CHAPTER I
INTRODUCTION

1.1 Background and Rationale

The triaxial compression test (ASTM D7012-14) has been widely used to determine rock strength and deformation under confinement, which are important parameters for the design and stability study of geological structures in civil as well as mining engineering works, including foundations for dams, structures, and bridges, and additional host rocks for underground mining and tunnels. The triaxial compression test is used in the laboratory to simulate these structures. A significant limitation of the traditional triaxial test method is that it is expensive, time-consuming, and requires a large number of standard samples. The multi-stage triaxial compression test (Wang, Feng, Yang, Han, and Kong (2022) and Minaeian, Dewhurst, and Rasouli (2020) and Yang (2012)) is more popular nowadays because it requires fewer samples to determine the triaxial strength. It is found that the multi-stage strength is often lower than the single-stage strength. The differences and representativeness of the multi-stage test results and the deformation modulus however require more investigation.

The multi-stage triaxial test concept was first introduced in the mid-1970s (Kovári and Tisa, 1975). It is necessary to test a variety of rocks to conduct a comparative study of the single-stage and multi-stage strengths. Accurate lateral and axial stresses of the specimen are typically difficult to measure due to non-uniform deformations of the specimen and local strain measurement by measuring equipment (Aghababaei, Behnia, and Moradian, 2019).

1.2 Research Objective

The objective of this study is to develop mathematical correlations between single stage and multi-stage triaxial compressive test results in terms of strength and deformability. Hoek-Brown strength criterion and Goodman stiffness relation between intact and fractured rocks are employed. Ten rock types with strength varying from soft to strong rocks are used. A polyaxial load frame is used to load and unload the specimens, which allows determining the compressive strengths and deformation moduli of the rocks under both single and multi-stage testing.

1.3 Scope and Limitations

The scope and limitations of the research include as follows:

1) Laboratory testing is conducted on 10 rock types, including Tak Fa gypsum, Maha Sarakham salt, Khao Khad bedded limestone, Phu Kradung sandstone, Khao Khad marble, Pha Wihan sandstone, Phu Phan bedded sandstone, Phu Phan sandstone, Rayoung-Bang Lamung granite, and Buriram basalt.

2) All rectangular rock specimens have nominal dimensions of 54x54x108 mm^3.

3) Polyaxial load frame is employed to apply axial and lateral loads to the specimens.

4) Single and multi-stage triaxial tests use the confining pressures ranges from 0 MPa to 40 MPa.

5) Testing procedures follow the ASTM D7012-14 (2014) standard practice where applicable.

6) All tests are carried out at ambient temperatures.

1.4 Research Methodology

A literature review, sample preparation, laboratory testing (single and multi-stage triaxial compression tests), strength and deformability analysis, mathematical relations, discussions and conclusions, and thesis writing comprise 7 steps during the research methodology depicted in Figure 1.1.

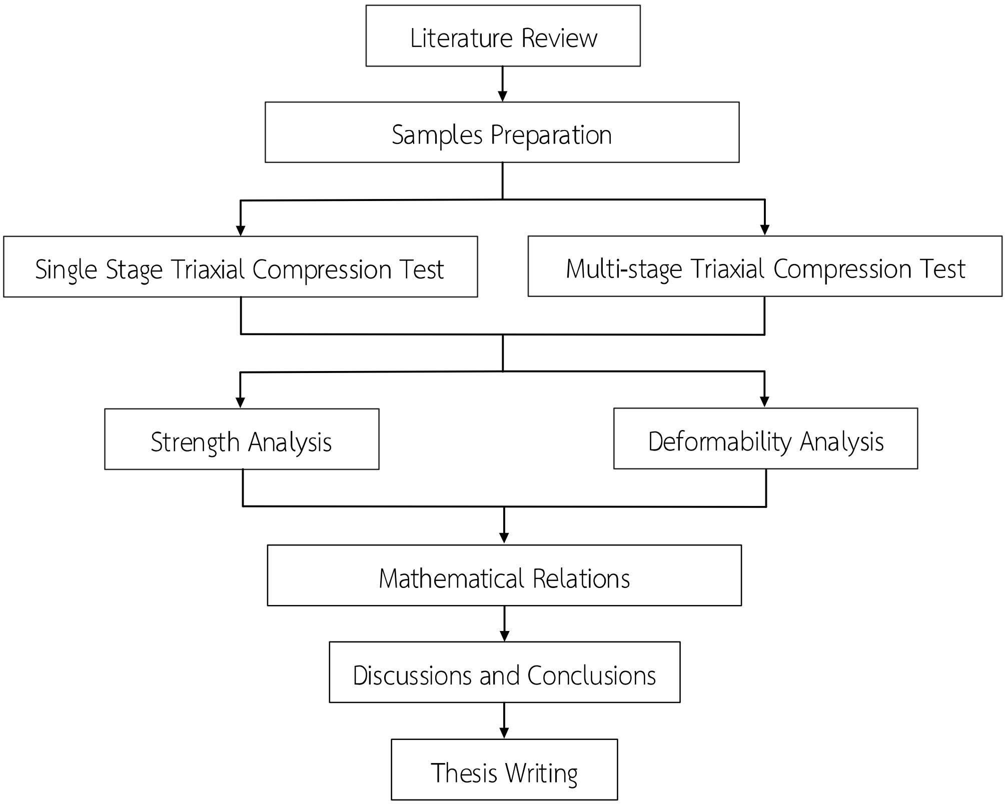

Figure 1.1 Research methodology.

1.4.1 Literature Reviews

Literature review is conducted on experimental studies related to the comparison of single and multi-stage triaxial compressive strengths and deformation moduli. Academic papers, conferences, and journals provide the material for this work. Chapter II offers a synopsis of the literature review.

1.4.2 Samples Collection and Preparation

Rock specimens are prepared from ten different rock types, ranging from soft to hard rock, collected from various locations within Thailand, including Tak Fa gypsum, Maha Sarakham salt, Bedded limestone, Phu Kradung sandstone, Khao Khad marble, Pha Wihan sandstone, Phu Phan bedded sandstone, Phu Phan sandstone, Rayoung-Bang Lamung granite and Buriram basalt. Each specimen is prepared into prismatic specimen with nominal dimension of $54 \times 54 \times 108$ mm^3. For sedimentary rocks, the bedding planes are oriented perpendicular to the major axis to standardize testing conditions to single stage, while one specimen for multi-stage triaxial compression tests.

1.4.3 Single and multi-stage triaxial compression test

Single and multi-stage triaxial compression tests are conducted using a polyaxial compression frame device (Fuenkajorn, Sriapai, and Samsri, 2012) to directly measure axial and lateral strains during both the loading and reloading phases. These tests are conducted under constant confining pressures ranging from 0 to 40 MPa. To decrease friction, neoprene sheets are positioned at every interaction between the rock surface and the loading plates. The deformation of the sample in axial and lateral orientations is measured using dial displacement gages. This includes the collapsed load, the displacement, and modes of failure. Then, the specimen's strength and elastic parameters are calculated and studied. The multi-stage triaxial strength from just one specimen is used to predict the single stage triaxial strength.

1.4.4 Strength criteria

Hoek-Brown Criteria (Hoek-Brown, 1980), which are used to determine rock mass strength, are applied to the triaxial strength data. They are formulated in the terms of σ_1 and σ_3 at failure. The predictability of these strength is assessed and compared using the coefficient of correlation (R^2). The higher R^2 value shows that the criterion is more predictable and gives consistent values for m and s for correlating the single and multi-stage triaxial compression test results.

1.4.5 Deformation modulus

Empirical relations are employed to estimate the deformation moduli of rock specimens. According to Goodman (1970), the deformation modulus of the single stage triaxial test results is predicted by using the obtained multi-stage triaxial test results.

1.4.6 Mathematical Relations

The mathematical relation developed for the strengths and deformability of the rocks will be applied and compared with the test results obtained elsewhere.

1.4.7 Discussions and Conclusions

Discussions are made to explain the comparison between single- and multi-stage triaxial compressive strengths. Similarities and discrepancies will be identified. Applicability and limitations of the analysis results will be explained. Conclusions are drawn from the experimental and analytical results.

1.4.8 Thesis Writing

All the study activities, methods, and conclusions have been compiled in the thesis.

1.5 Thesis Contents

Chapter I explains the background of issues and the importance of the research. The research objectives, methodology, scope, and limitations are identified. Chapter II provides a summary of the literature review results. Chapter III describes sample preparations. Chapter IV describes the laboratory testing. Chapter V presents the results. Chapter VI describes the testing results analysis. Chapter VII describes the discussion and conclusion of the research results, including recommendations for future research studies.