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Very Low Permeability Geomembranes Geosynthetics Design and Analysis of its Erosion Control Behavior

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Abstract-Geopolymers emerge as an ecological alternative for construction materials. These consist of a mixture of aluminosilicate sources and an alkaline solution that dissolves the silicon and aluminum monomers that come from the source to generate a gel called GP that will control the main properties of the geopolymer. The geopolymer stands out for having good resistance to compression, as well as good resistance to high temperatures and corrosive environments. They have great potential as a replacement for classical technologies such as concrete, however, require further applied research to determine their feasibility on an industrial scale.

Keywords- geo polymers, gel N–A–S–H; aluminum; silicon; sodium

I. INTRODUCTION

A geomembrane is very low permeability synthetic membrane liner or barrier used with any geotechnical engineering related material so as to control fluid (liquid or gas) migration in a human-made project, structure, or system. Geomembranes are made from relatively thin continuous polymeric sheets, but they can also be made from the impregnation of geotextiles with asphalt, elastomer or polymer sprays, or as multilayered bitumen geocomposites.

Continuous polymer sheet geomembranes are, by far, the most common. Geomembranes are thin, flexible materials that are manufactured in factories in a controlled environment. Geomembranes can be permeable or impermeable. Impermeable geomembranes are often used as a water barrier in hydropower structures, while permeable geomembranes are applied for the seepage water to pass by without taking away the soil. Geomembrane products are engineered to help provide cost-effective solutions and to meet specific design requirements in fluid barrier, containment and other geotechnical applications.

Geomembranes have been used since the 1950s and their use has steadily increased as a result of water resource concerns. It is now common to find local and state regulations calling for infrastructure designs that use geomembranes for containment, lining, and capping. Whether for potable water or animal waste, these materials have become central to project acceptance and success.

II. GEOMEMBRANE WORK

Geomembrane work is very useful when dealing with dams. Seepage control is just one use for geomembranes. They can be used when working with canals, reservoirs, storage basins, dams, and tunnels. In Europe, geomembranes have been used to repair old concrete and masonry dams. A geomembrane is a polymeric membrane that constitutes a flexible, watertight material with a thickness of one-half millimeter or more. The manufacture of geomembranes is done with a wide range of polymers. The types of polymers used can include plastics, elastomers, and blends of polymers. In the old days, geomembranes were installed on the upstream side of structures with either nails or adhesives. More recently, stainless steel anchors are prolific. This type of system uses two vertical U-shaped anchors. One anchor is larger than the other. The smaller anchor is fastened to the face of the structure first. Then the larger anchor is placed over the smaller one and connected to the face. This creates two voids to be filled with geomembranes.

III. POLYMERIC GEOMEMBRANES

Polymeric geomembranes are widely used as liners and covers for ponds, canals, reservoirs (liquid containments), and landfills (solid-material containment). The water vapor transmission values of thin (less than 1 mm thick) PVC and polyethylene membranes are very low, corresponding to hydraulic conductivities in the range 10^{-12}–10^{-15} ms^{-1}. Therefore, the simplest applications of geomembranes as hydraulic barriers (e.g., canal lining) rely on high-quality manufacturing (limited defects), field seaming, and minimization of installation damage.

These issues are addressed by specifying minimum values of the membrane thickness, puncture, tear, and impact resistance. Liner designs always include a protective soil cover to minimize risks of puncturing the membrane during service and to reduce problems of polymer degradation (due to UV exposure, etc.). Side-slope stability (raveling of the cover soil) is controlled by the interface shear resistance, while tensile strength parameters can be evaluated by considering the anchorage forces on the stretched membrane. Liner designs for storage of liquid chemicals are clearly intended to prevent transport of these contaminants into the underlying groundwater system. These situations favor the most chemically stable polymeric materials such as HDPE, while defects in the membrane (and/or its seams) will control the overall transmissivity of the liner. Geomembranes are often used together with a compacted clay liner to reduce the mass transport of chemicals.

IV. SCOPE OF WORK

Research indicated some noticeable drawbacks of fly ash based geopolymer like hardening characteristics, cracking with age, efflorescence, low reactivity level etc. Studies on the water cured fly ash based geopolymers, has not received proper attention in the past. Some more drawbacks may be noted here. It is observed that dissolution of sodium hydroxide in lower ambient temperature (in winter) is very low. The optimization of temperature level of activator prior mixing is essential to overcome this problem and have a considerably better geopolymer. Again, the rate of poly-condensation is dependent on the choice of oxide/combination of oxides in activator solution for different base and supplementary material/additives. Slow synthesis may provide an amorphous structure but partly crystalline. The sequential development of crystallized compound within the pores affects the product performance.

Objectives

The objectives of the research are:

- Examine the effect of different type of soils on erosion control performances of geopolymerGeomembranes.
- Evaluate the run off erosion control percentage of geopolymerGeomembranes in vegetated condition for different weaves.
- Designing of Geomembranes for better erosion control percentage.
- Mechanical strength and durability study of process modified geopolymer mortar and compare with conventional heat cured geopolymer and control cement mortar.
- Study on structural behaviours such as compressive strength, flexural strength, split tensile strength and bond strength of process modified geopolymer concrete and to compare with conventional heat cured geopolymer concrete.

V. RESEARCH HYPOTHESIS

Due to growing industrial production, the generation of wastes has been increased many folds with time and disposition is a challenging problem. On the other hand, carbon dioxide emission has increased to a great extent causing global warming. There is scarcity of ore also. Under this circumstances fruitful application of the waste materials is the need for the day. Limited use of waste materials (like slag, fly ash etc.) are made in cement manufacturing but major portion is used in road construction or for any filling purpose. This may create ground water contamination problem due to leaching of toxic and heavy metals, ultimately reaching to underground water reservoir. Joseph Davidovits introduced geopolymer as a synthetic material primarily.

VI. PROPOSED METHODOLOGY

1. Geopolymer Concrete (Gpcs)

Industrialization and road infrastructure are the two important aspects of a national growth, which critically depend upon power sector and production of cement. For power sector, India is largely depends upon coal based thermal power plants, these plants produce huge quantity of fly ash, which causes various environmental problems. Infrastructure development needs "cement" in large quantities. As cement demand increases, production also increases. Every ton of production of cement releases approximately one ton of Carbon-di-oxide into the atmosphere. Thus production of electricity and cement contributes huge amount of carbon-di- oxide emission and fly ash to the environmental pollution, which makes life on earth miserable. The fact we need to focus is depletion of natural resources, it is inevitable we have to look for alternative to ordinary Portland cement (OPC).

Geopolymer Concrete (GPCs) is one, which the potentiality of replacing OPC. It is a new class of concrete based on an inorganic alumina silicate binder system compared to the hydrated calcium silicate binder system of concrete is activated by alkaline liquids to produce the binder. The basic material used for the activation of the geopolimerization process is Fly ash, which is used in replace of conventional Portland cement.

To activate content in fly ash, sodium hydroxide solution and sodium silicate solution is used in combination. The geopolymer possesses the advantages of rapid strength gain, elimination of water curing, good mechanical and durability properties and are eco-friendly and sustainable alternative to Ordinary Portland Cement (OPC) based concrete. In the construction industry mainly the production of Portland cement causes the emission of air pollutants which results in environmental pollution. It reduces 80 - 90% CO_2 emissions.

Geopolymer is a material resulting from the reaction of a source material that is rich in silica and alumina with alkaline solution. This material has been studied extensively over the past few decades and shows promising as a greener alternative to ordinary Portland cement concrete. It has been found that Geopolymer has good engineering properties with a reduced carbon footprint resulting from the zero-cement content. Durability parameters depend on the pore structure of concrete matrix. When fibers like polypropylene are added to this concrete, its mechanical properties enhance. As its resistance against bending increases it becomes more suitable for Rigid pavements.

As such, for sustainable development, it is imperative, cement usage should be reduced and pollution causing fly ash should be utilized in huge quantities.

2. Methodology

1. Carrying exhaustive literature survey regarding various topics of project like Geopolymer concrete, fly ash, admixtures, mix design, paving properties, various standard testing methods etc.
2. Collection of various materials required for the studies. It is proposed to use Nayvelli fly ash, CONPLAST SP430 manufactured by FOSROC Limited, and cement Ultratech (43 grade), sodium hydroxide solution, sodium silicate solution in addition to this various other materials like sand, aggregates of different sizes are collected.
3. Various basic tests on materials are conducted. After proportioning and mix design of Control concrete, Geopolymer concrete, and Geopolymer concrete with polypropylene fibres, cubes and

beams are casted and tested for various paving properties.

4. Based on the results, conclusions are drawn
5. Preparation of project report in detail

VII.RESULT AND SIMULATION

7.1 Hypothesis Of The Study

Based on the extensive literature review, following hypothesis are framed.

Hypothesis 1:

H01: There is no significant possibility of some kind of time compressive strength increase when Geopolymer geomembranes geosynthetics (1:4 proportion of chemicals) is being used.

H1: There is significant possibility of some kind of time compressive strength increase when Geopolymergeomembranesgeosynthetics (1:4 proportion of chemicals) is being used.

Table 1. Compressive strength of geopolymer concrete and Fiber %.

Fiber	Compressive Strength
0.5	39.55
1	41.11
1.5	43.11
2	42

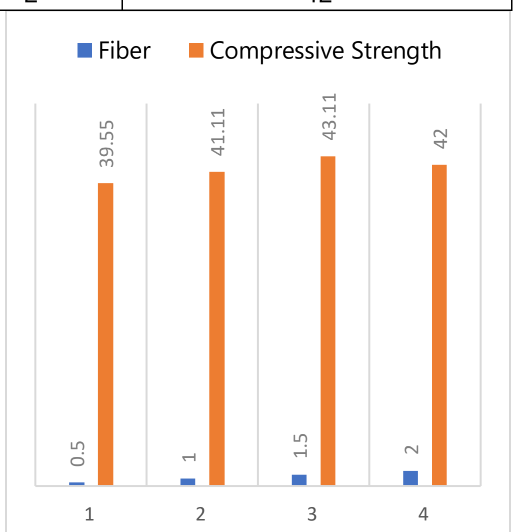

Fig.1 Compressive strength of geopolymer concrete and Fiber %.

Table 2. F-Test Two-Sample for Variances Hypothesis 1.

F-Test Two-Sample for Variances		
	Fiber	*Compressive Strength*
Mean	1.25	41.4425
Variance	0.416667	2.261158
Observations	4	4
df	3	3
F	0.184271	
P(F<=f) one-tail	0.09919	
F Critical one-tail	0.107798	

Test statistics Result:

In this F- Test F >Fcritical, hence Null hypothesis reject, and the alternate hypothesis is accepted.

Interpretation and Discussion:

It is seen that there is significant possibility of some kind of time compressive strength increase when Geopolymergeomembranesgeosynthetics (1:4 proportion of chemicals) is being used.

Hypothesis 2:

- **H01:** There is no significant possibility of some kind of time Flexural Strength Variation possible when Geopolymer geomembranes geosynthetics (1:4 proportion of chemicals) is being used.
- **H1:** There is significant possibility of some kind of time Flexural Strength Variation possible when Geopolymer geomembranes geosynthetics (1:4 proportion of chemicals) is being used.

Table 3. Flexural strength of Geopolymer concrete and Fiber.

Fiber	Flexural strength Strength
0.5	5.015
1	5.155
1.5	5.385
2	5.21

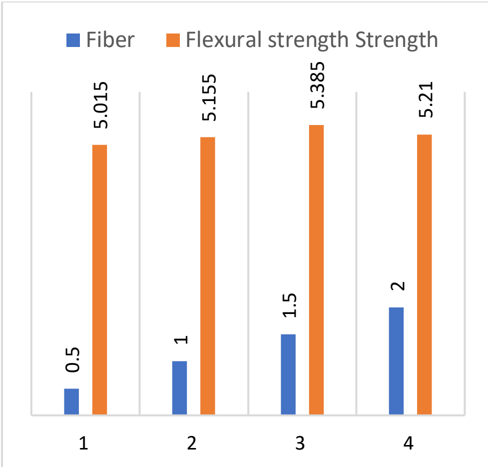

Fig.2 Flexural strength of Geopolymer concrete and Fiber.

Table 4. F-Test Two-Sample for Variances Hypothesis 2.

F-Test Two-Sample for Variances		
	Fiber	*flexural strength Strength*
Mean	1.25	5.19125
Variance	0.416667	0.023423
Observations	4	4
df	3	3
F	17.78885	
P(F<=f) one-tail	0.020509	
F Critical one-tail	9.276628	

Test statistics Result:
In this F- Test F >Fcritical, hence Null hypothesis reject, and the alternate hypothesis is accepted.

Interpretation and Discussion:
It is seen that there is significant possibility of some kind of time Flexural Strength Variation possible when Geopolymer geomembranes geosynthetics (1:4 proportion of chemicals) is being used.

Hypothesis 3:
H01: There is no significant possibility of some kind of time its erosion control behavior Variation possible when Geopolymer geomembranes geosynthetics (1:4 proportion of chemicals) is being used in compressive strength parameters.

- **H1:** There is significant possibility of some kind of time its erosion control behavior Variation possible when Geopolymergeomembranesgeosynthetics (1:4 proportion of chemicals) is being used in compressive strength parameters.

Table 5. Load at failure in KN and CS.

Load at failure in KN	Compressive strength (N/mm2)
970	43.11
955	42.44
960	42.66

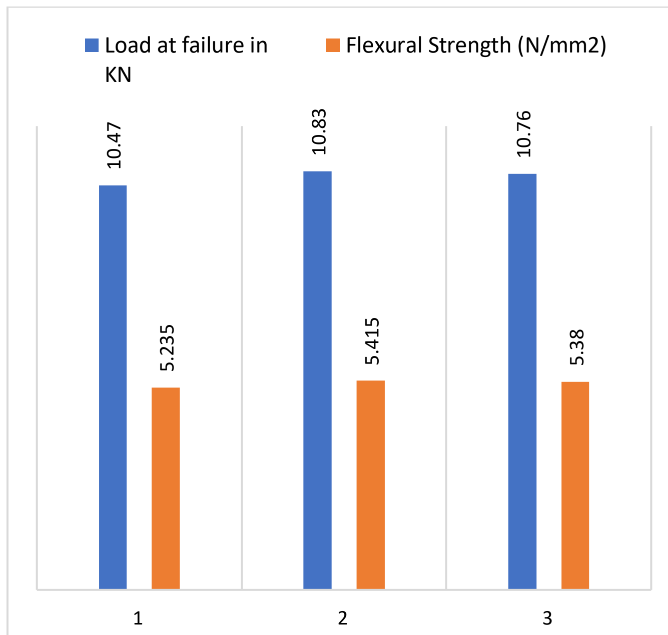

Fig.3 Load at failure in KN and CS.

Table 6. Load at failure in KN F-Test Two-Sample for Variances Hypothesis 3.

F-Test Two-Sample for Variances		
	Load at failure in KN	Compressive strength (N/mm2)

Mean	961.6667	42.73666667
Variance	58.33333	0.116633333
Observations	3	3
df	2	2
F	500.1429	
P(F<=f) one-tail	0.001995	
F Critical one-tail	19	

Test statistics Result:
In this F- Test F >Fcritical, hence Null hypothesis reject, and the alternate hypothesis is accepted.

Interpretation and Discussion:
It is seen that there is significant possibility of some kind of time its erosion control behavior Variation possible when Geopolymer geomembranes geosynthetics (1:4 proportion of chemicals) is being used in compressive strength parameters.

Hypothesis 4:

- **H01:** There is no significant possibility of some kind of time its erosion control behavior Variation possible when Geopolymer geomembranes geosynthetics (1:4 proportion of
- chemicals) is being used in Flexural strength parameters.
- **H1:** There is significant possibility of some kind of time its erosion control behavior Variation possible when Geopolymer geomembranes geosynthetics (1:4 proportion of chemicals) is being used in Flexural strength parameters.

Table 7. Load at failure inKN and Flexural Strength (N/mm2).

Load at failure in KN	Flexural Strength (N/mm2)
10.47	5.235
10.83	5.415
10.76	5.38

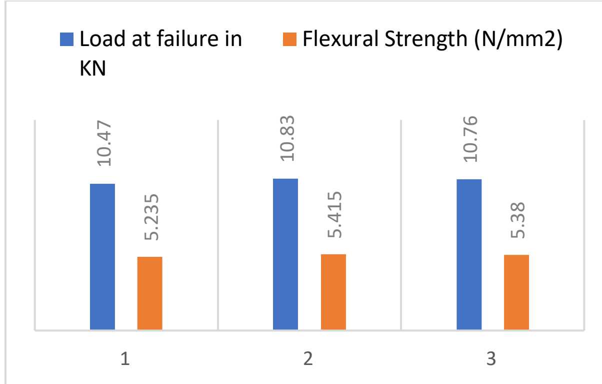

Fig.4 Load at failure in KN and Flexural Strength (N/mm2).

Table 8. F-Test Two-Sample for Variances Hypothesis 4.

F-Test Two-Sample for Variances		
	Load at failure in KN	Flexural Strength (N/mm2)
Mean	10.68667	5.343333
Variance	0.036433	0.009108
Observations	3	3
df	2	2
F	4	
P(F<=f) one-tail	0.2	
F Critical one-tail	19	

Test Statistics Result:
In this F- test F<F critical, hence null hypothesis accepted, and the alternate hypothesis is not accepted.

Interpretation and Discussion:
It is seen that there is no significant possibility of some kind of time its erosion control behavior variation possible when geopolymer geomembranes geosynthetics (1:4 proportion of chemicals) is being used in flexural strength parameters.

VIII. CONCLUSION

The study builds on and contributes to the development of ambient cured geopolymer concrete by taking into consideration of the prevailing local environmental conditions. Although number of studies have been reported with respect to the superior properties of heat cured geopolymer concrete compared to ordinary Portland cement concrete, only limited research work has been reported on the geopolymer concrete composites cured under ambient conditions particularly under Indian environmental situations and mix design approaches. As such, this study provides additional insight into the difference between the ambient and heat cured geopolymer concrete with respect to their strength development, durability in terms of acid resistance and resistance to high temperatures. Finally it can be concluded that replacement of 10-20% ground granulated blast furnace slag (or) ordinary Portland cement in fly ash based geopolymers eliminates the requirement of heat curing,

consequently it widens the applications of the geopolymer concrete beyond its application in precast products. The problem of low strengths at early ages can be compensated by the addition of accelerators or glass/ steel fibers. Durability performance of such geopolymer composites exposed to acidic environment and elevated temperatures is quite satisfactory compared to fly ash based geopolymer concrete cured under heat regime.

1. Compressive strength obtained for normal concrete 40.45N/mm2
2. Flexural Strength obtained for normal concrete is 4.73 N/mm2.
3. Trial ratios of NaOH: Na2SiO3 adopted are 1:2.5,1: 3 and 1:4. At 1:4 M40 grade strength is achieved.
4. Flexural strength of Geopolymer concrete is 5.14 N/mm2 which is more than normal concrete.
5. Cube strength of Geopolymer concrete at 1.5% of fiber at ratio 1:4 ratio is 42.68N/mm2.An increase of 5.51% is observed with fiber, when compared with normal concrete.
6. Flexural strength of Geopolymer concrete 1.5% of fiber at 1:4 ratio of chemicals is 5.38N/mm2.An increase of 13.74% is observed with fiber when compared with normal concrete.

The aim of the present investigation is to evaluate the mechanical properties of heat and ambient cured geopolymer concrete as well as to examine their durability performance with reference to acid resistance and behavior at elevated temperatures. Heat curing was applied for the geopolymer mortar/concrete (GPC) prepared with fly ash as the only source material. Ambient curing is used for geopolymer mortar/concrete (GPCC) prepared with combination of fly ash and GGBS/OPC. The influence of steel and glass fibers on the mechanical properties of ambient cured geopolymer concretes are also evaluated. Influence of various accelerators on the compressive strength development of ambient cured geopolymer concrete is evaluated at days curing period. Durability performance of heat and ambient cured geopolymer concrete is studied by exposing these specimens to 2 and 10% concentrations sulfuric and nitric acid solutions. The effect of elevated temperatures on the mechanical properties of heat and ambient cured geopolymer concretes are investigated.

IX. FUTURE SCOPE OF THE STUDY

The following research areas may be suggested for future scope of study. • Thermal expansion and shrinkage behavior (coefficient of thermal expansion) of nano silica modified geopolymer concrete and process modified geopolymer may be an important area of research.

1. The long term properties of nano silica modified geopolymer concrete and process modified geopolymer concrete (Process – I) may be studied in detail.
2. Detailed stress strain behaviour of modified geopolymer concrete may be an important area of study • The study on the thermal behaviour of such geopolymer concrete (nano silica modified and process modified) at elevated temperature may be an interesting area of research.
3. Similar studies can be executed on slag based geopolymer concrete instead of fly ash. Even a combination of fly ash and slag in the modified process may be an area of research

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