2). Large-scale deformation behaviour on the excavated slope for short term slope stability is predicted.

Further, the installation depths of prizometers and differential settlement gauges were decided based on the results of analysis by the Finite Element Method and the critical slip circles indicating the minimum safety factors.

Table 5.3.1 shows the number of instrument s to be distributed for each slope and the total length of boring for the installation of instruments.

5-4 System components of Monitoring System

The automatic monitoring system at the project site is composed of the sensor section, the switch box section and the logger section. The data logger is settled and managed in the control room of Charoenraj Pumping Station at the project site. The monitored data are recorded in a floppy diskette (3.5 inches), and its analysis is conducted by the use of the computer (NEC AP-IV) at the IEC Project Office.

(semi-automatic monitoring system)

The data by manual reading are inputted from the keyboard into the (NEC A-IV) at the IEC Project.

(Manual monitoring system)

Each section of the semi-automatic monitoring system has the following functions:

(1). Sensors

Sensors have the function of detecting the physical values (pressure, displacement and deformation) and converting such values into electrical values.

(2). Switch Boxes

In the case that the number of sensors is less than a few hundred, one data recorder is usually employed for their monitorings, The switch box has the role of changing

the data signals obtained from each sensor into the data recorder in sequence. In general, a switch box is installed at a place relatively close to a sensor, and the data obtained from each sensor are sent through a signal cable into the data logger.

(3). Data Logger (TDS 301)

The Data Logger has the following functions:

a). To control the on-off of the switch box in accordance with the monitoring interval set up in advance.

b). To change the analog signals sent form a sensor into the digital data (A/D Conversion)

c). To print the data out on real time

d). To record the data onto a floppy diskette

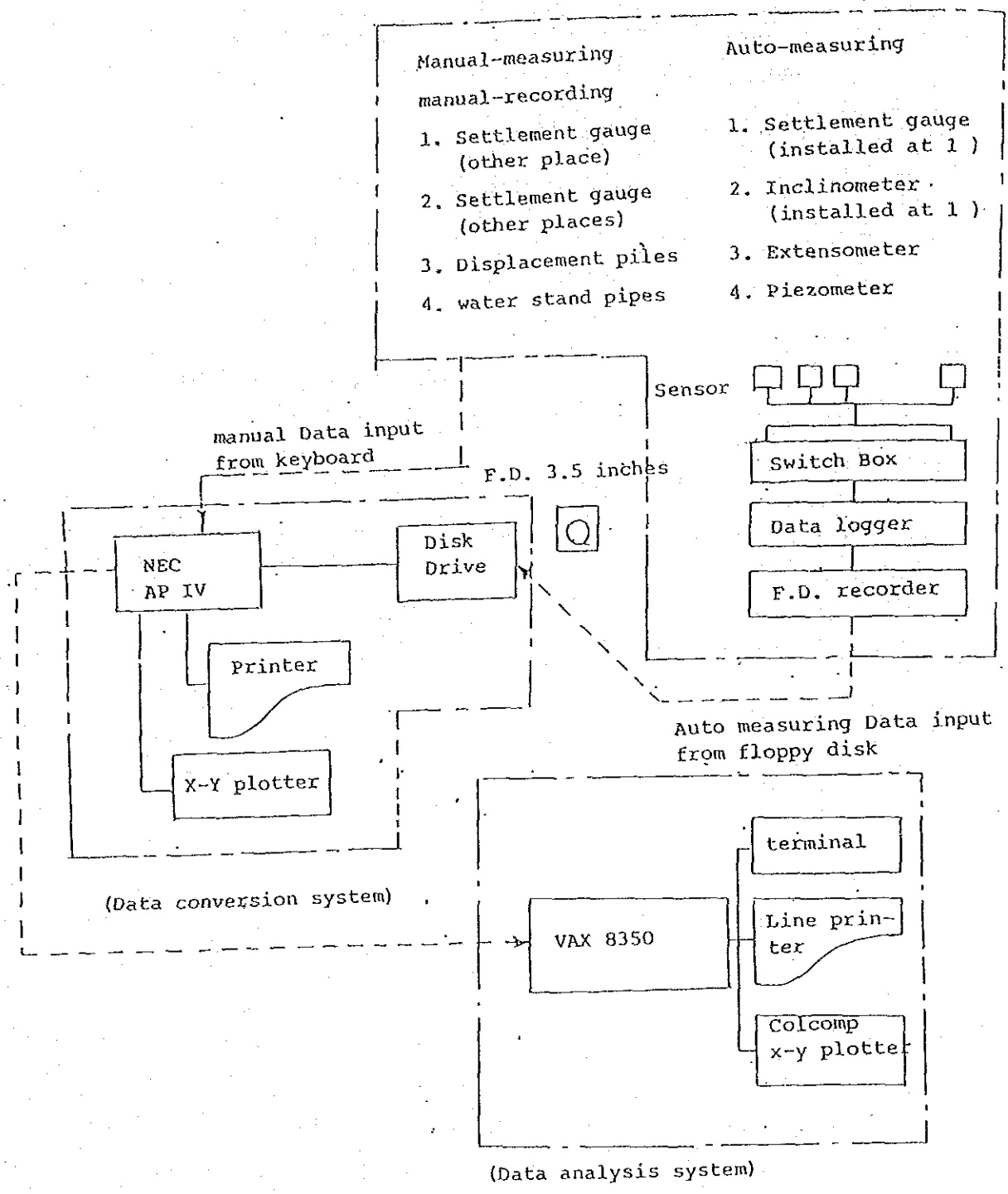


Fig.5.4.1 System Component of Monitoring System at Project Site

5-5 Software Components of Data Analysis

The data analysis program has functions to make time history process and the behaviour of excatation sections such as displacement, stresses, pore pressures occurring in the testing facility. The monitoring data processed by the data conversion system mentioned above (NEC AP TV) shall be compared with results obtained from the Elasto-Visco plasticity program used in the detailed design stage for this project. Table 5.5.1 presents the function of Data Analysis Software.

table 5.5.1 Function of Data Analysis Software

Functions	Items
Time History of Monitored Data	1. Horizontal displacement 2. Vertical displacement 3. Pore pressure 4. Ground water level 5. Stresses (total and effective stresses).
Monitoring Program	1. Display of Analysis Model Section 2. Distribution of Displacement (Analysis Data and Monitoring Data) 3. Distribution of total Stress and Effective Stress (Analysis Data and Monitoring Data)

5-6 Installation Method of Monitoring Instruments

1). Inclinometers

As shown in Fig. 5.6.1, install a flexible pipe into a boring hole first, and second, fix the pipe and the boring hole with bentonite cement. Finally, monitor the displacements automatically through the inclinometers which have been settled in the pipes on a multi-stage basis.

2). Differential Settlement Gauges

As shown in Fig. 5.6.2, fix magnet rings with steel rings between a boring hole and a casing, and then measure the points where magnet rings were fixed by inserting a sensor from the groundsurface.

3). Extensometers

Extensometer must be installed on the surface of slope. Furthermore, it is desired that effective monitoring should be carried out even in the excavation stage as shown in Fig. 5.6.3.

Therefore, extensometer should be installed with adequate adjustment on each excavation depth basis.

4). Piezometers

Monitoring by piezometers should be carried out according to the procedures shown in Fig. 5.6.4. Attention to be paid to the installation of piezometers are pointed out as follows:

a. The initial value should be measured on the ground before the insertion of the piezometer.

b. Boring holes should washed out with clean water before the insertion of the piezometer.

c. Sensors should be assembled in the water so that the air does not enter into their interiors.

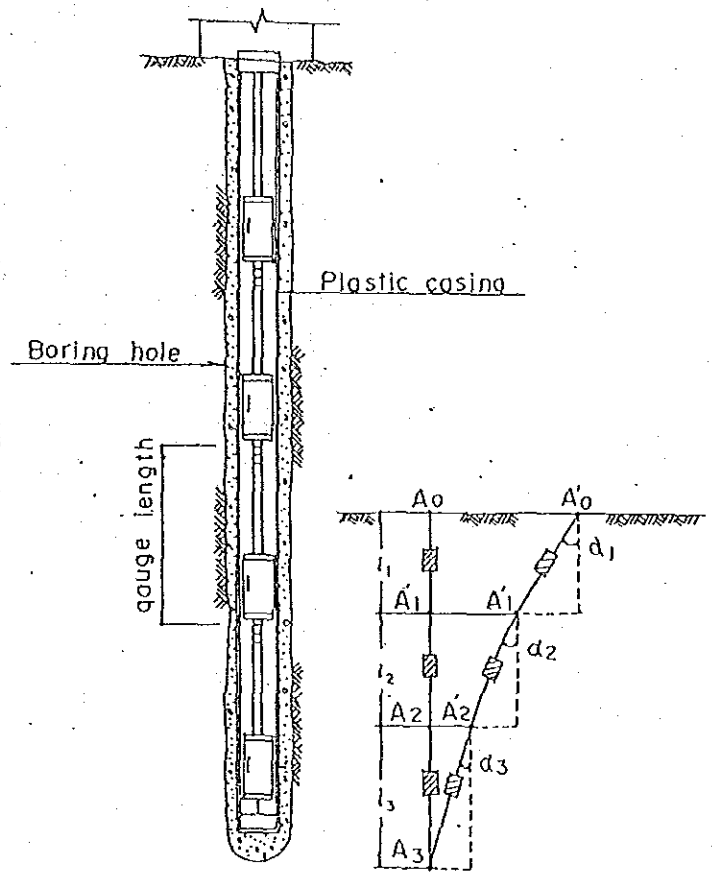
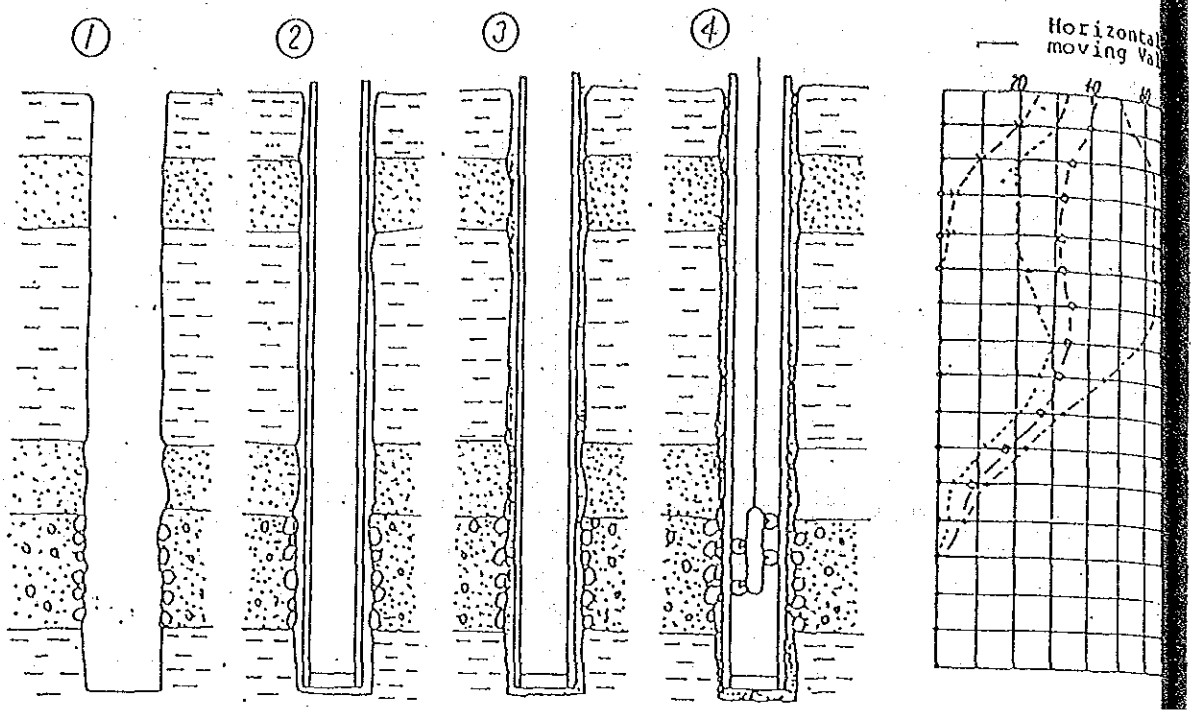


Fig.5.6.1(A) Installation of Inclinometers (Auto-measuring)



① Drill up to estimate depth by 86mm in dia.
② Install the inclinometer casing up to end of hole.
③ Grout with cement, bentonite mortar.
④ Read initial value after 5-7 days from installation work.

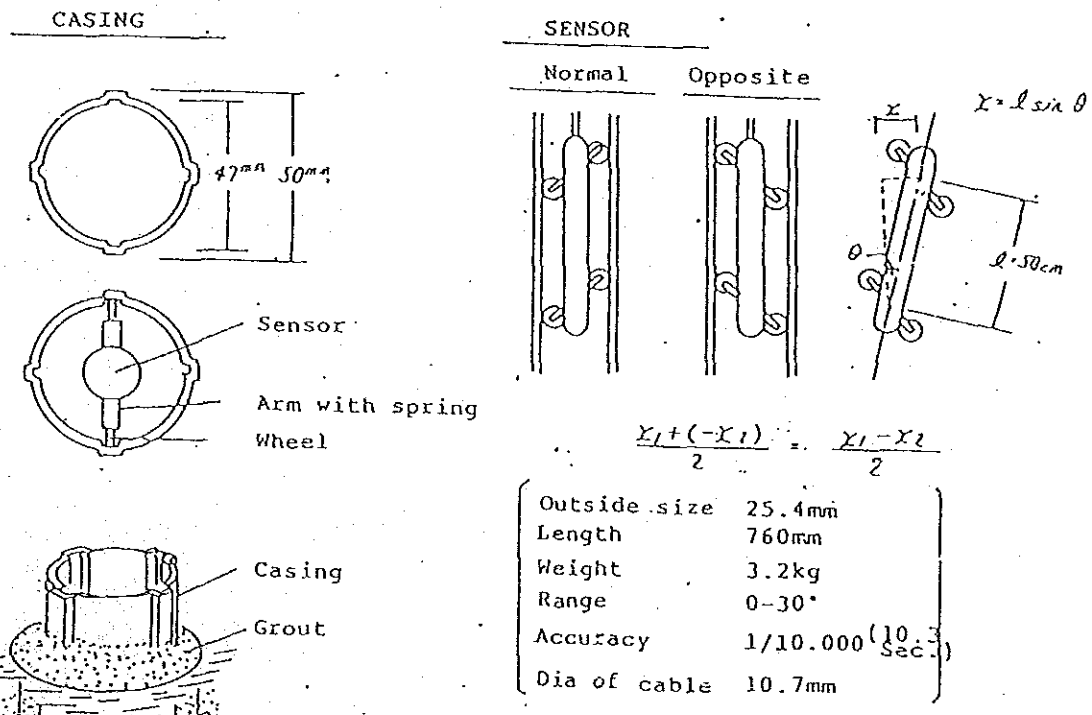


Fig.5.6.1(B) Installation of Inclinometers (Manual-reading)

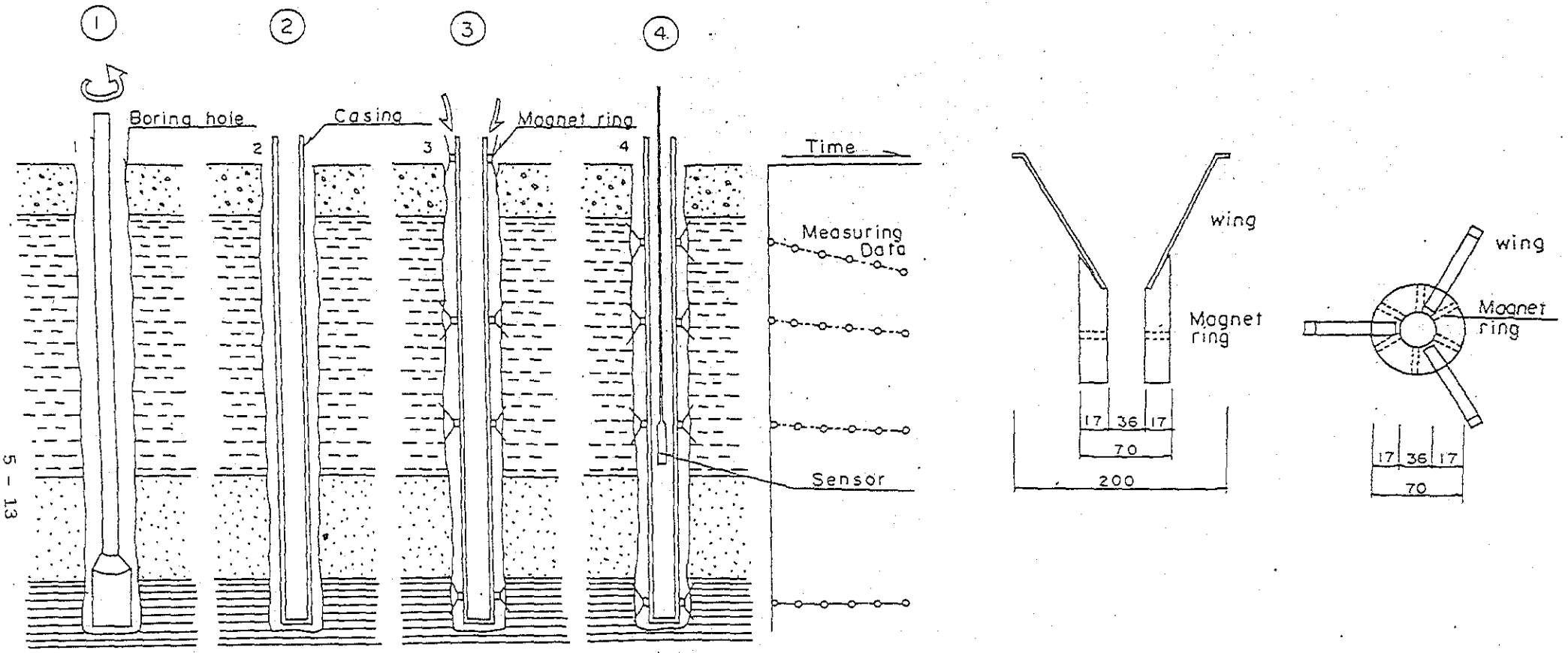


Fig.5.6.2 Installation of Differential Settlement Gauges

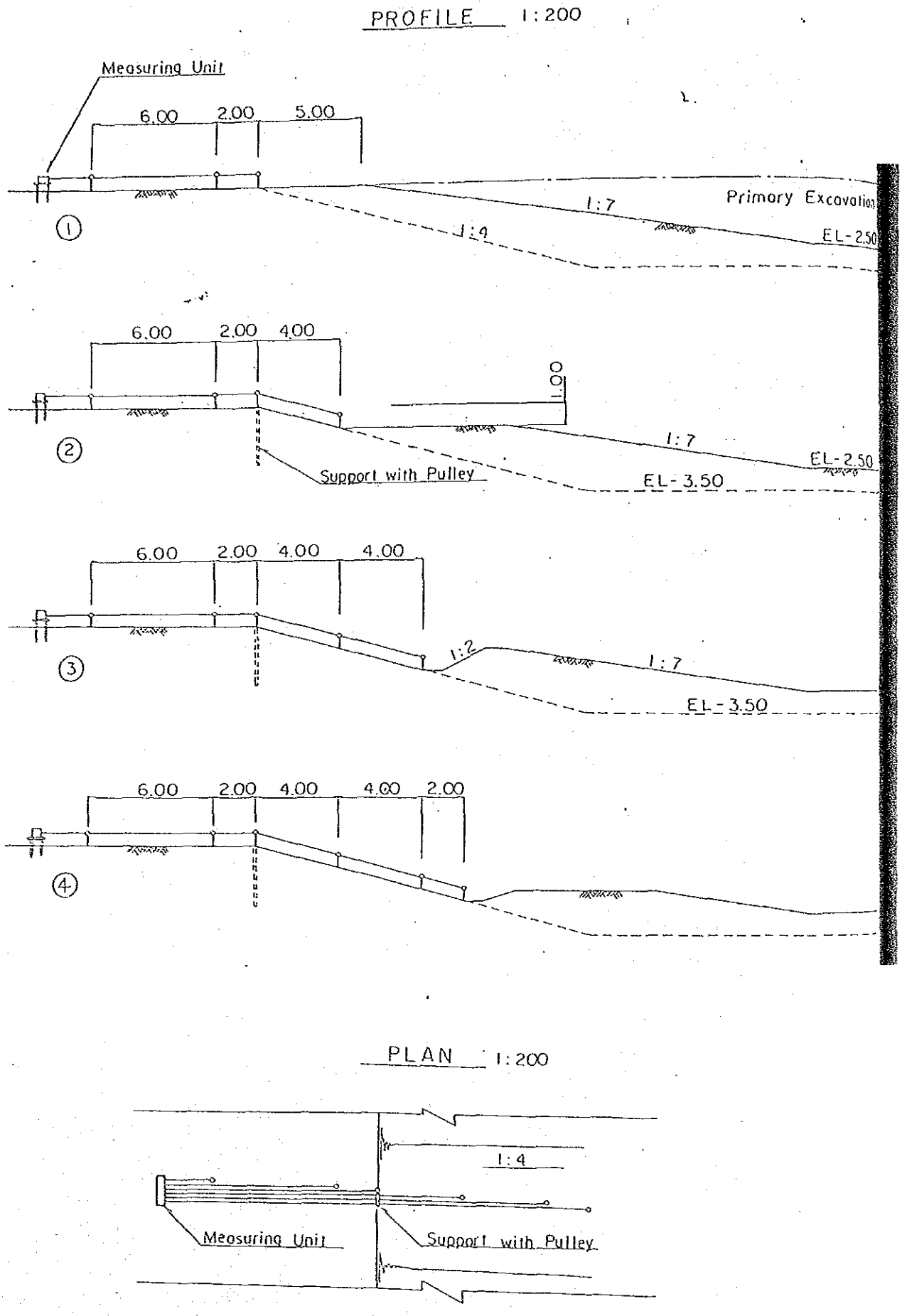


Fig.5.6.3 Installation of Extensometers

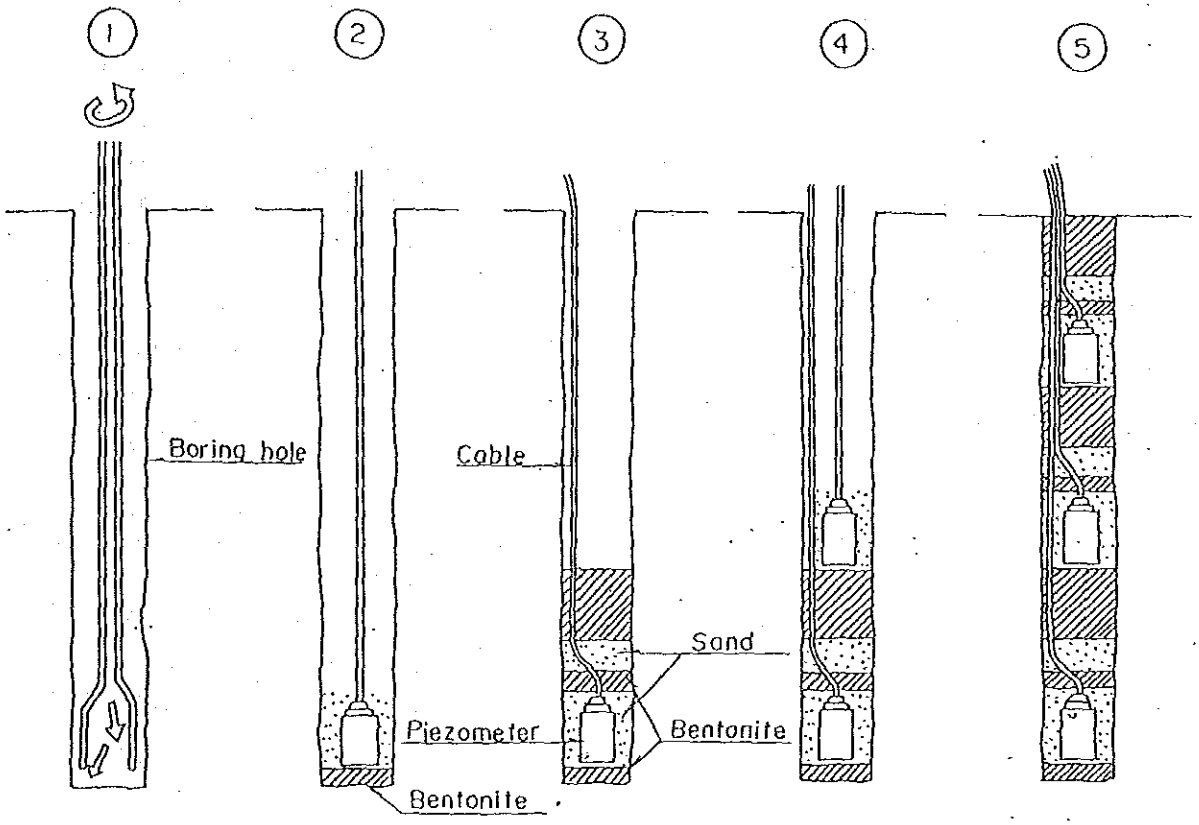


Fig.5.6.4 Installation of Piezometers

d. Measurements should be carried out during installation of sensors to check the water head.

5-7 Monitoring Method and Monitoring Schedule

1). Automatic Monitoring Instruments

a. Selection of the lead cable and its Installation
The lead cable used for site monitoring should be very durable and insulated, and should have the function of lightning-arrester because the effect of lightning is to be considered. The wiring route of the lead cable should be planned taking the construction plan for the main construction work into consideration. And adequate protection should be employed after the wiring work so that the cable can be protected from any damage during the construction work.

b. Installation Time of Instruments and Commencement of Monitoring
Instruments should be immediately installed after the completion of the foundation improvement work, and then the preliminary observation and monitoring should be promptly commenced.
If the instrument is installed under the foundation and the clay soil of that part is disturbed, and it takes a long time to return to the original non-disturbed condition, then, taking the above situation into account, the main monitoring should be commenced based on the preliminary monitoring results.
Piezometers should be installed before the commencement of the foundation improvement works because the behaviour of pore water pressure due to foundation improvement works are required for further analysis in the future.

As a rule, piezometers should be installed in the non-treatment foundation because if the piezometers are installed in the foundation to be improved, they will be damaged by the action of the lateral flow of the foundation caused by the foundation improvement works. However, taking the necessity of data on pore water pressure during foundation improvement works into account, one piezometere should be installed in the center of the foundation to be improved by sand compaction piles in order to obtain the data as much as possible. Table 5.7.1 presents the installation time of each monitoring instrument.

c. Frequency in Monitoring

Table 5.7.2 shows the frequency in the monitoring to be carried out by the use of automatic monitoring instruments. However, the schedule should be adequately revised, if required, according to the actual conditions of the construction progress and the behaviour of the foundation.

2) Manual Monitoring Instruments

a. Instruments Requiring Direct Measuring

In the monitoring system, three instrument,s that is, differential settlement gauges, displacement piles and water stand pipes, are applied for manual measuring.

As for monitoring of the displacement piles, the displacement of the piles should be measured from fixed points settled in appropriate places by the use of theodolite, levels and steel tapes.

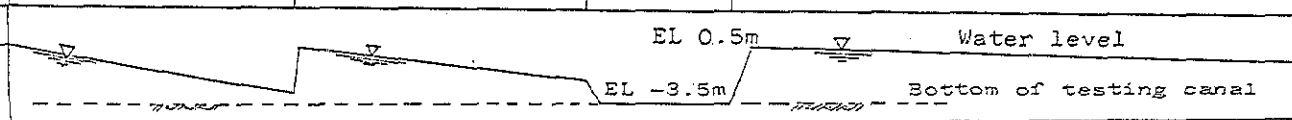
b. Frequency in Monitoring

Table 5.7.2 shows the frequency in monitoring to be carried out by the use of manual monitoring instruments. However, the schedule should be adequately revised, if required, according to the actual conditions of the construction progress and the behaviour of the foundation.

Table 5.7.1 Installation Time of Monitoring Instruments

Slope No.	Slope condition	Type of Instrument	No. of location	Installation Time: 1st month (Temporary work, 30days)	2nd month (Foundation improvement work, 60 days)	3rd month (Foundation improvement work, 60 days)	4th month (Excavation work, Primary stage, 120 days)	5th month (Excavation work, Primary stage, 120 days)	6th month (Excavation work, Secondary stage, 120 days)	7th month (Excavation work, Secondary stage, 120 days)	Remarks
1	Non-treatment Slope for short term slope stability 1:4	Inclinometer	3				○				
		Extensometer	1						○		
		Piezometer (1)	1		○						
		" " (2)	1				○				
		Setllement guage	3				○				
		Displacement piles	31						○	○	
		Water stand pipes	1		○						
2	Non-treatment Slope for long term slope stability 1:6	Inclinometer	1				○				
		Piezometer	2				○				
		Settlement guage	1				○				
		Displacement piles	23						○	○	
		Water stand piles	1		○						
3	Improved slope by soil cement columns	Inclinometer	1				○				
		Settlement guage	1				○				
		Displacement piles	23						○	○	
4	Improvement slope by sand Compaction piles	Inclinometer	2				○				
		Piezometer (1)	1		○						
		" " (2)	1				○				
		Settlement guage	2				○				
		Displacement piles	27						○	○	

Table 5.7.2 Measurement Times of Instrument

		Improve. Work	Primary excavation		Secondary excavation		After excavation work			
		30 days	23 days	23 days	30 days	30 days	20 days	20 days		
Auto reading	Auto-piezometer (Pore pressure guage)			1 time/4 hrs					1 time/day	
	Extensometer					3 times/day			1 time/day	
Manual & auto reading	Auto-inclinometer				1 time/4 hrs				1 time/day	
	Inclinometer (manual read.)				3 times/day				3 times/week	
	Settlement gauge (auto)				1 time/4 hrs				1 time/day	
	Settlement gauge (manual)				3 times/day				3 times/week	
Manual reading	Displacement piles (Topographic survey)					3 times/ day			1 time/week	
	Open-piezometer (Water stand pipe)				3 times/day				3 times/week	
Water level in canal	Work condition for construction		Dry excavation		Wet excavation		Watering	Dewatering		
	Variation of water level in testing canal									

5 - 8 Specifications and Installation Section of Instruments

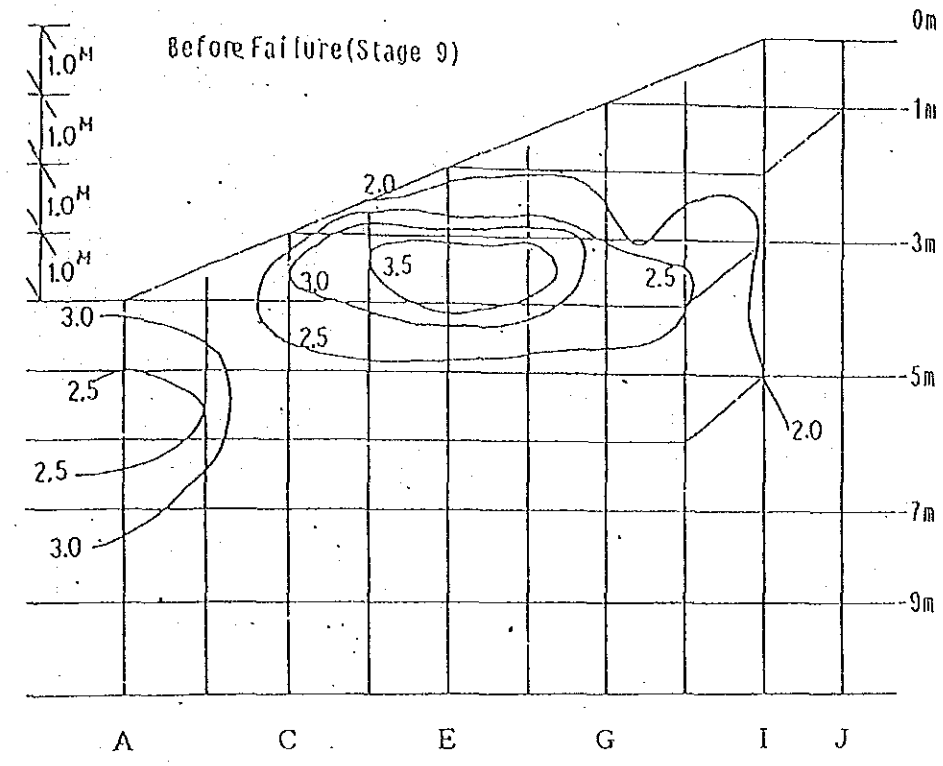
The specification of monitoring instruments are presented in Table 5.8.1.

The installation section and plan is determined from the results of F.E.M analysis as shown in Figs 5.8.1 to 5.8.3 on the basis of the construction plan for the testing facility.

The installation plan for monitoring instruments is presented in Figs 5.8.4 to 5.8.7.

Table 5.8.1 Specifications of Monitoring Instruments

Equipment Name		Item	Specification
Inclinometer	Casing	Material	Alluminium with plastic coating
		Diameter	Inner 47mm Outer 50mm
		Length	3.0m
		Installation	Install into borehole and grouting outside
		Joint	Fix by rivet and cover by sealing tape
	Probe	Range of Meas.	± 30°
		Linearity	0.05%
		Resolution	Less than 10 sec
		Dimension	Dia 30mm Length of wheel 500mm
	Recorder	Display	Depth and displacement
		Recording	5¼ inch floppy disk
		Print	Paper with 58mm wideness
		Auto Calculation	Displacement, summary displacement
	Measuring		Manual measuring using recorder
Settlement Gauge	Magnet Ring	Material	P.V.C. with magnet rod
		Dimension	Inner 40mm Outer 70mm Length 100mm
		Arm	3 Numbers, each 20cm length
	Indicator	Probe	22mm diameter and 150mm length
		Cable	with measure tape
		Accuracy	± 2mm
		Indicator	buzzer
	Measuring		Manual measuring
Piezometer	Piezometer	Material	Stainless steel with filter ring
		Range	Approx. 2 times of static water pressure
		Linearity	1% FS.
		Temperature	0 - 60°C
		Mechanism	Strain gauge
Extensometer	Sensor	Material	Steel
		Range	2000mm in displacement
		Linearity	0.5% FS
		Sensitivity	2.5×10^{-6}/mm
		Temperature	0 - 40°C
		Mechanism	Strain gauge
Recorder	Data Logger	Numbers of Channels	500
		Measuring Speed	0.08 sec/channel with 1 sec - 60min
		Power Source	AC 220V
	Disk Recorder	Disket	3.5 inch
		Interface	GP - IB
	Switch Box	Number of Channels	More than 50



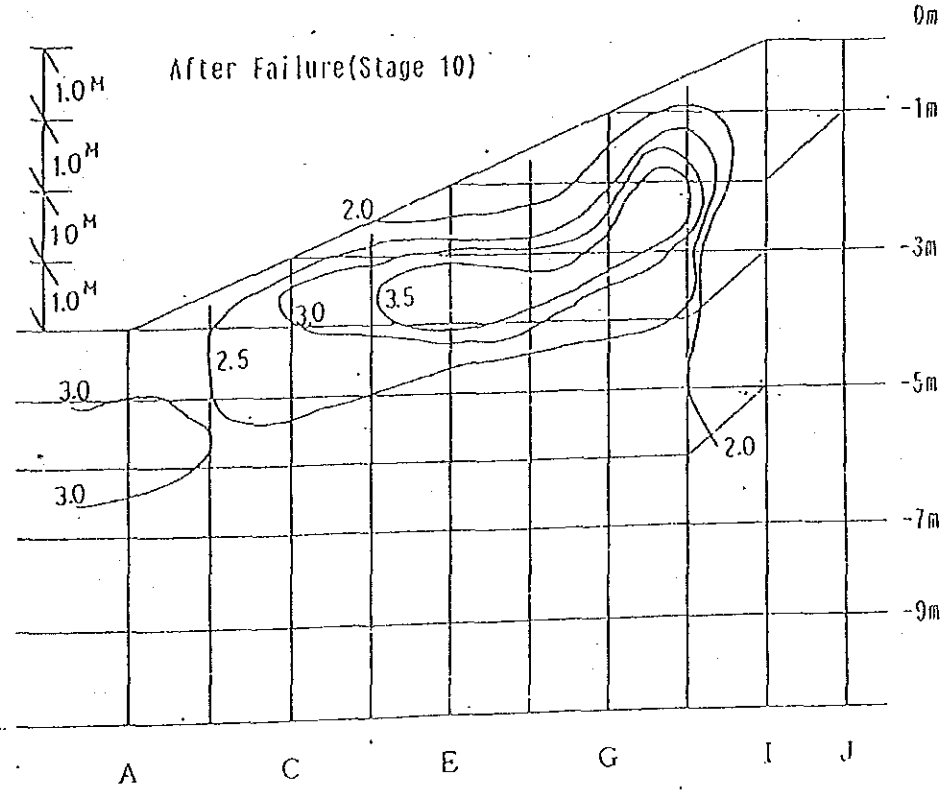


Fig.5.8.1 Results of Analysis for Pore Pressure

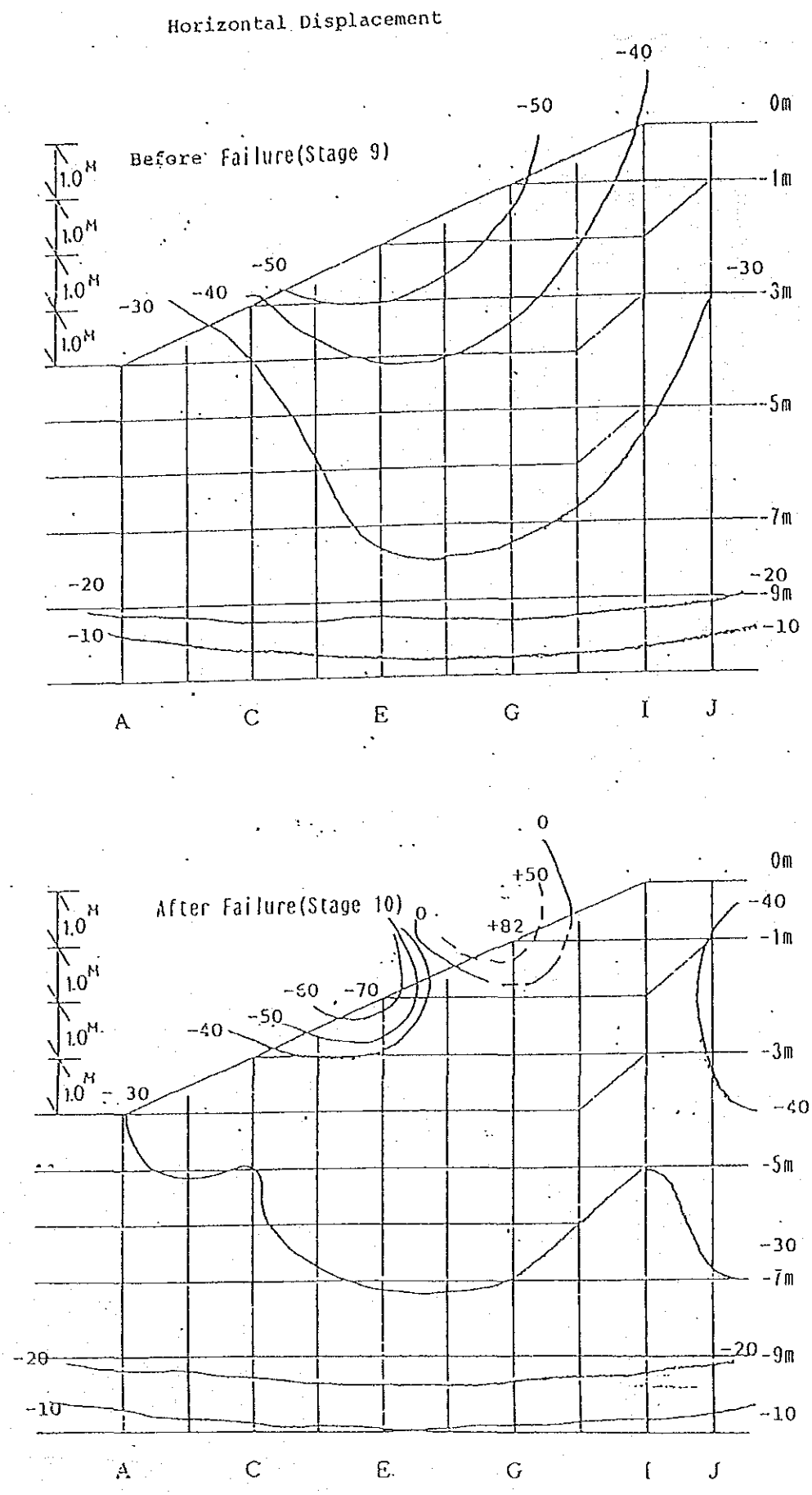


Fig.5.8.3 Results of Analysis for Vertical Displacement

Vertical Displacement

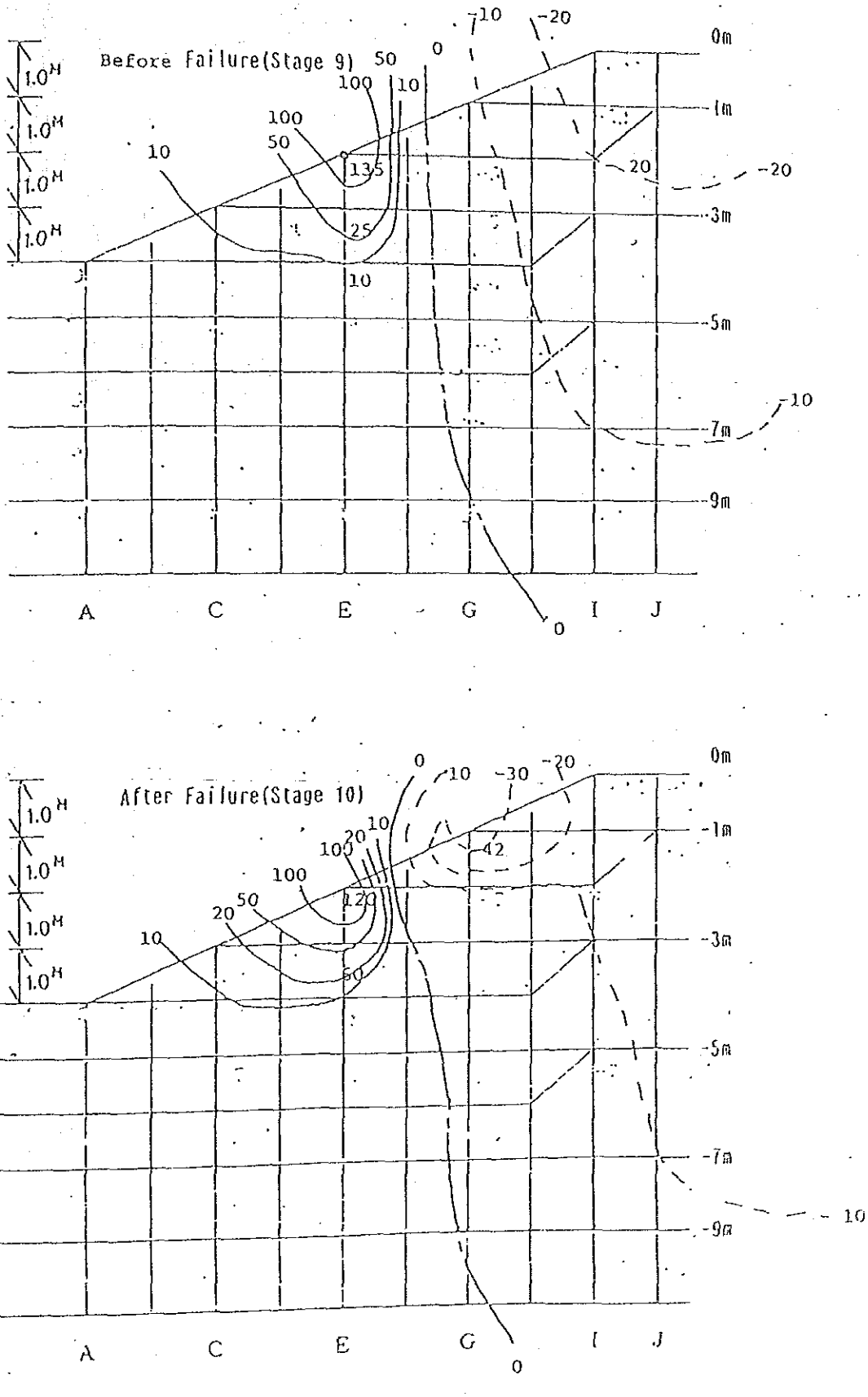


Fig.5.8.2 Results of Analysis for Horizontal Displacement

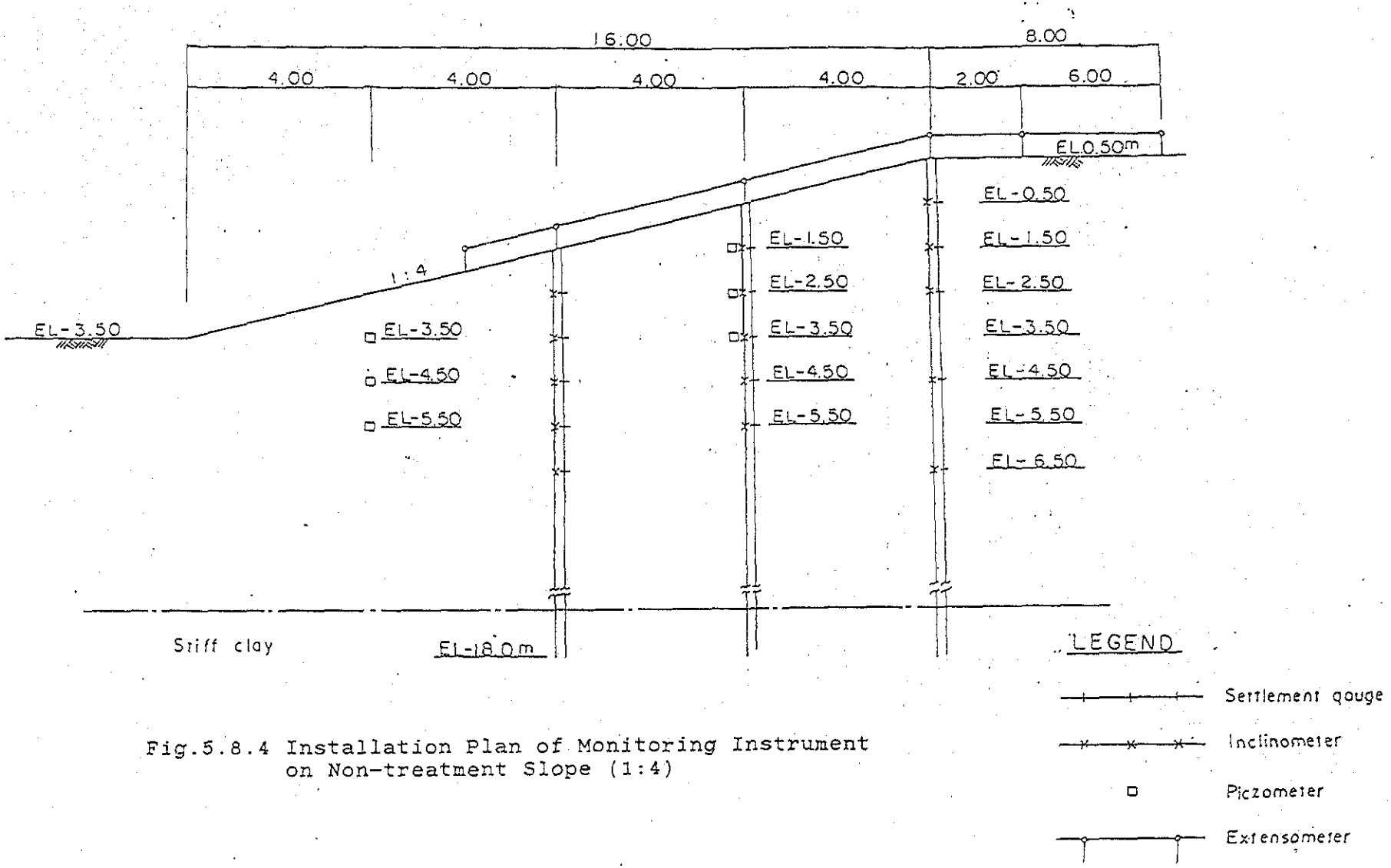


Fig.5.8.4 Installation Plan of Monitoring Instrument on Non-treatment Slope (1:4)

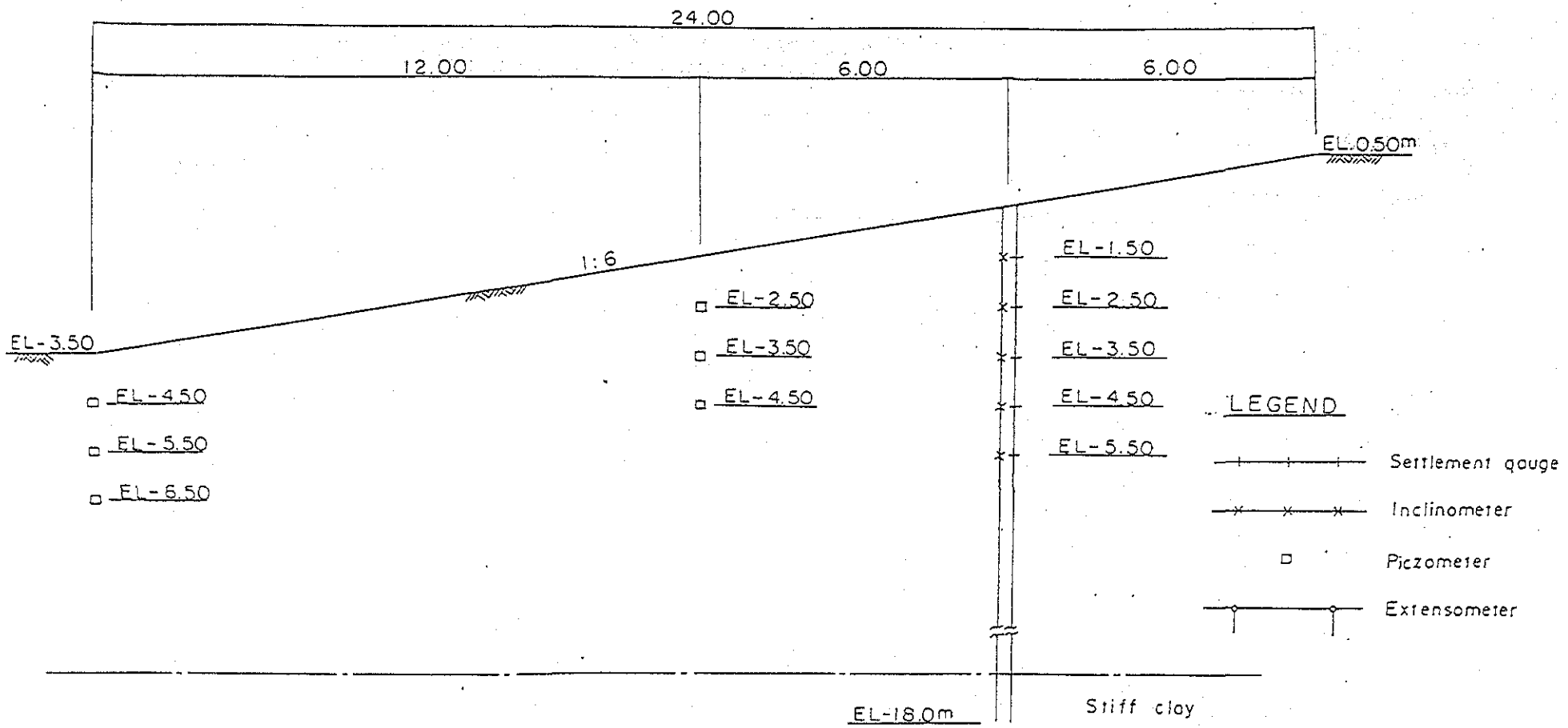


Fig.5.8.5 Installation Plan of Monitoring Instrument on Non-treatment Slope (1:6)

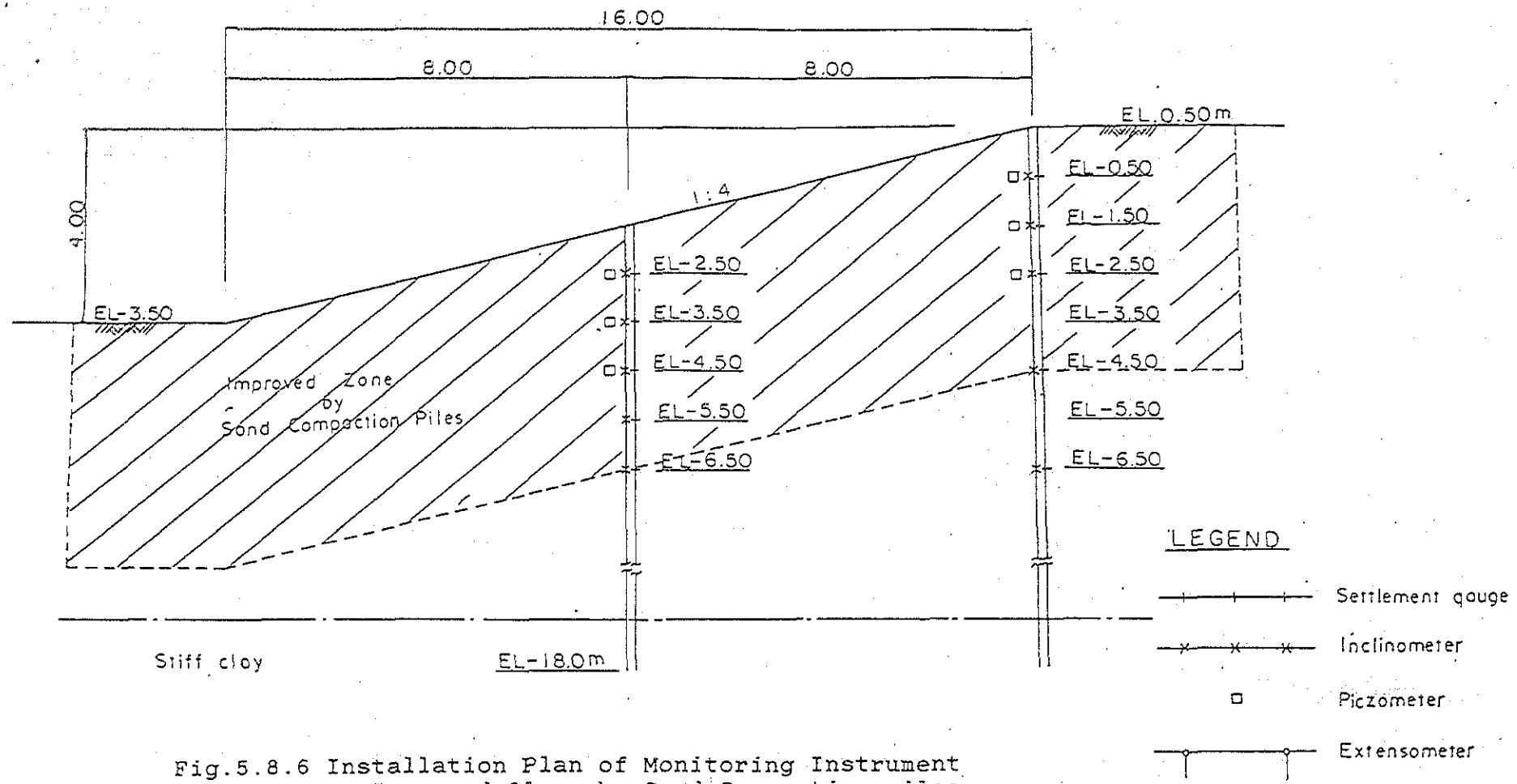


Fig.5.8.6 Installation Plan of Monitoring Instrument on Improved Slope by Sand Compaction piles

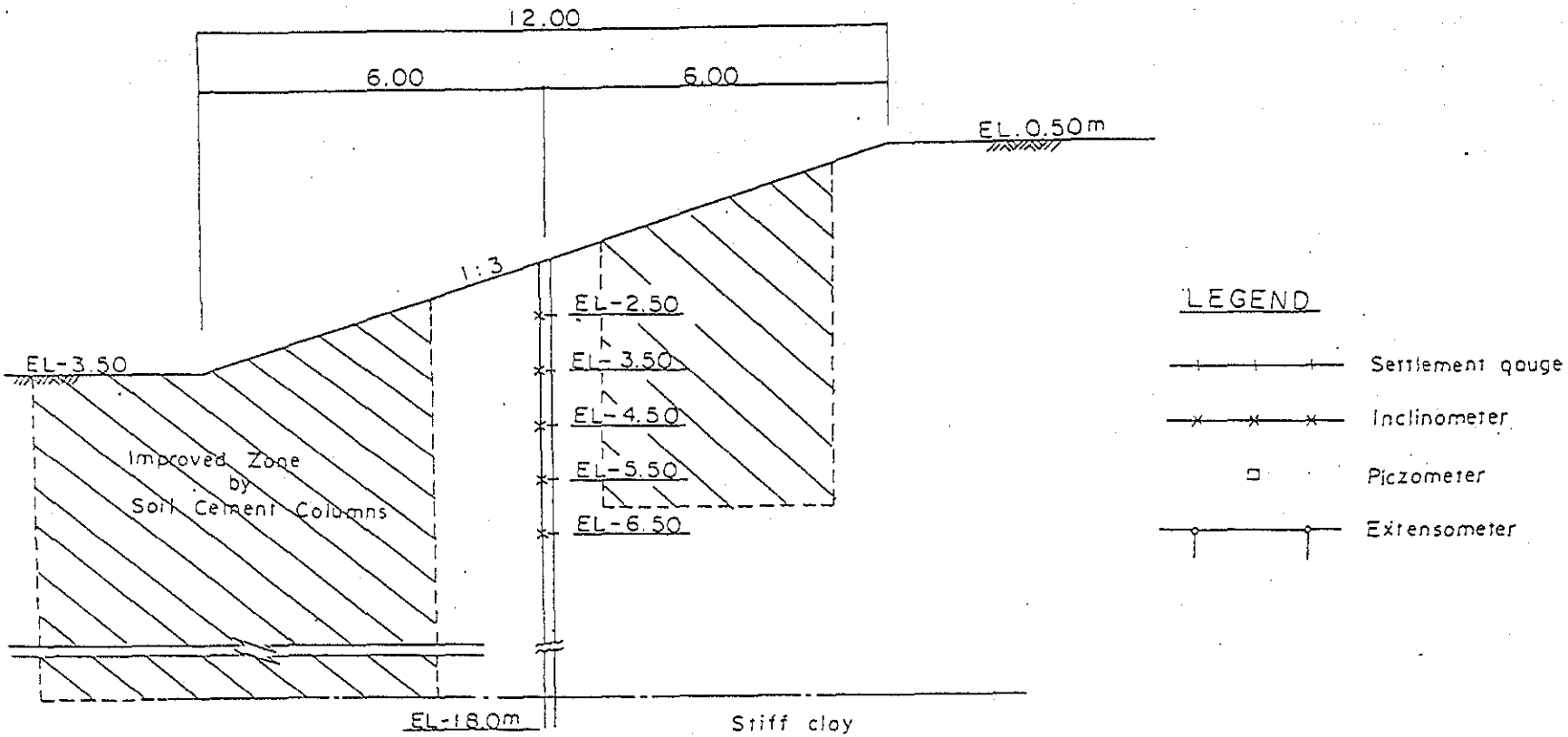


Fig.5.8.7 Installation Plan of Monitoring Instrument on Improved Slope by Soil Cement Columns

CHAPTER 6 CONSTRUCTION PLAN

6-1 Conditions on Construction and Order of Construction Process

The work is to construct testing canal facility, therefore,there are various conditions which restrict procedures of the construction. In order to establish a construction plan, following conditions shall be taken into consideration.

i) The work being carried out on the soft soil foundation,any influence to be caused by the operation of construction equipment shall be avoided as far as possible.

ii) Especially when excavating,no load shall be given on top of slopes.

iii) The monitoring instruments and those cables for observation of behavior caused in the foundation during excavation shall not be damaged during the construction.

iv) Excavation work shall be commenced after the completion of foundation improvement works.

v) As a nature of model infrastructure project,the construction period and the construction cost are limited.

An overall flowchart of construction process is shown in Fig. 6.1.1

6-2 Construction of Coffer Dam and Dewatering Work

1) Coffer Dam

The shrimp farms facing with the south and the east ends of the project site for the testing canal facility are operated by the use of the range of tide. The part of the shrimp farms facing with the site is

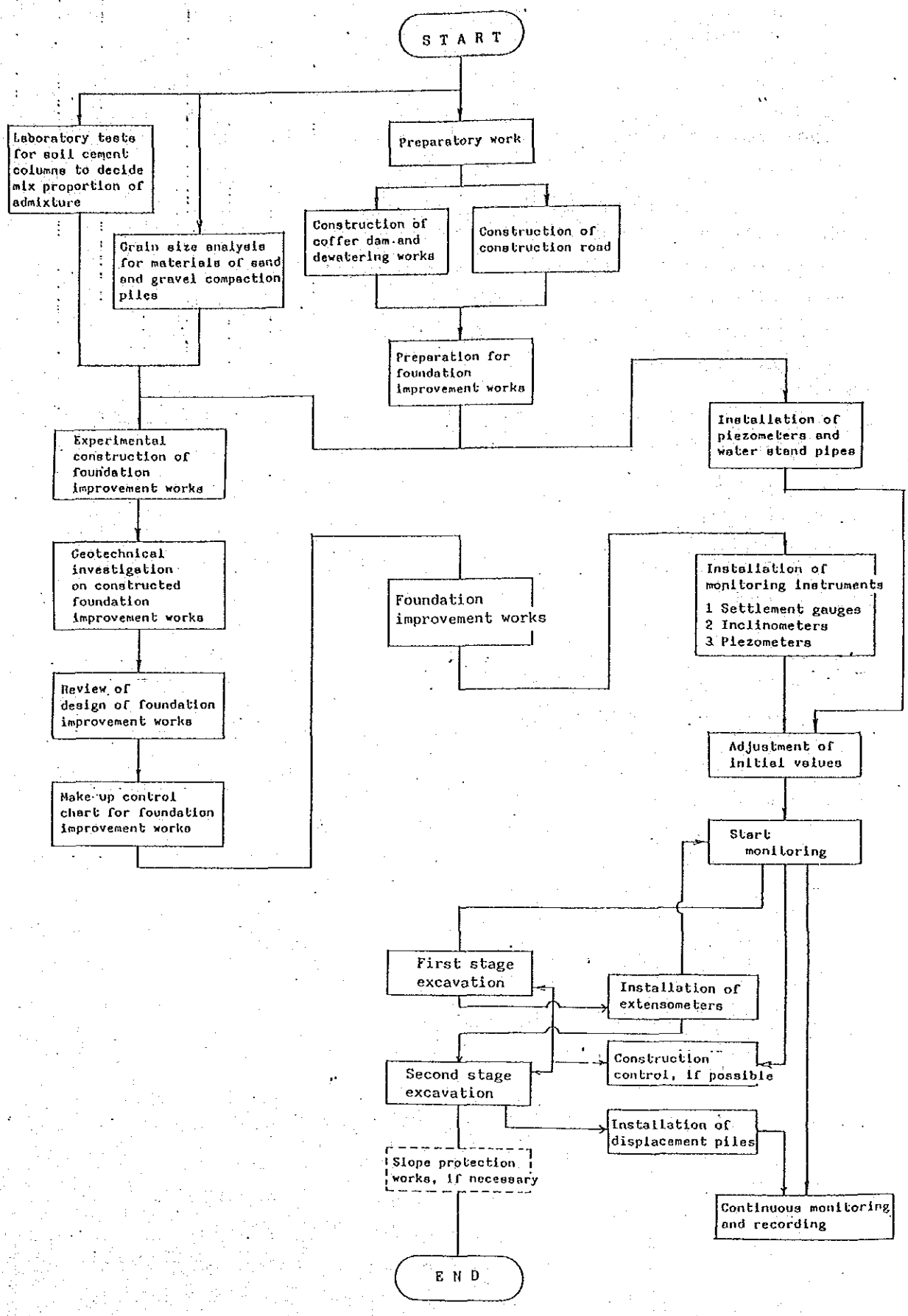


Fig.6.1.1 Flowchart of Overall Construction Procedure

surounded by small dikes with a elevation of EL.1.60 ~ EL.1.70m.

There is a low part at the sea side of the site, and sea water staying in the site comes from this part. An coffer dam therefore, shall be constructed at the said low part in order to protect the site from any influence of sea water.

The coffer dam shall be constructed following the standard cross section shown below.

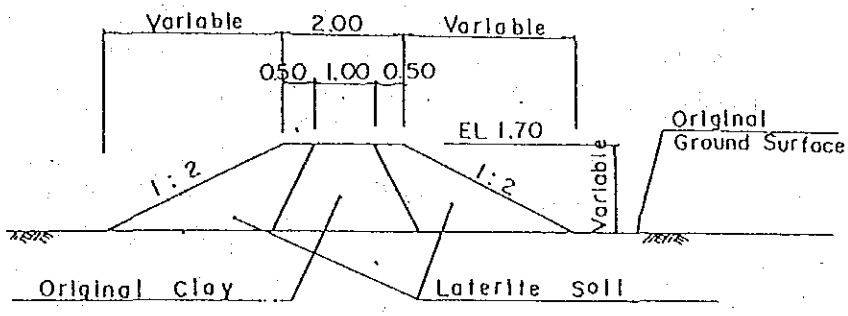


Fig.6.2.1 Standard Cross Section of Coffer Dam

Spreading soil by bulldozers and compacting by manpower shall be applied for the construction of coffer dam.

- Quantity of work : 95m³
  - Laterite : 61m³
  - Clay : 34m³

- Working capacity of a bulldozer (11ton class)

$$Q = \frac{60 \times q \times f \times E}{Cm} \qquad \cdots\cdots\cdots (6.1)$$

where,

Q : working capacity of a bulldozer in an hour's operation

q : Quantity of soil spread and excavated in one cycle (m³)

f : Bulk factor of soil

E : Efficiency of work

Cm : Time (min) required for one cycle obtanied from the following equation.

$$Cm = 0.034 \times L + 0.25$$

L : Carriage distance of soil (m)

$Cm = 0.034 \times 50 + 0.25 = 1.95$min.

therefore,

$$Q = \frac{60 \times 1.34 \times 1.0 \times 0.40}{Cm} = 16.5 m^3/hr$$

- Working capacity of compaction by manpower :
  Wooden tamper by manpower shall be applied to compaction work

$$q = \frac{10.0 m^3/day}{1.9 \text{ person}} = 5.2 m^3/day/person$$

- Requireddays for the work
  Ten (10) laborers ane disposed for the work.

$$95.0 m^3 \div (5.2^{m^3/day/person} \times 10^{person}) = 1.8 = 2days$$

2) Dewatering work
In case the water level in the site at EL.1.0m, total volume of water in the site is about $3,600 m^3$.
Two(2) 4 inches' pumps can drain it in

$$3,600 m^3 \div (0.33 m^3/min \times 60^{min} \times 24^{hrs} \times 2^{pumps}) = 3.7 \fallingdotseq 4days$$

The volume of water in the disposal area for soil is estimated at around $2,000 m^3$
$2,000 m^3$ of water can be drained by ,one (1) 4 inches' pump in

$$2,000 \div (0.33 \times 60 \times 24) = 4.2 \fallingdotseq 5days.$$

Drainage of water in the testing canal facility during the construction shall be done with one(1) 4 inches' pump, and drainage of water in the low part of the site shall be done with a 2 inches' pump from a shallow sump after making a small ditch to collect water to the sump from time to time.

6-3 Access Road and Temporary Work for Foundation Improvement

1) Plan of Access Road

In order for heavy machinery to work inside the soft soil foundation site, the machinery must operate from on the access road.

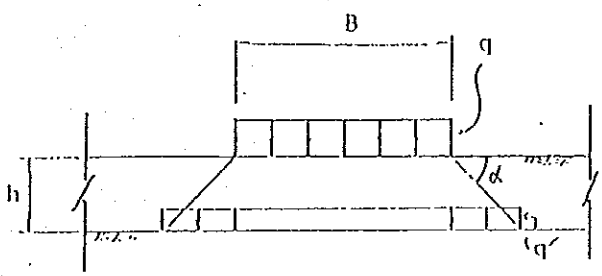
The plan of access road is presented in Fig.6.3.1.

2) Cross Section Access Roads

Thickness of embankment for access road shall be planned so that the stress in the foundation casued by operation of construction equipments may not exceed the undrained shear strength of the surface soil on the original foundation.

Supposing that loads on the access roads are distuibuted onto the original foundation, the stress in the original foundation can be expressed by the following equation according to Kögler's formula.

$$q' = \frac{q \cdot B}{B + 2 \times h \times \cot \alpha} \qquad \cdots\cdots\cdots (6.2)$$

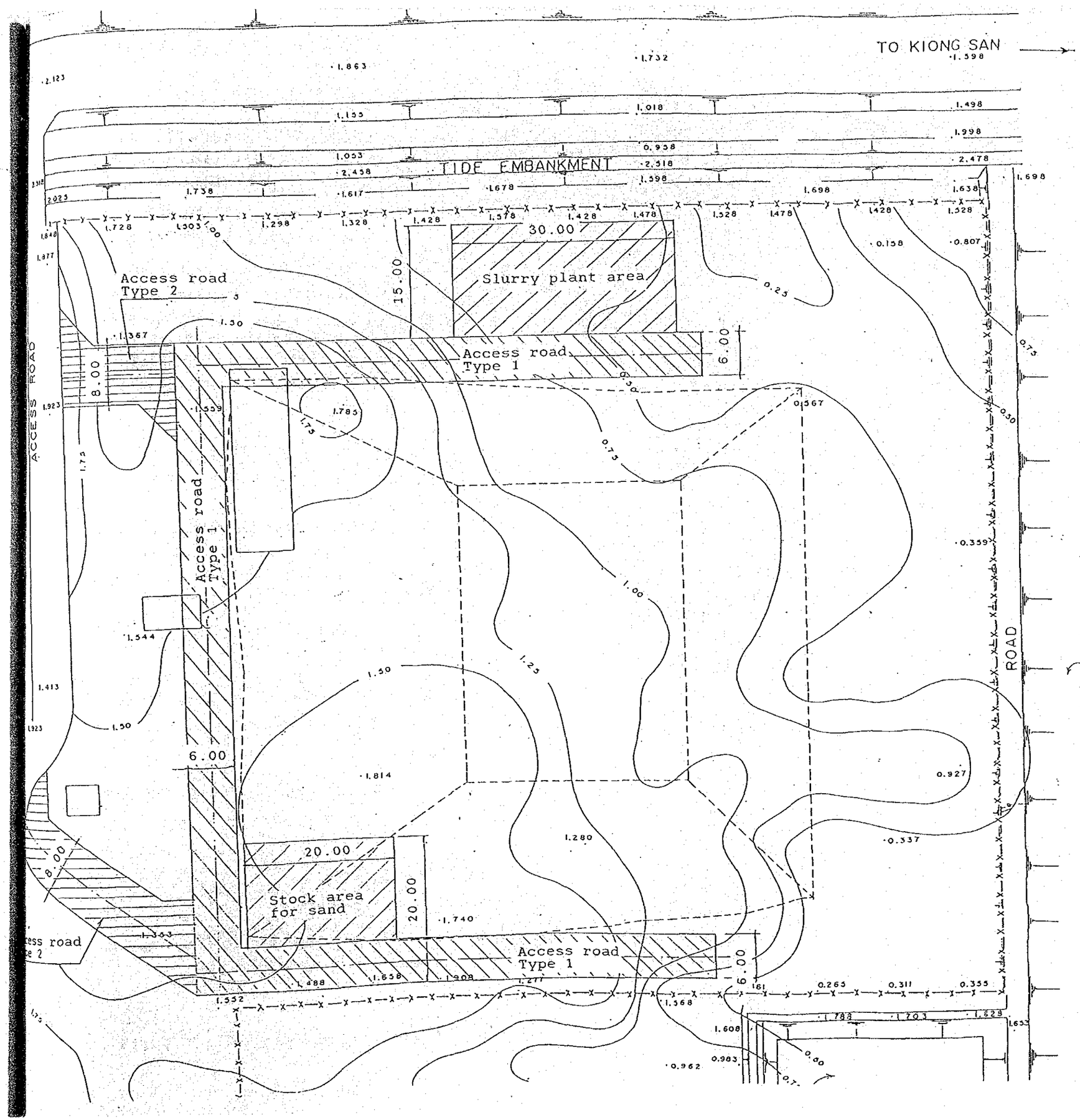


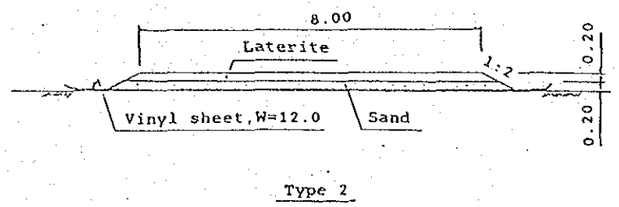
Let $\alpha = 45°$: then

$$q' = \frac{q \cdot B}{B + 2h} \qquad \cdots\cdots\cdots (6.3)$$

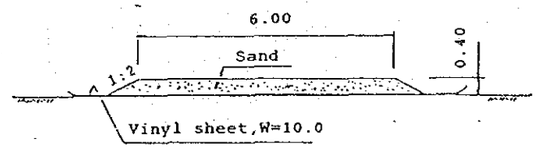
where,

- q' : Shear strength of surface soil on the original foundation (t/m^3)
- q : Load acting on the construction road (t/m^2)
- B : width of load acting (m)
- h : Thickness of embankment (m)





Type 2



Type 1

Typical Section of Access Road

Fig.6.3.1 Plan of Temporary Work

It is said that there is a relationship between cone bearing capacity(qc) and shear strength(Cu) as shown in the following approximate expression.

$$Cu = qc/10$$

Let $qc = 4.0 kg/cm^2$: then

$$Cu = 4.0/10 = 0.4 kg/cm^2 \quad 4.0 t/m^2$$

Contact pressure of 11tons' track is said to be $12 t/m^2$.

Required thickness of embankment, therefore, will be obtained as follows when $Cu = q'$.

From the equation (6.3) :

$$h = \frac{1}{2} \times \left(\frac{qB}{q'} - B \right) \quad \cdots\cdots (6.4)$$

$$\therefore \quad h = \frac{1}{2} \times \left(\frac{12.0 \times 0.5}{4.0} - 0.5 \right) = 0.50 m$$

The design cross section of the access road, therefore, will be as follows, taking into account the laying of vinyl sheet at the base of the access road.

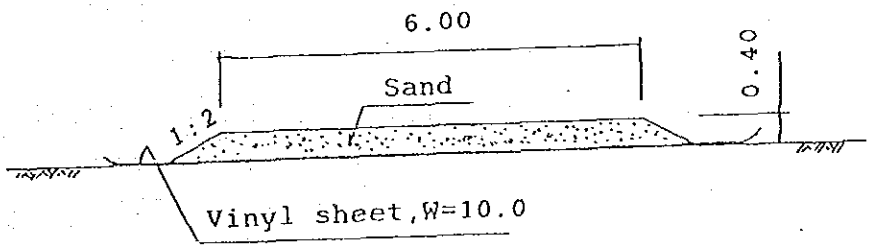


Fig.6.3.2(A) Typical Section of Access Road(Type 1)

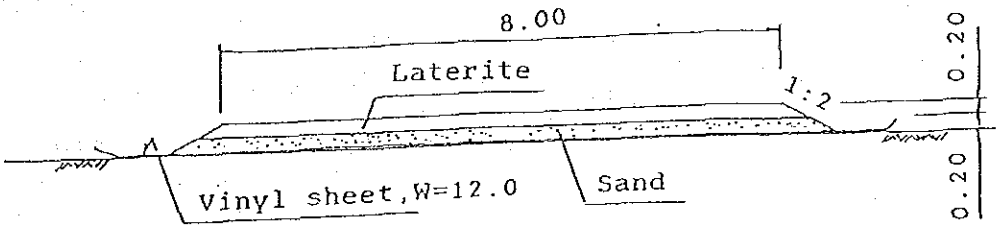


Fig.6.3.2(B) Typical Section of Access Road(Type 2)

3) Quantity of Work for Access Road

i) Road length

In the project site	:	230m
Disposal area of soil	:	40m
Total		270m

ii) Quantity of earth work

Lateritic soil	:	160m³
Sand	:	815m³
Total		975m³

iii) Required days for construction

Spreading and compacting soil is done by super swamp bulldozer

Spreading and compacting capacity of a bulldozer is obtained from the following equation

$$Q = \frac{Q_1 \times Q_2}{Q_1 + Q_2}$$

Where, Q : Spreading and compacying capacity of a bulldazer per an hour

Q_1 : Spreading capacity of a bulldozer per an hour

$Q_1 = 10\ E_1 \times (11D + 8)$

Where, E_1 : Efficiency of work (= 0.65)

D : Thickness of soil spreaded (= 0.20m)

$\therefore Q_1 = 10 \times 0.65 \times (11 \times 0.3 + 8) = 66.3 m^3/hr$

Q_2 : Compacting capacity of a bulldozer per an hour

$$Q_2 = \frac{V \times W \times D \times E_2}{N}$$

Where, V : Compacting speed (= 3,500 m/hr)

W : Effective comacting width (= 0.7 m)

D : Thickness of soil compacted (= 0.20m)

E_2 : Efficiency of work (= 0.75)

N : Time of compaction (= 4times)

$\therefore Q_2 = 3,500 \times 0.7 \times 0.3 \times 0.75/4 = 91.9 m^3/hr$

Accordingly , $Q = \frac{73.5 \times 137.8}{73.5+137.8} = 38.5 m^3/hr$

Daily working capacity of a bulldozer for spreading and compacting is

$$IQ = 38.5 \times 8^{hr/day} = 308.0 m^3/day$$

The required days for construction is

$$N = 975 m^3 \div 308.0 m^3/day \fallingdotseq 3.1 day$$

Therefore, 3 days shall be applied to the required days for construction.

iv) Construction Procedure

The construction procedure for the access road is as follows:

a. Lay a vinyl sheet at the base of the access road

b. Spread sand and/or laterite aoil layer over vinyl sheet with super swamp bulldozer.

4) Temporary Work for Foundation Improvement Work

The following temporary work will be carried out for the foundation improvement work:

i) In order to keep the base machine on a horizontal level, spread sand under the steel plate.

ii) Lay a steel plate to support the heavy machinery used in the construction of sand compaction piles and soil cement columns.

iii) The compund for the slurry plant used for the costructon of soil cement columns will be put as shown Fig.6.3.1. The construction of the compound of the slurry plant will be made from sand and vinyl. The compound will be 15m x 30m.

iv) The stock area for the sand that will be used for sand compaction piles will be located as shown Fig.6.3.1.

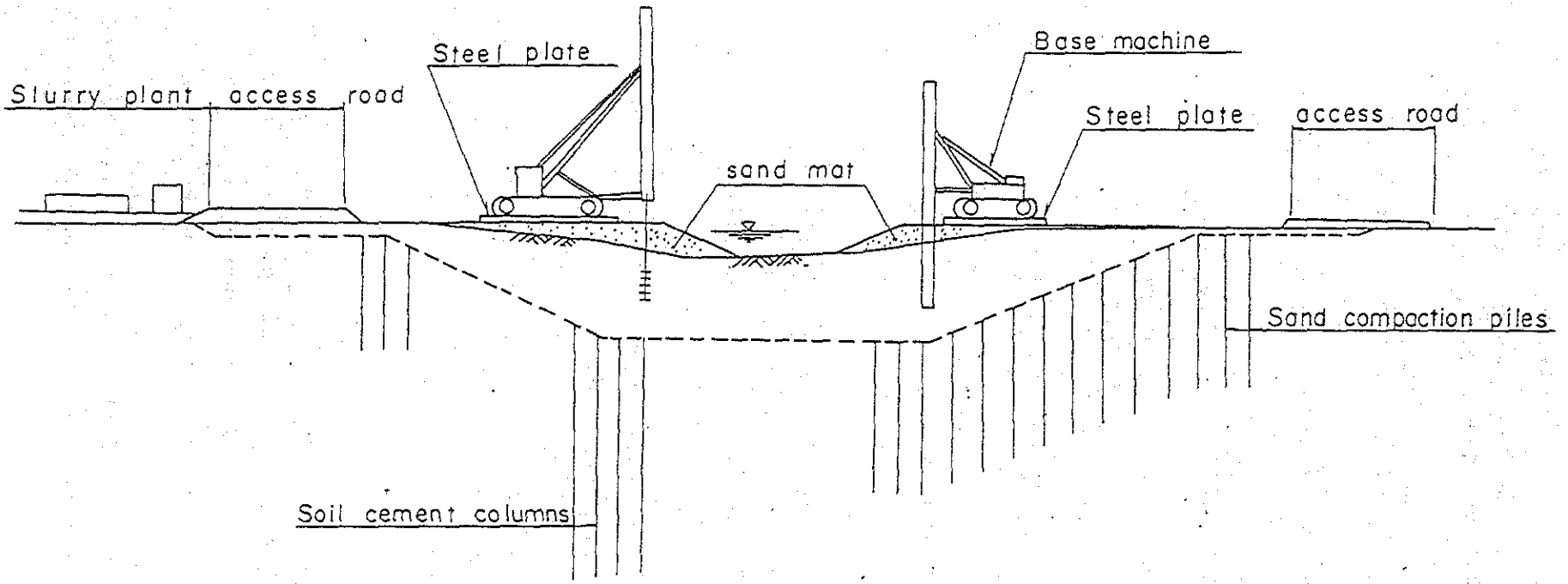


Fig. 6.3.3 Temporary Work for Foundation Improvement Work

6-4 Experimental Construction for Foundation Improvement Works

preceding the improvement works for foundation of the inside slopes of the testing canal, the following experimental works of improvement methods are carried out.

① Sand Compaction Pile Method
② Graval Compaction Pile Method
③ Soil Cement Column Method

The same construction equipments are used for sand compaction pile method and for gravel compaction pile method to obtain data for a comparative study on stability and on economical effciency of both methods.

The main objectives of this experimental construction works are as follows.

① To estimate of internal friction angle in constructed sand compaction pile and gravel compaction pile by standard penetration tests.

② To confirm shear strength of constructed soil cement column.

③ To confirm diameters of constructed sand compaction pile and gravel compaction pile.

④ To check influence on strength of nearby foundations caused by the introduction of sand compaction pile method and gravel compaction pile method.

⑤ To check influence on nearby foundation such as lateral flow and original ground surface caused by foundation improvement works

The following works are to be carried out in the experimental construction.

① Mixing test of soil cement column in a laboratory

② Physical property test on the materials for sand compaction pile and grvuel compaction pile

③ Experimental construction.

④ Test on confirming the effect of treatment (by geotchnical investigation work)

⑤ Arrangement of test results

1) Mixing test of soil cement column
Refer to chapter 6-5, 2), vii)

2) Physical property test on the materials for sand compaction pile and gravel compaction pile
The following tests are carried out on sand and gravel materials.

Sample : To be taken from each location of material at least one(1) sample for each of sand and gravel materials.

Test items : • Grain size analysis
• unit weight
• moisture content

3) Experimental construction

i) Location and quantities of experimental construction
The loactions are shown in Fig.6.4.1. The quantities of experimental construction by each method shall be as shown in Table 6.4.1, and the arrangement of piles are shown in Fig.6.4.2.

Table 6.4.1 Quantities of Experimental Construction

Consrction Method	Number of Pile	Length of Pile	Total Length of Pile	Remarks
Sond Compaction Pile	3	5.00 m	15.00 m	
Gravel Compaction Pile	3	5.00	15.00	
Soil Coment Column	2	6.00	12.00	included in the real construction

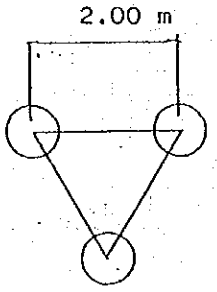


Fig. 6.4.2(a)
Sand Compaction Pile

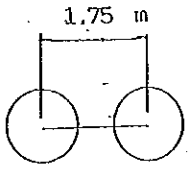


Fig. 6.4.2(c)
Sand Compaction Pile

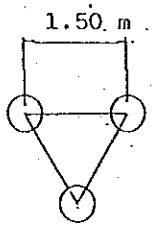


Fig. 6.4.2(b)
Sand Compaction Pile

Fig.6.4.2 Pile Arrangemet for Experimental Construction Works

ii) Geotechnical investigation and tests After the completion of the experimental construction, the following geotechnical investigation and tests are performed.

a) In-situ test
Items of in-situ test are as follows.

Table 6.4.2 Items and Quantities of In-situ Tests for the Experimental Construction

Item of Test	Sand Compaction Pile	Gravel Compaction Pile	Soil Cement Column
Standard Pentration Test(Inside the Piles)	• Location : Center of pile, 1hole • Boring Depth : 7m • Number of Test : 7times (Depth : every 1m)	Same as the left	—
Core Boring (Inside the Piles)	—	—	• Location : Center of pile, 1hole • Boring Depth : 6m • Core Sampling : 6samples (Depth : every 1m)
Thin Wall Sampling (Clay of original ground)	• Location : Center between Pile and Pile, 1hole • Boring Depth : 7m • Core Sampling : 4samples • Sampling Depth : -1.0, -3.0, -5.0, & -7.0	Same as the left	—
Field Deusity Test	• Location : Center of Pile, 2hole • Numbes of Test : 2times	Same as the left	—

b) Laboratory tests

Items of in laboratory tests are shown in Table 6.4.3.

Table 6.4.3 Items and Quantities of Laboratory Tests for the Experimental Construction

Item of Test	Sand Compaction Pile	Gravel Compaction Pile	Soil Cement Column
1. Test on Physical Property			
• Natural Moisture Content	• Pile Material : 2samples • Clay : 7samples	•Pile Material : 2samples •Clay : 7samples	
• Wet Density	• Clay : 4samples	•Clay : 4samples	
2. Mechanical Test			
• Unconfined Compression Test	• Clay : 4samples	•Clay : 4samples	• Pile : 6samples

6-5 Foundation Improvement Works

1) Sand compaction Pile Method and Gravel Compaction Pile Method

i) Location of the improvement works

The location of improvement works shall be the sea side test slope at the opposite side of the national road as shown in Fig. 6.5.1.

ii) Quantity of works

Table 6.5.1(a) Quantity of Works by Sand Compaction Pile

Length of Penetration	Improved Length	Improved Diameter	Number of Piles	Total Improved Length
7.88 m	5.0 m	0.70 m	217 Piles	1,085 m

Table 6.5.1(a) Quantity of Works by Sand Compaction Pile

Leugth of Penetration	Improved Length	Improved Diameter	Number of Piles	Total Improved Length
7.88 m	5.0 m	0.50 m	385 Piles	1,925 m

*) Improved Diameter is confirmed by the experimental construction works.

iii) Specification of construction

a) Improved diameter

The target value of improved diameter of sand compaction pile shall be 70cm ($A=0.385m^2$) and that of gravel compaction pile shall be 50cm ($A=0.196m^2$).

b) Material for improvement

The range of particle size of material for improvement used in improvement works in the past in Japan is as shown in Fig.6.5.2,and according to Japan Highway Public Corporation, sand material to be used for sand compaction pile is considered desirable to have effective grain size

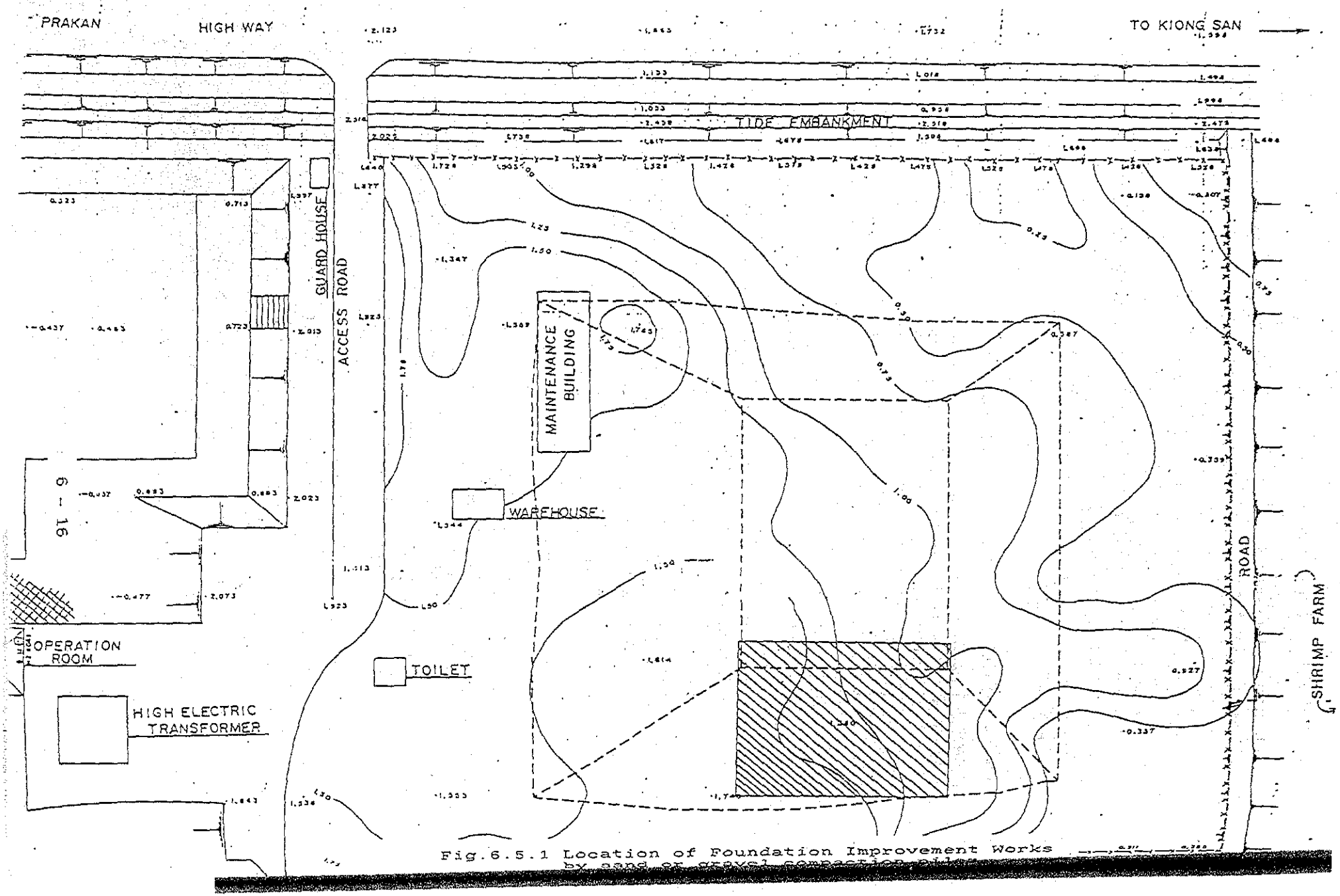


Fig.6.5.1 Location of Foundation Improvement Works by sand or gravel compaction piles

of D_{10}>0.1mm and coefficient of uniformity of $D_{60}/D_{10}=U>5$.

Grain size distribution of sand obtained from proposed sites to get sand materials, Mae Klong and Chao Phya rivers, are shown in Fig.6.5.2. According to the grain size distributions, effective grain size D_{10} is 0.2~ 0.3mm and coefficient of uniformity U is about 3, which can be said not so appropriate, however, there will be no problem if the sand is applied to the work.

iii) Construction equipment

Specifications of standard construction equipments for the work is as shown in Table 6.5.2.

Table 6.5.2 List of Standard Construction Equipment

Name	Standard Specification
Base Machine	Crowler crane, 25^t~ 27^t
Guide leader	L=15m
Hammer	3t class
Bumper	
Hopper	
Bucket	0.3m class
Casing	ϕ40cm, L=12m, steel
Compressor	75HP
Receiver Tank	$3m^3$, 7KVA
Generator	75KVA

Disposition of above equipment is shown in Fig.6.5.3, and the details of the structure of casing are shown in Fig.6.5.4.

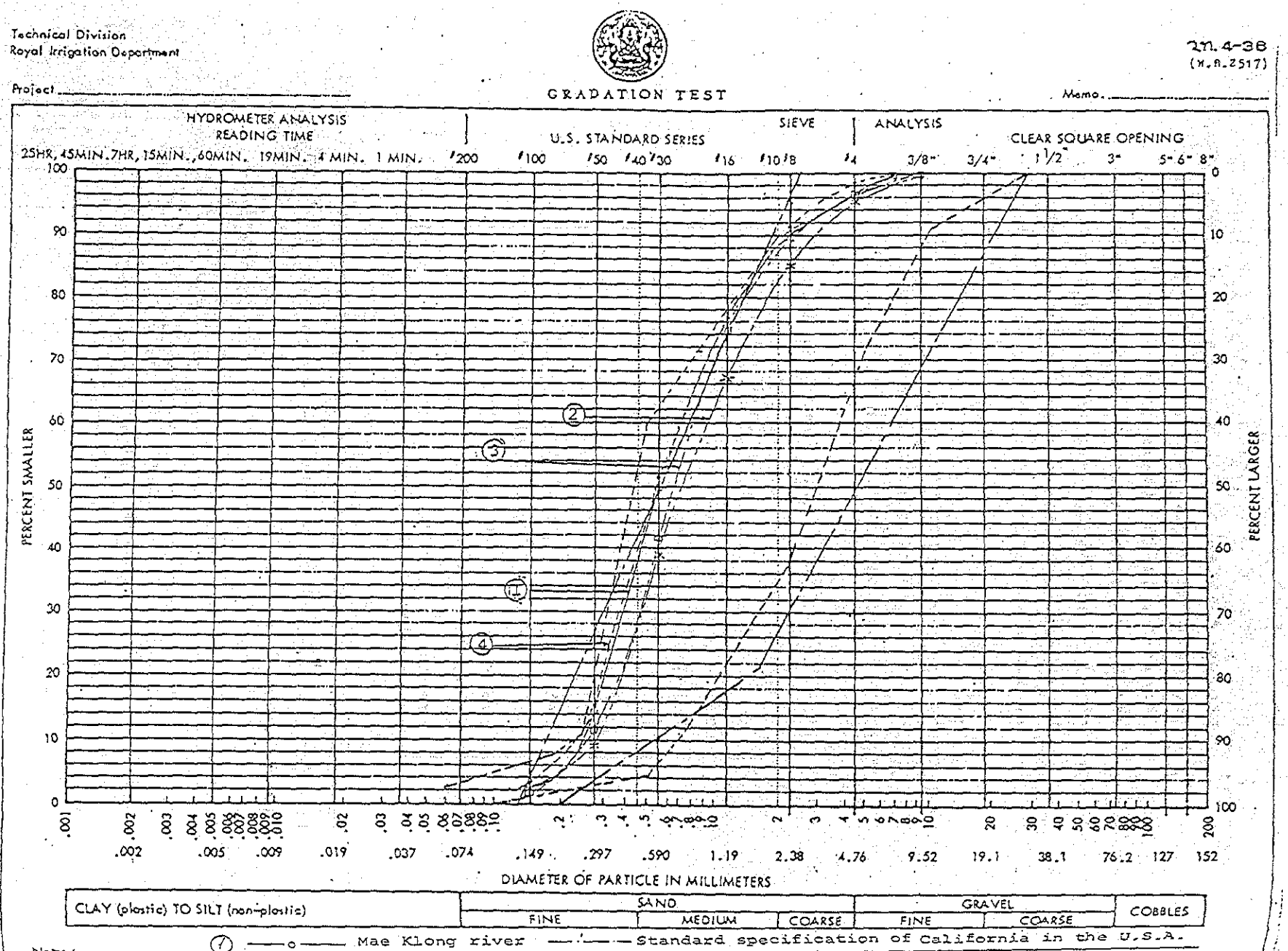


Fig.6.5.2 Grain Size Distribution Curve of Sand and Gravel Compaction Piles

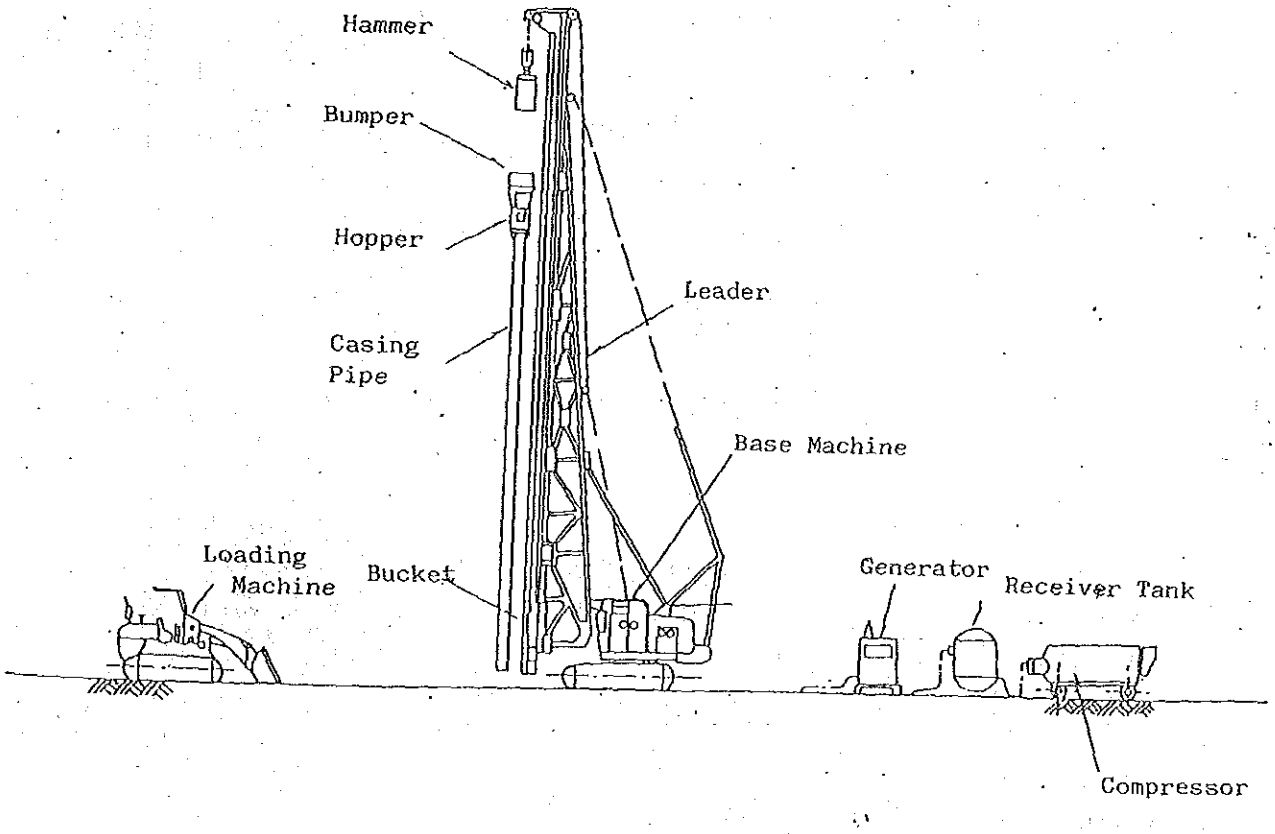


Fig.6.5.3 Typical Arrangement of Construction Equipment for Sand and Gravel Compaction Piles

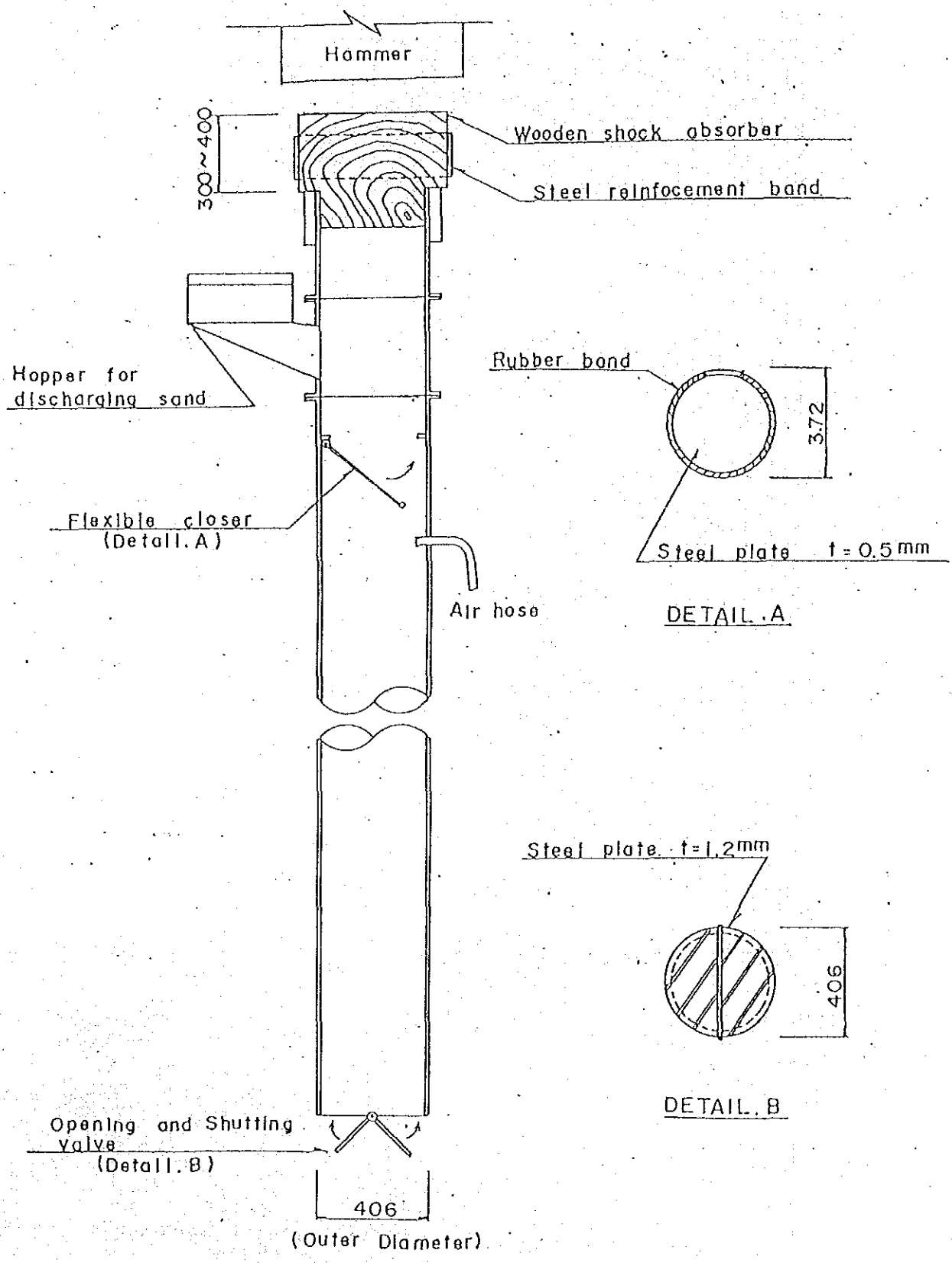
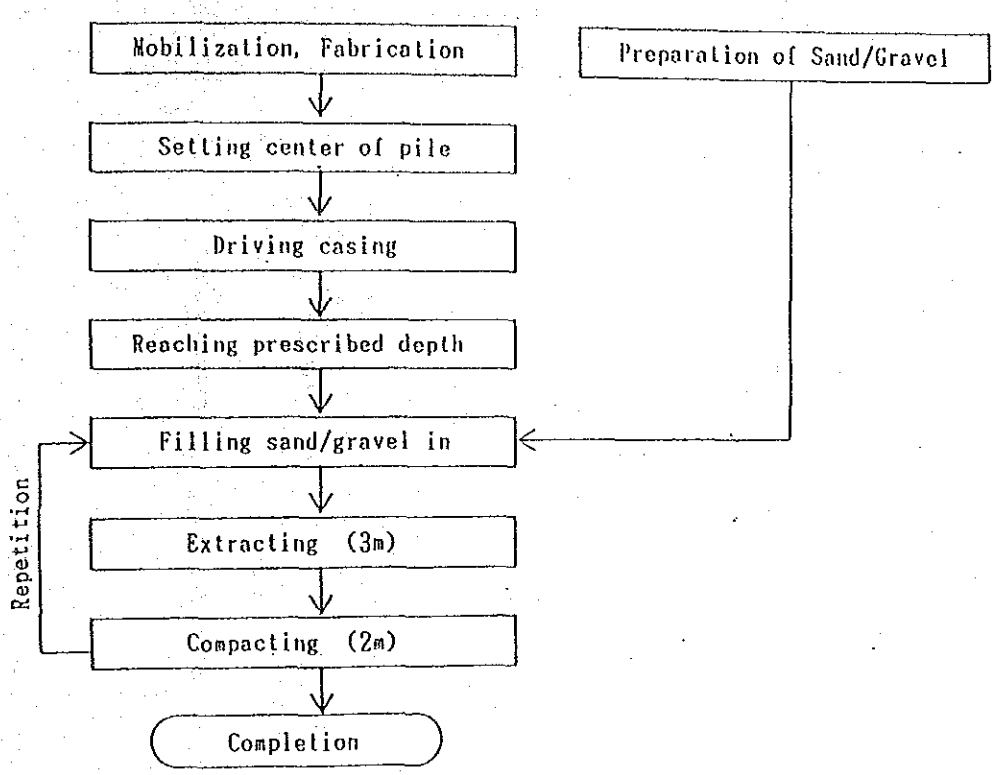


Fig.6.5.4 Example of Casing for for Sand and Gravel Compaction Piles

iv) procedure of the construction

The procedure of the construction is as follows.



An outline of construction procedure is as shown in Fig. 6.5.5.

In order to make improvement effect on foundation by these method greater, it is desirable to increase confining pressure against original ground so as to make shear strength greater. Piling works, therefore,shall be started from the outside to the inside concentrically in order.

v) Construction supervision

Quality control of works and an outline of its frequency required for the construction supervision are as shown in Table 6.5.3.

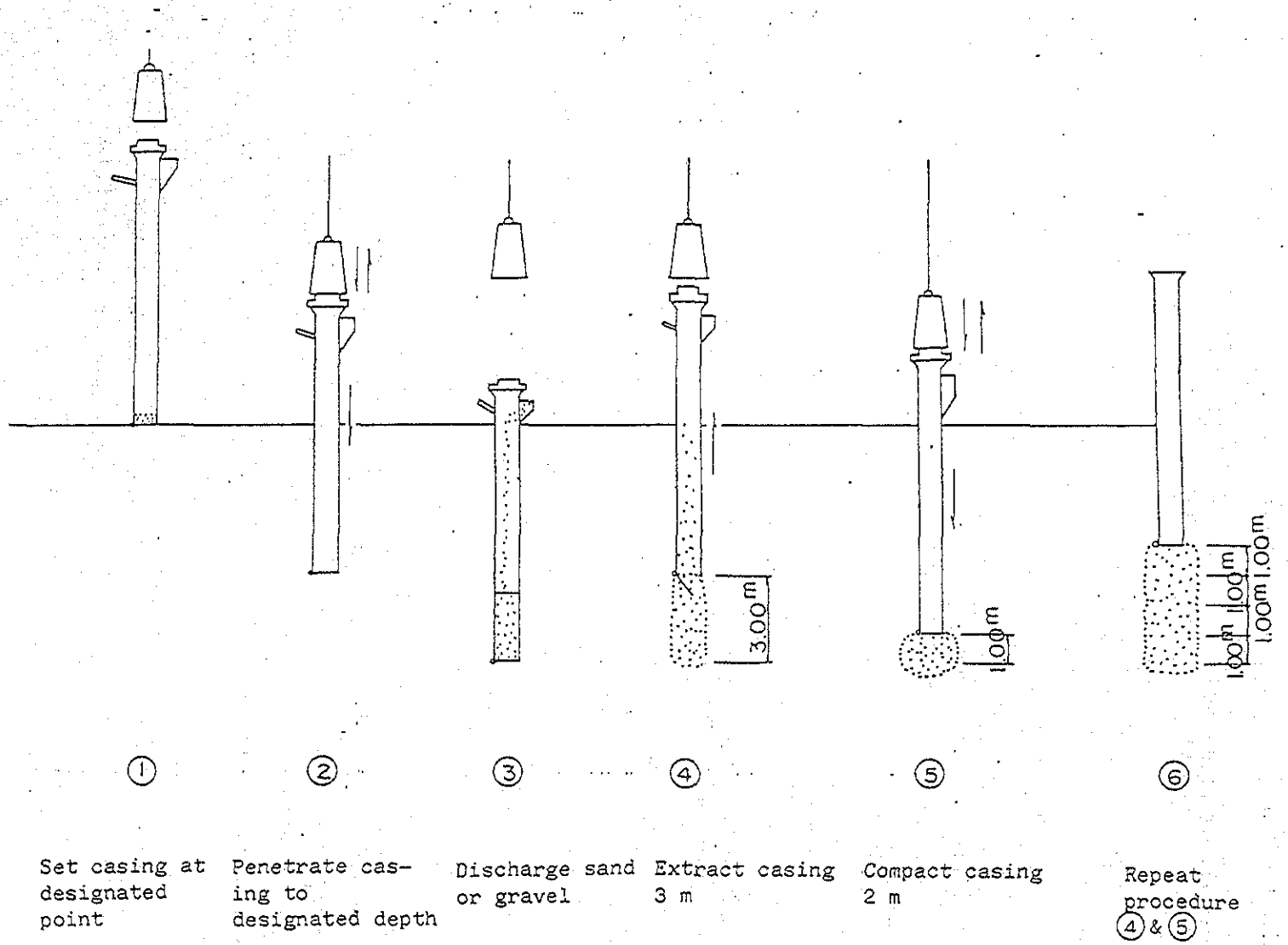


Fig.6.5.5 Construction Procedure of Sand and Gravel Compaction Piles

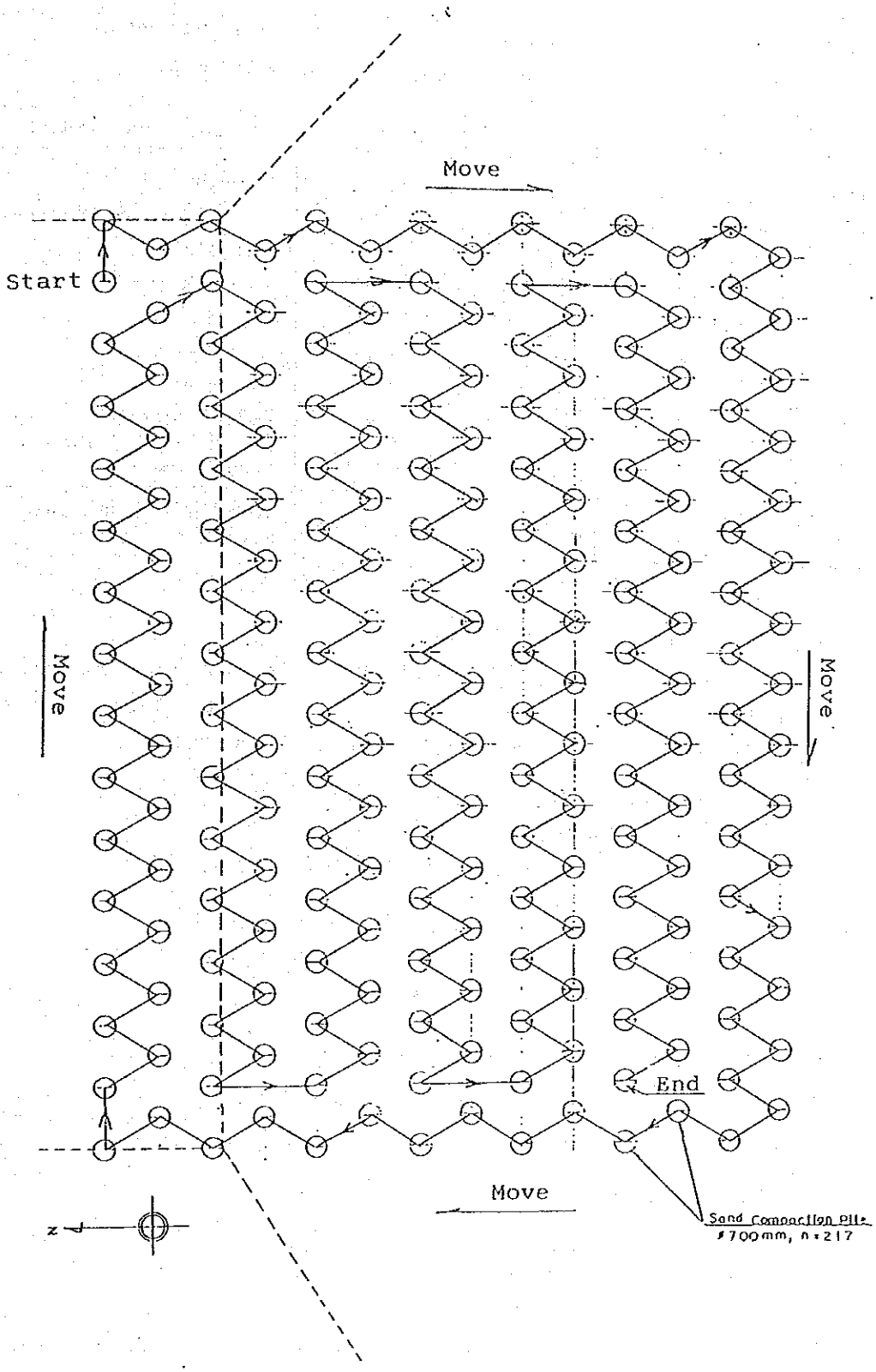


Fig.6.5.6 Construction Order of Sand Compaction Piles

Table 6.5.3. Construction Supervision of Sand Compaction Pile Method and Gavel Compaction Pile Method

Item of Contral	Control Method	Frequency of Control
Pile Materials	Grain size analysis	1time/50m³
Location of Piling	Topo-survey to set up pile	each pile
Depth of Piling	Apoint marked on a casing	each pile
Quantity of Pile Material to be filled in	Bucket	each pile
Strength of Pile	Standard penetration test	Item/30 piles, depth of every 1m
Strength of Original Ground	Unconfined compression test	Item/30 piles, thin wall sampling

vi) Construction capability

Required time for working procedure of construction equipment for sand compaction pile method and gravel compaction pile method is assumed as follows.

Diameter of casing : 40 cm
Driving casing : 0.47 min/m
Compaction of pile : 2.9 min/time
Filling materials : 1.20 min/time
Movement and installation : 12.0 min/time
Working time : 8hrs./day

vii) Required days for construction

Time for construction :
of 1 pile $Cm=12.0+0.47\times7.88+2.9\times5.0+1.2\times5.0=36.2$min/pile

Total duration of construction :
36.2min/pile$\times217$pile
$=7,8855.4$min

Reqeuired days for construction :
$7,855.4$min$\div60$min.$\times8$hr
$=16.4$ days

The required days for construction, therefore, are estimated at 17 days.

2) Soil Cement Column Method

i) Location of the improvement works

The location shall be the slope at the national road side as shown in Fig. 6.5.7.

ii) Quantity of the works

Table 6.5.4 Quantity of Works by Soil Cement Column

Position	Drilling Length	Column Length	Number of Column	Total Drilling Length	Total Column Length
Upper part	6.89 m	5.50 m	53 columns	365.17 m	291.50 m
Lower part	17.92	13.79	70	1,254.40	965.30
Total	(13.16 m)	(10.22 m)	123 columns	1,619.57 m	1,256.80 m

* Figures in parentheses are average value.

iii) Specification of the work

a) Diameter of mixing column

Diameter of mixing shall be 1,000m/m· (A=0.785m²)

b) Cement material

Improvement material shall be cement slurry made of ordinary portland cement with a specific gravity of 3.15.

Water-cement ratio (w/c) shall be 100% in weigh ratio.

c) Volume of cement

For 1.00m³ of original clay matercal, 198ℓ of improvement materials (150 kg of ordinary portland cement) shall be used, however the precise volume of cement shall be decided based on data obtained from mixing tests in a laboratory before the construction.

iv) Construction equipment

The standard construction equipment for the work is as shown in table 6.5.5.

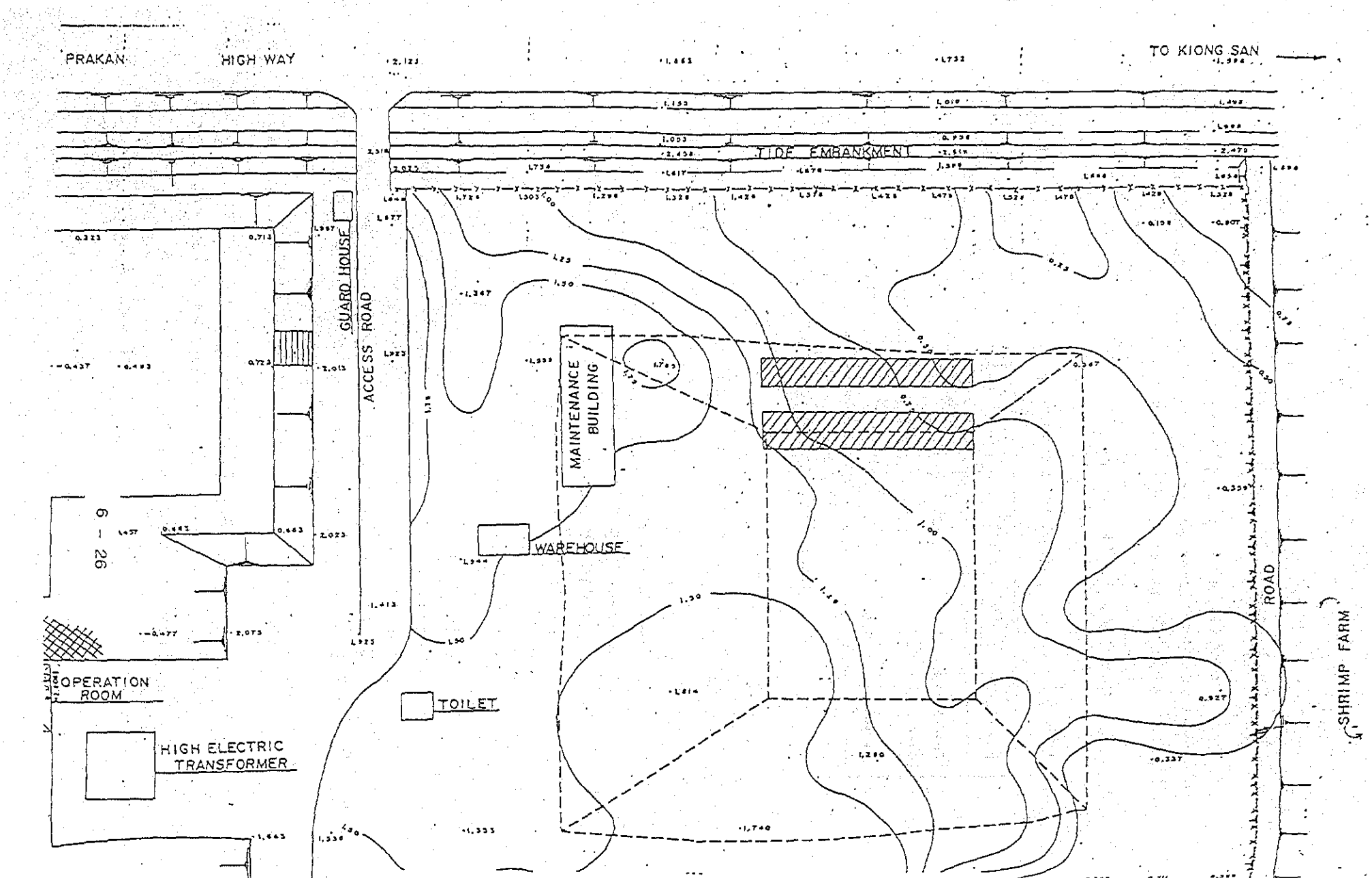
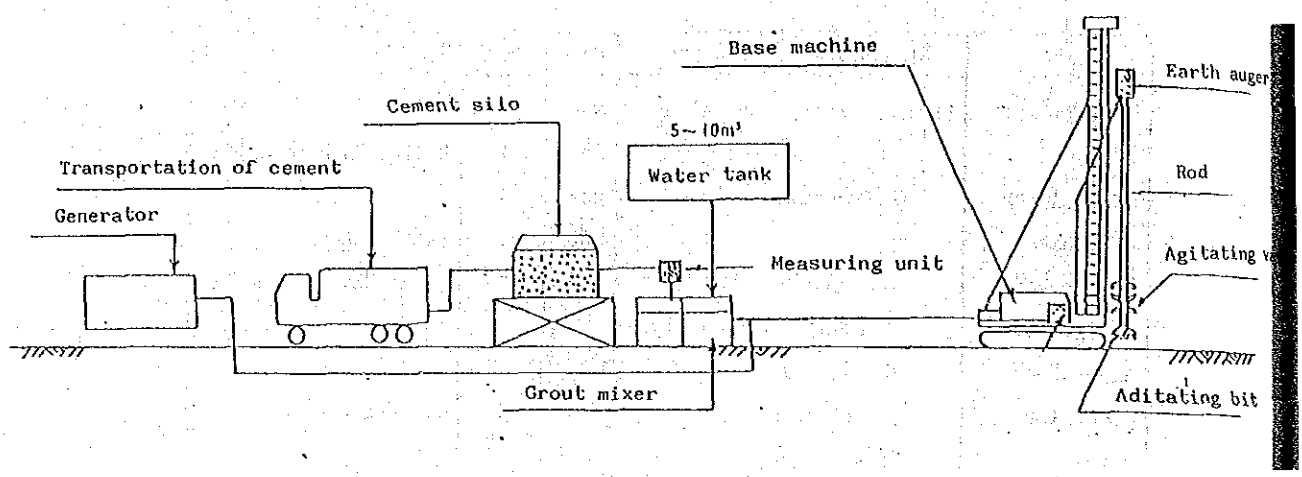


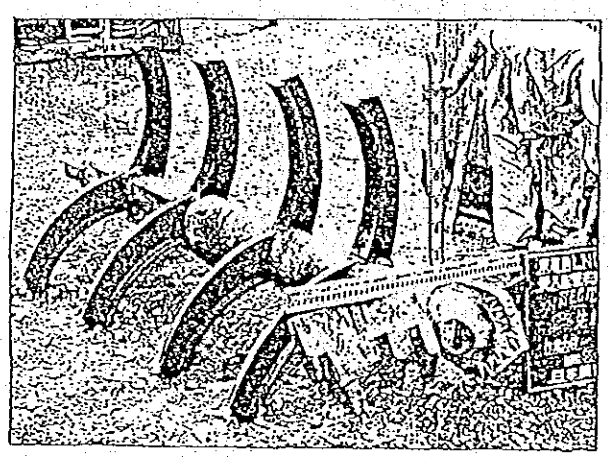
Fig.6.5.7 Location of Foundation Improvement Works by Soil Cement Columns

Table 6.5.5 List of Construction Equipment

Name	Standard Specification	unit	Nos.	Remarks
Base Machine	Crowler crane, 35^{t} class	Nos.	1	
leader		Set	1	Mixing Machime Guide
Earth Auger	D-60K class	Nos.	1	
Attachment		Set	1	Earth Auger
Mixing Rod	ϕ 200m/m	"	1	Lmax=25m
Mixing Vave	ϕ 1000m/m, double type	"	1	
Auger Head	ϕ 600m/m	"	1	
Generator	125KVA class	Nos.	1	for Earth Auger
Mixer	750ℓ×2	"	1	
Grouting Pump	150ℓ/min.	"	1	
Water Tank	$2m^3$	"	1	
Submergible	2inches			
Motor Pump		"	1	

Disposition of the above equipments is as shown in Fig 6.5.8





Example of agitating vane and agitating bit

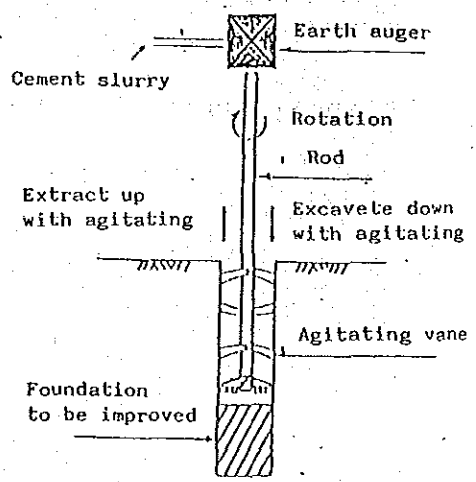
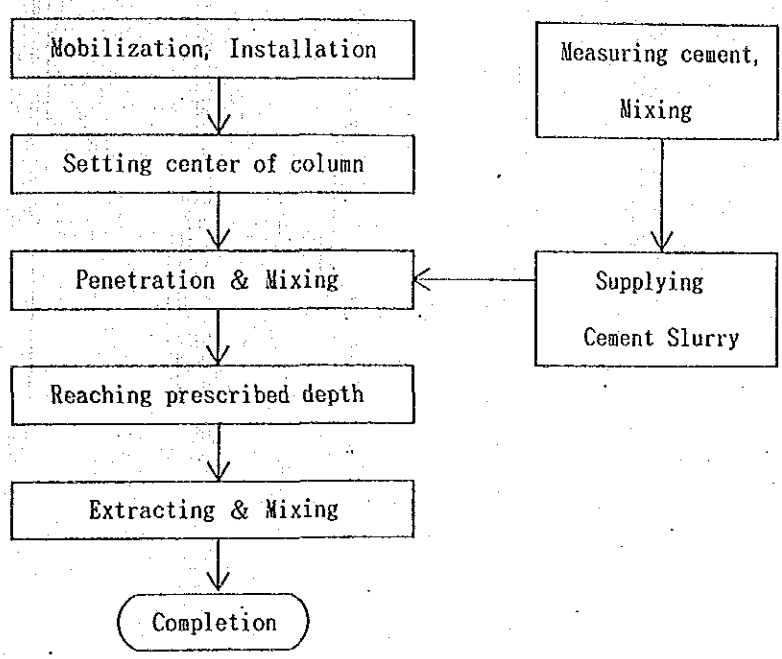


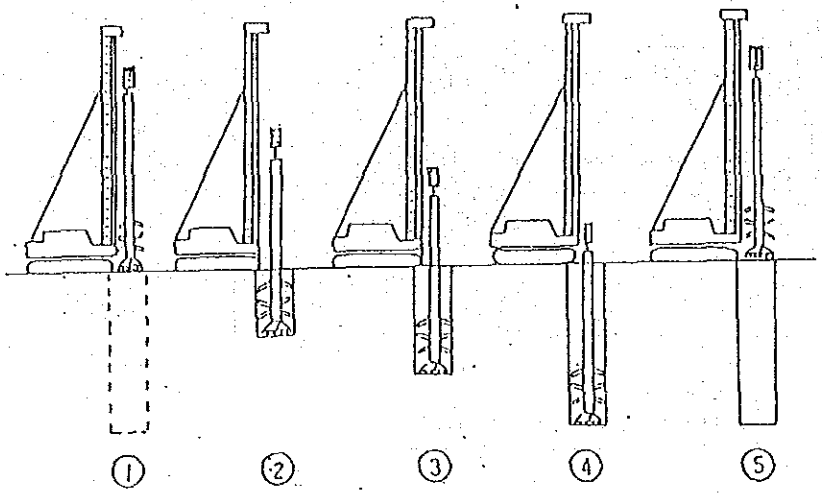
Fig.6.5.8 Typical Arrangement of Construction Equipment for Soil Cement Columns

v) Procedure of construction

A flowchart of the construction procedure by soil cement column is as below.



An outline of construction procedure is as shown in Fig 6.5.9., and a flowchart of supplying cement slurry is shown in Fig. 6.5.10.



① Set the rod and the hose filled with solidifier slurry in the center of the column.

② Excavate down to the pre-determined open-cut depth and start outflow of the solidifier slurry.

③ Start excavation, injection and agitation (improvement).

④ Complete the excavation, injection and agitation down to the determined depth. Stop outflow of the solidifier slurry, and start pulling up, mixing and agitating by reverse rotation.

⑤ Complete pulling out of the determined length

Fig.6.5.9 Construction Procedure of Soil Cement Columns

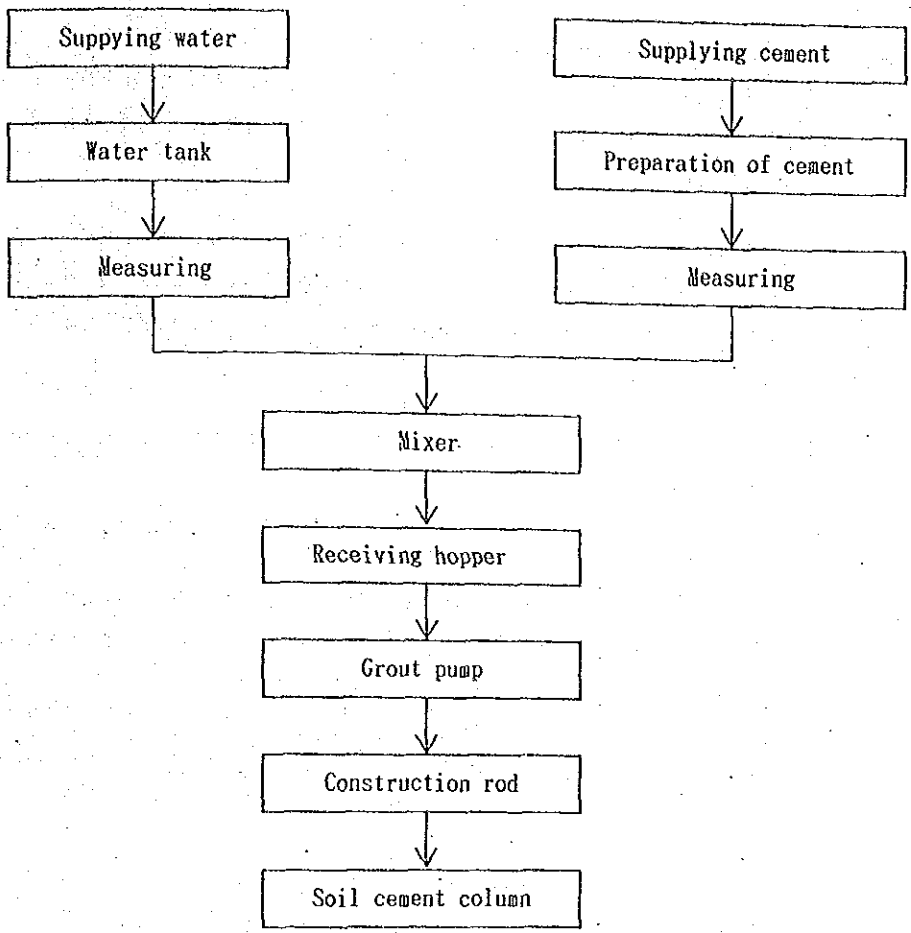


Fig. 6.5.10 Flowchart of Supplying Cement Slurry

vi) Construction control

The special attention shall be paided to the following matters for the construction of soil cement colums.

① To control quantity of cement slurry and velocity of penetration and extraction of mixing vane strictly so as to supply cement slurry to each depth precisely.

② To maintain perpendicularity of the construction equipments.

③ To set the control standard for rate of rotation, stirring torque and up-down speed of stirring of mixing vane taking into account its capacity.

④ Sine the construction is carried out on a soft soil foundation, safety of a base machine should be well-considered so as not to lower the work efficiency.

The following items will become items for construction supervision.

a) Density and amount of cement slurry to be injected

Specific gravity of cement slurry shall be measured in order to confirm whether or not the cement slury is being producted in specified mix proportion.

- Mixing proportion of cement slurry

An appropriate amount of mixed slurry in a batch is 500~600 litre when the capacity of a mixer is 750 litre.

Therefore, when the amount of water and cement is 400Kg respectively, as water-cement ratis is 100%, the volume of cement slurry to be producted(v) can be calculated by following equation.

$$V = \frac{\text{amount of cement used}}{\text{specific gravity of cement}} + \text{water}$$

$$= \frac{400}{3.15} + 400 = 527 \text{ liter}$$

The volume of cement slurry mixed up, therefore, is determined as follows.

amount of cement used : 400 Kg
amount of water used : 400 Kg
volume of cement slurry to be producted : 527 ℓ

as a result, 1 m^3 of cement slurry contains

$$\frac{400kg}{0.527m^3} = 759kg/m^3 \quad \text{of cement}$$

- Controlling specific gravity of cement slurry

  Specific gravity of cement slurry can be calculated as follows based on the mixing proportion of cement slurry.

  Specific gravity of cemet slurry

$$= \frac{400+400}{400/3.15+400} = 1.518$$

The specific gravity of cement slurry is controlled using control charts and its measurement freguency shall be once in the morning and in the afternoon.

- Amount of slurry to be injected

  Amount of soil to be improved is 0.785 m^3 in every 1m of depth. When the amount of slurry to be injected for 1m^3 of soil cement column is 150kg, the volume of cement slurry to be injected (Q) can be obtained by the following equation.

$$Q = \frac{150}{3.15} + 150 = 198\ell/m^3$$

When the improvement velocity in every 1m of depth(U) is 1.5 mim/m, the amount of slurry to be injected by a pump is

198ℓ/m x0.785m³/m÷1.5mim/m=104ℓ/m .
It follows that the amount of slurry to be injected by a pump should be controlled with in a range from 105ℓ/m to 115ℓ/m.
For example, the total amount of slurry to be injected for one column can be calculated as follows.

Improved length	Calculation	Total amount
11.5m	11.5x0.785x198	1,787ℓ
5.5m	5.5x0.785x198	858ℓ

b) Construction speed
Perpendicular construction speed for penetration and extraction of soil cement colum method is determined as 1,5mim/m respectively.
The construction speed is controlled by the use of marks made on the rod and rules.

c) Controlling rate of rotation of mixing vane
The rate of rotation of miximg vane is measured by eye estimation.

d) Controling perpendicularity
Vertical inclination of the leader is measured by a theodolite.

e) Quality control
In order to check the strength of constructed soil cement columns,unconfined compression test and measurement of unit weight are carried out on samples taken by core boring in the ratio of one colum out of 30 colums. Sampling of cores is done for every 1 m's depth.

vii) Mixing test in a laboratory
For the determination of the amount of cement slurry to be mixed with original clay to confirm the designed strength of cement colums, mixing tests of cement slurry and original clay is performed.

a) Flow chart of test

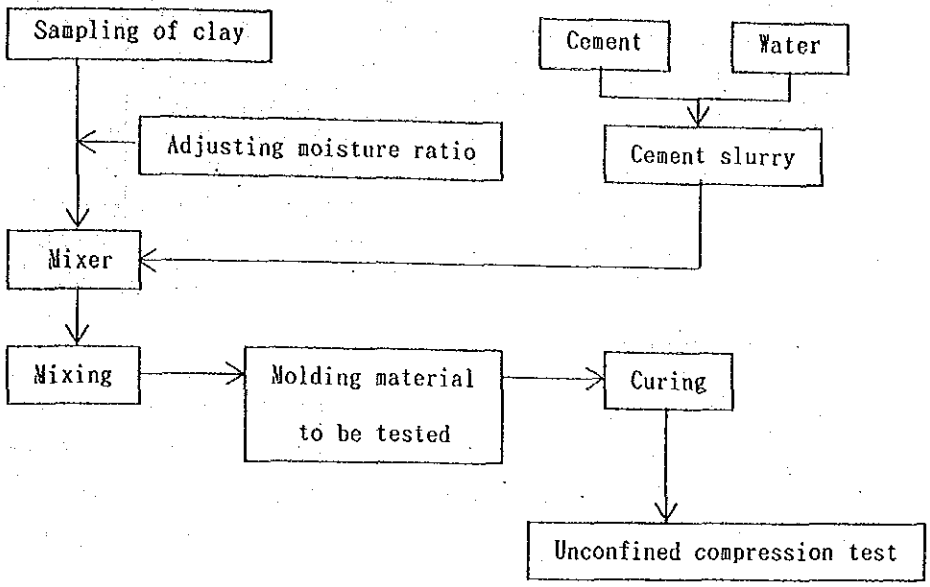


Fig. 6.5.11 Flow Chart of Test

b) Specification of test

The standard specifications for the mixing test in a laboratory are as follows.

Table 6.5.6 The Standard Specifcations for the Mixing Tests in a Laloratory

Item	Standard Specifications
Kind of material for improvement	Ordinary portland cement
Water-cement ratio(%)	100
Amount of cement to be mixed (kg/m³)	100, 150, and 200
Mixing time required (min)	10
Age (days)	7, 14 and 28
Molding size	ϕ 5cm height 10cm
Number of mold for one sample (Nos.)	2

The amount of cement slurry to be mixed with 1 m³ of original clay is as follows.

Table 6.5.7 Amount of cement slurry to be mixed

Amount of cement mixed	Amount of cement slurry to be mixed
100 kg/m³	132 ℓ/m³
150	198
200	264

c) Testing items

① Test for physical properties
- Unit weight : 3 samples obtained from each kind of mixture, 100kg/m³, 150kg/m³ and 200kg/m³.

② Tests for mechanical properties
- unconfined compression tests : 2 samples obtained from each mold, 18 samples in talal

ⅵ) Construction capability

Operation specifications of construction equipment for soil cement column metlhod which are used for the estimation of construction capability are assumed as follows.

Agitation method	:	1 cycle
Penetration speed to the prescribed depth from where injection of slurry is started.	:	1.0mim/m
Speed of agitation penetration	:	1.5min/m
Extracting speed with agitation	:	1.5min/m
Time required for movement and setting	:	12min/time
Working hours	:	8hrs/day

ix) Required days for construction

・Required time for construction of columm :

upper, Cm1=12+1.39x10x2+5.5x1.5x2=31.3min/column

Lower, Cm2=12+41.3x1.0x2+11.29x1.5x2=54.1min/column

・Total construction time :

31.3min/columnx53column+54.1min/column x70column
=5,445.9min

・Required days for construction :

5,445.9÷60÷8=11.3days

Therefoe, the required days for construction is estimated at 12 days.

x) Construction order

The construction order for soil cement columns is shown in Fig.6.5.12.

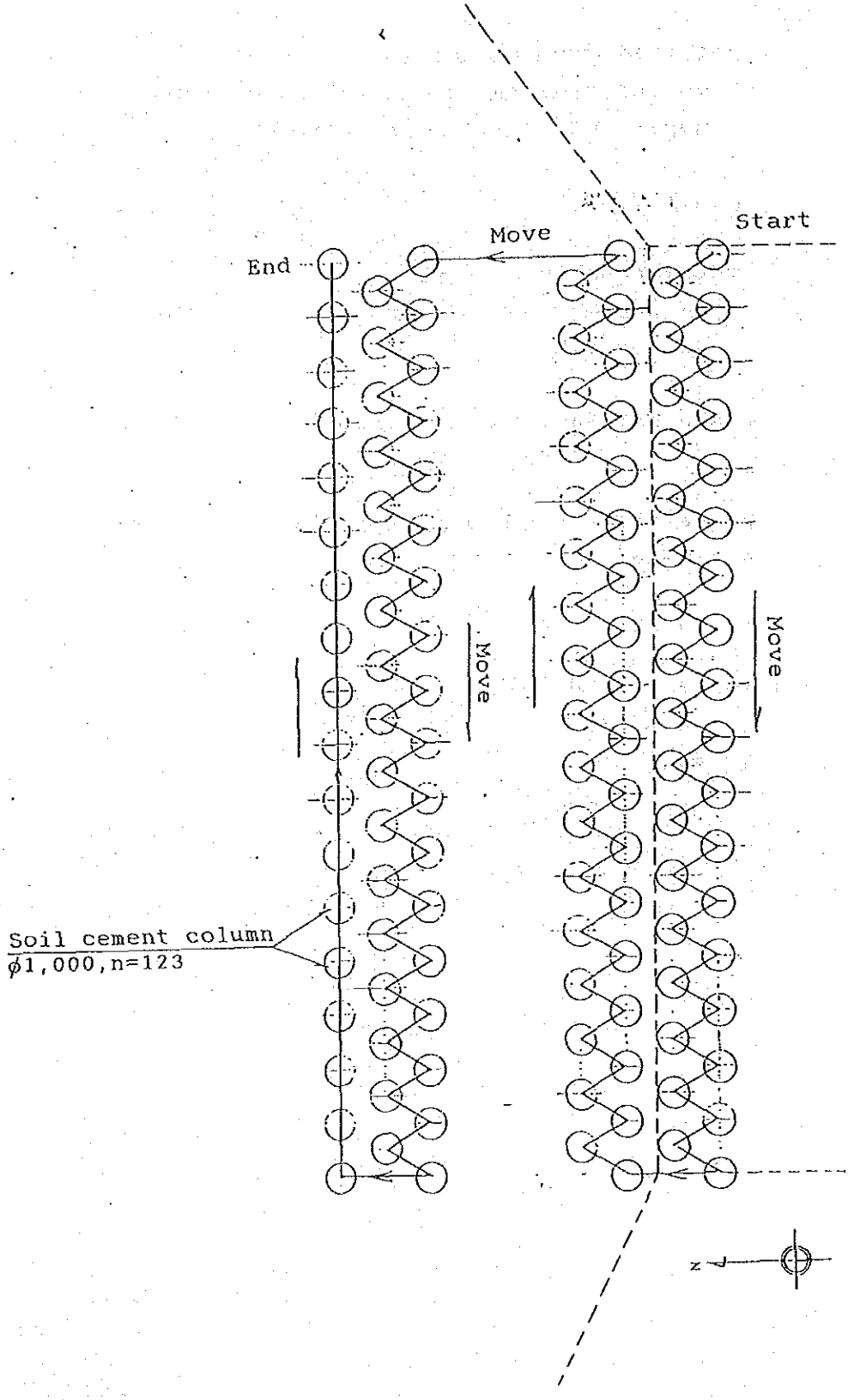


Fig.6.5.12 Construction Order of Soil Cement Columns

6-6 Excavation Works

1) Constructin Equipment

The required cone baring capacity of original ground to ensure the trafficability for passing of equipment is generally as follows taking into accont contact pressure of each machine.

Table 6.6.1 Contact Pressure and Required Cone Bearing Capacity of Equipment

Equipment	Contact Pressure (kgf/cm^2)	Cone Bearing Capacity (kgf/cm^2)
Super swampdozer	0.15 ∿ 0.23	more than 2
Sawampdozer	0.22 ∿ 0.43	more than 3
Bulldozer (11 ton)	0.50 ∿ 0.60	more than 5.5
Bulldozer (21 ton)	0.60 ∿ 1.00	more than 7
Backhoe (0.8 m^3)	0.42 ∿ 0.52	more than 5
Backhoe (0.4 m^3)	0.38 ∿ 0.39	more than 3.5
Crawler crane (35 ton)	0.51 ∿ 0.68	more than 6
Dump track	3.5 ∿ 5.5	more than 12

According to the test results of dutch cone tests performed at the project site, qc values present in the range of 0 to 5 kgf/cm^2. Accordingly, construction equipment except super swampdozer or swampdozer can not work in the site except some portions where are higher ground elevation and dried up not affected by sea water.

Therefore, sand mat or steel plates shall be placed on the ground surface in order to reduce the contact pressure of equipment for ensuring the trafficability of equipment.

2) Construction Method for Excavation Work

i) Primary Construction Stage

At the primary excavation stage, excavation by super swamp bulldozer shall be done up to a depth of 3m uder dry conditions as shown in Fig.6.6.1. The excavation line at ground level at this stage shall be 5m in length from the final excavation line.

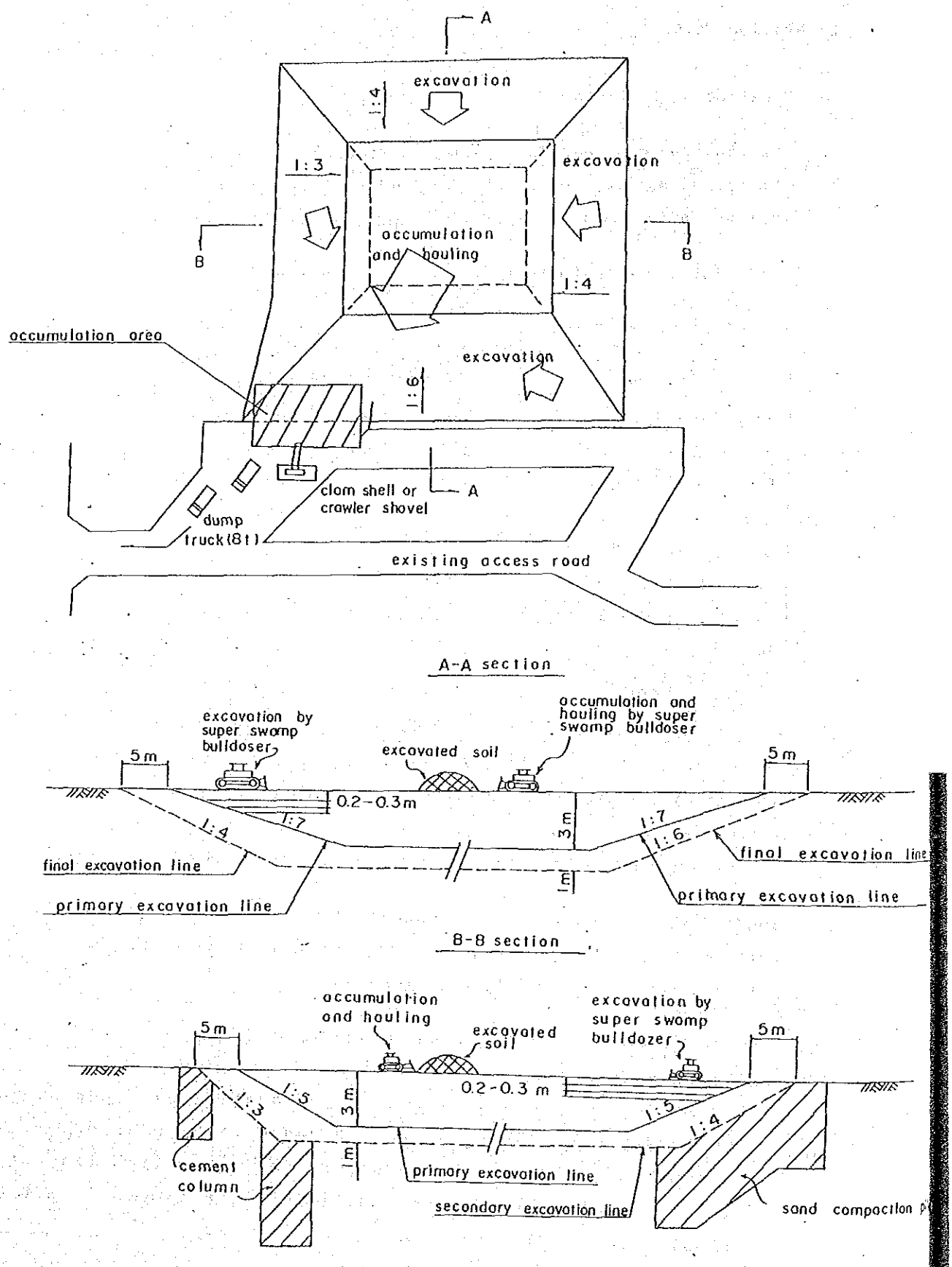


Fig.6.6.1 Construction Method of Primary Excavation

The gradient at this stage shall be 1:7 for the non-treated slopes and 1:5 for the treated slopes.

Two super swamp bulldozer shall be used for excavation work and removing the excavated soil.

The excavated soil will be deposited at the corner of the non-treated and cement columns slope. Accumulated excavated soil shall be loaded on 8t class dump trucks using clam shell or crawler shovels.

a) Work quantity of excavation

excavation volume : 8,690 m^3

b) Working capacity of equipment

Excavation and pushing by super swamp bulldozer

The working capacity of excavation and pushing by bulldozer per hour is calculated by the following equation.

$$Q = \frac{3,600 \times q \times f \times E}{Cm} \quad \cdots\cdots\cdots\cdots\cdots\cdots \quad (6.9)$$

where, Q : Working capacity per hour(m^3/hr)

q : Excavation volume in a cycle(m^3), in case of 10 ton class super swamp bulldozer, q=0.679

f : Bulking factor of soil(= 1.0)

E : Working coefficient(= 0.45)

Cm : Cycle Time(min.)

Cm = 0.034L + 0.25, L=hauling distance

L ≒ 30m, therefore,

Cm = 0.034 x 30 +0.25 = 1.27(min.)

$$Q = \frac{60 \times 0.679 \times 1.0 \times 0.45}{1.27} = 14.4 \ m^3/hr$$

Working capacity per day :

Qd = 14.4 x 8 = 115.2

② Loading by clamshell

The working capacity of clamshell per hour is calculated the following equation.

$$Q = \frac{3,600 \times q \times f \times E}{Cm} \quad \cdots\cdots\cdots\cdots\cdots \quad (6.9)$$

Where,

Q : Working capacity per hour (m^3/hr)

q : Excavation volume in a cycle (m^3)

$q = q_o \times K$ ..... (6.10)

q_o : Nominal capacity of bucket (m^3)

K : Loading coefficient (= 0.73)

f : Bulking factor of soil, refer to Table 6.6.2

Table 6.6.2 Bulking Factors of soil

Classification of Soil	Bulked soil / Original Soil	Compacted Soil / Original Soil
Clay	1.20 ~ 1.45	0.85 ~ 0.95

E : Working coefficient (= 0.45)

Cm : Cycle time (sec.)

in case circular angle (ϕ) is 180° , Cm = 42(se

Therefore,

$$Q = \frac{3,600 \times (0.80 \times 0.73) \times 1/1.20 \times 0.45}{0.054 \times 180 + 23}$$

$$= 18.8\ m^3/hr$$

working capacity per day : Qd

$$Qd = 18.8 \times 8 = 150.4\ m^3/day$$

③ Loading by crawler shovel

Working capacity of loading by crawler shovel per hour is calculated using equation (6.9).

where, $q_0 = 0.8\ m^3$

$k = 0.73$

$f = \frac{1}{1.2}$

$E = 0.50$

$Cm = 45(sec.)$

Then,

$$Q = \frac{3,600 \times (0.8 \times 0.73) \times 1/1.2 \times 0.5}{45} = 19.5\ m^3/hr$$

Working capacity per day :

$Qd = 19.5 \times 8 = 156.0\ m^3/day$

④ Hauling by dump track of 8 ton

The working capacity of hauling by dump track is calculated by the following equation.

$$Q = \frac{60 \times q}{Cm} \quad \cdots\cdots\cdots\cdots\cdots\cdots \quad (6.11)$$

Where,

Q = Working capacity per hour (m^3/hr)

q = Hauling capacity in a cycle (m^3)

$q = T/W$ ..... (6.12)

T : Nominal capacity

W : Unit weight of hauling soil

$q = \frac{8.0}{1.47/1.2} = 6.5\ m^3$

Cm : Cycle time (min)

$Cm = 0.0054 \times L \times \alpha + (Cms + 4.0)$ .. (6.13)

L : Hauling distance (= 500 m)

α : Correction factor due to road conditions (= 1.6)

Cms : Cycle time depending on the loading equipment (min)

$$Cms = 60 \times q/Qs \quad \cdots\cdots\cdots \quad (6.14)$$

Qs : Loading capacity by loading equipment, in case of loading by clamshell, Qs = 14.6 m^3/hr

$$Cms = 60 \times 6.5/14.6 = 26.7 \text{ (min)}$$

$$Cm = 0.0054 \times 500 \times 1.6 + (26.7 + 4.0)$$

$$= 35.0 \text{ (min)}$$

Accordingly,

$$Q = \frac{60 \times 6.5}{35.0} = 11.1 \ m^3/hr$$

Working capacity per day : Qd

$$Qd = 11.1 \times 8 = 88.8 \ m^3/day$$

④ Working capacity of spreading by bulldozer of 21 ton at the disposal area

The working capacity of spreding by bulldozer is calculated by the following equation.

$$Q = 10E \times (11D + 8) \quad \cdots\cdots\cdots \quad (6.15)$$

Where,

Q : Working capacity per hour (m3/hr)

E : Working coefficient (= 0.50)

D : Thickness of spreading (= 0.30 m)

Therefore,

$$Q = 10 \times 0.50 \times (11 \times 0.30 + 8)$$

$$= 56.5 \ m^3/hr$$

Working capacity per day : Qd

$$Qd = 56.5 \times 8 = 452.0 \ m^3/day$$

ii) Secondary Construction Stage

At this stage, excavation work shll be carried out by pontoons as shown in Fig.6.6.2.

Excavated soil shall be removed from the site by four large conveyor belts. excavated materials shall be deposited by the belts at the top of each slope. Accumulated excavated soil shall be removed by the same method described in the Primary Construction Stage.

a) Working quantity of excavation

Excavation volume : 6,910

b) Working capacity of equipment

① Excavatation by backhoe on a pontoon

The working capacity of excavation by backhoe on a pontoon is calculated using equation (6.9) as fore-mentioned.

where, $q = 0.4\ m^3$

$k = 0.9$

$f = 1.0$

$E = 0.45$

$Cm = 33$ sec.

Accordingly,

$Q = 17.7\ m^3/hr$

$Qd = 141.6\ m^3/day$

② Hauling capacity of belt conveyor

Hauling capacity of belt conveyor is calculated by the following equation.

$$P = 60 \times K \times (0.9 \times B - 0.05)^2 \times V \quad \cdots\cdots\cdots (6.16)$$

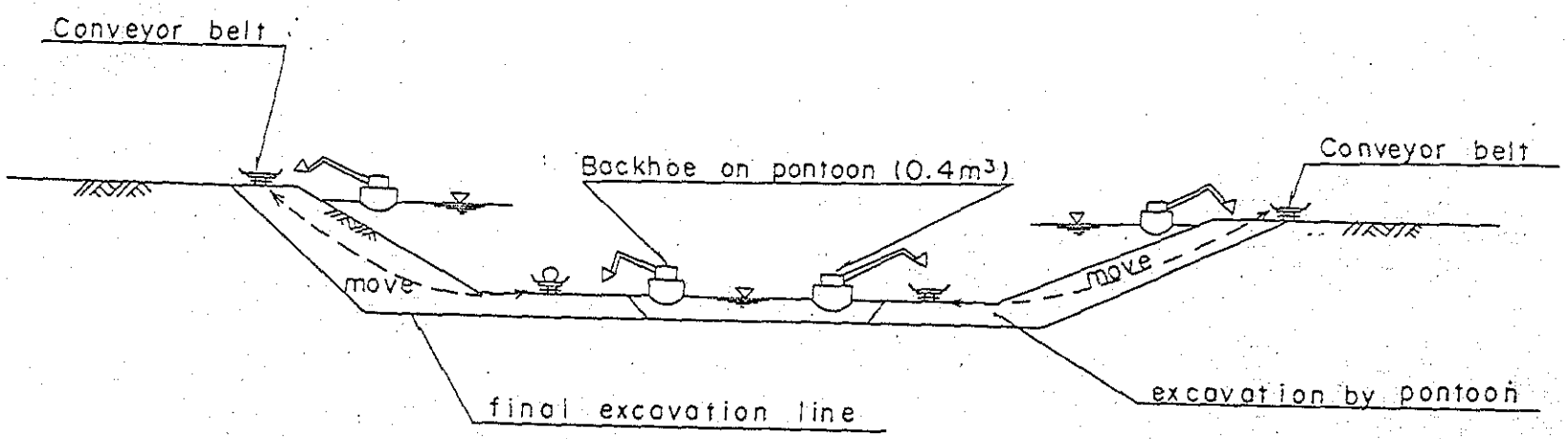


Fig.6.6.2 Construction Method of Secondary Excavation

Where,

P : Hauling capacity per hour (m^3/hr)

K : Coefficient due to trough angle of belt conveyor (=0.059)

B : Width of belt (= 0.35 m)

V : Velocity of belt convyor (= 30 m/min)

Therefore,

$$P = 60 \times 0.059 \times (0.9 \times 0.35 - 0.05)^2 \times 30$$
$$= 7.5\ m^3/hr$$

Working capacity per day : Qd

$$Qd = 7.5 \times 8 = 60.0\ m^3/hr$$

③ Loading capacity by manpower :

The loading capacity by manpower to the belt conveyor is calculated by the following equation

$$V = \frac{\text{Stationing of labourers}}{0.35} \quad \cdots\cdots \quad (6.17)$$

In case that ten (10) labourers are stationed around belt conveyor,

$$V = 10/0.35 = 28.6\ m^3/day$$

④ Loading capacity by clamshell

The loading capacity by clamshell is calculated using the equation (6.9).

Where, K = 0.73

f = 1/1.2

E = 0.45

Cm = 42 min

Therefore,

$$Q = \frac{3,600 \times (0.8 \times 0.73) \times 1/1.2 \times 0.45}{42}$$

$$= 18.8 \text{ m}^3/\text{hr}$$

Working capacity per day : Qd

$$Qd = 18.8 \times 8 = 150.4 \text{ m}^3/\text{day}$$

⑤ Hauling capacity by dump track

The hauling capacity of dump track is calculated using the equations (6.11),(6.12) and (6.13) as forementioned.

Where, in case of T = 8.0 ton.

Q = 11.1 m^3/hr

Qd= 88.8 m^3/day

3) Required Construction Period

i) Primary construction stage

The excavation volume by the primary construction stage is devided into two categories depending of the equipment to be used.

Applied equipment	Volume
Super swamp bulldozer + clamshell + dump trucks	4,345 m^3
Super swamp bulldozer + crawler shovel + dump trucks	4,345 m^3
Total	8,690 m^3

The required total number of equipment based on the foregoing plan is calculated as follows.

Super swamp bulldozer	:	8,690 ÷ 115.2m^3/day	=	75 nos.day
Clamshell	:	4,345 ÷ 150.4	=	29
Crawler shovel	:	4,345 ÷ 156.0	=	28
Dump trucks	:	8,690 ÷ 88.8	=	98

In case that two super swamp bulldozers are mobilized, teh required construction period for the primary construction stage is :

75 nos.day ÷ 2 nos ≒ 38 days

ii) Second stage excavation

The total required numbers of each equipment for the second stage excavation are computated as follows.

① Backhoe on a pontoon :

6,910 m^3 ÷ 141.6 m^3/day ≒ 49 numbers·day

② Belt conveyor:

6,910 m^3 ÷ 60.0 m^3/day ≒ 116 sets·day

③ Clamshell:

3,455 m^3 ÷ 150.4 m^3/day ≒ 23 number·day

④ Crawler shovel

3,455 m^3 ÷ 156 .0 m^3/day ≒ 22 number·day

⑤ Dump truck

6,910 m^3 ÷ 88.8 m^3/day ≒ 78 number·day

The required construction period is determined by the number of backhoe on pontoon, therefore, it becomes 49 days.

6-7 Plan of Disposal for Excavated Soil

The approximate excavated volume of soil is estimated at 16,000 m^3 for the testing canal facility. Considering the bulking of soil after excavation, the total volume of soil to be disposed is estimated at 20,000 m^3.

It is proposed that the area at the opposite side of the pumping station be used for the disposal area shown in Fig. 6.7.1.

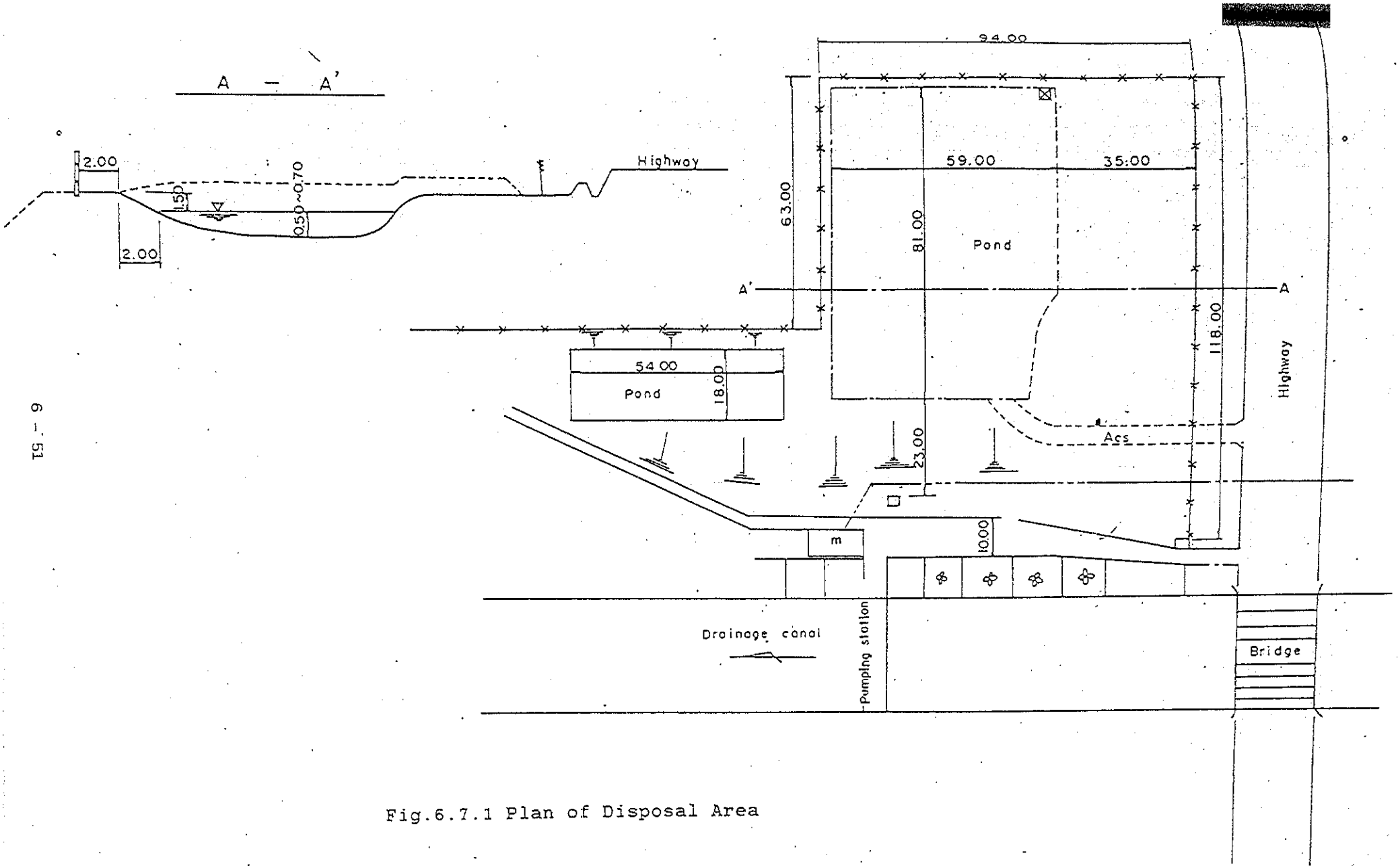


Fig.6.7.1 Plan of Disposal Area

6-8 Construction Time Schedule

The required time for the construction of the testing canal facility is 8 months including preparatory period for the Contract and settlement period.

The construction time schedule is shown in Fig. 6.8.1.

Work Items	Unit	Quantities
I. CONSTRUCTION OF TESTING CANAL FACILITY		
1. Tendering	-	-
2. Preparatory Work		
- Mobilization & Demobilization	L.S	-
- Dewatering	m^3	5,600
- Construction of Construction Road	m	270
3. Foundation Improvement work		
- Laboratory Tests	L.S	-
- Experimental Construction	L.S	-
- Construction of Soil Cement Columns	m	1,257
- Construction of Sand Compaction Piles	m	1,085
4. Earth Works		
- Construction of Coffer Dam	m^3	95
- Construction of Drainage Ditch	m	270
- Primary Excavation	m^3	8,690
- Secondary Excavation	"	6,910
5. Other Work		
- Related Work for Monitoring System	L.S	-
Shifting of Existing Houses	L.S	-
II. INSTALLATION OF MONITORING INSTRUMENT		
1. Auto-measuring Instrument		
- Inclinometer	Location	2
- Extensometer	"	1
- Piezometer	"	6
2. Manual-measuring Instrument		
- Inclinometer	Location	5
- Settlement Gauge	"	7
- Displacement Piles	Nos.	104
- Water Stand Pipe	Location	2

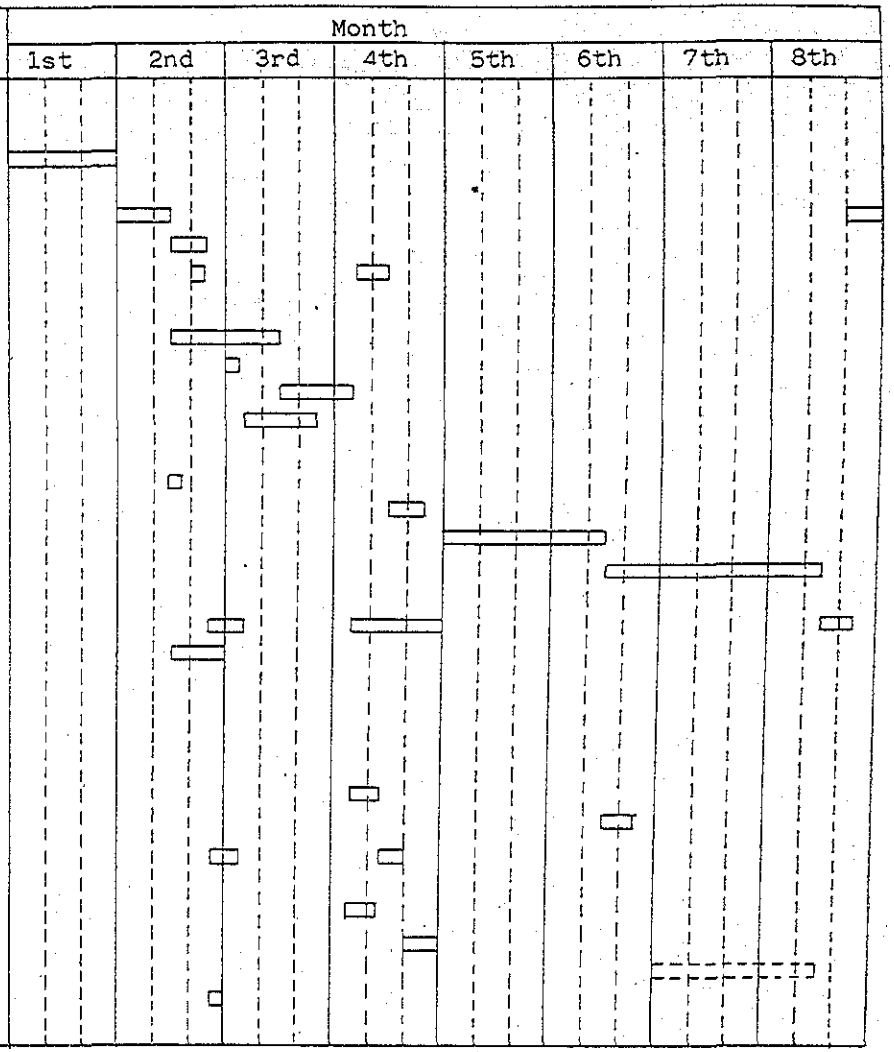


Fig.6.8.1 Construction Time Schedule

CHAPTER 7 COST ESTIMATION

7-1 Procurement Method for Materials Supplied by JICA

The construction of the testing canal facility is necessary to be carried out as the infrastructure improvement works for expediting smooth operation of the project type technical cooperation.

However, the project budget for the construction of the testing canal facility is limited, therefore the monitoring system except installation of displacement piles is necessary to be supplied by means of JICA's procurement method.

It is desirable to procure the monitoring system in Thailand taking into account the operation and maintenance for monitoring instrument.

The materials to be supplied by JICA's procurement method are listed in the following table.

MONITORING INSTRUMENT SUPPLIES BY JICA

1. Auto-measuring Inclinometer

Number of Sensors	:	5 nos.
Installation Places	:	8 places

2. Manual-reading Inclinometer

Number of Sensor	:	1 no
Installation Places of Casing	:	5 places

3. Extensometer

Number of Sensors	:	6 nos.
Installation Places	:	1 places

4. Piezometer

Number of Sensors	:	18 nos.
Installation Places	:	6 places

5. Differencial Settlement Gauge

Number of Sensors	:	35 nos.
Installation Places	:	7 places

6. Water Stand Pipe

Installation Places	:	2 places

7. Measuring Unit : 1 L.S.

8. Software for Data Processing : 1 L.S.

7-2 Project Cost

1) Estimation of Construction Cost

The standard prices for labourers, materials and equipment used generally in Bangkok as of March 1988 are applied to the estimation of the construction cost.

The construction cost consists of the direct construction cost and indirect construction costs such as common temporary works, general site expense and overhead expense.

The applied conversion rate ฿1.0 = ¥5.2 is applied to the estimation.

2) Project Cost

The total project cost will be as follows.

1.	Construction of the Testing Canal Facility	¥27,000,000
2.	Installation of Monitoring Instruments	¥22,000,000
	Total Project Cost	¥49,000,000

The breakdown of the cost and bill of quanties for the construction are shown as follows.

BREAKDOWN OF PROJECT COST

I. Construction Cost			
A. Direct Cost			
1. Earth Works	15,700 m^3	฿	1,831,000
2. Foundation Improvement Works by Sand Compaction Piles	1,090 m	฿	543,000
3. Foundation Improvement Works by Soil Cement Columns	1,260 m	฿	692,000
4. Experimental Construction Works for Foundation Improvement Works	1 L.S	฿	30,000
5. Other Miscellaneous Eorks	1 L.S	฿	13,000
6. Shifting of Existing Houses	1 L.S	฿	79,000
Sub Total		฿	3,188,000
B. Indirect Cost			
1. Common Temporary Works	1 L.S	฿	724,000
2. General Site Expense	1 L.S	฿	186,000
3. Overhead Expense	1 L.S	฿	397,000
Sub Total		฿	1,307,000
Total (A + B)		฿	4,495,000
II. Reservation	1 L.S	฿	450,000
III. Miscellaneous	1 L.S	฿	247,000
Grand Total (I + II + III)		฿	5,192,000
		(¥	27,000,000)
		(฿1.0=¥5.2)	

7 - 3 Bill of Quantities

BILL OF QUANTITIES

Item	Description	Unit	Quantities	Unit Price	Price	Remarks
I. Direct Cost						
1. Earth Works						
1-1	Excavation of testing canal facility by dry excavation	m^3	8,690			
1-2	Excavation of testing canal facility by wet excavation	m^3	6,910			
1-3	Embankment of coffer dam	m^3	95			
1-4	Excavation of drainage ditch	m	278			
1-5	Miscellaneous works	L.S				
	Sub Total					
2. Foundation Improvement Works by Soil Cement Columns						
2-1	Soil cement column of 5.5 m in average length	column	53			cement content:150kg/m^3 ϕ1,000mm
2-2	Soil cement column of 13.8 m in average length	column	70			- Ditto -

BILL OF QUANTITIES

Item	Description	Unit	Quantities	Unit Price	Price	Remarks
2-3	Temporary works	L.S				
	Sub Total					
3. Foundation Improvement Works by Sand Compaction Piles						
3-1	Sand compaction pile of 5.0 m in length	pile	217			ϕ 700 mm
3-2	Temporary works	L.S				
	Sub Total					
4. Experimental Construction Works for Foundation Improvement Works						
4-1	Laboratory tests for soil cement columns	L.S				
4-2	Laboratory tests for materials of sand and gravel compaction piles	L.S				
4-3	Experimental construction for sand compaction piles of 5.0 m in length and 0.70 m in diameter	pile	3			

BILL OF QUANTITIES

Item	Description	Unit	Quantities	Unit Price	Price	Remarks
4-4	Experimental construction for gravel compaction piles of 5.0 m in length and 0.70 m in diameter	pile	3			
4-5	Standard penetration test	time	14			
4-6	Boring for standard penetration tests	m	14			
4-7	Thin wall sampling	time	8			
4-8	Boring for thin wall sampling	m	14			
4-9	Core boring	m	6			
4-10	Field density tests for sand and gravel compaction piles	time	4			
4-11	Laboratory tests for natural moisture content of soil	sample	26			
4-12	Laboratory tests for wet density of soil	sample	26			
4-13	Laboratory tests for unconfined compression tests	sample	14			
	Sub Total					

BILL OF QUANTITIES

Item	Description	Unit	Quantities	Unit Price	Price	Remarks
5. Other Miscellaneous Works						
5-1	Installation of concrete fixed points	nos	8			
5-2	Installation of wooden displacement piles	nos	150			
5-3	Protection of monitoring instruments and cables	L.S				
		m	230			
	Sub Total					
6. Shifting of Existing Houses						
6-1	Shifting of existing house	L.S				192 m^2
6-2	Shifting of existing house	L.S				28 m^2
	Sub Total					
	Total (I)					

Item	Description	Unit	Quantities	Unit Price	Price	Remarks
II. Indirect Cost						
1.	Common temporary works	L.S				
2.	General site expense	L.S				
3.	Overhead expense	L.S				
	Sub Total					
	Total (II)					
	Grand Total (I + II)					

CHAPTER 8 BID DOCUMENTS (DRAFT)

8-1 Bid Documents (Draft)

8-2 Technical Specifications (Draft)

BID DOCUMENTS

C O N T E N T S

BID DOCUMENT

ON

CONSTRUCTION OF MODEL INFRASTRUCTURE OF SOFT SOIL FOUNDATION

FOR

THE IRRIGATION ENGINEERING CENTER PROJECT

IN

THAILAND

THAILAND OFFICE

JAPAN INTERNATIONAL COOPERATION AGENCY

JAPAN INTERNATIONAL COOPERATION AGENCY,THAILAND OFFICE

INVITATION TO BID

The Japan International Cooperation Agency,Thailand Office hereby invites you to submit the sealed written bids on the Construction of Model Infrastructure of Soft Soil Foundation for the Irrigation Engineering Center Project which is located in charoenvay,Samur Prakan Prefecture.

This Contract will include,among,others the followings;

1. Invitation to Bid
2. Instruction to Bidders
3. Terms and Conditions of the Contract
4. Pledge Agreement
5. Contract
6. Technical Specifications
7. Bill of Quantities
8. Drawings
9 Proposal

Bids shall be addressed to Mr. Tsutomu SAITO,President Representative,Japn International Cooperation Agency, Thailand Office,
C/O Embassy of Japan,1674,New Petchburi Road, Bangkok, Thailand,and marked "Sealed Proposal,Model Infrastructure Project of Softf Soil Foundation".

The date for the opening of bids will be held at..... o'clock p.m.(a.m.),.....Standard Time on (month) (day) ,1988 at the JICA,Thailand Office.Mr.Tsutomu SAITO PRESIDENT Representative of JICA Thailand Office.

INSTRUCTION TO BIDDERS

IB-01 PREPARATION OF BIDS

All bids shall be submitted in an original and three (3) copies on or before the hour and date fixed for receipt of bids, in accordance with the Invitation for Bids, and shall conform to the following requirements;

a) One copy of proposal shall be marked "Original". The original and copies of bids shall be submitted in its entirety with all blanks in the proposal properly filled in.

b) Bids prices shall be written in words as well as in figures. In case of discrepancy between the words and figures, the price in words shall prevail.

c) The proposal must be signed by the Bidder with his usual signature and shall show his full business address.

IB-02 BASIS ON WHICH BIDS ARE REQUESTED

The from of the Contract to be awarded is on fixed unit price basis of payment to the Contractor, as specifically set forth in these Contract Documents. Bids are requested on the above basis and a prpoposal which is on any other basis will not be considered.

Quotation of prices shall be made in Thai Bath and the Contractor shall be paid in Local Currency.

IB-03 BID SECURITY

The original, but not the copies of each bid, shall be accompanied by a proposal bond in an amount equivalent to (10)% of the total bid price in the form of cash or certified check, as a guarantee that the successful bidder will, within ten (10) days from receipt of the notice of award, enter into Contract with the Japan International Cooperation Agency, Thailand Office, and complete faithful performance of the work specified in these Contract Documents. In case the successful bidder fails for any reason to execute

such contract within the stipulated time, the bid security shall be forfeited to the Japn International Cooperation Agency, Thailand Office, as liquidated damages.

The bid securities will be returned without interest after the successful bidder has signed the Contract.

IB-04 DELIVERY OF BIDS

Bids shall be directly delivered to JICA Thailand Office,to Mr. Tsutomu SAITO on or before the hour and date set for the opening of bids.

IB-05 WITHDRAWAL OF BIDS

A bidder will be allowed to withdraw his bid prior to the time set for the opening of bids if he communicate his purpose in writting to the Japan International Cooperation Agency, Thailand Office, and his bid shall be returned to him unopened. No bid can be withdraw for any reason whatsoever after the opening of bids has been made.

IB-06 BIDDER'S RESPONSIBILITY

The Bidders shall be responsible for having taken steps to carefully examine all of the Contract Documents and also to have fully informed themselves as to all conditions, local and otherwise, affecting the carrying out of the Contract Works.

Failure to do so will be at the Bidder's risk.

IB-07 DATA TO BE SUBMITTED WITH PROPOSAL

All proposal shall contain the following document:

a) A construction schedule showing the detailed proposal plan of operation and construction of each main item in the Bill of Quantities from start to completion of the Contract work.

The schedule shall be in a bar chart form with weeks shown as the least unit of time and each main item on a separate horizontal line. The schedule shall also show expected monthly accomplishment and financial requirements based on the Bill of Quantities.

b) A list of equipment proposed to be used for the performance of the Contract work. This list shall specifically enumerate the number, type and capacity.

IB-08 INTERPRETATION OF CONTRACT DOCUMENTS

If the prospective Bidder is in doubt as to the true meaning of any part of the Contract Documents, the Bidder may submit to the Japan International Cooperation Agency, Thailand Office,a written request for interpretation allowing suffecient time for a reply to reach him before submission of his bid. Any interpretation of the proposed documents will be made only by a Supplemental Notice duly issued.

IB-09 PRE-BIDDING CONFERENCE

A pre-bidding conference will be scheduled on (month) (day) ,1988 at (hour) o'clock p.m./(a.m.) at JICA Thailand Office

Attendance for Conctractors is desirable but not mandatory.

IB-10 COMPARISON OF BIDS

In making its selection, the Japan International Cooperation Agency Thailand Office will not be bound to award a Contract to the Bidder submitting the Bid with the lowest indicated cost, but will take into consideration the bid prices, unbalanced bids, guaranteed completion time and other relevant consideration.

IB-11 AWARD OF CONTRACT

Bids will be opened in the presence of the Bidders who may desire to attend such opening by the Japan International Cooperation Agency, Thailand Office, at (hour) o'clock p.m./(a.m.) (Thailand) Standard Time on (month) (day), 1988.

Promptly after the opening of the bids the Japan International Cooperation Agency, Thailand Office will undertake a detailed study and appraisal of the proposal submitted. The Contract will be award to the Bidder whose proposal is considered to be most advantageous to the Japan International Cooperation Agency, Thailand Office. The Japan International Cooperation Agency, Thailand Office reserves the right

to reject any and all bids received.

IB-12 BID DOCUMENTS

BID DOCUMET SHALL INCLUDE THE FOLLOWING;

A) INVITATION TO BIDS

B) INSTRUCTION TO BIDDERS

C) TERMS AND CONDITIONS OF THE CONTRACT

D) PLEDGE AGREEMENT

E) CONTRACT

F) TECHNICAL SPECIFICATION

G) BILL OF QUANTITIES

H) DRAWING

I) PROPOSAL

TERMS AND CONDITIONS

OF THE CONTRACT

ON

CONSTRUCTION OF MODEL INFRASTRUCTURE OF SOFT SOIL FOUNDATION

FOR

THE IRRIGATION ENGINEERING CENTER PROJECT

IN

THAILAND

THAILAND OFFICE

JAPAN INTERNATIONAL COOPERATION AGENCY

TERMS AND CONDITION OF THE CONTRACT

Section 1 General Information

1.1 Objective

According to the Record and Discussion signed March 8,1985,a five-year-cooperation concerning the Irrigation Engineering Center Project in Thailand (hereinafter refered to asI.E.C Project) has been started since April 1,1985. Besides,the Royal Irrigation Department requested JICA to start the Model Infrastructure Project (hereinfter refered to as the Project) for the study on Soft Soil Foundation under the I.E.C. Project.

The objective of the work are to construct the Testing Canal Facility and Monitoring System for the purpopse of the investigation, planning and design of structures to be constructed on Soft Soil Foundation as one of I.E.C. Project's activities.

1.2 Location of the site

The job site is located in Bang Pu Kao Village,Samut Prakan Prefecture about 40km to the southeast of the center of Metropolitan Bangkok as the crow files and about 600 meters inland from the coast of the Gulf of Thailand. The location of the Project Site is at latitude about 13° 30′ north

and at longitude about 100° 45′ east.

1.3 Callaboration

According to the objective of technical cooperation, the counterpart agency of JICA, the Royal Irrigation Department (hereinafter refered to as R.I.D.), is executing several investigations around the job site. Prior to or during the course of the works, the Contractor shall make the good relation with R.I.D. for the satisfactory implmentation of the works to secure full collaboration. Should it happen that the relation between R.I.D. and the Contractor is disputed, the Contractor shall inform against the matter to the Inspection Committee who will conciliate the both parties.

Section 2 Submission of Notices

2.1 Work schedule

The Contractor shall submit the work schedule in the following item before the commencement of the work at the job site. If the Contractor intends to change the work schedule, the approval from the Inspection Committee shall be obtained prior to the modification of the schedule.

1. Preparation of facilities and transportation of equipment etc. to the job site.
2. Dewatering work
3. Construction road
4. Foundation treatment for foundation improvement work
5. Foundation Improvement works by Soil Cement Colums
6. Foundation Improvement works by Sand or Gravel Compaction Piles
7. Excavation of testing canal facility
8. Other work

Also the Contractor shall submit the machineries scheme including the numbers, and kind of machineries and using period of them.

2.2 Notices

The JICA and the Contractor shall submit the notices to each other, as necessary, in accordance with Article 19 in the Construction Contract Document within reasonable time except that special articles are provided in the Contract Document and Terms and Conditions of the Contract.

Section 3 Field Test and Inspection

The field tests in accordance with the Technical Specifications and the demands from the Inspection Committee shall be the responsibility of the Contractor. The charges for such field test shall be included in the total amount of the construction cost, and the Contractor is not entitled to claim any amount of the field test charges.

Section 4 Modification of Plan

In case JICA estimates the cost for the modification in accordance with Article 14, and if there are two portions, one for the increase and the other for the decrease of the construction cost resulting from such modification, JICA shall have the right to offset them in the payment and pay or claim the difference between the increase and decrease of the construction cost as the case may be.

Section 5 Release from the Work

After the final acceptance of the work by JICA, the Contractor shall remove its own temporary facilities, office, warehouses, construction roads, electric wiring, surplus material, debris and so forth which were provided by

the Contractor within 10 (ten) days.

Upon approval of the Inspection Committee for the removal of the abovementined facilities etc., the Contractor will be released from its responsibility of the works but remains respoonsible under 1 (one) year guarantee of the work as apecified in Article 11 in this Contract.

Section 6 General Obligations of the Contractor

6.1 Temporary office and residence

In case the Contractor intends to build the temporary office, residence and so forth, the Contractor shall submit the plan to the Inspection Committee for approval at least 10 (ten) days in advance of the commencement of the work.

The Contractor is required to always keep the buildings and facilities in good condition and to make proper drainage and sanitary system. Should the Contractor build them outside of the job site, the Contractor shall arrange with the owner of such land and at its own expense.

6.2 Fuel storage

In area of temporary office and residence, the fuel tank capacity shall not exceed the reguration of Thailand and shall be far away from the housing area.

Fuel storage and transportation shall be done with care and shall have a good system of fire prevention. If storage licence is required, the Contractor shall arrange for obtaining it.

6.3 Other facilities

All necessary facilities for the work and the Contractor's convenience shall be provided and maintained in good condition by the Contractor.

Section 7 Monitoring System

The installation work of monitoring instructions should be carried out by the nominated supplier himself, not the contractor.

In case that the Grovement of Jopan provides the Goverment of Thailand with the monitoring instructions such as inclinometers, settlement gauge, piezometers, extensoment, and so forth for the Project, the Contractor shall exercise utmost care so that his construction operation will not damage any installed monitoring instrument.

Section 8 General Text

The Contractor shall implement the works in accordance with the Contract Documents in broad sence, such as the Contract, Terms and Coditions of Construction Constract, Technical Specifications and Guideline for Supervision. Should the events occur that the both parties can not reach agreement on the interpretation of the above-mentioned Contract Documents in broad sense,both parties shall negotiate with sincerity and good faith for settlement of any disagreement,and if failing which the decision of the JICA shall prevail.

PLEDGE AGREEMENT

Date , 1988

To Japan International Cooperation Agency, Thailand Office

We, ...,the Contractorherby agree that all equipment, materials and supplies brought to the job site under the Construction Contract made with JICA dated on ..... 1988, shall be pledged by us with the JICA as security for our execution of work, and shall not be removed at any time without prior approval of JICA in writing.

We further agree that should there by any loss or damage to pledged equipment, materials and supplies kept at the job site, JICA shall bear no responsibility whatsoever for such loss or damag.

Coneractor's Signature)

CONTRACT

ON

MODEL INFRASTRUCTURE OF SOFT SOIL FOUNDATION

FOR

THE IRRIGATION ENGINEERING CENTER PROJECT

IN

THAILAND

THAILAND OFFICE

JAPAN INTERNATIONAL COOPERATION AGENCY

CONTRACT

ON

Construction of Model Infrastructure of Soft Soil Foundation for the irrigation Engineering Center Project in Thailand

This Contract is executed on the ..... day of ..... 1988 at the JICA Thailand Office between Japan International Cooperation Agency, Thailand office by Mr.Tsutomu SAITO, Resident Representative as its authorized representative of JICA Thailand called "JICA" of the one part,

and

whose office is situated at .....

road ..... Tambon ..... Amphon ..... Changwat .....

Tel. ..... Represented by .....

Nationality ..... Title .....

hereinafter called "the Contractor", of the other part.

Both parties mutually agree under the terms of this Contract as follows:-

Article 1 Purpose of agreement and Contract Price

THe JICA agrees to employ Contractor and the Contractor agrees to perform the work for the construction of Model Infrastructure of Soft Soil Foundation for the Irrigation Engineering Center Project located at Charoensay,

Samut Prakam Prefecture,for the toal amount of .....

..... Baht.(..... .....), hereinafter called "Contract Price".

The following documents shall form integral part of the Contract:-

Terms and conditions of this contract .....

Pledge agreement .....

Technical specifications .....

Bill of Quantities .....

Drawings .....

Article 2 Performance Bond

As a security for the faithful performance of the work under this Contract, the Contractor has on the execution of this Contract deposited a perfoumance bond with JICA ..... Baht (.....)in cash,or in Iieu thereof a Bank Guarantee issued by the .... bearing the number ..... and dated ..... in the amount of ..... Bhat (.....) which represents five (5) percent of the Contract Price, the name of the issuing bank and the form of the bank guarantee are to be approved by JICA.

The JICA will return the performance Bond in cash or the bank guarantee to the Contractor as the case may be at the end of the twelve (12) months after final acceptance of the work by JICA as stipulated in Article 15 of this Contract, provided taht the completed work shall not show any defect or damage caused through the fault of the Contractor, or through the fault of any new Contractor in the case of termination of Contract by JICA under Article 4.

Should the Contractor by in default, JICA shall have the right to demand payment from all or any part of the performance bond. In addition, the Contractor shall remain liable for the full loss sustained by JICA.

Article 3 Payment

The JICA agrees to effect payments for the work to the Contractor in the following manner:-

a. Advance Payment, to be effected upon the bringing of equipment and materials required for the work and properly stored at the job site by the Contractor and of value estimated by the Inspection Committee. _____ _____ which corresponds to Thirty (30) percent of the Contract Price shall be paid upon signing of this Contract.

b. Interim Payment, to be effected according to the progress of the work satisfactorily executed by the Contractor and accepted by the Inspection Committee. _____ which corresponds to Thirty (30) percent of the Contract price shall be requested for payment at _____.

c. Final Payment, to be effected upon the satisfactory completion of the work by the Contractor and accepted by the Inspection Committee.

The remainder of _____ which corresponds to Forty (40) percent of teh Contract Price, shall be paid after the Final Certificate by the JICA for payment to the Contractor.

Payment under (b) and (c) shall be effected within _____ day after the respective acceptance of the work by the Inspection Committee.

Taxes payable by the Contractor, if any, shall be deducted at source by JICA on each payment.

It is expressly understood that payments by JICA do not mean acceptance responsibilities under this Contract.

Article 4 Completion Time

The Contractor agrees to commence the work at the site within ten (10) days from the date of signing of the Contract (commencement date) and the Contractor agrees to satisfactorily complete the work within ..... days (completion time) after the date hereof which will become due on ..... 1987 (completion date).

If the Contractor fails to commence the work by the above commencement date, or should in the course of the construction any event occour which may reasonably cause JICA to believe that the Contractor will not be able to complete the work on the completion date, or should the Contractor fail to meet any of the Contract requirements, JICA shall have tha right to terminate the Contract by giving written notice to the Contractor.

However, in case that the Contractor fails to complete the work by the completion date, or to meet any of the Contract requirements, if the Inspection Committee judges that the Contractor has the ability for completion of the work within reasonably extended period, the Contractor may be permitted by JICA to continue the work beyond the completion date but within the time.

Article 5 Penalty

In case that the Contractor is in default as mentioned in Article 4, the Contractor agrees to be responsible to JICA as follows:-

5.1 In case of the termination by the default of commencement for the work, the Contractor shall pay a penalty of twenty thounsand Baht (20,000.00 Baht) per day counting from the commencement date until the new Contract is completely executed with a new Contractor for this work, the period of which is included the time spent for finding the new Contractor and excuting the new Contract etc.

5.2 In case JICA judges that the Contractor will not be able to complete the work within the completion time and thereby terminates the Contract, the Contractor shall pay a penalty of twenty thousand Baht (20,000.00 Baht) per day counting the number of days in the same manner as prescribed in 5.1 above. However, the JICA may reduce such number of days according to the ratio between the completed work and the total work as may be decided by the Inspection Committee.

5.3 In case the Contractor fails to complate the work by the completion date or to meet any Contract requirement, the Contractor shall pay a penalty of twenty thousand Baht (20,000.00 Baht) per day counting from the date

following the completion date until the work satisfactorily completed and accepted by the Inspection Committee.

Aricle 6 Compensation

If JICA sustains any losses as direct or indirect damages caused by the Contractor's failure, the Contractor shall compensate JICA for such losses. The parties agree that time is essential for completion of the work.

Article 7 JICA's right for default

The JICA has the sole and absolute right to decide whether to terminate the Contract, to impose only the penalty on the Contractor or to claim the compensation for fhe damage as stated in Article 5 or Article 6. The money due to JICA exercising its right under this article shall be retained and deducted form any money due to the Contractor but yet unpaid, including from the performance bond. If the total amount of the loss is larger than the money above-mentioned, the Contractor agrees that the JICA has the right to retain the construction equipment, materials and supplies etc. and demand payment of the balance from such equipment etc. or proceeds of sale thereof.

Article 8 Contractor's responsibility on termination of the Contract

After the Contract has been terminated in accordance with the foregoing Article 4, JICA shall have the right to employ another Contractor (hereinafter called the "New Contractor") to carry out the ramaining parts of the work, and the payment for the Contactor that fail to complete the work shall be made out of the necessary Contract Price for the remaining work. Should the remaining amount after payment of the advence and interim payment from the Contract price, be insufficient to effect payment to the new Contractor, the difference between such remaining amount and actual cost estimated by JICA for the satisfactory completion work carried out by the New Contractor, shall be deemed as direct loss sustained by JICA, and the Contractor shall pay such difference to JICA within ten (10) days from the date of request by JICA, failing which interest at the rate of eighteen (18) percent per annum shall be charged thereon.

Article 9 Inspection Committee

The Inspection Committee, authorized to act on behalf of JICA will be appointed by JICA and the Inspection Committee is entitled to do all things that JICA may do so. The Inspection Committee shall control and supervise the work

all the times shether it is in the preparation or implementation of the work and the Contractor shall promptly furnish all necessary Facilities for proper inspections of the work in accordance with the Inspection Committee's repuest. At any moment the Inspection Committee can request the Contractor to stop the Works, if necessary and the Contractor shall have no claim on JICA for extension of the completion time due to such suspension of the work under this Article.

The inspection will not be deemed as the acceptance of the work, and the Contractor shall not be relieved from his responsibility to meet the Contract requirements by the fact that the Inspection Committee exercise their duties. Should it be found that the work has not been satisfactorily performed in the faithful manner, the Contractor shall correct any part of the work indicated by the Inspection Committee within the period specified by the Inspection Committee.

Article 10 Prohibition for the equipment removal

Should the Contractor fail to complete the work during the completion time or the Inspection Committee judges that the Contractor will not be able to satisfactorily complete the work, any equipment and materials brought to the site for use on the work shall not be removed without the prior approval of the Inspection Committee in writing.

Article 11 Rectification of the defective construction

For a further period of one (1) year after satisfactory completion and final acceptance of the work by JICA, whether completed by the Contractor or by the new Contractor in case of termination of Contract under Article 4, any damage to the work which is caused by the Contractor's fault, either because of defective workmanship or the use of inferior materials or any other cause, shall be made good as necessary by the Contractor to the satisfaction of JICA at no extra cost.

In case of the termination of the Contract, JICA may decide which part of the work should come under the Contractor's responsibility, and requests the Contractor to make good of the damaged work. Should the Contractor fail to do so within period specified after receipt of written request to do so from the JICA, JICA shall have the right to employ another Contractor to carry out such work and the Contractor agrees to fear all expenses incurred.

Article 12 Discrepancies among the Contract Documents

If, prior to or during the course of the work, any discrepancies are found in the drawings and/or the Technical Specification etc. attached to the Contract, the Contractor

shall follow the ruling given by the Inspection Committee at no additional cost to JICA.

Article 13 Construction method and temporary work

The construction method including implementation schedule and plan of the temporary work such as installation of temporary facilities, offices, ware houses, construction roads, electric wiring, etc. shall be submitted by the Contractor and approved by the Inspection Committee at least 10 (ten) days in advance of the commencement of the work.

Should the cost of the above temporary work be estimated in the unit cost of each work items of Bill of Quanities in this Contract, and the Contractor is not entitled to claim any amount of charges for the temporary work.

Article 14 Mondification of plan

If the Inspection Committee finds it necessary to make modification of construction design, quantities and/or materials and so forth during the course of construction, JICA has the right to order the modification of the work to the Contractor, and such order shall be made in writing from the Inspection Committee to the Contractor.

The JICA agrees to adjust upwards or downwards the necessary expense for such modification to the Contractor, which will be estimated by unit price in the bill of quantities of the Contract in case of modification of quantities of construction works. In the case of additional work which are not quoted by unit price in the bill of quantities of the Contract, the Inspection Committee will make estimation thereof and JICA will pay to the Contractor for such additional works accordingly. But if the Contractor does not agree to such estimation, the Contractor is then entitled to negotiate with JICA. Also the extension of the completion time due to the modification shall be given by JICA who shall have the sole right to decide the number of days of such extension.

Article 15 Acceptance of the work

When the entire work has been completed, the Contractor shall submit the invoice in written form indicating the work actually completed to the Inspection Committee. If there are compliance with drawings or Technical Specifications, JICA shall accept the work as the final acceptance of satisfactory completion work within ten (10) days after the receipt of the written form and it shall be deemed that the final acceptance has been made on such date of the receipt of the written form.

On the other hand, should non-compliance with drawings or Technical Specifications or defects be found in the work executed by the Contractor, the Inspection Committee will have the right not to accept the work and to order the rectification of the work. If the required period for the rectification of the work is beyond the completion date, the Contractor shall not be relieved from its responsibility to pay the penalty as stipulated under clause 5.3, and after the completion of rectification of the work, then the final acceptance will be made in the same manner as descirbed in the first paragraph of this Article.

During the course of construction, whether in the completion time or of extended time specified in the last paragraph of Article 4, JICA has the right to accept a part of the work already completed in the written form which shall be considered as a part of final acceptance. However, both parties shall negotiate with each other for the maintenane and usage of the accepted part of the work, and the Contractor is not entitled to request the extension of the completion time due to any interruption caused by the use of such accepted work by JICA, the Inspection Committee or the officers of Thai Government authorities, or any delay in repairing such accepted work.

Article 16 Construction engineer

The Contractor shall appoint a construction engineer at his own expence for the supervision of the work performance, who shall be authorised to act on behalf of the Contractor, and the instructions given to him shall be deemed as given to the Contractor. and accepted by JICA, who shall stay at the job site all the time and shall not leave without obtaining the prior approbal of the Inspection Committee. If the Contractor replaces the construction engineer, the Contractor shall obtain the prior approval from the Inspection Committee in writings.

Article 17 Replacement of Labour, Engineer and Foreman

The Inspection Committee may request the Contractor to remove any of the Contractor's labours, foremen or engineers if it appears to the Inspection Committee that such labourer, foreman or engineer is incompetent for his job or is not suitable or is not capable of handling his workmen or staff, and the Contractor shall promptly replace any such labourer, foreman or engineer. No extra cost or claim for extension of time will be allowed because of such replacement.

Article 18 Sub- Contractor

The Contrctor shall not sub-contract or assign any portion of the work under the Contract without obtaining the prior appoval of JICA who has the sole right to decide which portion of the Works may be sub-contracted or assigned to the sub-Contractor. However, the Contractor shall be fully responsible fothe work done by the sub-contractor.

Article 19 Notice

All notices required by the Contract shall be effective only at the time of receipt thereof, and only when received by the parties concerned at following address:-

JICA Thailand Office.
1674/1 New Petchburi Road, Bangkok.

The Contractor .....
.....
.....
.....

All notices required by the terms of the Contract shall be made in writing in English Laungage,and delivered by registered mail or hand delivery.

Article 20 Dispute

In the event of any dispute arising from the interpretation and performance of the terms of the Contract, both parties agree to make the best attempt with sincerity and in good faith to negotiate and amicably settle such dispute, failing which the parties agree to refer such dispute to arbitration under Thai Commercial Arbitration Rules and Regulation, Bangkok, by twoo(2) arbitrators, each of which is to be appointed by each party. If either party fails to appoint its arbitrator within seven (7) days or should the arbitrator fail, within fifteen (15) days after their appointment, to agree upon the decision of the dispute or no decision is reached on the appointment of an umpire, then dispute shall be brought before the Court the Thainland decision under the laws and procedures of the Kingdom of Thailand.

The Contract is executed in duplicate of same tenor, one of the original copy to be kept by JICA and the other original copy to be kept by the Contractor. Both JICA and the Contractor have set their signatures and affixed the seals thereto in the presence of the witnesses.

JICA

Mr.Tsutomu SATO, Resident Representative,
Thailand office, Jaapan International Cooperation
Agency

Contractor

Witness

Witness

8-2 Technical Specifications (Draft)

TECHNICAL SPECIFICATIONS

ON

CONSTRUCTION OF MODEL INFRASTRUCTURE OF SOFT SOIL FOUNDATION

FOR

THE IRRIGATION ENGINEERING CENTER PROJECT

IN

THAILAND

THAILAND OFFICE

JAPAN INTERNATIONAL COOPERATION AGENCY

(JICA)

TECHNICAL SPECIFICATIONS

PART 1. SPECIAL PROVISION

PART 2. GENERAL CONSTRUCTION FACILITIES

PART 3. CARE OF WATER DURING CONSTRUCTION

PART 4. COFFER DAM

PART 5. EXCAVATION

PART 6. EXPERIMENTAL CONSTRUCTION OF FOUNDATION IMPROVEMENT WORKS

PART 7. IMPROVEMENT WORKS OF FOUNDATION BY SAND COMPACTION PILE METHOD

PART 8. IMPROVEMENT WORKS OF FOUDATION BY SOIL CEMENT COLUMN METHOD

PART 9. IMPROVEMENT WORKS OF FOUNDATION BY GRAVEL COMPACTION PILE METHOD

PART 10. OTHER RELATED CONSTRUCTION WORKS

TECHINCAL SPECIFICATIONS

PART 1 SPECIAL PROVISION

1-01 The Contractor shall exercise utmost care so that his construction operations will not damage any existing structure except such structures as specified to be dismantled. Any damages on the such existing structure or facilities shall be made good by the Contrctor at his expense.

1-02 If it is necessary in the prosecution of the work to interrupt or obstruct the drainage of the surface,the flow of artificial drains and the flow of irrigation canal, the Contractor shall provide for the same during the progress of the work in such a way that no damage shall result to either natural or artificial irigation or drainage which he may interrupted,he shall be held liable for all damages which may result therefrom during the progress of the work.

1-03 The Contractor is expected to visit the location of the work and make his own estimate of the facilities needed for the work.
In the successful execution of the Contract, the Contractor is expected to familiarize himself with local conditions, availability of labour, transporation facilities,uncertainties

of weather,and other contingencies. From investigations, made at site, it is believed that topographical conditions are approximately as shown on the drawings, but the nature of the materials and the depth of satisfactory foundations, are not guaranteed. It is expressly understood that JICA will not responsible for any deduction, interpretation, or conclusions made by the Contractor. JICA does not guarantee that other materials will not vary from those indicated by the drawings.

1-04 Elevation referred to the datum plane are to be determined from bench marks established by JICA or the Inspection Committee at the site of the work.

1-05 The Inspection Committee will establish the necessary survey monuments and bench marks at convenient points in the area covered by this contract for use of the Contractor in laying the lines and grades required for the proper conduct and execution of the work. All stakes, bench marks, etc., placed by the Inspection Committee in laying out the work shall be carefully guarded and preserbed by the Contractor, and in such case stakes or marks are misplaced or rendered useless through the carelessness or negligence of the Contractor or his agents, employees or workmen, they will be replaced by the Inspection Committee at the expense of the Contractor.

1-06 The Contractor shall execute the work to the lines and grades given by the drawings and/or the Inspection Committee. The Contractor shall, at his own expense, furnish all stakes, templates, pattern, platforms and labor that may be required in setting or laying out any part of the work.

PART 2 GENERAL CONSTRUCTION FACILITIES

2-01 SCOPE

This part covers the construction and/or maintenance of access roads, setting up of Contractor's camp facilities, providing camp security and the disposition of the Contractor's various facilities at the end of the Contract.

2-02 ROADS

(a) The Contractor shall improve, repair and widen, if necessary, existing roads to satisfactorily meet his haulage requirements. He shall also construct all other roads within the construction area which he deems necessary in the prosecution of his work. The improving, widening new roads shall be made without cost to JICA, and same shall be the responsibility of the Contractor during and up to the completion of all construction work under the Contract.

2-03 CONTRACTOR'S CAMP FACILITIES

(a) If the Contractor deems necessary, he shall grade his camp site; construct his office, employees'housing, warehouses, machine and repair shops, fuel storage tanks; and provide such other facilities that the Conrtactor deems necessary for maintaining health, peace and order in the camp and work area.

(b) The location,construction, opeation and maintenance of such camps and facilities shall be subject to the approval of the Inspection Committee. At least ten(10) calendar days to the date on which the Contractor desires to begin to work on in feature of camp construction, the Contractor shall submit for the approval of the Inspection Committee drawings and specifications, in sufficient detail to permit determination of suitability of the construction in compliance with these specifications, and no camp construction of any kind shall be undertaken until such drawings and specifications have been approved by the Inspection Committee.

2-04 CAMP SECURITY

The Contractor shall provide his own security force to the extent that the deems necessary for maintaining peace and order in the camps and work areas and to safeguard materials and equipment.

2-05 DISPOSITION OF CAMP AND CONSTRUCTION FACILITIES

After the completion of the work covered by the Contract,the entire camp of the Conrtactor, including its water supply system, quarters, warehouses, shops and other facilities therein; and all other temporary installations at work areas shall be removed by the Contractor and the site shall be cleaned.

APART 3 CARE OF WATER DURING CONSTRUCTION

3-01 SCOPE

In accordance with specifications contained in this part, the Contractor shall care the water during construction so that improvement work of foundation and excavation of testing canal can be performed in areas free from water. Care of water during consrtuction shall include provision for drainage and pumping system for dewatering the specified areas corresponding to the construction methods and the stages, the construction of coffer dam, drainage canal and temporary bulkheads necessary for the protection of construction operations from encroachment by water.

3-02 DRAINAGE AND PUMPING

The contractor shall submit a water control plan during a whole construction period for approval by the Inspection Committee at least one (1) week in advance of the dewatering all work areas so that work can be carried out in a suitable dry condition by draining and/or pumping all water during the process of construction until its completion except for a certain space of pontoon if used.

The Contractor shall construct drainage ditches, pits,culverts, dikes or other protective work to ensure that surface water of any origin be kept away from the work areas and shall furnish, operate, and maintain at his own expense all necessary pumps, to keep all work areas in amply dry condition, and prior to final acceptance of the work by JICA, the Contractor shall remove, fill or plug all temporary drainage structures and pumping equipments at his expense.

The Contractor shall be fully responsible for any damage or delay to the work caused by failure of dewatering of protective work, and also shall repaire or reinstate at his expense any damage to foundations, excavation slopes or any other parts of the work.

Pumped water shall be discharged to a suitable distance as far as possible from the work area. The systems used for dewatering and water eliminations shall not cause any damage to the testing canal facility.

3-03 PAYMENT

No separete payment shall be mada for the care of water during construction. But the cost of furnising, constructing, operating, maintaining,and removal of temporary drainage structures, canals, and pumping system necessary to keep construction operations free from water shall be included in

the item of Temporary Works as indicated in the Bill of Quantities.

PART 4 COFFER DAM

4-01 SCOPE

This part covers the work necessary to construct, maintain a coffer dam necessary to protect the works from water coming from and/or discharging any source including sea, river, rain and subterranean, so that performed work, except where precisely approved, can be performed free from stagnant and/or running water.

4-02 COFFER DAM

A coffer dam at the lower part near an existing shrimp farm shall be constructed and maintained in accordance with the drawings and these specifications.

The coffer dam at the lower part is to be constructed for the permanent structure. The Contractor shall install dischrage pumps near the coffer dam and shall operate the dewatering artificially during construction period at this own expense.

4-03 MATERIALS

The Contractor shall submit for the appoval of the Inspection Committee locations, areas, drawing and other necessary specifications of borrow areas which the Contractor proposes to use for obtaining fill material.

The Contractor shall maintain and operate sufficient excavating and hauling equipment so that an adequate amount of fill material from all sources is available as required. Operations in borrow areas shall not be on danger roads, buildings, or structures. Borrow areas shall be graded to provide drainage from all parts of the excavated areas. When operations in a borrow area have terminated, the area shall be dressed to a neat and orderly appearance, as approved by the Inspection Committee.

Materials containing brush, roots, sod or other perishable material will not be considered suitable for fills. The suitability of the materials shall be subject to the approval of the Inspection Committee.

4-04 FOUNDATION PREPARATION

All horizontal and sloped earth surfaces, upon which embankment material is to be placed or other foundation surfaces whose locations are specifically indicated by the Inspection Commmittee, shall consit of undisturbed or compacted material and shall be clean, damp, free from standing or running water and free from organic matter;and shall be as a foundation for the material to be placed upon them.

4-05 FILL

The fills shall be constructed to the lines, grades and cross sections indicated on the drawings, unless otherwise directed by the Inspection Committee. Generally,a tolerance of plus or minus 0.05 meter from the slope lines and grades shown on the drawings will be allowed in the finished surfaces of the embankments except that the tolerances shall not be continuous over an area greater than twenty (20) square meters.

The fill material shall be dumped and spread in horizontal layers having an uncompacted thickness of not over 20 cm. When material is spread, chunks larger than 10 cm in the size shall be broken down by approved means or removed.

The Contractor shall keep the elevation of coffer dam indicated on the drawings during the construction period of the work using extra banking or additional banking at this own cost.

PART 5 EXCAVATION

5-01 SCOPE

In accordance with the specifications, contained in this part, and as shown on the drawings, or otherwise directed by the Inspection Committee the Contractor shall perfrom all required open excavation and foundation preparation pertinent to the construction work.

5-02 EXCAVATION SLOPES OF TESTING CANAL

The excavation slopes of testing canal facility consists of the following four (4)types.

1. Non-treatment foundation, slope 1:4
2. Non-treatment foundation,slope 1:6
3. Sand compaction pile treatment,slope 1:3
4. Soil cement column treatment,slope 1:4

5-03 OPEN EXCAVATION

(a) Genral

Open excavation under these specifications consists of the removal, hauling, dumping, and satisfactory disposal of the all materials from required excavations for testing canal and miscellaneous excavations for other structures included under this Contract.

Open excavation shall be performed to the lines and grades

shown on the drawings or established by the Inspection Committee. The Inspection Committee may modify slopes of excavation to fit conditions encountered during construction. Such changes or modifications shall not considered by the unit prices bid. All necessary precautions shall be taken to preserve the ground outside the specified lines and grades in the soundest possible condition.

(b) Commencement of exvavation works

The excavation works of testing canal facility shall be commenced after the foundation improvement works. Any work of excavation shall not be commenced without prior approval of the Inspection Committee. After the commencement of excavation works, any loads shall not be placed on the top of slope except for the two(2) corners shown on the drawings and any heavy equipment also shall not be allowed to travel on these places.

(c) Influence of construction equipment

The Contractor shall pay upmost careful attention to decrease the influence by construction equipment on the soft soil foundation during excavation works.

At the excavation works, the contractor shall take care not to loosen the foundation of testing canal.

(d) Finishing works

Finishing excavation works shall be performed to use manual digging within thirty(30)centimeters from specified lines. The specified lines shown on the drawings shall be finished to be flat and smooth as much as possible.

(e) Monitoring instruments

The Contractor shall exercise the time of installation of monitoring instruments and cables. The Contractor shall not give any damages to the monitoring instruments and cables. In cases where any damages are caused to these facilities, the Contractor shall be liable to repair or compensate such damages at his own expense by the date appointed by the Inspection Committee.

(f) Other conditions

i. The Contractor shall pay attention to overturing, sliding and non-uniform settlement of heavy equipment on soft soil foundation.

ii. On the soft soil foundation, the maximum converted weight of heavy equipment shall be deducted less than 0.3 kgf/cm^2 using sandmat or steel plate, etc.

5-04 DISPOSITION OF EXCAVATED MATERIALS

The material comming from the excavations and not suitable to be utilized for fills, backfills and aggregates must be unloaded in disposal areas indicated on the drawings or designated by the Inspection Committee.

The Contractor shall submit for the approval of the Inspection Committee on appropriate utilization plan of the spoil area which the Contractor uses for the work under this Contract, and any kind of disposition shall not be undertaken before obtaining the said approval. Excavated material not suitable for fill or otherwise not needed shall be wasted in approved spoil areas. Spoil piles shall be constructed to the stable slopes of the material being wasted. Any spoil pile exceeding two (2) meters in height above the ground surfance shall not be performed. Spoil material shall be spread and graded so that surface drainage will not be concentrated and will not create and/or accelerate undesirable erosion in spoil areas.

5-05 MEASUREMENT FOR PAYMENT OF OPEN EXCAVATION

A survey of the areas to be excavared shall be made by the Contractor prior to the commencemnt of the work under this Contract, and all measurements of excavation shall be based on this survey without regard to any change that may occur during the prosecution of the work. All such surveys shall be the subject to check and approval by the Inspection Committee. Volumes will be computed and shall be the amount between the

original groud determined by the survey and the slopes, lines and grades shown on the drawings or established by the Inspection Committee.

PART 6 EXPEREMENTAL CONSTRUCTION OF FOUNDATION IMPROVEMENT WORKS

6-01 SCOPE

Preceeding the improvement works for foundation of the inside slopes of the testing canal, the following experimental works of improvement methods shall be carried out as shown on the drawings.

i. Sand compaction pile method

ii. Graval compaction pile method

iii. Soil cement column method

6-02 MAIN OBJECTIVE OF EXPERIMENTAL CONSTRUCTION

The Contractor shall exercise the bellow mentioned main objective of this experimental construction works.

i. To estimate internal friction angle in constructed sand compaction piles and gravel compaction piles by standard penetration tests.

ii. To confirm shear strenth of constructed soil cement column,

iii. To confirm diameters of constructed sand compaction piles and gravel compaction piles.

iv. To check influence on strength of nearby foundations caused by the introduction of sand compaction piles and grevel compaction piles.

v. To check influence on nearby foundation such as

lateral flow and swelling of original ground surface caused by foundation improvement works.

6-03 TEST ITEMS

The following tests shall be carried out in the experimental construction works.

i. Mixing test of soil cement column in a labolatory
ii. Physical property tests on the materials for sand compaction piles and gravel compaction piles.
iii. Implementation of field experimental construction
iv. Test on confirming the improvement effect of treatment (by geotechnical investigations and tests)
v. Arrangement of test results

6-04 MIXING TEST OF SOIL GEMENT COLUMN

Testing condition is shown in the PART 8.

6-05 PHYSICAL PROPERTY TEST

The following tests shall be carried out on sand and gravel material. which will be used for the main construction works.

Sample : at least one(1)sample for each of sand and gravel material from every borrow pit

Test Item : • Grain size analysis

• Unit weight

• Moisture content

6-06 FIELD EXPERIMENTAL CONSTRUCTION

The location and pile arrangement of the field experimental construction such as sand compaction piles, gravel compaction piles and soil cement columns are shown on the drawings, also the quantities of the field tests by each method shall be based on the Bill of Quantities and the following table.

Quantities of Experimental Construction

Consrction Method	Number of Pile	Length of Pile	Total Length of Pile	Remarks
Sond Compaction Pile	3	5.00 m	15.00 m	
Gravel Compaction Pile	3	5.00	15.00	
Soil Coment Column	3	6.00	12.00	mcluded in the real construction

Teh following geotechnical investiagation and tests shall be performed after the completion of the field experimental construction.

Items and Quantities of In-situ Tests for the Experimental Construction

Item of Test	Sand Compaction Pile	gravel Compaction Pile	Soil Cement Column
Standard Penetration Test(Inside the Piles)	• Location : Center of pile, 1 hole • Boring Depth : 7m • Number of Test : 7times (Depth : every 1m)	Same as the left	—
Core Bouing (Inslde the Piles)	—	—	• Location : Center of pile, 1 hole • Boring Depth : 6m • Core Sampling : 6samples (Depth : every 1m)
Thin Wall Sampling (Clay of original ground)	• Location : Center between Three Piles, 1 hole • Boring Depth : 7m • Core Sampling : 4samples • Sampling Depth : -1.0, -3.0, -5.0, & -7.0	Same as the left	—
Field Deusity Test	• Location : Center of Pile, 2hole • Numbes of Test : 2times	Same as the left	—

Items and Quantities of Tests in Laboratory for the Experimental Construction

Item of Test	Sand Compaction Pile	Gravel Compaction Pile	Soil Cement Column
1. Test on Physical Property			
• Natural Moisture Conteut	• Pile Material : 2samplas • Clay : 7samplas	•Pile Material : 2samplas •Clay : 7samplas	
• Wet Density	• Clay : 4samplas	•Clay : 4samplas	
2. Mechanical Test			
• Unconfined Compression Test	• Clay : 4samplas	•Clay : 4samplas	• Pile : 6samples

PART 7 IMPROVEMENT WORKS OF FOUNDATION BY SAND COMPACTION PILE METHOD

7-01 GENERAL

After the field experimental construction mentioned in the Clause 6-03, the improvement works of foundation by sand compaction pile method shall be carried out at the location as shown in the drawings.

7-02 WORK QUANTITY

The quantity of the works shall be as follows but the improved diameter shall be confirmed by the field experimental construction works.

Quantity of Work by Sand Compaction Pile

Leugth of Pevitration	Improved Length	Improved Diameter	Number of Piles	Total Improved Length
7.88 m	5.0 m	0.70 m	217 Piles	1,085 m

7-03 SIZE OF IMPROVED DIAMETER

The target value of improved diameter of sand compaction piles shall be 70 cm(A=0.385m²).

7-04 SAND MATERIAL

The range of particle size of sand material shall be D_{10}>D.1mm in the effective diameter of the sand and $D_{60}/D_{10}=U>5$ in the coefficient of uniformity. However the

Contractor shall follow the instruction of the Inspection Committee in case thet the coefficient of uniformity can not be satisfied with the above value.

7-05 CONSTRUCTION EQUIPMENT

The construction equipments shall be based upon the following class. The Contractor shall submit his list of construction equipment which shall be used at the job site and the approval from the Inspection Committee shall be obtained prior to the commencement of the works.

List of Construction Equipment

Name	Standard Specification
Base Machine	Crawler crane, $25^t \sim 27^t$
Guide leader	L=15m
Hammer	3t class
Bumper	not specified
Hopper	not specified
Bucket	0.3m class
Casing	ϕ40cm, L=12m, steel
Compressor	75HP
Receiver Tank	$3m^3$, 7KVA
Generator	75KVA

7-06 PROCEDURE OF CONSTRUCTION

The procedure of the construction shall be conformed to the following flow chart. In case of other construction procedure, the approval from the Inspection Committee shall be required before the commencement of the works. In order to make improvement effect on foundation by this method qreater, piling works shall be started from the outside then moved to the inside concentrically in order as shown on the drawings.