


CONSTRUCTION OF A FACTORY BUILDING WITH GROUND IMPROVEMENT BY PRE LOADING

K.A Madunishanthi

 University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk
This thesis was submitted to the in partial fulfillment of the requirements for the Degree of
Master of Engineering in Foundation Engineering.

Department Of Civil Engineering

University Of Moratuwa

Srilanka.

93884

December 2008.

CONTENTS

CHAPTER 01 - INTRODUCTION

- 1.1 Background
- 1.2 Proposed Methodology
- 1.3 Outline of the thesis

CHAPTER 02 - IDEALIZATION OF SUBSOIL CONDITION AM) BUILDING LAYOUT.

- 2.1 Building Layout
- 2.2 Sub soil condition and Details of the structure.
- 2.3 Idealization of sub soil condition
 - 2.3.1 Sub soil profile stage 1
 - 2.3.2 Sub soil profile - stage 2
- 2.4 Laboratory test results



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mru.ac.lk

CHAPTER 3 - GROUND IMPROVEMENT PROCESS AND MONITERING.

- 3.1 Ground improvement process
- 3.2 Filling process
- 3.3 Monitoring of settlement and pore water pressure
- 3.4 Theoretical Analysis of the total settlement
 - 3.4.1 Theoretical analysis of the total settlement - Stage 1
 - 3.4.2 Theoretical analysis of the total settlement - Stage 2
- 3.5 Filling Sequence
- 3.6 Observed Settlement
- 3.7 Observed Behavior of the Structure after Ground Improvement

CHAPTER 4 - MODELING THE SETTLEMENT BEHAVIOUR AND COMPARISON WITH OBSERVED SETTLEMNET

- 4.1 The Modeling of the consolidation settlements.

- 4.2 Comparison of predicted and observed settlements
- 4.3 Comparison of predicted and observed settlement for stage 1
 - 4.3.1 Comparison of predicted and observed settlement for stage 1 using Terzaghi Theory
 - 4.3.1.1 Comparison of predicted for stage 1 using Terzaghi Theory by varying compressibility parameters to match the observations.
 - 4.3.2 Comparison of predicted and observed settlement with incremental placement of the fill
 - 4.3.3 Comparison of predicted and observed settlement with
 - 4.4 Comparison of predicted and observed settlement for stage 2
 - 4.4.1 Comparison of predicted and observed settlement with incremental placement of the
- 1111
- 4.4.2 Comparison of predicted and observed settlement with $U\% = \frac{KT'}{}$ -

CHAPTER 5 - CONCLUSIONS



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

Acknowledgement

I wish to acknowledge with thanks, the valuable guidance and assistance of Prof. S. A. S. Kulathilaka, Senior lecture, University of Moratuwa.; during this research forwarded.

I also wish to acknowledge the assistance of Ms. Pradeepa of The Soil Mechanical laboratory of The University of Moratuwa.

I would like to extend my sincere appreciation to Eng. Hussein Fazliabas Managing director of Perigon Lanka Pvt Limited who granted me leave and encouraged me to complete my research work.

My gratitude is extended to The University of Moratuwa for providing me with this opportunity to further my academic aspirations.

I further wish to acknowledge The Asian Development bank and The Ministry of Science and Technology of Sri Lanka for funding this research through the science and Technology Personal Development project.



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

CONTENTS

	Page
CHAPTER 01 – INTRODUCTION	
1.1 Background	01
1.2 Proposed Methodology	01
1.3 Outline of the thesis	01
CHAPTER 02 - IDEALIZATION OF SUBSOIL CONDITION AND BUILDING LAYOUT.	
2.1 Building Layout	02
2.2 Sub soil condition and Details of the structure.	02
2.3 Idealization of sub soil condition	
2.3.1 Sub soil profile – stage 1	02
2.3.2 Sub soil profile – stage 2	03
2.4 Laboratory test results	03
CHAPTER 3 - GROUND IMPROVEMENT PROCESS AND MONITERING.	
3.1 Ground improvement process	10
3.2 Filling process	12
3.3 Monitoring of settlement and pore water pressure	12
3.4 Theoretical Analysis of the total settlement	14
3.4.1 Theoretical analysis of the total settlement – Stage 1	15
3.4.2 Theoretical analysis of the total settlement – Stage 2	16
3.5 Filling Sequence	17
3.6 Observed Settlement	18
3.7 Observed Behavior of the Structure after Ground Improvement	21
CHAPTER 4 - MODELING THE SETTLEMENT BEHAVIOUR AND COMPARISON WITH OBSERVED SETTLEMNET	
4.1 The Modeling of the consolidation settlements.	24
4.2 Comparison of predicted and observed settlements	28
4.3 Comparison of predicted and observed settlement for stage 1	
4.3.1 Comparison of predicted and observed settlement for stage 1 using Terzaghi Theory	28
4.3.1.1 Comparison of predicted for stage 1 using Terzaghi Theory by varying compressibility parameters to match the observations.	34
4.3.2 Comparison of predicted and observed settlement with incremental placement of the fill	40
4.3.3 Comparison of predicted and observed settlement with $U\% = KT^{2/3}$	46

4.4 Comparison of predicted and observed settlement for stage 2	51
4.4.1 Comparison of predicted and observed settlement with incremental placement of the fill	51
4.4.2 Comparison of predicted and observed settlement with $U\% = KT^{2/3}$	53
CHAPTER 5 - CONCLUSIONS	55



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

LIST OF FIGURES

	Page
Figure 2.1 Building layout & locations of Boreholes & Settlement Gauges	04
Figure 2.2 Vertical sub surface profile across BH -2, BH-3, BH-1, BH-4&BH-5 (Stage01)	05
Figure 2.3 Vertical sub surface profile BH-7, BH-8&BH-6 (Stage 01)	06
Figure 2.4 Vertical subsurface profile across Boreholes	07
Figure 2.5 e Vs $\log(\sigma)$ plot for BH3 – 2.5-3.0-m – Sample1	08
Figure 2.6 e Vs $\log(\sigma)$ plot for BH1 – 6.5-7.0-m – Sample2	09
Figure 3.1 Settlement Vs Time	11
Figure 3.2 e Vs Log σ Relationship	11
Figure 3.3 Settlement plate	13
Figure 3.4 Detail of an open standpipe piezometer	13
Figure 3.5 Idealized Sub soil profile across settlement plate 2 at stage 1	14
Figure 3.6 Idealized Sub soil profile across settlement plate 8 at stage 1	15
Figure 3.7 Idealized Sub soil profile across settlement plate 2 at stage 2	16
Figure 3.8 Loading sequence of the fill at stage 1	17
Figure 3.9 Loading sequence of the fill at stage 2	17
Figure 3.10 Elevation of the main building stage 1	22
Figure 3.11 Elevation of the extension building for stage 2	23
Figure 4.1 Compressible Clay layer in between permeable sand layers.	24
Figure 4.2 Variation of Degree of consolidation over the layer thickness with T	26
Figure 4.3 Variation of average degree of consolidation with Time Factor T_v	27
Figure 4.4 Comparison of predicted settlement with observed settlement for $c_c/1+e_0=0.137$, $c_v=2.0$ m ² /yr and $c_v=2.5$ m ² /yr –settlement gauge 2 at stage1	30
Figure 4.5 Comparison of predicted settlement with observed settlement for $c_c/1+e_0=0.137$, $c_v=8.5$ m ² /yr , $c_v=9.0$ m ² /yr and $c_v=14.0$ m ² /yr –settlement gauge 2 at stage1	30
Figure 4.6 Comparison of predicted settlement with observed settlement for $c_c/1+e_0=0.137$, $c_v=2.0$ m ² /yr and $c_v=2.5$ m ² /yr –settlement gauge 8 at stage1	32
Figure 4.7 Comparison of predicted settlement with observed settlement for $c_c/1+e_0=0.137$, $c_v=14.0$ m ² /yr and $c_v=20.0$ m ² /yr –settlement gauge 8 at stage1	33
Figure 4.8 Comparison of predicted settlement with observed settlement for $c_c/1+e_0=0.093$, $c_v=2.0$ m ² /yr and $c_v=2.5$ m ² /yr –settlement gauge 2 at stage1	36
Figure 4.9 Comparison of predicted settlement with observed settlement for $c_c/1+e_0=0.093$, $c_v=8.5$ m ² /yr , $c_v=9.0$ m ² /yr and $c_v=14.0$ m ² /yr –settlement gauge 2 at stage1	36
Figure 4.10 Comparison of predicted settlement with observed settlement for $c_c/1+e_0=0.086$, $c_v=2.0$ m ² /yr and $c_v=2.5$ m ² /yr –settlement gauge 8 at stage1	38

LIST OF FIGURES

Page

- Figure 4.11 Comparison of predicted settlement with observed settlement for $c_v/1+e_0=0.086$, $c_v=14.0 \text{ m}^2/\text{yr}$ and $c_v=20.0 \text{ m}^2/\text{yr}$ –settlement gauge 8 at stage 1 39
- Figure 4.12 Comparison of predicted settlement with observed settlement with incremental placement of fill for $c_v/1+e_0=0.137$ for S2 at stage 1. 42
- Figure 4.13 Comparison of predicted settlement with observed settlement with incremental placement of fill for $c_v/1+e_0=0.093$ for S2 at stage 1. 42
- Figure 4.14 Comparison of predicted settlement with observed settlement with incremental placement of fill for $c_v/1+e_0=0.137$ for S8 at stage 1. 45
- Figure 4.15 Comparison of predicted settlement with observed settlement with incremental placement of fill for $c_v/1+e_0=0.086$ for S8 at stage 1. 45
- Figure 4.16 Comparison of predicted settlement with observed settlement I for $c_v/1+e_0=0.093$ for $U\% =KT^{2/3}$ relationship for S2 at stage 1. 48
- Figure 4.17 Comparison of predicted settlement with observed settlement I for $c_v/1+e_0=0.086$ for $U\% =KT^{2/3}$ relationship for settlement gauge 8 at stage 1. 50
- Figure 4.18 Comparison of predicted settlement with observed settlement with incremental placement of fill for $c_v/1+e_0=0.137$ for S4 at stage 2. 52
- Figure 4.19 Comparison of predicted settlement with observed settlement with incremental placement of fill for $U\% =KT^{2/3}$ relationship for $c_v/1+e_0=0.137$ for S4 at stage 2. 54

LIST OF TABLES

	Page
Table 2.1 Consolidation Test result for BH3 at 2.5 -3.0 m	08
Table 2.2 Consolidation Test result for BH1 at 6.5-7.0m	09
Table 3.1 Observed settlement readings at stage 1	19
Table 3.2 Observed settlement readings & piezometer reading at stage 2	20
Table 4.1 Variation of Time Factor with Degree of Consolidation	26
Table 4.2 Predicted settlements for $c_c/1+e_0 = 0.137$, $c_v = 2.0 \text{ m}^2/\text{yr}$ and $c_v = 2.5 \text{ m}^2/\text{yr}$ for settlement gauge 2 at stage 1.	28
Table 4.3 Predicted settlements for $c_c/1+e_0 = 0.137$, $c_v = 2.0 \text{ m}^2/\text{yr}$ and $c_v = 2.5 \text{ m}^2/\text{yr}$ for settlement gauge 8 at stage 1	31
Table 4.4 Predicted settlements for $c_c/1+e_0 = 0.093$, $c_v = 2.0 \text{ m}^2/\text{yr}$ and $c_v = 2.5 \text{ m}^2/\text{yr}$ for settlement gauge 2 at stage 1.	33
Table 4.5 Predicted settlements for $c_c/1+e_0 = 0.086$, $c_v = 2.0 \text{ m}^2/\text{yr}$ and $c_v = 2.5 \text{ m}^2/\text{yr}$ for settlement gauge 8 at stage 1	37
Table 4.6 Predicted settlements for $c_c/1+e_0 = 0.137$, $c_c/1+e_0 = 0.093$ and $c_v = 20.0 \text{ m}^2/\text{yr}$ for settlement gauge 2 at stage 1 by considering loading Sequence of the fill.	39
Table 4.7 Predicted settlements for $c_c/1+e_0 = 0.137$, $c_c/1+e_0 = 0.086$ and $c_v = 24.0 \text{ m}^2/\text{yr}$ for settlement gauge 8 at stage 1 by considering loading Sequence of the fill.	43
Table 4.8 Predicted settlements for $c_c/1+e_0 = 0.093$, $c_v = 2.5 \text{ m}^2/\text{yr}$, $c_v = 15.0 \text{ m}^2/\text{yr}$, $c_v = 20.0 \text{ m}^2/\text{yr}$, $c_v = 30.0 \text{ m}^2/\text{yr}$ and $c_v = 36.0 \text{ m}^2/\text{yr}$ for settlement gauge 2 at stage 1 for $U\% = KT^{2/3}$.	46
Table 4.9 Predicted settlements for $c_c/1+e_0 = 0.086$, $c_v = 2.5 \text{ m}^2/\text{yr}$, $15.0 \text{ m}^2/\text{yr}$, $30.0 \text{ m}^2/\text{yr}$, $36.0 \text{ m}^2/\text{yr}$ and $c_v = 50.0 \text{ m}^2/\text{yr}$ for settlement gauge 8 at stage 1 for $U\% = KT^{2/3}$.	48
Table 4.10 Predicted settlements for $c_c/1+e_0 = 0.137$ and $c_v = 2.5 \text{ m}^2/\text{yr}$ for settlement gauge 4 at stage 2 by considering loading sequence of the fill.	51
Table 4.11 Predicted settlements for $c_c/1+e_0 = 0.137$ and $c_v = 2.5 \text{ m}^2/\text{yr}$ for settlement gauge 4 at stage 2 for $U\% = KT^{2/3}$.	53
Appendix 1 – Tables	A1
Appendix 2 – Logs of Boreholes	A23