SIMULATION STUDY ON VARIOUS SHAPES OF PAD FOOTING SUB-STRUCTURE ON BATU PAHAT SOFT SOIL

RASHIDAH BINTI ADON @ MOHD DON

This dissertation is submitted as a fulfillment of the requirements for the award of
The Degree of Master of Civil Engineering

Faculty of Civil and Environmental Engineering
Universiti Tun Hussein Onn Malaysia

MAY 2009

PTTA UTHM
PERPUSTAKAAN TUNKU TUN AMINAH

Specially dedicated to my

Dearest father and mother, Mr Adon @ Mohd Don and Aisyah Bte Wage, all my family members, roommates and friends who helped me accomplish this research.

Thanks for all your valuable contributions, patience and love.

PTTA UTHM
PERPUSTAKAAN TUNKU TUN AMINAH

ACKNOWLEDGEMENT

Praise be to Allah, Lord of the Worlds

In preparing this project report, I was in contact with many people, researchers, academicians and practitioners. They have contributed towards my understanding and thoughts. In particular, I wish to express my sincere appreciation to my supervisor, Associate Professor Dr Hj Mohd Idrus bin Hj Mohd Masirin for his encouragement, guidance critics, friendship and help during the development of this project report. Without her continued support and interest, this research would not have been the same as presented here.

I am very thankful to Ir Agus Sulaeman, Mr Felix and En Amir Salikin who have contributed towards my understanding and thoughts. My sincere appreciation also extends to all my friends and others who have provided support at various situations especially Royline Perseveranda Louis, Adzizah Ibrahim and Juliana Idrus. Their views and tips are useful indeed.Thanks to all for helping me either directly or indirectly in the completion of this report project.

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

ABSTRACT

This study describes a study on the geotechnical behavior of pad footing shapes using a finite element code, PLAXIS. In determining the suitability of footing to loadings, design criteria requires that the shapes and sizes should function according to the soil and types of structures erected on it. Higher loading will require bigger footing as this will give better support. Theoretically, a larger surface area will disseminate the loadings and reduce possibility of failure. However, this is not economical as more materials will be needed for the construction of the footing. Footing shapes is hypothetically considered as a factor that might affect the performance of footing. Non-linear finite element analyses based on a stress-strain model were performed to obtain the load-settlement responses of axially loaded on pad footings. It is essential since such design analysis, which is based on numerical analysis, could have advantages in providing preliminary expected outcomes for the modeling purpose. In conjunction to this matter, the potential of PLAXIS V8 finite element to predict the settlement of various shapes pad footing are performed successfully.

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

ABSTRAK

Kajian ini menerangkan mengenai ciri-ciri geoteknik bagi bentuk tapak asas menggunakan analisis unsur terhingga, PLAXIS. Dalam menentukan kesesuaian tapak ke beban, kriteria bagi reka bentuk memerlukan bentuk dan saiz yang berfungsi mengikut jenis tanah dan jenis struktur yang dikenakan.Beban yang lebih tinggi memerlukan tapak yang lebih besar untuk memberikan sokongan yang lebih baik. Secara teori, permukaan yang lebih luas akan menyebarkan beban dan mengurangkan kebarangkalian untuk mengalami kegagalan. Walaubagaimanapun, teori ini kurang praktikal kerana melibatkan kos bagi bahan-bahan yang diperlukan untuk pembinaan tapak. Secara andaian hipotesis, bentuk tapak perlu diberi pertimbangan sebagai salah satu faktor yang akan menentukan prestasi kegagalan tapak. Analisis unsur terhingga yang terhad berdasarkan model tekanan-tegangan dilakukan untuk mendapatkan hasil yang bertindakbalas apababila beban bersudut 90 darjah dikenakan pada asas tapak. Ini adalah amat penting kerana analisis rekabentuk ini berasaskan analysis angka, dimana ianya berpotensi untuk memberikan kesan atau akibat yang diduga bagi tujuan permodelan. Sehubungan dengan itu, kebolehan unsur terhingga PLAXIS V8 untuk meramal kestabilan pelbagai bentuk asas tapak dilakukan dengan jayanya.

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

CONTENTS

CHAPTER	TITTLE	PAGE
	DECLARATION	ii
	DECLARATION (SUPERVISOR)	iii
	DEDICATION	iv
	ACKNOWLEDGEMENT	v
	ABSTRACT	vi
	ABSTRAK	vii
	TABLE OF CONTENT	viii
	LIST OF TABLES	xii
	LIST OF FIGURES	xiii
	LIST OF SYMBOLS	xvi
	LIST OF APPENDICES	xvii
I	**INTRODUCTION**	
	1.1 Preface	1
	1.2 Problem Statement	2
	1.3 Focus of the Study	3

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

1.3.1 Aim of the Study
1.3.2 Objective of the Study
1.4 Scopes of the Study 4
1.5 Flow Chart of Research Project 5

II LITERATURE REVIEW

2.1 Simulation for Geotechnical Engineering 6
2.1.1 Types of Simulation 7
2.1.2 Advantages and Disadvantages 9
2.2 Footing 11
2.2.1 Definition of Footing 11
2.2.2 Types of Footing 12
2.2.3 Function and Criteria of Footings and Foundation 17
2.2.3.1 Bearing Capacity Equation 18
2.3 Contributing Factors Towards Footing Performance
2.3.1 Materials 22
2.3.2 Construction Work and Quality 23
2.3.3 Site Condition and Soil Properties 24
2.3.4 Footing Shapes and Sizes 24
2.4 Overview of Soils Geotechnical Properties Towards Engineering Fit For Purpose 25
2.4.1 Types of Soil 25
2.4.2 Soil Stabilization Methods For Construction Proposes 27
2.4.2.1 Vibrofloatation 27
2.4.2.2 Dynamic Compaction 28

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

2.4.2.3 Stone Columns 29
2.4.2.4 Compaction Grouting 30
2.4.2.5 Reinforcement Soil 31
2.4.3 Sub-Structures Construction 32
2.5 Finite Element Method in Geotechnical Engineering 35
2.5.1 Definition 36
2.5.2 Geometric Idealisation 37
2.5.3 Plaxis Finite Element Modelling 38
2.5.3.1 Mohr-Coulomb Model 39

III RESEARCH METHODOLOGY

3.1 Introduction 41
3.2 Research Schedule 42
3.3 Gathering Data and Information 44
3.3.1 Identify the Scope of Study 44
3.3 2 Literature Review 44
3.3.3 Soil Testing 45
3.3.2.1 Sample Preparation and Setting Up 46
3.3.2.2 Problems of Triaxial Testing 49
3.4 Application of Programming in the Design 50
3.5 Design Shapes 51
3.6 Numerical Modelling 53
3.7 Nomenclatures 60

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

IV RESULTS AND ANALYSIS

4.1 Introduction 61
4.2 Graphical Output 62
4.3 Vertical Displacement against Loading 140
4.4 Pore Presseure Against Loading 144
4.5 Distribution Percentage against Loading 149

V CONCLUSION

5.1 Conclusion 154
5.2 Recommendations 155

REFERENCES 156

APPENDIX 159

PTTA UTHM
PERPUSTAKAAN TUNKU TUN AMINAH

LIST OF TABLES

TABLE	TITLE	PAGE
3.1	Soil (clay) properties- Mohr–coulomb model	53

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

LIST OF FIGURES

FIGURES	TITLE	PAGE
1.1	Flow Chart of Research Project	5
2.1	Parts of Footing and Foundation	12
2.2	Types of Footing	13
2.3	Pad or Individual Foundation	14
2.4	Pad Footings	15
2.5	Continuous or Strip Footing	16
2.6	Mat or Raft Footing	17
2.7	Vibrofloatation	28
2.8	Dynamic Compaction	29
2.9	Stone Columns	30
2.10	Compaction Grouting	31
2.11	Reinforcement Soil	32
2.12	Construction of underground drainage system	33
2.13	Excavation tunneling and retaining wall	34
2.14	Parking Basement Construction	34
2.15	Excavation work for high rise building	34
2.16	Excavation work for underground train system	35
2.17	Finite element	36
2.18	Examples of plane strain	37
2.19	Examples of Axisysimmtery	38
3.1	Triaxial Apparatus	46

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

3.2	Sample Preparation	49
3.3	Haunched, Square and Circular Footing	52
3.4	General setting in software	55
3.5	Geometry of numerical modeling	55
3.6	Defining the material properties	56
3.7	Finished geometry inputs, material assign, loading imposes and mesh generation	57
3.8	Water pressure generated by the software	58
3.9	Initial stresses	58
3.10	Defining calculating phases and error massage indicating the ultimate load could hold by soil body.	59
4.1-4.13	Square shape with single storey loading	62
4.14-4.26	Trapezium or haunched Shape with single storey loading	75
4.27 – 4.39	Circular shape with single storey loading	88
4.40- 4.52	Square shape with double storey loading	101
4.53 – 4.65	Trapezium or haunched Shape with double storey loading	114
4.66 – 4.78	Circular shape with single storey building	127
4.79	a) Graph Vertical Displacement against Loading of Single Storey on Square Shape	140
	b) Graph Vertical Displacement against Loading of Double Storey on Square Shape	140
	c) Graph Vertical Displacement against Loading of Single Storey on Trapezium/Haunched Shape	141
	d) Graph Vertical Displacement against Loading of Double Storey on Trapezium/Haunched Shape	141
	e) Graph Vertical Displacement against Loading of Single Storey on Circular Shape	142

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

	f) Graph Vertical Displacement against Loading of Double Storey on Circular Shape	142
4.80	a) Graph Pore Pressure against Loading of Single Storey on Square Shape	144
	b) Graph Pore Pressure against Loading of Double Storey on Square Shape	145
	c) Graph Pore Pressure against Loading of Single Storey on Trapezium/Haunched Shape	145
	d) Graph Pore Pressure against Loading of Double Storey on Trapezium/Haunched Shape	146
	e) Graph Pore Pressure against Loading of Single Storey on Circular Shape	146
	f) Graph Pore Pressure against Loading of Double Storey on Circular Shape	147
4.81	a) Graph Distribution Percentage against Loading of Single Storey on Square Shape	149
	b) Graph Distribution Percentage against Loading of Double Storey on Square Shape	150
	c) Graph Distribution Percentage against Loading of Single Storey on Trapezium/Haunched Shape	150
	d) Graph Distribution Percentage against Loading of Double Storey on Trapezium/Haunched Shape	151
	e) Graph Distribution Percentage against Loading of Single Storey on Circular Shape	151
	f) Graph Distribution Percentage against Loading of Double Storey on Circular Shape	152

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

LIST OF SYMBOLS AND ABBREVIATIONS

q_{ult}	- Ultimate bearing capacity
Nc,Nq,Nγ	- Bearing capacity factors
$s_c,s_q,s\gamma$	- Shape factors
$d_c,d_q,d\gamma$	- Depth factors
$i_c,i_q,i\gamma$	- Inclination factors
D_f	- Depth of foundation
B	- Width of Foundation
ρ	- Bulk density
c	- Cohesion
θ '	- Friction angle
γ	- Bulk unit weight
s_u	- undrained shear strength
USCS	Unified Soil Classification System
E	- Young modulus
υ	- Poisson's ratio
ψ	- Dilatancy angle

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	Single Storey House Layout Plan	159
B	Double Storey House Layout Plan	164
C	Plaxis Result	169

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

CHAPTER I

INTRODUCTION

1.1 Preface

Peninsular Malaysia extends from latitude 1^0 20'N to latitude 6^0 20'N and longitude 104^0 20'E lies in a tectonically stable region known as the Sundra Land (Tjia, 1980). According to Masirin et al (2003), Malaysia is one of the countries in the world that has substantial land area that is covered by soft soil. It covers more than 3 million hectares that is more than 8% of the total Malaysia's land area, with Sarawak having the largest coverage 1.7 million hectares or more than 13% of the state land area.

In times of urbanization growth with the rapid economic development and lack of suitable land for infrastructures, construction and maintaining building over soft clay is often associated with problems. Soil medium has very complex and erratic mechanical behavior because of the nonlinear, stress dependent, anisotropic and heterogeneous nature of it. The constructions method in this formation is not only governed by direct cost but also the long term maintenance costs, durations of completion and cost benefits.

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

Therefore, many researchers and organization has motivated to find alternative materials and technique that not contributing too much cost. Simulation or finite element method has proved to be most of the cheaper, faster and realistic tool of the construction process than performing the multiply test of the design each time. The introduction of inexpensive, but sophisticates, computer hardware and software has resulted in considerable advances in the analysis and design geotechnical structures.

The principle of using the finite element method in the study of geotechnical problems has been established for some while and the extensive literature on the subject indicates that geotechnical engineers have had a great deal of success in using this type of analysis (Burt, 1978). It has been used in many fields of engineering practice for over thirty years; and only relatively recently that it has begun to be widely used for analyzing geotechnical problems. This is probably because there are many complex issues which are specific to geotechnical engineering. Increasingly, management is viewing simulation as a very inexpensive insurance policy[2].

1.2 Problem Statement

Foundations and footings are crucial to success of a building. Traditionally footing shape has been studied both experimentally and theoretically for decades using Terzhagi, 1943; Mayerhof, 1951, 1963; Brinch Hansen, 1970 equation. But the normal shapes that propose by them are only squared, circular and rectangular. Most design codes or device manuals are based on such approaches. At present, there are many different methods of calculation and design available for analyzing geotechnical structures. Because all of these methods are based on simplified analysis, they cannot provide the engineer with all the desired design information and only provide very limited indications of soil.

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

The introduction of numerical or finite element software has resulted in considerable advances in the analysis and design of footing structures. Therefore, it is of great encouragement to study and understand the use of software in solving practical problem.

1.3.1 FOCUS OF THE STUDY

1.3.1 Aim Of The Study

The primary aim of the research project is to identify the most suitable footing shape when constructed on Batu Pahat Soft Clay (BPSC) to reduce settlement and which will be cost effective.

1.3.2 Objective Of Study

In specific, the major objectives of this study include:

1. To attempt simulation of different pad footing shapes using PLAXIS V8 software.

2. To analyze and identify the performance of different pad footing shape under soft clay condition

3. To critically evaluate and analyze the settlement and bearing capacity behavior of different pad footing shapes

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

1.4 Scopes Of Study

Research scope will concern on simulation analysis of bearing capacity and settlement of two different shapes of pad footing on the given condition of soft soil using PLAXIS software. It will concentrate on the use of Mohr Coulomb models of soils behavior. The load will be based on actual drawing of single and double storey building calculated using ESTEEM software. In achieving the objectives of this study, only clay soils were focused. In this regard, PLAXIS Version 8 will be used to perform two dimensional analyses of pad footing. The parameters of the soil on this study are based on the soil properties of Research Centre of Soft Soil (RECESS).

PTTA UTHM
PERPUSTAKAAN TUNKU TUN AMINAH

1.5 Flow Chart of Research Project

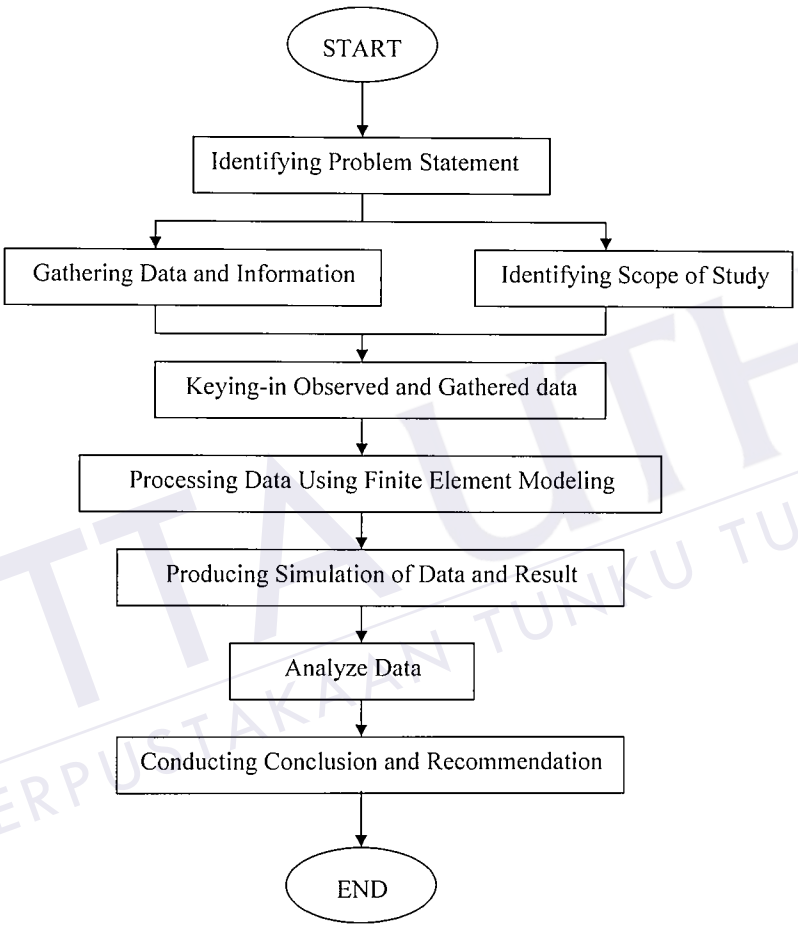

Figure 1.1 Flow Chart of Research Project

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

CHAPTER II

LITERATURE REVIEW

2.1 Simulation for Geotechnical Engineering

As geotechnical projects are becoming larger and more complex, simulation has become a popular problem solving methodology for engineers, designers and managers (Doukidis and Paul, 1990). Great advances in the understanding of soil behaviour and a revolution in computer technology has opened up a new ways to tackle old problems. Simulation has proved to be a very powerful tool in a very large area of applications. The reason is its great versatility, flexibility and power. As a result of this, many software packages have been developed for modeling simulation problems (Paul, Hlupic and Nikourkaran, 1998). Recent surveys of management science practitioners, simulation and statics have the highest rate of application over all other tolls by over a 2:1 margin.

From the engineering point of view, knowing the actual behavior of a system by making a duplicate having the same characteristics as the original, with the use of a computer or a model is known as simulation. According to Webster's Collegiate Dictionary simulation means "to feign, to obtain the essence of, without the reality".

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

Thus according to Schriber (1987), simulation involves the modeling of a process or system in such a way the model mimics the response of the actual system to events that take place over time. While Robert E Shannon define simulation as a process of designing a model of real system and conducting experiments with this model for the purpose of either understanding the behavior of the system and or evaluating various strategies for the operation of the system.

Therefore in its purest form, simulation can be consider to be branch of applied mathematics and as a cost effective way of pre-testing proposed systems, plans or policies before developing expensive prototypes, field tests or actual implementations.

2.1.1 Types of Simulation

Simulation is used for understanding effects because use of an actual subject is not only costly but involves certain risks. In other words, by applying different variables to the model and doing simulation, it is possible to perform numerical experiments easily in response to different condition (Mikihiko Ohnari, 2003). The simulation analysis of different types of systems are conducted for the purposes of (Pedgen et al., 1995)

i) Gaining insight into the operation of a system

ii) Developing operating or resource policies to improve system performance

iii) Testing new concepts and or system before implementation

iv) Gaining information without disturbing the actual system

In addition, simulation has several types. These include (Drake M.A,2003)

i) Discrete event simulation

Discrete event simulation relies on entity arrivals and service completions. The resulting interaction between constrained resources dynamically drives the model. Events take place instantaneously in discrete steps. Manufacturing system simulations are often developed as discrete event models.

ii) Continuous simulation

Continuous simulation is based on the interaction of variables as they change over time. Continuous systems are often based on interrelated algebraic or differential equations. An example of a continuous simulation is a model of economic competition. This relationship can be analyzed with interrelated partial derivatives. As in discrete event applications, time is an important factor in continuous simulation. However, unlike a discrete system, the state of the model changes constantly in response to time.

iii) Monte Carlo Simulation

Monte Carlo simulation derives its name from the atmosphere of chance associated with the world-famous gambling center of the same name. John Von Neumann used the code name Monte Carlo at Los Alamos while developing random number-based experiments during the development of the atomic bomb. The name stuck and still represents this type of modeling. Monte Carlo simulations use random numbers to solve certain stochastic problems where the passage of time plays no role. Although tracking time in continuous and discrete event simulation is essential, in Monte Carlo it is not.

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

iv) Gaming

Refer to the use of simulation to generally enhance a learning process. Gredler provides five criteria that describe this type of simulation. These are:

a) simulation are problem based learning units set into motion by task, policy, issue, crisis or problem

b) the subject matter relates to complex situations not cut and-dried problems

c) participant carry out roles associated with their position and the situation they find themselves in

d) Outcomes are based on a combination of chance and the actions of the participants

e) Participants experience the reality of the situation by fulfilling their roles realistically and conscientiously.

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

2.1.2 Advantages and Disadvantages

In addition simulations have specific benefits. There are a few advantages to performing a simulation rather than actually building the design and testing it. This simulation has the following benefits:

REFERENCES

Banks, J (1998). "Handbook of Simulation Principles, Methodology, Advances, Application and Practice" John Wiley & Sons, Atlanta, Georgia.

Braja M. Das, (1999). "Principles of Foundation Engineer".4th Edition, California State University, Scramento: PWS Publishing.

Brinkgreve R.B.J, (2001). "PLAXIS:Finite Element Code for Soil and Rock Analysis".Delft University of Technology & PLAXIS: Nertherlands.

Budhu, M (2000). "Soil Mechanics and Foundations", John Wiley and Sons.

Cerato,A.B,Lutenegger,A.J (2003). "Model Footing Tests on a Finite Layer of Granular Soil". FONDSUP 2003 International Symposium.

Dearbon Home Inspiration Chicago (2006) "Principles Home Inspection Structures"

D. Padmini at al (2007). "Ultimate Bearing Capacity Prediction of Shallow Foundaton on Cohesionless Soils Using Nerofuzzy Models" Scince Direct, Vol 35 p 33-46

Donald P. Coduto (2001). "Foundation Design Principles and Practices" Prentice-Hall, New Jersey

Junhwan lee et al (2005) . "Bearing Capacity of Circular Footings under Surcharge Using State-Dependent Finite Element Analysis" Scince Direct, Vol 32 p. 445-457

Lymon c. Reese, William M. Isenhower and Shin-Tower Wang (2006). "Analysis and Design of Shallow and Deep Foundations" John Wiley & Sons, Canada.

Mark R. Miller, Rex Millex, Glen E.Baker (2005). " Carpentry and Construction" McGraw-Hill, United States.

MJ Tomlinson (2001). "Foundation design and Construction" TJ International Ltd, Padstow, Cornwall.

Mohd Nazrin(2006). " Simulation of pavement Deformation for Different Approach Slabs Concepts Constructed on Batu pahat Soft Soil" UTHM

Neol Simons & Bruce Menzies (2001) "Foundation Engineering" Thomas Telford Publishing, London.

Nikoukaran, J et Hlupic,Vlatka, Paul, R.J (1998) "Criteria for Simulation Software Evaluation". Proceeding of the 1998 Winter Simulation Conference.

N.J. Seward (2006). "Structural Foundation Designers' Manual" Blackwell Publishing, United Kingdom

P.A. Vermeer(2000). "On The Future of PLAXIS" Computational Geotechnics. Balkema, Rotterdam.

Reference Manual Plaxis Version 8 (2002). Delf University of Technology & Plaxis. A. Balkelma Publisher, Netherland.

Robert W. Day (2005). "Foundation Engineering Handbook" McGraw- Hill, United States.

Santana, M.T et Lamas, P.C (2007). "Computational Tools for Teaching Graduates Courses in Geotechnical Engineering". International Conference on Engineering Education-ICEE, Coimbra Portugal.

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

Tjia, H.D (1987). "Geomorfologi." Dewan Bahasa dan Pustaka, Kuala Lumpur

Tedd Benson (2007). "The Timber Frame Home: Design, Construction and Finishing" The Taunton Press, United States.

PTTA UTHM
PERPUSTAKAAN TUNKU TUN AMINAH