International Journal of Research in Engineering, Science and Management
Volume-2, Issue-8, August-2019
www.ijresm.com | ISSN (Online): 2581-5792

A Study on Thin and Ultra-Thin White Topping Using Geopolymer Concrete

M. N. Lavanya[1], R. Suhas[2]
[1]*Student, Department of Construction Technology & Management, Dayananda Sagar College of Engineering, Bengaluru, India*
[2]*Assistant Professor, Department of Construction Technology & Management, Dayananda Sagar College of Engineering, Bengaluru, India*

***Abstract*: Present scenario of urban road construction is mainly dependant on cement concrete as a paving material as it serves an impermeable & durable service life lasting for many decades. Hence, this huge demand often calls for a greater and a deeper research in this area. In this regard, this project work was taken up to suggest a sustainable alternative to cement concrete which is currently having a lot of environmental concerns. This dissertation work presents an advanced method in inception of a green concrete in Rigid pavement construction especially in urban roads. Geopolymer concrete (GPC) can be an eco-friendly substitute for Cement Concrete used especially in case of Thin (TWT) & Ultra-thin White-topping (UTWT). The present study concentrates more on the usage of Geopolymer concrete with 100% replacement of cement in case of TWT and UTWT. This paper reviews several materials for producing geopolymer concrete such as fly ash, aggregates, M-sand and alkaline solution. Geopolymer concrete which is formed by geo-polymerization process between fly ash and alkaline solution (like sodium hydroxide and sodium silicate). The grade which is chosen for the study is M - 40. The mixes were designed for molarity of 10M, 12M & 14M. Strength properties of the mixes are tested and thus, pavement thicknesses are decided. Based on the design, cost analysis is carried out. Also, energy calculations are carried out & the energy efficiency is analyzed.**

***Keywords*: Molarity, Geopolymer, Fly ash, alkaline solution, Embodied energy.**

1. Introduction

A. General

Introduction includes about present situation about the construction of pavement. Also explains about objective, aim and scope of the project.

Highways in addition to transport has definite to shift in the direction of manufacture concrete pavement. The defaulting mode of structure on national highways after in view of factor connected to weather condition, consumption of fuel, cost maintenance and service life of pavement. Mainly aims to sponsor environment friendly structure in performance of highway plans.

Preliminary cost of rigid pavement is noticeably higher than flexible pavement, till today flexible pavement has been developed favoured. The lifespan cost of rigid pavement has shown be more inexpensive than flexible pavement, while choosing the type of pavement initially consider the life cycle cost. Life-cycle cost is the primary investment cost and the preservation cost for design life of the pavement construction. The preliminary cost of rigid pavement can be bringing down to some additional of fly ash. It is mix in addition with coarse aggregate and fine aggregate. In this case, Lifecycle cost decreases further. Rigid pavement is normally chosen for location facing hefty rainfall or soaked areas. India takes 4.87 million km way network crosswise the world. It is next largest road network crosswise the world. Frequently 85% of the nation's passenger traffic travel on the Indian road network. Highways and Expressways made with road network much quicker in India. Network in Highway enlarge with the adding of 18,637 km of Expressways in the year 2022. Build hundreds of kilometres of roadway certainly includes high proportion use of natural resources. India's financial development rest on initially safe, efficient, and well-conditioned road ways. It comprises not only National highways also additional roads similar to state highways and village road too. It enables fast movement of requirement of goods and passengers. And also, creation of highways has stretched an all-time in height and still increased step of construction is projected to stay for the approaching years. Indian roads are mostly asphalt-based bitumen roads and relate to concrete roads are identically small.

B. Geopolymer

Defines the chemistry and terminology of geo polymers, and additional analyses of geopolymer knowledge also presented here.

1) Chemistry and terminology

Geopolymer first well-defined by Davidovits in 1978. He also advised chemical breakdown of geopolymer founded on silica-aluminate. Geo polymer concrete moulded by the geo polymerisation between alkaline solution and fly ash.

2) Sources of alkaline liquids and materials

Main elements of geopolymer concrete is alkaline solution and basis materials. Geo polymer which is ironic in aluminium (Al) and Silica (Si) The special of source material for creation geopolymer concrete be subject on the cost, convenience,

demand of users, and application of it. Alkaline liquids which is got from alkali metals that are generally sodium or potassium based.

C. Objectives of the study

- To develop high performance GPC incorporating Fly ash and M-sand.
- It evaluates and find about the energy properties of geopolymer concrete due to substitute of cement by fly ash and M-sand.
- To compute the reduction of slab thickness as per IRC-58-2011 with different slab temperature with various concrete mixes.
- It examines the cost and energy analysis of GPC with fly ash and M-sand.

2. Literature review

It includes the literature reviews of various study and use of many alternative materials in concrete.

Chin and Cheng (2003): Study described the production of fire-fight geopolymer with M-sand. The grouping of sodium silicate and potassium hydroxide castoff as alkaline solution. The left-over material by-products fly ash and M-sand are most latent bases of geopolymer. Learning have been linked to use of sources solids.

R. Kawade P. A. Salunkhe S. D. Kurhade (2011): Test consequences have discovered that compressive strength rises with rise in molarity. manufacture of Portland cement contribute5-7% of entire greenhouse gas discharge also munches large quantity energy .so it is important to find substitute to adhesive. Fly ash is a byproduct of coal gained from thermal power bush. also amusing in silica and alumina. The paper, fly ash is hand-me-down to produce a geopolymer material. Geopolymer is a solid subsequent from the response to factual that is ironic in silica, alumina and alkaline resolution. Geopolymer concrete is entirely cement permitted concrete, fly ash turns as folder and alkaline result act as an activator. Fly ash, alkaline activator experience geo polymerization procedure harvest alumina silicate gel. Alkaline resolution use to existing training is grouping of sodium silicate (Na2Sio3) with sodium hydroxide (NAOH)ratio 2.5. Ranking elected to examination stayed M40. mixture was calculated for molarity of 12M, 14M and 16M. Test outcomes have revealed compressive strength surges with growth in molarity.

M. I. Abdul Aleem, P. D. Arumairaj (2012): Learning evaluates the ingredients of geopolymer concrete. Its asset and potential tenders. Geopolymer produced deprived of using in the least cement. Fly ash found by the by -creation of coal gained by thermal power plant and which is ironic in silica and alumina and it is exceptional concrete material than that of present material.

Brajesh Mishra (2015): Paper pronounces white toppings also defines ultra-thin and tinny white toppings Thin white topping is an attached layer of concrete of width 100 mm to 150 mm while an ultrathin layer is 50 mm to100 mm thick When the thinness of the concrete coating is 200 mm, extra and not bonded to the asphalt it is named unbonded or conventional White topping. Bonded White topping, use of ultrathin white topping (UTW) is favoured for deteriorated asphalt concretes with fatigue and rut suffering. real thickness of ultrathin white topping is dependent on traffic filling, present asphalt pavement thinness and grouping of concrete. Due to replication of wheel masses, difference in fever and other environmental belongings most of pavements get injured. Casing of asphalt pavement with a layer of cement concrete is called as White topping.

Harikrishna Damer, and Srikanth Maheshwaram (2017): Work existing aim reviewing the compressive gift behaviour of geopolymer actual with and short of totalling M- sand at dissimilar remedial rules, and also at unlike Molarities of Alkaline liquids involves of fly ash, alkaline liquids and M-sand. Alkaline liquid to the fly ash ratio as 0.45 and also changing cement by100% fly ash. Compressive strength is gritty at 24hrs, 48hrs and 96hrs by oven remedial at temperature 60ºc and likening these results by adding beaker fibres as 0.04% by bulk of geopolymer Concrete.

3. Materials and methodology

A. Materials

1) Fly ash (IS:3812)

Fly ash it is a by-product of waste solid. It is obtained from powdered coal burning and other materials. Its requirement is established to in accordance with Indian standard specification (IS:3812) in our experiment fly ash is taken from Somanahalli, near Yodhavana hills. Thalghatapura, Bangalore. Specific gravity of fly ash is 2.4, and also fineness modulus is 10%.

Fig. 1. Sample of fly ash material

2) Coarse aggregates (IS:383)1970

It is acquired from a local source. The coarse aggregates used size between 10mm to 20mm with fineness modulus is 7.92% and with specific gravity is 2.63. And also tested aggregate impact value is 20.5% and crushing value 35%.

3) Fine aggregates (IS:383)1970

In this study M-sand has been used as a concrete mixture as a fine aggregate as M-sand is produced from gravel, slag and crushed stone. M-sand we should fallow the Indian standard (IS:2386 & IS:383). Specific gravity of fine aggregate 2.25. Also, water absorption 0.4 and bulk density 2.45 g/cm^3.

Fig. 2. Sample of M-sand material

4) Alkaline solution

Alkaline liquid used as a grouping of sodium hydroxide solution and sodium silicate. Sodium silicate solution (Na_2o=13.7%, Sio_2=29% and H_2o=55.9% by mass). Sodium hydroxide we get in pellets or flakes we get it from local contractors. Sodium hydroxide which is in pellets form liquified in water already doing the experiment for 24 hours to contract solution.

Fig. 3. Preparation of Alkaline solution

5) Water

Water is use for partying and preserving of concrete mixture. Which would be clean after salt acid and oil .as they decrease the strength of hardened concrete and fresh concrete. For Portland water we should fallow the IS:456.

B. Experiment investigation

1) Concrete Sample

Mix design of concrete for M40 grade of geopolymer we fallow the IS 10262:2009. I have done with fly ash, M-sand, aggregates. alkaline solution and water, M40 mix of geopolymer prepare cube size 150X150X150 mm and beam size 100X100X500 mm specimens are casted.

Table 1
Mix design for M40 Geopolymer

Materials	Quality in terms (kg/m^3)
Fly ash	400
Fine aggregates	670
Coarse aggregates	1282
Water cement ratio	0.3
Sodium silicate	60
Sodium hydroxide	60

2) Methodology

This research work, M40 grade of geopolymer concrete is used. for the testing of strength tests that is compressive, Flexural and Fatigue flexural strength test with include the average of three specimen after 7,14 and 28 days.

Fig. 4. Concrete mixing

4. Results and discussions

A. Introduction

This section describes the results and discussion regarding experimental works. The results which we got after proper grade of mixing .it also includes properties of hardened and fresh concrete.

B. Fresh concrete test properties

1) Vee-bee test

This test can be done by vee-bee consistometer machine. It is the time required for concrete from moulding to demoulding stage. it should be taken in seconds noted by stopwatch. The results are given below by tables and graph.

Fig. 5(a). Slump test

Fig. 5(b). Vee Bee test

Table 2
Vee Bee test for diff molarity

Molarity	Vee Bee time (s)
10M	20
12M	19
14M	18

2) Compressive strength

Test which measures the ability of the concrete to resist loads done by compressive testing machine. Cubes as to be prepare with 150X150X150 mm. It measures the strength of concrete in hardened state followed by Indian standard code IS:516-1957.

Fig. 6. Compressive test of sample cube

Table 2
Compressive strength of sample cubes

No of days	Average compressive strength
After 7th days	40.2
After 14th days	43.75
After 28th days	45.95

3) Flexural strength of concrete

Flexural strength of the concrete to be find out by beam. After curing of 28 days over it is allow it for complete dry there after it is to be tested by keeping it on flexural testing machine and the results obtained are tabulated in table and plot on graphs.

4) Fatigue test for geopolymer concrete

Table 3
Flexural strength for 28 days for diff molarity

Molarity	Average flexural strength for 28 days
10M	4.8
12M	5
14M	5.1

Fig. 7. Fatigue test for sample beam

Fatigue test regulate the characteristic behaviour of geopolymer material mix below fluctuating loading condition, Test led on the basis of IRC 37:2018, Test are done on conventional M40 grade. The examination specimen is of size of 100X100X500 mm load put on on the specimen are exposed to half sine wave from cyclic loading.

Fatigue test be conducted for evaluating the fatigue life of specimen. Test be shown on loading specimen with 65% of resultant flexural strength in the testing. Fatigue Carried on neat specimens of 65% load for deformation of 3mm vertically.

Table 4
Fatigue test for geopolymer for 65% loading

Cycle Count	Time (sec)	Load Output (kgs)	H1 Out put (mm)	H2 Out put (mm)	V1 Out put (mm)	V2 Out put (mm)
0	0.10	182.36	0.836	1.474	0.424	0.633
500	106.78	184.93	0.825	1.528	0.848	1.382
1000	207.78	208.11	0.810	1.593	1.408	2.010
1500	307.77	271.22	0.905	1.531	2.508	2.65
2000	407.77	275.08	0.885	1.510	2.999	3.355
2500	507.78	168.19	0.751	1.441	3.1	3.89

5. Cost and energy analysis

A. General

The technology and the relative work in construction industrial. Construction of pavements at low maintenance cost. We must talk about utilization of material about its cost. Cost of material is the important thing in the economic and social development of the country and also concentrated on environment positivity.

B. Material cost analysis

Nowadays increase the development of construction industry. But it must be economical. Take any type of project in construction its cost parameters in social development. Economic parameters, the cost of conventional concretes depend upon cost of concrete and materials, the concrete materials like aggregates sand fly ash water etc. they should be economical.

Table 5
Amount savings in $1m^3$ production of GPC and OPC

Concrete grade	Cost of $1m^3$ production of OPC	Cost of $1m^3$ production of GPC	Cost in savings (Rs.)	Savings (%)
M40	4998	4585	413	8.2
M50	5357	4934	423	7.8

From above calculations, the cost of $1m^3$ production of OPC is higher than that of GPC. That is for M40 grade of OPC is8.2% higher than GPC and for M50 grade of OPC is 7.8% higher than GPC. Hence it is concluded that the production of Geopolymer concrete cost is lower than of ordinary Portland cement.

C. Energy analysis

Table 6
Energy savings in $1m^3$ production of GPC and OPC

Concrete grade	Energy (MJ/m^3) for $1m^3$ production of OPC	Energy (MJ/m^3) for $1m^3$ of GPC	Energy savings (MJ/m)	Savings in %
M40	2347.8	1321.1	1026.7	43.8
M50	2571.7	1437.2	1134.5	44.1

Due to widely increase of construction urbanisation, increase

the energy consumption of construction materials. Embodied energy is the considered for energy analysis of construction materials. It expressed in term of MJ/kg.

From above calculations, the energy for $1m^3$ production of OPC is higher than that of GPC. That is for M - 40 grade of OPC, it is 1026.7(MJ/m^3) which means it is 43.8% higher than GPC and for M - 50 grade of OPC is 1134.5(MJ/m^3) that is 44.1% higher than of GPC. Hence it is concluded that the energy saving in GPC higher than that of OPC.

6. Conclusion

- The use of Fly ash can be efficiently with whole replacement of cement 100% there is no necessary to expose the geopolymer to longer curing period.
- Addition of Fly ash and M-sand has considerably enhanced the strength characteristics of concrete.
- Compressive and flexural strength increases with increase in molarity.
- The maximum flexural strength was $5.1N/mm^3$ for higher molarity**.**
- Fatigue strength of 65% the cycles are decreasing as increasing in load.
- Cost of production of GPC is lower and it saves around 8.2% when compared with OPC.
- Energy analysis shows that GPC saves around 44% embodied energy when compared with OPC.

7. Scope of future study

In the present study only, limited experiments are conducted to comparatively study the probability analysis of fatigue and comparison of cumulative fatigue life in different grades of concrete pavements

There will be future studies are as follows:

- To evaluate the strength properties and fatigue behaviour of different grades of concrete.
- To study the effect of different beam size on flexural fatigue strength of concrete at varying stress level
- To develop reliable statistical models on flexural fatigue behaviour of concrete under varying stress conditions due to transit load.
- Stress- strain curve can be plot studied their behaviour.
- Usage of different materials instead of fine aggregate and check for various in strength.

References

[1] Sourav K R. Das, Amarendra K R, Mohapatra and A.K. Path. "Geo - polymer concreate as green concrete for future", IJCER, 2014, pp 21-28.
[2] Brajesh Mishra, "A study on Thin white topping an alternative for pavement treatment", IJERD, Vol. 2, 2015, pp. 07-11.
[3] Singh, B. Ishwarya, G. Gupta, and Bhattacharyya S. K, "Recent developments of Geo polymer concrete", Construction and Building Materials, CSIR, Vol. 85, Jan. 2015.
[4] S. P. Shide, "Ultra white thin topping", ISOR, pp. 123-132, Nov. 2015.
[5] Hari Krishna Damera and Sri Kanath Maheshwaram, "Strength properties of fly ash-based Geo - polymer concrete with and without fibres", GJESR, Oct 2017.
[6] Irfat Bashir, Hemant Sood and Kshipra Kapoor "Geo polymer concrete an eco-friendly construction material", IJLREC, Vol. 5, Issue 3, pp. 10-12, May-June 2017,
[7] Hari Krishna Damera and Sri Kanath Maheshwaram, "Strength properties of fly ash-based Geo polymer concrete with and without fibres", GJESR, Oct. 2017.
[8] Chin and cheng, "Fire resistance Geo polymer by granulated blast furnace slag" Mineral Engg., vol. 16. Pp. 205-210, 2003.
[9] S. K. Khanna, C. E. G Justo, A. Veeraragavan, "Highway Engineering".
[10] IS 383:1970 Indian standard specification for "Coarse and fine aggregates from natural source of concrete".
[11] IS 2386:1963 Indian standard specification for "Methods of test for aggregates for concrete''
[12] IS 10262:2009 Indian standard specification for "Mix proportioning guidelines for concrete"
[13] IRC 58:2011 "Guidelines for the design of plain jointed rigid pavements for highway".
[14] IS 516:1959 "Methods of test for strength of concrete.
[15] IS 456:2000 Code practice for plain and reinforced concrete.
[16] IRC 37: 2018 design for flexible pavements.
[17] IRC 76: 2015 "Guidelines for conventional and thin white topping".
[18] Marco Aurelio, Luciano G, Marlova Piva, "A case study about embodied energy in concrete and structural masonry buildings", 2014.