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Management of Construction and Demolition Waste

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ABSTRACT
In India a huge quantity of construction and demolition wastes are produced every year. These wastes require a large place to dump and hence the disposal of these wastes has become a problem. Also the continuous use of natural resources for making conventional concrete leads to the reduction in their availability and results in the increase of the cost of the aggregates. When recycle concrete aggregate is used in the structural concrete, the assessment of physical, mechanical and durable characteristics are very important. The physical and mechanical properties of natural aggregate and recycle aggregates are characterised. The experimental investigation was done on the M30 grade of concrete. A control specimen was created with 100% recycled aggregate at different concentration of alkaline activator (10M, 12M and 14M) and this specimen compared with a conventional concrete. Cube compressive strength of geopolymer concrete with recycle concrete are evaluated. A total 24 cubes were casted to determine the compressive strength at 7 days and 28 days. As the concentration of alkaline activator is increased, the early strength of specimen increased.

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I. CHAPTER 1 INTRODUCTION

PROBLEM STATEMENT

Construction and demolition waste is waste generated or produced during the new construction, renovation and demolition of building and structure. It is most often disposed in landfills however recent recognition of the potential for the diversion waste component from the landfill has led to construction and demolition waste becoming a target of interest of recycling. Over the past decade India enjoyed fast economic growth achieving GDP growth of 9%. Due to the increase in the economic growth after development and redevelopment projects in the country and subsequent increase in the urbanization in the cities has made construction sector to increase drastically, but also environmental impacts from construction and demolition (C & D) waste are increasingly becoming a major issue in urban solid

waste management. This creates a huge challenge in terms of space for disposal, unauthorized dumping, mixing with biodegradable waste etc.
The various streams of wastes to be considered will include;

- Excavated materials,
- Concrete
- Tiles, brick, ceramics, asphalt concrete,
- Plaster,
- Glass,
- Metal and steel,
- Plastics,
- Wood, asphalt, and
- Concrete rubbles, etc.

According to Technical institute of forecasting assessment (TIFAC), The total quantum of waste from construction industry is estimated to be 12 to 14.7 million tons per annum. Quantity of different constituents of waste that arise from Construction Industry in India are estimated as follows:

Table 1.1: Constituents of construction and demolition waste

Constituent	Quantity Generated in million Tons p.a. (Range)
Soil, Sand & gravel	4.20 to 5.14
Bricks & Masonry	3.60 to 4.40
Concrete	2.40 to 3.67
Metals	0.60 to 0.73
Bitumen	0.25 to 0.30
Wood	0.25 to 0.30
Others	0.10 to 0.15

Source: TIFAC (technical institute of forecasting and assessment council

There is a high potential for recycling and reuse of this construction demolition waste, the quantity of construction and demolition waste being recycled in India is very low as compare to the other countries.
Population growth, urbanization, and large-scale consumption of raw materials are causing a vast array of environmental, social and economic problems across the globe. Although climate change is perhaps the most pervasive of these issues to be found in scientific and political discourse, there are many other issues associated with waste disposal, contamination, and land use that are closely intertwined with the consequences of humanity's expansion into the natural world. In an effort to mitigate these negative effects the global community set the goal of sustainable development.

Scientific community are continuously developing and adapting a new technology to preserve the natural world from the contamination of the construction waste. Once such technique is recycling waste material through the use of geopolymerzation as a binder to replace Portland cement. If we use at larger level then it has a potential to reduce the greenhouse gas (GWG) during the production of ordinary Portland cement.

Portland cement is the most common used binder material for concrete. However, it is an energy-intensive material that causes the production and release of CO2 from greenhouse gases from global warming, as well as causing soil degradation due to limestone mining. This requires the development of ecological binding material and geopolymer concrete is one of those potential materials.

The relatively inexpensive and readily available power generated from the combustion of coal remains one of the main forms of generating energy for the planet. The world's dependence on coal power will not disappear overnight, and, therefore, the waste produced during the coal combustion process, such as fly ash, is likely to remain an enduring issue in environmental sustainability. Replacing OPC in concrete with a geopolymer binder produced from fly ash is a method that can help alleviate these two pressing environmental concerns.

"Although the use of Portland cement is still inevitable for the foreseeable future, much effort has been made to reduce the use of Portland cement in concrete". This effort includes the use of supplemental cementation material for starters, fly ash, silica dust, granules, furnace slag, rice husk and 3etakaolin ash and the search for alternative Portland cement binders. In this context, Davidov's (1998) proposed geopolymer technology showed a huge potential for its use in several concrete industries as an alternative binder with Portland cement towards terms of reducing global warming, "the geopolymer technology can reduce the emissions of CO2 to the atmosphere caused by cement. And the 80% aggregate industries.

The removal of fly ash the environmental issue has become severe. This necessitated the creation of a modern ecological concrete in which a significant volume of fly ash is used.

The following are the some of the problems that are solved when fly ash is used in large proportions:

1. It reduces the usage of Portland cement.
2. It reduces the emission of CO_2.
3. The natural materials/resources like limestone, clay etc., can be conserved, which are used during the cement manufacturing.
4. Utilization of waste material.
5. Economic Design.

AIM

This study is mainly focused on recycling of construction waste material through the use of geopolymer instead of ordinary Portland cement as a binder material. And compare the compressive strength of conventional concrete with varying concentration of alkaline activator.

OBJECTIVES

The main objectives of this study are as follows:

1. To replace cement with fly ash and Alkaline solutions.
2. To develop the mix design process for fly ash based geopolymer concrete.
3. Compare the compressive strength with varying concentration of alkaline activator.

SCOPE OF STUDY

1. To develop geopolymer concrete using locally available construction waste using fly ash as a binder material.
2. Commercially available chemicals will be used for preparing alkali solutions for activation of fly ash to act as binder material.
3. This study was extended to find the comparison of Mechanical properties that includes compressive strength, workability, compaction factor, slump with conventional concrete.
4. Cubes of 150mmX150mmX150mm for the compressive strength test is to be used.

RESEARCH METHODOLOGY Materials used in the study

The following are the materials used in the investigation.

1. Class 'F' fly ash
2. Crushed concrete rubbles as coarse aggregate
3. Fine Aggregates (sand)
4. Sodium hydroxide (NaOH)
5. Sodium silicate solution (Na_2SiO_3)

Experimental investigations

Development of Geopolymer concrete mix

The test samples were taken as 150 × 150 × 150 mm cubes, melted and stored at room temperature for hardening. A mixed design method aimed at workability and strength for GPC based on low calcium fly ash. However, alccofine have been added to achieve the required compressive strength at room temperature. "The total mass of fly ash and alkaline activation solution was obtained by deducting the total aggregate content from the assumed density of 2400 kg / m^3. The ratio of sodium silicate to sodium hydroxide by mass was maintained at 1: 2.5, which fixed the cubes within 24 hours of melting. The main goal to perform the procedure is to achieve the desired compressive strength of 38 Mpa at the end of 28 days. Fine aggregates, coarse aggregates and fly ash were mixed in a mixer. The form of sodium hydroxide granules was mixed with distilled water to prepare alkaline activator solutions (AAS). AAS was then produced by adding sodium hydroxide and sodium silicate solutions. Therefore, geopolymer concrete is produced after adding AAS to fine aggregates, coarse aggregates, and fly ash.

Preparation of test specimens and curing

Various researchers have tried different methods for the sample preparation of the geopolymer concrete and suggested that the compressive strength of the GPC is not affected by mixing (Junaid et al.2015). The procedure suggested for the preparation of the GPC samples is as discussed below:

1. NaOH will be prepared before 24hrs of the

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casting and uniformly mixed with the Na_2SiO_3 1hr prior to the mixing of the ingredients of the GPC.

2. All the ingredients of GPC mixture are then mixed for at least 5min in the Pan mixture, then poured into 150mm size standard cube moulds and compaction was done on a vibrating Table for about 4-5 minutes.
3. However, the ambient cured samples are kept at the room temperature (27°**C**) till the time of testing.
4. Therefore, plasticizer (2%) and alccofine (10%) were introduced in GPC mix in order to target the required slump and compressive strength.

This was casted in three layers of concrete blocks. Each layer has been well compacted by 16 mm diameter tamping rod. Both cubes were placed on a vibrator table and vibrated for 2 min to proper concrete compaction. Using trowel the top surface was levelled after concrete compaction.

Tests Conducted

"At the end of desired curing period, the casted specimens were subjected to the compressive strength" and change in mass with the specimen size 150 × 150 × 150 mm to study the effectiveness of geopolymer concrete.

II. CHAPTER 2 LITERATURE REVIEW

Portland cement generates large quantities of carbon dioxide (CO2) which is responsible for global warming, so it is a greenhouse gas". The prefabricated solid concrete pavers are versatile, aesthetically appealing, functional, and economic require few or even no maintenance, if fabricated yet appropriately positioned. Pebbles may be used on different users. Different forms of industrial waste are available on local markets others and could be used in the building sector of waste materials to environmental changes. Various papers and research articles based on fly ash replaced by various percentages of cement replaced by various percentages have been revised and have been found to increase strength, durability and reduce costs and use of waste materials.

table 2.1: Literature Survey

S.no	Author	Year	Conclusion
1	Thaarrini	2019	Preliminary investigations were carried out on the geopolymer mortar and the optimal replacement of the textile effluent was 50% with a molarity of 6 M with an alkaline liquid-binder ratio of 0.4 and 0.5. With optimal parameters, the geopolymer concrete blocks were manufactured and tested for their mechanical properties. The results show that the mercerization effluent of cotton can be used as a partial replacement of the alkaline activation solution of geopolymer concrete.
2	Dr. R.Kumutha, S.Aarthy and Dr.K.Vijai,	2018	Develop the double layered geopolymer concrete paver blocks by the activation of fly ash and GGBS by adding polyester fibres in the top half thickness of paver blocks. Test results indicated that addition of polyester fibres in paver blocks has significant advantages with respect to flexural strength and abrasion resistance.

3	Abhay Tawalare, Rupali Kejkar and Mahesh Kumar	2018	"Performance with geopolymer paver block using natural aggregate and recycled aggregate as fine aggregate and slag as coarse aggregate. The geopolymer paver block with recycled aggregates having mixed proportion as GPC4 shows all the test results within the limit as per IS15658, so it can be used in residential driveways, light vehicles / public pedestrian and light vehicle paths".
5	Darshan Pokharkar, SanchitShirsath, Majidul Islam, Yogesh Wadge	2017	Test results show that incorporating the use of rubber pads with the inclusion of different percentages of waste steel aggregates in paver blocks gives up to 50% more impact power than ordinary paver blocks.
6	Vikas Kumar Patel and V. V. Singh	2017	Specific paper and study works based on fine aggregates (sand) replaced by various percentage of other industrial waste materials and cement replaced by different percentages of other slurry base material and found that resistance, resilience and cost reduction and usage of waste material improved.
7	K. Ashok Kumar and Dr. P. Partheeban	2017	Following 20 days of atmospheric recovery, the compressive strength of the Geopolymer concrete paver block was 14.4 percent lower than the control concrete paver block of grade M35.
8	D.V. Karunarathne, K. Arulolipavan and K.M.L.A. Udamulla	2017	The compressive strength, slip/skid resistance and water absorption of GPC paving blocks were determined and were compared with SLS 1425 part 1 and 2. GPC paving blocks for all strength classes which is cured in 80 ºC ambient temperature is found to satisfy all SLS specifications while compressive strength of geo polymer concrete paving bocks cured in ambient temperature is found to be less than the design strength.
9	C. Banupriya, Sharon John, R. Suresh, E. Divya and D. Vinitha	2016	Geopolymer brick provided strong compressive strength using 65 per cent FA & 35 per cent GGBS. "Small volume fly ash based geopolymer concrete (mix ratio of 65, 70, 75 and 80 percent FA) used for bricks and high

			volume ground granulated blast furnace slag based geopolymer concrete (mix ratio of 65, 70, 75 and 80 percent GGBS) used for paver blocks".
10	Basil M.Mali and Renjan Abraham	2016	Test results show that low-calcium fly ash-based geopolymer concrete pavers have excellent compressive strength in a short time (3 days) without water healing and are ideal for practical applications.
11	Anjali Gargav and Dr.J.S.Chauhan	2016	The geopolymer has the advantages of quick strength gain, water healing removal, strong mechanical and toughness properties and is an environmentally friendly and sustainable alternative to concrete based on Ordinary Portland Cement (OPC)..
12	S.Kavipriya&Dr.R.Ilangovan	2016	The test results show that cement concrete showed better performance when 0.5 per cent of the inclusion of polypropylene fibers (PP) was a comparatively better result when 1 per cent of PP fibers were added as geopolymer concrete records. The findings also show that GPC performs comparatively better than CC with and without inclusion of fiber.
13	G. Gayathri,V.S. Ramya,T.Yasotha and M. Dheenedhayalan	2016	In this study, e-waste was used to substitute sand by 0 percent, 10 percent, 20 percent, 30 percent, 40 percent and 50%. In addition, the strength characteristics of cubes, beams and geopolymer concrete cylinder with E-waste with varying mixing ratios can be realized.
14	Rismy Muhammed, DeepthyVarkey	2015	Test results show that it provides strong results for abrasion resistance and flexural strength at 28 days respectively with the addition of PPF by 0.2 per cent. Based on the test results, the PFRGPC was found to have comparatively greater power than the GPC & OPC pavers.
15	Rounak Hussain	2015	From the test results it was observed that compressive power of the grades M30 and M35 was reached in early

			ages under ambient healing.
16	Kewal	2015	Tests for both the compressive strength of the concrete will be performed; the compressive strength test will be conducted for 7 and 28 days. Obviously, it takes some more experimental works to research the method from an environmental point of view.
18	Priyanka Ramkripal Singh and N.D. Shah	2014	Ferndandez-Jimenez reported that the secret to a fly ash- based geopolymer product with optimum binding properties was extracted from the use of a fly ash material with the following properties: less than five per cent of unburned material; less than 10 per cent of Fe2O3; low CaO content; 40–50 per cent relative silica; 80–90 per cent of particles with a diameter of less than 45 µm; and high CaO content;vitreous phase.
19	Aman Jatale1, Kartikey Tiwari, Sahil Khandelwal	2013	Fly-ash effect on workability, setting time, density, air quality, compressive power, elasticity modulus are studied. Based on this analysis, compressive strength v / s W / C curves were designed to allow direct design of concrete mixtures of grades M15, M20, M25 with difference percentage of fly-ash.
20	Aaron Darius Vaz, Donal Nixon D'Souza, NoothanKaliveer, Satish K.T and Amar S.M	2012	The usage of geopolymer concrete in precast concrete paver blocks and contrasts the output with the same mix proportions of commercially available OPC paver blocks. The mix design was built with a target strength of 47 Mpa to produce paver blocks that are suitable for highways. The experiments were carried out and the findings were tabled.

22	Shankar H. Sanni	2012	The test results indicate that when compared to traditional concrete, the heat-curing fly ash-based geopolymer concrete has excellent resistance to acid and sulphate attack. Geopolymer development has thus a relatively higher strength, excellent volume stability and better durability.
23	F. D.B. Raijiwala and H.S. Patil	2011	Once the samples were combined at 25 degrees Celsius and healed at 30 degrees Celsius, the compressive strength was weak at an early stage, but slowly increased.
24	E. Lloyd, N. and Rangan	2009	Geopolymer concrete has excellent properties and is well-suited for the manufacture of precast concrete goods that are required after a disaster to rehabilitate and retrofit the structures. It also outlined the economic benefits and contributions of concrete geopolymer to sustainable development.
25	DjwantoroHardjito, Steenie E. Wallah, Dody M. J. Sumajouw, and B.VijayaRangan	2004	The research demonstrates the effects of various parameters on Geopolymer concrete properties. This also describes the use of concrete geopolymer and future research needs.

Properties of recycle concrete aggregate

Particle shape and texture:

RCA tends to be very angular and rough due to the crushing of old concrete, and because of the presence of hardened cement paste/mortar adhered to the surfaces of original coarse aggregate. Typically, RCA particles contain 30 to 60% old cement paste/mortar, depending on the aggregate size. A greater amount of old cement paste/mortar is attached to the smaller size fractions of coarse aggregate. RCA is similar to crushed rock in particle shape, but the type of crushing equipment influences the gradation and other characteristics of crushed concrete

Specific gravity:

The specific gravity of RCA is usually lower than that of NCA. The lower specific gravity of RCA is due to the presence of old cement paste/mortar on the aggregate particles that makes it less dense than NCA because of greater porosity and entrained air structure. The typical values of specific gravity of RCA range from 2.1 to 2.5 in the saturated surface-dry condition that are 5 to 10% lower than that of NCA.

Bulk density:

The bulk density of RCA is significantly lower than that of NCA. According to the experimental results of Yong and Teo (2009), the bulk density of RCA has been found to be 9.8% lower than that of natural gravel aggregate. This is mostly due to the higher porosity of RCA in the presence of adhered cement paste/mortar.

Absorption:

The absorption of RCA is significantly higher than that of NCA. When demolished concrete is crushed, a certain amount of cement paste/mortar from the original concrete remains attached to RCA particles. The attached cement paste/mortar possesses a greater porosity than the original aggregate; this is the main reason for the higher absorption of RCA.

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2.2 SUMMARY OF PAST STUDIES

Concrete Is perhaps the most commonly distributed building plastic in the production. Ordinary Portland Cement (OPC) has historically acted as a concrete binder. OPC process means vast amounts of fossil fuels to be combusted and calcareous decomposition, resulting in substantial carbon dioxide (CO2) emissions into another atmosphere.The release of CO2 seems to be the primary cause of global warming, but it has become a major concern. Geopolymer technology was introduced should mitigate this.

There has been today that heavy responsibility for the environment that have started work on sustainability and ecological approaches towards infrastructure growth. The other big concern currently is hazardous waste disposal. Coal-fired power plants contain solid waste as fly ash and tin ash. “This same management of this waste poses a significant engineering problem with more stringent environmental legislation. Work today merged sustainability with waste management to produce a magnificent commodity called Geopolymer concrete.

Focusing on a series of research articles There are numerous concentrated solution to geopolymer technology which appear quite obscure. That lack of comparable requirements including concrete specifications requires concretes apart from concrete OPCs or different geopolymer concrete requirements. In general, geopolymer concrete would be restricted to non-structural or high-performance structural applications. The quality of the fly ash, the relationship between the binder and the aggregate, the morality of the activating solution, the type of fine aggregate, and the hardening conditions influence the development of the resistance in the geopolymer concrete for improving the workability. It is possible to add super plasticizer or additional water.

When triggering with such an alkaline solution fly ash can indeed be converted to something like a binding material. It is found that even a higher sodium hydroxide concentration and a lower mass-by-mass ratio of sodium silicate towards sodium hydroxide contribute to greater compressive force. Geopolymer concrete compressive strength decreased to increased water-to-mass-geopolymer ratio. That increase of temperature of polymerisation enhances their compressive power. Concrete containing possesses excellent chemical resistance and would be the best alternative and used in hostile environments.

III. CHAPTER 3

EXPERIMENT PLAN

INTRODUCTION

The materials are collected from a specific location and they study properties.

1. Mixing concept of M30 grade concrete with correct w/c ratio is performed using these properties.
2. Cubes test in laboratory, in order to study the compressive strength of concrete cubes.
3. 150mm x 150mm x 150mm concrete cubes were casted and tested at 7, and 28-days and recorded compressive strength.
4. Conclusions shall be made on the basis of test results.

MATERIAL USED

In this experimental work, there are various materials used like…

1. coarse aggregate
2. fine aggregate
3. Alccofine
4. Fly ash
5. Sodium hydroxide
6. Sodium silicate

Coarse aggregate

In this test, coarse aggregate is recycled concrete aggregate with maximum size of 20mm to minimum size of 10mm will be used. Recycled concrete aggregate is obtained by the crushing waste concrete from the laboratory tested concrete samples.

Table 3.1 : Properties of coarse aggregate

S.NO	Property	Test value
1	Bulk density	1449
2	Specific gravity	2.47
3	Fineness modulus	3.47

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Fig 3.1 recycle coarse aggregate

Fine aggregate

The sand used for this investigation was collected locally from a 4.75 mm layer with an accurate gravitational value of 2.80. The fine aggregation properties are shown in the following table.

Table 3.2: properties of fine aggregate

Property	**Value**
Bulk density	1.49 g/cm^3
% of voids ratio	34.23 %
Voids Ratio	0.58
Specific Gravity	2.258

Fig 3.2 sand

Sodium hydroxide

The sodium hydroxide (NaOH) solution was prepared by dissolving either the flakes or the pellets in water. The mass of NaOH solids in a solution varied depending on the concentration of the solution expressed in terms of molar, M. For instance, NaOH solution with a concentration of 12M consisted of 12x40 = 480 grams of NaOH solids (in flake or pellet form) per liter of the solution.

Fig 3.3 sodium hydroxide pebbles

Alccofine

It is a fine material available in powdered form. It effects strength workability and durability of slag based geopolymer concrete.

Sodium silicate

Its aqueous solution known as sodium silicate used as mineral binder.

Experiment plan

Fig 3.4 sodium silicate

The experimental project studied the various mechanical qualities, including compressive strength, build and control 24 standard cubes of 150mm x 150mm x 150mm.

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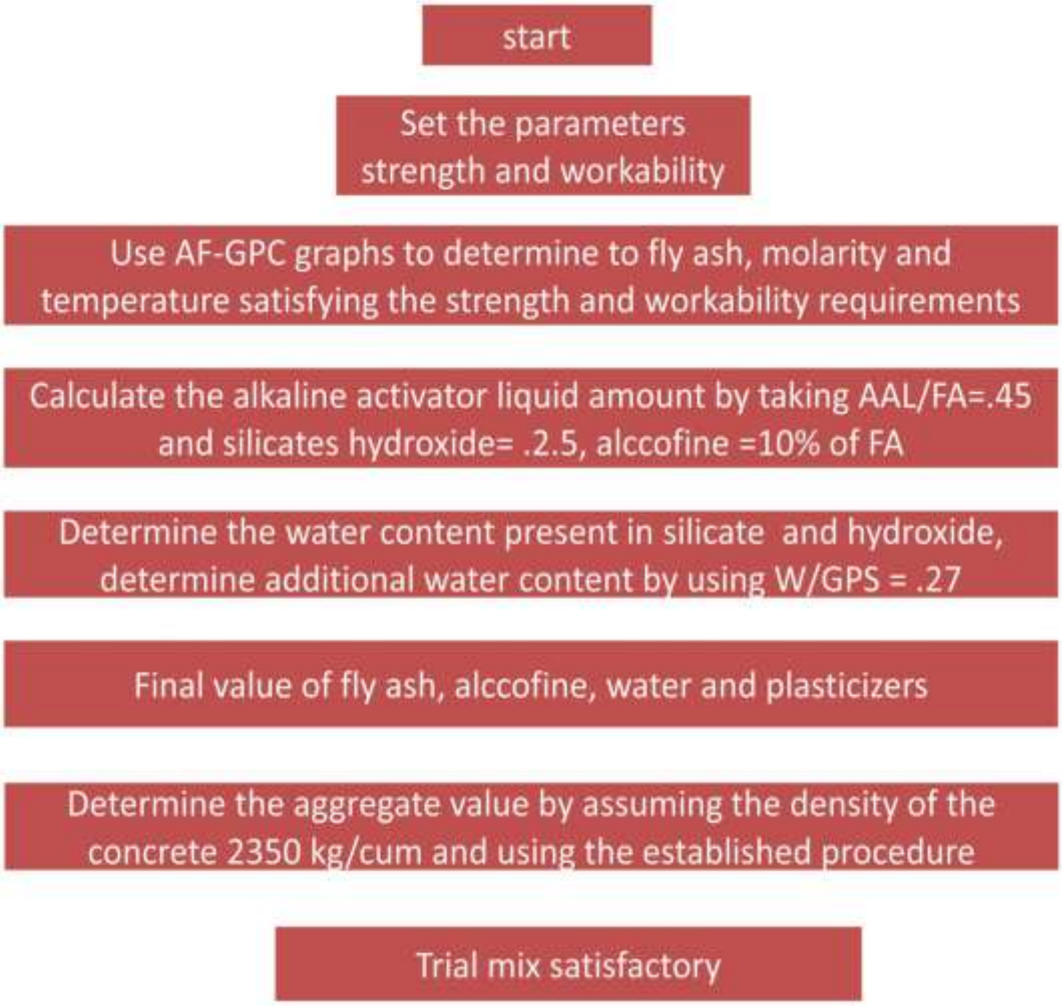

Fig 3.5 flow chart of casting cubes

MIXING

Hand mixing technique was used for mixing various ingredients. The mixture was carefully Mixed throughout dry condition, then applied sand to both the mixture. Once again, the mixture was gently mixed out over coarse aggregate. After which, water has been added slowly during mixing to chemical admixture. Mixing has been done on a regular basis upon obtaining a workable mixture stopped.

Fig 3.6 mixing of ingredients

CASTING

For casting moulds were used and it was occupied Throughout three strata. The concrete cubes are casted 20 times respectively. Vibration became set with table vibrator also on cube moulds. Vibrations that validate uniform compaction are continuous for one minute. Since the specimen was carried out 24 hours from mold and placed in an ambient curing at room temperature for 7, 14 and 28 days. 20 cubes and Geo-polymer concrete was casted.

Fig 3.7 casting of cubes

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Curing
In this test, we have used a water cured technique in which cubes are kept under distilled for 28 days.

Test counducted:
Compressive strength test machine was used to carry out the compressive strength of cubes. The typical test protocol is followed at each concrete mix test as well as the result was analyzed.
Procedure for cube test:
1. Remove the specimen from the water after specified curing time, and wipe out the excess surface water from the specimen (cubes).
2. Note the dimension of the specimen
3. Clean the bearing surface of testing machine
4. set the cubes in the machine in such way that load shall applied to the opposite side of the cube.
5. Rotate the movable portion gently by hand so that it touches the top surface of the specimen.
6. Apply the load gradually without giving shock and continuously at the rate of 140kg/cm2/minute till the cube fail.
7. Record the maximum load at which cube fail.

Fig 3.8 Universal testing machine

IV. CHAPTER 4 MIX DESIGN

METHOD PROPOSED FOR MIX PROPORTIONING
That following mix-proportioning framework is developed based on experimental analysis carried out during the current studies.

DATA REQUIRED FOR MIX DESIGN
1. Characteristic compressive strength of Geopolymer Concrete (fck) .
2. Fineness of fly ash in terms of specific surface in m^2/kg .
3. Workability in terms of flow .
4. Fineness modulus of fine aggregate .

This same appropriate fine aggregate with fly ash-based geopolymer concrete is reviewed in addition testing process.
DESIGN STEPS
Target Mean Strength (Fck) for Mix Design
Fck = fck + 1.65 x S Or
Fck =fck + X

As per IS 10262: 2019.

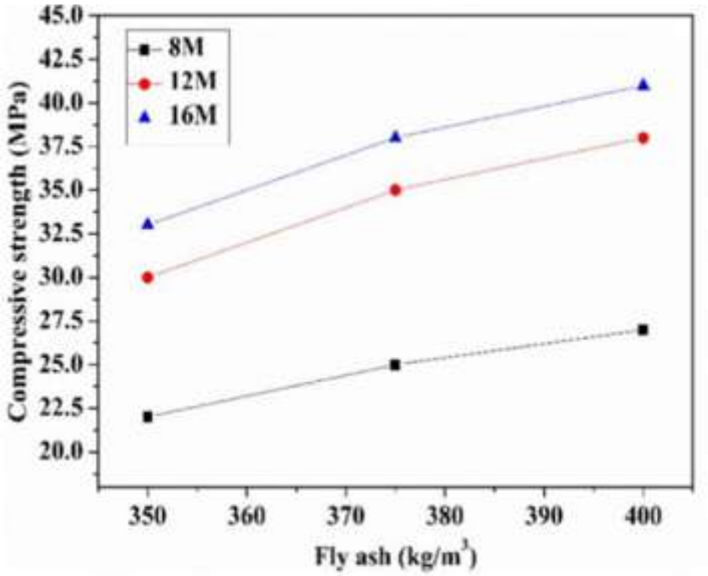

Fig 4.1: Compressive strength with varying fly ash content, at 27^{0}C temperature **Table 4.4:** Workability bands used in this study

Fly Ash (FA) Kg/cum	FA<350	350<FA<375	375<FA<400	FA>400
Degree of workability/Slump	Less (<75)	Medium (>75 but<100)	High (>100 but <150)	Very High (>150)

Selection of Quantity of Fly ash (F)
Amount in fly ash picked dependent upon goal indicates fly ash intensity but fineness of solution-to-fly ash ratio 0.27.

Table 4.5: Properties of fly ash

Oxides	Percentage
SiO_2	60.54
Al_2O_3	26.20
Fe_2O_3	5.87
CaO	1.91
MgO	0.38
K_2O+Na_2O	1.02
SO_3	0.23
Loss on ignition	2

Calculation of the Quantity of Alkaline Activators

Depending on the mass of fly ash (F) calculated throughout the preceding stage, that total solution sum is produced through mass utilizing solution-to-fly ash ratio for 0.27. Afterwards, the total amount with sodium silicate as well as sodium hydroxide would be made the decision did decide mass and use the ratio with sodium silicate nano silica sodium hydroxide 1:2.5.

Calculation of Total Solid Content in Alkaline Solution: Sodium hydroxide solutions that use the given equations, based on the quantity in solids found for each solution .

$$\frac{AAL}{FA} = \frac{\text{Sodium Silicate solution} + \text{Sodium hydroxide solution}}{\text{Fly Ash}} = 0.45$$

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Selection of Quantity of Water

Geopolymer concrete workability depends upon overall volume of water like water found throughout all alkaline solutions as well as the degree for robustness. Choose minimum mass of fluid expected for attain the ideal durability, depending mostly on smoothness of both the water fly ash.

Degree of workability	Flow in percentage	Quantity of water required in kg/m^3			
		Fineness of fly ash in m^2/kg			
		<300	300–400	400–500	>500
Low	0–25	80	85	100	110
Medium	25–50	90	95	110	120
High	50–100	100	110	120	135
Very high	100–150	120	130	140	160

Correction in Water Content

"In solid, volume involved by fine and coarse total is around 70–85% of all out volume. Likewise, finer particles have enormous surface zone when contrasted with coarser one and subsequently required more water to deliver functional blend. IS 10262 recommended some amendment in water content for the blend proportioning of concrete cement based on evaluating of fine total". In geopolymer concrete, the job of water is to make serviceable cement. Along these lines, it is prescribed to apply same revision to geopolymer concrete in the proposed blend plan based on reviewing zones of fine total.

Grading zone of fine aggregate as per IS 383 [20]	Correction in water content (%)
Zone-I	−1.5
Zone-II	–
Zone-III	+1.5
Zone-IV	+3

Calculation of Additional Quantity of Water

Alkaline solutions that also includes many such amounts of water based on one's composition have been used in geopolymer concrete. However, to satisfy certain criteria of robustness, additional water can be introduced internally to both the blend, that is measured as:

Additional water quantity; when needed = Full water volume-Water present within alkaline solutions.

Selection of Fine-to-Total Aggregate Content

Fine-to-total aggregate content is taken on the basis of grading (fineness modulus) of fine aggregate .

Calculation of Fine and Coarse Aggregate Content

Fine and Coarse Aggregate Contents is obtained using following relations

Total quantity of aggregate = Wet Density of Geopolymer concrete - Quantity of Geopolymer Binder + Additional water; if any

Sand content = Fine-to-total aggregate content in % * Total quantity of aggregate Coarse aggregate content = Total quantity of aggregate - Sand content

4.4MIX DESIGN FOR GEOPOLYMER CONCRETE GRADE M30 ACCORDING TO THE PROPOSED METHOD

Analysis leading to a variety mix proportions for M30 grade with geopolymer concrete is conducted utilizing proposed methodology based mostly on mix design measures mentioned in the subsequent segment. That mix design can be considered according to preliminary data:

1. Characteristic compressive strength of Geopolymer Concrete (fck) = 30 MPa.
2. Workability in terms of flow: (Degree of workability—Medium)
3. Fly ash: Fineness in terms of specific surface: 384 m^2/kg
4. Alkaline activators (Na_2SiO_3 and NaOH)

(a) Concentration of Sodium hydroxide in terms of molarity: 12 M

5. Solution-to-fly ash ratio by mass: 0.45
6. Sodium silicate-to-sodium hydroxide ratio by mass: 1:2.5

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Design Steps

1. Target mean strength

Fck =fck + 1.65*S Fck = 30 +1.65 * 5 Fck = 38.25 MPa

Or Fck = fck + X Fck = 30 + 6.5

Fck = 36.5 Mpa

The higher value to be adopted, therefore target strength will be = 38.25 Mpa

1. Its quantities for fly ash used in the GPC development is to choose correct alkaline activator liquid (AAL) and fly ash (FA) ratio. It has already been observed that even a value of 0.3 and 0.6 is appropriate with realistic use (Hardjitoet al.2005, Junaidet al., 2015), but this research have required a value of 0.45 and ready that AF-GPC-Graphs.

2. Calculation of the quantity of alkaline activators liquid

Compute the amount of liquid alkaline activators: Solution/Fly ash ratio by mass = 0.45

Mass of (Na2SiO3 + NaOH)/Fly ash = 0.45 Mass of (Na2SiO3 + NaOH)/384 = 0.45 Mass of (Na2SiO3 + NaOH) = 172.8 kg/m^3

Take the sodium silicate to sodium hydroxide ratio by mass 1 Mass of sodium hydroxide solution (NaOH) =AAL/3.5

= 172.8/3.5

= 49.37 kg/m^3

Mass of sodium silicate solution (Na2SiO3) = solution=2.5× sodium hydroxide solution water= 2.5 x 49.37 = 123.42 kg/m^3

3. Calculation of total solid content in alkaline solution

The concentration of solid content in NaOH or Na2SiO3 be based on weight and the composition of NaOH (44.4 percent of solids by weight for 12 M) and Na2SiO3 (40.6 percent of solids by weight as defined mostly by supplier), is shown below.

Mass of solids in NaOH = (44.4/100)×49.37 = 21.92kg

Mass of water in NaOH = 49.37 -21.92 =27.45 kg

Mass of solids in Na2SiO3 = (40.6/100)×123.42 = 50.10kg Mass of water in Na2SiO3 =123.42– 54.42 = 73.32 kg

4. Calculation of additional quantity of water (Wextra)

Water (sum of masses of additional free water and water used during the preparation of Na2SiO3 and NaOH) to geopolymer binder (sum of masses of fly ash, alccofine, NaOH solids and Na2SiO3 solids) ratio (W / GPB) was kept at 0.27, Pavithraet al.2016).

$$\frac{W}{GPB} = \frac{WOH + WSI + Wextra}{AF + FA + SolidsNaOH + SolidsNa2SiO3} = 0.27 \ldots\ldots\ldots$$

Moreover, the AF-GPC-Graphs has been developed for W/GPB equals to 0.27. So, extra water quantity can be calculated using the Eq (W_{extra}+27.45+73.32)/(38.4+384+21.92+50.10) = 0.27 from which W_{extra} = 51.62 kg.

Total solid content = Mass of solids in NaOH + Mass of solids in Na2SiO3= 21.92+ 50.10 = 72.02 kg/m^3

5. Selection of water content

For medium degree of workability and fineness of fly ash of 384 m^2/kg, water content per cubic meter of geopolymer concrete.

Water content = 110 kg/m^3

6. Adjustment in water content

For sand conforming to grading-3, correction in water content Adjustment in water content = -1.5%

Total quantity of water required = 110- (1.5/100) x 110 =108.35 kg/m^3

7. Calculation of fine and coarse aggregate content

Total aggregate content = (Wet density of GPC) - (Quantity of fly ash + Quantity of both solutions + extra water) = 2400 – (384 + 172.8 + 51.62) = 1791.58 kg/m^3

Sand content = (Fine – to - total aggregate content in %) x (Total quantity of all-in- aggregate) = (35/100) x 1791.58 = 627.053 kg/m^3

Coarse aggregate content = (Total quantity of all-in-aggregate) - (Sand content) = 1791.58 – 627.053 kg/m^3 = 1164.52 kg/m^3

Quantity of materials required per cubic meter for M30 grade of geopolymer concrete.

Table 4.6: Materials required for M30 grade geopolymer concrete

Ingredients of geopolymer concrete	Fly Ash	NaOH	Na2 SiO3	Sand	Coarse Aggregate	Alccofine (AF)	Extra water
Quantity (kg/m3)	384	49.37	123.42	627.052	1164.52	38.4	51.62

V. CHAPTER 5 RESULTS AND ANALYSIS

Workability

Workability is measured by slump test. Cubes were casted in two batches, every batches consist a 12cubes and four cubes of each molarity concentration.

Table 5.1 workability of 1st batch of geopolymer concrete

Molarity	10M	12M	14M
Workability (slump)	65	72	80

Table 5.2 workability of 2nd batch of geopolymer concrete

Molarity	10M	12M	14M
workability	68	75	84

These table shows workability of geopolymer concrete. Workability increases as the molarity concentration increases.

COMPRESSIVE STRENGTH TEST RESULT

Compressive strength test gives an overview of both the concrete consistency, since performance is directly correlated to both the hydrated cement paste structure. Compressive strength was investigated on the cube specimens at 7 and 28 days.

Table 5. 1: Compressive strength of conventional concrete

Grade of concrete	Water-Cement Ratio	7 days compressive strength(N/mm^2)	14 days compressive strength (N/mm^2)	28 days compressive strength (N/mm^2)
M30	0.45	26.93	34.93	43.2

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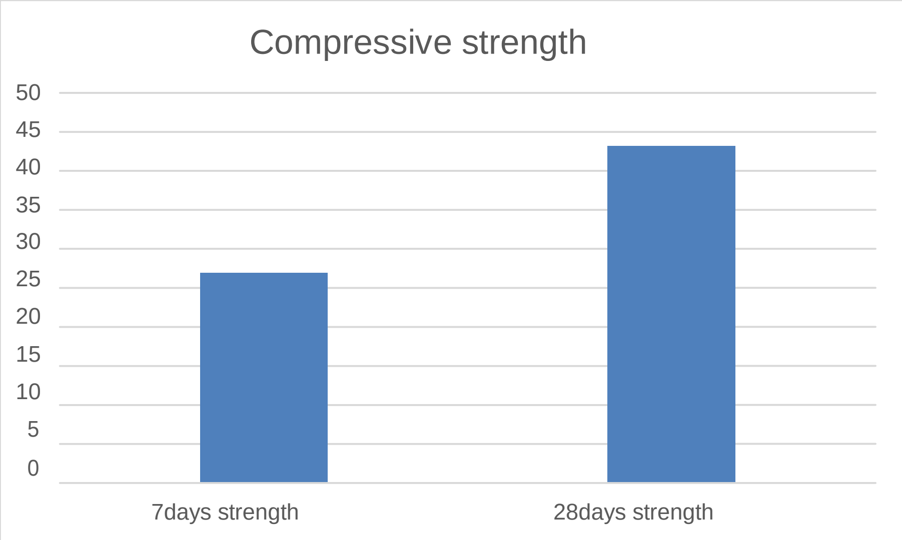

Fig 5.3: Variation of compressive strength for conventional concrete

Table 5.2: Compressive strength of geopolymer concrete (C&D waste)

Concentration of NaOH	7days strength (N/mm2)	28days strength (N/mm2)
10M	18.96	27.4
12M	19.02	28.9
14M	21.9	29.7

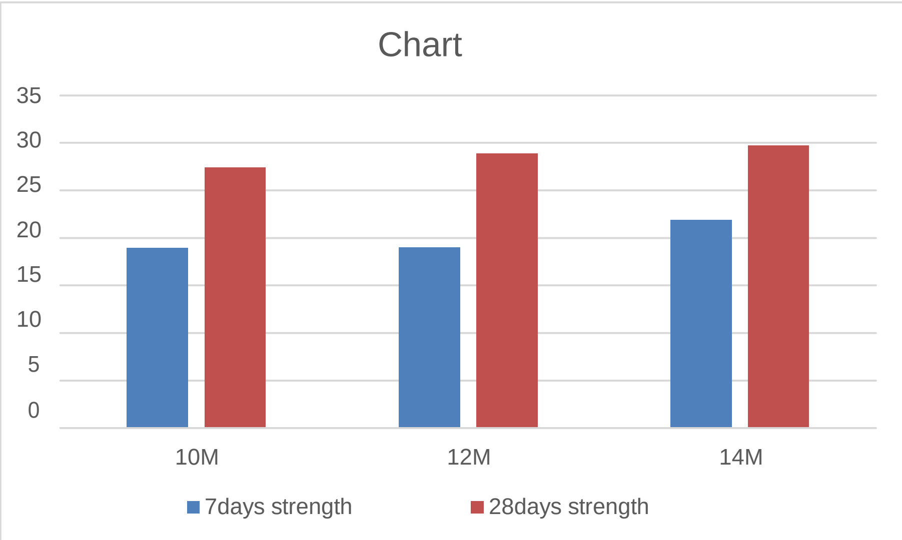

Fig 5.4: Variation of compressive strength for geopolymer concrete with recycle concrete aggregate

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Fig 5.2 shows that the compressive strength of geopolymer concrete increases with the number of days passes as well as the molarity concentration increases.
Comparison of conventional concrete and geopolymer concrete (RCA) with every concentration of NaOH (10M, 12M and 14M).

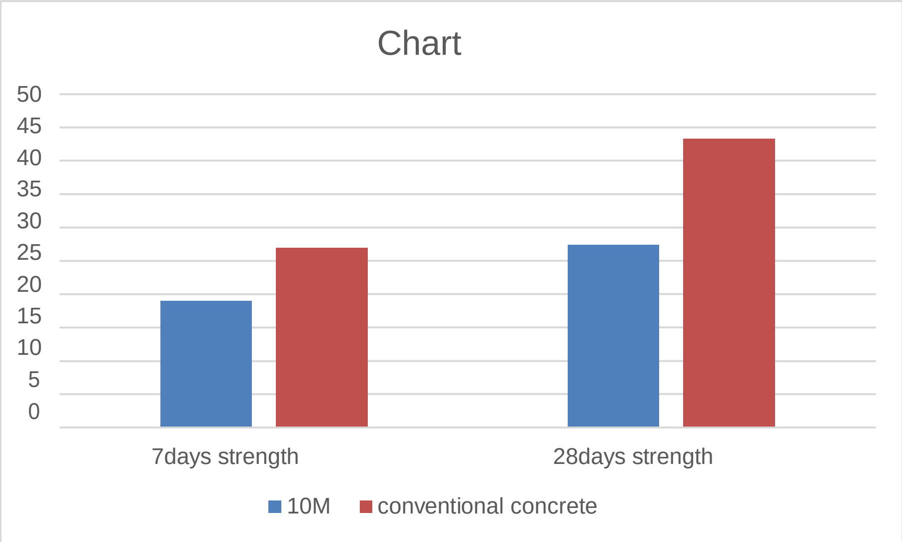

Fig 5.5: **Comparison of compressive strength for conventional and geopolymer concrete (10M)**

Reduction in M30 grade of compressive strength is 35% (10M) were observed when the natural aggregate replaced by recycled concrete aggregate.

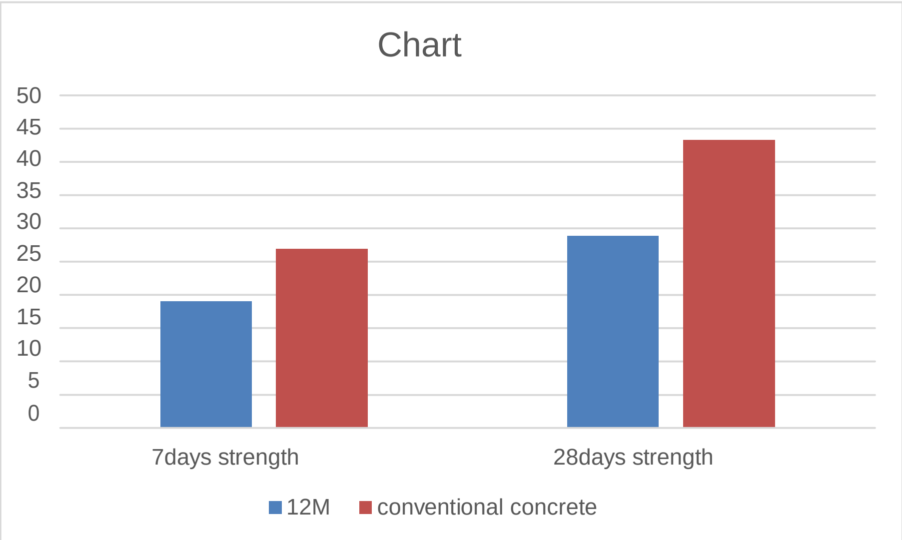

Fig 5.4: **Comparison of compressive strength for conventional and geopolymer concrete (12M)**

Reduction in M30 grade of compressive strength is 33% (12M) were observed when the natural aggregate replaced by recycled concrete aggregate.

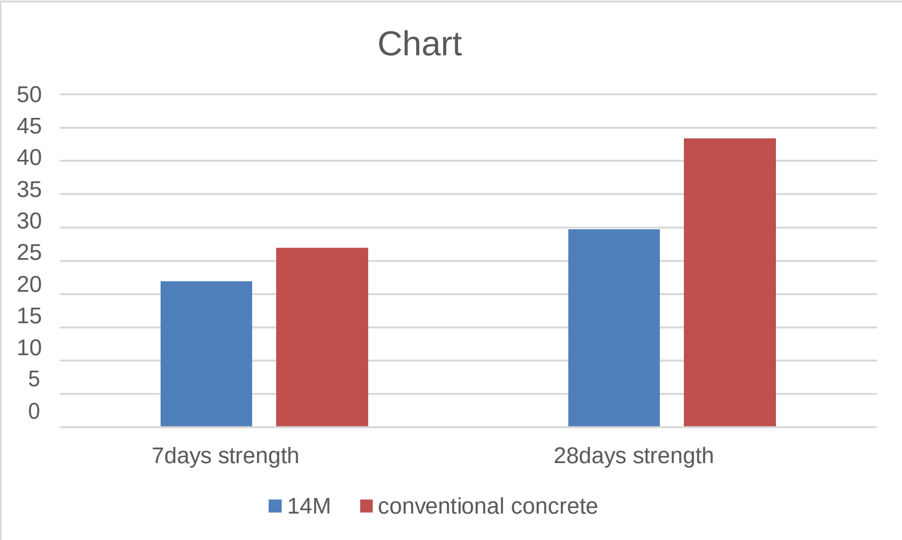

Fig 5.5: **Comparison of compressive strength for conventional and geopolymer concrete (14M)**

Reduction in M30 grade of compressive strength is 31.3% (14M) were observed when the natural aggregate replaced by recycled concrete aggregate.

It is observed that strength of conventional concrete is higher than the geopolymer concrete from recycle concreter aggregate at the age 7 and 28 days. However, at the age of 28 days, the strength of the GPC is less than conventional concrete. In GPC there is polymerization process in which water comes out and reduce the strength of GPC and the other reason is GPC were casted using recycle concrete aggregate, on the other hand in conventional concrete there is hydration process in which the water is consumed and the strength gain is much at the age of 28 days because hydration of the concrete is completed significantly and 99% strength of OPC is achieved.

Environmental and economic benefits

In a recently published report (Material consumption patterns in India, 2016), it showed the effects and consumption of natural coarse aggregates in India. Quarrying operations cause destruction of natural ecosystems and wildlife habitats, disruption of hydrological resources, air and noise pollution due to blasting, drilling and movement of heavy vehicles. At the same time, the demand for natural aggregates is expected to increase, since concrete will remain the main component of construction. According to the report, the construction industry in India will have a demand of more than 2 billion tones aggregates by 2020. Therefore, use of alternative materials is a way forward for sustainable practice. The results of current study clearly show that recycled concrete aggregates can be used in making of concrete, and this will have environmental benefits by reducing our dependence on mining for natural aggregates. Also, Indian roads are mostly paved by bituminous concrete and the trend of milling existing deteriorated pavement is growing. Therefore, the amount of recycled concrete aggregate generated is more when compared to that utilized in the construction industry. The economic benefit of replacing natural aggregates by recycled concrete aggregates was evaluated. The cost of geopolymer concrete primarily depends on the aggregates and the chemicals used.

VI. CHAPTER 6 CONCLUSION

Conclusion

- Result obtained from activation mixture of recycle concrete aggregate with different proportioned alkali activator prove the possibility of producing geopolymer cement from construction wastes.
- Results obtained for 28-day compressive strength confirm that waste concrete is suitable for geopolymerization reactions. The maximum achievable 28-day compressive strength is 30 MPa.