UNDERGRADUATE THESIS

SHEAR STRENGTH AND DURABILITY CHARACTERISTICS OF VOLCANIC SOILS MIXED WITH CEMENT

RICHO BRIAN
NPM : 2017410119

ADVISOR: Prof. Paulus Pramono Rahardjo, Ir., MSCE., Ph.D.

PARAHYANGAN CATHOLIC UNIVERSITY
FACULTY OF ENGINEERING DEPARMENT OF CIVIL ENGINEERING
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BANDUNG
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2021

SKRIPSI

KARAKTERISTIK KUAT GESER DAN KETAHANAN CAMPURAN TANAH VULKANIK DENGAN SEMEN

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EXAMINER 1:	**Anastasia Sri Lestari, Ir., M.T.**	
EXAMINER 2:	**Dr. Ir. Rinda Karlinasari, M.T.**	

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PERNYATAAN

Yang bertandatangan di bawah ini, saya dengan data diri sebagai berikut:

Nama : Richo Brian

NPM : 2017410119

Program Studi : Teknik Sipil

Fakultas Teknik, Universitas Katolik Parahyangan

Menyatakan bahwa skripsi / ~~tesis~~ / ~~disertasi~~[*)] dengan judul:
Karakteristik Kuat Geser dan Ketahanan Campuran Tanah Vulkanik dengan Semen
adalah benar-benar karya saya sendiri di bawah bimbingan dosen pembimbing. Saya tidak melakukan penjiplakan atau pengutipan dengan cara-cara yang tidak sesuai dengan etika keilmuan yang berlaku dalam masyarakat keilmuan. Apabila di kemudian hari ditemukan adanya pelanggaran terhadap etika keilmuan dalam karya saya, atau jika ada tuntutan formal atau non formal dari pihak lain berkaitan dengan keaslian karya saya ini, saya siap menanggung segala resiko, akibat, dan/atau sanksi yang dijatuhkan kepada saya, termasuk pembatalan gelar akademik yang saya peroleh dari Universitas Katolik Parahyangan.

Dinyatakan: di Bandung

Tanggal: 27 Juli 2021

Richo Brian (2017410119)

[*)] coret yang tidak perlu

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ABSTRACT

Volcanic soils are commonly found in Indonesia, as such very frequently used as embankment material for construction projects. Volcanic soil has higher shear strength, permeability and compressibility compared to alluvial soils. However, this only applies when the volcanic soil is chemically bonded in its original state, when excavated these characteristics no longer applies. Therefore, turning volcanic soils into problematic soils with low shear strength which is also vulnerable when exposed to water, causing instability problems during embankment process. Due to these problematic characteristics cement is added to the soil to increase the shear strength and durability of the volcanic soil. Soil cement mixture is used under these circumstances due to its cementation properties, which provides the best outcome in terms of increasing the shear strength and durability of soils. Mixing soil and cement also saves budget and time for the construction project as it becomes unnecessary to replace the existing soil with imported soil. Index properties of the soil sample is tested beforehand to make sure the soil is volcanic soil by referring to past research about volcanic soil index properties. The test conducted to investigate the shear strength and durability parameter is the unconsolidated undrained triaxial test and dispersion test. To investigate the optimum cement percentage CBR test is used as a control, where the requirement needed is for the CBR design value to exceed 10%.

Keywords: Shear Strength, Durability, Volcanic Soil, Cement, Embankment

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ABSTRAK

Tanah vulkanik adalah tanah yang seringkali dijumpai di Indonesia, sehingga seringkali digunakan sebagai material untuk timbunan pada proyek konstruksi. Pada kondisi aslinya tanah vulkanik memiliki kuat geser dan ketahanan yang baik karena ikatan kimia yang ada pada tanah vulkanik. Namun, apabila tanah vulkanik dikeruk untuk dijadikan sebagai material untuk timbunan karakteristik tersebut tidak berlaku karena ikatan kimia tersebut hilang. Hal tersebut menjadikan tanah vulkanik sebagai tanah yang bermasalah karena setelah ikatan kimia tersebut hilang kuat geser tanah vulkanik turun secara drastis ditambah tanah vulkanik yang memang rentan jika terekspos terhadap air, jika tanah vulkanik digunakan sebagai material timbunan pastinya akan terjadi masalah instabilitas. Solusi untuk mengatasi masalah ini adalah menambahkan campuran semen kepada tanah vulkanik untuk meningkatkan kuat geser dan ketahanannya terhadap air. Campuran semen digunakan karena sifat sementasi dari semen yang memberikan hasil terbaik perihal meningkatkan kuat geser dan ketahanan tanah vulkanik. Pencampuran semen pada tanah vulkanik juga menghemat waktu dan biaya proyek konstruksi karena tidak perlu mengganti tanah yang ada dengan tanah impor. Properti indeks tanah diperiksa terlebih dahulu untuk memastikan bahwa tanah tersebut adalah tanah vulkani, dengan acuan riset yang sudah ada mengenai tanah vulkanik. Uji triaksial UU dan uji dispersi dilaksanakan untuk mencari parameter kuat geser dan ketahanan tanah vulkanik. Kadar semen optimum dicari dengan menggunakan uji CBR sebagai kontrol, dimana desain CBR yang diperlukan perlu lebih dari 10%.

Kata Kunci: Kuat Geser, Ketahanan, Tanah Vulkanik, Semen, Timbunan

FOREWORD

Writer's most sincere praise and gratitude for The One Almighty God, for His blessings and grace for completing this undergraduate thesis titled "Shear Strength and Durability Characteristics of Volcanic Soils Mixed with Cement".

This undergraduate thesis also may not be complete without the guidance, prayer and help from a lot of parties. Therefore, also most sincere gratitude to the parties involved:

1. Parents and family for the prayers and support given to encourage writer to successfully complete this undergraduate thesis.
2. Professor Paulus Pramono Rahardjo, Ph.D., as the advisor to this undergraduate thesis who always patiently guides, advices and teaches writer during the process of completing this undergraduate thesis.
3. Mr. Stefanus Diaz Alvi, S.T., M.T., who actively helps guide writer by giving recommendations and solution as to completing this undergraduate thesis.
4. Mr. Budijanto Widjaja, Ph.D., as the head of geotechnical laboratory in Parahyangan Catholic University who allows writer to perform experimentation in the geotechnical laboratory.
5. Mr. Andrias Suhendra Nugraha, S.T., M.T., who gives useful advices during laboratory testing process and arranges the schedule for CBR test so that writer can also use the CBR machine.
6. All lecturers and teaching staff from the Parahyangan Catholic University Geotechnical Department, for teaching writer throughout university and giving critics and advices for the completion of this undergraduate thesis.
7. Mr. Andra Ardiana, S.T., Mr. Yudhirama and Mr. Adang and all geotechnical laboratory staff who provides help for writer in laboratory testing so that the laboratory testing may result in a success.
8. Charles Maxwelliem, Evan Justine, Mikael Rafael, Kres Arjunaningrum, Averina Alifa, Deta Noveren Geidia Faza and Delaneira Princess Seourin as fellow comrades who under the guidance of Professor Paulus Pramono

Rahardjo, Ph.D., strives together with writer to achieve completion of this undergraduate thesis from start to finish.

9. Arnold Widjaja, Leonardo Singgit, Andre Djoharsyah, Reynaldo Benedict, Fendi Santoso, Hubert Fernaldy Tjipto, Herbert Fernaldy Tjipto, Aristotelis Justin Balaskas and Brian Thomas as childhood friends from Pelangi Kasih school who always gives support and encouragement for writer to complete this undergraduate thesis.
10. Muhammad Rizki Iskandar as fellow lab researcher who helps with writer in process of laboratory testing.
11. Christopher Cusan as a close friend who always give support and encouragement for writer to complete this undergraduate thesis.
12. Dicky Prasetyo, Grisella Aglia and Kevin Lie who provides writer with their undergraduate thesis as reference and shares their insight and knowledge as to completing this undergraduate thesis.
13. Muhammad Fachreza, Ryan Gilang Wicaksono, Nathaniel Wijaya, Aditya Dharmawan, Sandro Ganes Septio, Glen Hadi Wijaya, Vincent Candelano and Ryan Santoso as close friends in college who always provides assistance, knowledge and support throughout college with writer until the completion of this undergraduate thesis.
14. All of the friends from Parahyangan Catholic University Civil Engineering Department 2017 Batch for their help and support throughout writer’s time in Parahyangan Catholic University.
15. All parties involved that are not yet mentioned above who helps writer throughout his undergraduate thesis process.

Bandung, 14 July 2021

Richo Brian

2017410119

CONTENTS

NOMENCLATURE

a	:	Correction factor for grain size distribution
A_0	:	Original area (cm^2)
A_c	:	Corrected area (cm^2)
c	:	Cohesion (kg/cm^2)
cu	:	Undrained shear strength (kg/cm^2)
C_0	:	Zero correction
C_c	:	Coefficient of curvature
C_t	:	Temperature correction
C_u	:	Coefficient of uniformity
Ca	:	Calcium (meq/L)
CBR	:	California Bearing Ratio
CI	:	Consistency Index
D	:	Grain size diameter (mm)
D_{10}	:	Grain size corresponding to 10% passing (mm)
D_{30}	:	Grain size corresponding to 30% passing (mm)
D_{60}	:	Grain size corresponding to 60% passing (mm)
e	:	Void ratio
ESP	:	Exchangable Sodium Percentage (%)
FI	:	Flow Index
Gs	:	Specific gravity of soil
Gt	:	Specific gravity of water
k	:	Proving ring calibration
K	:	Correlation value for soil and temperature
L	:	Effective depth (cm)
L_0	:	Original height (cm)
Load	:	Load dial reading
LI	:	Liquidity Index
LL	:	Liquid Limit
Mg	:	Magnesium (meq/L)

n	:	Porosity
Na	:	Sodium (meq/L)
PL	:	Plastic Limit
PI	:	Plasticity Index
qu	:	Unconfined compressive strength (kg/cm^2)
R	:	Maximum dial reading - First load dial reading (kg)
R_a	:	Actual hydrometer reading
R_c	:	Hydrometer reading correction
Sr	:	Degree of Saturation (%)
S_t	:	Sensitivity
SAR	:	Sodium Adsorption Ratio
SL	:	Shrinkage Limit
t	:	Elapsed time (min)
TDS	:	Na + Ca + Mg (meq/L)
TI	:	Toughness Index
V	:	Total Volume (cm^3)
Vs	:	Volume of Solid (cm^3)
Vv	:	Volume of Void (cm^3)
w	:	Water content (%)
W	:	Weight of the soil (kg)
Wc	:	Weight of cement (kg)
Ws	:	Weight of dry soil (g)
Ww	:	Weight of water (g)
Wbw	:	Weight of container + water (g)
Wbws	:	Weight of container + soil solution (g)
η	:	Aquades viscosity (poise)
ΔL	:	Sample displacement (cm)
$\Delta\sigma$	:	Deviator Stress (kg/cm^2)
γ	:	Unit weight of the soil (g/cm^3)
γd	:	Dry unit weight of the soil (g/cm^3)

γw	:	Unit weight of water (g/cm^3)
σ	:	Normal stress (kg/cm^2)
ϕ	:	Friction Angle (˚)
τf	:	Shear stress (kg/cm^2)
ε	:	Strain (%)

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CHAPTER 1
INTRODUCTION

1.1 Motivation

Volcanic soils may be formed through lava, pyroclastic flows and volcanic ash. Volcanic soils from lava is formed through weathering the color of the soil is usually red due to this process, pyroclastic flow creates pyroclastic deposits which forms volcanic soil and volcanic ash forms tufa which then forms volcanic soils. Volcanic soils are widely encountered around the world especially here in Indonesia since Indonesia is located in the "Pacific Ring of Fire" a region around much of the rim of Pacific Ocean where volcanic eruptions and earthquakes frequently occur, as such volcanic soils are frequently used as embankment materials for projects in Indonesia. Volcanic soils have higher shear strength and permeability with high compressibility in comparison to alluvial soils, however this only implies in its original state when it is chemically bonded, when excavated this bond perishes causing its shear strength to decrease significantly, volcanic soils are also vulnerable to water which may cause instability problems during embankment process, in most cases the structure of the compacted soils collapses when in water. An approach used by engineer to encounter these problems is adding cement mixture to the volcanic soils used for embankment, cement mixture is added to increase its shear strength and durability to prevent instability problems from occuring.

Cement mixture is used due to its cementation properties, cement mixture provides the best outcome in terms of increasing shear strength and durability of volcanic soils used for embankment, cement also has reasonable price to be used in a project. Although frequently used in projects through experience, actual characteristic of the shear strength and duarability of volcanic soils mixed with varying cement mixture is not yet examined in a laboratory. This research is conducted to display the difference of characteristics between original volcanic soils and volcanic soils mixed with cement.

This research uses volcanic soils taken from Cilangkap bridge in West Java, Indonesia to then be further examined in a laboratory. Data such as Mohr-Coulomb circles, deviator stress versus strain graph, shear stress versus horizontal displacement graph, maximum shear stress vs normal stress graph are displayed as a result to this research. Shear strength parameters are also obtained through these tests which are the cohesion (c) and friction angle (ϕ), which are further used to describe the characteristics of the shear strength and durability of volcanic soils.

1.2 Problem Definition Summary

Volcanic soils have different properties in contrast to common alluvial soils, thus mixed with cement mixture may provide different results. Research is conducted using volcanic soils mixed with cement mixture to investigate the difference between their shear strength and durability, the optimum percentage of cement mixture to be added in correspond to its durability is also examined. The main problem is that these particular datas are seldom investigated through research by engineers, as it may prove critical especially in embankment projects, thus thorough research of these volcanic soils characteristics should be examined.

1.3 Research Objectives

Objectives of the research are as follows.

1. Investigate the shear strength parameters cohesion (c) and friction angle (ϕ) of original soil and soil mixed with cement.

2. Examine the effect of cement mixture added to volcanic soils as to how it increases volcanic soils shear strength and durability.

3. Investigate optimum cement mixture percentage of soil cement mixture.

1.4 Research Scope

The research scope are as follows.

1. Volcanic soil samples are taken from Java, Indonesia.
2. Provide volcanic soil samples and do laboratory test to investigate the physical as well as engineering properties of the soil.
3. Shear strength parameters are investigated through unconsolidated undrained triaxial test conducted in laboratory, with California Bearing Ratio (CBR) as control to investigate the optimum cement percentage for the soil with the minimum CBR design needed is 10%.

1.5 Research Method

1. Literature Study

   Study of basic knowledge of volcanic soils, laboratory tests such as the unconsolidated undrained triaxial test and unconfined compression test and basic knowledge of in-situ testing such as compaction using standard proctor.
2. Sample Preparation

   Preparing volcanic soil sample to used for research purpose, such as compacting beforehand volcanic soils obtained from an ongoing project in Java, Indonesia.
3. Laboratory Testing

   Data for this undergraduate thesis is primarily investigated only through laboratory testing such as undrained shear strength from unconsolidated undrained triaxial test, durability using dispersion test and then California Bearing Ratio test to investigate its optimum cement percentage.
4. Data Analysis

   Shear strength properties of volcanic soils are the displayed as a result of this analysis in correspondence to the percentage of cement mixture mixed with it aiming to investigate its optimum percentage using California Bearing Ratio test as control, relation to its durability is also displayed throughout this research using the soil dispersion test.

1.6 Thesis Outline

CHAPTER 1 INTRODUCTION

This chapter discusses the motivation, problem definition summary, research objectives, research scope, research method, thesis outline and the flowchart of this undergraduate thesis.

CHAPTER 2 BACKGROUND

This chapter discusses the basic theory for laboratory testings such as the unconsolidated undrained triaxial test and unconfined compression test and in-situ testing such as compaction using standard proctor. This chapter also discusses the basic data of soils such as the index properties and atterberg limits for the volcanic soils.

CHAPTER 3 RESEARCH PROCEDURES

This chapter discusses as how the research is carried out in laboratory using the unconsolidated undrained triaxial, dispersion test and California Bearing Ratio test.

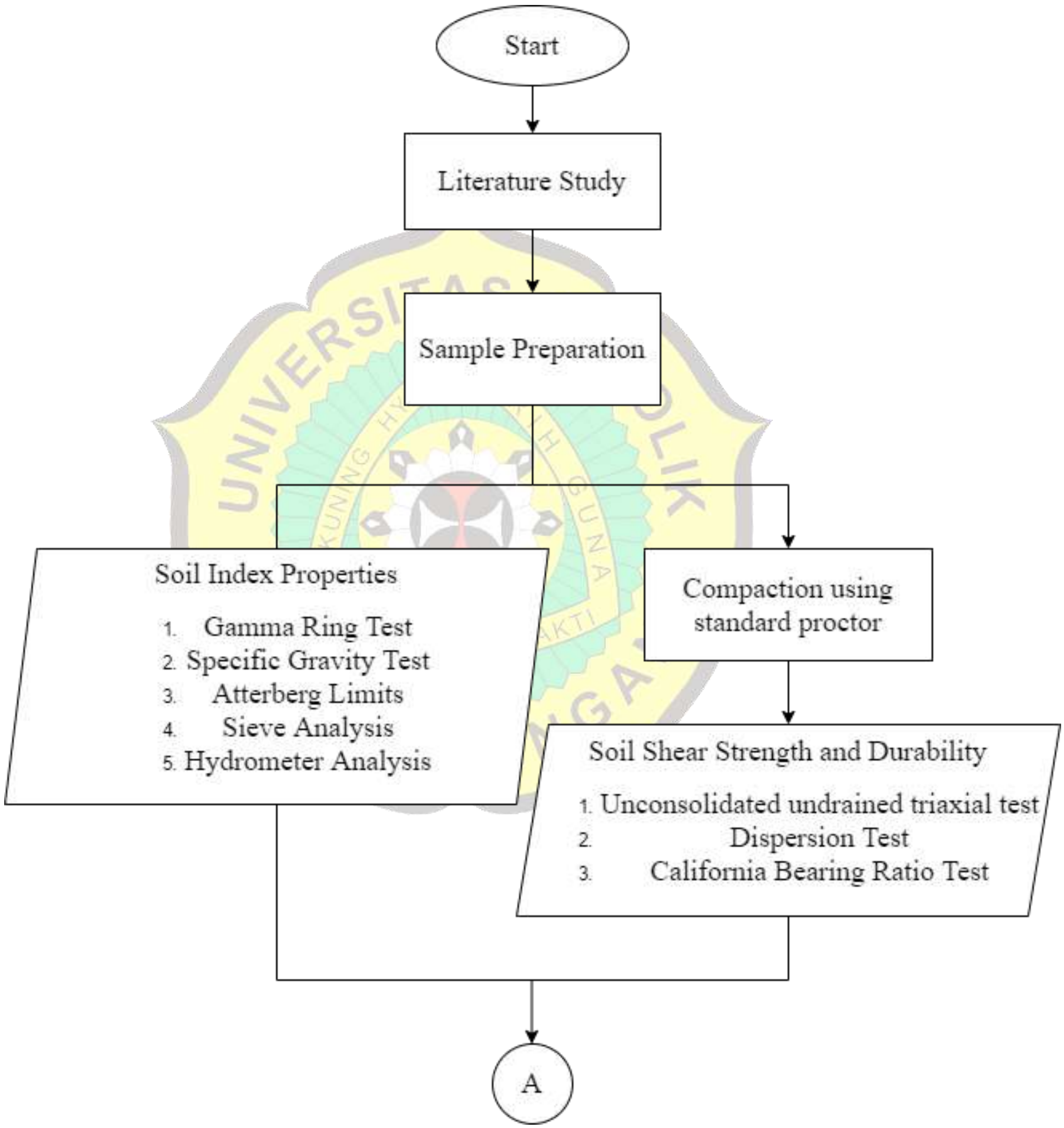
CHAPTER 4 EXPERIMENTAL INVESTIGATION

This chapter discusses the data and analysis obtained through the unconsolidated undrained triaxial test using Coulomb circles, deviator stress versus strain graph, shear stress versus horizontal displacement graph, maximum shear stress vs normal stress graph also the shear strength properties it produces. Soil dispersion grade using the dispersion test. Lastly the optimum cement percentage using the California Bearing Ratio graph.

CHAPTER 5 CONCLUSION AND RECOMMENDATION

This chapter discusses the overall conclusion and recommendation from this undergraduate thesis.

1.7 Flow Chart



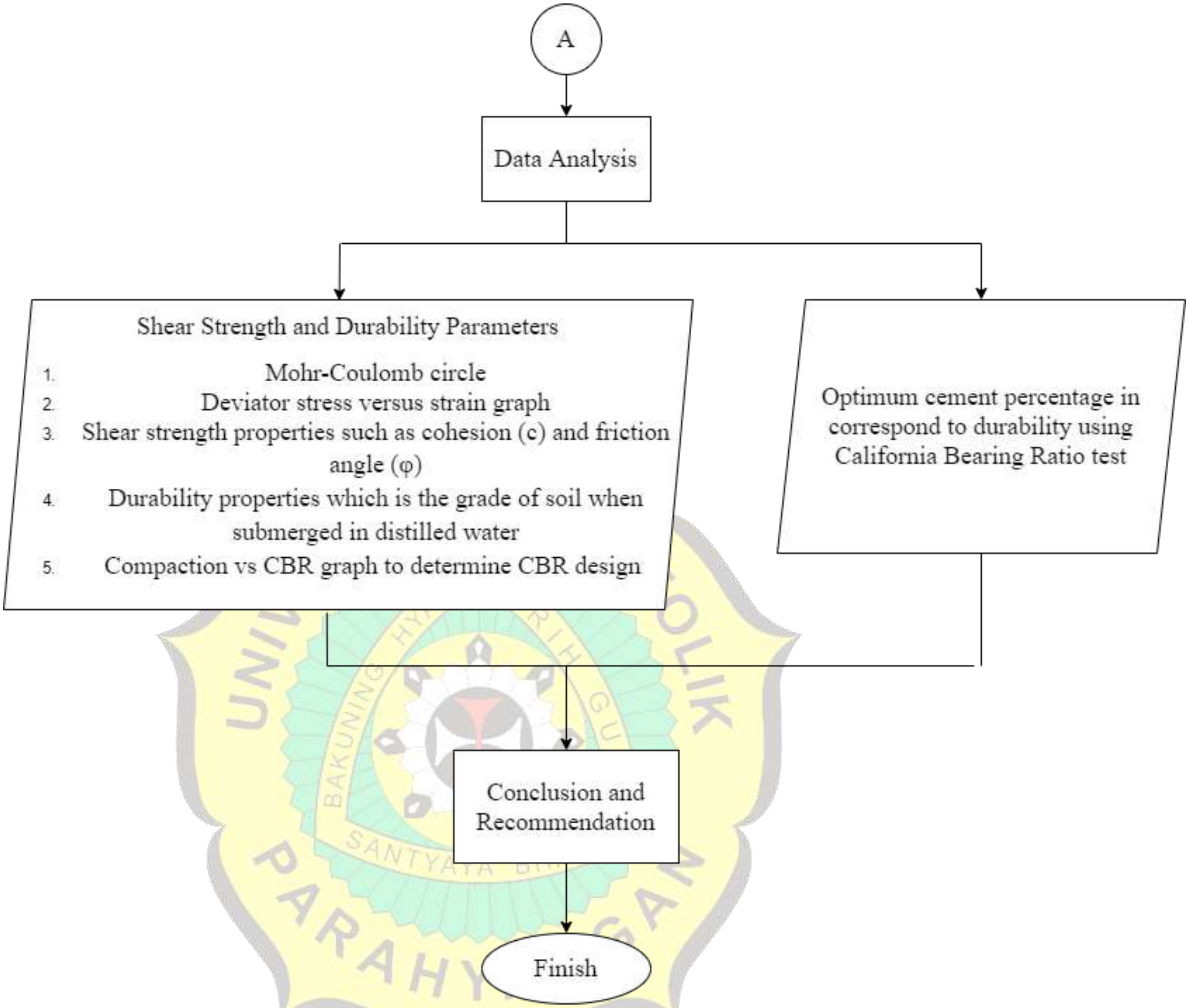


Figure 1.7.1 Thesis flowchart