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Usage Of Geopolymer in Concrete Roads of India A Review

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Abstract: The process of geopolymers is very comparable to that of cementation. Inorganic ceramic polymers made of aluminosilicates and cross-linked with alkali metal ions are known as geopolymers. Poor water percentage is used for manufacturing to make an amorphous geopolymer rather than crystalline zeolites. Geopolymer concrete is a variant of concrete which is made by aluminate and silicate reaction with material fly ash, slag from iron as a replacement of OPC. geopolymer concrete uses fly ash as an alternate binding material. The high content of silica and alumina reacts with alkaline solution of sodium hydroxide NaOH or potassium hydroxide and potassium silicate to form a gel that binds fine aggregates with coarse aggregates. The objective of the review article is to find the applicability of geopolymers in concrete that can be used as a replacement to OPC concrete and its applications in construction technology.

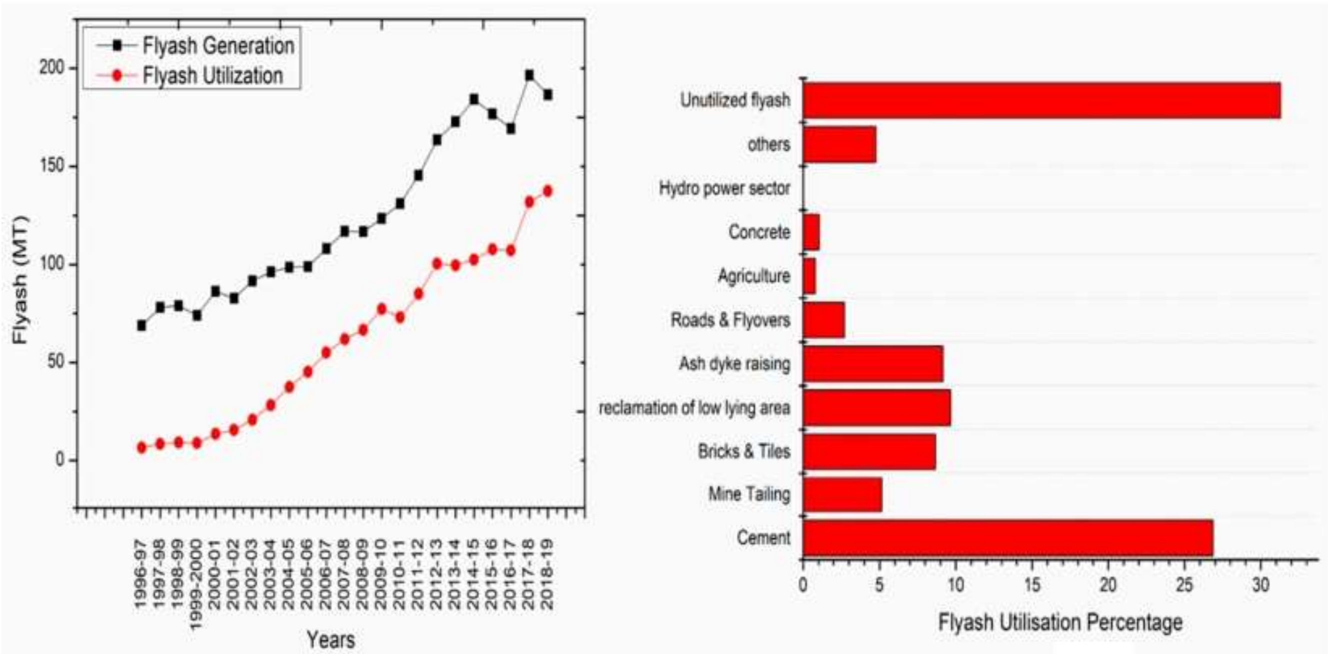
Keywords, Geopolymers, Geopolymer Concrete, OPC sustainability.

Introduction: Years (1984, 2008, 2010). A French material Scientist who is known for the Invention of Geopolymer chemistry came with materials that are broadly Characterized by networks of Inorganic molecules. Geopolymer concrete uses fly ash as an alternate binding material instead of cement. Alumina (Al) and Silica (Si) are abundant in fly ash (AI). The alkaline solution of sodium hydroxide (NaOH) or potassium hydroxide and potassium silicate react with silica and alumina ($K2SiO3$). It produces a gel that holds fine and coarse aggregates together. One of the important and impressive natures of geopolymer concrete is it doesn't use water for bonding, Because of this reason the alkaline solution reacts with silicon and aluminum which are present in fly ash. A quick and fast chemical reaction takes place in the polymerization process under the Alkaline condition of SI-AI minerals.

Geopolymerization is a complex process. To understand this process, we need to use a combination of experimental techniques to understand the mechanistic steps involved in converting Aluminosilicates to geopolymers.Infrared spectroscopy and high-energy X-ray analyses provides important data about the behavior of geopolymer slurries in situ. Calorimetry and rheology are being used to quantify mass products. Mathematical analysis provides additional insights into the reactions' progress. For a better understanding of geopolymerization kinematics. Because the reaction process is so complex, it requires the utilization of existing techniques as well as the invention of new techniques. The use of fly ash instead of OPC as a binding material in geopolymer concrete has a promising future in the construction industry. The basic reason is that it provides same properties as OPC-based concrete provides, which has similar structural qualities.

Figure 1a shows the usage and generation of fly ash from the year 1996 to 2019, it is the data taken from mineral yearbook.

Figure 1b shows us the usage of fly ash in different departments in the year 2019 alongside their percentage.



(a) (b)

Literature review

D. Niragi et. Al (2020) studied that geopolymer upon being mixed with GGBS and flash fly-ash showed an improved improvisation on the properties like compressive flexural and tensile strength. The range of properties was considered to be appropriate in terms of road repair applications. The formation of hydration products form mixes 7 and in-situ performance of mix 7. (70GGBS+20FA+10SF) is a good solution for the repair in road payment.

M.G Girish et. Al (2006) investigated that the cement concrete used in the construction of rigid pavement required high degree of compaction and vibration techniques that needed a lot energy. They attempted to make self-consolidating geopolymer concrete which was prepared from class F fly ash, GGBS, alkaline solution (NaOH and Na_2SiO_3) coarse aggregate and quarry dust. The mix position at Target strength of 40 MPA but the mix failed to exhibit sufficient green strength due to low yield stress and low viscosity

S. Kumar and P. Sagarika (2021) conducted research on exercise of geopolymer total and fly debris with various evaluation of M20, M30 and M40.They used fly debris rich in aluminum and silicon to confront climate issues because of utilization of normal development material. low calcium fly debris synthetically activated by high soluble for structuring a glue that ties the materials in the blend. The impact of fly debris content on compressive strength of M25, M30 and M40 at an age of 3,7 and 28 days. The expand in the properties like compressive strength, split elasticity, flexural strength in activator proportion i.e, 1:2, 1:2.5, 1:3. Flexural strength was examined and the geopolymer concrete has almost no dry shrinkage.

V. Manvendra et. al (2022) studied that geopolymer concrete with different chemical composition and reactions involved in a binding material is a perfect alternate to ordinary Portland cement which produces one ton of CO_2 while manufacturing meanwhile 97% of CO_2 emissions are reduced during the formation of geopolymer concrete as compared to OPC having better durable, economical, low energy consumption, thermally stable, eco-friendly and cementless. Geopolymer concrete has reduced the cost of concrete by the use of industrial waste in the concrete production the, embodied energy of geopolymer concrete is less as compared to ordinary Portland cement concrete for the same compressive strength.

B.J. Magge et. al (2018) investigated research on geopolymer cement mortars suitability for providing strong highway solutions research focused on developing cost effective and eco-friendly highway maintenance solutions. By using favorable mix designs in geopolymer cement motor and carrying potential use of geopolymer concrete mortar based artificial aggregate as a cost-effective alternative to calcined bauxite for high friction surfacing applications. Wide range of tests were done in phase 1 on Benhem geopolymer cement and performance levels were identified. Compressive strength at 28 days ranged from 54- 69, 58-7 respectively. The stability of the approach was confirmed using XRD analysis. The 60% GGBS mix to traffic loading were found to be acceptable. The texture and the skid resistance were found to be below minimum requirements, no deformations were noted other than some minor shining of geopolymer on the surface.

MATERIAL AND METHODOLGY

In various researches articles most, common methodology used is found to be similar given

Material used: Fine aggregate sand, coarse aggregate is used obtained from the local sellers and crushers. NaOH is available in pellet form in the market. Solution of 10 molar is used, Sodium hydroxide's molecular weight is 40. So, for the preparation of 10 molar solution we need 400 grams of sodium hydroxide (10× 40 = 400 grams) in 1000 ml water completely dissolved.

$Na_2 Sio_3$ is also available in market places. Sodium Silicate is also used with mix proportion of Sio_2 to Na_2O, two were used.

Given the percentage of water is 55.8%, 29.5% of Sio_2, 14.6% Na_2O.

Mix Proportion: Fine aggregates, coarse aggregates, and fly ash with ratio of 1.35: 3.17:1, including NaOH and NA_2sio_3. Alongside with fly ash 0.35 ratio according to previous studies by (Van C Bui and Wallah Rangan). Coarse aggregates and fine aggregates with some modifications in quantities were used to create 4 mixes for trial.

Mix 1: 1.3 :3.10: 1

Mix 2: 1.4: 3.20: 1

Mix 3: 1.5: 3.30: 1

Mix 4: 1.6: 3.40: 1

For the above mixes fly ash solution ratio was unchanged that is 0.35.

Mixing of Geopolymer concrete: geopolymer concrete was made manually by mixing fine aggregates, coarse aggregates and fly ash with alkaline solution. Cube moles of 150MM were used to place geopolymer country in three layers and 25 blows were given by 25 AM and tamping rod for compaction of each layer.

Table mix 1 (1:1.3:3.10)

Materials	Kg/m^3
Fly ash	408.00
Sand	530.40
Coarse aggregates (20mm in size)	1264.80
Na_2Sio_3 solution	103.00
NaOH Solution (10 molar)	41

Table mix 2 (1:1.4 :3.20)

Materials	Kg/m^3
Fly ash	408.00
sand	571.20
Coarse aggregates (20 mm in size)	1305.60
Na_2Sio_3 solution	103.00
NaOH Solution (10 molar)	41.00

Table mix 3 (1:1.5:3.3)

Material	Kg/m^3
Fly ash	408
Sand	612
Coarse aggregates (20 mm in size)	1346
Na_2Sio_3 solution	103.00
NaOH Solution (10 molar)	41.00

Table mix 4 (1:1.6:3.4)

Material	Kg/m^3
Fly ash	408
Sand	652
Coarse aggregates (20 mm in size)	1387
Na_2Sio_3 solution	103.00
NaOH Solution (10 molar)	41.00

Data Analysis: The data that is compressive strength and split tensile strength is taken from researches and it is shown here in the form of tables

Compressive strength: In most of the cases test was done on cubes made out of mixes after 7 days and 28 days of curing. The outcomes of the compressive strength test on cubes are shown below.

Compressive strength (N/mm^2) in 7 days

Mix 1	Mix 2	Mix 3	Mix 4
1:1.3: 3.10	1:1.4:3.20	1:1.5:3.3	1:11.6:3.4
32.1	43.5	46.9	42
36.8	42.4	48.6	41.5
37.9	41.0	47.9	39.8

Compressive strength (N/mm^2) in 28 days.

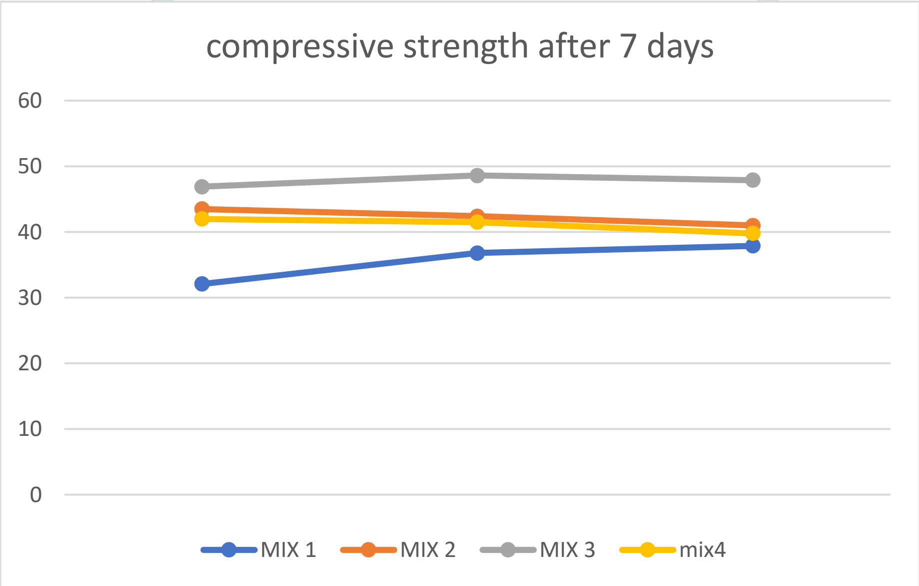
Mix 1	Mix 2	Mix 3	Mix 4
1:1.3: 3.10	1:1.4:3.20	1:1.5:3.3	1:11.6:3.4
37	47	51.3	48.9
39.2	47.9	53.2	49.5
43	47.6	52.5	48

Split tensile strength: in most of the cases the Split tensile strength test was done on the trial cubes for 7 days and 28 days. The outcomes of the test are shown below.

Split tensile strength (N/mm^2) in 7days.

MIX 1	Mix 2	Mix 3	Mix 4
1:1.3: 3.10	1:1.4:3.20	1:1.5:3.3	1:11.6:3.4
5	4	6	5.5
5.5	5.8	5.2	5.7
4	4.7	5.5	5.3

Split tensile strength (N/mm^2) in 28days

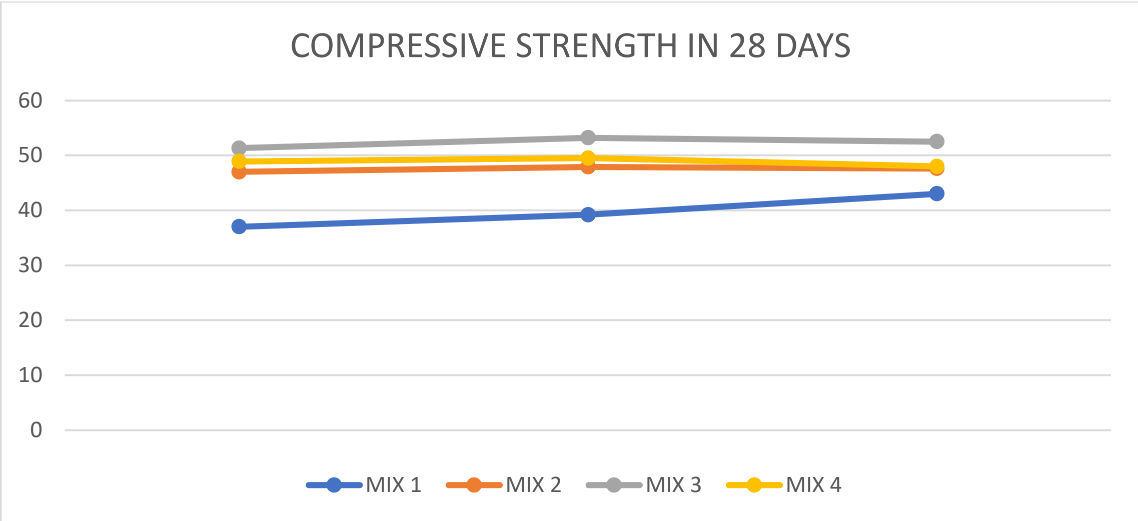


MIX 1	Mix 2	Mix 3	Mix 4
1:1.3: 3.10	1:1.4:3.20	1:1.5:3.3	1:11.6:3.4
6	5.2	7.2	7
6.7	6.8	6.5	7.1
5.3	5.5	6.1	6.4

Results and discussion: The data we have taken from the researches is shown below in the form of graphical representations

The Graphical representation of all the trial mixes is shown above;

1) Trial mix 1 shows the lowest strength in 7 days testing because the mix ratio was not according to the requirements.
2) Trial mix 3 shows the most desirable strength in testing because the mix ratio is somewhere close to the required one.



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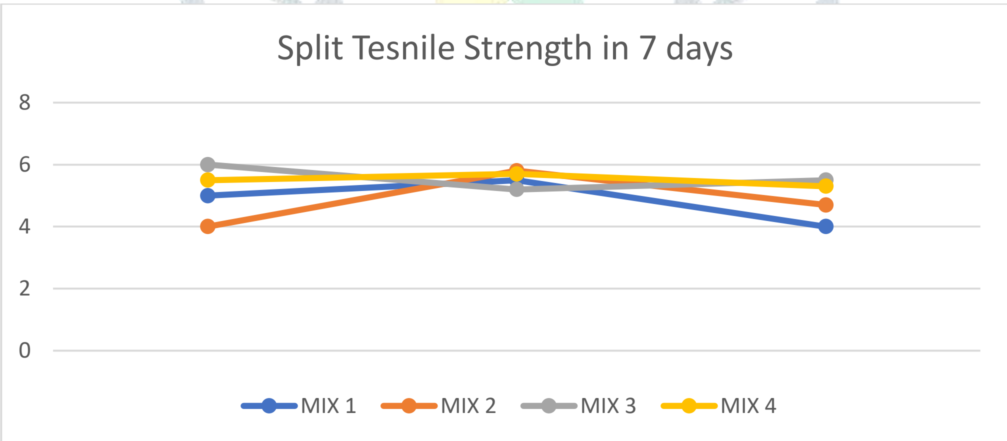
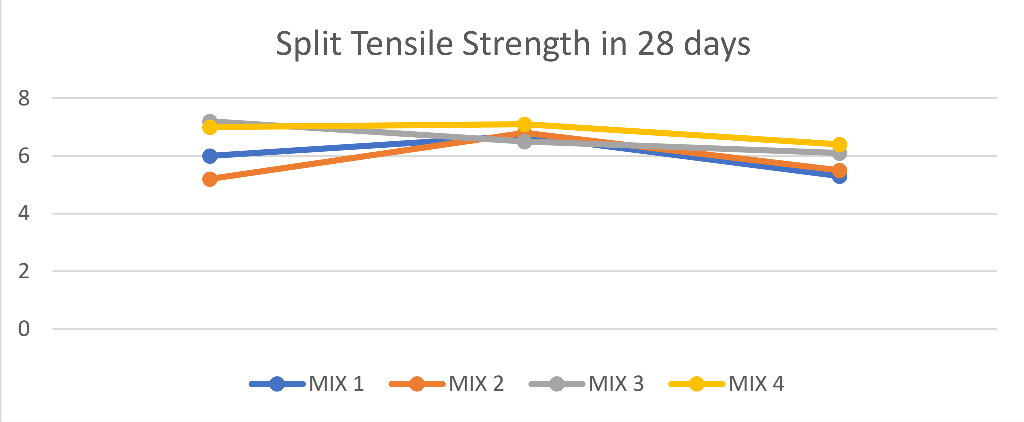


Split tensile strength in 7 days is shown in graphical form

1) Mix 1, Mix 2 has shown the same initial results and that is the least split tensile strength achieved.
2) Mix 3 has shown the maximum split tensile strength because the mix ratio is close to the one required.



Split tensile strength in 28 days is shown in graphical form.

1) Mix 2 has shown the lowest Split tensile strength.
2) Mix 3 has shown the highest split tensile strength.

Conclusion

Based on the compressive and Split tensile strength some conclusions can be drawn.

- The geopolymer concrete made from the trail mix designs looks promising for payment applications because of the in-situ performance of mix
- Most feasible ratio according to the review done trial Mix 3 is most suitable for the required strength
- Geopolymer concrete is the best way to replace traditional OPC concrete taking economy and nature into consideration
- Due to the resistance offered by geopolymer concrete to chemical attacks it makes it more useful for the repairment application of roads
- Geopolymer concrete has low carbon dioxide emission as compared to OPC concrete and it has promising future in construction industry.

References

1.) Niragi Dave, Vaishali Sahu, Anil Kumar Misra, (2020), "Development of geopolymer cement concrete for highway infrastructure applications."
2.) Kumar Saurabha, Sagarika Panda, (2021), "The activities of Geopolymer aggregate and Fly ash with different Grades of concrete M25, M30, & M40."
3.) Manvendra Verma, Nirendra Dev, Ibadur Rahman, Mayank Nigam, Mohd. Ahmed and Javed Mallick, (2022) "Geopolymer Concrete: A Material for Sustainable Development in Indian Construction Industries.
4.) B.J. Magee, A. Wilkinson, D. Woodward, S. Tretsiakova-McNally and P. Lemoine, (2018), "A Preliminary Investigation into Geopolymer Cement Mortar's Suitability for Providing Resilient Highway Solutions."
5.) M.I. Abdul Aleem, P.D. Arumiraj, (2012), "Optimum mix for the geopolymer concrete."
6.) Vemundla Ramesh, Dr. Koniki Srikanth, (2020), "Mechanical Properties and Mix Design of Geopolymer concrete."
7.) J. Davidovits, GEOPOLYMERS Inorganic polymerie new materials, GEOPOLYMER IN~, CORDI-GEOPOLYMERE SA, 20 RUE DE LA FERE, 02100 SAINT QUENTIN, FRANCE
8.) Pavithran. G, Maniarasan. S. K, (2017), "Experimental Investigation on Geopolymer Concrete Under Different Modes of Curing."
9.) Djwantoro Hardjito,(2005), "Studies on Fly Ash-Based Geopolymer Concrete."