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INVESTIGATION ON GEOPOLYMER CONCRETE KERB STONE

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Abstract - *Nowadays, the impact of cement manufacturing for construction applications is growing because to the increased urbanization in developing countries. Cement manufacture generates huge amounts of greenhouse gases, which are to responsible for global warming. In our research, we primarily focus on OPC concrete kerb replacement using fly ash-based geopolymer. Alumino-silicate materials like fly ash, GGBS, metakaolin, and other similar materials can be geo-polymerized in a technique that does not require cement for binding, hence lowering the environmental impact. Therefore, the primary goal of this research project is to use geopolymer concrete based on fly ash to improve the kerb's qualities. This research also focuses on lowering the carbon footprint produced by Cement & Fresh Aggregates by using a C&D waste like Reclaimed Asphalt Pavement Material (RAP) in different replacement conditions. Our exploratory investigations have demonstrated that fly ash could be utilised effectively in concrete as a full reinstatement for cement. The compressive and flexural strength of M-40 grade GPC 0% RAP is more than the GPC with 100% RAP. Based on our findings, up to 50% RAP–aggregates could be used in geo–polymer kerb for better strength compared to completely replacement of RAP. As we replace RAP with coarse aggregate it significantly reduces the cost.*

Keywords: Geopolymer Concrete, M-Sand, Fly ash, RAP, Alkali Activators, Carbon Footprint

1.1 INTRODUCTION

One of the global industries with the quickest growth rates is construction. Current estimates indicate that 30 billion tonnes of cement are required annually throughout the world. Since limestone is the main ingredient in ordinary Portland cement, a huge lack of the material is possible in the next 25 to 50 years. Secondly, one ton of cement generates 1–ton of CO2, which was a serious environmental problem. Therefore, it is recommended to seek for new binder materials.

The impact on cement usage in the construction stream is increased as a result of the infrastructure's rapid growth. Huge gas emissions from cement lead to global warming and are extremely dangerous to human life.

The thermal industry generates a lot of fly ash, which is then just deposited on the ground. Toxic chemicals leach into the groundwater supply from industrial waste. These problems may be solved by rearranging the components in Geopolymer Concrete. Since geopolymer concrete does not include cement, there will be a reduction in the production of cement, and hence a decrease in carbon dioxide emissions. With its high strength-to-weight ratio, low permeability, resilience to chemicals, and low combustibility, geo polymer has become a popular choice among these binders.

1.2 GEOPOLYMER CONCRETE KERB

In 1978, a French scholar named Davidovits coined the term "geopolymer" to describe a wide variety of materials characterised by inorganic molecular networks (Geopolymer Institute 2010). The geopolymer gets its silicon (Si) and aluminium (Al) from thermally activated natural resources like Metakaolinite or industrial wastes like fly ash or slag (Al). Binder is produced by dissolving silicon and aluminium in an alkaline activating solution, which causes them to polymerize into molecular chains.

It is possible to create geopolymers without using cement by using chemicals of alumino-silicate materials as fly ash, GGBS, metakaolin, etc. Calcium is important because it can enhance flash setting, which must be properly monitored, in geopolymers made from fly ash.

The source material is mixed with both a secondary supply of silicate and an activating solution that provides enough alkaline (usually sodium hydroxide or potassium hydroxide) to liberate the Si and Al (sodium silicate is most commonly used). Heat may be required to induce polymerization depending on raw materials and activating solution, while certain systems has been created to cure at ambient temperature.

1.3. Objective of The Study:

The aim of this project investigations is as per the following:

1. To design and develop drain integrated kerb system.

2. To characterize the laboratory properties of the materials used in drain integrated kerb.

3. To demonstrate the installation and working of drain integrated geopolymer kerb for a test stretch in urban condition.

4. To evaluate the cost and compare with conventional surface drainage system in urban condition.

2.1 Methodology:

The phase sequences of this study are as follows:

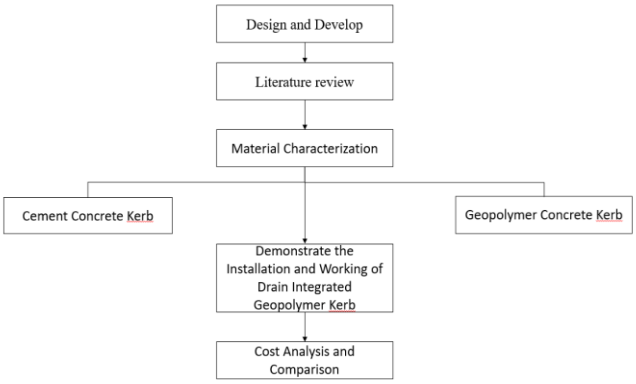


Chart-1: Flowchart of Methodology.

2.2 MATERIAL COLLECTION AND SPECIFICATIONS

2.2.1 Coarse aggregate (IS: 383-1970)

It is gathered from a local source that is close by. The utilized coarse aggregate has a specific– gravity of 2.74, a water-absorption of 2.0%, and impact and crushing values of 20.2% and 25.27%, respectively.

2.2.2 Fine aggregate (IS: 383-1970)

It is gathered from a local source that is nearby. M-Sand, which is retained on a 4.75mm size sieve, is the fine aggregate that is utilized. where the specific gravity is 2.66, the fineness modulus is 3.43, and water absorption is about 0.7%.

2.2.3 Fly ash (IS 3812-2013)

It is a resource produced from coal burning. Here, type F fly ash is utilized, which has reduced calcium level. It is a binding substance that helps concrete have fewer voids. Fly ash has a fineness of 0.6% and a specific gravity of 2.3.

2.2.4 Alkaline activators

Alkali activator utilized in this is NaOH (Sodium hydroxide) and sodium silicate (Na2SiO3). To ensure proper binding for the geopolymer mix, sodium hydroxide is employed as alkali activators in the form of flakes with water. The mass ratio of NaOH to Na2SiO3 is maintained at one.

2.2.5 Reclaimed Asphalt Pavement (RAP)

When pavement materials are damaged, taken out, or repaired, these materials are produced. This includes crushed aggregates and asphalt. Here, a 10mm down sieve size RAP size is utilized. In this present study available RAP is used with varying percentages of 0%, 50% and 100%.

2.3 MIX PROPORTIONING FOR GPC KERB

It is a method of determining the relative quantity of ingredients needed to make concrete with the required strength at a reasonable price. Strength, workability, and durability are just a few of the many characteristics of GPC which are strongly impacted by its composition. GPC is made up with one or maybe more material (such as fly ash, GGBS, metakaolin etc.), alkaline activators (such as silicates and hydroxide solution), aggregates and chemical admixtures. Using various naturalresources, alkali activators, and cure regimes to make GPC leads to a complex mix design. As a result, before developing a concrete, materials attributes should be considered.

2.3.1 Mix design for M-40

Where, M-40 mix design is prepared. The cube size of 150*150*150mm and beam size of 100×100×500mm specimens were casted with addition of 0 %, 50 % and 100 % RAP.

Materials	Quantity (kg/m³)
Fly ash	400
Fine aggregate	500
Coarse aggregate	700
Sodium silicate	200
Sodium hydroxide	200

Mix Proportions

2.4 BASIC TESTS ON MATERIALS

1. Coarse Aggregate
   a. Specific gravity
   b. Water absorption
   c. Sieve analysis
   d. Aggregate impact value
   e. Aggregate crushing value
2. Fine Aggregate
   a. Fineness modulus
   b. Specific gravity
3. Fly ash
   a. Fineness
   b. Specific gravity

3. CASTING AND CURING OF SPECIMEN

Geopolymer Concrete is mixture of fly ash,coarse, fine aggregate and RAP. In this research work, M-40 grade GPC is used.

3.1 General

Moulding: **3 layers, 25 blows**

Demoulding: **After 24 hours.**

Type of Curing: **Oven curing**

Curing periods: **24 hours**

3.2 CASTING OF MOULD

4 Result and Discussion

4.1 General

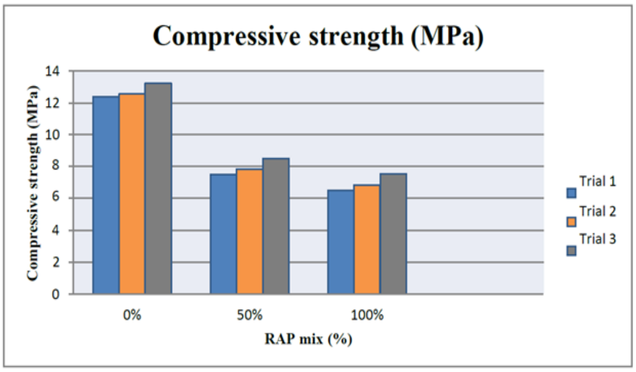
Experimental investigation is carried out on M-40 concrete with the incorporation of RAP 0, 50 and100% percentages. In this mix proportions various parameter are tested. Compressive, flexural strength and fatigue resistant, obtained by performing tests conducted and discussed.

4.2 GEO POLYMER MIX PROPORTIONS

Trial mix	Fly ash (kg/m^3)	NaOH (kg/m^3)	Na2SiO3 (kg/m^3)	Fine aggregate (kg/m^3)	Coarse aggregate (10mm) (kg/m^3)	RAP (kg/m^3)
1	400	200	200	500	700	0
2	400	200	200	500	350	350
3	400	200	200	500	0	700

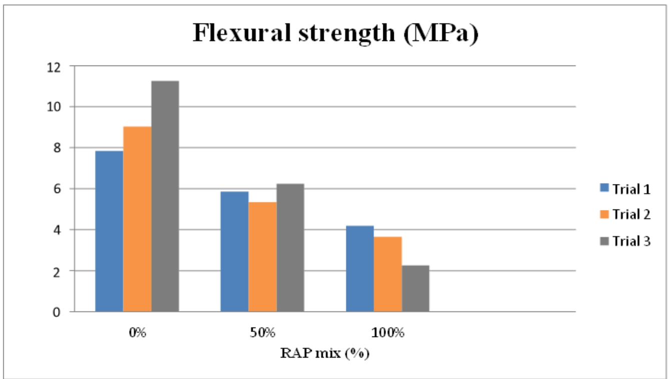
4.3 COMPRESSIVE STRENGTH

Both the average compressive strength of GPC with and without RAP addition are shown in figure 4.1, as well as in table 4.2. The combination of GPC with 0% RAP yields the highest compressive strengths (12.4, 12.5 and 13.22 MPa). The results demonstrate that its hardness contributes positively to its quality.



4.4 FLEXURAL STRENGTH

The best execution was previously mentioned for the geopolymer mixture consisting of 0% integration of RAP and demonstrated in Table 4.3. Flexural strength of various geopolymer concrete implies significant improvement with the addition of fibers using 2-point loading setups.



5 Scope

- ***Geopolymer concrete*** is a new type of construction material that is both innovative and environmentally beneficial. It is an alternative to Portland cement concrete. We can reduce global warming, which is one of the world's major problems, by employing geopolymer concrete.
- Geopolymer minimises the demand for Portland cement, which emits a lot of CO2.
- Waste resource such as fly ash are used in the production of geopolymer concrete.

6 Cost Analysis

6.1 Cost Analysis for Normal Drainage Work For 1km Stretch

Soil dressing	Cum	300.00	28.13	8,439.00
Granite jelly layer	Cum	240.00	177.00	42,480.00
PCC	Cum	160.00	3000.00	4,80,000.00
RCC	Cum	1260.00	3500.00	44,10,000.00
Shuttering	Sqm	6302.58	131.65	8,29,735.00
Steel	MT	43.32	7600.00	3,29,232.00
TOTAL				**60,99,886.00**

6.1.1 Cost Analysis for 1 unit of conventional concrete

Materials	**Mix proportion Kg/m^3**	**Kg/m^3**	**Price per kg**	**Cost for material**
Cement	430*0.04	17.2	9	154.8
Coarse aggregate	1030*0.04	41.2	0.65	26.78
Fine aggregate	718*0.04	28.72	0.8	22.97
Total cost				204.55

6.2 Cost Analysis for Geopolymer Concrete Drain for 1km Stretch

Sl.no	Length	No.of kerbs for 1M	No.of kerbs for 1km	Cost per unit kerb	Total Kerb cost for 1km stretch
1	1000	2.174	2174	197.00	4,28,300.00

Labour Cost: - 43,500.00

Transportation: - 10,000.00

Excavation: - 8,500.00

TOTAL COST: - 4,90,300.00

6.2.1 Cost Analysis for Geopolymer Concrete Drain Per Unit

Materials	Mix proportion Kg/m³	Kg/m³	Price per kg	Cost for material
Fly ash	400*0.04	16	0.5	8
NaOH	200*0.04	8	12	96
Na_2SiO_3	200*0.04	8	8	64
Fine Aggregate	500*0.04	20	0.8	16
Coarse Aggregate	350*0.04	14	0.65	7
RAP	350*0.04	14	0.4	5.6
Total Cost				**196.6**

7 CONCLUSIONS

- From these exploratory examinations, its proven that fly ash can be used efficiently as an additive in GPC.
- As GPC has been proven to be effective for pre-cast constructions world-wide, this research has successfully demonstrated the usage of GPC in Kerbs as a sustainable replacement.
- Tests on compression resistance showed that GPC had a higher resistance to compression than conventional concrete kerb.
- It has been discovered that the flexural strength of GPC is more than that of conventional concrete kerb.
- Research showed that 50% RAP + 50% Normal aggregates can be effectively utilized in GPC kerb for better strength & durability compared to completely replacement of RAP as per IRC.
- This research has successfully proven that the unit cost of GPC is same as conventional concrete.
- By reduction of Cement and almost half of fresh aggregates usage, this research was able to develop a strong replacement for conventional concrete kerb.

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