DESIGN A RETAINING WALL USING GEOPOLYMER

BY

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I declare that this project is entirely my own work except where due references are made .

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Abstract

Main purpose of this project is to replace standard concrete with geopolymer concrete. Geopolymer concrete is a "go green" concept where it doesn't use any cement but only replace with fly-ash and also some alkaline activators. This geopolymer concrete is very suitable to build a retaining wall of a port or harbor and also sewage system due to the high early strength of it and also it is high resistance to corrosion attack .

This project will compare the compressive strength of a standard concrete and also the geopolymer concrete by using the same mix proportion to achieve a fair result. Geopolymer concrete will not achieve a high early strength if the procedure and mix proportion are not in order but it still will achieve a strength of a normal concrete .

Conclusion that I made is geopolymer can replace standard concrete but high early strength of it its not guarantee .

Content

CHAPTER 1

1.1 Introduction to geopolymer

The production of portland cement is an energy-intensive process that releases a very large amount of greenhouse gas into the atmosphere . Therefore, efforts have been made to promote the use of pozzolans to partially replace portland cement in concrete production. Other efforts seek to totally replace portland cement with other forms of cementitious materials such as geopolymers.

A geopolymer or alkali-activated cement is an inorganic, alumino-silicate–based material (Davidovits 1999; Hardjito et al.2004a;Bakharev 2005a). The strengths of geopolymer and concrete are of the same order as those made with normal portland cement (Fernandez-Jimenez et al. 2005; Chindaprasirt et al. 2007a). The texture and appearance are similar. Furthermore, it is known that geopolymers possess good mechanical properties as well as fire and acid resistance . A wide range of materials is being used for geopolymerization, including materials rich in Si (e.g., fly ash, slag, and rice husk) and materials rich in Al (e.g., clays like kaolin, bentonite, and burned clays). Because of its availability, fly ash is considered among the important sources of geopolymer).

In this project , it is a Fly ash–based geopolymer concrete (GPC), which is comprised of fly ash, sand, coarse aggregate, and an alkaline solution of sodium hydroxide and sodium silicate, can play a significant role with respect to environmental control of green house effects. The reduction in the carbon dioxide emission from cement production can contribute significantly to global temperature reduction.

Concrete that is exposed to the marine environment is subjected to several types of aggressive agents. These include mechanical agents (e.g., waves and tides), erosion (the effects of waves), chemical attack (sulfates and the action of chlorides in sea water), and climatic agents (temperature variations). Within this context, deterioration of concrete structures might be attributable to aggressive waters (e.g., seawater) or the corrosion of steel reinforcement (i.e., with respect to reinforced concrete). Additionally, concrete durability, independent of its intrinsic characteristics, is variable in accordance with the type of exposure in the marine environment and degree of immersion. Concrete that is in contact with sea water is subjected to various chemical reactions such as those that involve sulfates, chlorides, and magnesium ions.Several chemical mechanisms occur,e.g.,crystallization of expansive salts, precipitation of insoluble composites ,ionic attacks, and so on. Permeability is the major factor for determining the long-term durability of concrete in the marine environment. The denser the concrete, the more difficult it will be for destructive agents to penetrate and flow through its pores.

With respect to geopolymer concrete preparation, the mixture is a 100% byproduct (fly ash), i.e., the portland cement is completely replaced with the geopolymer paste. Current studies on geopolymer concrete are primarily focused on geopolymer technology to prepare fly ash–based geopolymer concrete and property determination. However, no specific publications are available with respect to the durability of geopolymer concrete in the marine environment. This project is to investigate the durability performance of geopolymer fly ash–based concretes that have been subjected to natural seawater exposure by building a retaining wall used at the port .

1.2 Objective

The primary objective of this project is geopolymer able to achieve high early strength . The secondary objective was geopolymer able to replace Ordinary Portland Cement (OPC). The third objective is to compare the compressive strength of geopolymer concrete and control concrete .

1.3 Problem Statement

Due to the excessive carbon dioxide in atmosphere release by production of concrete using cement ,an alternative solution should be use. Geopolymer is an alternative solution for the current situation where it reduces 80% to 90% of carbon emission .

1.4 Scope of studies

The scope defines the design and construction of a retaining wall using geopolymer that must have a high early strength and able to replace cement and also comparison in compressive strength and stress of geopolymer concrete and standard concrete. The research utilized low calcium (ASTM Class F) fly ash as the base material for making geopolymer concrete. The fly ash was obtained from only one source, because the main focus of this study was the short-term behaviour and the engineering properties of fly ash-based geopolymer concrete. As far as possible, the technology and the equipment currently used to manufacture OPC concrete were also used to make the geopolymer concrete. The concrete properties studied included the compressive test .

1.5 Significant of studies

Building a concrete retaining wall that doesn't use any cement but alkaline activators .and fly-ash to replace cement. Geopolymer concrete is an alternative way to replace standard concrete with a "go green" concept where carbon dioxide emission is reduce by 80% - 90% . Furthermore, geopolymer can withstand high corrosive chemical substances and suitable to use in places like port or sewage system where index of corrosive chemical is high in content . Besides that , geopolymer is a high early strength concrete where it gain its maximum strength in the early stage .

Chapter 2(Literature Review)

2.1 Introduction

Davidovits originated the term geopolymer to represent the alkaline binder of silicon and aluminum for polymerization of a source material such as fly ash. Since that time, considerable progress as been madein evaluating the properties of flyash–based geopolymer concrete. This is prepared with the most common liquid alkaline binder, i.e., a combination of sodium hydroxide (NaOH) or potassium hydroxide (KOH) with sodium silicate (Na_2SIO_3) or potassium silicate (K_2SiO_3). Some of the significant contributions are those of Davidovits , Hardjito and Rangan , Wallah and Rangan , Deventer and Provis and Muntingh .

The production of cement is increasing about 3% annually (McCaffrey 2002). The production of one ton of cement liberates about one ton of CO2 to the atmosphere, as the result of de-carbonation of limestone in the kiln during manufacturing of cement and the combustion of fossil fuels (Roy 1999) One of the main contribution material to geopolymer are fly ash. The contribution of Portland cement production worldwide to the greenhouse gas emission is estimated to be about 1.35 billion tons annually or about 7% of the total greenhouse gas emissions to the earth's atmosphere (Malhotra 2002).

Cement is also among the most energy-intensive construction materials, after aluminium and steel. Furthermore, it has been reported that the durability of ordinary Portland cement (OPC) concrete is under examination, as many concrete structures, especially those built in corrosive environments, start to deteriorate after 20 to 30 years, even though they have been designed for more than 50 years of service life (Mehta and Burrows 2001). The concrete industry has recognized these issues. For example, the U.S. Concrete Industry has developed plans to address these issues in 'Vision 2030: A Vision for the U.S. Concrete Industry'. The document states that 'concrete technologists are faced with the challenge of leading future development in a way that protects environmental quality while projecting concrete as a construction material of choice.

Public concern will be responsibly addressed regarding climate change resulting from the increased concentration of global warming gases. In this document, strategies to retain concrete as a construction material of choice for infrastructure development, and at the same time to make it an environmentally friendly material for the future have been outlined (Mehta 2001; Plenge 2001). In order to produce environmentally friendly concrete, Mehta (2002) suggested the use of fewer natural resources, less energy, and minimize carbon dioxide emissions. He categorized these short-term efforts as 'industrial ecology'. The long-term goal of reducing the impact of unwanted by-products of industry can be attained by lowering the rate of material consumption. Likewise, McCaffrey (2002) suggested three alternatives to reduce the amount of carbon dioxide (CO2) emissions by the cement industries, i.e. to decrease the amount of calcined material in cement, to decrease the amount of cement in concrete, and to decrease the number of buildings using cement.

(Fly ash) There are two main types of fly ash, namely Class F and Class C fly ash which are waste products of the combusted coal in thermal power plants. Fly ash is collected in electrostatic precipitators, and then transferred to large silos for shipment. When needed, fly ash is classified by precise particle size requirements, thus assuring a consistant quality product. Class F fly ash is the most commonly found type where it is generally low in lime, usually under 15 %and contains a greater combination of Silica, Aluminium and Iron (greater than 70 per cent)than class C fly ash. Class C fly ash normally comes out of coal power plants with higher lime content generally more than 15 % often as high as 30 %.Elevated levels of Calcium Oxide (CaO) may give class C unique self-hardening characteristics .It is also revealed that the Calcium content in fly ash plays a significant role in strength development and final compressive strength. Higher the Calcium content results in faster strength development and higher compressive strength. However, in order to obtain the optimal binding properties of the material, fly ash as a source material should have low Calcium content and other characteristics such as unburned material lower than 5%, Fe2O3 content not higher than 10%.Itis also stated that the presence of Calcium in flyash in significant quantities could interfere with the polymerisation setting rate and alters the microstructure. Therefore, it appears that the use of low Calcium (Class F) fly ash is more preferable than high Calcium (Class C) fly as has a source material to make geopolymers.

2.2 History

Geopolymers were first trialed in some concrete applications by Glukhovsky and co-workers in the Soviet Union post-world war two, known then as 'soil-cements'. Zeobond staff members have analysed these structures, now over 50 years old, focusing on their inherent durability.And also with respects to archaeological applications, in the mid-1980s, Joseph Davidovits presented his first analysis results carried out on genuine pyramid stones. He claimed that the ancient Egyptians are capable in generating a geopolymeric reaction in the making of a re-agglomerated limestone blocks.

2.3 Material used

Control Concrete	Geopolymer Concrete
Water	Fly ash
Cement	Hydrated Lime
Sand	Gypsum
Course Aggregate	Sodium Hydroxide
Superplasticizer	Sodium Silicate
	Course Aggregate
	Sand
	Superplastisizer

Chapter 3(Methodology)

3.1 Mix Proportion

All design using DOE

Predicted strength =40MPa

MIX PROPORTION FOR GEOPOLYMER CONCRETE :

Material	Density (kg/m^3)
Fly ash	572
Hydrated Lime	38
Gypsum	26
Sodium Silicate	183
Sodium Hydroxide	74
Sand	480
Course Aggregate	1074
Superplasticizer	0.75litter = 100kg of cement ,so 477

MIX PROPORTION FOR STANDARD CONCRETE :

Fly ash = 572

Hydrated lime = 38 } represent cement = 636

Gypsum =26

Sodium Hydroxie =74 } represent water = 257

Sodium Silicate = 183

Course Aggregate(10-12mm) = 1074

Sand = 480

Superplasticizer =477

Formula to get the mass in KG for each material:

0.15 x 0.15 x 0.15 x 15 = 0.050525

+ 10% wastage

Y m3

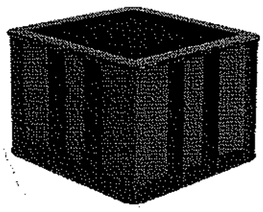
Y x (density of material) = mass of material (KG)

3.2 Material and Equipment

1) 150mm x 150mm x 150mm plastic mould cube

- For casting usage

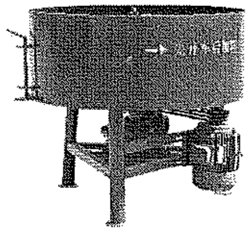
cement and



2) Cement mixer

-To mix or stir

aggregat

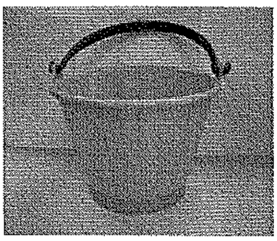


3) Pail

-To put pipe water

the mass of

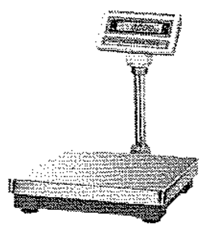
concrete cube



4) Weighing Machine

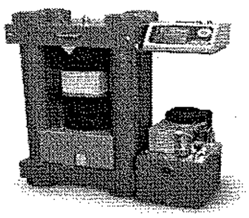
- To measure

Material and



5) Compression Test Machine

- To test the strength of the concrete cube



6) Scoops

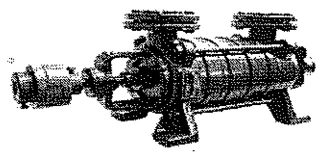
-to ease the work of scooping up cement or fly-ash

7) Hydraulic Oil

-To apply internal surface of platic mould

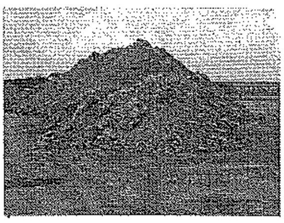
8) Air Compressor

- to ease the job of taking off the concrete cube from the plastic mould



9) Fly ash

(Basically can get from blasting of rocks or hill. Fly ash act as a cement for the geopolymer part due to the content of alumina and silicate)



10) Hydrated lime(Figure 3.2.10A and 3.2.10B)

Calcium hydroxide, traditionally called slaked lime, is an inorganic compound with the chemical formula $Ca(OH)_2$. It is a colorless crystal or white powder and is obtained when calcium oxide is mixed, or "slaked" with water

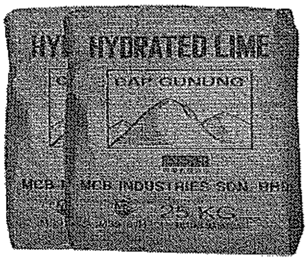


Figure 3.2.10A

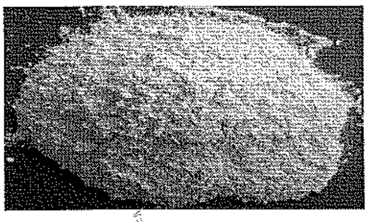


Figure 3.2.10B

11) Gypsum

Gypsum is a soft sulfate mineral composed of calcium sulfate dihydrate, with the chemical formula CaSO. $2H_2O$. It can be used as a fertilizer, is the main constituent in many forms of plaster and in blackboard chalk, and is widely mined

12) Sodium hydroxide (Figure 3.2.12)

(Sodium hydroxide, also known as lye and caustic soda, is an inorganic compound. It is a white solid and highly caustic metallic base and alkali salt which is available in pellets, flakes and granules) The one I using Is pellet types and I need to dissolve it in water to get a sodium hydroxide solution. Concentration used were 10% sodium hydroxide.

Figure 3.21

13) Sodium silicate (Figure 3.2.13)

Sodium silicate is the common name for compounds with the formula $Na_2(SiO_2)_nO$. A well known member of this series is sodium metasilicate, Na_2SiO_3. Also known as **waterglass** or **liquid glass**, these materials are available in aqueous solution and in solid form. The pure compositions are colourless or white, but commercial samples are often greenish or blue owing to the presence of iron-containing impurities.

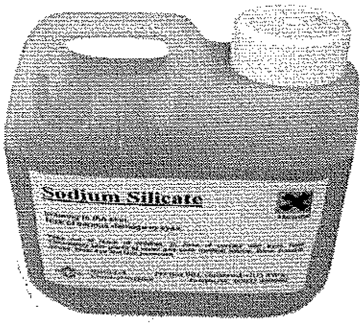


Figure 3.2.13

14) Sand(Figure 3.2.14)

sand were used to represent fine aggregate such as ceramic powder) ,Sand that had been used have the maximum size of 2.36mm. Make sure the sand is fully dried before mixing with other materials to ensure the optimum weight needed.

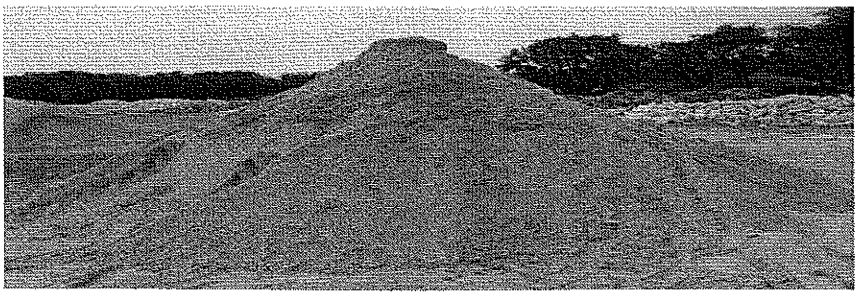


Figure 3.2.14