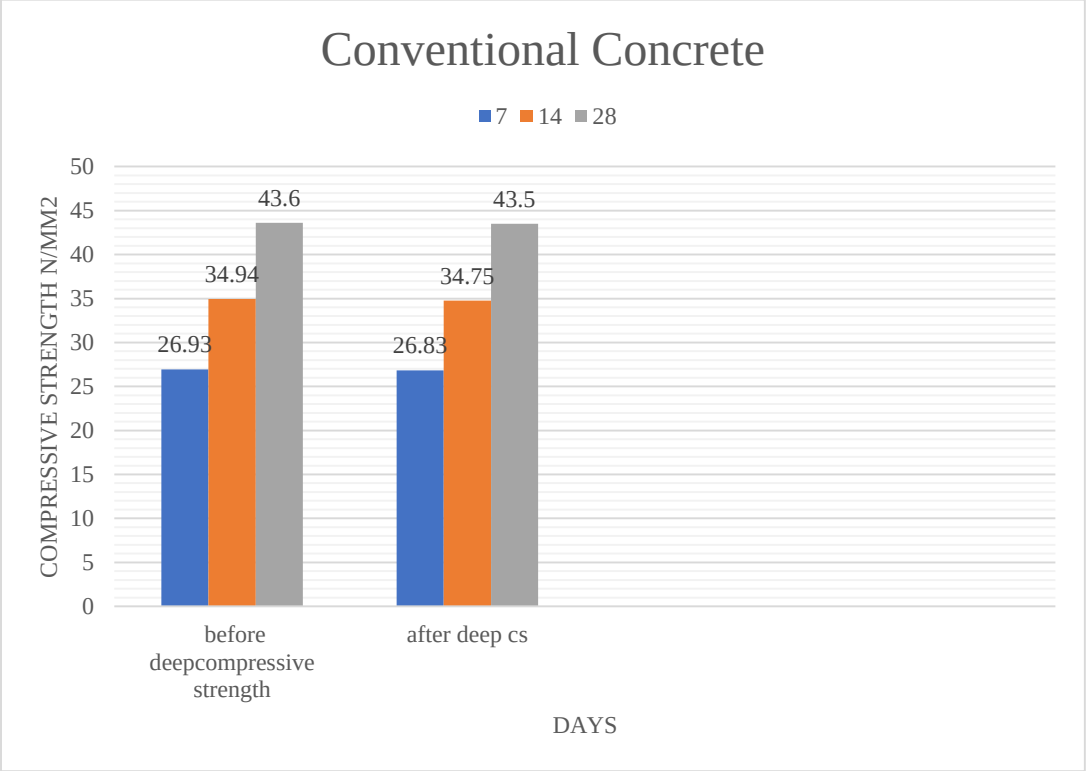
4.5 Chloride Test

Concrete experiences a few responses when exposed to ocean water. Concrete isn't 100% impenetrable, the water that saturates into the solid reason's consumption of rebar. The result of consumption being higher in volume than the material they supplant, apply pressure which brings about absence of solidness to fortified cement. The speed of the wave activity causes scraped area of cement. The ocean water obstruction tests were

done on 150 mm size solid shape examples at 7,14 days old or 28 days relieving. The 3D shape examples were drenched in water weakened with 0, 19 and 38g/l of NaCl. After 7,14 or 28 days, the examples were taken out from arrangement and surface of solid shapes were cleaned. The compressive quality of examples was discovered, or the loss of compressive qualities were determined.

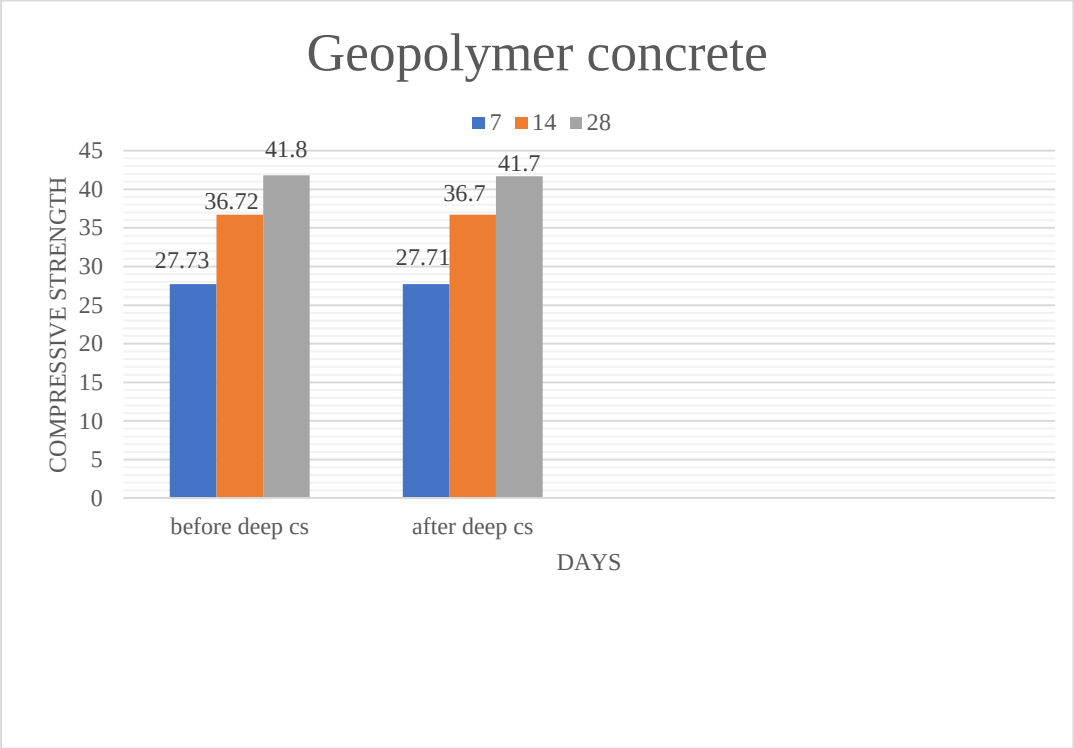
4.6 Sulphate Test

Decay of cement because of sulphate activity is regularly portrayed by the development in concrete. The sulphate obstruction test was completed on 150 mm size solid shape examples at 7,14 days old or 28 days relieving. The block examples were inundated in water weakened with 0,2 and 4g/l of $MgSO_4$. Following 7,14 or 28 days, the examples were taken out from arrangement and surface of solid shapes were cleaned. The compressive quality of examples was discovered, and the loss of compressive qualities were determined.



Graph 4: represents comparison compression strength of conventional concrete before or after deep in solution of sodium chloride or magnesium sulphate.

In this study we have done the compressive strength test under the CTM and found some results, at 7^{th},14^{th} and 28^{th} compression strength of Conventional concrete. The compression strength of Conventional concrete after deep in solutions is slightly less for example shown in the graph.



Graph 5-Comparison of compression strength of Geopolymer concrete before or after deep in solution of sodium chloride or magnesium sulphate.

V. CONCLUSIONS

1. From the above results, we examined that compression strength of geopolymer concrete is extra than conventional concrete at 7 days but on stage of 28 days compression strength of geo polymer concrete is less than the conventional concrete because in GPC there is a polymerization process in which water comes from the cubes when we cured at the room temperature due to which the strength of GPC is reduced.
2. On the other hand, in OPC concrete there is a hydration process in which water is consumed by the concrete when we cured the concrete in the water due to which the strength of OPC is gain at the stage of 28 days because the hydration process of the conventional concrete is completed within 28 days significantly and 99% strength of OPC is achieved. Hence, we concluded that the GPC is better in early days in high strength achievement while on the other hand OPC obtained higher strength later.
3. The cement is 100% replaced by making geopolymer concrete in order to decrease CO_2 emission due to which it reduces pollution, and it is eco-friendly.
4. Despite its drawbacks, geopolymer concrete is a more affordable and environmentally friendly alternative to traditional Portland cement. The main reason for its limited utilization is the disconnect between scientific research and its actual implementation in the building industry. This restriction can be removed by doing systematic study.
5. In terms of mechanical properties, geopolymer is on par with or superior to Portland cement.
6. This one possesses superb properties in both acidic and alkaline atmospheres.
7. High fire resistance and poor thermal conductivity characterize geopolymer concrete.

8. Long - term durability
9. Special high temperature characteristics.
10. Geopolymer is fire resistant and can withstand temperatures between 1000 and 1200 °C without losing its performance.
11. The workability of GPC can be achieved by adding 2% admixture because the high viscosity alkaline solution makes the concrete less workable.
12. Based on compressive strength accomplished in this study, the paver blocks which are made from the GPC are also used in light and medium traffic applications.

V. REFRENCES

- Ralli, Z.G.; Pantazopoulou, S.J. (2021). State of the art geopolymer concrete. International Journal of Structural Integrity, 12(4), Article [article number]. (August – 2021).
- Gencel, O.; Gholampour, A.; Tokay, H.; Ozbakkaloglu, T. Replacement of natural sand with expanded vermiculite in fly ash-based geopolymer mortars. Applied Science, 11(4), Article 1917 (February -2021).
- Imtiaz L., Rehman S.K.U., Memon S.A., Khan M.K., and Javed M.F., A review of recent developments and advances in eco-friendly Geopolymer concrete, Applied Sciences, Vol. 10, No. 21, Article 7838. (November - 2020.)
- Gambo, S.; Ibrahim, K.; Aliyu, A.; Ibrahim, A.G.; Abdulsalam, H. Performance of metakaolin-based geopolymer concrete at elevated temperature. Nigerian Journal of Technology, 39(3) (September - 2020)
- Praveen Nagarajan & Saranya P and Shashikala a P “Effect of supplementary cementitious materials on strength of GGBS geopolymer concrete” Volume 21 Issue (6 October -2019).
- Aindala Dinesh, Nanak Pamnani & Kunchapu Suresh “A study on mechanical properties of Geopolymer concrete made with 100% GGBS” Volume 06 Issue 11 (October -2019).
- S. GOVINDHAN & V. NIVEDHA “EXPERIMENTAL STUDY OF GEOPOLYMER CONCRETE BLOCKS” Volume: 06 Issue: 03(March – 2019).
- Ankush Kataria, Sonia, Rakhi & Sonia “Utilization of Steel Slag as Partial Replacement of Cement in Concrete Pavement” Volume 6 Issue X, (October- 2018).
- Padmanaban M S & Sreerambabu J “GEO POLYMER CONCRETE WITH GGBS (GROUND GRANULATED BLAST FURNACE SLAG)” (February - 2018).
- D. Naveen Kumar & DR. Kolli Ramujee “Durability Characteristics of Fiber Reinforced

Geopolymer Concrete Incorporated with Fly-ash and GGBS" Volume: 04 Issue: (November -2017).

- J. Srinivas & B. Prakash "AN EXPERIMENTAL STUDY ON EFFECT OF GGBS ON STRENGTH CHARACTERISTICS OF GEOPOLYMER CONCRETE" International Journal of Scientific & Engineering Research, Volume 7, Issue (July – 2016).
- C. Banupriya, Sharon John, R. Suresh, E. Divya and D. Vinitha "Experimental Investigations on Geopolymer Bricks/Paver Blocks" (April - 2016).
- M.POOJIDHA & K. NIRMALKUMAR "REVIEW PAPER ON GEOPOLYMER CONCRETE BY USING GGBS" Volume: 03 Issue: (August – 2016).
- Ajay Kumar Singh "Strength and Durability Test of Fly Ash and GGBS Based Geopolymer Concrete" Vol. 6, Issue, (Part -1) (August 2016).
- B.A.V. Ram Kumar & J. Venkateswara Rao "Effect of Inclusion of Glass Fibers and GGBS in Concrete Paver Blocks" Volume 12, Issue 5 Ver. III (Sep. - Oct. 2015)
- Rounak Hussain "A STUDY ON PROPERTIES OF BOTTOM ASH-GGBS GEOPOLYMER CONCRETE FOR PAVER BLOCKS" Volume (April – 2015).
- Paras S. Pithadiya & Abhay V. Nakum "EXPERIMENTAL STUDY ON GEOPOLYMER CONCRETE BY USING GGBS" Volume: 04 Issue: (April – 2015).
- IS: 456:2000 – Code of practice for Plain and Reinforced Concrete.
- IS: 10262-2019 – code of practice for Concrete Mix Proportioning
- IS: 16714:2018 – Code of Practice for Slag.
- IS: 383:1970 – Specifications for Coarse and Fine Aggregates.