WASTE TO PRODUCT : POTENTIAL OF MG-RICH GYPSUM ADDITIVE FOR STRENGTH IMPROVEMENT OF PEAT SOIL.

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Diploma in Civil Engineering Technology

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ABSTRAK

Sekitar 2 juta hektar tanah gambut boleh ditemui di Malaysia, dengan sebahagian besarnya berada di kawasan pantai di Sarawak. Di Semenanjung Malaysia, tanah gambut telah diusahakan dengan pelbagai jenis tanaman makanan dan kelapa sawit di negeri Johor, Selangor, dan Perak. Tanah gambut adalah lembap dalam bentuk semula jadinya, dengan paras air yang sangat tinggi di permukaan tanah. Ia juga lembut kerana ia organik yang terdiri daripada komponen tumbuhan yang mereput secara semula jadi. Tanah gambut juga dikenali sebagai tanah organik. Tanah gambut mempunyai ketumpatan pukal yang rendah kerana ia bersifat organik. Tanah gambut menjadi lembap kerana paras air yang tinggi dan kualiti tanah yang lembut, dan sukar untuk berjalan di atas gambut yang tidak dikeringkan tanpa tenggelam. Tanah gambut di Malaysia sering dinaiki air dan berpaya. Oleh sebab itu, beberapa kawasan tanah gambut telah ditetapkan sebagai paya. Walau bagaimanapun, apabila pembangunan berkembang, semakin banyak tanah mineral tak organik telah habis, dan sempadan tanah gambut telah didekati. Di tempat-tempat tertentu di Malaysia, seperti dalam kajian kami di mana kami mendapatkan sampel dari Pekan hingga Gebeng, Pahang, terdapat sedikit pilihan untuk jenis tanah yang digunakan kerana negeri ini mempunyai bahagian tanah gambut yang besar. Tanah gambut mempunyai kekuatan ricih yang agak rendah; walau bagaimanapun, ia berpotensi untuk meningkat dengan ketara dalam kekuatan selepas penyatuan. Kekuatan ricih berkaitan dengan banyak pembolehubah, termasuk asal tanah, kandungan air, kandungan organik dan tahap penguraian. Kekuatan ricih gambut ditentukan oleh keadaan saliran. Penilaian kekuatan ricih tidak berdrainas amat penting kerana kehadiran tanah gambut hampir selalu berada di bawah paras air bawah tanah. Tujuan penyelidikan ini adalah untuk menunjukkan daya maju mengekalkan tanah gambut menggunakan bahan tambah sisa konkrit sebagai bahan tambahan, serta menilai tindak balas gambut terhadap pembaikan tanah untuk pembinaan di atasnya untuk mencapai SDG 11 iaitu menjadikan penempatan inklusif, selamat, berdaya tahan dan mampan

ABSTRACT

Around 2 million hectares of peatland can be found in Malaysia, with the majority of it being in coastal regions in Sarawak. In Peninsular Malaysia, peat land has been cultivated with a variety of food crops and palm oil in the states of Johor, Selangor, and Perak. Peat soils are moist in their natural form, with a very high water table at the soil surface. It is also soft because it is organic, which consists of plant components that decay in nature. Peat soil is also known as organic soil. Peat soil has a low bulk density because it is organic in nature. Peat soils become moist due to the high water table and soft soil quality, and it is difficult to walk on undrained peat without sinking. Peat land in Malaysia is often flooded and swampy. Because of this, some areas of peat land have been designated as swamps. However, as development progressed, more and more inorganic mineral soil was depleted, and the border of peat bogs was approached. In certain places in Malaysia, such as in our study where we obtained samples from Pekan to Gebeng, Pahang, there is little choice for the type of soil used because the state has a large proportion of peat land. Peat soils have relatively low shear strengths; however, they have the potential to significantly increase in strength after consolidation. Shear strength is related to many variables, including soil origin, water content, organic content, and degree of decomposition. The shear strength of peat is determined by the drainage conditions. Assessment of undrained shear strength is particularly important because the presence of peat soils is almost always below the groundwater table. The purpose of this research is to show the viability of maintaining peat soil using concrete waste additives as an additive, as well as evaluate the response of peat for soil improvement for construction on it to achieve SDG 11, which is to make settlements inclusive, safe, resilient, and sustainable.

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INTRODUCTION

Background of study

This study is about improving the strength of peat soil using a stabilization method with the addition of industrial waste, namely gypsum as an additive. Many industries, especially in projects involving 'rare earth' materials, produce gypsum waste around the world. This study will use gypsum produced by the chemical laboratory at UMP. Recycle this waste to improve problem soils. This fulfills one of the objectives of SDG 11 which is to make settlements inclusive, safe, resilient and sustainable. Our study uses peat soil as the main material.

One method for strengthening peat soil is soil stabilisation. Chemical stabilisation is a method of improving soil structures and fabric by adding or mixing chemical admixtures. The chemical reaction within the soil will cause changes in moisture content, shear strength, compressibility, pH values, and other engineering properties of the soil. The chemical stabiliser may hasten bonding in the soil, but bonding rate are affected by the type of stabiliser used.

Problem statement

Geotechnical and civil engineers have classified peat soils as one of the most challenging and problematic soil types. Many methods can be used to improve peatland placement.

This study was using a waste material as an additive to improve peatland unconfined compressive strength. Problematic soil placement will be stabilised using laboratory gypsum. Due to its high compressibility and consolidation solution, it has given engineers difficulties and caused concern in the development and construction industries.

Peat land is dangerous if an engineer plans construction on it without changing its original quality. The most notable qualities of peat soil are its poor shear strength, high compressibility, high moisture content, and high organic content, which make it an unsuitable soil type for building operations.

Objective

The aim of this study to understand the strength improvement of peat soil after stabilized with gypsum additive. To achieve the aim, the objectives are as follows:

1. To determine the unconfined compressive strength of untreated peat soil and uncured peat soilwith 10% gypsum additive.

2. To understand the effect of curing times on the unconfined compressive strength of treated peat soil with 10% gypsum conditions at 7 and 28 days

Scope

The site visit was conducted in Gebeng which is an industrial area in the state of Pahang. This visit was done to take peat soil samples. This is to study the properties of peat soil. The soil classification map in the State of Pahang was used to identify areas of peatland for sample collection. In addition, the purpose of this study is to find out the strength of peat soil by using a chemical stabilization approach that involves mixing industrial waste which is gypsum. Waste from a "rare earth" industrial waste processing plant is collected.

Visual classification of peat soils is used to facilitate sample collection, and the samples will be placed at the FTKA Geotechnical Laboratory for further testing. Tropical peat samples for this investigation will be collected in the Gebeng Pahang region. Unconfined compressive strength (UCS) tests will be performed on untreated peat soils and peat soils treated with different concentrations of gypsum. The test results were recorded and analyzed to find out the behavior and strength of gypsum-treated peat and untreated peat after curing for seven and 28 days, respectively.

Importance of study

The importance of our study is to understand the basic behaviour of the problematic geotechnical soil in Malaysia. Researchers and industry practitioners still lack understanding of soft soil, which is why so many problems occur when construction is carried out on peat bogs.

The soil stabilisation method can be uesd to see the reaction between the peat soil and the chemical agent, which is gypsum. The chemical reactions that occur in the soil will change the moisture content, shear strength, compressibility, pH value, and engineering properties of the soil. The soil binding process can be enhanced by chemical stabilizers.

Expected Outcome

Research can address the fundamental behaviour of Malaysia's problematic soils. Industry experts and scholars still only have a limited understanding of how soil moisture content varies. In the early stages of building, such as the design stage, it is crucial to choose the suitable construction method. Because they disturb the environment, current or popular land restoration techniques like soil replacement and removal are ineffective. A more sustainable solution will be achieved by avoiding the process of removing and replacing the soil.

CHAPTER 2

LITERATURE REVIEW

2.1 Theoritical Background

2.1.1 Peat soil

Peat soil is a form of marginal soil that can be found all over the world. It goes by the names peat, moor, mire, and fen as well. More than 30% of the organic matter in peat soil, which is rich in degraded plant matter, is organic matter. Peat soil is formed according to its age, which is affected by the type of microorganisms that aid in the decomposition process as well as the climate, rain, tidal level, and fundamental plant material. Around 2 million hectares of peat soil can be found in Malaysia, with the majority of it being in coastal regions in Sarawak.

Figure 2.1

In general, peat soil is categorised into three groups based on the depth at which it is found. Peat soil comes in three different depths: shallow peat soil is between 0.5 and 1.5 metres deep, medium deep peat soil is between 1.5 and 3.0 metres deep, and deep peat soil is over 3.0 metres deep. The decaying process that occurs causes the ground level to drop by 1 inch per year (M Anem, 2011).

Figure 2.2

The characteristics of peat soil are its rapid subsidence and poor drainage especially when excess water is applied to peat soi (it is difficult to remove water from peat soil areas). The water level is usually equal to the height of the ground. Peat soils are also very acidic (low pH).

There are many locations in Kuantan that have peat soil. The presence of soft or peaty soil causes serious difficulties for engineers. These characteristics affect construction issues and challenges in several ways, such as failures, coasts and pre-construction difficulties. Peat soil usually has an organic content of about 75%. Therefore, we used all samples to examine the shear strength of untreated, untreated and preserved peat soils using concrete waste.

2.1.2 Gypsum

Gypsum is a soft sulphate mineral that is composed of calcium sulphate dihydrate and has the chemical formula $CaSO_4.2H_2O$. It is widely used as a fertiliser, a primary ingredient in many types of plaster, blackboards, and wall chalk, as well as a fertiliser. Gypsum has a hardness rating of 2 according to the Mohs mineral hardness scale, which is based on scratch hardness comparison. It forms as an evaporite mineral and as an anhydrous hydration product.

Figure 2.3

Gypsum decreases erosion and improves soil moisture absorption. Gypsum will not change the pH of the soil significantly, but even without a significant change in pH, gypsum is able to change the pH value of the soil.

Gypsum can also aid to strengthen the structure of the soil. Many people think of soil as a homogenous and immobile material. In actuality, soil is a complex mixture of pore space, water, soil bacteria, and inorganic and organic particles. Its composition changes as a result of environmental factors including rainstorms, fertilisation, or the uptake of nutrients by plants.

2.1.3 Unconfined Compressive Strength Test (UCS)

The Unconfined Compression Test is a laboratory test used to obtain the Unconfined Compressive Strength (UCS) of soil specimens. Unconfined Compressive Strength (UCS) means the maximum axial compressive stress that a specimen can withstand under zero confining stress. Due to the fact that the stress is applied along the longitudinal axis, the Unconfined Compression Test is also known as the Uniaxial Compression Test. UCS is a widely used parameter in geotechnical design, but may not represent in-situ strength.

Figure 2.4

2.2 Study Method

Peat soil will be strengthened by adding gypsum and other strengthening agents. Peat soils are considered problematic soils due to their high compressibility, high water content, and low shear strength (Sani et al., 2021). For engineers, the presence of soft or peaty soil poses serious difficulties. Pre-construction difficulties, post-construction failures, construction expenses, maintenance issues, and short- and long-term impacts are just some of the ways these characteristics contribute to construction problems and difficulties (Hua et al., 2016).

The organic matter in peat is partially degraded and contains decayed plant remains. This occurs when the rate of accumulation exceeds the rate of disintegration. If the rate of destruction is slower than the rate of addition, peat will build up (Kazemian et al., 2009). Regardless of latitude or attitude, it gathers at any time in good conditions, that is, when it rains heavily and the soil is completely saturated. Furthermore, due to factors such as fiber origin, temperature and humidity level, the concentration of peat may vary from one area to the next.

2.3 Previous Finding

Based on the past research when those gypsum were used to treat the soil, the mechanical strength and densification of the peat soil stabilisation were increased compared to when gypsum was used as a standalone stabiliser (Sani et al., 2021).

These qualities result in hurdles before construction, failures after construction, high expenses during construction, maintenance problems, and both immediate and long-term effects, among other concerns and problems (Hua et al., n.d.). Problems and challenges are regularly experienced when construction on peat fields. Even a little increase in load would create instability and long-term consolidation settling due to the extremely poor bearing capacity (Wahab et al., 2020). Major obstacles that engineers must overcome include instability, slip failure, localised sinking, and long-term settlement (Nasrun & Bin, 2018).

2.4 Relevance of the Study

Despite of the fact, we use all of the waste is for utilizing industrial waste to significantly increase the compressibility of problematic soil. The technique of stabilising soil involves mixing it with various elements to enhance the engineering features of the soil. To enhance a soil's engineering qualities and performance, soil stabilisation entails changing or maintaining one or more soil parameters (Afrin, 2017).

Soil stabilisation by adding various elements, such as chemical and mechanical stabilisation. By combining a certain type of soil with others of different grades, mechanical stabilisation includes modifying the grading of the soil. A mound of compacted dirt may arise from this. Contrarily, chemical stabilisation refers to the alteration of soil characteristics by the addition of chemically active substances. However, the focus of this study is on chemical stabilisation, which entails combining chemical processes, such as the addition of soil amendments, with deep, medium, or top soil layers. In this study, gypsum and concrete scrap will be employed as chemical additives.

2.4.1 Challenges of Modern Facilities on Peat Land

Peat soil is difficult to recognize and analyze in regards of shear strength. The accuracy in determining shear strength is influenced by the origin, water content, organic content, and level of humification of peat soil (Huat et al., 2014). Peat's high levels of breakdown and moisture reduce its shear strength, however a high mineral concentration might increase shear strength (Zainorabidin & Mansor, 2016). Due to its strong fibre content, shallow peat often has higher shear strength than more humified peat that varies in depth (Norhaliza et al., 2019).

Hence, by using a sustainable design, choosing the right materials, cutting construction costs, increasing service life, and requiring less maintenance are only a few of the difficulties associated with developing infrastructure on peat. The most frequent issues with peat construction include settlement, inadequate bearing capacity, poor stability during excavation, and high ground water tables.

2.4.2 Chemical Stabilisation

Chemical stabilisation is a method of soil stabilisation in which processes within the soil are sparked and the soil's geotechnical properties are changed by the use of chemical agents. Soil alteration, soil stabilisation, or both can be categorised as types of soil improvement. To alter a soil's physical properties, active additives like cement and lime are used, whereas soil stabilisation entails improving a soil's texture, strength, CBR value, and shrink-swell qualities to make it totally suitable for long-term building (Sani et al., 2021).

When concrete waste fragments are mixed with peat soil, there is an increase in the shear strength of the peat soil. This shows that there is a chemical reaction that occurs in peat soil and concrete waste.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will discuss the research approach used in this study. The research methodology will explain why the options were to implement the objectives of this study. To achieve both goals, the approach will be implemented in two stages. A methodological flowchart is shown to clearly describe the approach taken to achieve the goal. How to perform the test is discussed at length in this chapter.

3.2 Methodology Flowchart

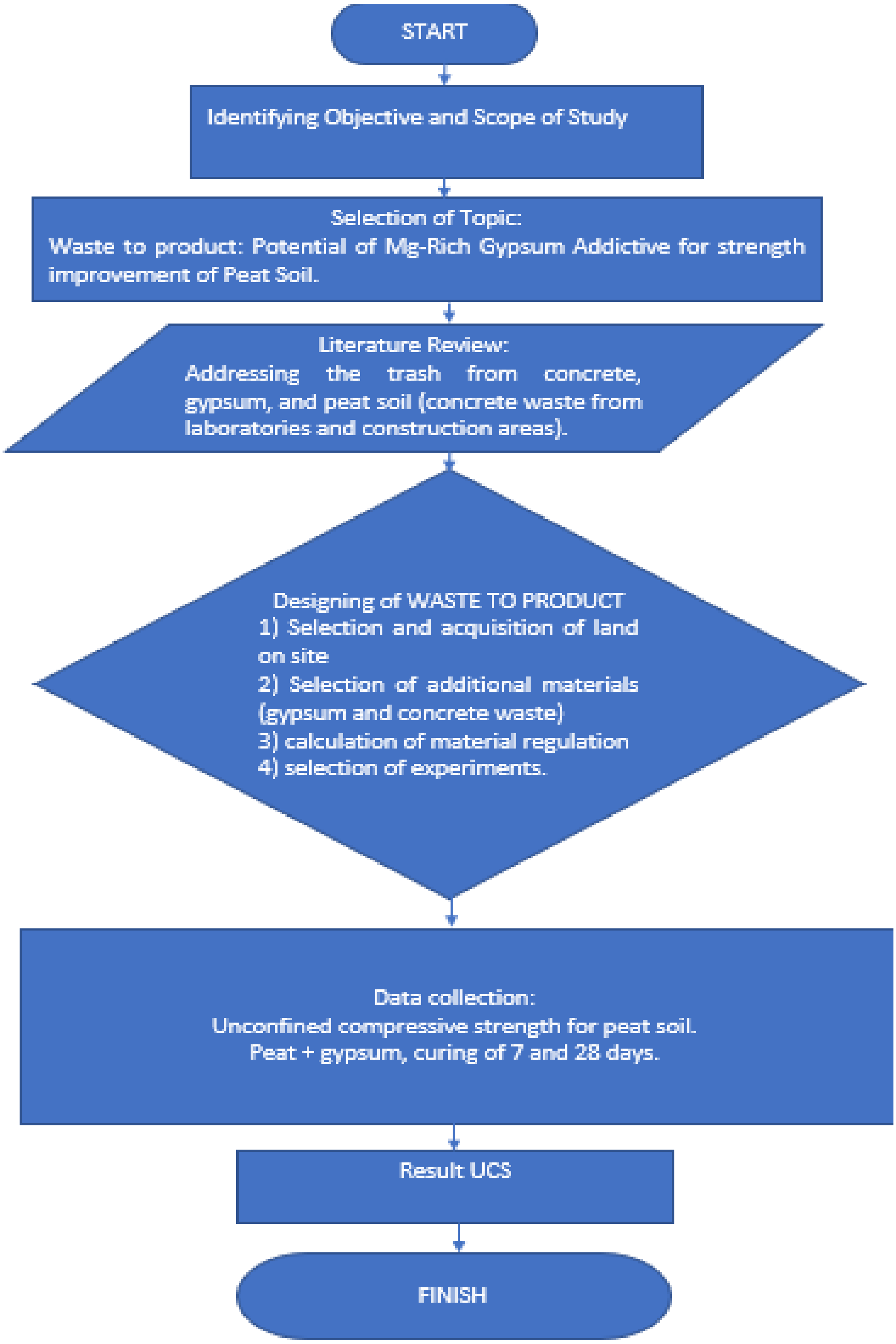

Figure 3.1

3.3 Study Methodology

This research is an experimental study focusing on the design of industrial gypsum to strengthen problematic soils. Peat soil samples were taken from the peat industrial area in Gebeng, State of Pahang. Laboratory test methods for this study will be conducted according to British standards (BS 1377:1990). Experimental studies are mainly focused on laboratory tests to identify the important characteristics of peat soils and the appropriate dose/proportion of stabilizers (residual concrete) that should be used economically to offer efficient stabilization of peat soil strength. Both treated and untreated soil samples were tested for engineering properties such as unconfined compressive strength (UCS) tests.

3.4 Sample collection

To determine the factors that favour the development of peat land, a short site visit was made to Gebeng (an industrial area) in the State of Pahang. Samples are obtained for laboratory testing, as shown in the figure below. Site investigations are very helpful in collecting extensive data on the genesis and evolution of peatlands. Apart from the creation and growth of peatlands, this demonstrates that environmental factors such as temperature, humidity, and rainfall, among others, are the most important in the sites visited. It has been found that these factors affect the growth, characteristics, and formation of peat soils in both direct and indirect ways.

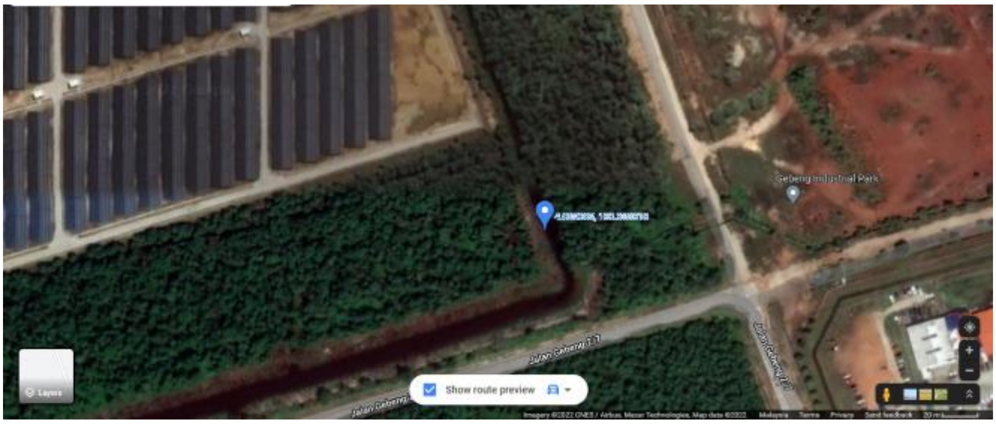

Figure 3.2 peat soil location at Gebeng, Pahang

Peat soil samples taken have a slightly foul smell and vary in colour from black to dark brown. Peat soils are further distinguished from inorganic soils such as clay and sand by being spongy and highly compressible. Cross-referencing the location with the Pahang state land use map centred on the reported position has been done. The industrial area in Gebeng, Pahang (4°00'18.0" N, 103°22'12.2" E), was chosen as the focus of the study.

3.4.1 Preparation (Air drying soil)

For sampling, British Standard 1377 Part 1:1990 was used as a guide. Before being physically broken down into any form of aggregate, the peat samples were first air-dried at room temperature for 24 hours, then oven-dried for the same amount of time at 105°C.

Figure 3.3

3.4.2 Sample Preparation Gypsum

Gypsum is classified into many types like impression plaster (type I), dental plaster (type II), dental stone (type III), improved stone (type IV), and high expansion improved stone (type V) (ADA 1985), but this study used a by-product from industry. It has a similar character or chemical compound to industrial gypsum, such as ceilings, partitions, gypsum plasterboard, and others. Rare earth material comes from the earth's surface, and after processing, it produces neutralisation underflow (NUF).

Gypsum is produced by industry and stored in the soil mechanics and geotechnics laboratory at Universiti Malaysia Pahang. Because gypsum is too difficult to crush manually, it is oven-dried for 24 hours before being crushed with an LA Abrasi machine.

The gypsum powder is then sieved using a 2 mm sieve. The diagram below shows the situation before and after gypsum is converted into powder.

Figure 3.4

3.4.3 Sampling 3 sample each

Experiments were conducted at the Soil Mechanics & Geotechnics Laboratory of the Faculty of Civil Engineering Technology (FTKA) at UMP. Experiments are conducted to explain the geotechnical characteristics of the soil. The moisture content at the sample site will be assessed once it arrives at the laboratory to avoid moisture gain or loss. Because peat soils are easily disturbed, the test was completed quickly to avoid any change in the amount of water in the soil sample.

Figure 3.5

3.5 Gantt Chart

The Gantt chart below shows the activity planning for the final year project. During the 4-month plan period, which runs from October 2022 to January 2023, the study was completed according to the set schedule.

TASK/ WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14
BRIEFING														
LITERATURE REVIEW														
RESEARCH														
EXPERIMENTAL														
CURING TIMES														
RESULT														
ANALYSIS														
WRITE / CREATE														
EDIT														
REVIEW														
SUBMIT														

Table 1.1

CHAPTER 4

RESULT AND ANALYSIS

4.1 Introduction

The research results have been recorded and analysed in this chapter to see the level of achievement of the two main objectives of this study. The previous chapter has explained the research methodology that covers this topic. This chapter presents the conclusions drawn from the data analysis. As a result, this chapter includes discussion, data interpretation, and hypothesis testing.

4.2 UCS of AN gypsum ratio

To determine the optimal ratio for additives, the test was repeated with different ratios, such as 5%, 15%, and 20%.

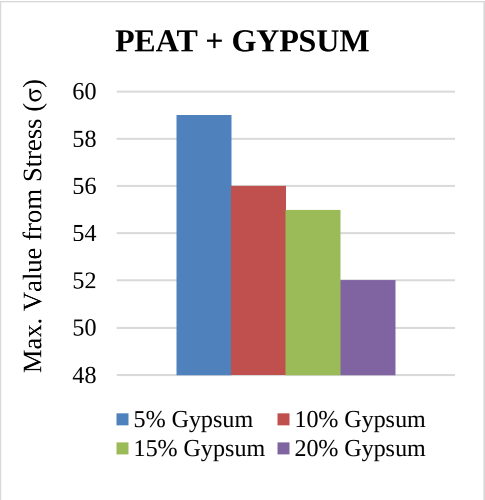

Figure 4.1

As the result, peat with 5% gypsum has the highest strength value (kPa). So the highest value was chose to see the curing effect on the sample.

4.3 Results of tests on physical and geotechnical properties

The following is the data obtained for shear strength. This shear strength is used to analyse whether gypsum can be used as an additive for improving peatlands for future use. The shear strength of untreated peat soil is 36 kPa, while that of untreated soil is 82 kPa. For our research, we need to identify whether curing time affects the shear strength of peat soil after 7 and 28 days.

Parameter	UCS for Peat (kPa)			
	Untreated	Uncured	Cured (Air curing)	
			7TH DAY	28TH DAY
Peat	36	-	-	-
P (90%) +G (5%)	-	59	178	294

Table 2.1 P: peat soil G: gypsum

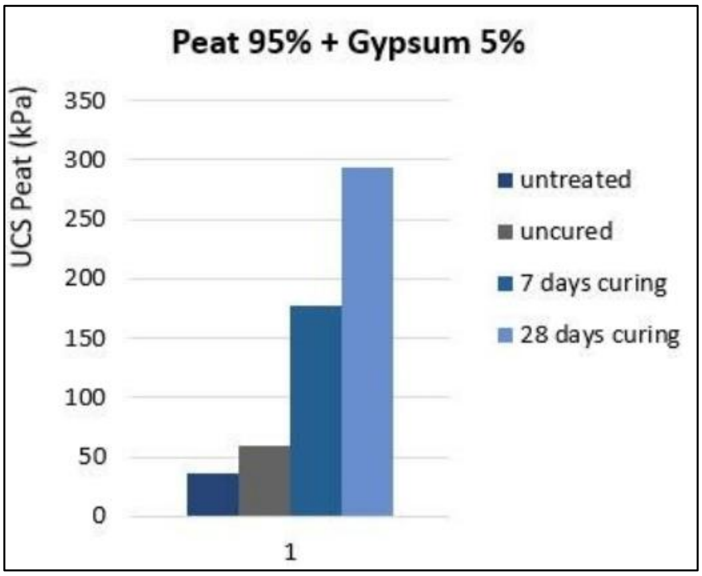

Figure 4.2

Based on the above values, treated peat soil that has been preserved for 28 days has the highest shear strength.

After 7 days and 28 days of curing, the stabilised peat soil’s compressive strength incresed accordingly. The compressive strength of stable peat increases as the curing period increases. Following the stabilisation of the peat soil, the stabilised peat consequently displayed a noticeably increased compressive strength supporting the possible use of gypsum as a binding substance.

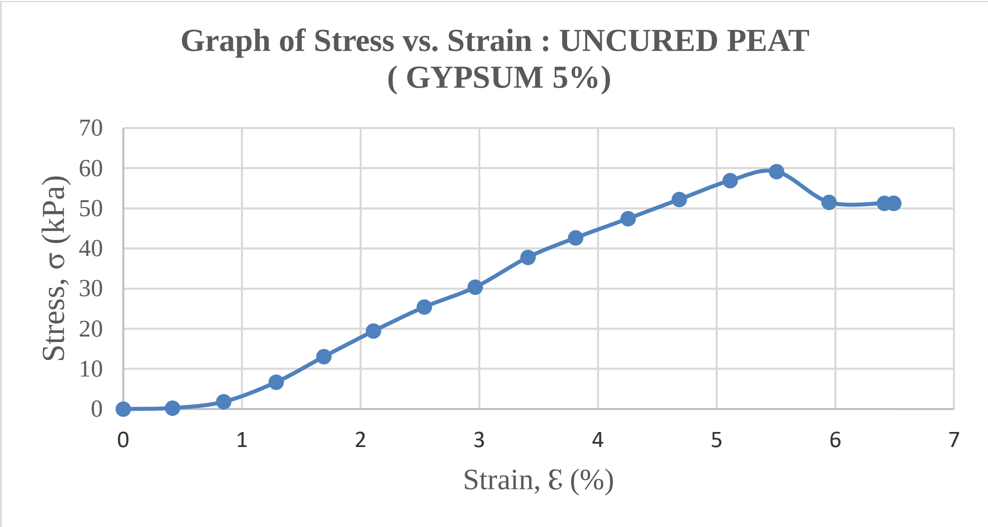

Figure 4.3

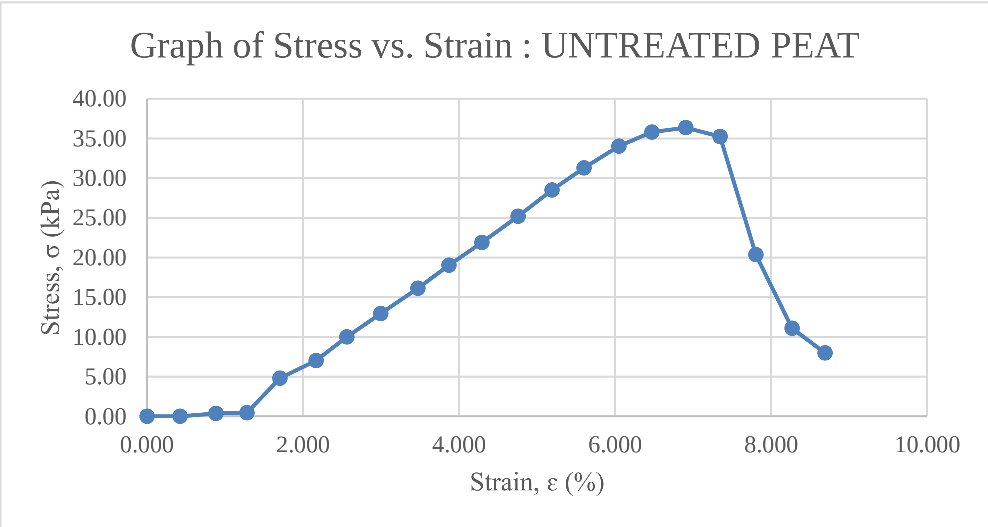

Figure 4.4

The graph below shows the results for average data at 7 curing days.

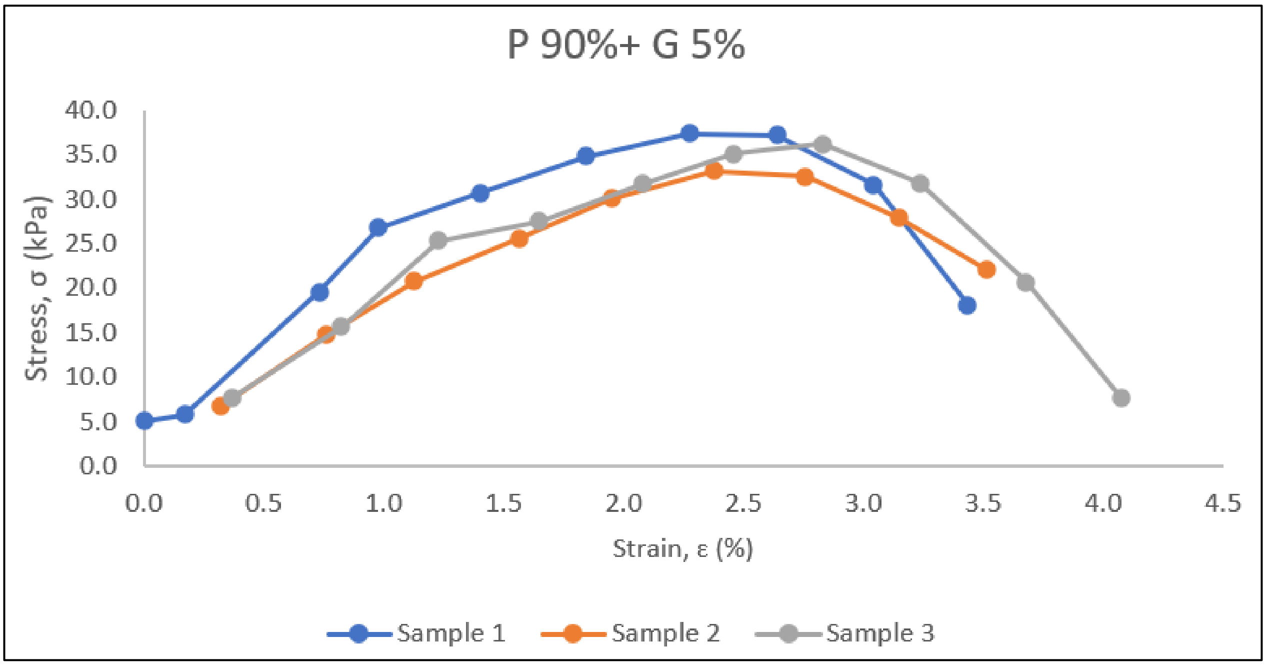

Figure 4.5

The graph below shows the results for average data at 28 curing days.

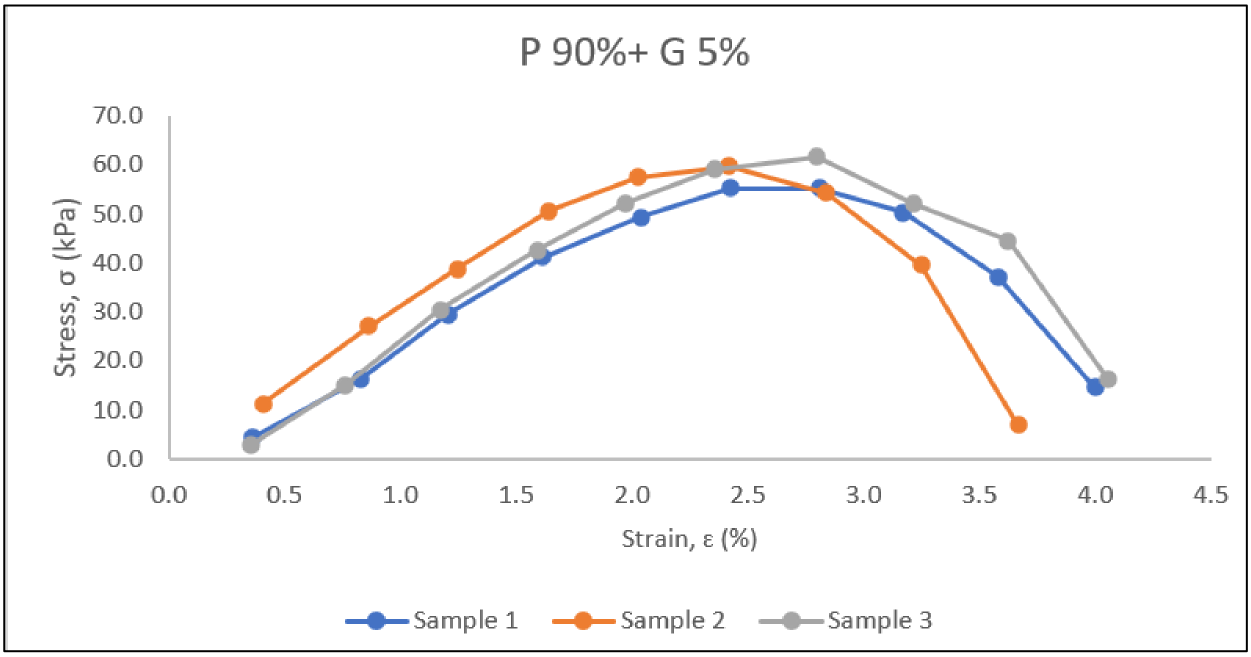

Figure 4.6

CHAPTER 5

CONCLUSION

This study focused on the assessment of the potential of additional materials, namely gypsum, for increasing the strength of peat soil. The main point of this study is to increase the strength of peat soil with gypsum and to understand the effects of curing times of 7 and 28 days on the strength of peat soil mixture at the optimum ratio of gypsum.

The recorded results are increasing from untreated, uncured, 7 days of curing, and 28 days of curing. The results show that the strength is greatest after 28 days of curing. The results of this study demonstrate that gypsum, a by product waste, successfully alters the properties of peat soil to solve construction-related problems. Peat soils create challenging issues for building projects due to their high organic matter and moisture content. However, using soil stabilisation as a binding component has proven to be one of the finest strategies to increase the quality of soil engineering and decrease waste. Therefore, using gypsum to enhance the soil is highly advised. The studies indicate that gypsum and peat soil can interact to strengthen the soil.

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APPENDICES