Victor de Mello Lecture in Goa

by

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Griffith University Gold Coast Campus
Gold Coast, Australia

4th de Mello Lecture in Goa: A.S. Balasubramaniam

It gives me great pleasure to give the 4th de Mello Goa Lecture at the invitation of Prof. Savoikar in association with Brazilian Geotechnical Society and Portuguese Geotechnical Society. The previous lectures were given by Luiz de Mello, Prof Pedro Pinto and Prof Madhav. I have known Victor during my time at the Cambridge University and when he gave the Rankine Lecture Series of ICE London. My lecture will be rather informal with personal touch. I invited Victor to a large Dam Conference at AIT in Bangkok in 1980. There were some Giants in Geotechnical Engineering giving lectures and these include Prof de Mello, Dr Arthur Penman, Dr Alan Meigh, Prof Harry Seed, Prof Walter Wittke and many others. Details of these and others can be found in the web :

http://seags.ait.asia/links-for-easy-access/


PROF WALTER WITTKE

4th de Mello Lecture in Goa: A.S. Balasubramaniam

Son of a Professor Medical Colonel M.P. and a German Swiss mother Victor de Mello was born in Goa, Portuguese India, in 14 May 1926, attended British boarding school in India, moved to Boston in 1944; as a brilliant student at the MIT he obtained both his BSc and MSc in 1946 and his doctoral degree in 1948. He immigrated to Brazil in 1949 to be a Brazilian, both because of deep-rooted cultural affinities with Goa, and because of the nostalgic challenges of unopened frontiers of tropical civil engineering. It is in Brazil and from Brazil that Victor has grown from his strong roots into a big tree, spreading his teachings to the four winds and the fruit of his works through countless projects built.

4th de Mello Lecture in Goa: A.S. Balasubramaniam

Some of the honors received by victor include being a honorary member of many Societies of Soil Mechanics (Argentina, Japan, Portugal, Southeast Asia, Venezuela), Fellow of the Third World Academy of Science in Trieste Italy, Foreign Associate of the National Academy of Engineering of the USA, President of the International Society of Soil Mechanics and Geotechnical Engineering (1981-1985), Vice-president of the International Society for Rock Mechanics (1970-1974), Founder and President of the Brazilian Society of Soil Mechanics and geotechnical Engineering (1964-1966), recipient of the Terzaghi Award twice in Brazil and of the Manuel Rocha Award in Portugal, Terzaghi Orator ISSMFE (1994), member of the National Academy of Engineering of Brazil and of Argentina.

LUIZ de Mello EXCELLENT GEOTECHNICAL ENGINEER : Gave The de Mello GOA LECTURE AS WELL

The first Dr. Victor de Mello lecture was presented by Prof. Madhira Madhav, Professor Emeritus IIT Hyderabad and JNTU on the topic "Carrying Capacity of Foundations on and in the Ground"

SEAGS-AGSSEA Folders: AIT Related Materials: Griffith University: Prof. Bala Summary Folders: Other Leading Universities – Cambridge University: etc

- **Prof. Bala: Summary Folders**

- **Biodata**
- **Publications**
- **Google Scholar**
- **Balkema Books**
- **Kevin Nash Gold Medal**
- **Activities at NTU**
- **Activities in University of Peradeniya**

Arthur Casagrande-Architect behind First ICSMGE held in 1936 in Harvard University: Left over Exam Papers sent to me in 1970 to Sri Lanka: While clearing his Office: In his Final Year Stay – Harvard University:

Victor was a Guest Lecture in our SEAGS Conference held in HK in 1972: He gave an ex cellent lecture: **3rd SEAC 1972 Hong Kong**

Proceedings of the 3rd Southeast Asian Conference on Soil Engineering, 6-10 November 1972, Hong Kong (Volume 1)

Proceedings of the 3rd Southeast Asian Conference on Soil Engineering, 6-10 November 1972, Hong Kong (Volume 2)

OUR SEAGS SOCIETY THEN INVITED HIM FOR 8th SEAGC in KL: Victor was then the President of ISSMGE and gave excellent lecture and participated in all events.

I also attended the Harry SEED ICSMGE in San Francisco and then the Brazilian event held in honour of de Mello.

I like to devote this lecture to emphasize that Academics must widen their roles in undertaking project based work and continuing education to engage in organizing Courses and Conferences for their colleagues and profession in general.

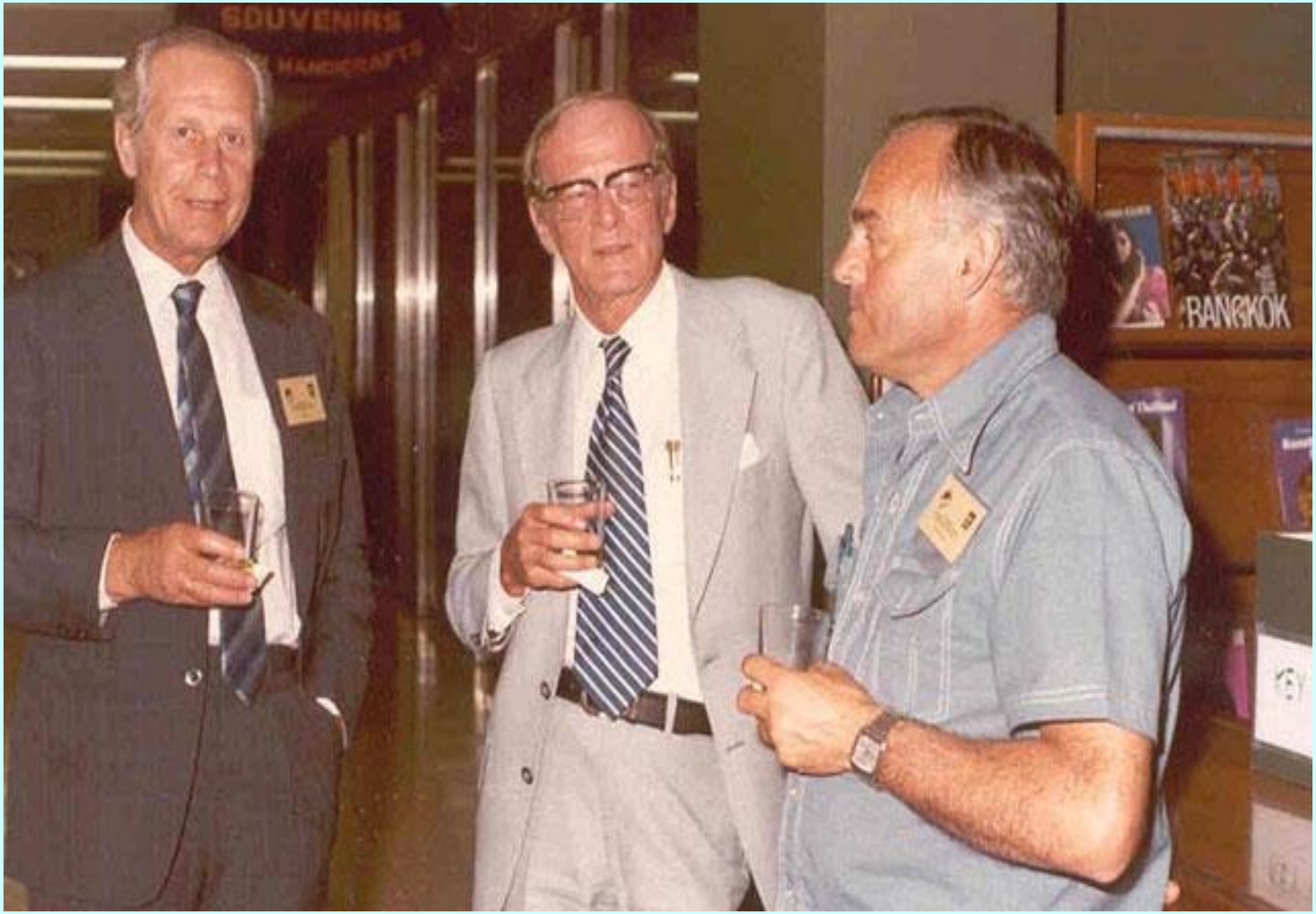
Reviewer : Journals

1: Ains_Sham Enginering Journal—Middle-east Asia
2: ASCE Constructed Facilities
3: Journal of Chinese Institute of Engineers
4: Clay Mineralogy Journal
5: Engineering Geology Journal
6: Geotechnical & Geological Engineering Journal
7: ASCE-Geotechnical & Geo-environmental Engineering Journal
8: ASTM: Geotechnical Testing Journal
9: Geotechnique
10: Geotechnique Letters
11: Ground Improvement: ICS London
12: International Journal of Geomechanics
13: Soils & Foundations, JGS

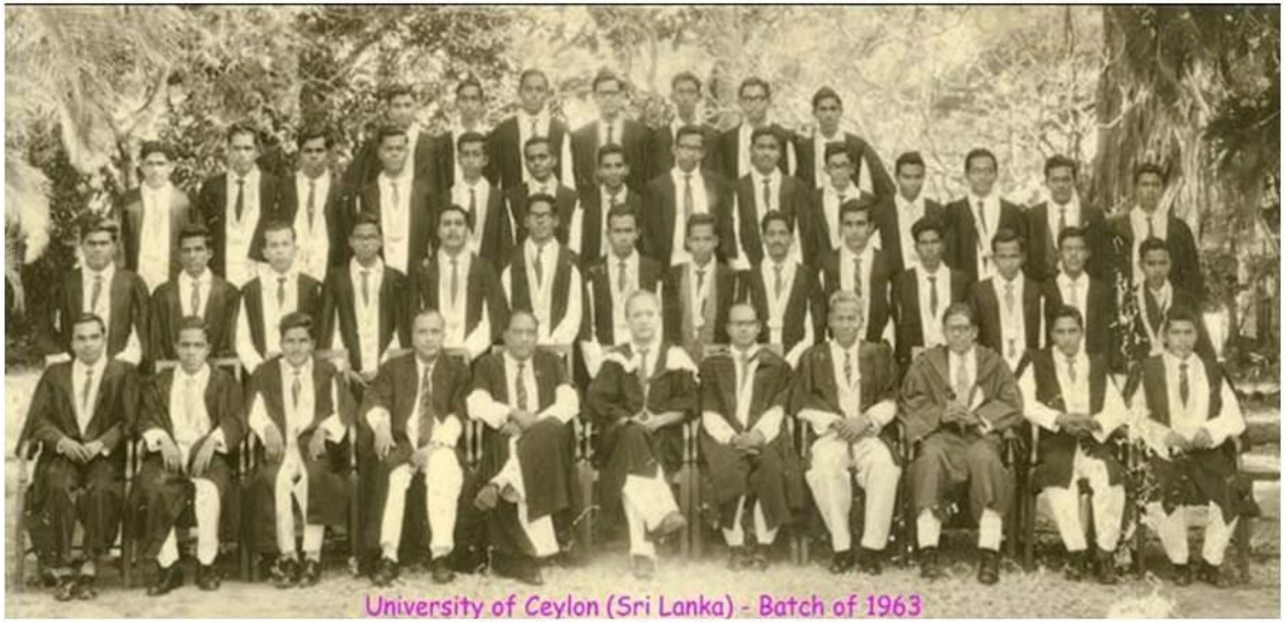
4th de Mello Lecture in Goa: A.S. Balasubramaniam

I worked in Sri Lanka from 1970 to 1973 after returning from Cambridge and NGI. During this time I brought the practicing engineers close to the Engineering faculty. I did the same at AIT as well for 27 years from 1973 to 2001.I engaged in Professional activities as the Secretary of the Southeast Asian Geotechnical Society, and also as President;later as the Vice President of ISSMGE. I was involved with the Society Journal. Organized numerous Short Courses, Conferences etc. My research activities spanned to many countries in Asia, especially, SE Asia comprising, Thailand, Singapore, Malaysia, Indonesia, Hong Kong, Taiwan etc. . I had excellent relationship with the Japanese Society and all the leading Scholars in Japan.


THIRTEENTH SOUTHEAST ASIAN GEOTECHNICAL CONFERENCE
第十三屆東南亞大地工程會議


SOUVENIRS
BANGKOK


APPLIED GROUND IMPROVEMENT
TECHNIQUES
7-11 DECEMBER 1992



Third row standing in left

1980

1990

2006

2008

2010

Planning, Execution and Analysis of Large Scale Field Tests in Geotechnics Test Embankments

By

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Professor of Geotechnical Engineering,
Griffith University Gold Coast Campus
Gold Coast, Australia

Difficulties in undisturbed sampling and inherent limitations in laboratory tests have encouraged the execution of large scaled field tests. These tests are some time conducted to directly measure the engineering properties of soils but often to back-calculate these values reliably from full-scale trials conducted prior to the actual design.

In this brief lecture, case studies of embankments in soft clays where large scale field trials are conducted in many countries such as Norway, Thailand, Malaysia and Australia will be discussed and how the performance of these tests have often deviated from their intended purpose.

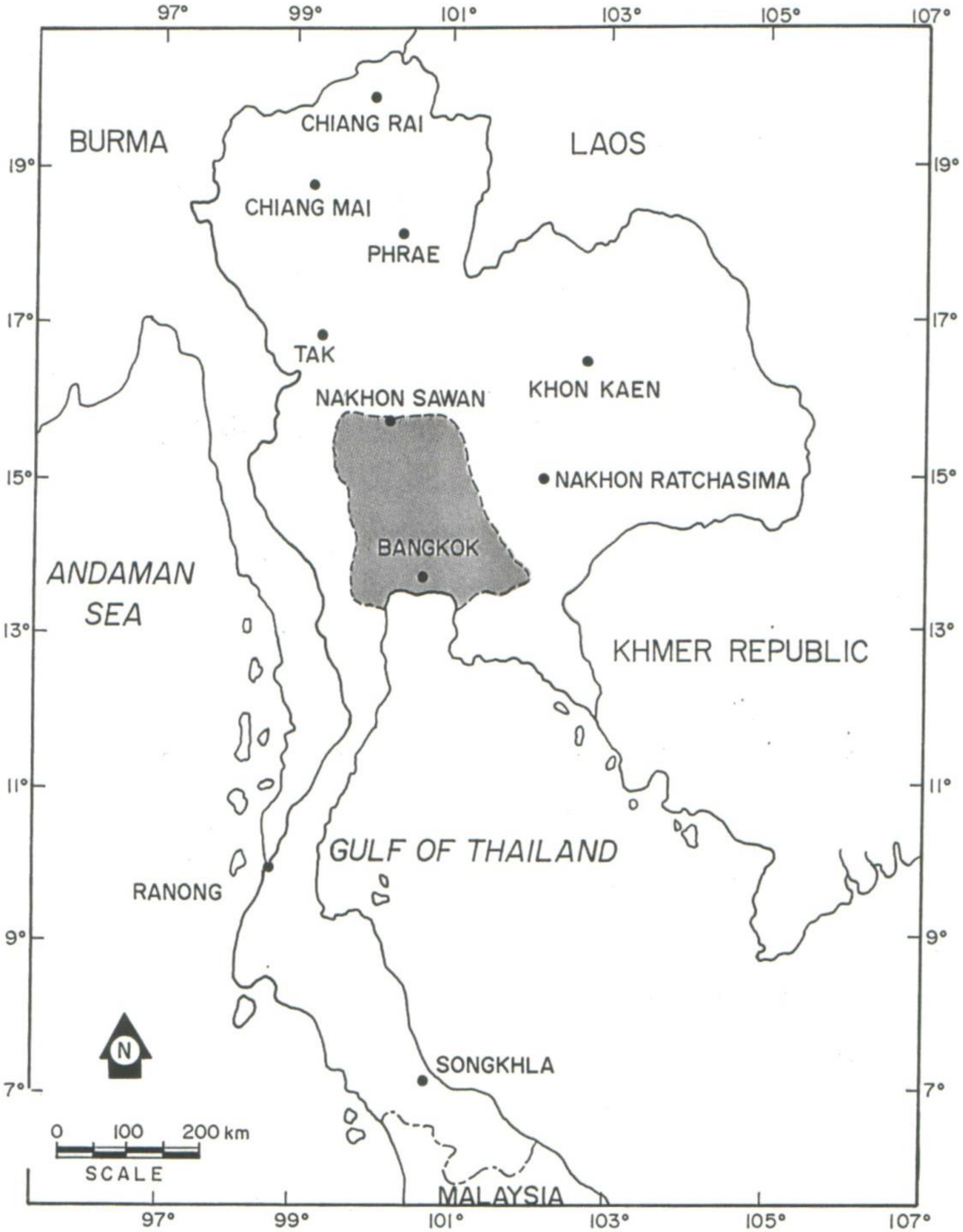
Drawbacks in Preparing this Lecture

1. No students (For help)
2. Very poor library
3. Very poor laboratory (try hard to improve)
4. No computer softwares
5. Absolutely no contact with industries & government and state agencies

Gold Coast

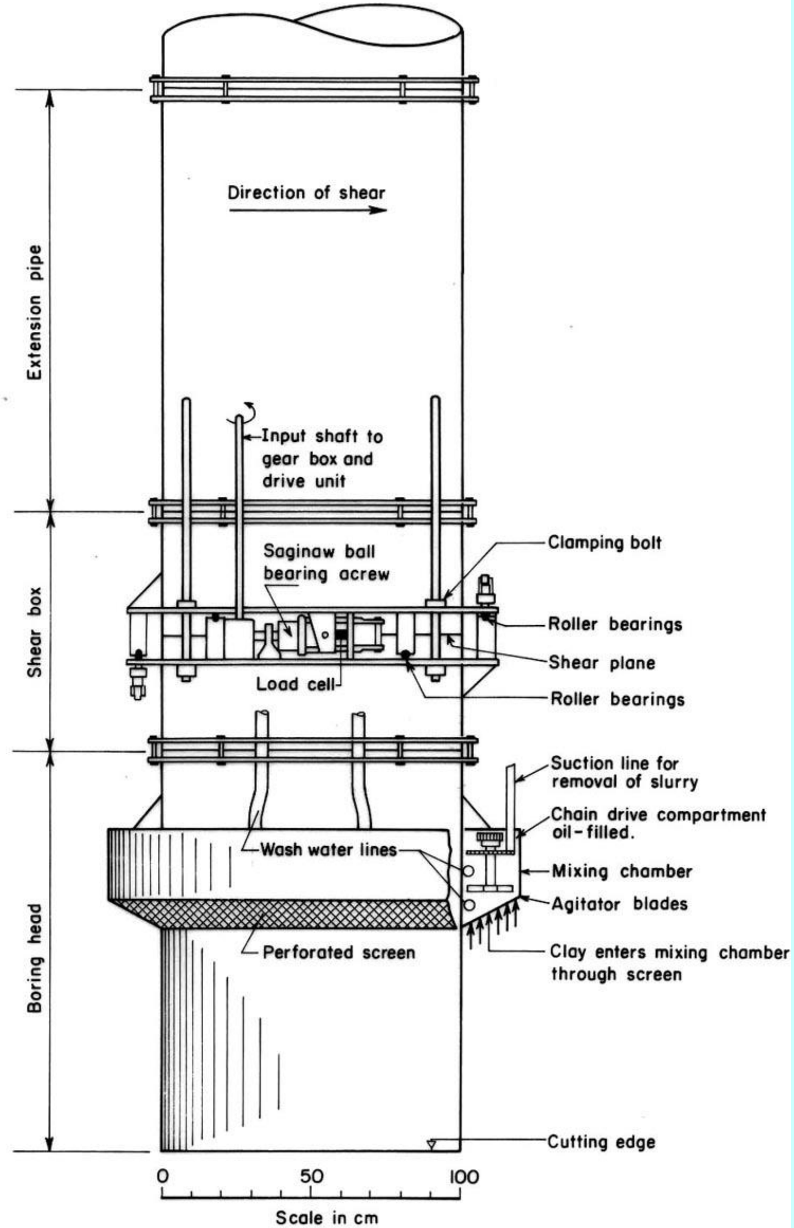
Sydney

Canberra

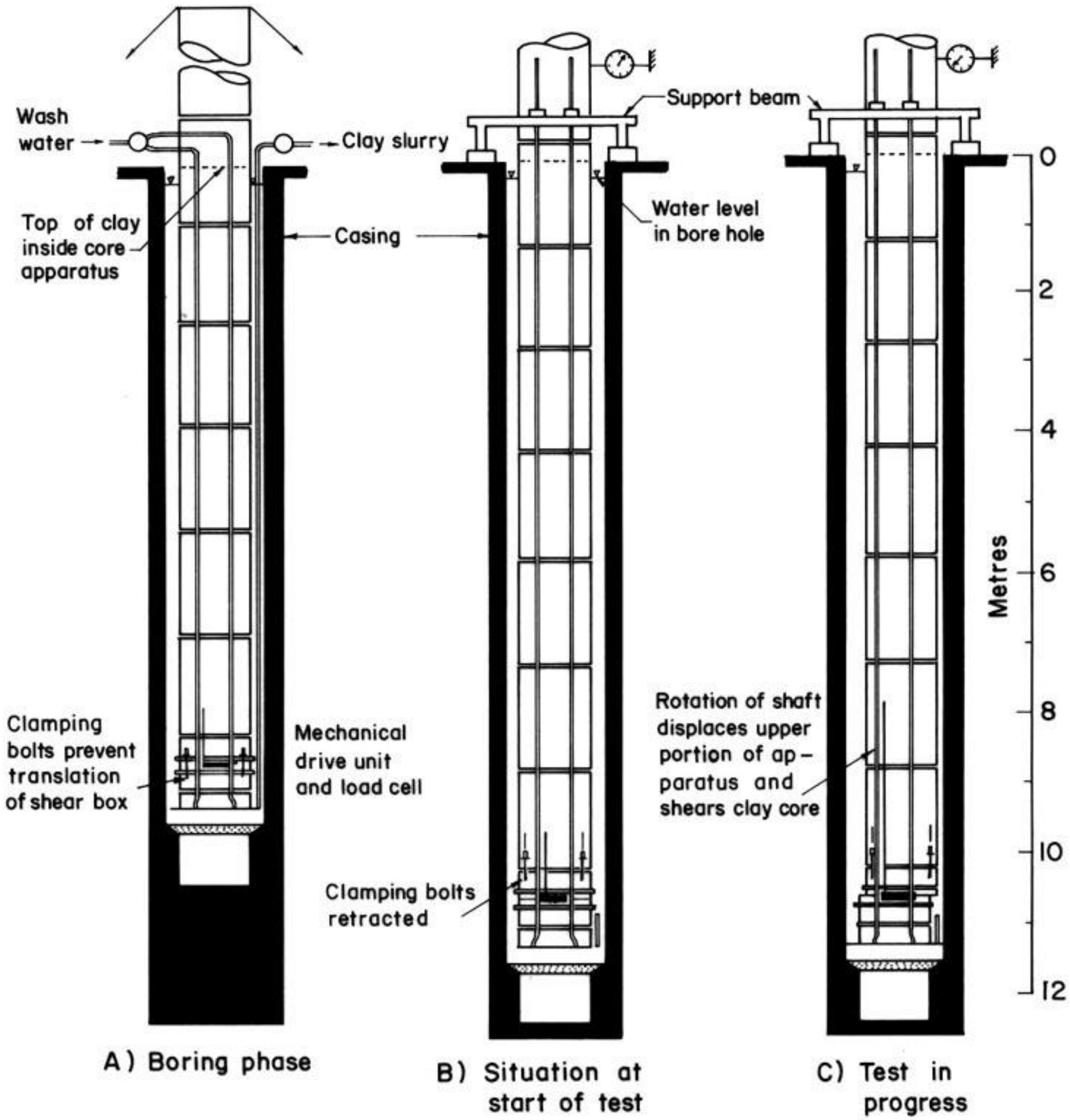


Location Map of the Lower Central Plain of Thailand Showing Approximate Location of Bangkok

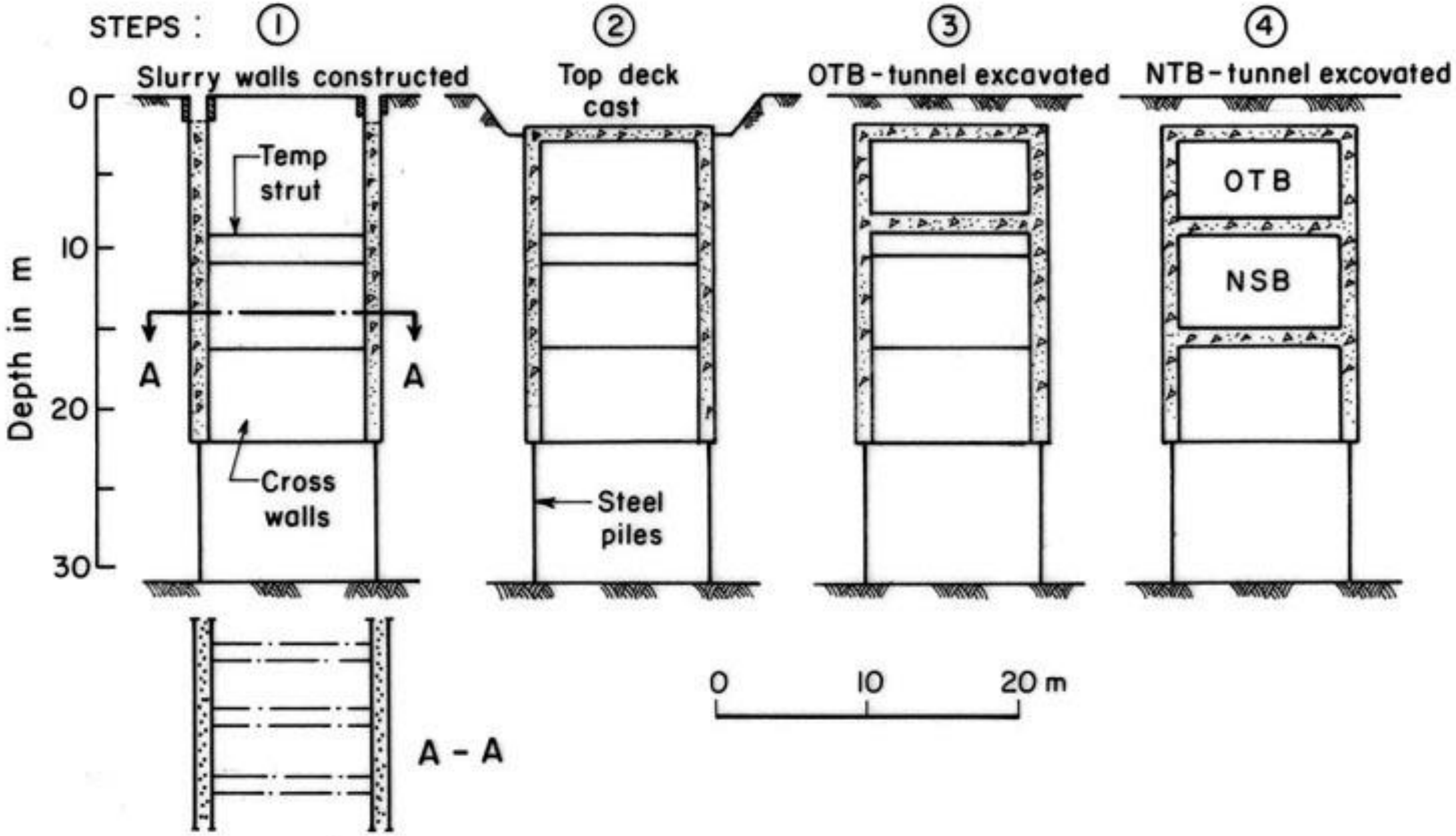
Large Scaled Tests
and
Instrumentation



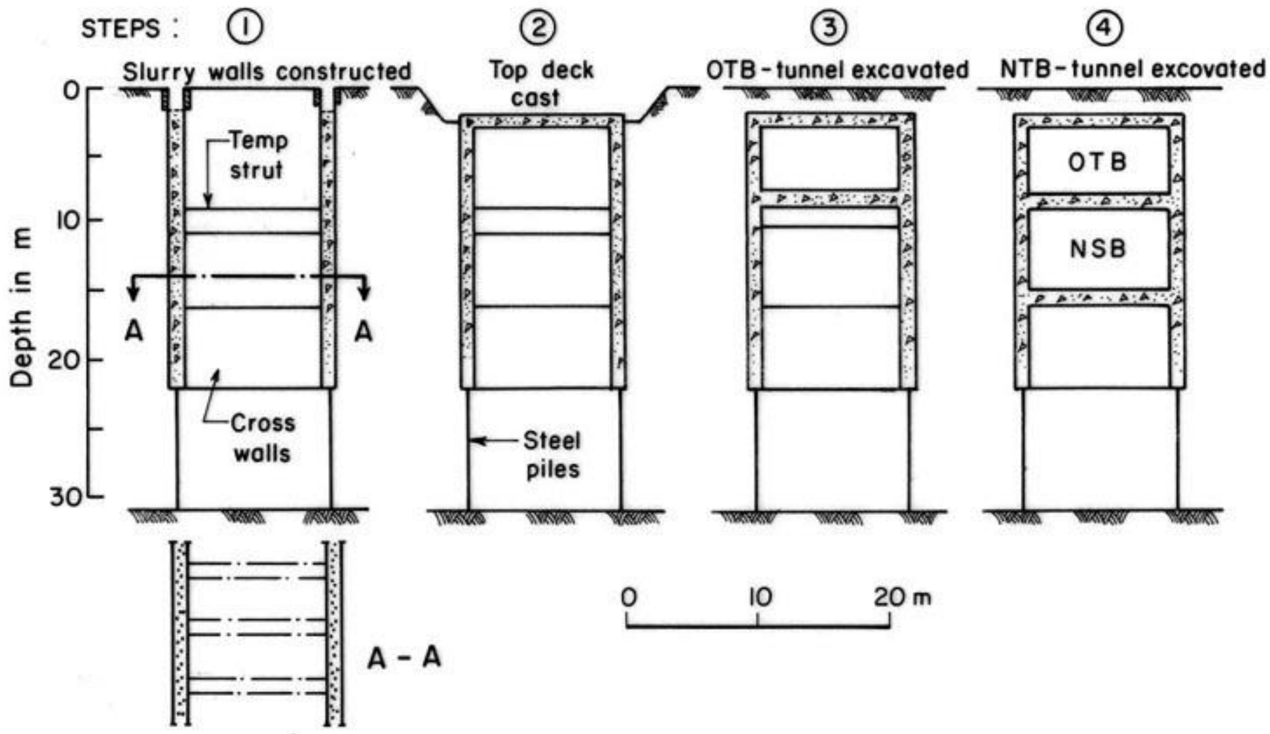
Details of the direct shear field apparatus for measuring the undrained shear strength on a horizontal failure plane.



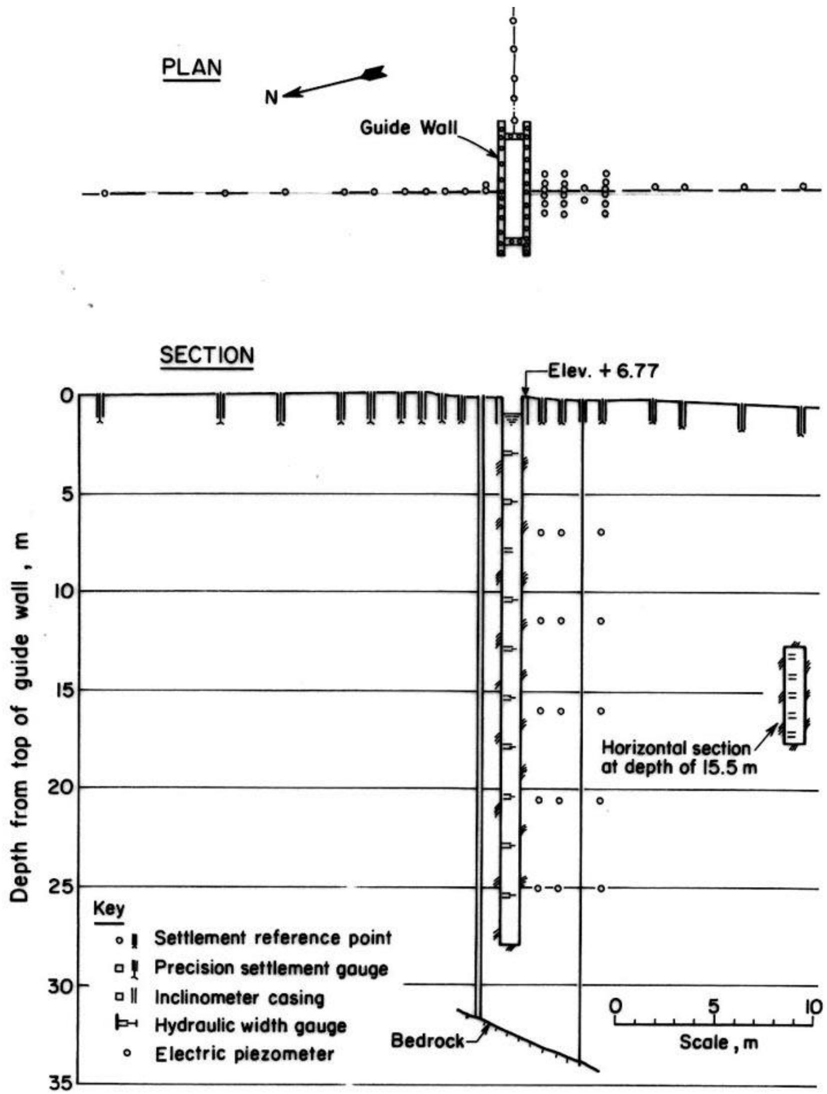
Scheme showing the operating principle of the in-situ direct shear apparatus



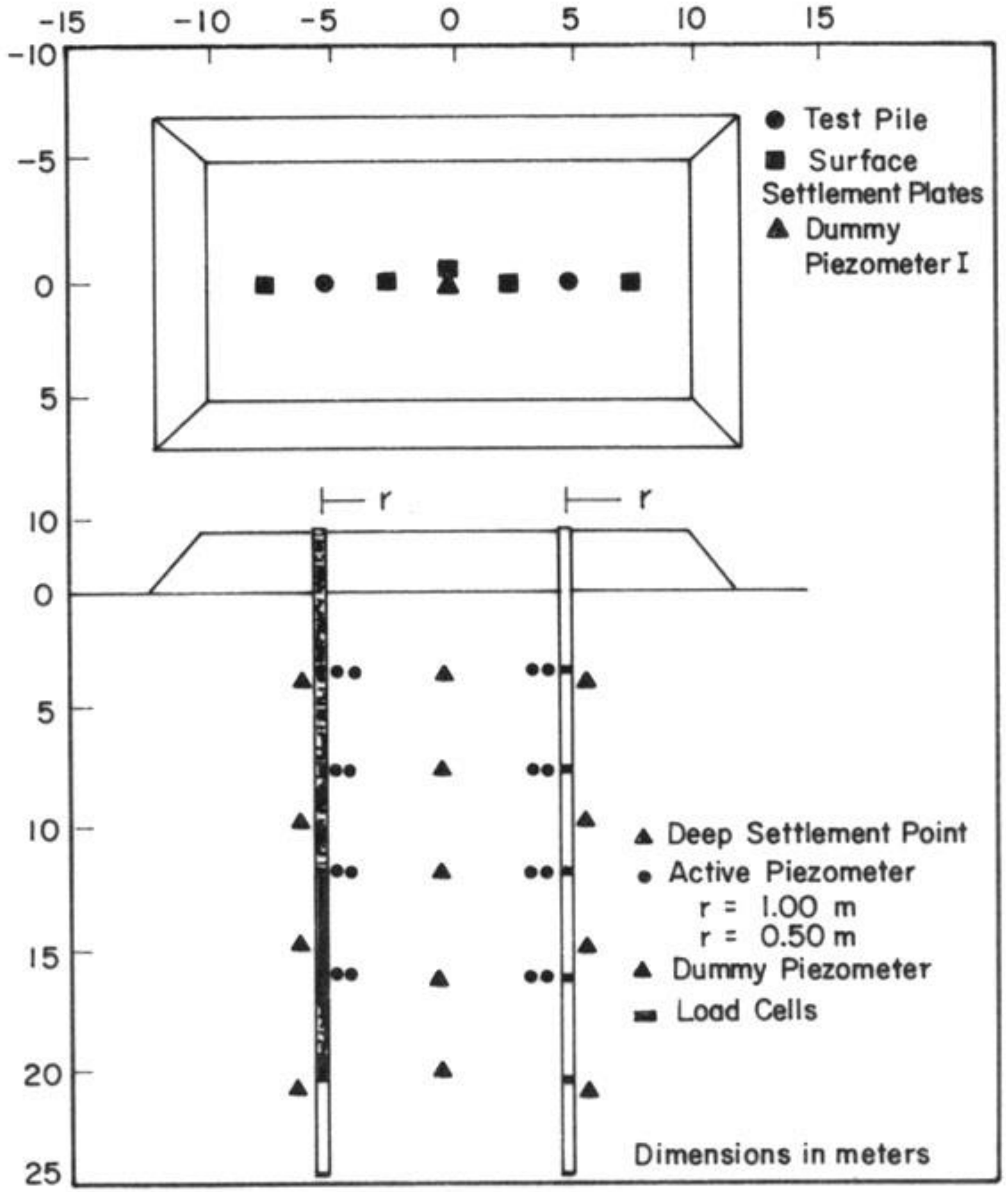
Construction sequence, Studenterlunden.



Construction sequence, Studenterlunden.



Details of test trench at Studenterlunden



-15
-10
-5
0
5
10
15
-10
-5
0
5
Test Pile
Surface Settlement Plates
Dummy Piezometer I
r
r
10
0
5
10
15
20
25
Deep Settlement Point
Active Piezometer
r = 1.00 m
r = 0.50 m
Dummy Piezometer
Load Cells
Dimensions in meters

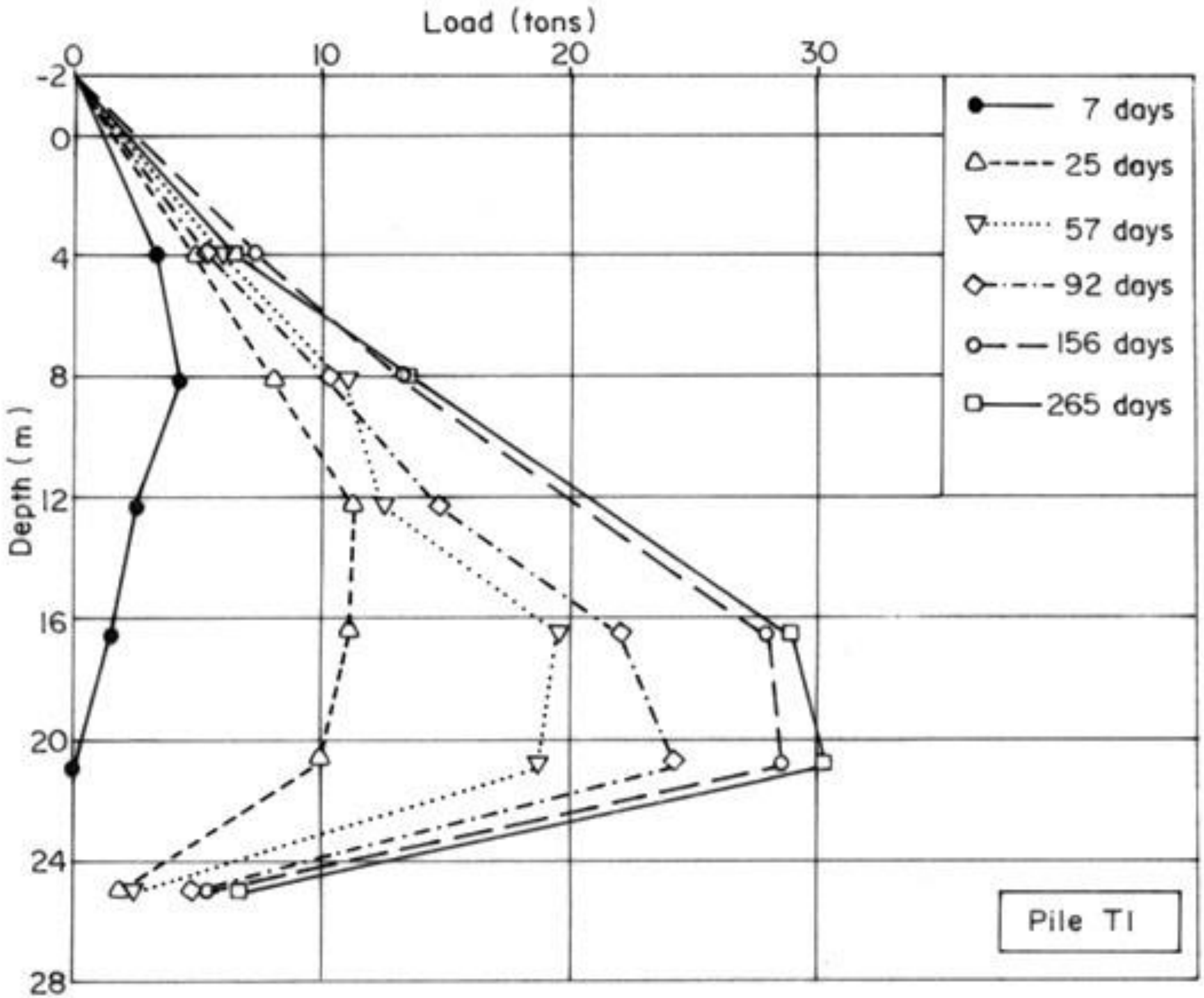


Fig. 7 Load Distribution along Pile Shaft (Pile T1)

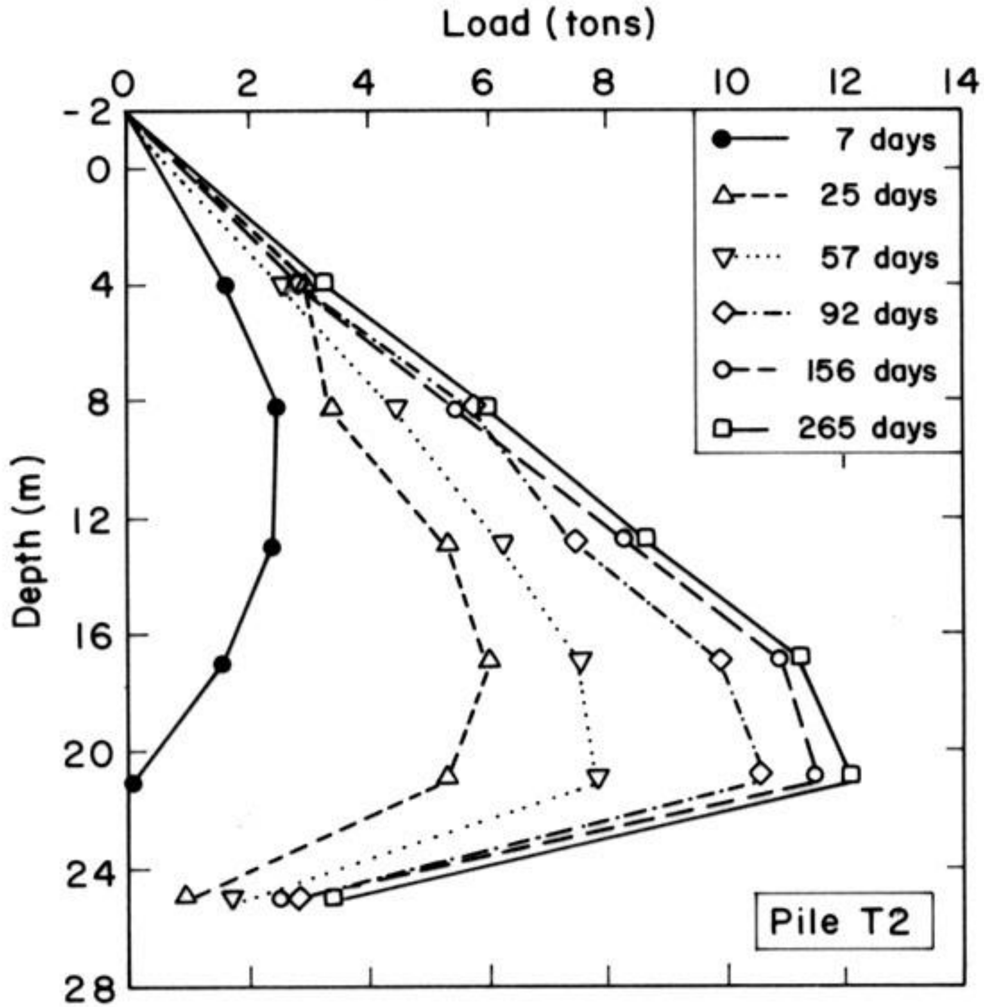


Fig. 8 Load Distribution along Pile Shaft (Pile T2)

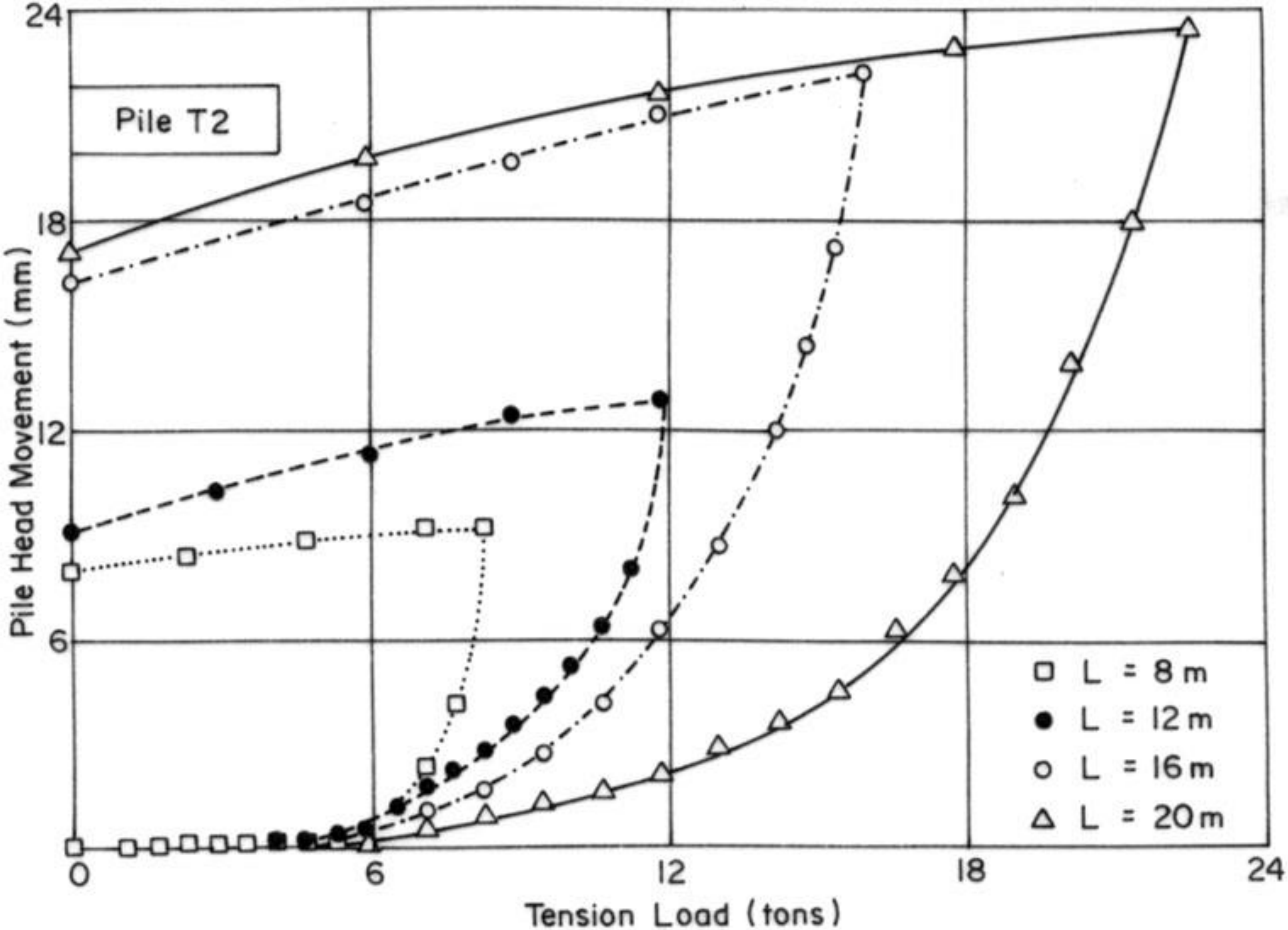


Fig. 5 Load - Uplift Curve of Pile T2

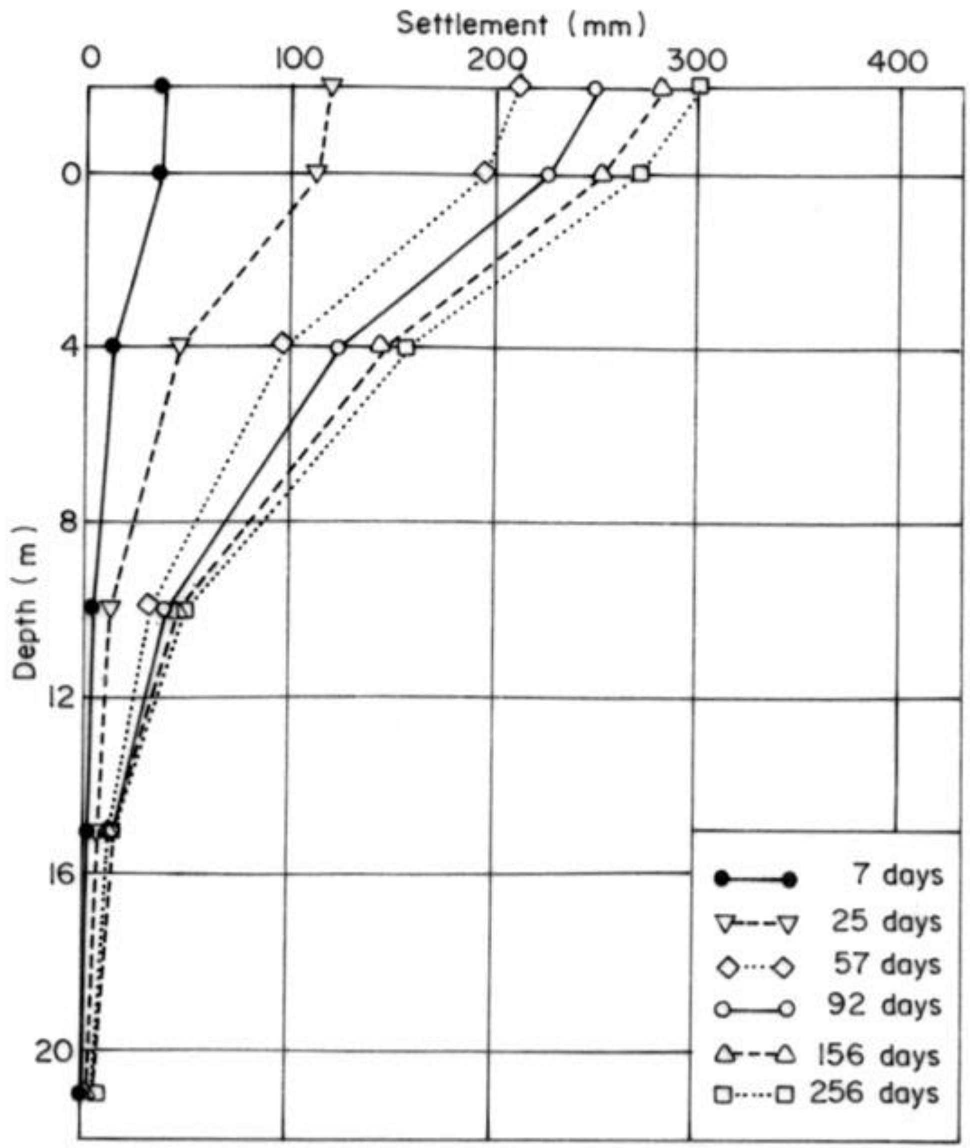
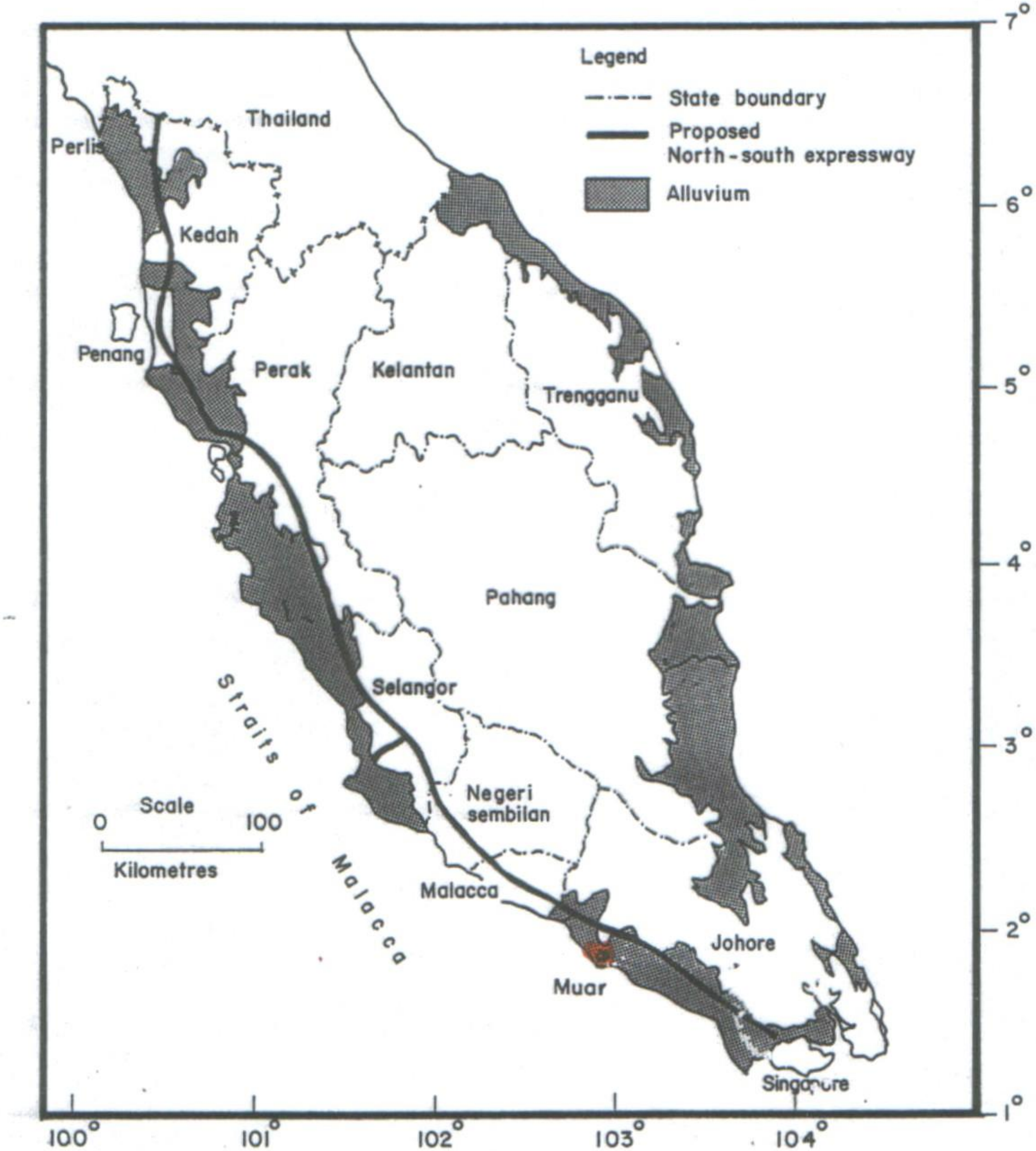


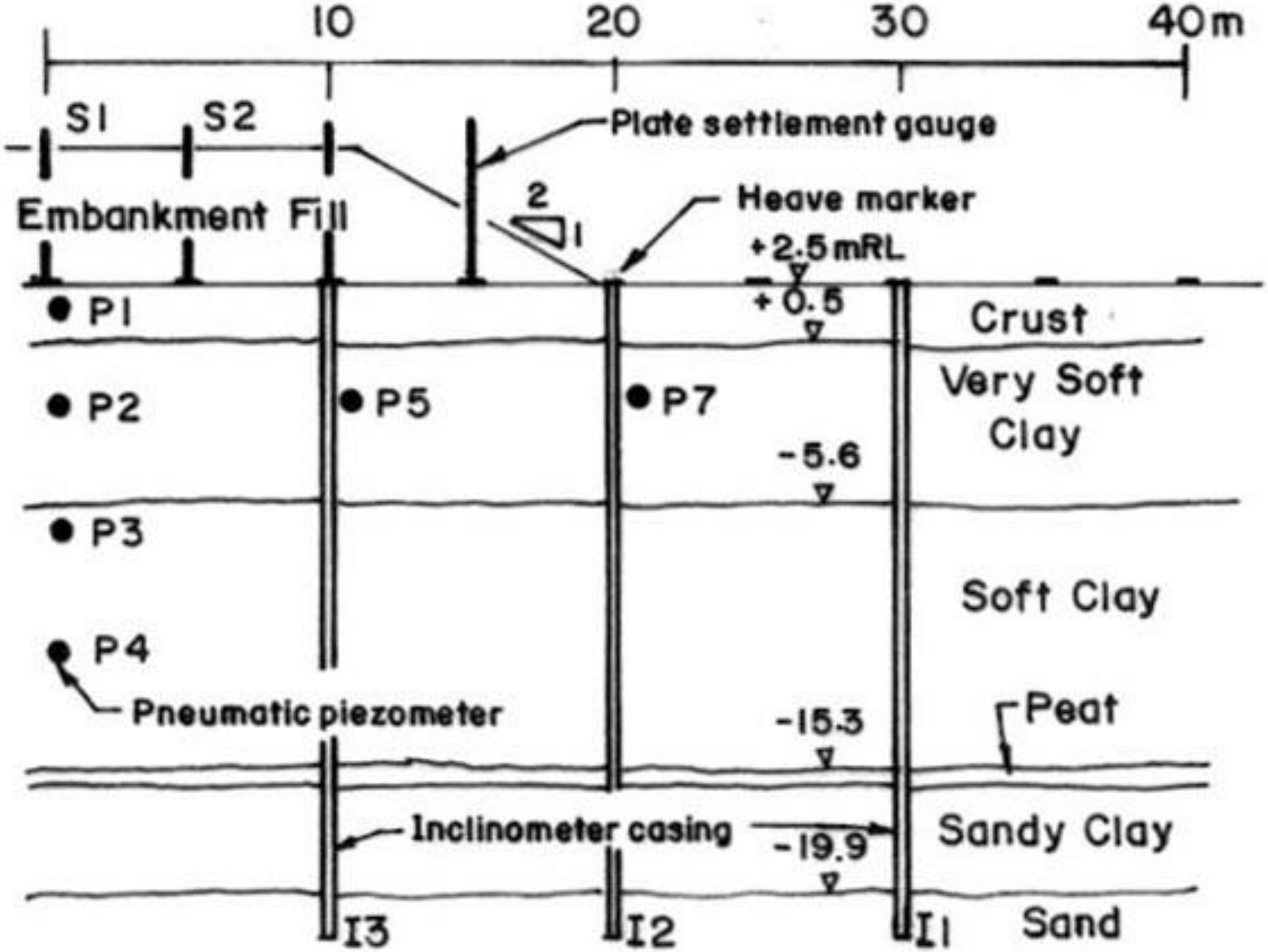
Fig.9 Distribution of Ground Settlement (Pile T1)



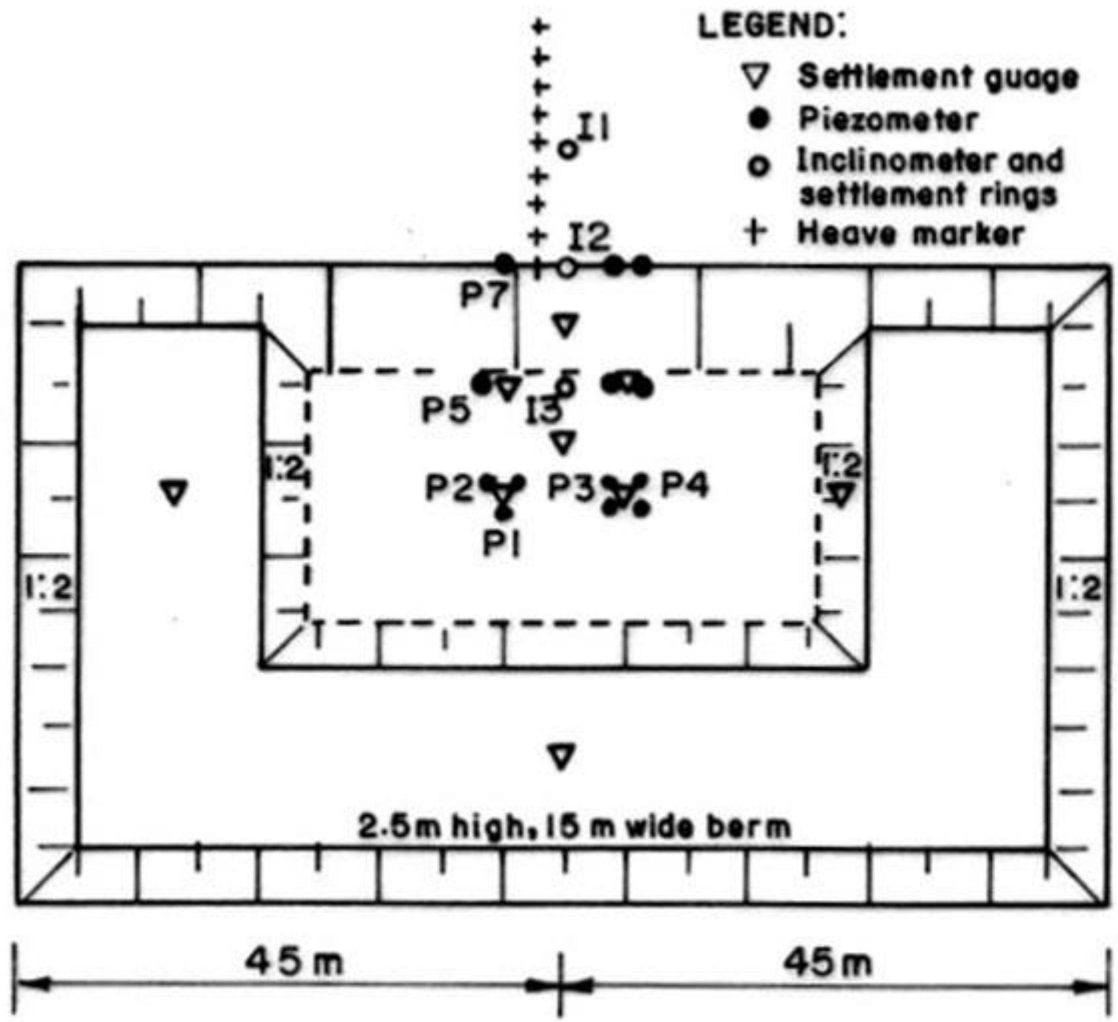
River and Coastal Alluvium of Peninsular Malaysia

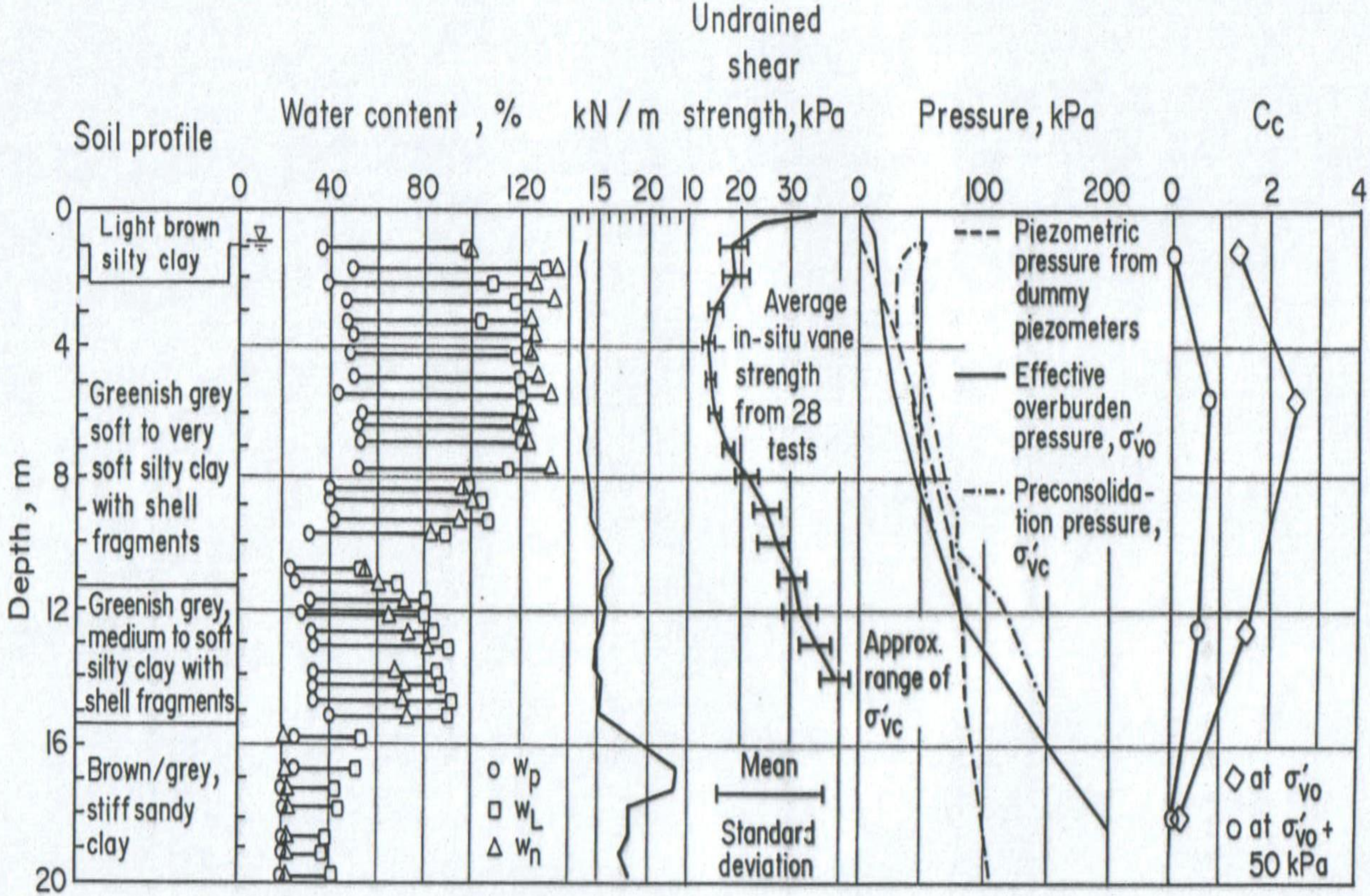
Level (mRL)	Soil Description	Liquid Limit ω_L (%)	Plastic Limit ω_P (%)	Natural Water Content ω_n (%)	Plasticity Index	Grain Size (%) Clay	Grain Size (%) Silt	Grain Size (%) Sand	$\frac{C_c}{1+e_o}$	$\frac{C}{1+e_o}$	Preconsolidation Pressure P_c (KPa)
+2.5 mRL to +0.5	Weathered Crust	108	55	70		42	57	1	.24	.04	110
+0.5 to -5.5	Very Soft Silty Clay with Decated Leaves and Roots	90	40	100	50	48	52	0	.48	.04	40
-5.5 to -15.3	Soft Silty Clay with Traces of Shell Fragments Occasionally Sand Lenses	80	30	60	50	40	60	0	.31	.04	60
-15.3 to -15.9	Peaty Soil										
-15.9 to -19.9	Sandy silt / clay with Organic Matters					22	43	35			
below -19.9	Dense Medium to Coarse Sand with Gravels SPT N = 21 to 37										

Description of Soil Profile and Index Properties Used in the Analysis

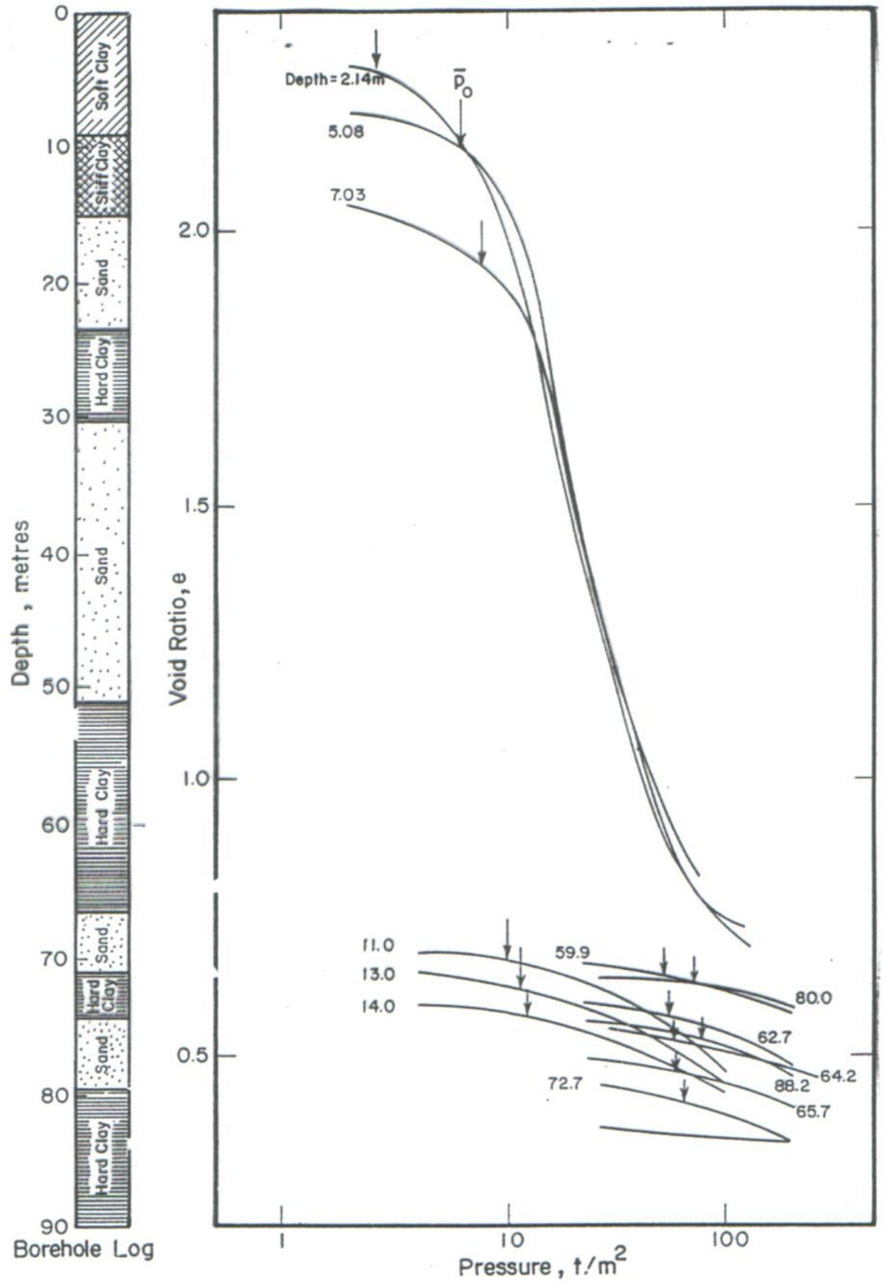


10
20
30
40m
S1
S2
Plate settlement gauge
Embankment Fill
2
1
Heave marker
+2.5mRL
+0.5
P1
Crust
P2
P5
P7
Very Soft Clay
-5.6
P3
Soft Clay
P4
Pneumatic piezometer
-15.3
Peat
Inclinometer casing
-19.9
Sandy Clay
I3
I2
I1
Sand


LEGEND:
Settlement guage
Piezometer
Inclinometer and settlement rings
Heave marker
I1
I2
I3
P7
P5
P2
P3
P4
P1
1:2
1:2
1:2
1:2
2.5m high, 15 m wide berm
45 m
45 m



Geotechnical characteristics of soft Bangkok clay at Bangpli



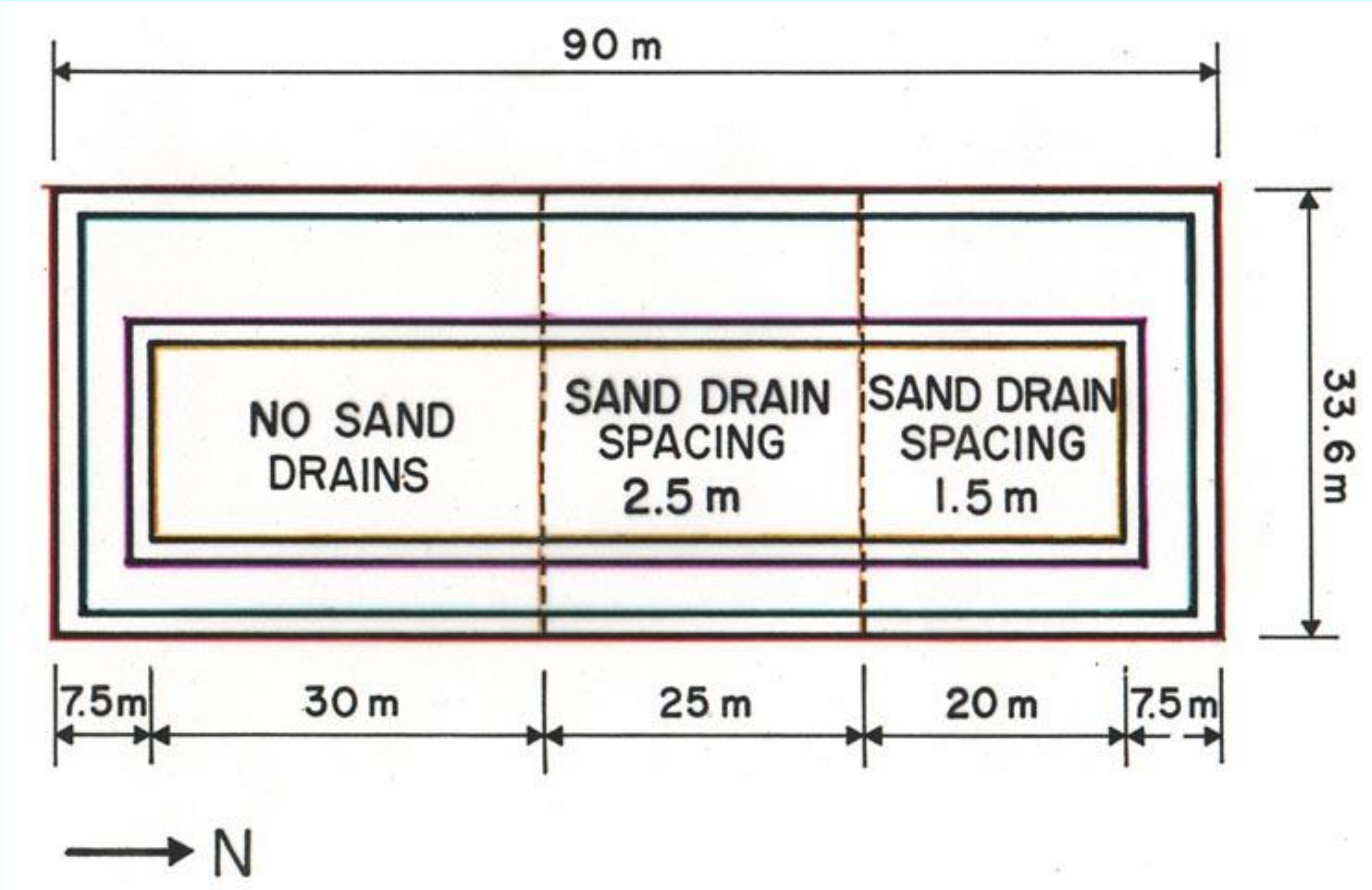
Typical Clay Compression Curves at AIT (after TAESIRI, 1976 & KANJANAKAROON, 1977)

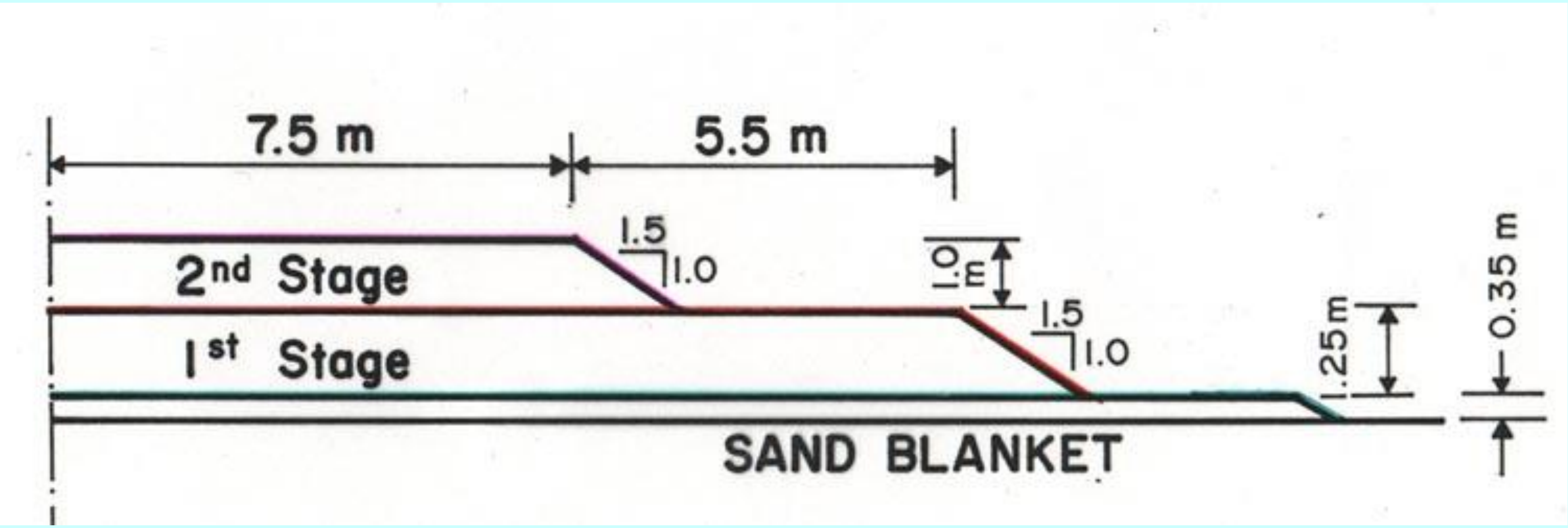
Trial embankments

** Dockyard site-Bangkok
(Sandwick drains)

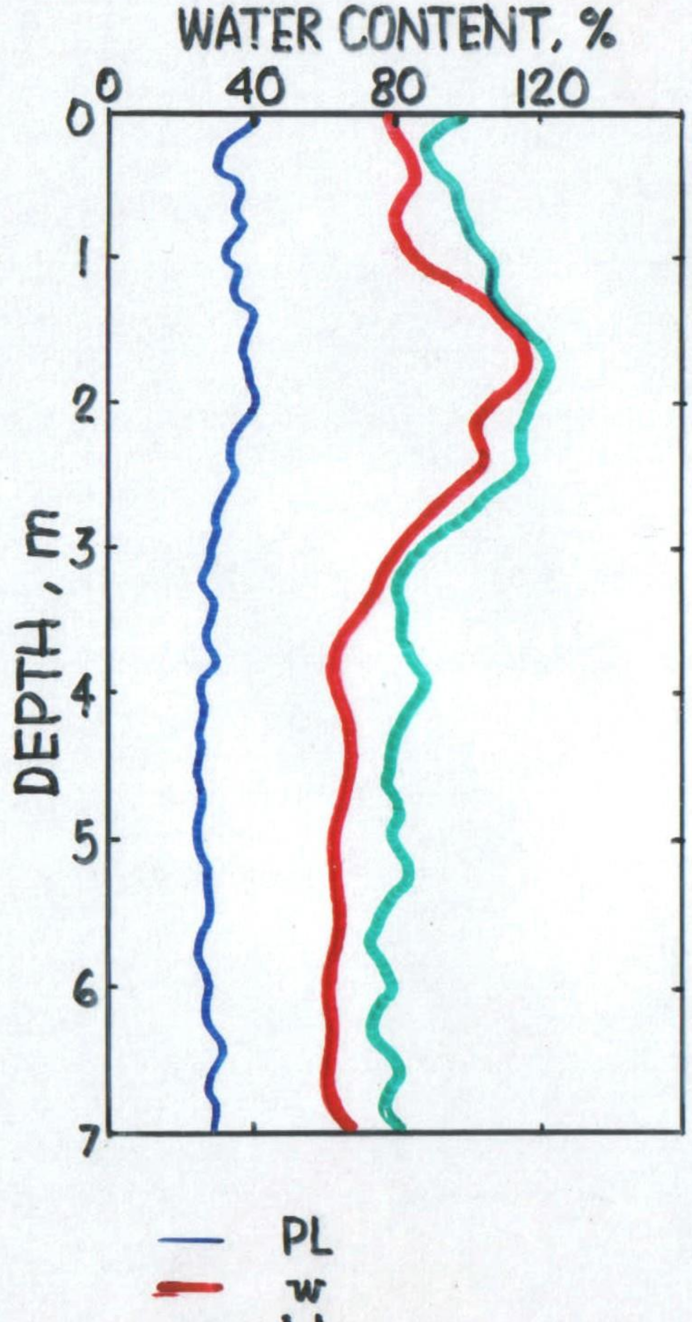
** Muar Flat site- Malaysia
(Many ground improvement schemes)

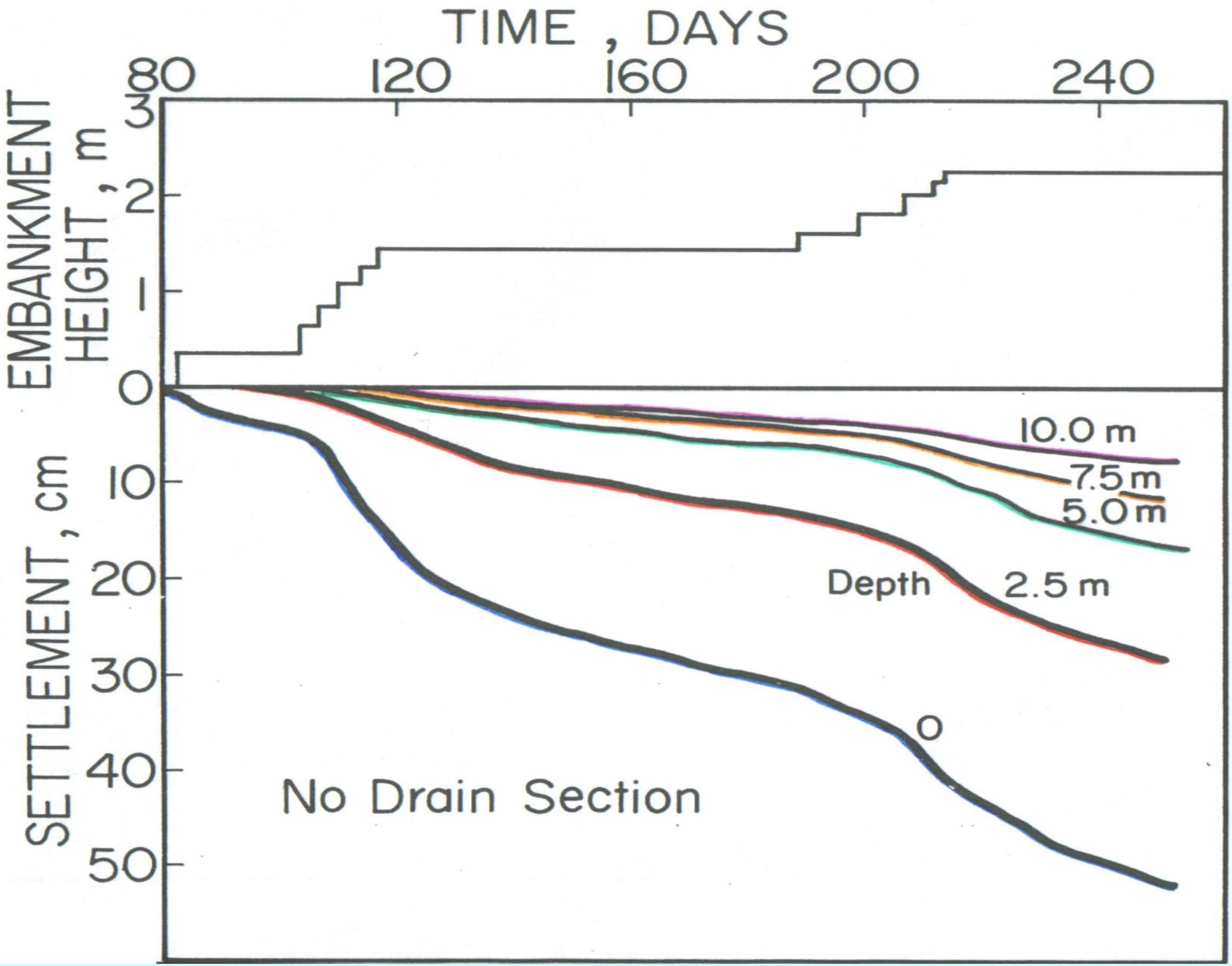
** Airport site- Bangkok
(Prefabricated vertical drains - PVD)


90 m
NO SAND DRAINS
SAND DRAIN SPACING 2.5 m
SAND DRAIN SPACING 1.5 m
33.6 m
7.5 m
30 m
25 m
20 m
7.5 m
N

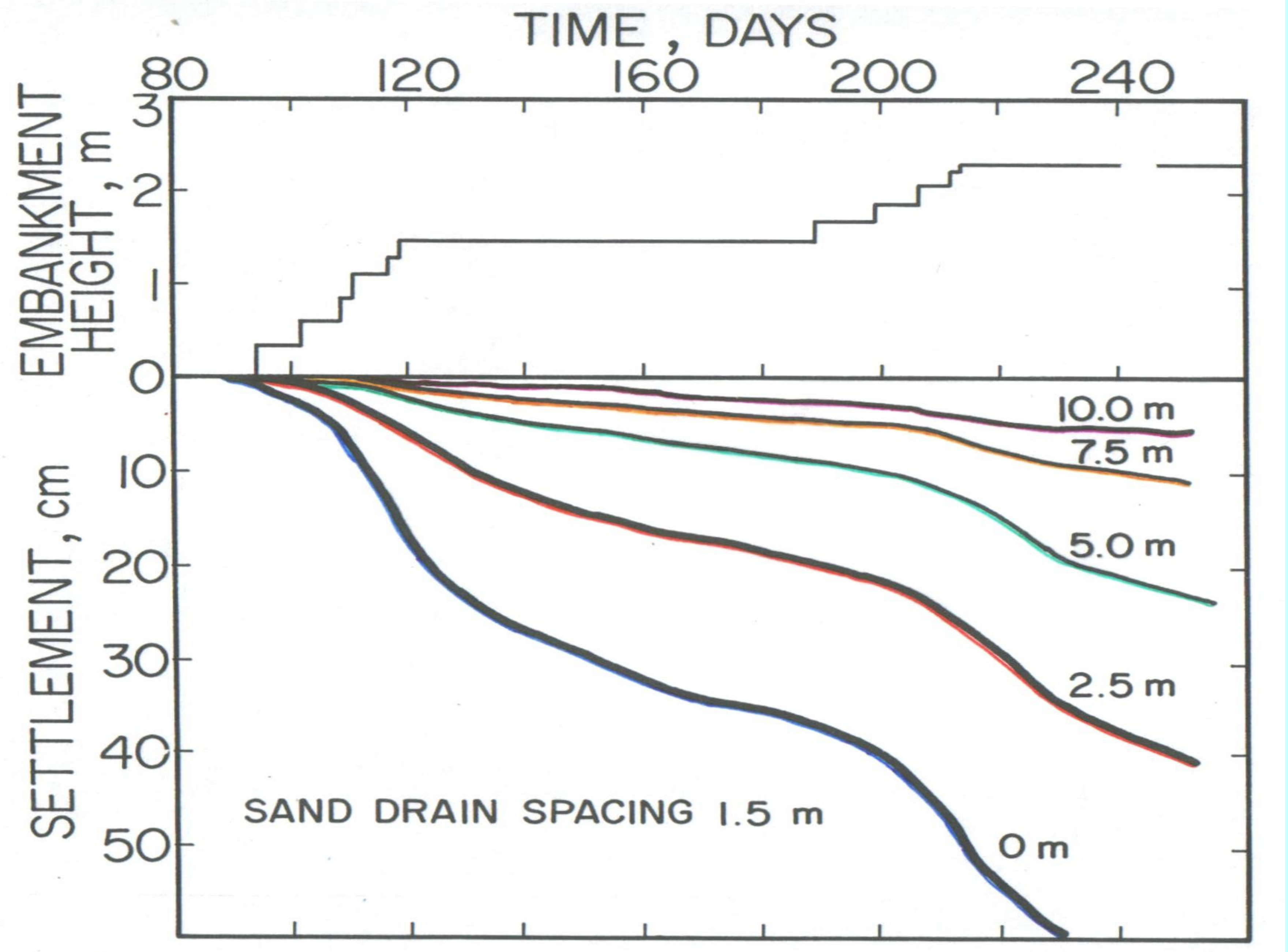


7.5 m
5.5 m
1.5
1.0
2nd Stage
1.0 m
1.5
1.0
1st Stage
1.25 m
0.35 m
SAND BLANKET

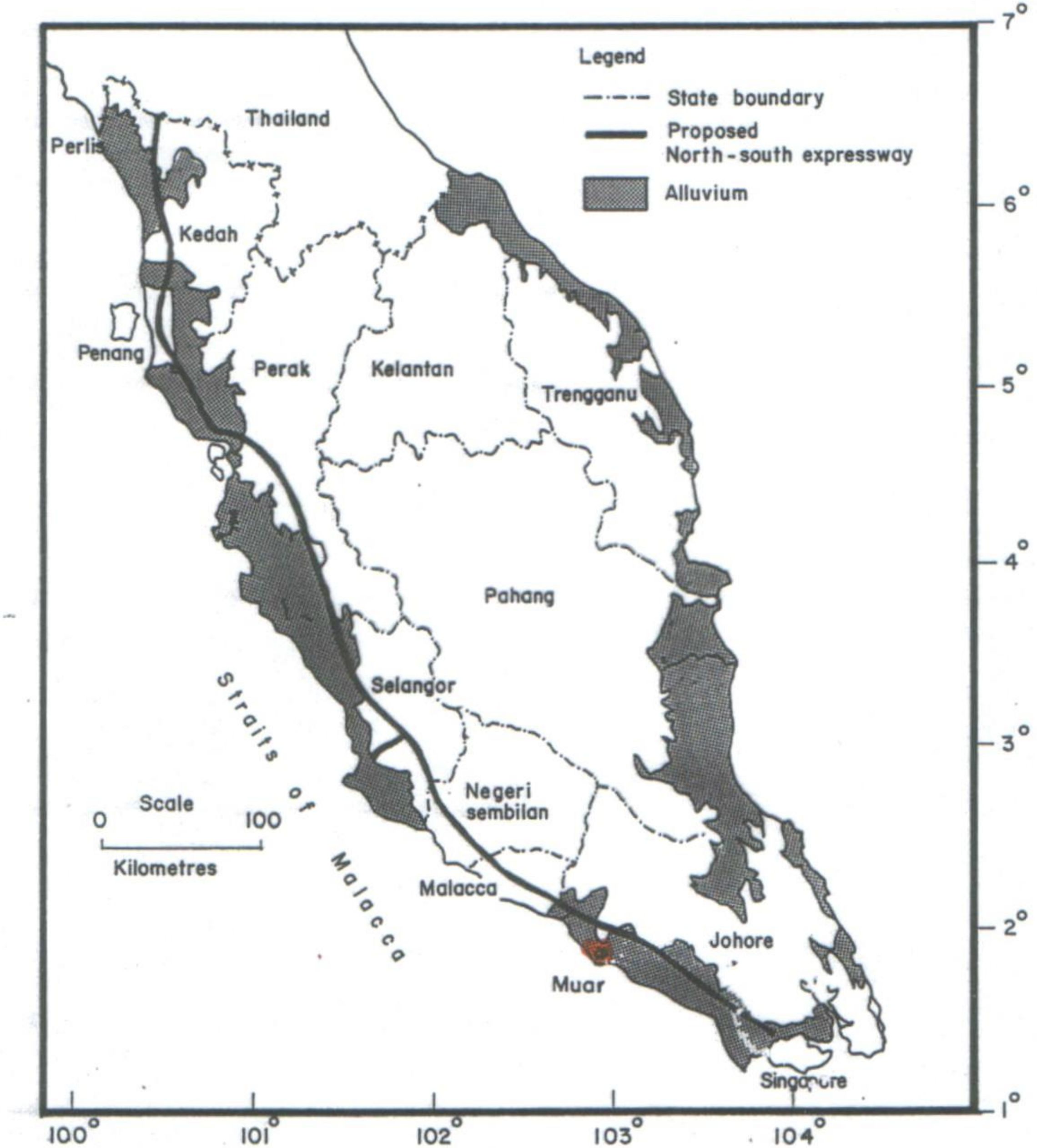

WATER CONTENT, %
0
40
80
120
0
1
2
3
4
5
6
7
DEPTH, m
PL
w
LL



TIME , DAYS
80
120
160
200
240
EMBANKMENT HEIGHT , m
3
2
1
0
SETTLEMENT , cm
10
20
30
40
50
10.0 m
7.5 m
5.0 m
Depth
2.5 m
0
No Drain Section



TIME , DAYS
80
120
160
200
240
EMBANKMENT HEIGHT , m
3
2
1
0
SETTLEMENT , cm
10
20
30
40
50
10.0 m
7.5 m
5.0 m
2.5 m
0 m
SAND DRAIN SPACING 1.5 m



River and Coastal Alluvium of Peninsular Malaysia

-Electro-osmosis

-Chemical injection

-Sand sandwich

-Pre-loading with drains

-Micropiles

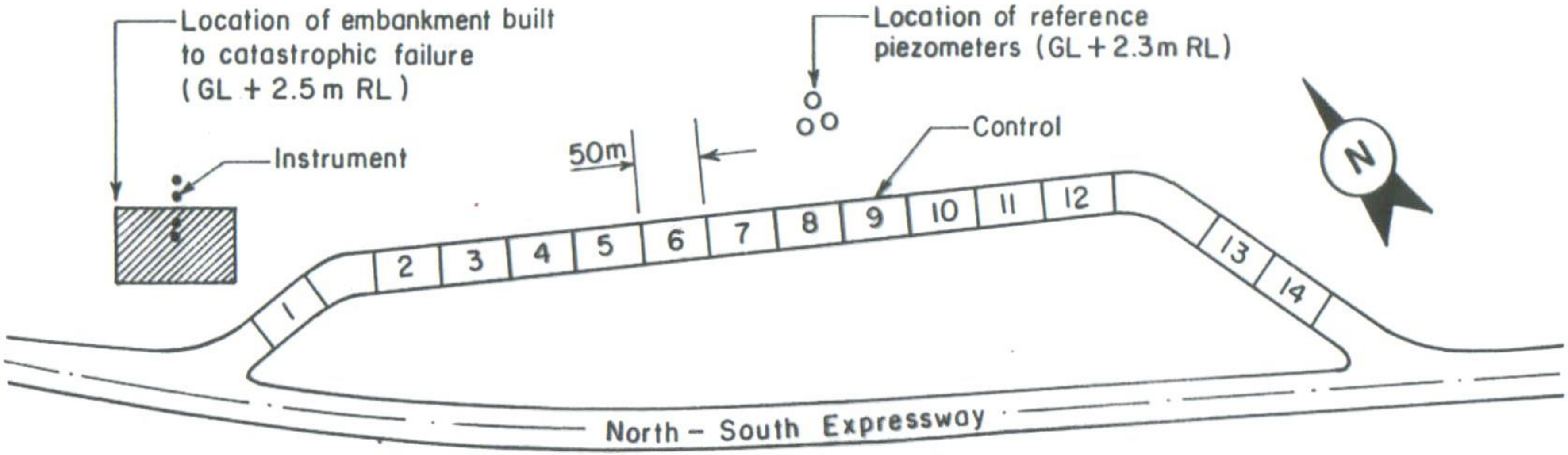
-Vacuum pre-loading

-Sand compaction piles

-Well point pumping

-Pre-stressed spun piles

LEMBAGA LEBUHRAYA MALAYSIA
TRIAL EMBANKMENTS

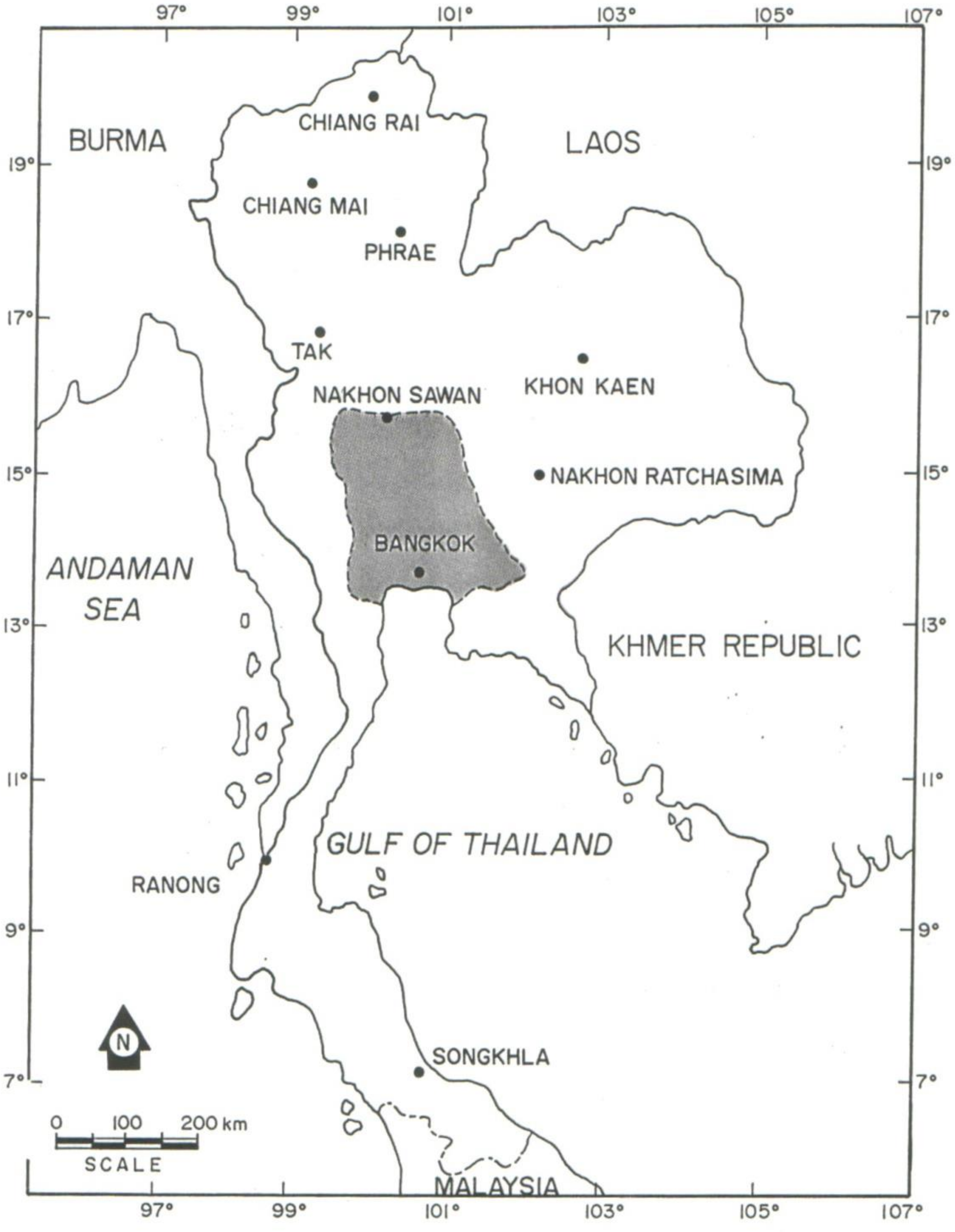


Method of Ground Improvement :

- Electro - osmosis (6)
- Chemical Injection (1 & 4)
- Sand Sandwich (13)
- Preloading & Drains (11, 12 & 14)
- Micro Piles (3)
- Vacuum Preloading (10)
- Sand Compaction Piles (8)
- Well-point Preloading (5)

Prestressed Spun Piles (7)

Layout of Trial Embankments



Location Map of the Lower Central Plain of Thailand
Showing Approximate Location of Bangkok

Full scale field tests of prefabricated vertical drains (PVD) for the Second Bangkok International Airport

Fig. A-19 PVD Installation in Field

Fig. A-20 PVD Installation in Field

Scope of Work

1. From published information, the types of suitable Prefabricated Vertical Drains (PVD).

2. Laboratory tests to determine the desirable PVD properties.

3. Field performance of at least three PVD types.

4. Controlling parameters, i.e., PVD properties, spacing and depth of PVD.

5. Comparative performance of PVD and sand drains (as studied in 1983).

6. Criteria for selecting PVD, design approach, installation procedures and specifications.

Background

1. Previous negative experience with large diameter sand drains by NGI in highway projects in Bangkok.

2. Previous negative experience with sandwicks at the Dockyard site in Bangkok.

3. Previous negative experience with vacuum drains at the airport site in Bangkok.

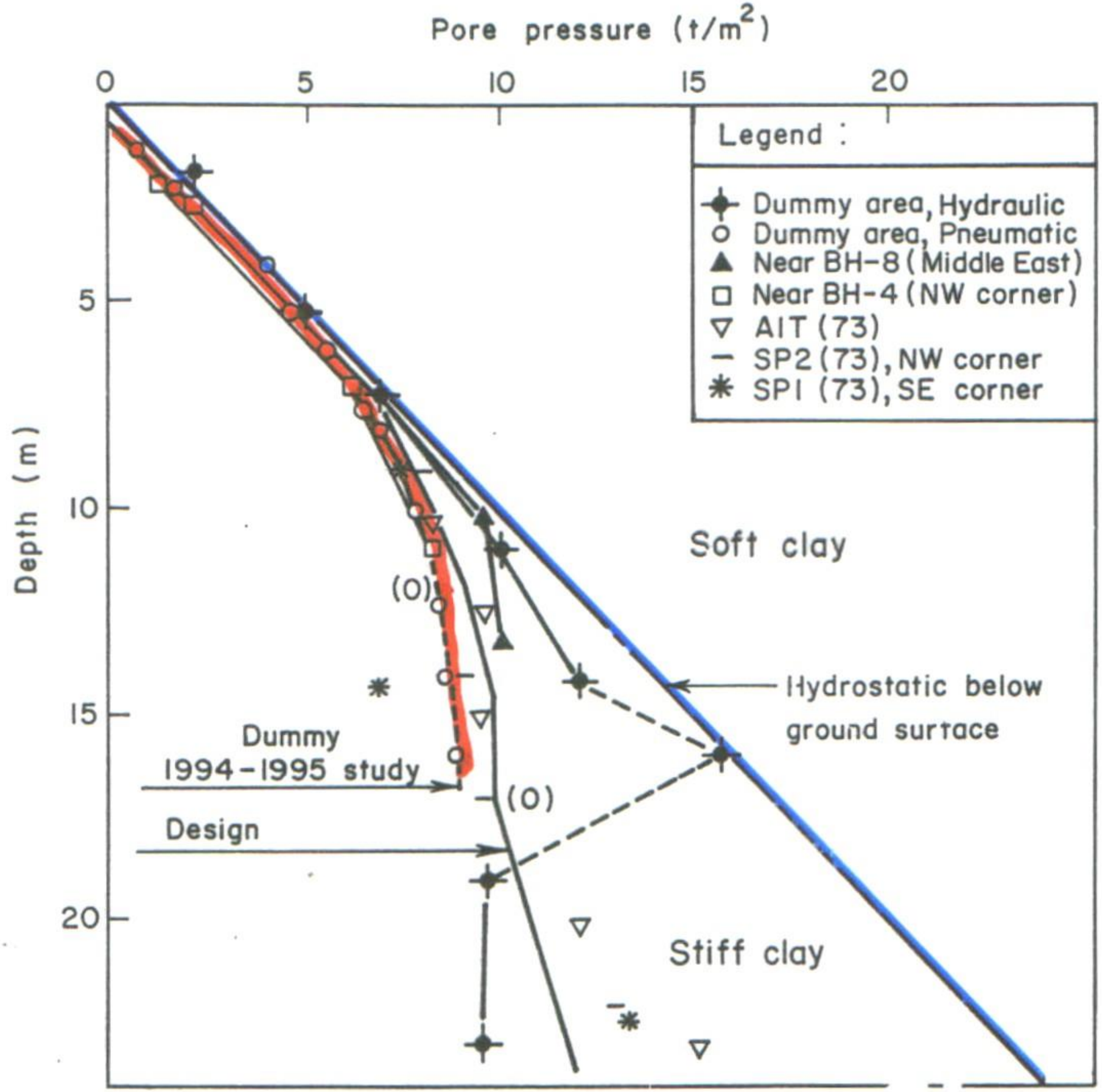
4. No clear evidence of pore pressure dissipation at the Changi reclamation project in Singapore.

5. Performance of Desol PVD at the Muar site in Malaysia.

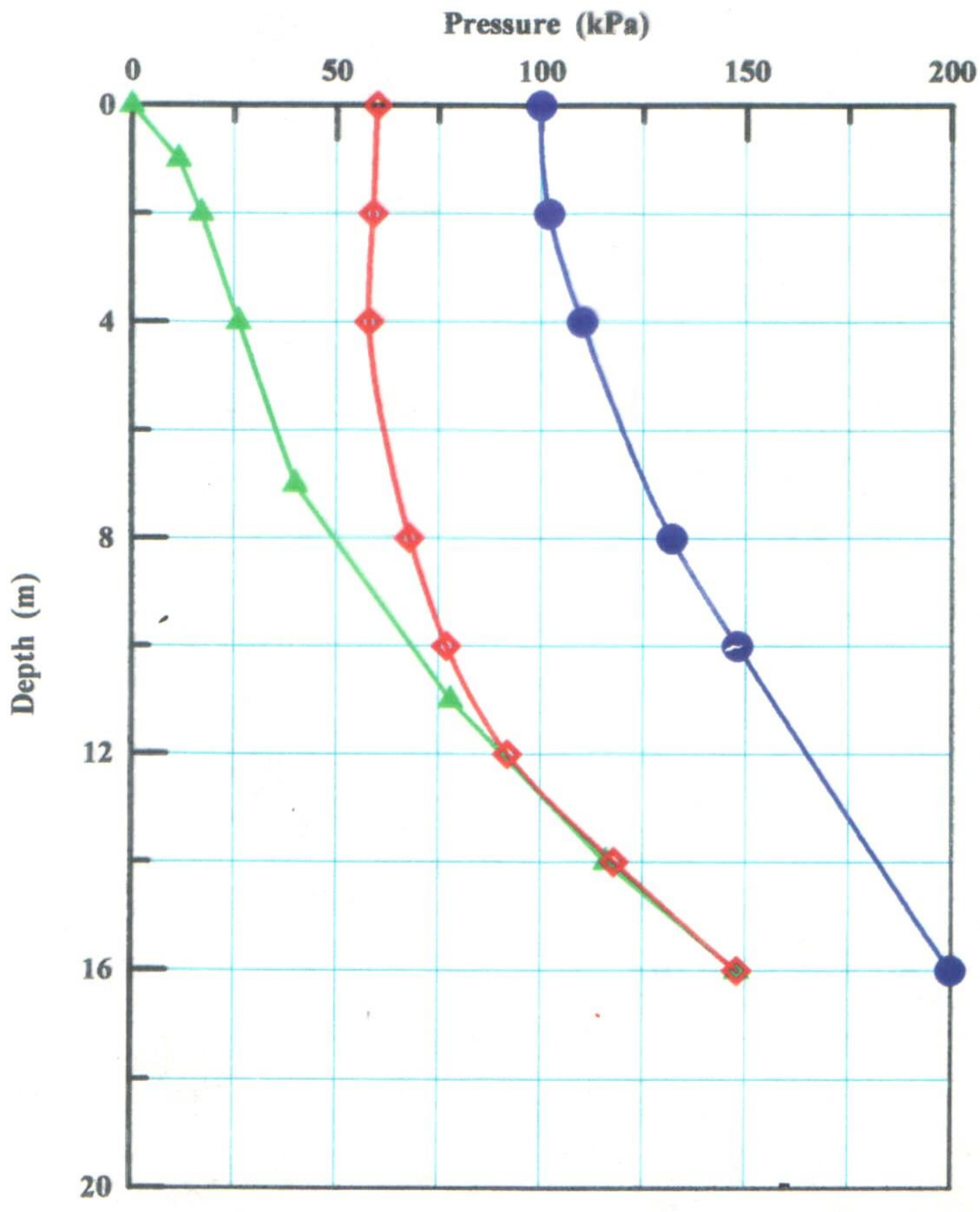
6. Piezometric draw-down due to deep well pumping and possible fear of hydraulic connections between PVD and the underlying aquifers in Bangkok.

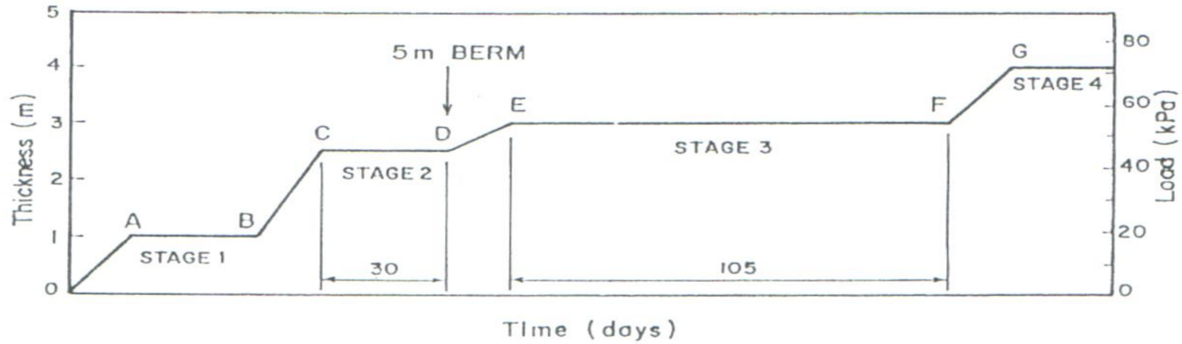
Geotechnical Investigation at Nong Ngo Hao Airport Site

Phase	Year	Title
I	1972 - 1974	Geotechnical Investiga-tions by Asian Institute of Technology and N.D. Lea and Associates, Kampsax
II	1983 - 1984	Pre-loading with Sand Drains, and , Vacuum-Drains; Moh and Associates and NACO
III	1992	An Independent Soil Engineering Study; Norwegian Geotechnical Institute in cooperation the STS Engineering Consultant Co. Ltd.
IV	1993 - 1995	Full scale Field test of Prefabricated vertical drains by the Asian Institute of Technology



Variation of Piezometric Pressures with Depth


Pressure (kPa)
0
50
100
150
200
Depth (m)
0
4
8
12
16
20



SUMMARY OF THE STABILITY ANALYSIS

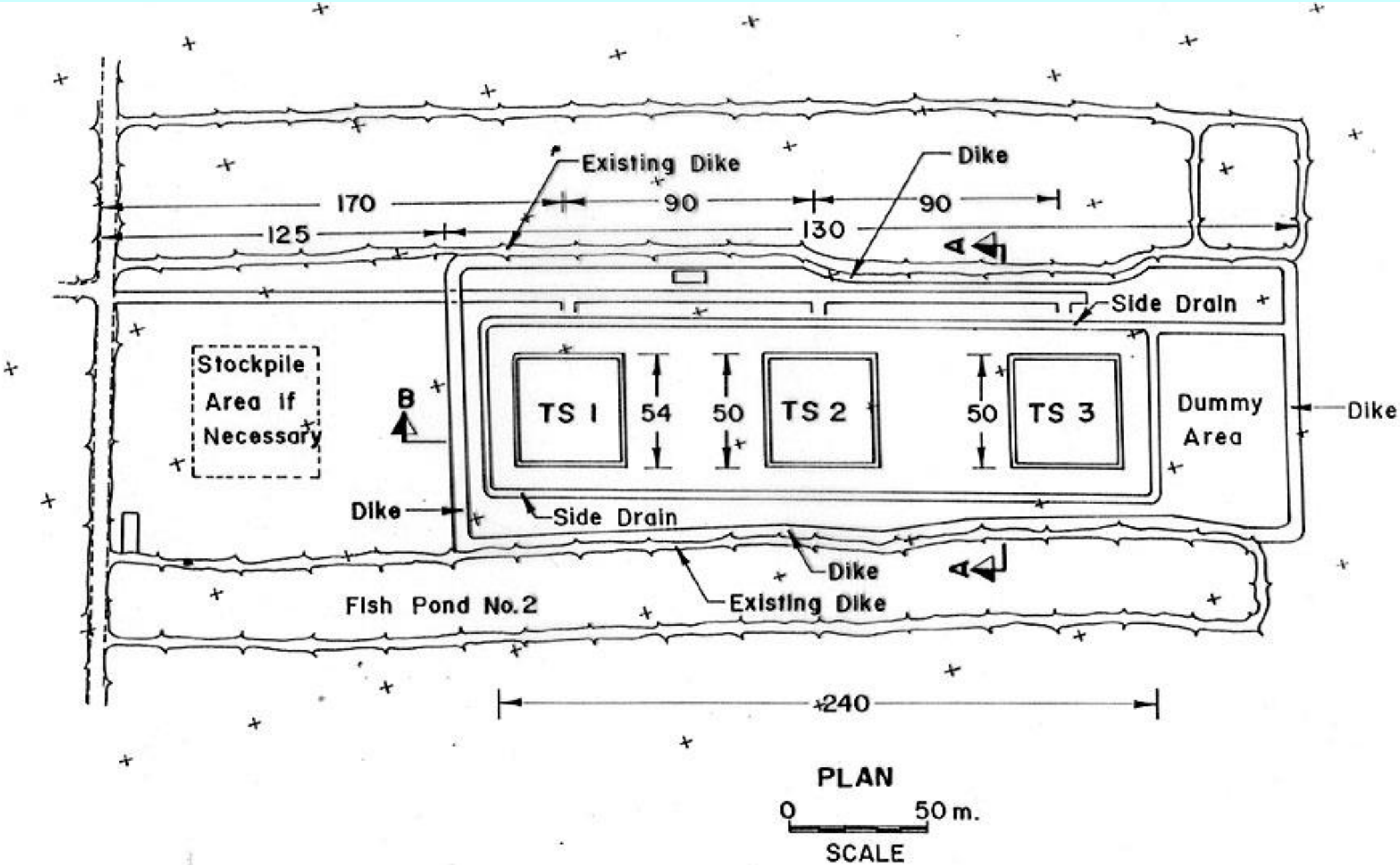
POINT	THICKNESS (m)	LOAD (kPa)	DURATION (Days)	FACTOR OF SAFETY	
				with 5 kPa Load	without Load
C	2.5	45		1.18	1.30
D	2.5	45	30	1.33	1.48
E	3.0	54		1.23	1.34
F	3.0	54	105	1.54	1.65
G	4.0	72		1.26	1.34

Calculated Strength Gain and Settlement at the End of Each Loading Stage

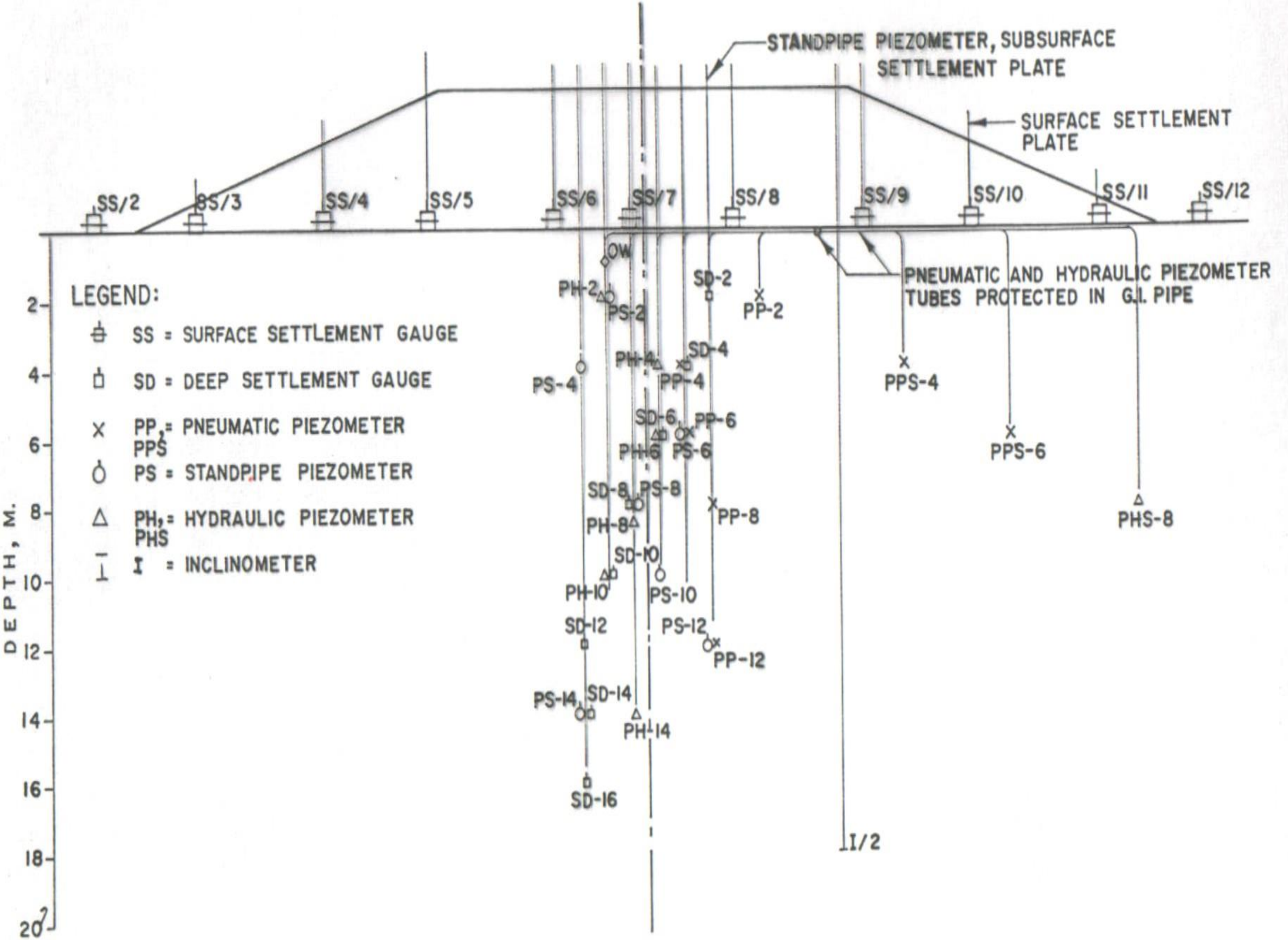
POINT	$\Delta\sigma_v'$ (kPa)	$RS_u = S_u/S_{uo}$	$\Delta\sigma_v'/\Delta q_c$	$\Delta\sigma_v'/\Delta u_p$	S_c (cm)	S_c/S_{cf}
D	11.4	1.07	0.25	0.25	22	0.17
F	35.1	1.42	0.65	0.83	65	0.50

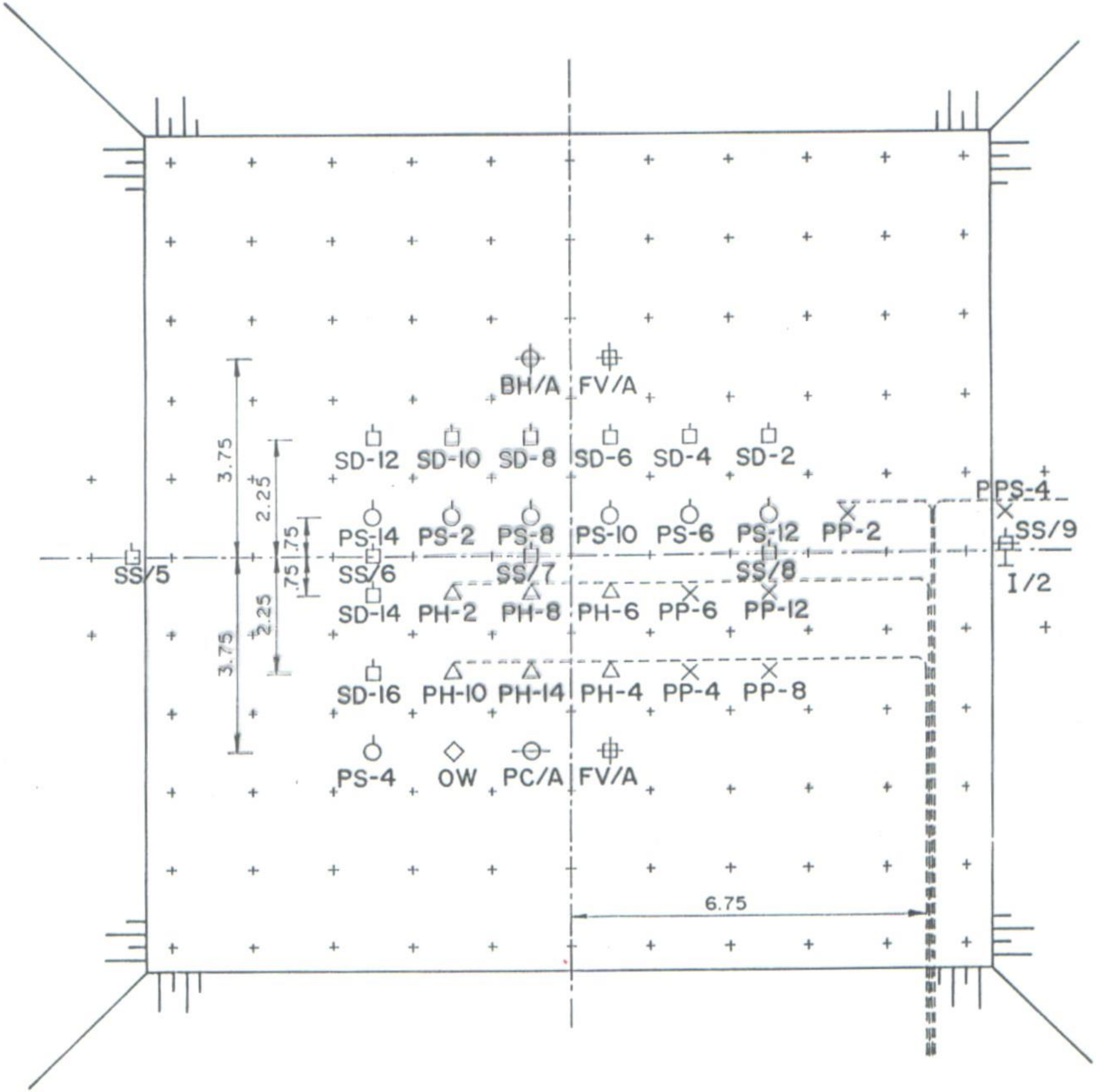
$\Delta\sigma_v'$: Increase of effective stress at calculated time
q_c : Embankment load at calculated time
Δu_p : Excess pore pressure just after adding the additional load including the remaining pore pressure from the previous stage
S_c : Consolidation settlement at calculated time
S_{cf} : Final consolidation settlement at 72 kPa load=130 cm

Fig. 4.18 Summary of Stability and Settlement Analyses for Embankment TS3 (with 1.0 m Drain Spacing)


Existing Dike
Dike
170
90
90
125
130
A
Side Drain
Stockpile
Area if
Necessary
B
TS 1
54
50
TS 2
50
TS 3
Dummy
Area
Dike
Dike
Side Drain
Dike
A
Fish Pond No. 2
Existing Dike
240
0
50 m.
SCALE

PLAN


STANDPIPE PIEZOMETER, SUBSURFACE SETTLEMENT PLATE
SURFACE SETTLEMENT PLATE
SS/2
SS/3
SS/4
SS/5
SS/6
SS/7
SS/8
SS/9
SS/10
SS/11
SS/12
PNEUMATIC AND HYDRAULIC PIEZOMETER TUBES PROTECTED IN G.I. PIPE
OW
PH-2
PS-2
SD-2
PP-2
PH-4
SD-4
PP-4
PS-4
PPS-4
SD-6
PP-6
PH-6
PS-6
PPS-6
SD-8
PS-8
PH-8
PP-8
PHS-8
SD-10
PH-10
PS-10
SD-12
PS-12
PP-12
PS-14
SD-14
PH-14
SD-16
I/2
LEGEND:
SS = SURFACE SETTLEMENT GAUGE
SD = DEEP SETTLEMENT GAUGE
PP, PPS = PNEUMATIC PIEZOMETER
PS = STANDPIPE PIEZOMETER
PH, PHS = HYDRAULIC PIEZOMETER
I = INCLINOMETER
DEPTH, M.
2
4
6
8
10
12
14
16
18
20



BH/A
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SD-12
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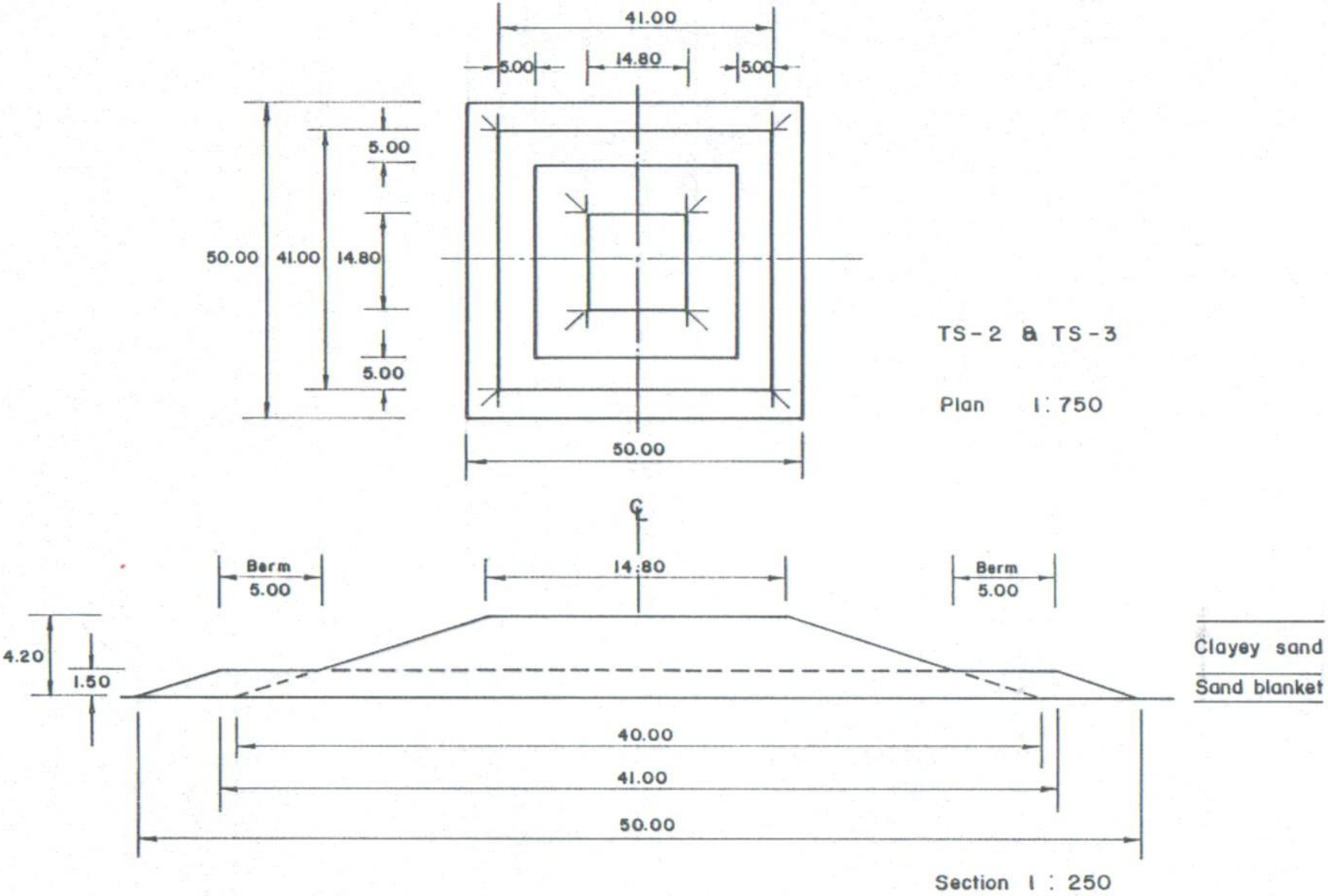


Details of Test Embankments TS2 and TS3

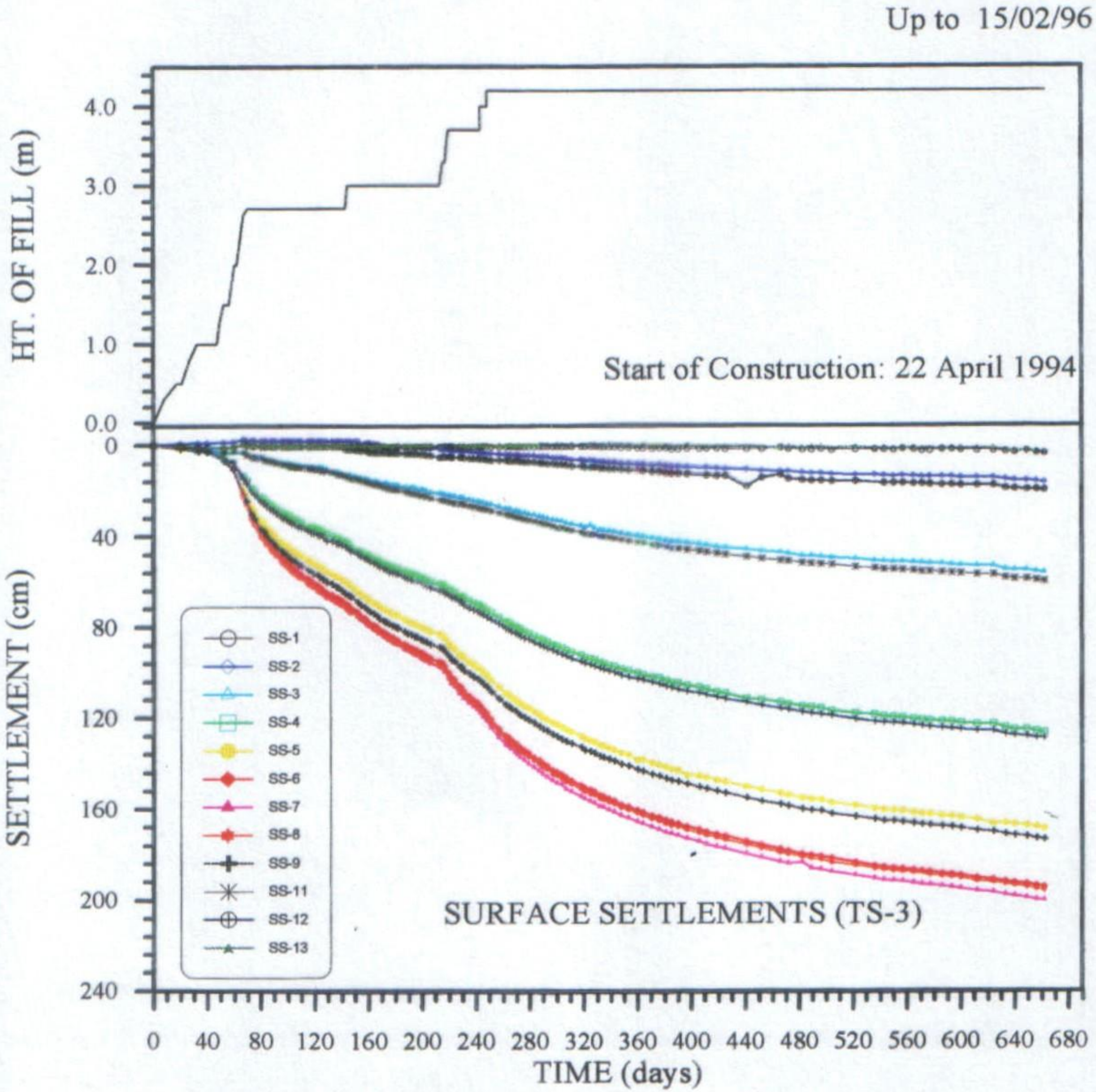
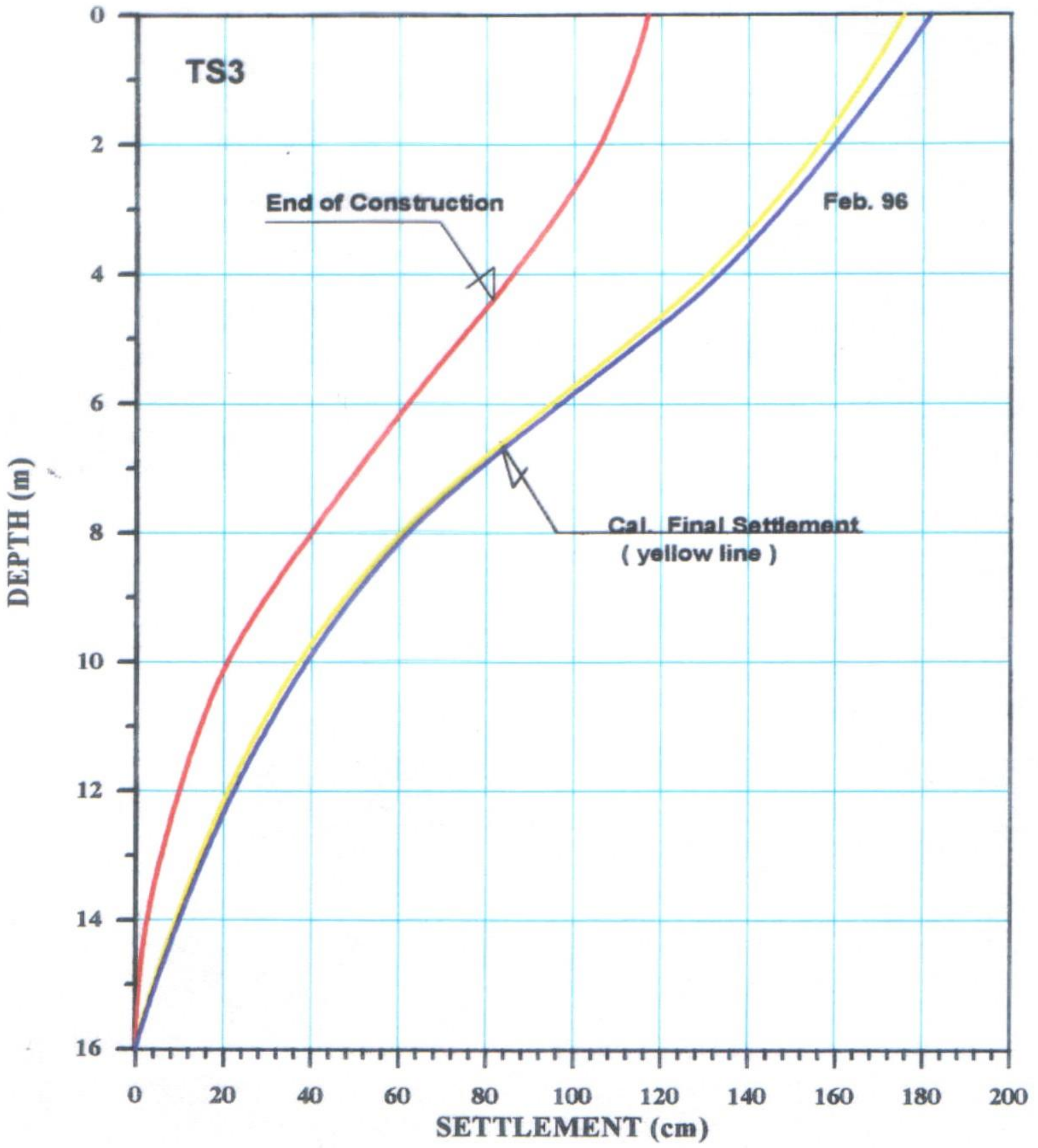


Fig. 3 Time-Settlement Plot (TS3) with Loading Schedule (Surface Settlement Gauge Measurements)



SETTLEMENT PROFILES OF TS3

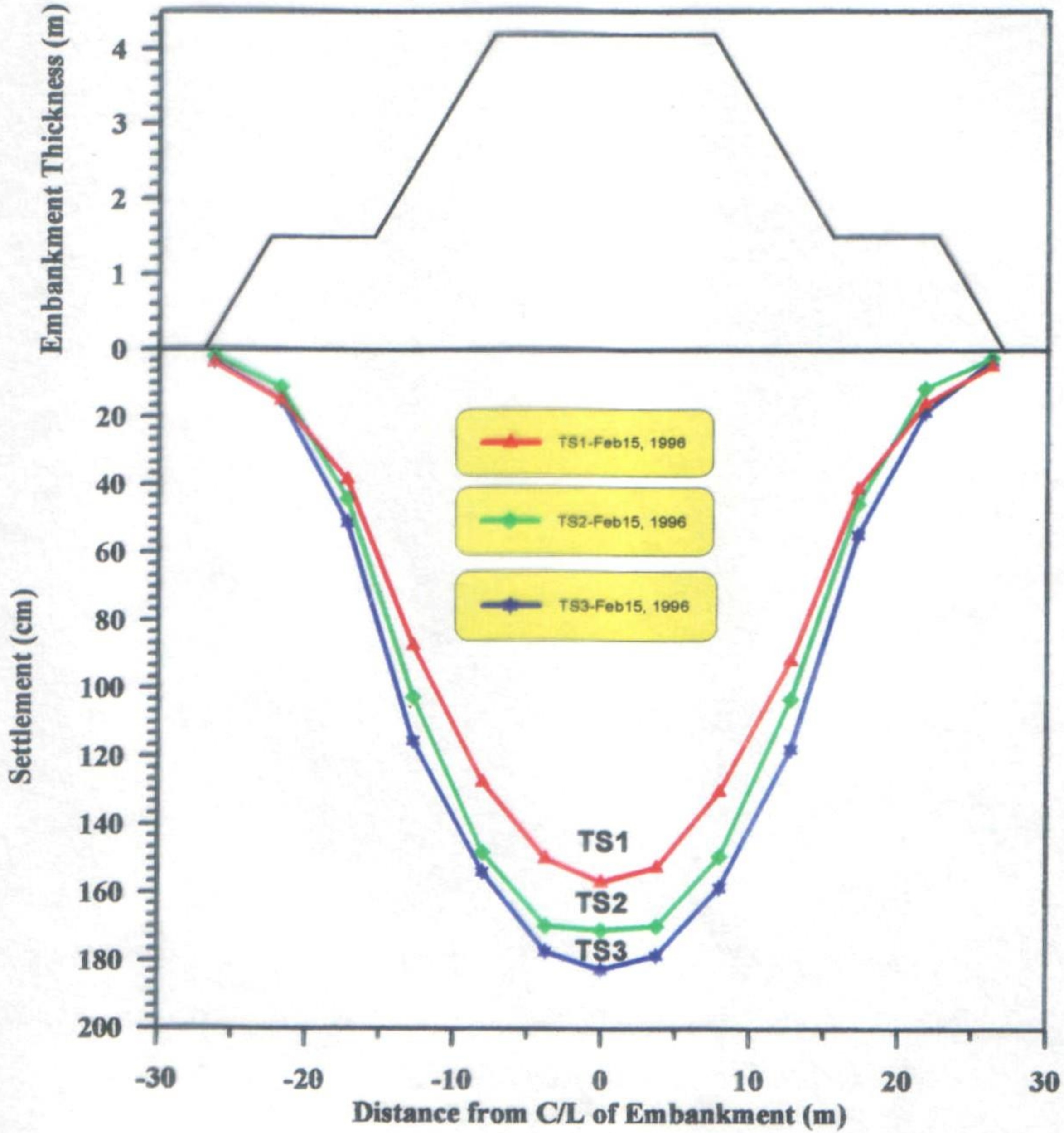


Fig. 6.7 Surface Settlement Profile across the Embankments Cross Sections (TS1, TS2 and TS3)

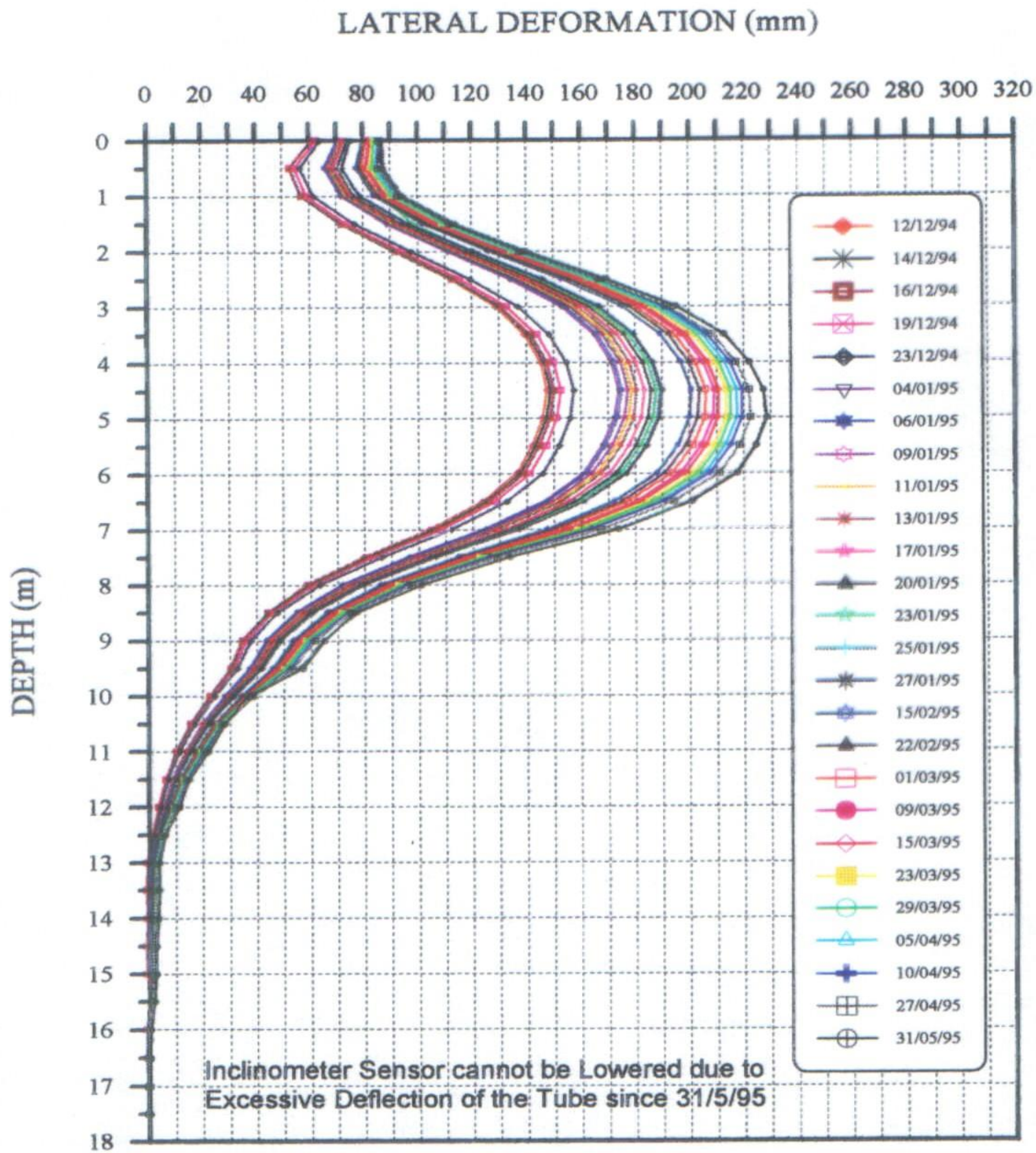


Fig. 12 Lateral Deformations with Depth (TS3 - I2)

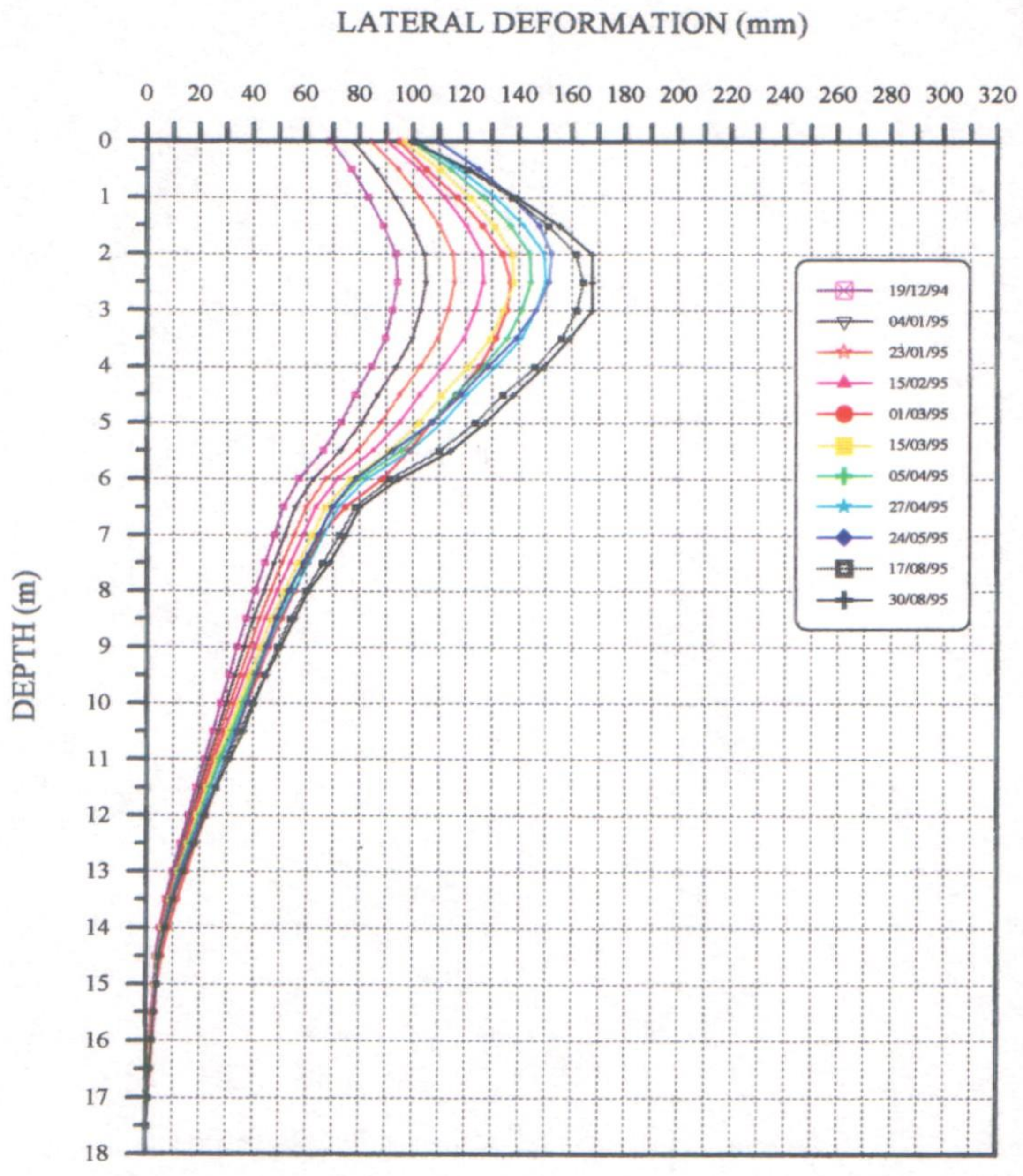
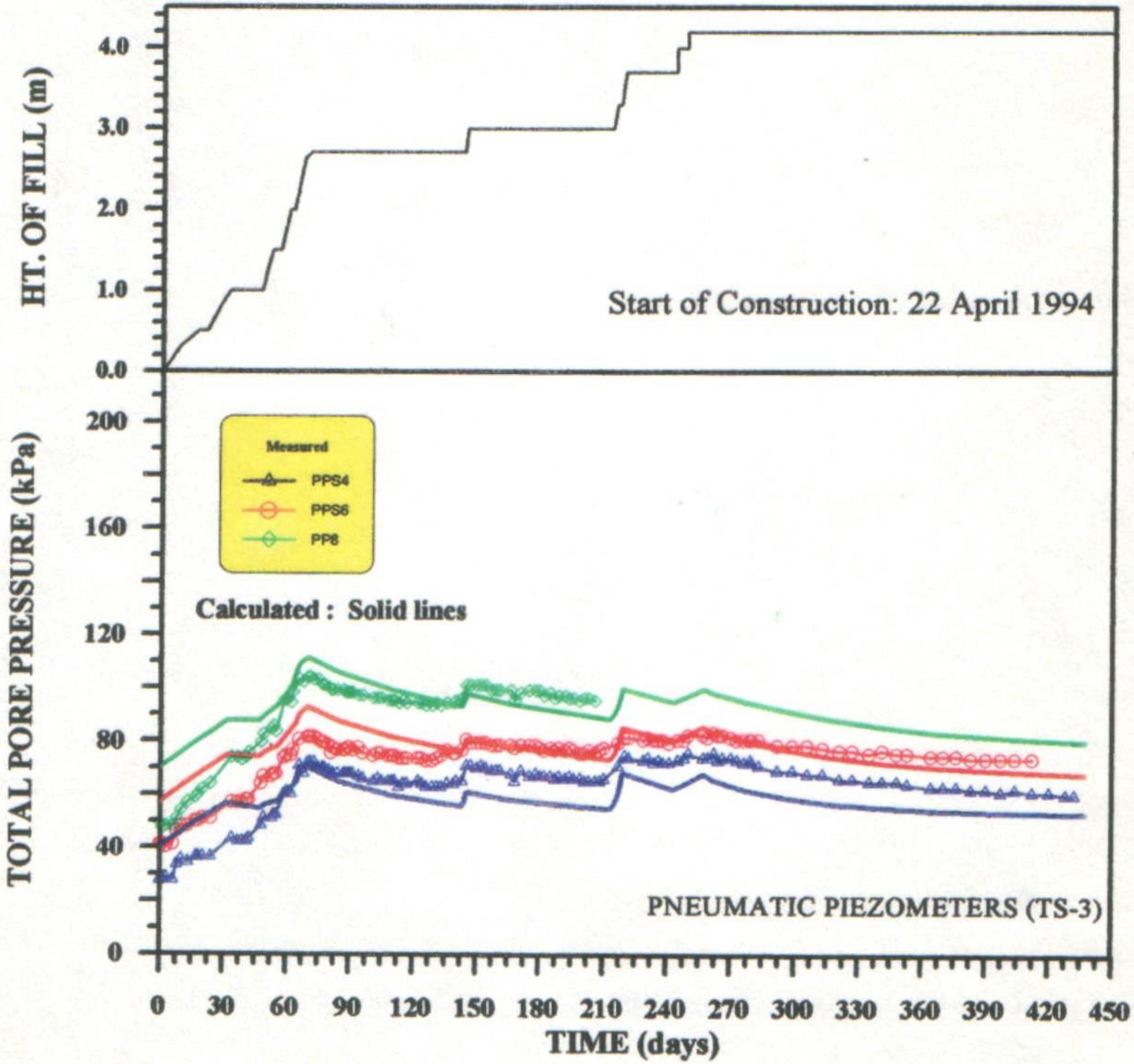


Fig. 9 Lateral Deformations with Depth (TS3 - I1)



Comparison of FEM Calculated and Measured Total Pore Pressures at Different Depths 4 m, 6 m, and 8 m for TS3 Embankment

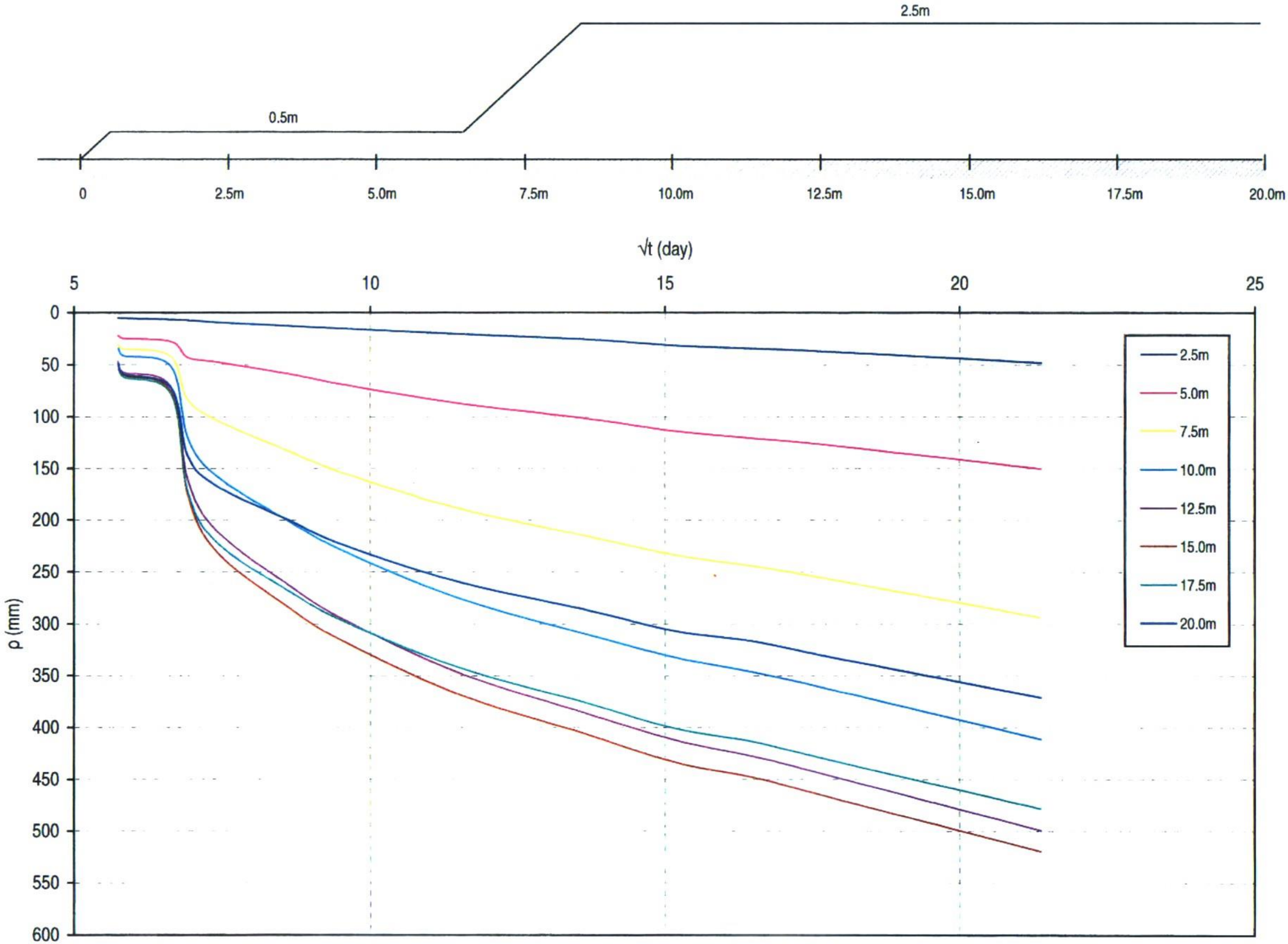


Figure 3.11: Insitu vertical settlement profile at various distances along the embankment with no ground improvement

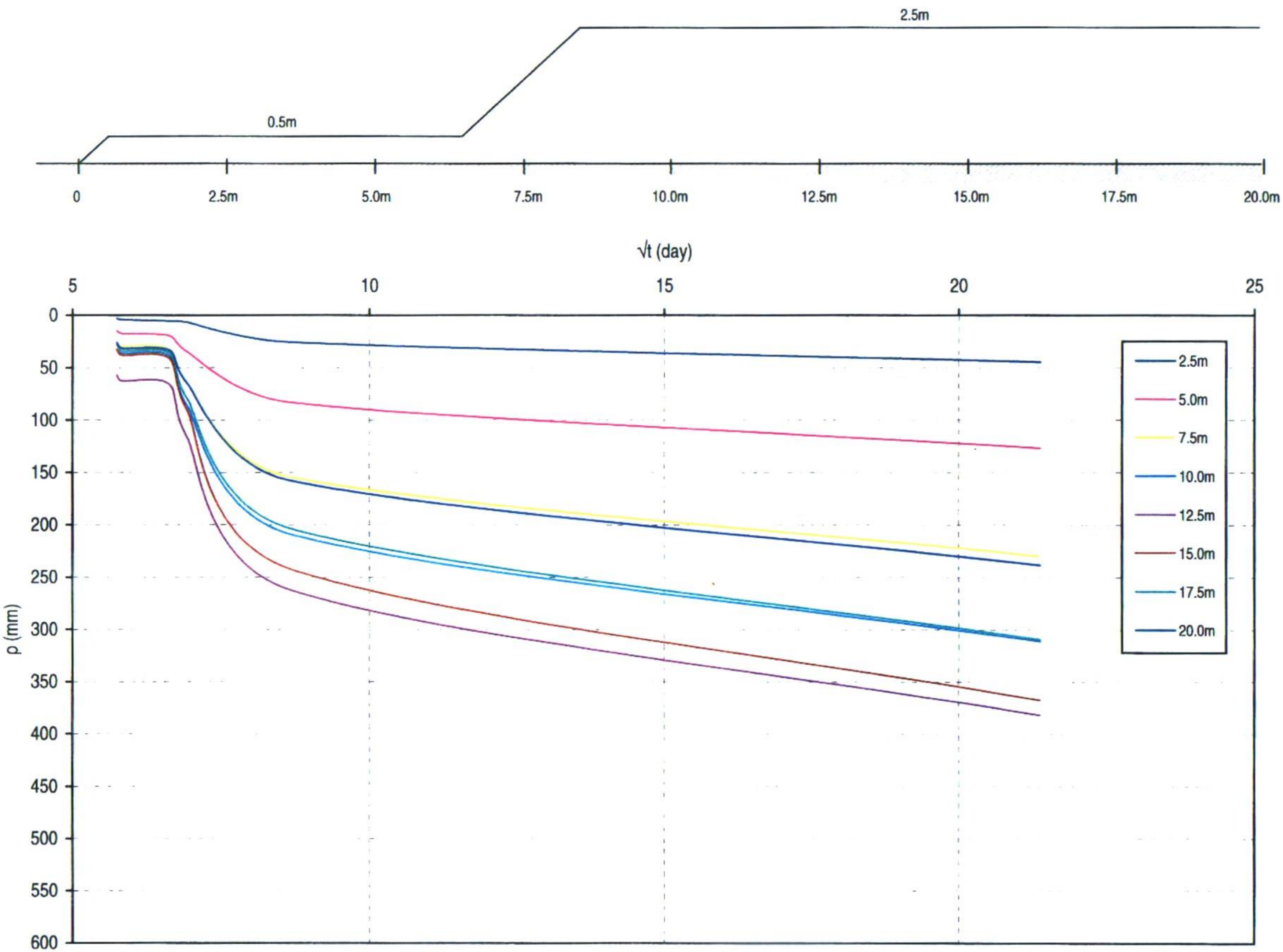


Figure 3.12: Insitu vertical settlement profile at various distances along the embankment with stone columns at 2m spacing

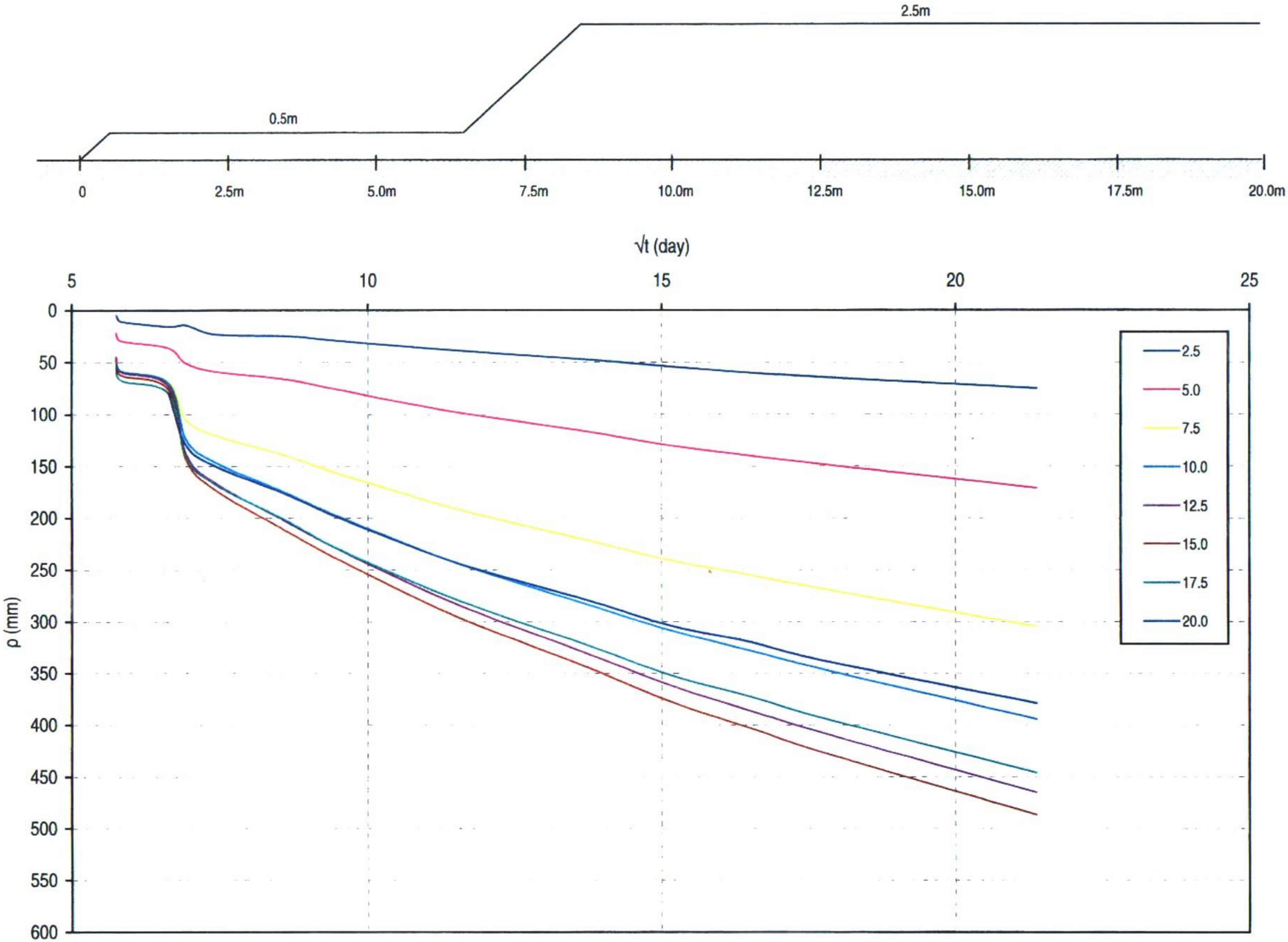
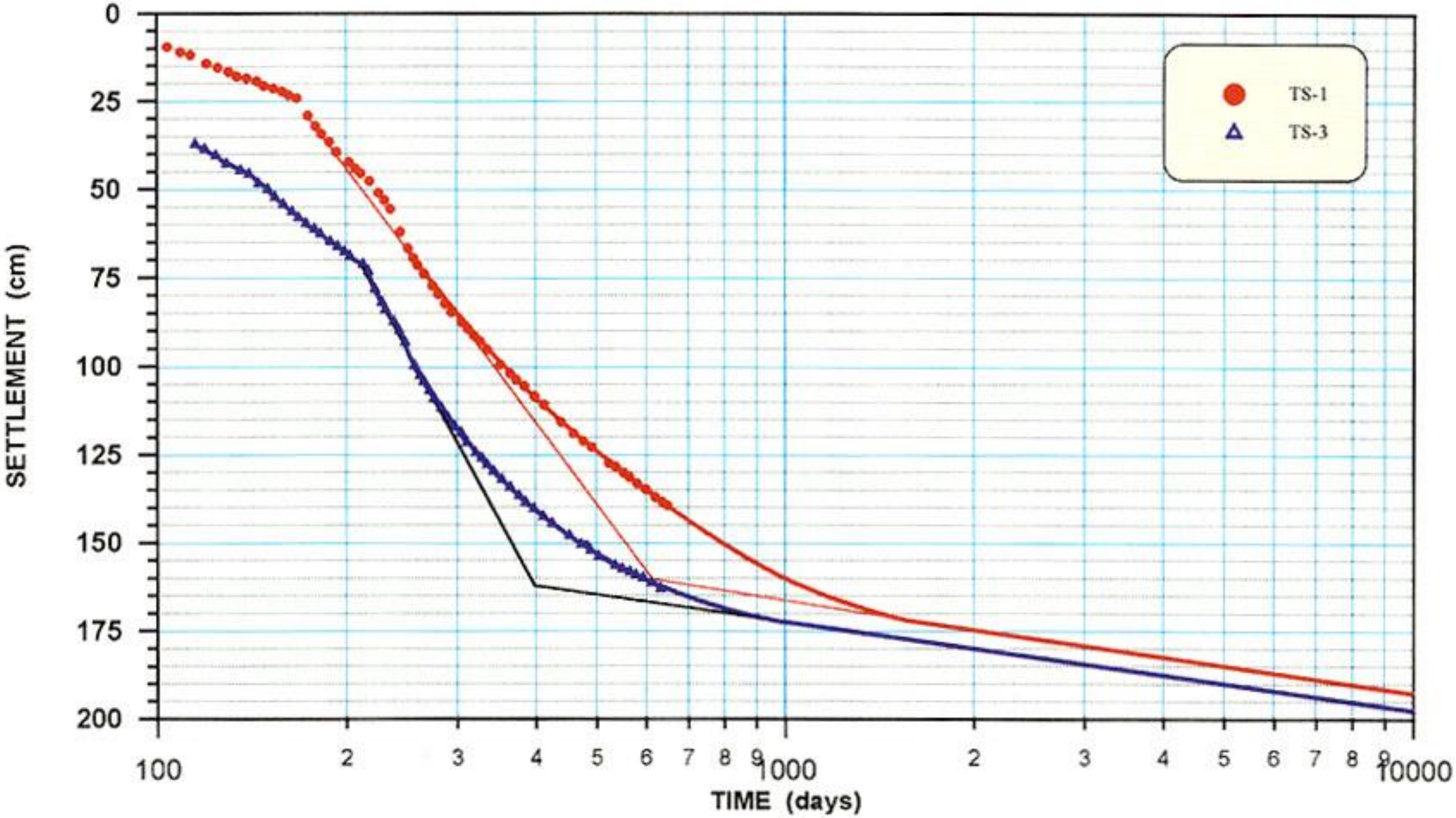
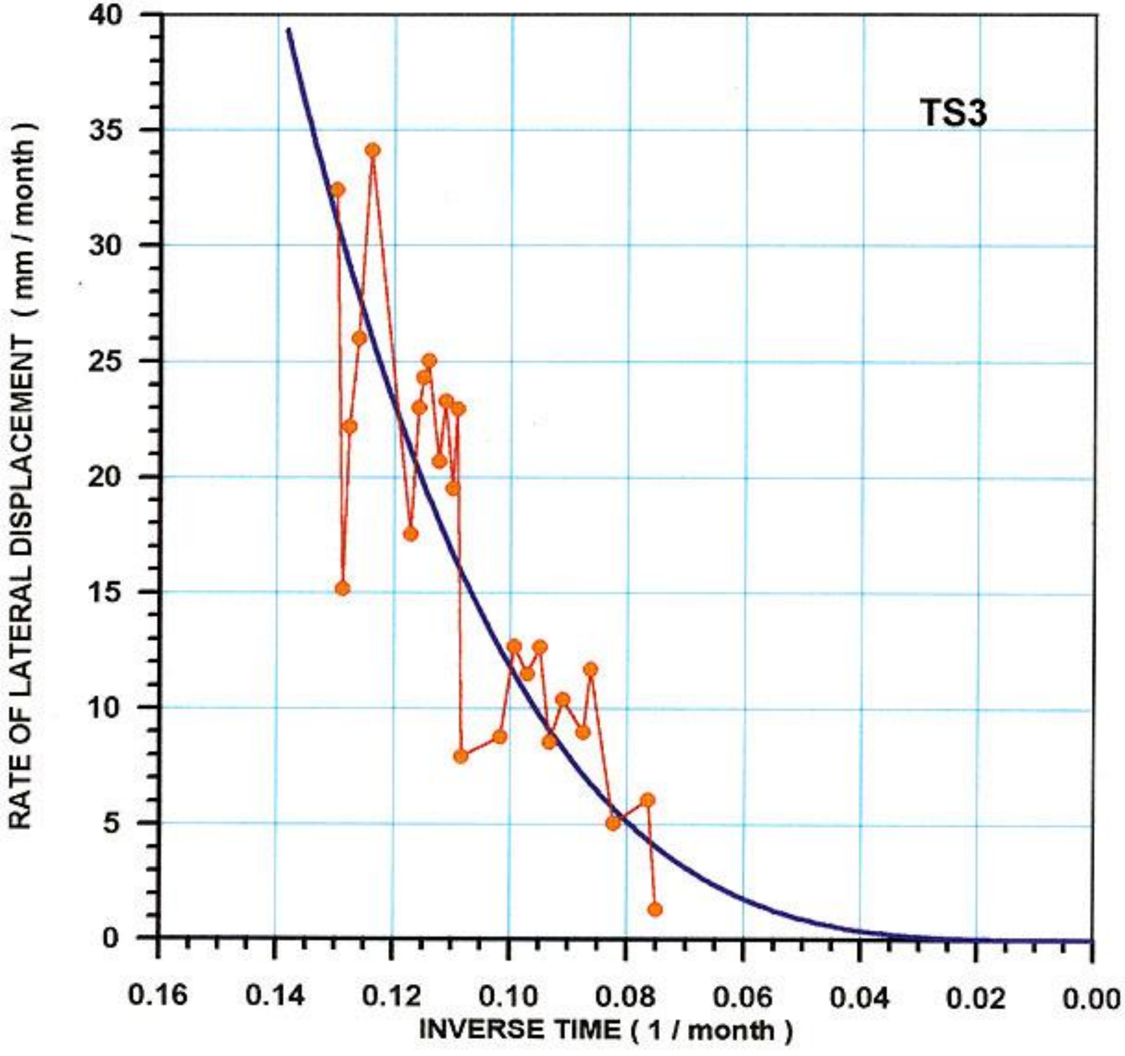


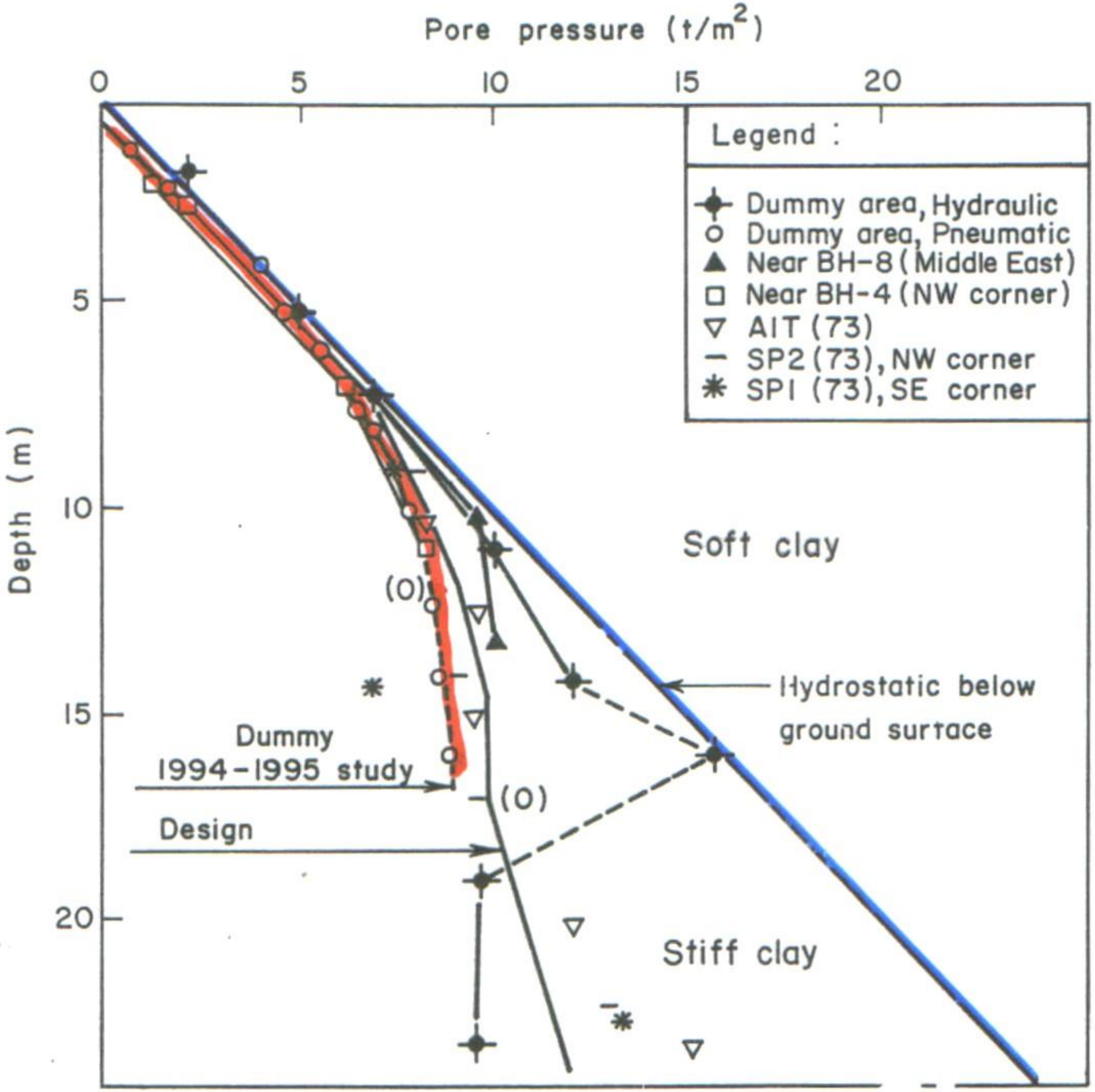
Figure 3.13: Insitu vertical settlement profile at various distances along the embankment with stone columns at 3m spacing



CONSOLIDATION SETTLEMENT vs LOG TIME PLOTS FOR TS1 AND TS3



RATE OF LATERAL DISPLACEMENT vs INVERSE TIME PLOT FOR TS3



Variation of Piezometric Pressures with Depth

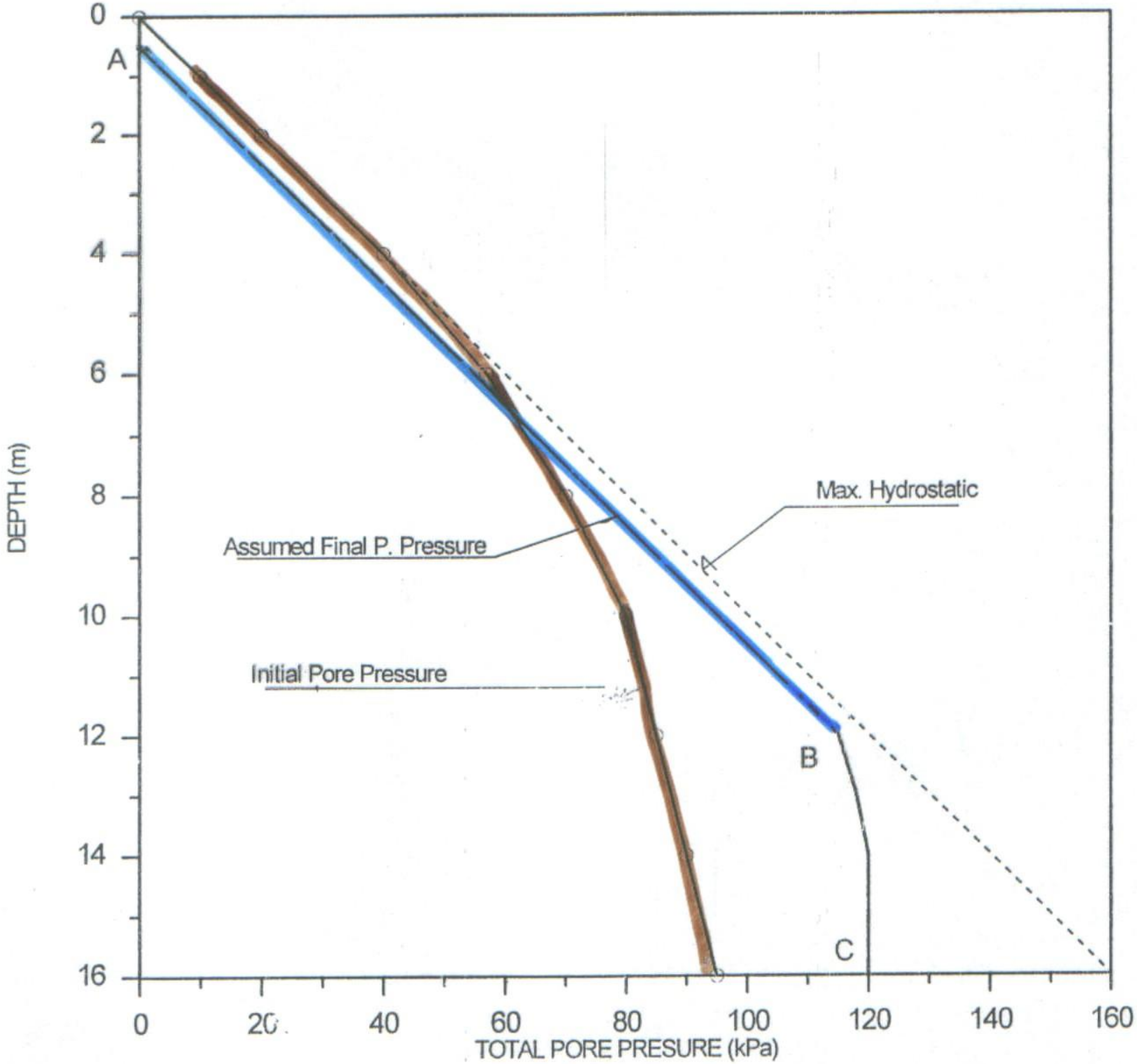
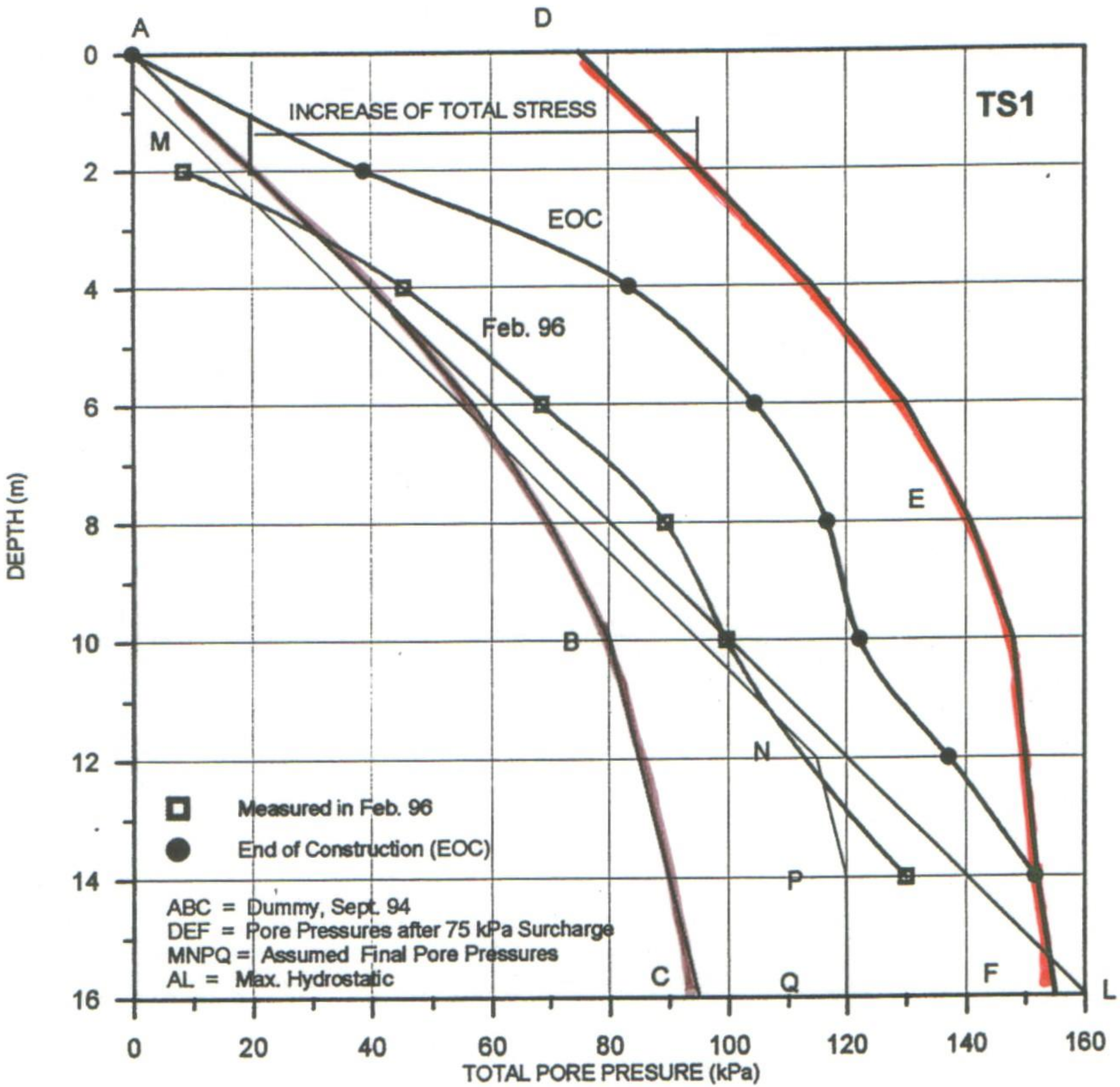


Fig. 6.26: Piezometric Drawdowns (Initial and Assumed Final Values)



PORE PRESSURE PROFILE IN TS1

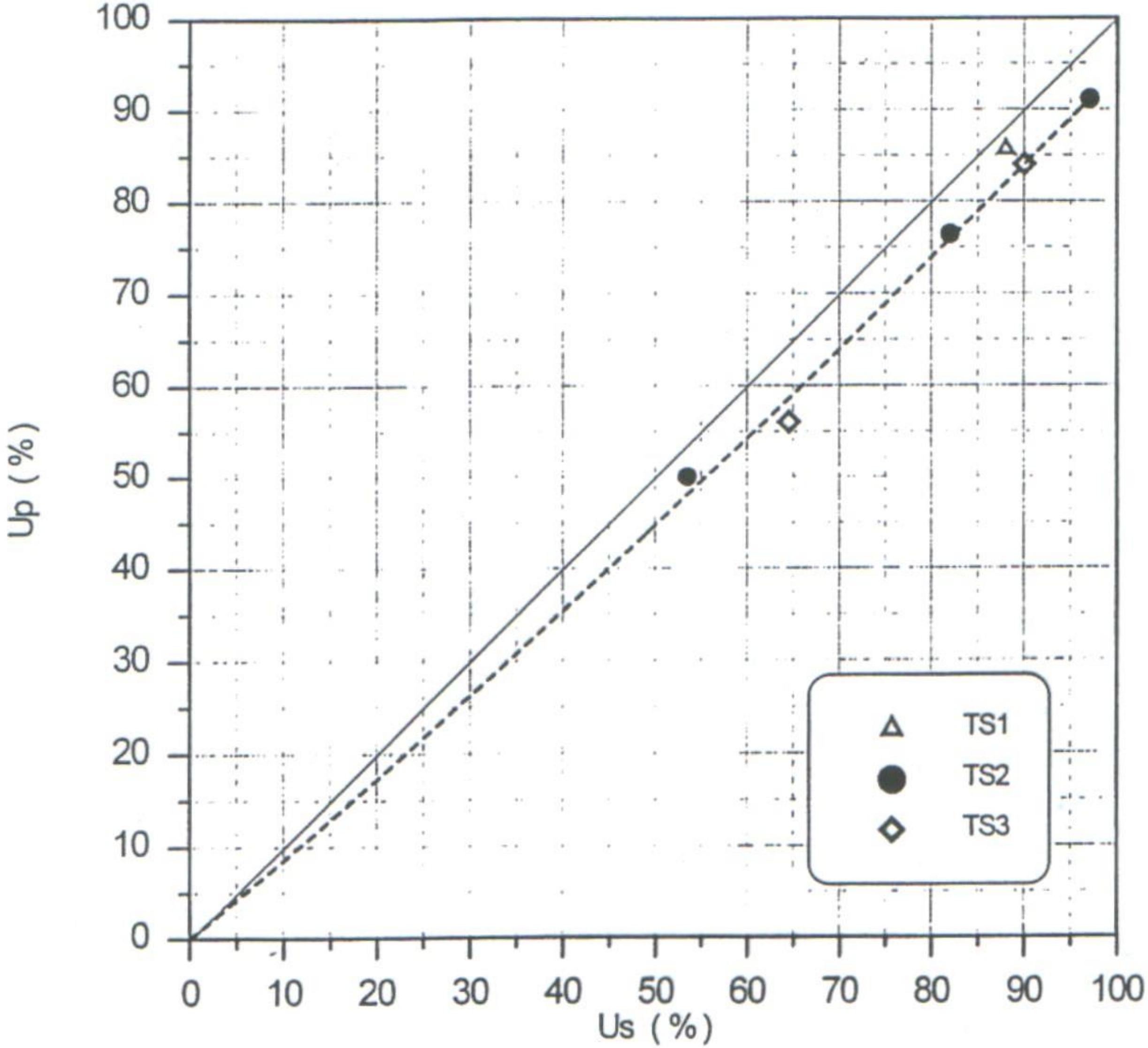
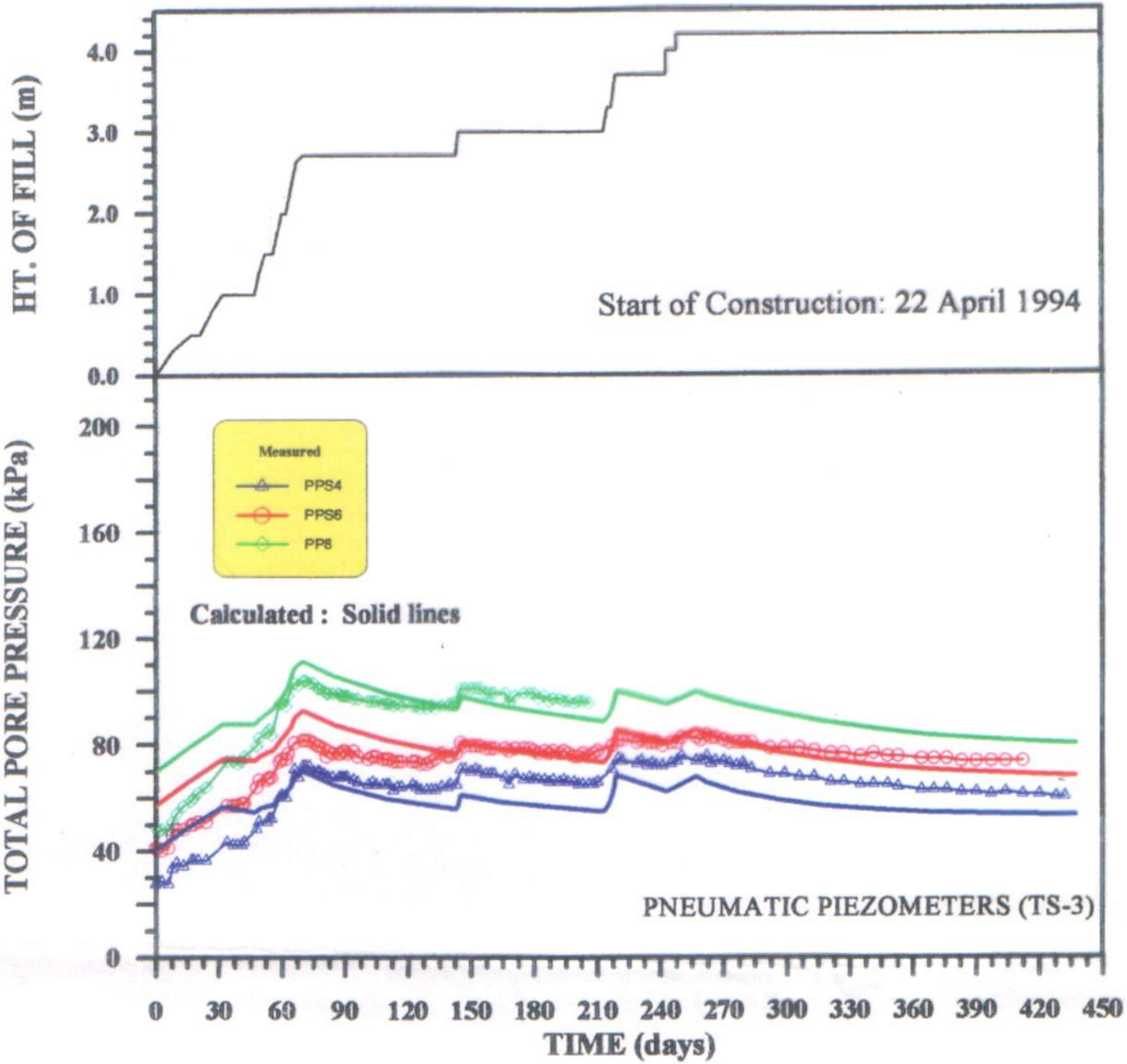
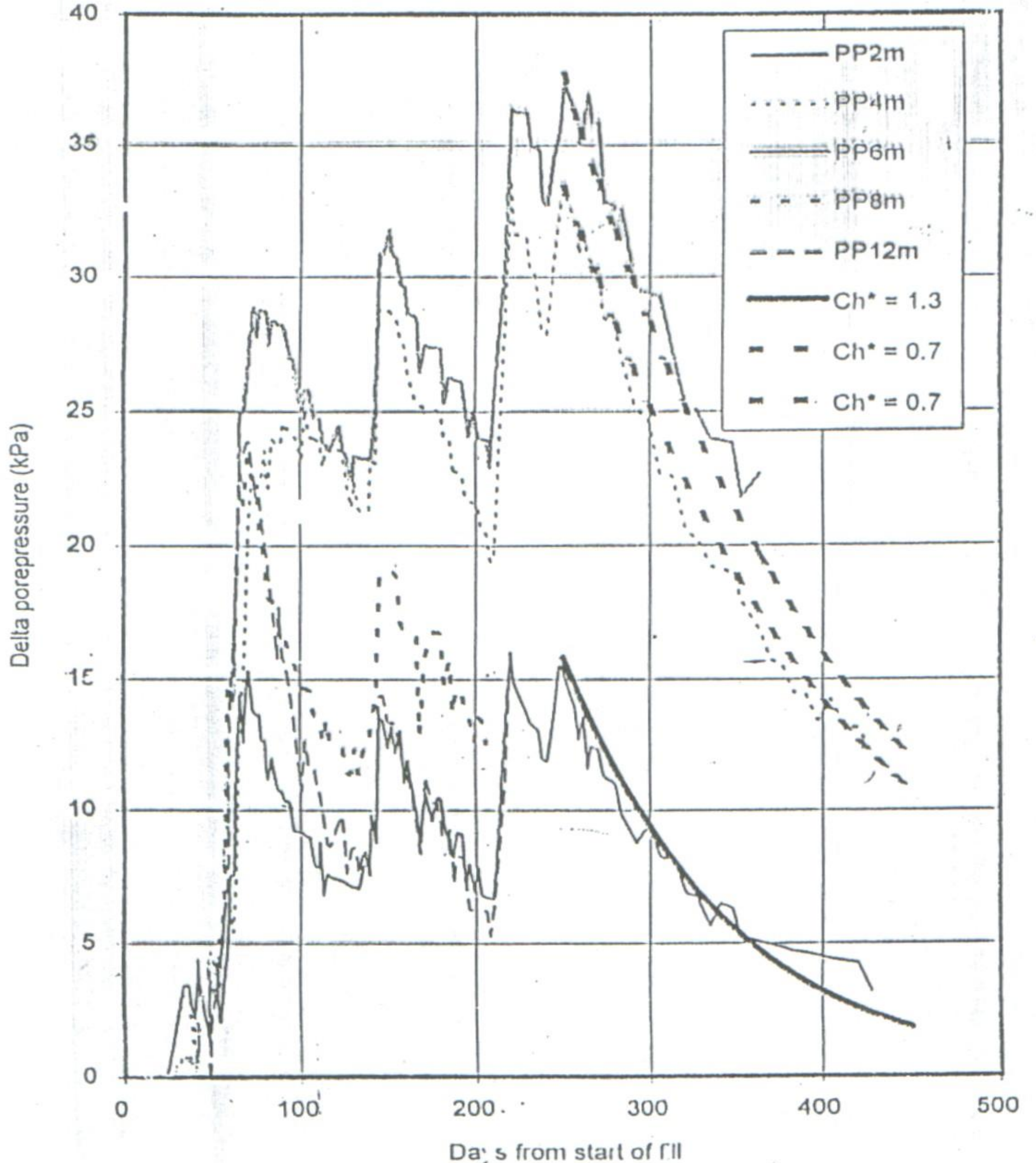


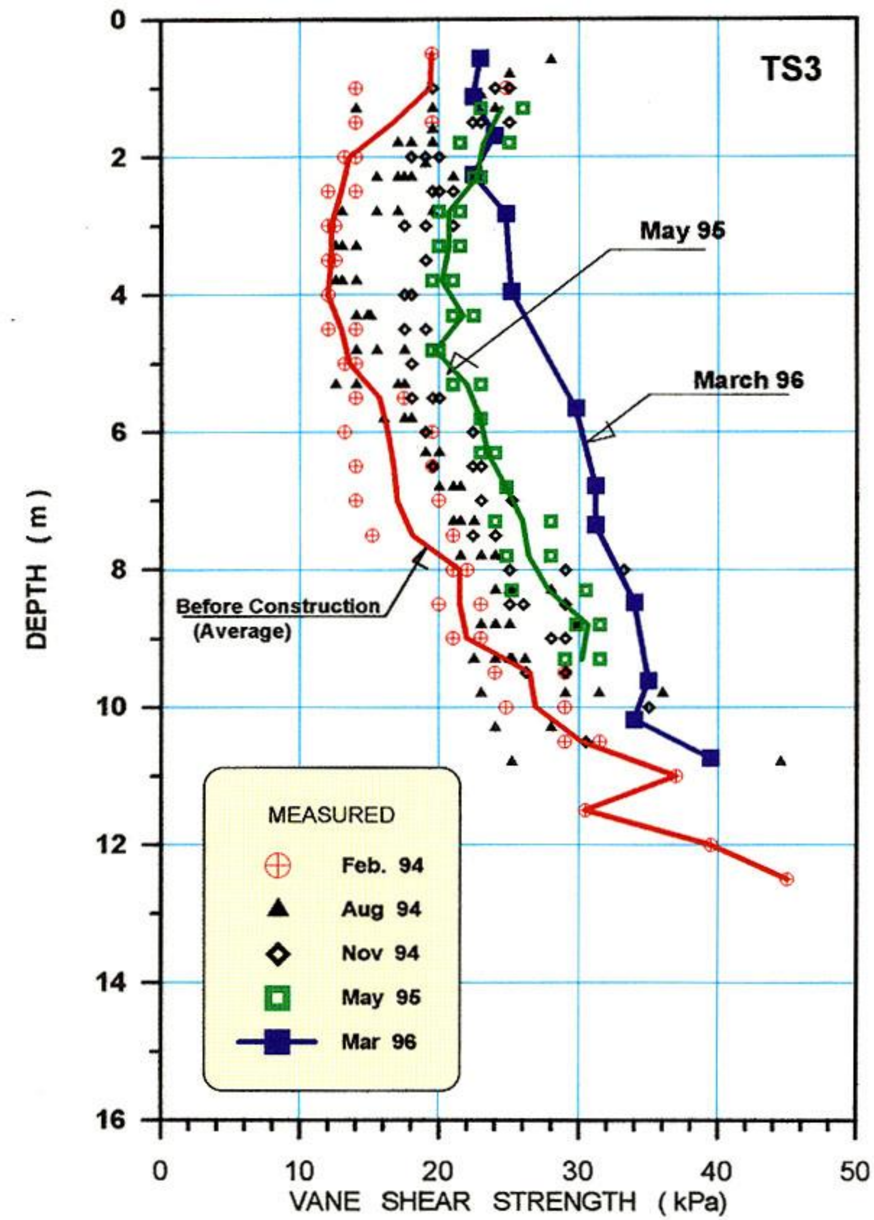
Fig. 14 Relation of Degree of Consolidation from Settlement (Us and Up)



Comparison of FEM Calculated and Measured Total Pore Pressures at Different Depths 4 m, 6 m, and 8 m for TS3 Embankment

Figure 3.1 Back calculation of pore pressure dissipation TS3





Field Vane Shear Strength Measured in Embankment TS3

Finite element analysis

Bangkok Airport Embankment

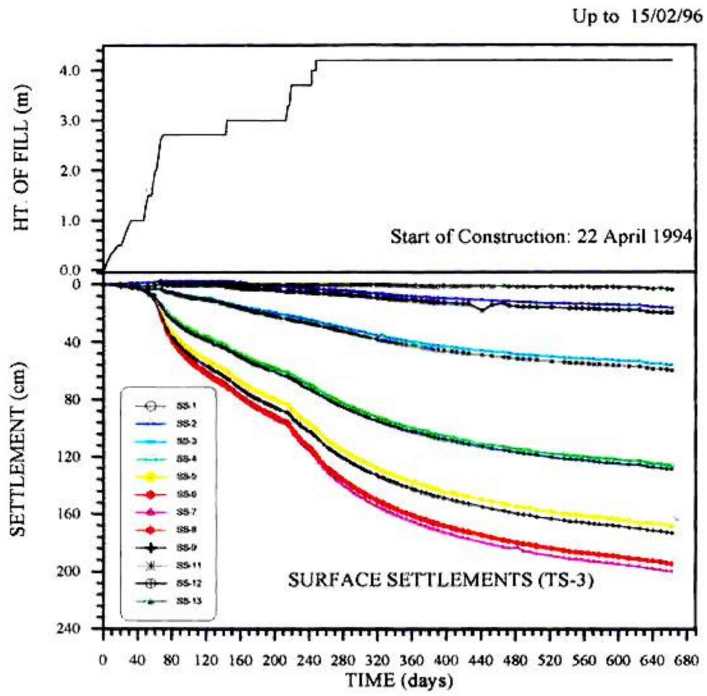


Fig. 3 Time-Settlement Plot (TS3) with Loading Schedule (Surface Settlement Gauge Measurements)

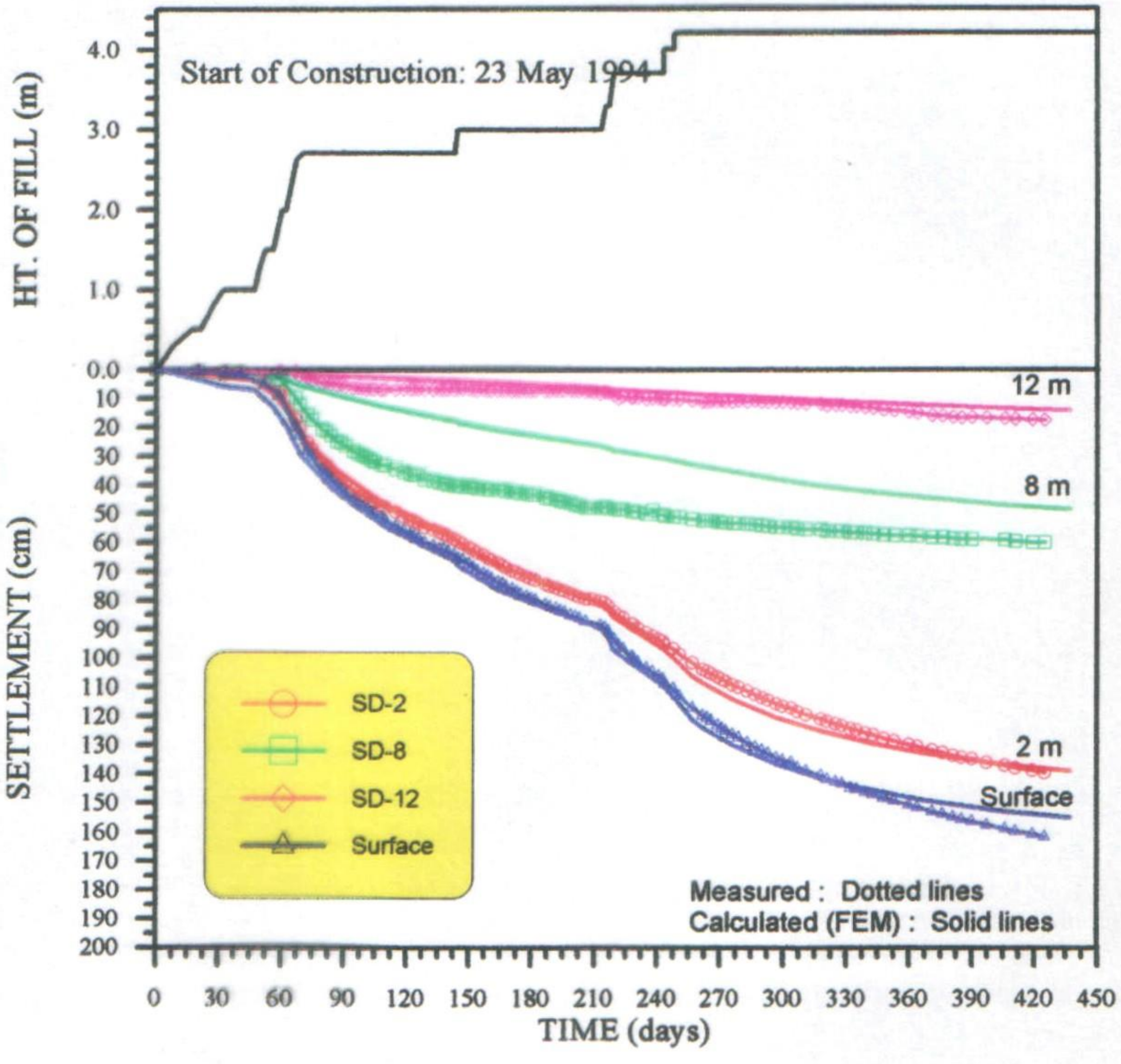


Fig. 6.42 Comparison of Calculated (by FEM) and Measured Settlements at 0 m, 2m, 8m, and 12m Depth for TS3 Test Embankment

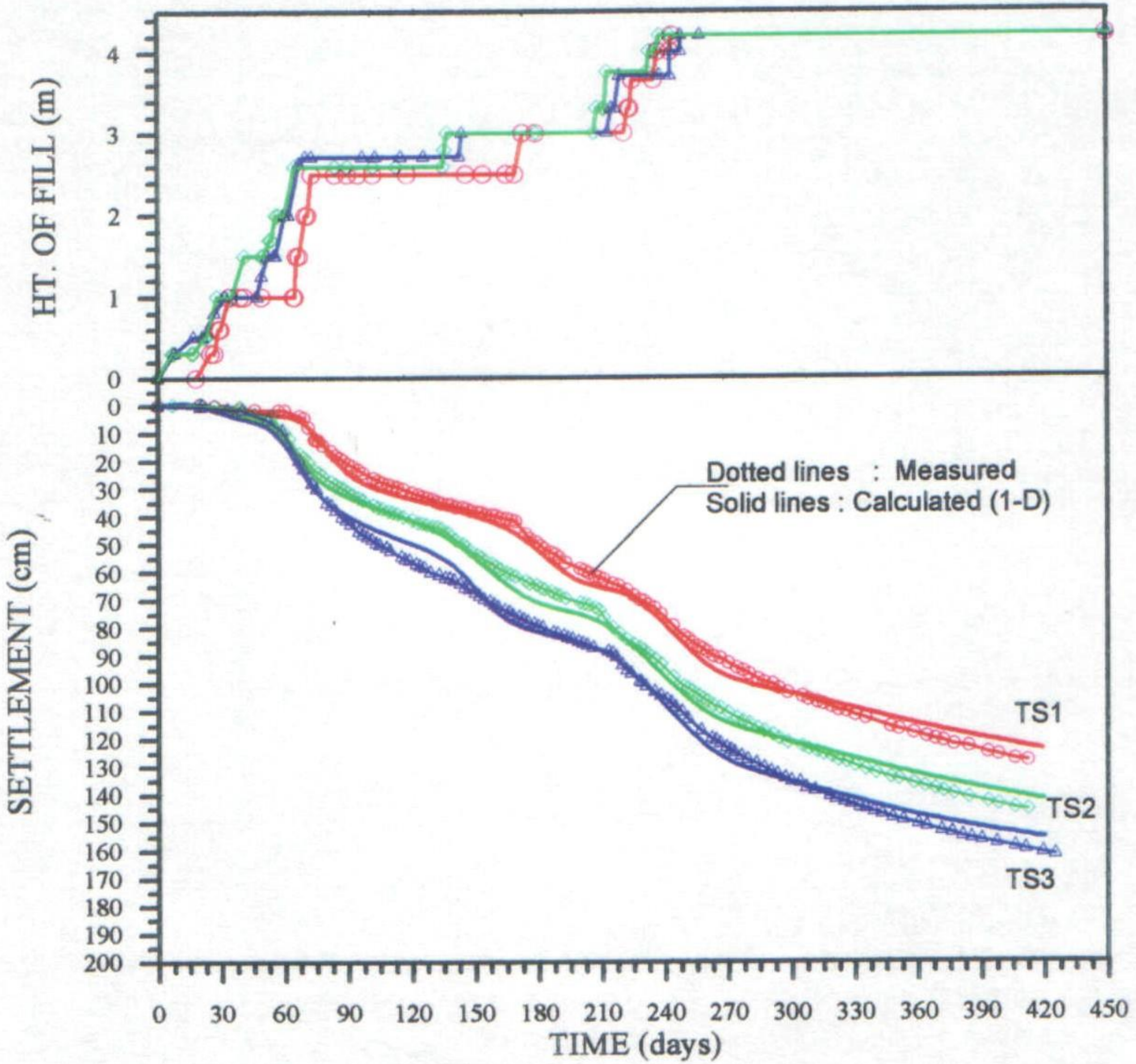
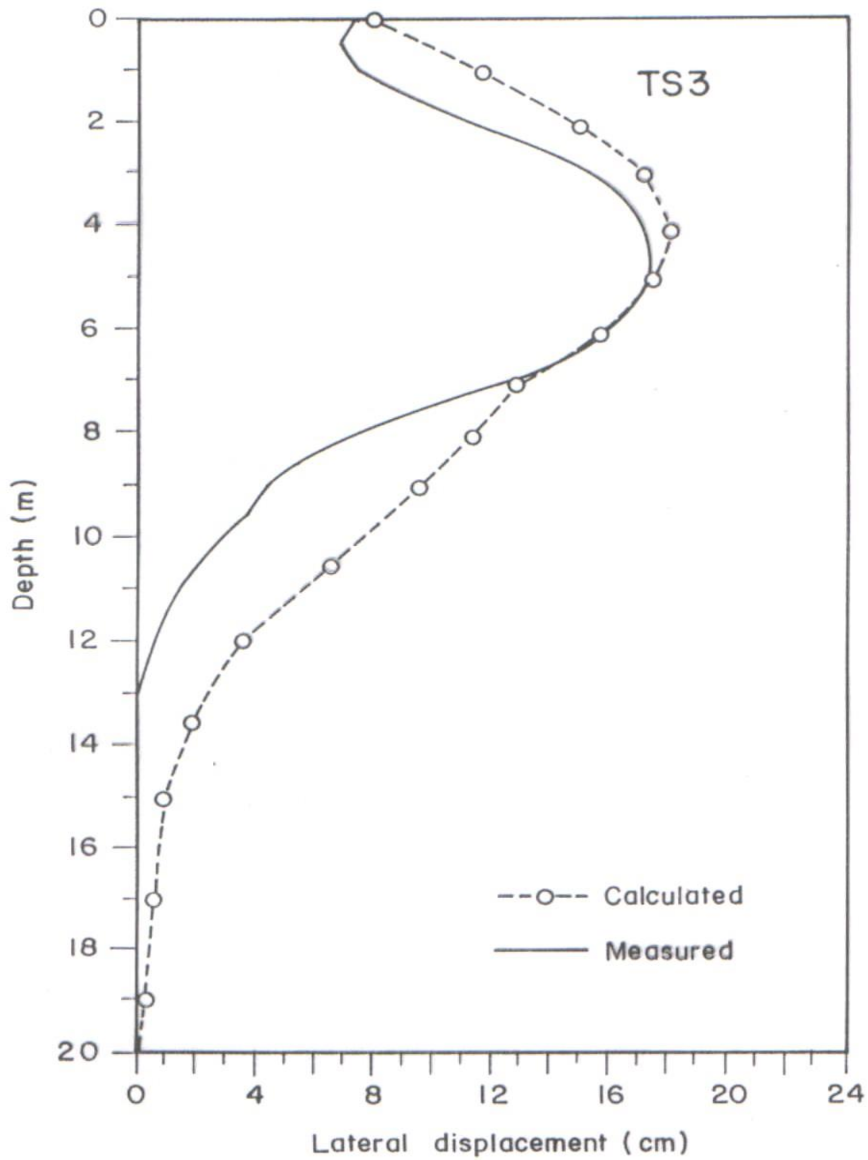


Fig. 6.35 Comparison of Measured and 1-D, Calculated Settlements for Three Test Embankments TS-1, TS-2, and TS-3



Comparison of Computed (FEM) and Measured Lateral Deformations at the end of Construction for Embankment TS3

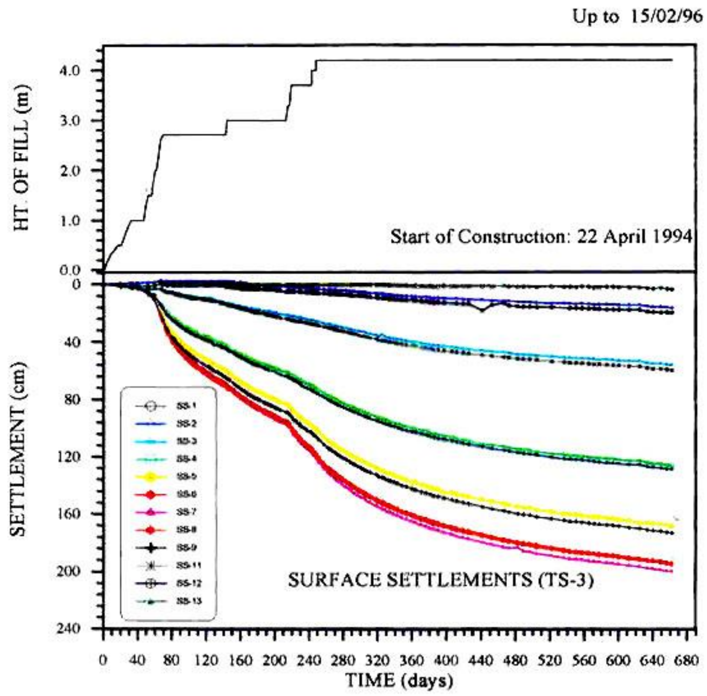


Fig. 3 Time-Settlement Plot (TS3) with Loading Schedule (Surface Settlement Gauge Measurements)

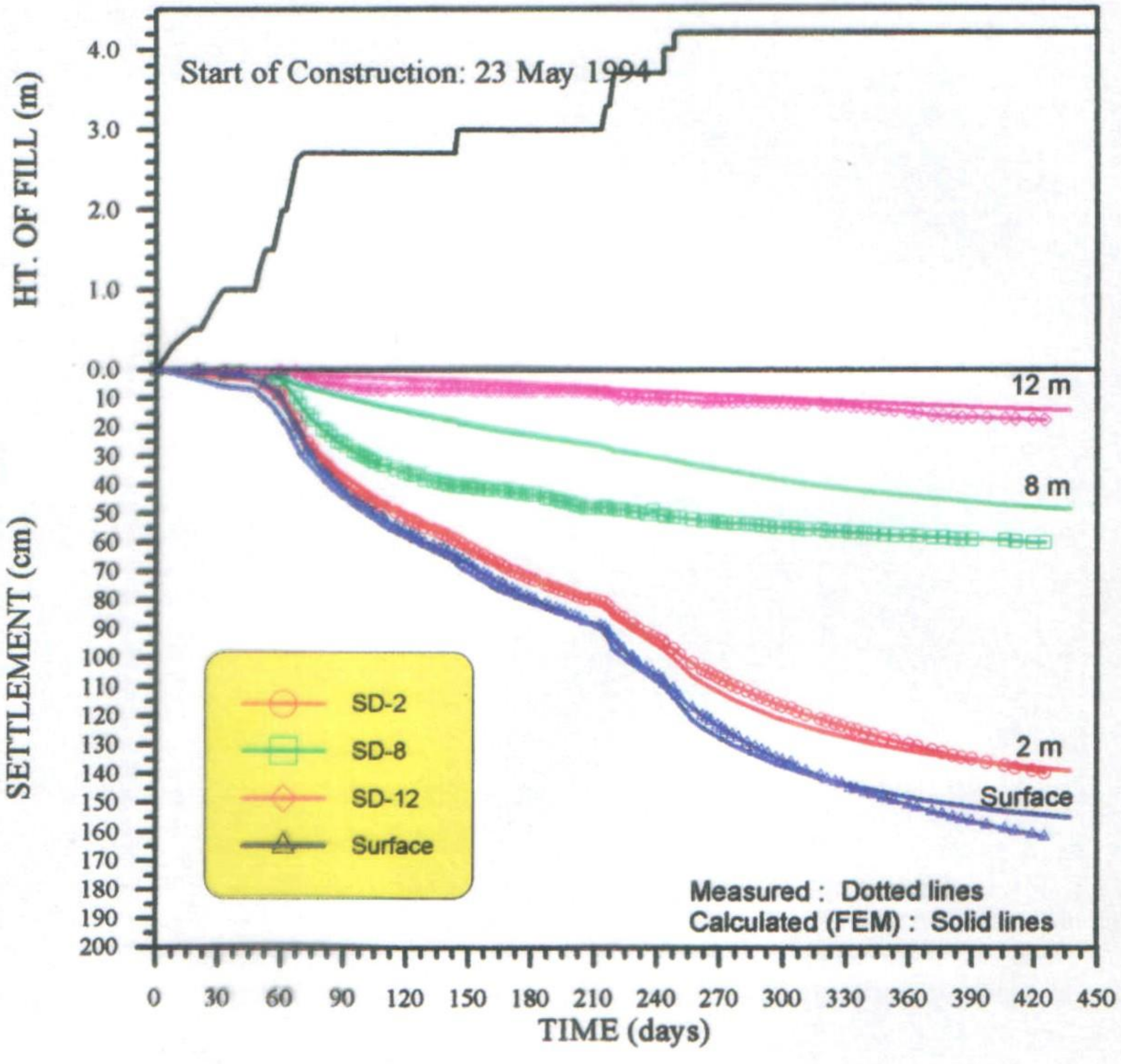


Fig. 6.42 Comparison of Calculated (by FEM) and Measured Settlements at 0 m, 2m, 8m, and 12m Depth for TS3 Test Embankment

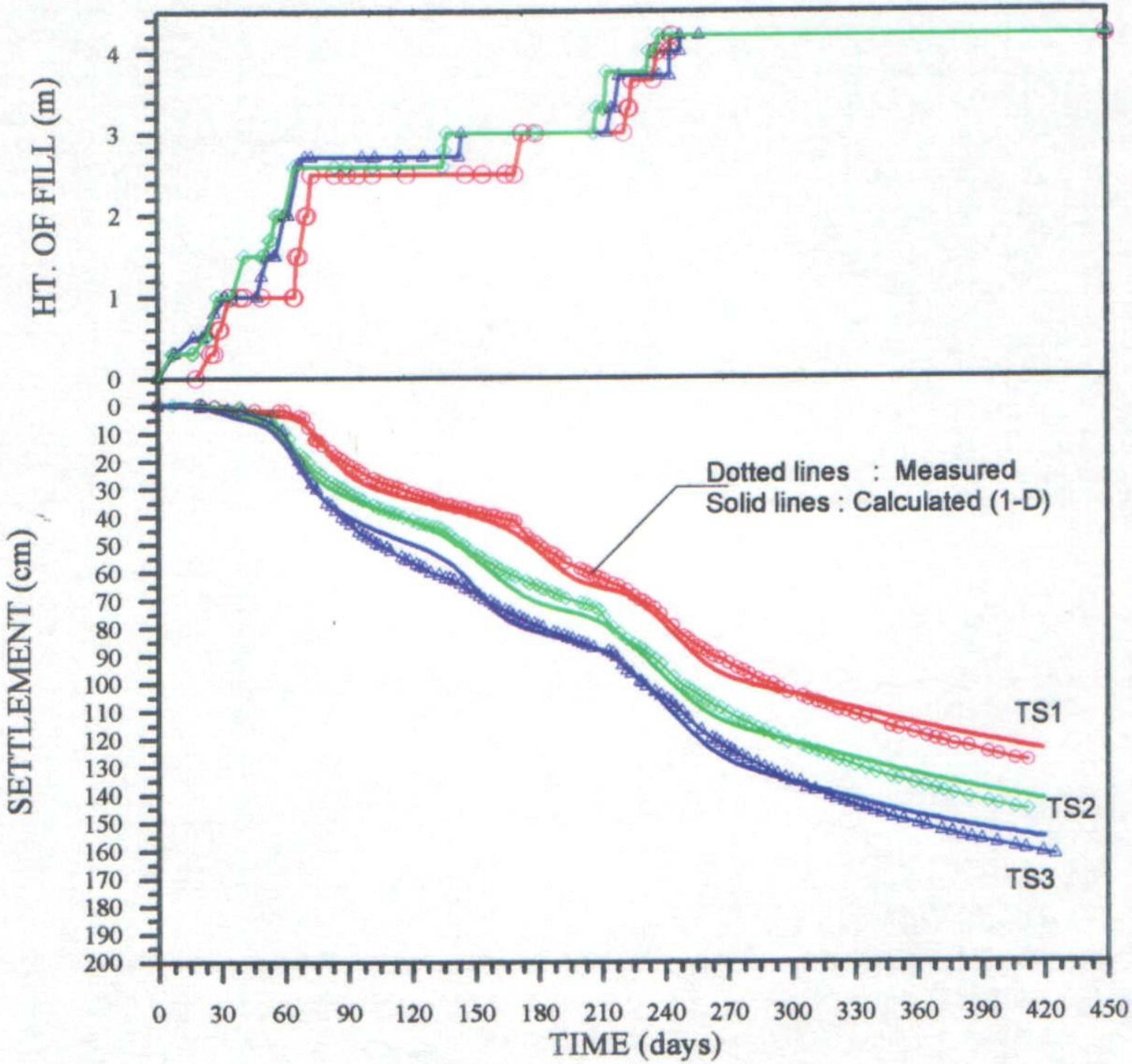
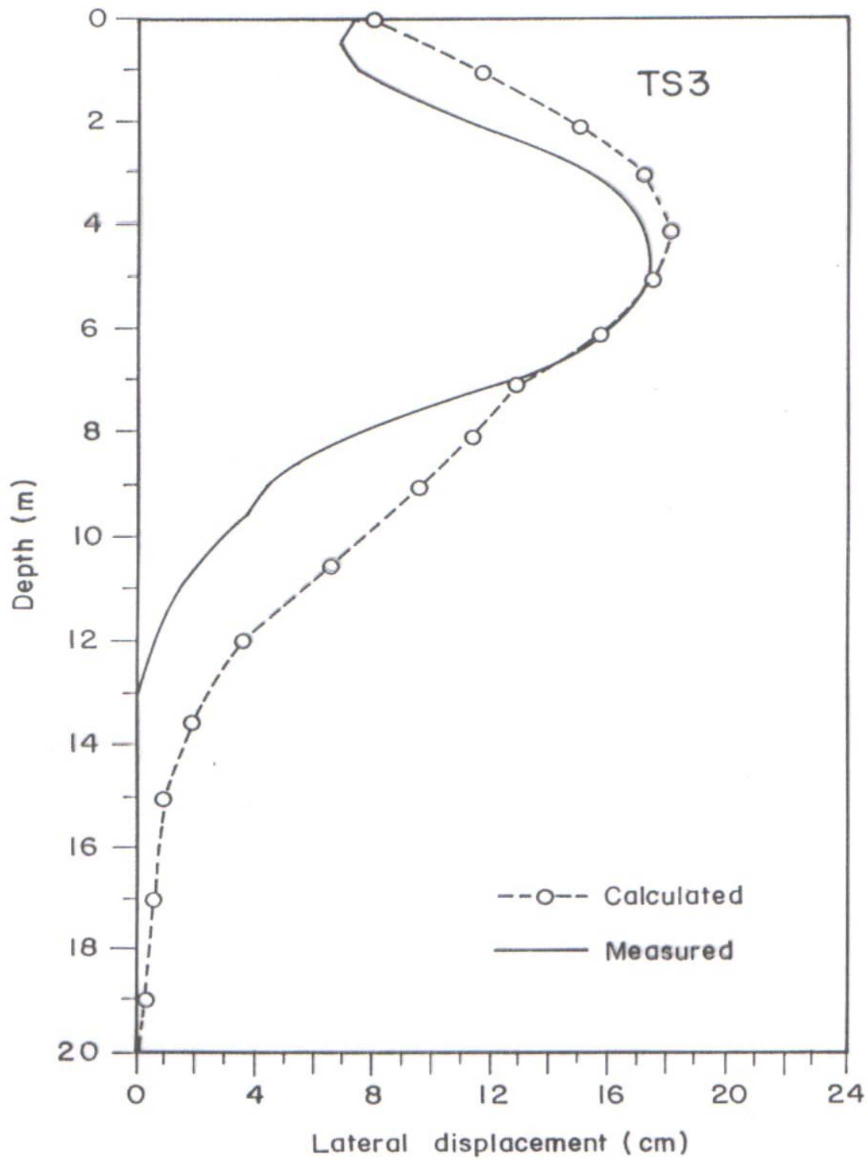


Fig. 6.35 Comparison of Measured and 1-D, Calculated Settlements for Three Test Embankments TS-1, TS-2, and TS-3



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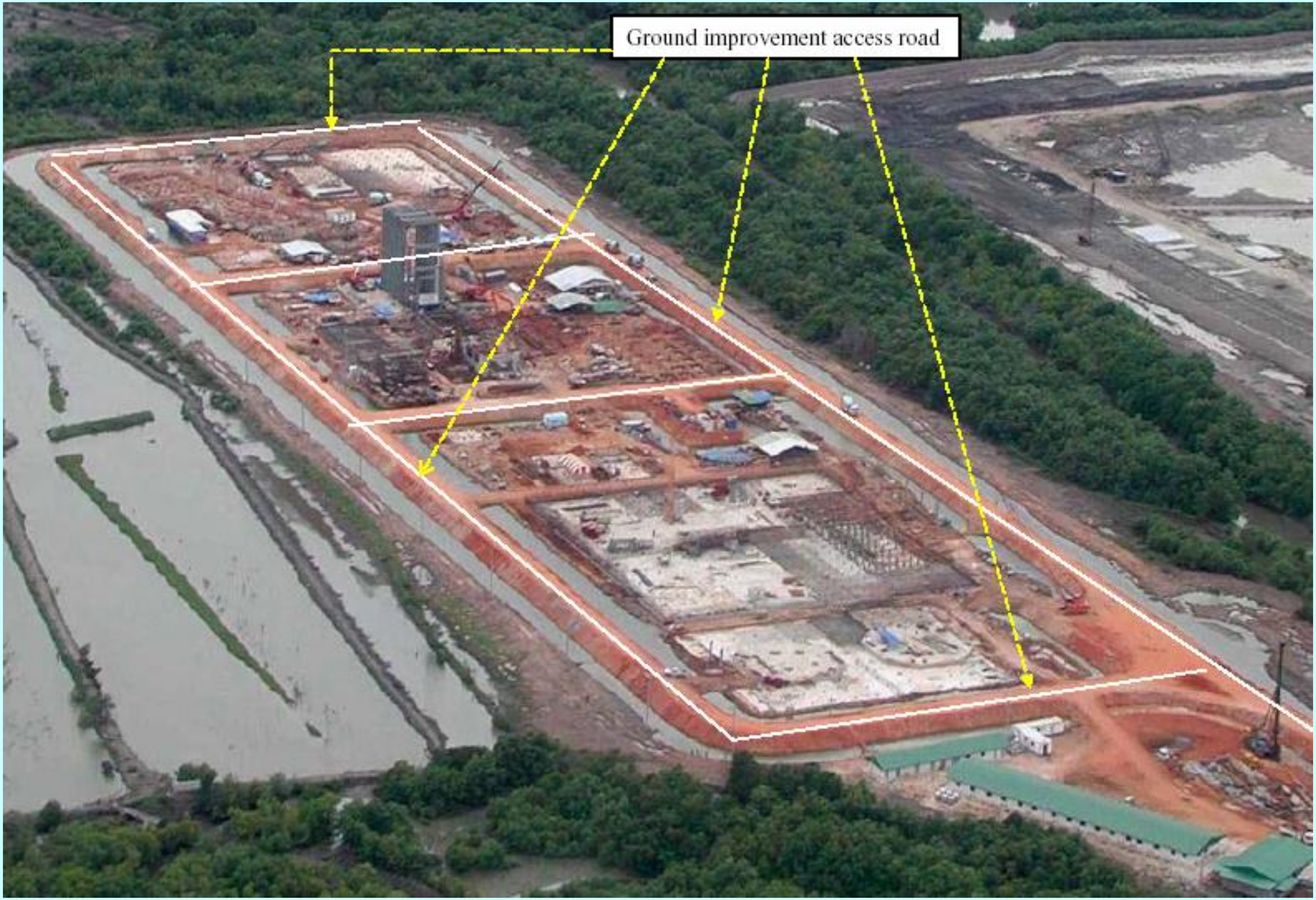

Ground improvement access road

A Profile of His Career

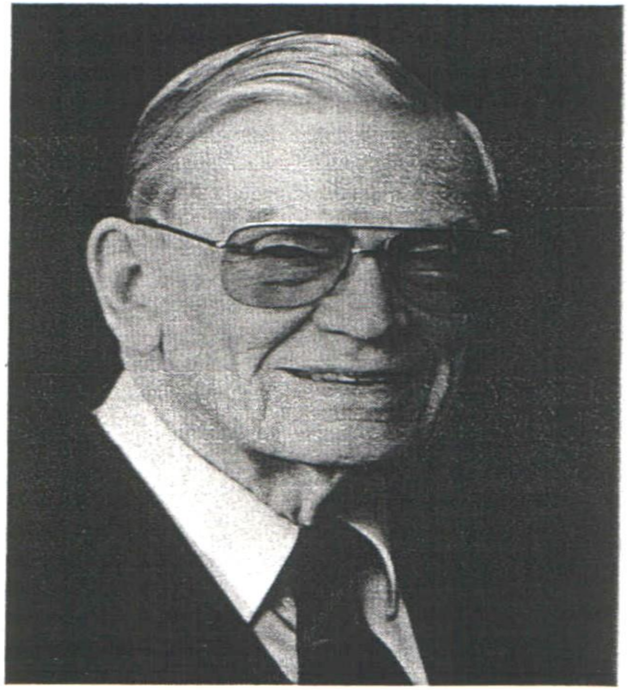
August 13, 1926

Ralph Peck

In checking up on the quality of work being done by pupils, I am very much pleased to see that the quality of your work is high and very uniform. This indicates that you should be successful in future work.

H. S. Philips
Principal
Aaron Grove Junior High School

The prediction quoted above, made by a Junior High School Principal to a young boy in 1926 was certainly correct. That 14-year old boy has since become one of the leaders in his profession and is known worldwide for his contributions to engineering and engineering education.



Ralph B. Peck, 1999

His advice has been sought on numerous major national and international projects including foundations, tunnels, dams, pipelines and airfields. His impact on the profession has been most significant because of his commitment to education in both his academic and professional engineering life. His teaching and research, in the 32 years at the University of Illinois, were directed toward integrating the theory and practice of geotechnical engineering – a task that he achieved and will be remembered for above all.

A brief review of his career is summarized on the following two pages. To keep within his field of expertise, geotechnical engineering, this information is presented in the form of a bore hole profile – something that he knows and has worked with throughout his career.

OUR EXPANDING GEO INDUSTRY

TRIUMPHS AND PERILS

by

Ralph B. Peck

GeoLogan 1997

Who will train our students to carry out the indispensable function of general civil engineering? Will they be teachers who understand design and construction, who can give their students a sense of proportion, a sense of the fitness of things? Or will they be persons with no first-hand knowledge of practice? I am indebted to my colleague Walt Hanson for noticing the following advertisement in an ASCE publication under the heading, "Faculty Positions Available":

> "A tenure track position in the Department of Civil Engineering is available for a geotechnical engineer with expertise in one or more of the following areas: computational mechanics, constitutive modeling, soil dynamics, and earthquake engineering. Interests in innovative areas such as computeraided engineering and expert systems are desirable. The appointee will be expected to develop active research programs and to teach at both the undergraduate and graduate levels."

Teach what at the undergraduate level? Foundation investigation, analysis and design, and construction pitfalls and practices? I can only hope that both the advertising university and the respondents take for granted that the "geotechnical engineer" who responds will know something about the history and practice of foundation design and construction, will at least once hand the students a specimen of soil and ask if it is silt or clay and approximately what are its liquid limit and plasticity index. Where is the applicant who satisfies the

T. WILLIAM LAMBE, Inc. *Consulting Geotechnical Engineer*

December 24, 1996

Professor A.S. Balasubramaniam
Asian Institute of Technology
P.O. Box 4
Klong Luang Pathumthani 12120
Thailand

Dear Professor Bala:

The following responds to your letter of 5 December.

I would agree with you that a lot of geotechnical work will occur in the 21st Century. I see a lot of activity by the geotechnical firms. I do not, however, see active and exciting research and devlopment in geotechnical engineering as we saw during the 50's and 60's. I think several factors contribute to the lack of top quality geotechnical research - i.e. lack of research funds; large growth in our Profession which becomes more and more a business; decreased strength of our socities; etc.

Best wishes for the season and the New Year.

Sincerely yours,

TW Lambe

T. William Lambe

TWL/cl

Proceedings of the Institution of Civil Engineers
Geotechnical Engineering 155
July 2002 Issue 3
Pages 155–158

Paper 12829

Keywords:
codes of practice & standards/
education & training/geotechnical
engineering

Briefing

What is the matter with geotechnical engineering?

J. Atkinson, *Professor of Soil Mechanics, City University, London*

In this essay the author argues that education in the basic theory of structures, hydraulics and geotechnics is being neglected in favour of training in the practical aspects of geotechnical engineering and an over-reliance on design codes and standards.

1. INTRODUCTION

When I was invited to write this briefing note the brief was: be contentious; open a discussion. I have never found that particularly difficult. I think there is a lot wrong with geotechnical engineering as currently practised. It is a good time to open the debate–to discuss what is wrong and what to do about it.

2. WHAT IS THE PROBLEM?

There are several statements doing the rounds, such as: two-thirds of ground engineering is done by non-geotechnical engineers; too much of the time of good geotechnical engineers is spent in court and on claims; the greatest source of claims and disputes is in the ground. If these are true then something is wrong.

But many of the major advances in the theory and practice of ground engineering have been developed in UK universities or by UK industry; UK universities have taught ground engineering at undergraduate and postgraduate level for more than a generation. In the UK there is a pool of world-beating skills in ground engineering.

So why is there a problem, and where does it start: in education, in training, or in practice? Do civil engineers and construction managers really understand the contribution that ground engineering should make to their projects?

Is the root of the problem scientific and technical? Is it education and training? Or is it managerial and cultural?

3. EDUCATION AND TRAINING: WHO SHOULD DO WHAT?

I graduated in civil engineering from Imperial College a long time ago. I had passed examinations in theories of structures, hydraulics, soil mechanics, and so on; I was educated. My first post was Assistant under Agreement: the agreement was that my employer would provide the training required by the Institution of Civil Engineers and that I would work for very little money.

For many years now it has been different. Employers say they want graduates who are trained and who can earn money for the company on their first day at work. Look at the criteria set by the Joint Board of Moderators for accreditation of degree courses in civil engineering. As a consequence many current courses in civil engineering include a substantial element of practice. Industry has shifted much of the responsibility for training onto the universities.

This has important implications. First, training is best acquired on the job, and it is difficult to do well in the classroom or laboratory. Second, and more importantly, because universities are now required to incorporate elements of training as well as new topics into their courses, something has to go. The introduction of a four-year course helps a little, but not that much.

What has gone is time spent on basic theories and understanding. Too few graduates have really grasped the fundamental theories of structures, hydraulics and geotechnics. Few really understand the basic principles of geotechnics, such as effective stress, drained and undrained events, compression and consolidation, or the influence of geological history on soil and rock profiles and properties. Many have not done a triaxial test, analysed the data and thought about the results. (In his recent Rankine lecture Professor Potts made much the same point in the specific context of expertise in geotechnical numerical analyses.) If students have not grasped the basics by the time they graduate they never will, because their supervising engineers didn't either–and so it goes on.

Most geotechnical engineers have a postgraduate qualification, often an MSc. They should have a good understanding of basic theories and principles–but sometimes I wonder. There have been one-year postgraduate taught MSc courses and three-year PhD research programmes in geotechnical engineering in the UK for over 40 years. These have produced, by my calculations, over 2500 postgraduates in geotechnical engineering, of whom at least one third must be currently employed in the UK construction industry.

So why does UK ground engineering have so many problems? Perhaps there are simply not enough ground engineers to go round–but, if so, what are we doing closing MSc courses?

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