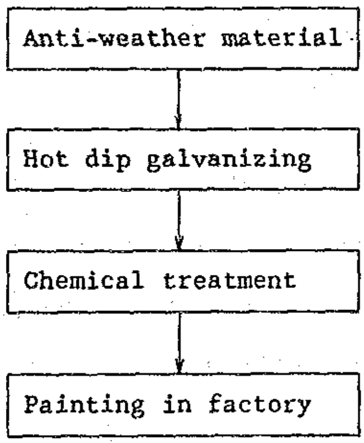
8. CAUTION FOR TOWER MATERIAL AGAINST CORROSION

8.1 General

The area where towers are to be installed is situated very near the sea, with very little precipitation throughout the year and very high humidity in the summer. As such, salt deposit on the tower surface will show marked increases as there will be no washing off by rain. Salt will easily melt getting H_2O in a high humidity environment. As salt water can easily damage steel, special treatment shall be required for the steel material.

8.2 Protection Process

The following process is recommended.



8.3 Details of Each Process

(1) Tower material

Low alloy steel with chemical composition of P, Cu, Cr, Ni, Mo, Ti, Zr, etc., which is called anti-weather steel, has the characteristic of inhibiting rust formation as shown in Fig. 8.1.

The rust grows during the first one or two years of exposure and after that, the growth becomes very steady. Once creation of this steady rust adheres to the steel surface, it works as a protective film much like paint, thereby restraining further advance of rust.

Therefore, no galvanizing nor painting is required if steady rust can be created on the steel surface.
However, to create steady rust, it is necessary for the rust to be exposed to a certain climatic condition.

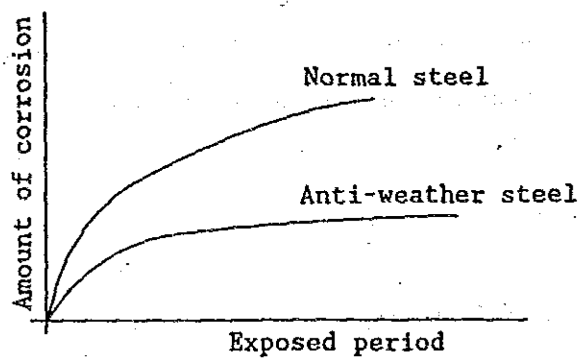
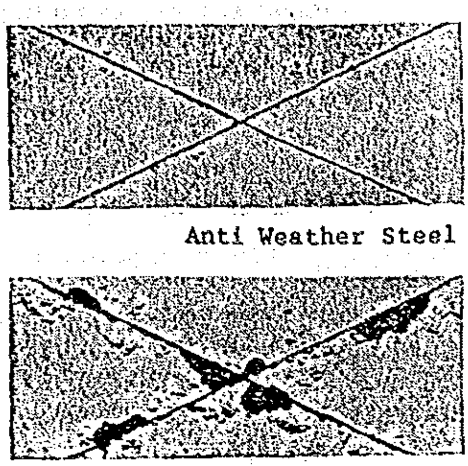


Fig. 8.1

In areas of very high humidity and extremely small precipitation, as rain cannot be expected to wash off salt or sulfurous acid gas from the surface of the steel, the rust will grow without attaining good quality.

Anti-weather steel costs approximately 10% more than the normal steel in Japan. However, this steel has the advantage in that the term of effectiveness of the paint is much longer than on normal steel, which means, maintenance costs can be reduced. According to the Corrosion Committee of the England Steel Association, the terms for repainting are 2.5 to 3 years and 4 to 5.1 years for normal steel and copper contained steel, respectively.

Fig. 8.2 shows the comparison of progress of rust on the painted surface of anti-weather steel and normal steel on which the surface was scratched to penetrate the steel interior.



Anti Weather Steel

Normal Steel

Fig. 8.2

(2) Hot dip galvanizing

Zinc galvanizing work shall conform in all respects to ASTM A-123 or JIS H0401-83 and H9124-87, and shall be performed by the hot dip process. The thickness of zinc shall not be less than 900 g/m^2, or 50% more than the standard thickness, for steel having a thickness not less than 6 mm.

(3) Chemical treatment

Galvanized steel shall be applied with phosphatizing compounds to ensure the adhesion of paint. After the phosphatizing compounds become dry, the non-reactioned liquid shall be washed out with water and powder remaining on the surface shall be removed by brushing. If white rust or rust is created on the galvanized surface, it shall be removed completely with a wire brush or power tool before applying phosphatizing compounds. Surface treatment and chemical treatment shall be done with scrupulous care, as these treatments are highly important for ensuring durability of the paint.

(4) Painting in factory

Undercoat paint

Undercoat paint shall be anticorrosive paint made of special epoxy resins, and shall be applied as early as possible after completing the chemical treatment mentioned in item (3).

Final coat paint

Final coating shall comprise anti-weather type paint having polyurethane resins. Two coats shall be applied.

(5) Example of painting

(i) Surface treatment of material

Removal of dust, grease, white stains and all foreign matter

(ii) Phosphatizing compounds

Application of PALBOND PB-36T, several coats

(iii) Undercoating

Application of 0.2 kg/m^2 and 50 μ of thickness of HI-PON 20 ACE

(iv) Final coating

Application of two coats of 0.12 kg/m^2 and 30 μ thickness each of HI-PON 50

9. INSTRUCTION FOR MAINTENANCE WORK

There are two meanings to the words maintenance work in overhead transmission lines. One is in relation to the life of the facilities, while the other is to maintain the system in satisfactory operation.

9.1 Maintenance Work for Satisfactory Operation

(1) Ordinary patrol

General conditions of the transmission lines and their surroundings visually investigated and check at least once a month for detection of any interference or hazardous situation.

(2) Trouble patrol

Situation and conditions of trouble are investigated in detail whenever trouble occurs.

(3) Inspection

Salt deposit density on insulator discs and corrosion on hardware of insulator strings are periodically checked. Faulty insulators and wash discs are detected. Damaged discs and/or hardware is replaced whenever required. The interval of disc washing shall be determined by measuring of ESDD as mentioned in Clause 9.3.

9.2 Care for Durability of Tower Life

(1) Inspection

Check shall be carried out on the condition of paint coat on tower members by visual inspection every 6 months and adhesion test of paint coat once a year.

(2) Repainting

The most effective way to ensure the durability of towers in areas similar to those found in this project is to carry out repair painting in a careful manner.

Repainting should be done as follows.

(i) Remove all rust and loose paint coat from the surface of tower members by chipping, brushing or with a motor driven tool. Remove all foreign matter such as dirt, grease, salt, etc., using cloth soaked in thinner or some other suitable liquid.
This work should be carried out with extreme care. Insufficient removal will result in the repainted coat peeling off or corrosion forming under the repainted coat.

(ii) Two coats of anticorrosive repair paint should be applied on the surface after rust or loose paint has been removed. This paint should be the same paint as the undercoating.

(iii) Anticorrosive undercoating should be applied.

(iv) Two coats of anti-weather type final coating should be applied.

All paint to be applied for repainting should be the same paint as the old paint.

9.3 Measurement of Contamination on Insulator Disc

(1) Conception

Measurement of Equivalent Salt Deposit Density (ESDD) on insulator discs is recommended to establish a cleaning schedule of the insulators. Data obtained will also be useful for determining the design criteria for future projects.

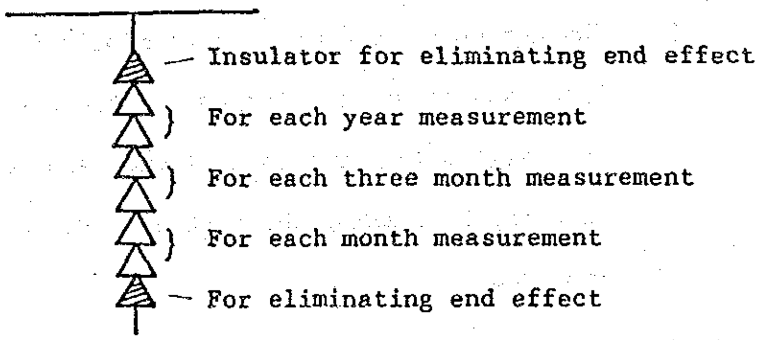
The conception of the measurement should be as follows.

Period : at least 3 years

Place : Several points (Select towers on which insulator strings of specimen will be hanged.)

Interval of contamination measurement:

each month, each three months and each year



Insulators after ESDD measurement should be re-installed on structures for the next exposure.

The design is based on 0.5 mg/cm^2 and 0.3 mg/cm^2 of ESDD for 220 kV line and 132 kV line, respectively.

(2) Measurement of ESDD

(i) Procedure of measurement

(a) Beaker, measuring cylinder, etc., should be well washed so as to remove electrolyte prior to measurement. Hands and glaves should be washed clean and free from dirt.

(b) Distilled water of 200 - 400 cm^3 is placed into 2 beakers (more water is added for heavy contamination).

(c) Absorbent cotton or a brush is immersed in distilled water. Conductivity* and water temperature are measured.

(* Refer to item (v) for measuring conductivity)

(d) Contaminants are wiped away separately from top and bottom surfaces of the insulator with wet absorbent cotton or brush. A gloved hand is preferred for precise measurement.

(e) The cotton or brush with contaminant is put back into each beaker for top and bottom surfaces (see Fig. 9.1). The contaminants should be dissolved in water by shaking the cotton or brush while immersed.

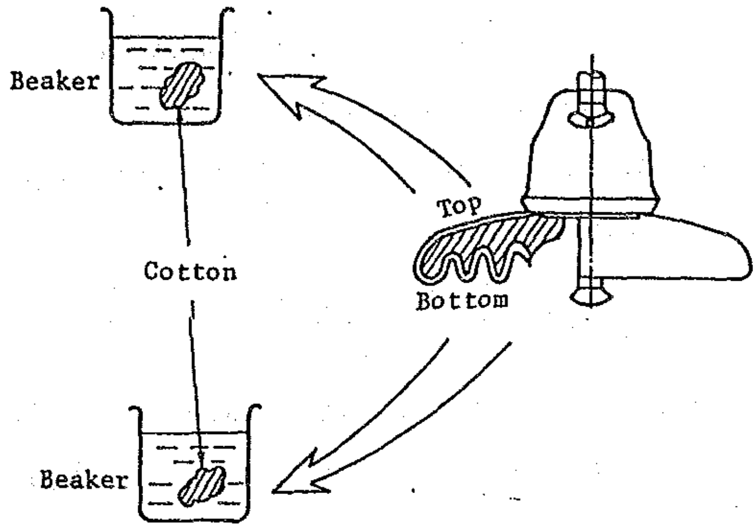


Fig. 9.1

(f) Wiping is repeated so as not to leave any contaminant remaining on the insulator surface.

(g) Attention should be paid to maintain the quantity of water (i.e. the quantity should not be changed very much before or after collecting contaminants).

(h) Conductivity of the water containing the contaminants is measured with a conductivity meter.* At the same time, the temperature of the water is measured.

(* Refer to item (v) for measuring conductivity)

(ii) Calculation of ESDD

(a) The measured conductivity of the water containing the contaminants is corrected into the conductivity at 20°C by referring to the attached Fig. 9.2.

(b) Fig. 9.3 shows the relationship between the conductivity at 20°C and the salt (NaCl) concentration of salt water. From Fig. 9.3, the amount of equivalent salt in the water is obtained.

(c) The ESDD on the insulator surface is calculated by the following equation.

$$W = 10 \times \frac{V \times (D_1 - D_2)}{S}$$

where, W : Equivalent salt deposit density, mg/cm^2

V : Amount of distilled water, cm^3(g)

D_1: Equivalent salt concentration of the water containing contaminants, %

D_2: Equivalent salt concentration of the water with cotton or brush before collecting contaminants, %

S : Surface area of insulator, cm^2

(d) For reference, an example of a data sheet for measuring ESDD is shown in Table 1.

(iii) Measurement of non-soluble material deposit density (NDD)

Measurement of NDD is made by weighing residuum in the water containing the contaminants. Residuum can be obtained by filtering water with filter paper and then drying the filter paper completely (Refer to Fig. 9.4).

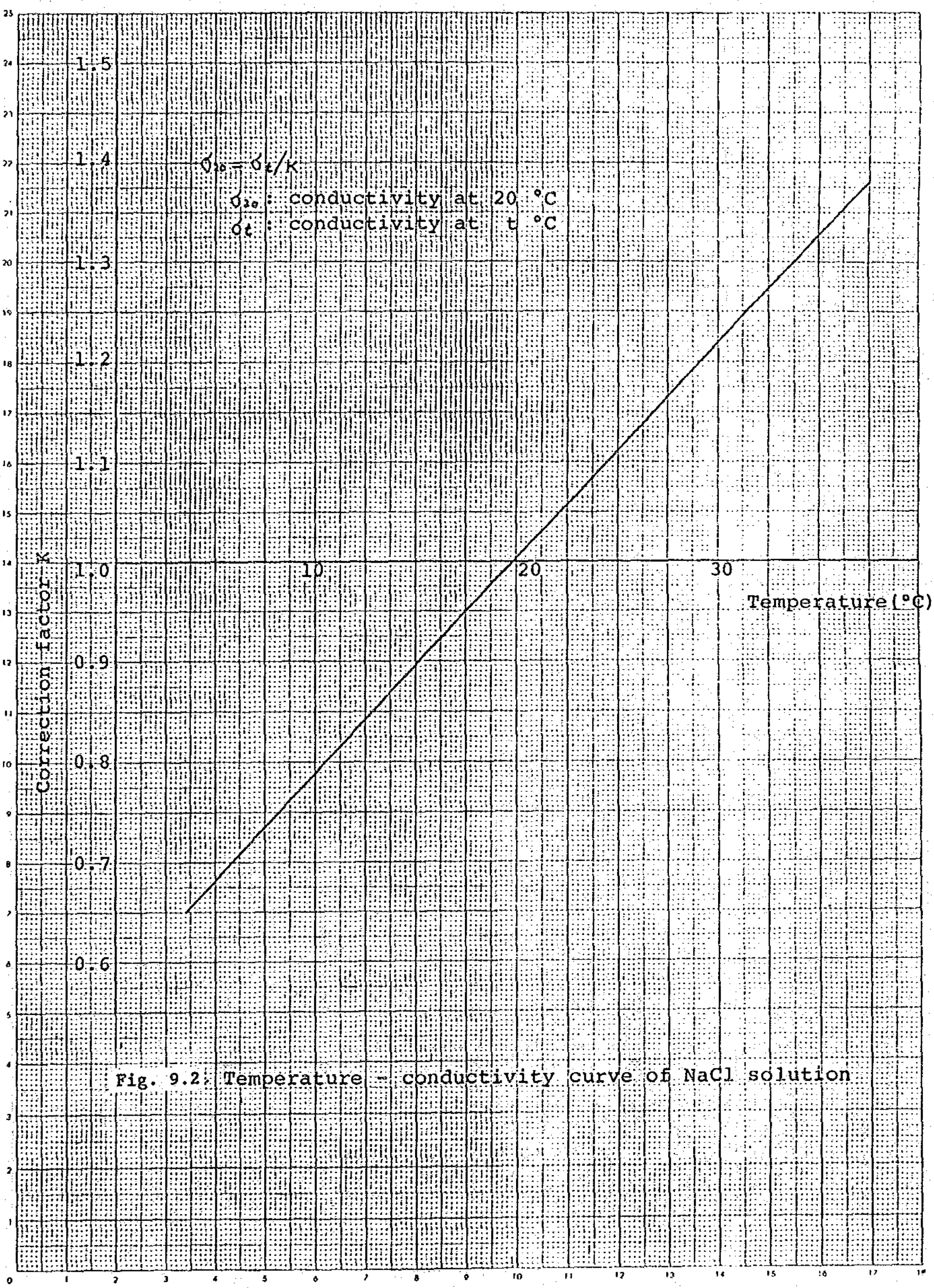


Fig. 9.2. Temperature - conductivity curve of NaCl solution

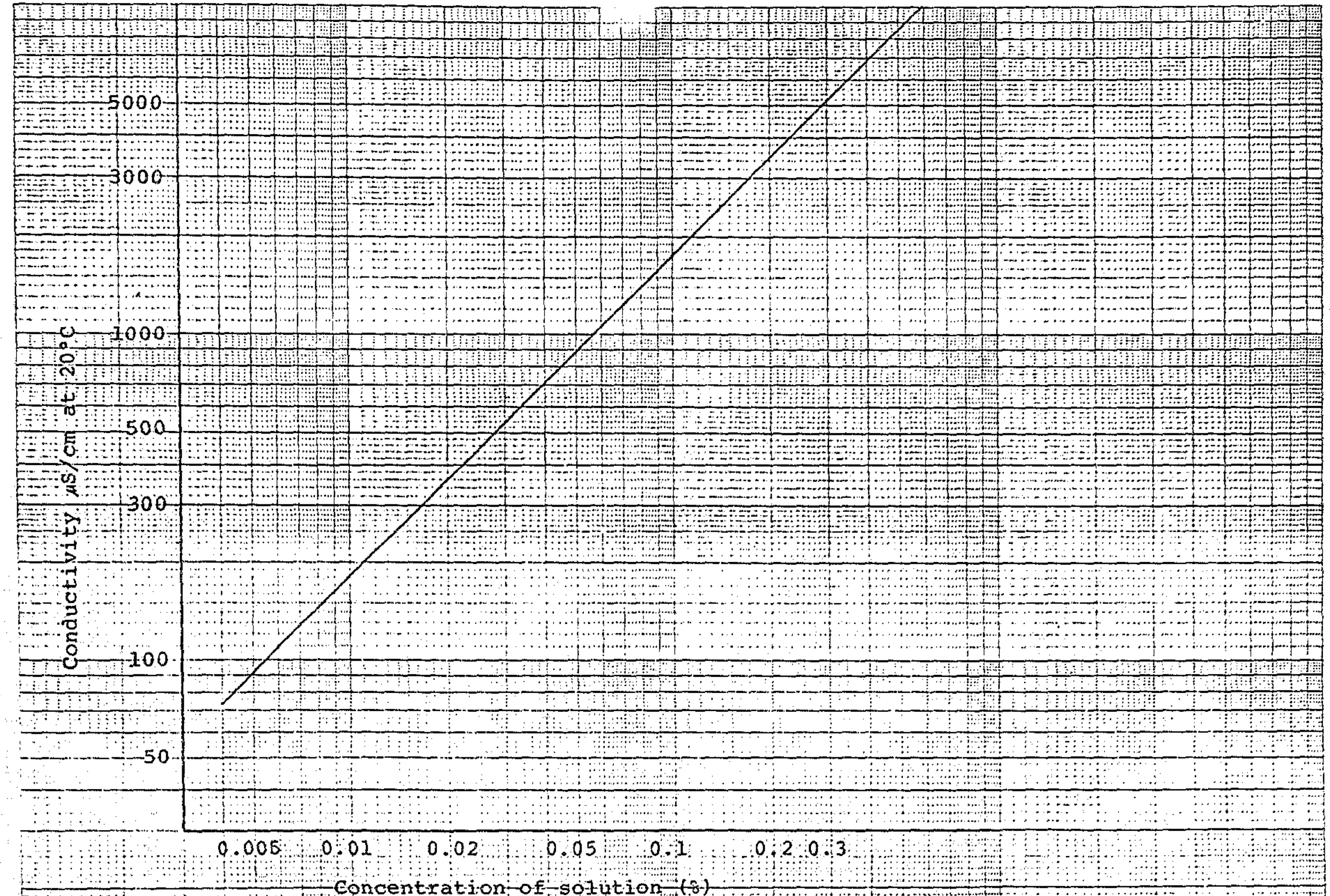


Fig. 9.3 Concentration - conductivity curve of NaCl at 20°C

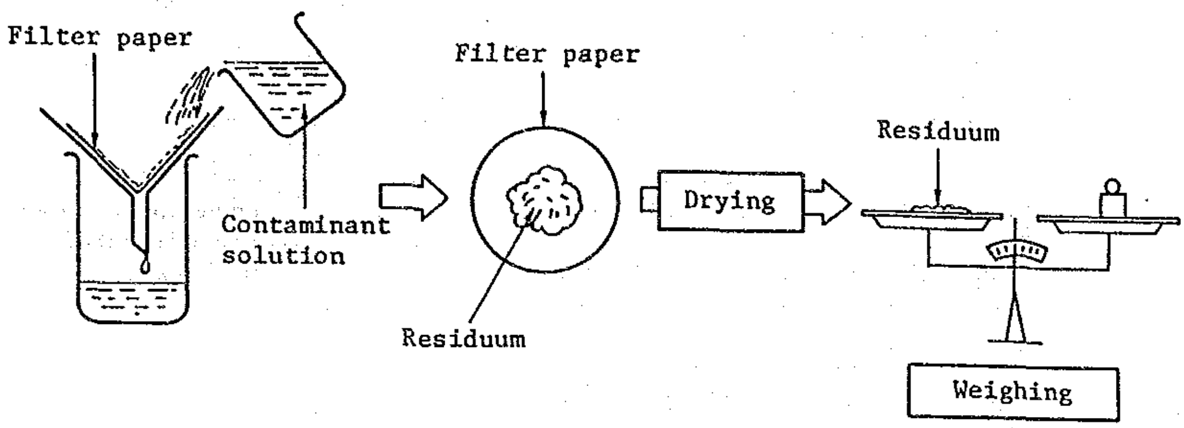


Fig. 9.4 Concentration - conductivity curve of NaCl at 20°C

(iv) Analysis of contaminants

The following chemical and physical analysis is made on sample contaminants.

- Qualitative analysis by the X-ray diffraction topography
- Quantitative chemical analysis on soluble and non-soluble material*
- Particle size distribution analysis

* Soluble material

Na, Ca, K, Mg, Zn, Si, Cl, SO_4, NO_3, CO_3

Non-soluble material

SiO, Al_2O_3, Fe_2O_3, CaO, ZnO, Na_2O, K_2O

Procedure of chemical analysis is as shown in Fig. 9.5

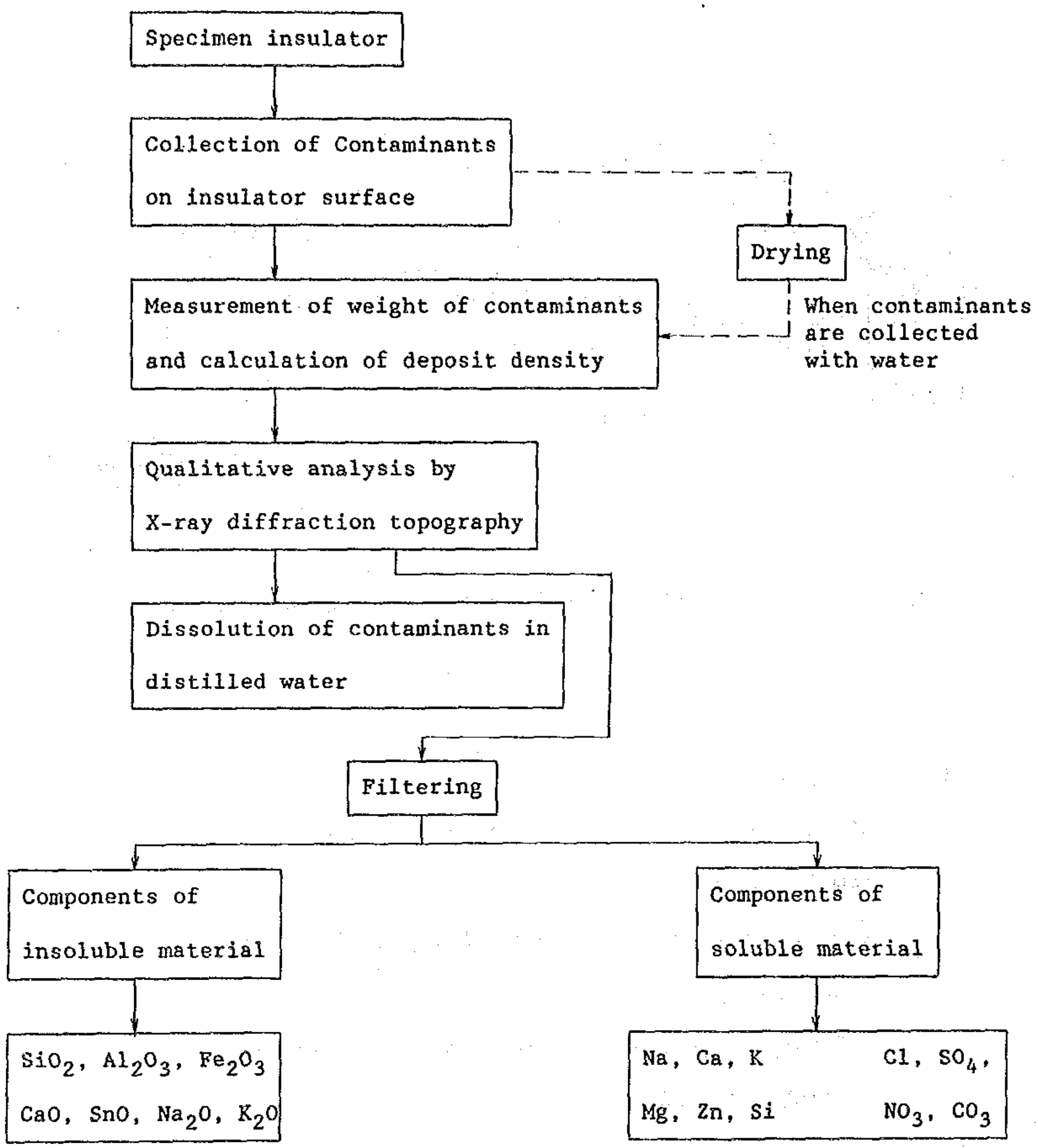


Fig. 9.5 Procedure of Chemical Analysis of Contaminants

(v) Details of Conductivity Meter

(a) FEATURES

Temperature Measurement Function (equipped)

Temperature measurement is essential for conductivity measurement. However, there is no need to prepare a thermometer as the temperature can be measured using the same electrode.

Handy, Lightweight

Handy and lightweight, convenient for measurement both in laboratory and in field, shaped to suit to carriage and measurement.

Simply Designed Electrode

Equipped with three pole electrode for excellent performances, cleaning is easy.

(b) STANDARD SPECIFICATIONS

MODEL	:	SC51
Measuring Range	:	0 - 20 μS/cm, 0 - 50^{o}C
Indication	:	3 1/2 digits, digital indicator (quartz)
Analyzing Capability	:	0.01 microS/cm (in the range 0 - 20 microS/cm) 0.1^{o}C (for temperature measurement)
Temperature of Solution	:	0 - 50^{o}C
Power	:	Dry battery (006P x 1 unit, Max. 50 hours continuous operation)

Tolerance	:	± 3% per span (for conductivity measurement) ± 1°C (for temperature measurement)
Net Weight	:	300 g

Measurment Date :

Sample Insulator
Surface area (Top) : (cm2)
(Bottom) : (cm2)

Table 1 MEASURMENT RESULT OF EQUIVALENT SALT DEPOSIT DENSITY (ESDD)

Location (Tower No.)	Insulator string for measurement: String type	No. of units per string	Position of sample from ground	Measurement results: Surface	Before or after collecting contaminants	Water volume (c.c.)	Temperature of water (T °C)	Conductivity at T °C.. (μS/cm)	Conductivity at 20°C (μS/cm)	Concentration of salt (%)	Quantity of salt (mg)	ESDD (mg/cm²)	Av. ESDD on whole Surface (mg/cm²)
				Top	Before								
					After								
				Bottom	Before								
					After								
				Top	Before								
					After								
				Bottom	Before								
					After								
				Top	Before								
					After								
				Bottom	Before								
					After								
				Top	Before								
					After								
				Bottom	Before								
					After								
				Top	Before								
					After								
				Bottom	Before								
					After								

10. TOWER FOUNDATIONS

10.1 Geological Profile

The report on the geological survey of the project should be referred to for details of the geological conditions.

Power will be transmitted for approximately 1.3 km through underground cables from the West Wharf Thermal Power Plant to the first transmission tower, from where the line of transmission towers will run to the Baldia Grid Station, first along the coastline and then, turning inland along the periphery of the Pakistan Air Force (PAF) Base.

From the geological point of view, the route of the transmission towers can be divided into 3 zones: Coastal Zones I and II, and the Inland Zone. Boring surveys have been carried out along the coast at 7 locations: TL-1, TL-2, TL-5, TL-6, TL-7, TL-8 and TL-9. At the 3 points of TL-1, TL-2 and TL-5 in Coastal Zone I, the supporting layer consists mainly of fine sand and sandy silt, with silty clay running down to depths of 10 to 15 m. At the 4 points of TL-6, TL-7, TL-8 and TL-9 in Coastal Zone II, the upper layers are made up of fine and coarse sand, with silty shale below. The depths of the supporting layers are small in Zone II, with N-values between 20 and 60 at depths of 1.0 to 2.0 m. The groundwater levels tend to be high in the Coastal Zones at GL -0.3 to 3.0 m.

According to the boring surveys carried out at points TL-10, TL-11 and TL-12 in the Inland Zone, the surface layer consists of coarse sand mixed with gravel and sandy silt, while silty shale, conglomerate and limestone are found in the layers below. The N-value reaches 60 at 1.0 m below ground, providing a geological composition most suitable for spread foundations. No groundwater was observed.

10.2 Transmission Towers

10.2.1 Tower Types

The transmission towers can be divided into the following 10 types.

AS, A, AL, B, C, D, DR (220 kV - 2 cct)
A4, D4, DR4 (220 kV - 2 cct, 132 kV - 2 cct)

10.2.2 Loads

Loads are transmitted down from the upper structures. The stationary load used in the design is the load which will be applied at the wind velocity of 38 m/s, while the abnormal load is that which will result when the conductors of the transmission lines have been broken. In the design, the greater of the two between the stationary load and two-thirds of the abnormal load will be used. These design loads vary according to the 10 towers types as follows.

Table 10.2.1 Load Conditions

Tower Type	Compression (tons)	Uplift (tons)
AS	37.54	25.49
A	49.27	34.09
AL	57.95	40.17
B	55.84	41.65
C	85.59	68.77
D	95.63	80.88
DR	124.05	107.47
A4	110.95	84.56
D4	207.39	171.08
DR4	245.32	201.88

10.3 Geological Conditions

10.3.1 Outline

Geological conditions, which have a major bearing on the shapes of foundations, were ascertained through boring surveys, and the soil is classified according to the results of site tests, such as the standard penetration test. Mine water levels are taken into account in the foundation design. The results of the standard penetration test, which is performed to ascertain the hardness of the soil, is used in deciding whether to use pile foundations or spread foundations. As saft soil, consisting of clay with N-values below 2 or sand with N-values below 5, continues underneath the bottom of the foundation, spread foundations will be unable to bear loads from the upper structures and the stability of the structure cannot be maintained. Therefore, pile foundations are advantageous for supporting the foundation bodies and securing the stability of the upper structures.

10.3.2 Soil Consistency

Soil characteristics are indicated by the physical properties of the soil (cohesion, internal friction angles, stress-strain curves) used in the design calculations. The constants for each are estimated from the N-values using the following formula.

$$qu = N/8$$

N : N-value according to standard penetration test

qu: uniaxial compressive strength (kg/cm^2)

$$C = qu/2$$

C : cohesion (kg/cm^2)

The relationship between the N-value and the uniaxial compressive strength is clarified through the laboratory and on-site tests described below.

Table 10.3.1 Relationship between N-value and qu-value

	Very Soft	Soft	Medium	Hard	Very Hard	Solid
N-Value	below 2	2 to 4	4 to 8	8 to 15	15 to 30	above 30
qu-Value (kg/cm^2)	below 0.25	0.25 to 0.5	0.5 to 1.0	1.0 to 2.0	2.0 to 4.0	above 4.0

(According to proposals by Terzaghi and Peck)

The relationship between N-value and internal friction angle is as follows.

$$\phi = \sqrt{15N} + 15$$

ϕ: internal friction angle (degrees)

The bearing capacities of the spread foundations and pile foundations are calculated from the physical properties above, and the piles are designed using the strength constant of the stress-strain curve obtained from the horizontal loading tests on site.

The following have been selected as the boring sites and physical properties for use in the design based on the geological survey.

Table 10.3.2 Representative Boring Sites and Physical Properties

Type of Foundation	Boring Site	Adhesion C (t/m^2)	Internal Friction Angle ϕ (degrees)	Stationary Volume Weight of Soil (t/m^3)
Pile (Coastal I)	TL-1	0	20	1.8
Spread (Coastal II)	TL-6	0	35	1.8
Spread (Inland)	TL-12	0	40	1.8

τ (shear strength) = 5 t/m^2 will be taken into account in the calculations for the resistance to uplift in the spread foundations in the Inland Zone, since ample shear strength can be expected here as seen from the results of the unconfined compression test (qu-value) in the geological survey report.

10.3.3 Groundwater

Groundwater levels also have a major bearing on the shapes of the foundations. Special consideration must be made, particularly in the Coastal Zones I and II. Since the buoyancy due to groundwater will lighten the weight of the foundation concrete and soil that provide resistance against uplift, the foundations in Coastal Zones I and II should be larger than those in the Inland Zone where groundwater need not be taken into account. Particularly, in I-type foundations, the existence of groundwater necessitates deeper flooring surfaces, making the work more difficult.

The following design groundwater levels have been selected on the basis of the results of the geological survey.

Table 10.3.3 Design Groundwater Levels

Foundation Type	Zone	Design Groundwater Level (m)
Pile	Coastal I	GL $\pm$ 0
Spread	Coastal II	GL $\pm$ 0
Spread	Inland	no groundwater

10.4 Foundation Types

Tower foundations can be divided into 2 types: the spread foundations, in which the loads from the towers are transmitted directly to the supporting ground, and the pile foundations usually used when supporting layers are deep under ground. The foundation types can be classified as follows.

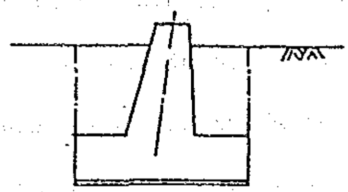
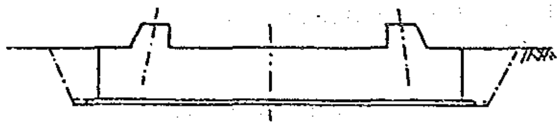
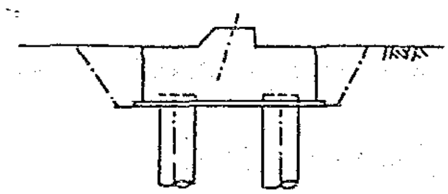
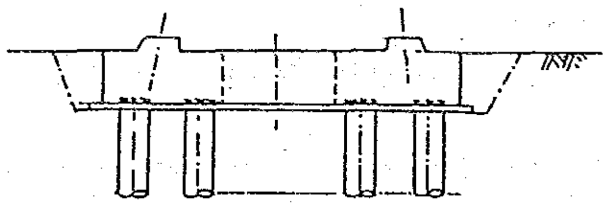
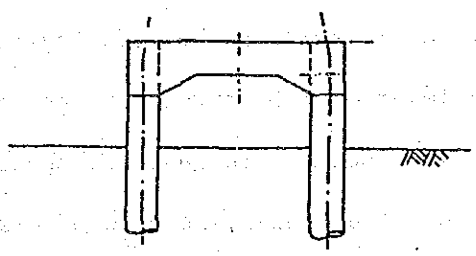
Spread Foundations	I Type, Independent Type
	IV-1 Type, MAT Type

Pile Foundations	III Type, Independent Type
	IV-2 Type, Integrated Type
	Rigid Frame Type

Upon comparative study of various foundation types, I type will be used for spread foundations and III type in pile foundations.

Rigid frame foundations will be used in portions crossing the Layari River in Coastal Zone I, and will take into account the flood water levels.

Table 10.4.1 Foundation Types

Foundation Type		Configuration
SPREAD	I Type	
MAT	IV1 Type	
PILE	III Type	
	IV2 Type	
	Rigid Frame	

10.5 Piles

Piles are used in soft ground having supporting layers deep below the ground surface. Here spread foundations will be inadequate for maintaining the stability of the structures. Pile foundations are used when boring surveys reveal that the N-value of the soil is below 2, in the case of clayey soil, and below 5, in the case of sandy soil, or where the supporting layers are found more than 4 to 5 m below ground. Piles can be classified into the following types.

< Classification by Materials >

Driven Piles
- Concrete Piles
- Prestressed Concrete Piles
- Steel Piles

Cast-in-Place Piles - Cast-in-Place Concrete Piles

< Classification by Functions >

Piles
- Point Bearing Piles
- Friction Piles

Point bearing piles have the function of transmitting the loads from the upper structures to the hard ground, which represents the supporting layer, through the soft layers in between. The supporting layer must be strong enough to support the loads that are expected to occur. In general, the supporting layer must have on N-value of 10 or above, in case of clayey soil, and 30 or above, in case of sandy soil. Friction piles, on the other hand, are used when the loads are relatively small. They transmit the loads to the ground through friction between the sides of the piles and the ground.

The choice of the type of pile is determined by geological conditions, loads, strengths of the pile materials and economic considerations.

Cast-in-place concrete piles 22 inches (559 mm) in diameter have been selected for use under the present conditions from our experience in past construction work. The diameter will be increased to 36 inches (914 mm) for rigid frame foundations and for foundations D4 and DR4 types having larfge loads.

All piles will be point bearing piles.

10.6 Comparative Study of Tower Foundations

Transmission towers are divided into groups according to load and geological conditions and zones, and comparisons were made among foundation types. The most suitable foundation types as determined from economic comparison on each tower type are as follows.

10.6.1 Results of Comparative Study

Table 10.6.1 Results of Comparative Study

Zone	Tower Type Group	Tower Type Studied	Foundation Type Studied	Most Suit. Found. Type	Remarks
Inland & Coastal II	As, A	AS	I, IV-1	I	no groundwater (Inland)
					groundwater GL±0 (Coastal II)
	D, B, C, DR	D	I, IV-1	I	no groundwater (Inland)
					groundwater GL±0 (Coastal II)
Coastal I	A4, AL	A4	III, IV-2	III	groundwater GL±0 (Coastal I)
	DR4, D4	DR4	III, IV-2	III	groundwater GL±0 (Coastal I)

AL type towers in areas crossing the Layari River in the Coastal Zone I will be provided with rigid frame foundations in consideration of the possibility of floods. Note: These were omitted from the comparative study.

10.6.2 Comments on Foundation Types for Each Tower Type

AS Type - These towers will be constructed in Coastal Zone II and Inland Zone. I type foundations have been selected for use on the basis of the results of the comparative study.

Table 10.6.2 Comparison of Construction Costs between I and IV-1 Type Foundations in AS Type Towers (Coastal Zone II)

Foundation Type	Type of Work	Unit Cost (Rs/m^3)	Quantity (m^3)	Estimated Cost (Rs)
I	Excavation	100	234	168,000
	Concrete	2,000	72.7	
IV-1	Excavation	50	159	346,100
	Concrete	3,000	112.7	

A Type - A type towers will be constructed in the Inland Zone. I type foundations have been selected for use from the results of the comparative study on AS type towers.

AI Type - In view of the geological conditions at the sites for these towers, pile foundations will be used. III type foundations have been selected for use from the results of the comparative study on A4 type towers. Some of these towers will have rigid frame towers.

B Type - These towers will be constructed in Coastal Zone II and the Inland Zone. I type foundations have been selected for use from the results of the comparative study on D type towers.

C Type - These towers will be constructed in Coastal Zone II and the Inland Zone. I type foundations have been selected for use from the results of the comparative study on D type towers.

D Type - These towers will be constructed in Coastal Zone II and the Inland Zone. I type foundations have been selected for use from the results of the comparative study.

Table 10.6.3 Comparison of Construction Costs between I and IV-1 Type Foundations in D Type Towers (Coastal Zone II)

Foundation Type	Type of Work	Unit Cost (Rs/m^3)	Quantity (m^3)	Estimated Cost (Rs)
I	Excavation	100	633	440,300
	Concrete	2,000	188.5	
IV-1	Excavation	50	400	929,900
	Concrete	3,000	303.3	

DR Type - These towers will be constructed in Coastal Zone II and the Inland Zone. I type foundations have been selected for use from the results of the comparative study on D type towers.

A4 Type - Pile foundations will be used due to the geological conditions affecting these towers, and will be constructed in Coastal Zone I. III type foundations have been selected for use from the results of comparative study.

Table 10.6.4 Comparison of Construction Costs between III and IV-2 Type Foundations in A4 Type Towers (Coastal Zone II)

Foundation Type	Type of Work	Unit Cost (Rs/m^3)	Quantity (m^3)	Estimated Cost (Rs)
III	Excavation	50	342	
	Concrete	3,000	162.8	1,023,900
	Piles (ϕ22")	1,800	288.0	
IV-1	Excavation	50	384	
	Concrete	3,000	264.8	1,504,800
	Piles (ϕ22")	1,800	384.0	

D4 Type - Pile foundations will be used due to the geological conditions affecting these towers, and will be constructed in Coastal Zone I. III type foundations have been selected for use from the results of comparative study on DR4 type towers.

DR4 Type - Pile foundations will be used due to the geological conditions affecting these towers, and will be constructed in Coastal Zone I. III type foundations have been selected for use from the results of comparative study.

Table 10.6.5 Comparison of Construction Costs between III and IV-2 Type Foundations in DR4 Type Towers (Coastal Zone II)

Foundation Type	Type of Work	Unit Cost (Rs/m^3)	Quantity (m^3)	Estimated Cost (Rs)
III	Excavation	50	688	
	Concrete	3,000	361.3	2,439,900
	Piles (ϕ22")	5,900	224.0	
IV-1	Excavation	50	762	
	Concrete	3,000	533.3	2,934,000
	Piles (ϕ22")	1,800	720.0	

Table 10.6.6 Types of Tower Foundations

Tower Type	Boring Site	Foundation Type	Spread Foundations	Pile Foundations	Remarks
AS-D	TL-12	I	*		
AS-C	TL-6	I	*		
A-D	TL-12	I	*		
AL-S	TL-1	III	*		
AL-R	TL-1	Rigid Frame		*	
B-D	TL-12	I		*	
B-C	TL-6	I	*		
C-D	TL-12	I	*		
C-C	TL-6	I	*		
D-D	TL-12	I	*		
D-C	TL-6	I	*		
DR-D	TL-12	I	*		
DR-C	TL-6	I	*		
A4-S	TL-1	III		*	
D4-S	TL-1	III		*	
DR4-S	TL-W1	III		*	

Note: Letters to the right of the tower type indicate the following.

1. D: Inland Zone (no groundwater)
2. S: Coastal Zone I (with groundwater)
3. C: Coastal Zone II (with groundwater)
4. R: Rigid Frame

10.7 Detailed Design

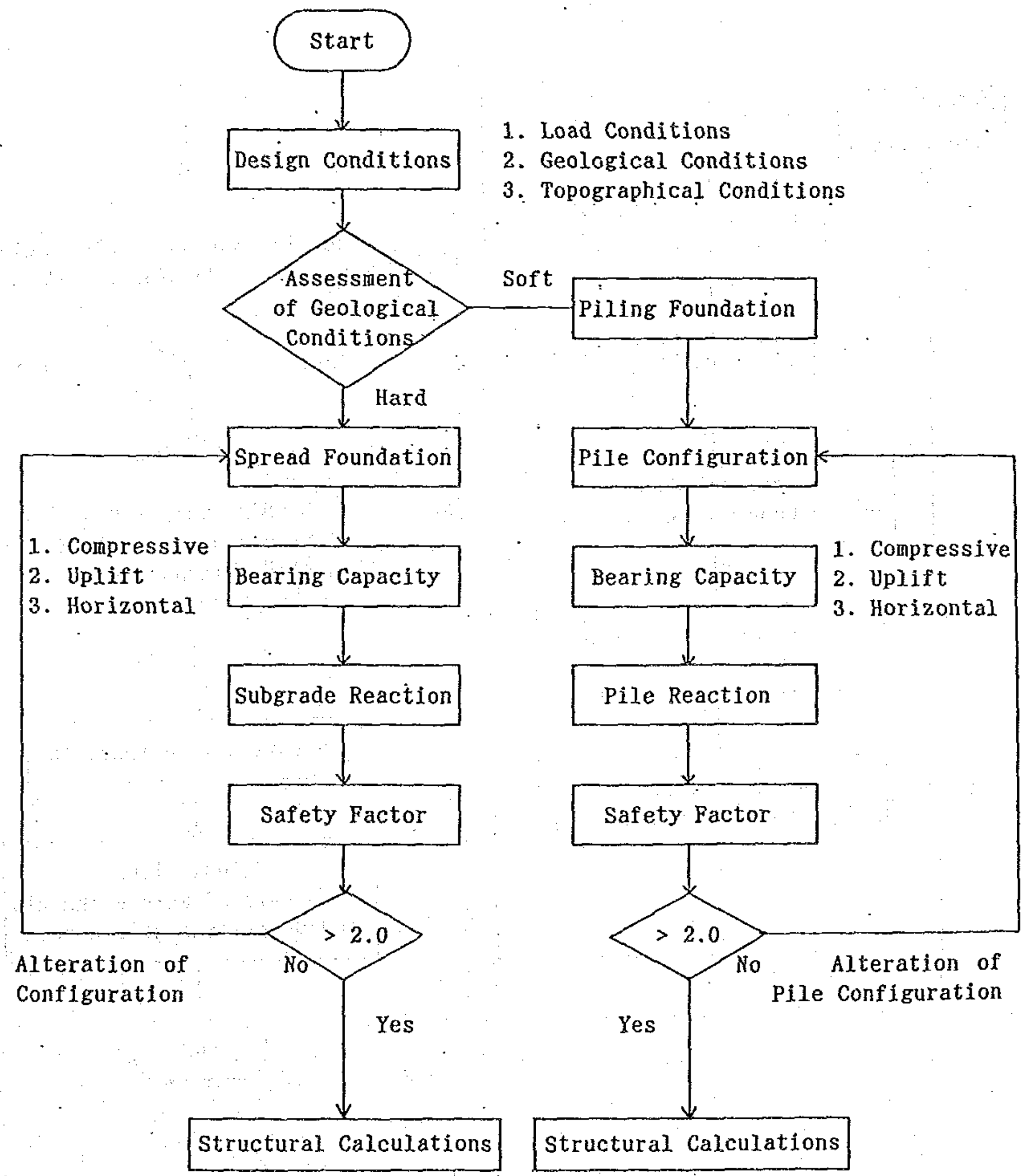
Computations for detailed design will be made in accordance with the design flowcharts.

For rigid frame foundations, safety calculations for towers will be incorporated in the safety calculations. Also, analyses will be carried out regarding their rigid frame structures.

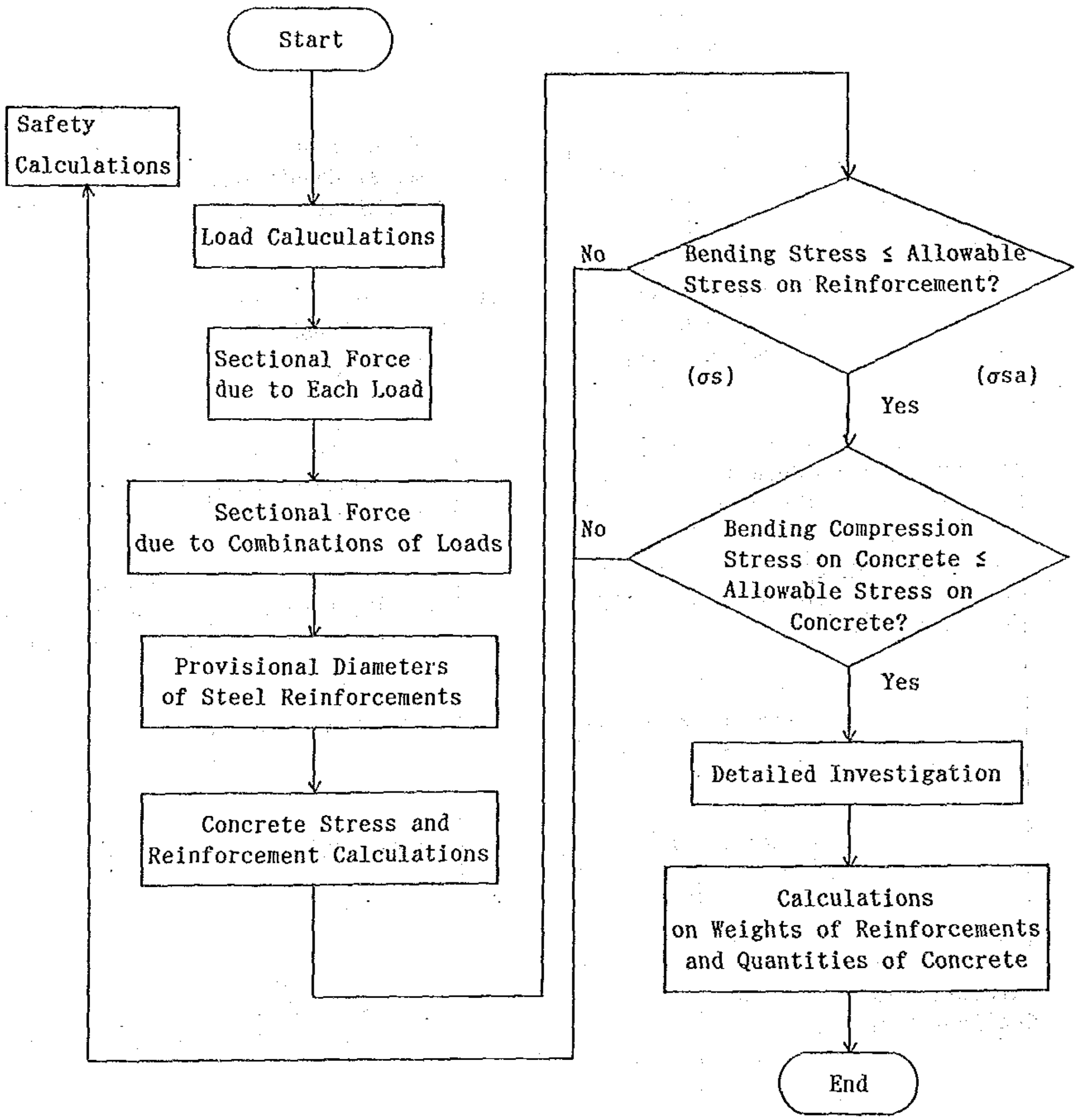
10.7.1 Design Flowchart

Flowcharts for Design of Transmission Tower Foundations

(a) Safety Calculations



(b) Structural Calculations



10.7.2 Design Calculation Formulas

(1) Shape of foundation size

After completion of selecting the foundation type, the three-dimensional aspect of each section of the foundation will be determined tentatively.

The following limits are derived from past experience and study results.

(a) Column

o Top width: a

$a \geqq 3L$ (or 3ϕ)

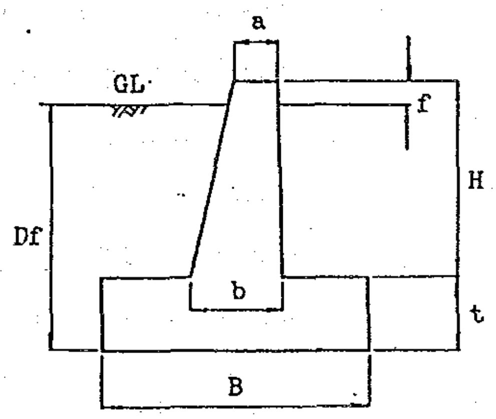


Fig. 10.7.1

where: L = Flange width of post of angle steel tower

ϕ = Diameter of post of steel pipe tower

o Bottom width: b

. Shallow foundation: $b \geqq a + 0.15\,H$

. Deep foundation: $b \geqq a + 0.15\,H$ and

$b \geqq B/4$

where: H = Column height

B = Footing width

o Column height above the ground: f

f = 30 cm (Standard)

(b) Footing

o Shape: principally square

o Thickness: $t \geqq B/5$

If compression load is more than 200 ton, thickness shall be at least 1 meter.

(2) Stability of Spread Foundation

(a) Yield bearing capacity: qcy

The foundation bearing capacity shall be calculated by Terzaghi's formula, as follows:-

$$qcy = 1/1.5\{\alpha\ C\ Nc + \beta\gamma_{s1}\ B\ Nr + \gamma_{s2}\ D_f\ N_q\}$$

where:

qcy = Yield bearing capacity (t/m^2)

α, β = Shape coefficient shown in Table 10.7.1

Table 10.7.1 Shape Coefficient

Form of foundation	Continuous	Square	Rectangular	Circular
α	1.0	1.3	1 + 0.3 B/L	1.3
β	0.5	0.4	0.5-0.1 B/L	0.3

B & L = Each denotes width and length of rectangular footing, respectively. (B<L)

C = Soil cohesion beneath the foundation (t/m^2)

γ_{s1} = Average unit weight of soil beneath the foundation (t/m^3)

(For a portion below the ground water surface, submerged weight shall be considered.)

γ_{s2} = Average unit weight of soil above the foundation bottom level (t/m^3)

(For a portion below the ground water surface, submerged weight shall be considered.)

D_f = Embedment depth from the ground level to the foundation bottom (m)

Nc,Nr,Nq = Bearing capacity factors, functions of angle of internal friction ϕ (Table 10.7.2)

Table 10.7.2 Bearing Capacity Factors

ϕ	Nc	Nr	Nq
0^o	5.3	0	3.0
5^o	5.3	0	3.4
10^o	5.3	0	3.9
15^o	6.5	1.2	4.7
20^o	7.9	2.0	5.9
25^o	9.9	3.3	7.6
28^o	11.4	4.4	9.1
32^o	20.9	10.6	16.1
36^o	42.2	30.5	33.6
more than 40^o	95.7	114.0	83.2

(b) Yield uplift capacity: qty

As shown in Fig. 10.7.2 vertically excavated and backfilled, uplift capacity will be calculated according to the following equation based on the shearing method.

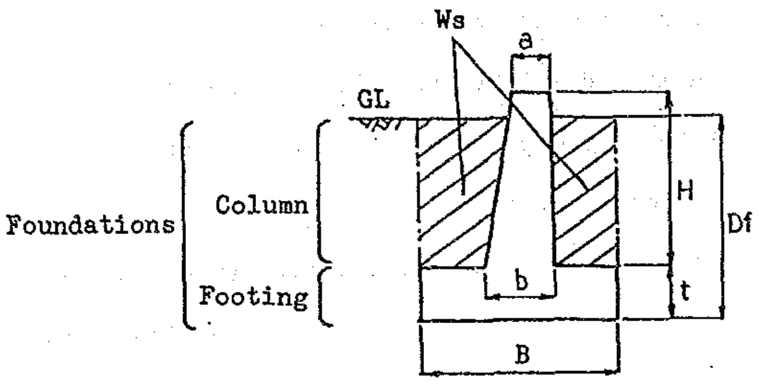


Fig. 10.7.2

$qty = K\{Wc + Ws + 1/1.5 L \cdot D_f (C + 1/2 \gamma_{s2} \cdot D_f \cdot \tan\phi/(1 + \sin\phi))\}$

$qty = K\{Wc + Ws + 1/1.5\ L \cdot t \cdot \tau\}$ (rocky area)

where:

K = Reduction rate in uplift capacity due to overturning moment

$$K = \frac{1}{1 + 6\ e\ B/(B^2 + b^2)} \quad (\geq 0.67)$$

B = Footing width (m)

e = $Q_B\ H/(T - W_{CT})$ (m)

b = Bottom width of column (m)

Q_B = Horizontal component of brace member force (ton)

H = Column height (m)

T = Uplift acts on foundation from tower (ton)

W_{CT} = Sum weight of a column and a part of footing under the column area (ton)

Wc = Foundation weight (ton)

(Submerged weight shall be considered for a portion under the ground water surface)

Ws = Backfilled soil weight (For a portion under the ground water surface, submerged weight shall be considered)

L = Surrounding length (m) - 4 x B

D_f = Embedment depth from the ground surface (m)

C = Average cohesion of soil on footing (ton/m^2)

γ_{s2} = Unit weight of soil on footing (ton/m^3)

(Submerged weight shall be considered below ground water surface)

ϕ = Internal friction angle of soil on footing (degree)

τ = Shear strength (t/m^2)

(c) Maximum bearing pressures against compressive force: σ cmax

Horizontal force Q_B simultaneously reacts against a compressive force (C). Maximum bearing pressures (σcmax) at footing edge is to be calculated from following formula:

$\sigma cmax = P/A \cdot \mu$

where:

P = Vertical force acts on foundation (ton)

P = C + Wc + Ws

C = Compressive force (ton)

Wc = Weight of foundation (ton)

Ws = Weight of soil on footing (ton)

A = Footing area (m^2)

$A = B \times B$

μ = Incremental rate in bearing pressure at footing edge due to overturning moment by horizontal force, Q

(i) $\mu = 1 + \frac{6e}{B}$; (in case of $e \leq B/6$)

(ii) $\mu = \frac{2}{3(1/2-e/B)}$; (in case of $B/6 < e < B/2$)

where:

e = eccentricity shown in Fig. 10.7.3

$e = Q_B(H + t)/P$ (m)

B = Footing width (m)

H + t = Depth from top of column to foundation bottom (m)

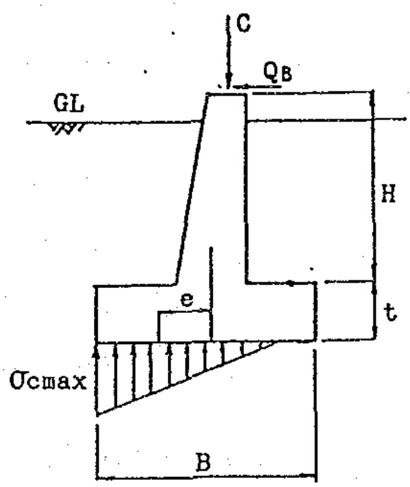


Fig. 10.7.3

(d) Safety factor

Safety factor regarding each compressive force and uplift shall be as shown in Table 10.7.3 below.

Table 10.7.3 Safety Factor Regarding Each Load

Kind of load	A	B	E
Compressive force	$q_{cy}/\sigma_{cmax} \geq 2.0$	$q_{cy}/\sigma_{cmax} \geq 2.0/1.5$	-
Uplift	$q_{ty}/T \geq 2.0$	$q_{ty}/T \geq 2.0/1.5$	$W_c + W_s \geq T_o$

where:

T = Uplift (ton)

To = Continuous uplift load (E-load (ton))

Regarding the safety factor shown in Table 10.7.3, the safety factor of 2.0 is applied to the normal condition load A against the yield bearing capacity for short term loads, i.e., B-load (abnormal condition). The safety factor of 2.0 is given not against the yield bearing capacity, but the ultimate bearing capacity, which is 1.5 times that of the former.

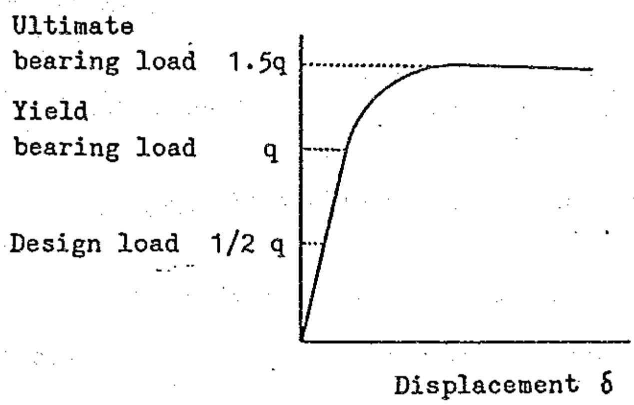


Fig. 10.7.4

(e) Anchoring

Anchor shown in Fig. 10.7.5 below:

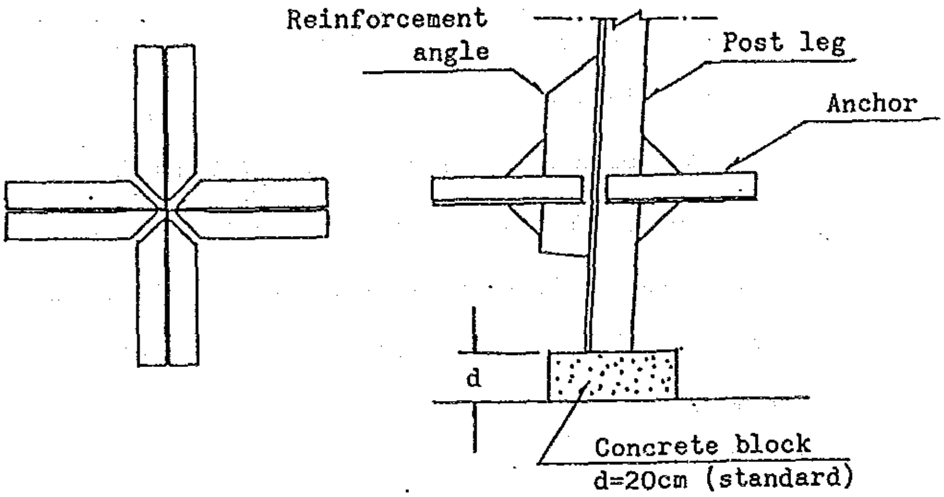


Fig. 10.7.5 Structural Detail of Anchor

(3) Stability of Pile Foundation (III Type)

Pile foundations are usually provided in soft stratum areas. Under axial compression, the piles are supported by the shearing resistance concentrating on the embedded pile surface (skin friction) or by the bearing resistance at the pile tip (end-bearing), or both.

Piles whose supporting capacity is dominated by skin friction are termed friction piles. Those predominantly supported by end bearing and skin friction are termed bearing piles. Tensile loading is resisted solely by skin friction.

(a) Bearing capacity against compression

(i) Friction piles

$$Qcy = 1/1.5 \{(Ns \cdot ls/5 + qu \cdot lc/2) \cdot U\} - 2Wp$$

(ii) Bearing piles

o Steel pile driven by hammer

$$Qcy = 1/1.5 \{30 \cdot \eta \cdot N \cdot Ap + (Ns \cdot ls/5 + qu \cdot lc/2) \cdot U\} - 2Wp$$

o Cast-in-place concrete pile

$$Qcy = 1/1.5 \{15 \cdot N \cdot Ap + (Ns \cdot ls/5 + qu \cdot lc/2) \cdot U\} - 2Wp$$

where:

Qcy = Yield compressive bearing capacity per piece of pile (ton/piece)

η = Coefficient of occlusion of pipe pile

$\eta = 0.16\ L_B/D\ (\leq 0.8)$ (In case of open-end pile)

$\eta = 1.0$ (In case of closed-end pile)

L_B = Length in bearing stratum at the pile tip (m)

D = Inside diameter of pile (m)

N = Average N value of bearing stratum

Ap = Pile cross sectional area (m^2)

Ns = Average N value of sandy stratum into which pile is penetrated (≤ 50)

ls = Length of sandy stratum in which pile is penetrated (m)

qu = Average unconfined compressive strength of clayey soil stratum in which pile is penetrated (ton/m^2) (≤ 16)

In the case of no corresponding data, presumptive equation for qu is shown below.

qu = 1.25 Nc

lc = Length of clayey soil stratum in which pile is penetrated (m)

U = Periphery of pile (m)

Wp = Weight per piece of pile (ton/piece)

(b) Bearing capacity against uplift

$Qty = 1/1.5\{Ns \cdot ls/5 + qu \cdot lc/2) \cdot U\} + Wp'$

where:

Qty = Yield capacity against uplift per piece of pile (ton/piece)

Ns = Average N value of sandy stratum in which pile is penetrated (≤ 50)

ls = Length of sandy stratum in which pile is penetrated (m)

qu = Average unconfined compressive strength of clayey soil stratum in which pile is penetrated (ton/m^2) (≤ 6)

lc = Length of clayey soil stratum in which pile is penetrated (m)

U = Periphery of pile (m)

Wp' = Weight per piece of pile when buoyancy is taken into account (ton/piece)

(c) Compressive reaction of pile

$Ncmax = P/n + M/\Sigma m\ Xi^2 \cdot Xo$

where:

Ncmax = Maximum compressive reaction of pile (ton/piece)

P = Resultant of load in vertical direction (ton)

$P = C + Wc + Ws$

where: C = Compressive force from tower (ton)

Wc = Weight of foundation (ton)

Ws = Weight of soil on footing (ton)

M = Moment at the graphical center of footing (t.m)

$M = Q_B(H + T)$

where: Q_B = Component of horizontal load of brace member force (ton)

H = Column height (m)

t = Thickness of footing (m)

Xo = Distance from the gravity center of pile group to the center of pile on the outermost side (m)

ΣmXi^2 = Secondary moment pertaining to the gravity center of pile group (m^2)

n = Number of piles (piece)

(d) Uplift reaction of pile

$$Ntmax = (1-k)\left(\frac{T}{n} + \frac{M}{\Sigma mXi^2} \cdot Xo\right)$$

where:

Ntmax = Maximum uplift reaction of pile (ton/piece)

K = Reduction rate of uplift reaction due to weight of foundation

$$K = \frac{Wc' + Ws'}{Wc' + Ws' + n\ Qty}$$

Wc' = Weight of foundation when buoyancy is taken into account (ton)

Ws' = Weight of soil on footing when buoyancy is taken into account (ton)

n = Number of piles (piece)

Qty = yield bearing capacity against uplift per pile (ton/piece)

T = Uplift load from tower (ton)

M = Moment at the graphical center of footing (t.m)

Xo = Distance from the gravity center of pile group to the center of pile on the outermost side (m)

Σmxi^2 = Secondary moment pertaining to the gravity center of pile group (m^2)

(e) Safety factor

Safety factor applied to each compressive force and uplift is as shown in Table 10.7.4 below.

Table 10.7.4 Safety Factor Applied to Each Load

Kind of load	A	B	E
Compressive force	Qcy/Ncmax ≧ 2.0	Qcy/Ncmax ≧ 2.0/1.5	--------
Uplift	Qty/Ntmax ≧ 2.0	Qty/Ntmax ≧ 2.0/1.5	Wc+Ws+nWp' ≧ To

where:

To = Continuous Uplift load (E-load (ton))

(4) Design Conditions

(a) Allowable unit stress

Table 10.7.5

Item		Allowable unit stress Long term	Short term	Remarks
Reinforcing steel bars	Tensile unit stress	2,000 kg/cm^2	3,000 kg/cm^2	SD30
Reinforced concrete	Compressive unit stress	60 kg/cm^2	90 kg/cm^2	$\sigma 28$ = 180 kg/cm^2
	Shearing unit stress	6 kg/cm^2	9 kg/cm^2	
	Bearing unit stress	60 kg/cm^2	90 kg/cm^2	
	Bond unit stress	12.0 kg/cm^2	18.0 kg/cm^2	
Stee pipe pile	Compressive unit stress	1,600 kg/cm^2	2,400 kg/cm^2	SKK 41
	Tensile unit stress	1,600 kg/cm^2	2,400 kg/cm^2	
	Shearing unit stress	900 kg/cm^2	1,350 kg/cm^2	
Modulus of elasticity	Concrete	2.4×10^5 kg/cm^2		$\sigma 28$ = 180 kg/cm^2
	Steel pipe pile	2.1×10^6 kg/cm^2		SKK 41

o The allowable strength of reinforced concrete is calculated according to JEC-127, Design Standards for Transmission Tower (Japanese Electrotechnical Committee).

The modulus of elasticity of reinforcing steel bars and that of steel pipe pipe are calculated respectively on the basis of Structural Design Standards for Architectural Foundation and the Design Standards for

Architectural Pile Foundation (Architectural Institute of Japan).

(b) Unit weight

Table 10.7.6 Unit Weight of Materials

	(ton/m^3)	Submerged	Remarks
Reinforced concrete	2.4	1.4	$\sigma 28 = 180$ kg/cm^2
Steel pipe pile	7.85	6.85	SKK41

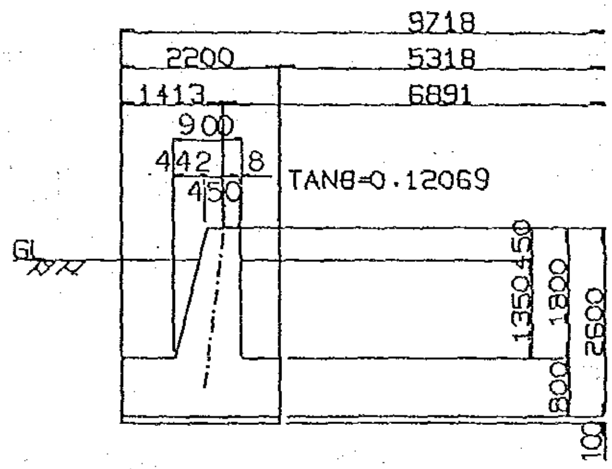
10.7.3 Foundation Design

(1). As-D-I

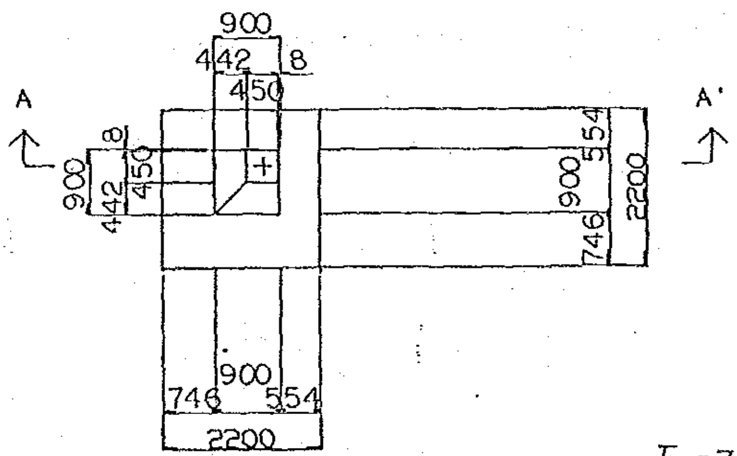
C = 37.54 t
T = 25.49
Q = 2.89
Q_B = 1.10

PROFILE

S=1/100



A-A' SECTION



F_c = 7.21 > 2.00

F_t = 2.07 > 2.00

PLAN

INDIVIDUAL TYPE TOWER FOUNDATION (I , II)

------------------------------INPUT DATA------------------------------

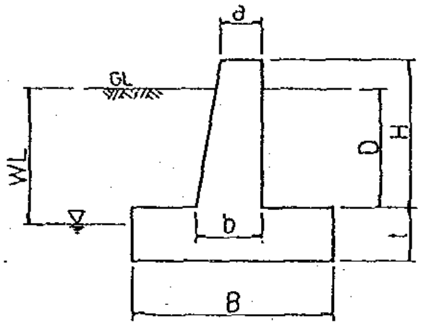
TOWER NAME............NO. AS-D-I

(1)LOAD CONDITION

Comp. Load....................C = 37.54 TON
Uplift Load...................T = 25.49 TON
Hori. Load....................Q = 2.89 TON
Hori. Load....................QB= 1.10 TON
E-Load........................TO= 14.24 TON

(2)DIMENSION OF FOUNDATION

a = 0.450 M
b = 0.900 M
B = 2.200 M
t = 0.800 M
H = 1.800 M
D = 1.350 M
WL=- 10.000 M
γ = 2.40 TON/M^3



(3)SOIL CONDITION

Unit Weight of Soil (beneath the foundation)......S1= 1.800 TON/M^3
Unit Weight of Soil (on the foundation)...........S2= 1.440 TON/M^3
Cohesion (beneath the foundation)................C1= 0.000 TON/M^2
Cohesion (on the foundation).....................C2= 0.000 TON/M^2
Angle of Internal Friction (on the foundation)....ϕ = 40.000 °
Bearing Capacity Factor..N1= 95.400 N2=114.000 N3= 83.200 (ϕ =40 °)

(4)FOUNDATION TYPE

Foundation Type (shallow type...1,deep type...2)... 1

-----------------------------------RESULT-----------------------------------

(5)VERTICAL LOAD

```
Weight of concrite..........................WC=    11.334 TON
Weight of Soil..............................WS=    10.439 TON
Weight of Column and a part under Column...WC'=     3.596 TON
Vertical Load.........................P=C+WC+WS=   59.313 TON
```

(6)PILE CAPACITY

```
Comp. Side..................................QCY=  100.000 TON/M^2
Uplift Side.................................QTY=   51.451 TON/M^2
Hori. Side..................................QHY=   40.000 TON/M^2
```

(7)SOIL REACTION   Upper Limit

1)Comp. Side

```
Eccentricity....E=QB*(H+T')/P=  0.048 M <= B/6=  0.367 M
Incremental Rate....................MU=1+6*E/B=  1.132
Max. Soil Reaction.................Qmax=P/A*MU= 13.866 TON/M^2
```

2)Uplift Side

```
Eccentricity...................E=QB*H/(T-WC')=  0.090 M
Reduction Rate.........K=1/(1+6*E*B/(B^2+b^2))=  0.826
```

(8)HORIZONTAL SOIL REACTION

```
Max. Horizontal soil Reaction....QHmax=Q/(B*t)=  1.642 TON/M^2
```

(9)SAFETY FACTOR

```
Comp. Side.......................SFC=QCY/Qmax=   7.211 >=  2.00 =OK=
Uplift Side........................SFT=QTY/T=   2.018 >=  2.00 =OK=
Hori. Side.....................SFH=QHY/QHmax=  24.360 >=  2.00 =OK=
```

(10)E-LOAD   From Upper Limit.

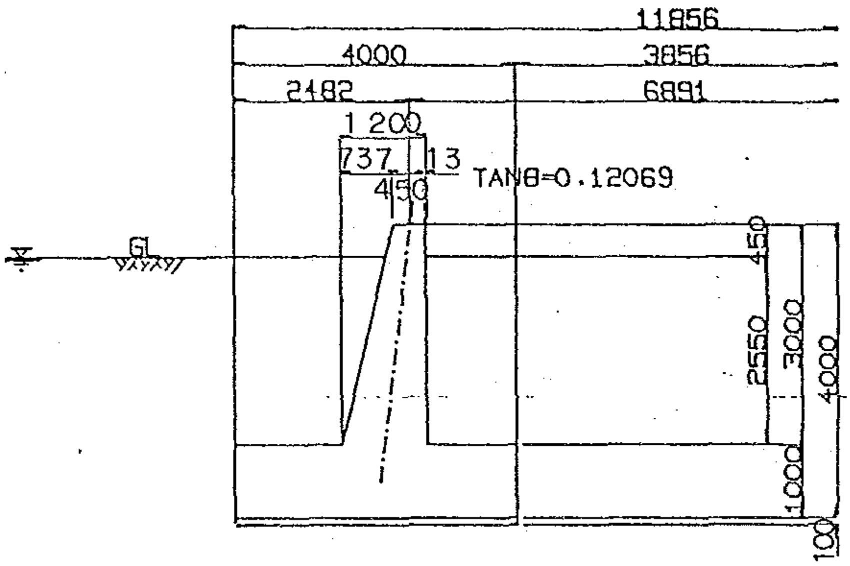
```
WC+WS'=   19.685 TON >= TO=   14.240 TON =OK=
   (WS'=WS*0.8)
```

(2). As- C -I

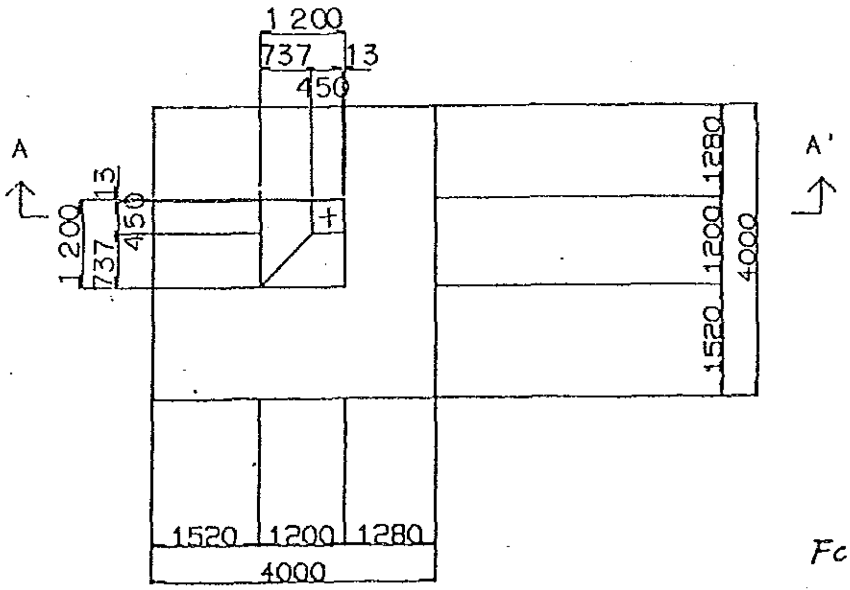
C= 37.54^t
T= 25.49
Q= 2.89
Qa= 1.10

PROFILE

S=1/100



A - A' SECTION



Fc= 7.37 > 2.0

Ft= 2.13 > 2.0

PLAN

INDIVIDUAL TYPE TOWER FOUNDATION (I , II)

------------------------------INPUT DATA--------------------------------------

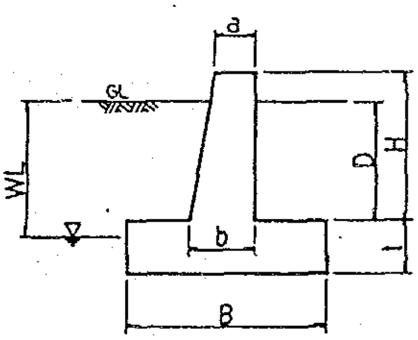
TOWER NAME............NO. A_s -C-I

(1)LOAD CONDITION

```
Comp. Load....................C =  37.54 TON
Uplift Load...................T =  25.49 TON
Hori. Load....................Q =   2.89 TON
Hori. Load....................QB=   1.10 TON
E-Load........................TO=  14.24 TON
```

(2)DIMENSION OF FOUNDATION

```
a =   0.450 M
b =   1.200 M
B =   4.000 M
t =   1.000 M
H =   3.000 M
D =   2.550 M
WL=-  0.000 M
γ =   2.40 TON/M^3
```



(3)SOIL CONDITION

```
Unit Weight of Soil (beneath the foundation)......S1=  1.800 TON/M^3
Unit Weight of Soil (on the foundation)...........S2=  1.440 TON/M^3
Cohesion (beneath the foundation)................C1=  0.000 TON/M^2
Cohesion (on the foundation).....................C2=  0.000 TON/M^2
Angle of Internal Friction (on the foundation)....φ = 35.000 °
Bearing Capacity Factor..N1= 35.400 N2= 23.400 N3= 27.800 (φ =35 °)
```

(4)FOUNDATION TYPE

Foundation Type (shallow type...1,deep type...2)... 2

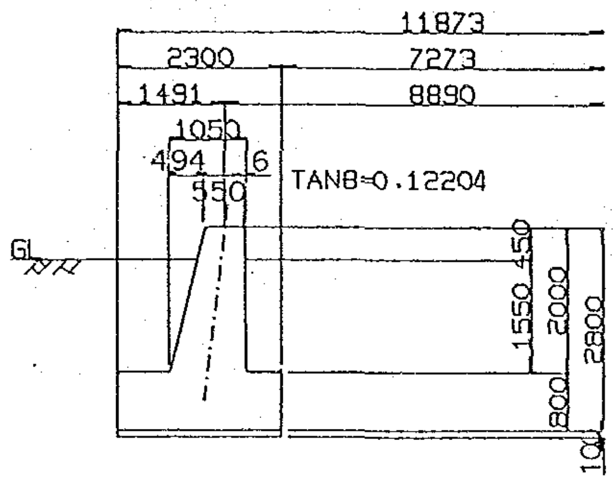
```
----------------------------------RESULT----------------------------------------

(5)VERTICAL LOAD

   Weight of concrite..........................WC=   43.638 TON
   Weight of Soil..............................WS=   69.720 TON
   Weight of Column and a part under Column...WC'=    5.187 TON
   Vertical Load.......................P=C+WC+WS=  150.898 TON

(6)PILE CAPACITY

   Comp. Side..................................QCY=  72.603 TON/M^2
   Uplift Side.................................QTY=  54.378 TON/M^2
   Hori. Side..................................QHY=  29.041 TON/M^2

(7)SOIL REACTION

  1)Comp. Side

   Eccentricity....E=QB*(H+T')/P=  0.029 M <= B/6=  0.667 M
   Incremental Rate......................MU=1+6*E/B=  1.044
   Max. Soil Reaction..................Qmax=P/A*MU=  9.844 TON/M^2

  2)Uplift Side

   Eccentricity......................E=QB*H/(T-WC')=  0.163 M
   Reduction Rate.........K=1/(1+6*E*B/(B^2+b^2))=  0.817

(8)HORIZONTAL SOIL REACTION

   Max. Horizontal soil Reaction....QHmax=Q/(B*t)=  0.723 TON/M^2

(9)SAFETY FACTOR

   Comp. Side........................SFC=QCY/Qmax=  7.375 >=  2.00 =OK=
   Uplift Side..........................SFT=QTY/T=  2.133 >=  2.00 =OK=
   Hori. Side.......................SFH=QHY/QHmax= 40.195 >=  2.00 =OK=

(10)E-LOAD

   WC+WS'=    42.614 TON >= TO=    14.240 TON =OK=
      (WS'=WS*0.8)
```

(3). A-D-I

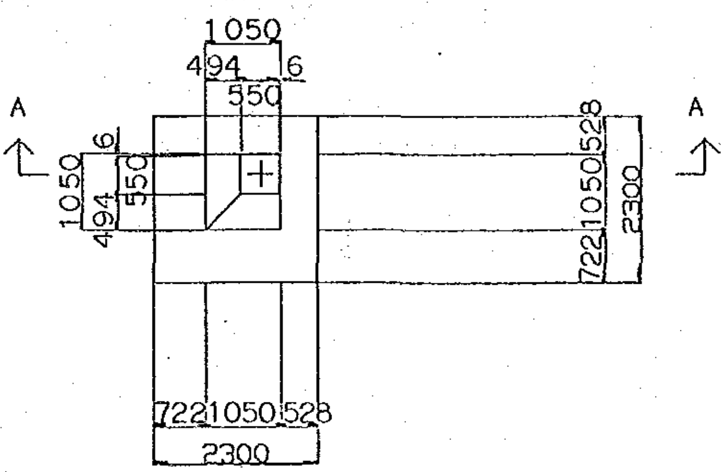
C = 49.27[+]
T = 34.09
Q = 4.14
Q_B = 1.53

PROFILE

S=1/100



A-A' SECTION



Fc = 6.11 > 2.00
Ft = 2.01 > 2.00

PLAN

INDIVIDUAL TYPE TOWER FOUNDATION (I , II)

-------------------------------INPUT DATA-------------------------------------

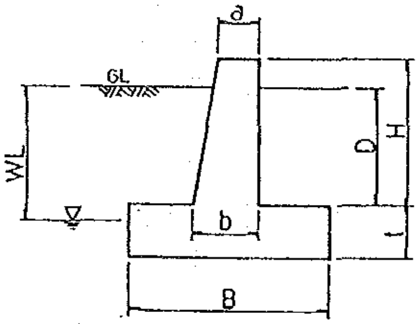
TOWER NAME............NO. A-D-I

(1)LOAD CONDITION

Comp. Load...................C = 49.27 TON
Uplift Load..................T = 34.09 TON
Hori. Load...................Q = 4.14 TON
Hori. Load...................QB= 1.53 TON
E-Load.......................TO= 1.89 TON

(2)DIMENSION OF FOUNDATION

a = 0.550 M
b = 1.050 M
B = 2.300 M
t = 0.800 M
H = 2.000 M
D = 1.550 M
WL=- 10.000 M
γ = 2.40 TON/M^3



(3)SOIL CONDITION

Unit Weight of Soil (beneath the foundation)......S1= 1.800 TON/M^
Unit Weight of Soil (on the foundation)...........S2= 1.440 TON/M^3
Cohesion (beneath the foundation).................C1= 0.000 TON/M^2
Cohesion (on the foundation)......................C2= 0.000 TON/M^
Angle of Internal Friction (on the foundation)....φ = 40.000 °
Bearing Capacity Factor..N1= 95.700 N2=114.000 N3= 83.200 (φ =40 °)

(4)FOUNDATION TYPE

Foundation Type (shallow type...1,deep type...2)... 2

------------------------------------RESULT------------------------------------

(5)VERTICAL LOAD

```
Weight of concrite..........................WC=    13.329 TON
Weight of Soil..............................WS=    12.679 TON
Weight of Column and a part under Column...WC'=    5.289 TON
Vertical Load.......................P=C+WC+WS=    75.278 TON
```

(6)PILE CAPACITY

```
Comp. Side................................QCY= 100.000 TON/M^2
Uplift Side...............................QTY=  68.558 TON/M^2
Hori. Side................................QHY=  40.000 TON/M^2
```

(7)SOIL REACTION   Upper Limit

1)Comp. Side

```
Eccentricity....E=QB*(H+T')/P=  0.057 M <= B/6=  0.383 M
Incremental Rate....................MU=1+6*E/B=  1.148
Max. Soil Reaction...............Qmax=P/A*MU= 16.343 TON/M^2
```

2)Uplift Side

```
Eccentricity....................E=QB*H/(T-WC')=  0.106 M
Reduction Rate.........K=1/(1+6*E*B/(B^2+b^2))=  0.813
```

(8)HORIZONTAL SOIL REACTION

```
Max. Horizontal soil Reaction....QHmax=Q/(B*t)=  2.250 TON/M^2
```

(9)SAFETY FACTOR

```
Comp. Side......................SFC=QCY/Qmax=  6.118 >=  1.33 =OK=
Uplift Side......................SFT=QTY/T=  2.011 >=  1.33 =OK=
Hori. Side....................SFH=QHY/QHmax= 17.777 >=  1.33 =OK=
```

(10)E-LOAD   From Upper Limit

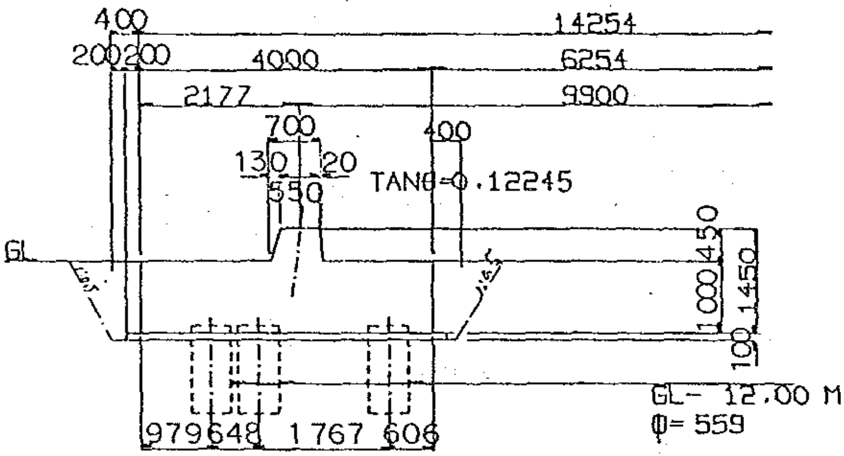
```
WC+WS'=   23.472 TON >= TO=    1.890 TON =OK=
   (WS'=WS*0.8)
```

(4). AL-S-III

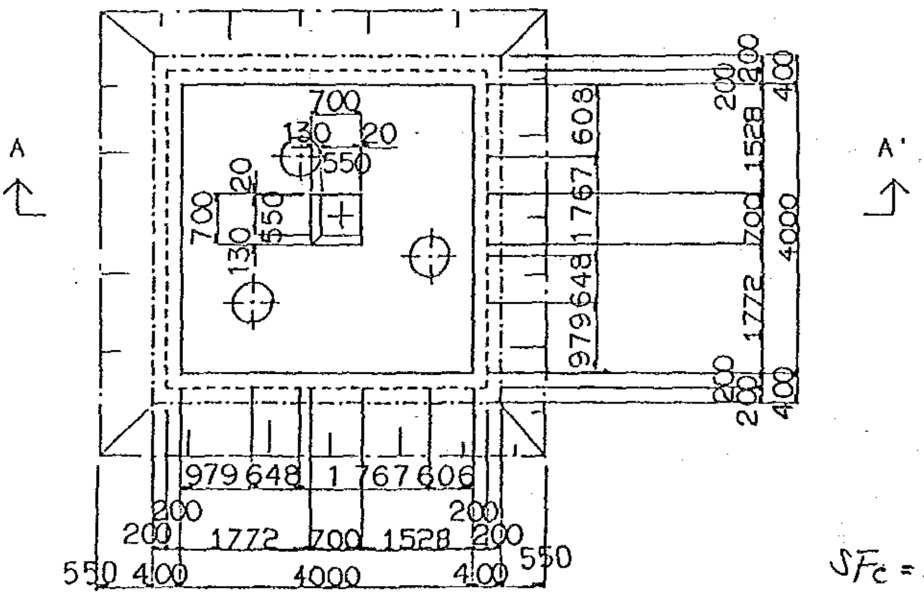
$C = 57.95^{t}$
$T = 40.17$
$Q_A = 1.72$

PROFILE

S=1/100



A-A' SECTION



$SF_c = 2.54 > 2.00$

$SF_t = 2.01 > 2.00$

PLAN

PILE TYPE TOWER FOUNDATION (Ⅲ)

----------------------------------INPUT DATA----------------------------------

TOWER NAME.....NO. AL-S-Ⅲ

(1)LOAD CONDITION

Comp. Load........................C = 57.95 TON
Uplift Load.......................T = 40.17 TON
Hori. Load........................Q = 6.89 TON
Hori. Load........................QB= 1.72 TON
E-Load............................TO= 2.29 TON

(2)STRATUM DATA

No.	Stratum No.	N-Value(N)	Thickness(L)	N*L
1	1	0(0)	1.00 M	0.000(0.000)
2	1	1(1)	2.00 M	2.000(2.000)
3	2	3(3)	1.00 M	2.500(2.500)
4	1	7(7)	6.50 M	45.500(45.500)
5	2	16(6)	1.50 M	24.000(9.000)

Sand (total)....................NS*LS= 47.500 TON
(47.500)
Clay (total)....................QU*LC= 26.500 TON
(11.500)

(3)WATER TABLE......................WL=- 0.000

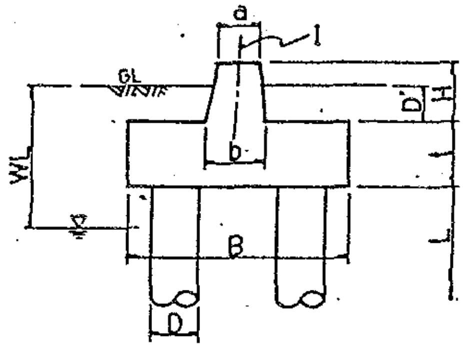
(4)N-VALUE OF BEARING STRATUM.........N = 29

(5)BULK DENSITY

Concrete...........................γ = 2.400 TON/M^3
Soil (on the foundation)...........S2= 0.000 TON/M^3

(6)DIMENSION OF FOUNDATION

a = 0.550 M
b = 0.700 M
B = 4.000 M
t = 1.000 M
H = 0.450 M
D'= 0.000 M
I = 0.12245



(7)PILE TYPE (driven pile...1,cast in place conc. pile...2).... 2

(8)PILE CONDITION

Diameter of Pile....................D = 0.559 M
Length of Pile......................L = 12.000 M
Unit Weight (without buoyancy)......G1= 0.589 TON/M
Unit Weight (with buoyancy).........G2= 0.344 TON/M
Blockade Ratio......................R = 1.000

(9)LIMIT OF PILE CAPACITY

Comp. Side.........................QCA= 124.000 TON/UNIT
Uplift Side........................QTA= 49.000 TON/UNIT

(10)CONFIGURATION

Row of pile	Number(UNIT)	Distance(M)
1	1	1.394
2	1	-0.373
3	1	-1.021

Eccentricity.......................E= 0.000 M

```
----------------------------------RESULT----------------------------------
(11)VERTICAL LOAD

  1)Without Buoyancy

  Weight of Concrete....................WC=   38.824 TON
  Weight of Soil (on the foundation)....WS=    0.000 TON
  Vertical Load..................P=C+WC+WS=   96.774 TON

  2)With Buoyancy

  Weight of Concrete....................WC=   22.824 TON
  Weight of Soil (on the foundation)....WS=    0.000 TON
  Vertical Load..................P=C+WC+WS=   80.774 TON

(12)PILE CAPACITY

  Comp. Side...QCY=15*R*N*π*D^2/4+((NS*LS)/5+(QU*LC)/2)*π*D)/1.5-2*WP
               =  84.849 TON/UNIT

  Uplift Side..QTY=((NS*LS)/5+(QU*LC)/2)*π*D+1.5WP')/1.5
               =  21.638 TON/UNIT

(13)OVERTURNING MOMENT

  1)Without Buoyancy

  Comp. Side..............MC=QB*(H+t)+P*E=     2.494 TON-M
  Uplift Side....MT=QB*(H+t)+|T-WC-WS|*E=     2.494 TON-M

  2)With Buoyancy

  Comp. Side..............MC=QB*(H+t)+P*E=     2.494 TON-M
  Uplift Side....MT=QB*(H+t)+|T-WC-WS|*E=     2.494 TON-M

(14)WEIGHT OF PILE

  Without Buoyancy......................WP=    6.479 TON/UNIT
  With Buoyancy........................WP'=    3.784 TON/UNIT
```

(15)LOAD DISTRIBUTIVE

Without Buoyancy......................KA= 0.374
With Bouyancy.........................KA= 0.260

(16)PILE REACTION

1)Comp. Side

Row of pile	Without Buoyancy (TON/UNIT)	With Buoyancy (TON/UNIT)
1	33.371	28.037
2	31.960	26.627
3	31.443	26.110

2)Uplift Side

Row of pile	Without Buoyancy (TON/UNIT)	With Buoyancy (TON/UNIT)
1	9.075	10.730
2	8.193	9.687
3	7.869	9.304

(17)SAFETY FACTOR

1)Without Buoyancy

Comp. Side.................SFC=QCY/NCmax= 2.542 >= 2.0 =OK=
Uplift Side................SFT=QTY/NTmax= 2.384 >= 2.0 =OK=

2)With Buoyancy

Comp. Side.................SFC=QCY/NCmax= 3.026 >= 2.0 =OK=
Uplift Side................SFT=QTY/NTmax= 2.016 >= 2.0 =OK=

(18)E-LOAD

1)Without Buoyancy

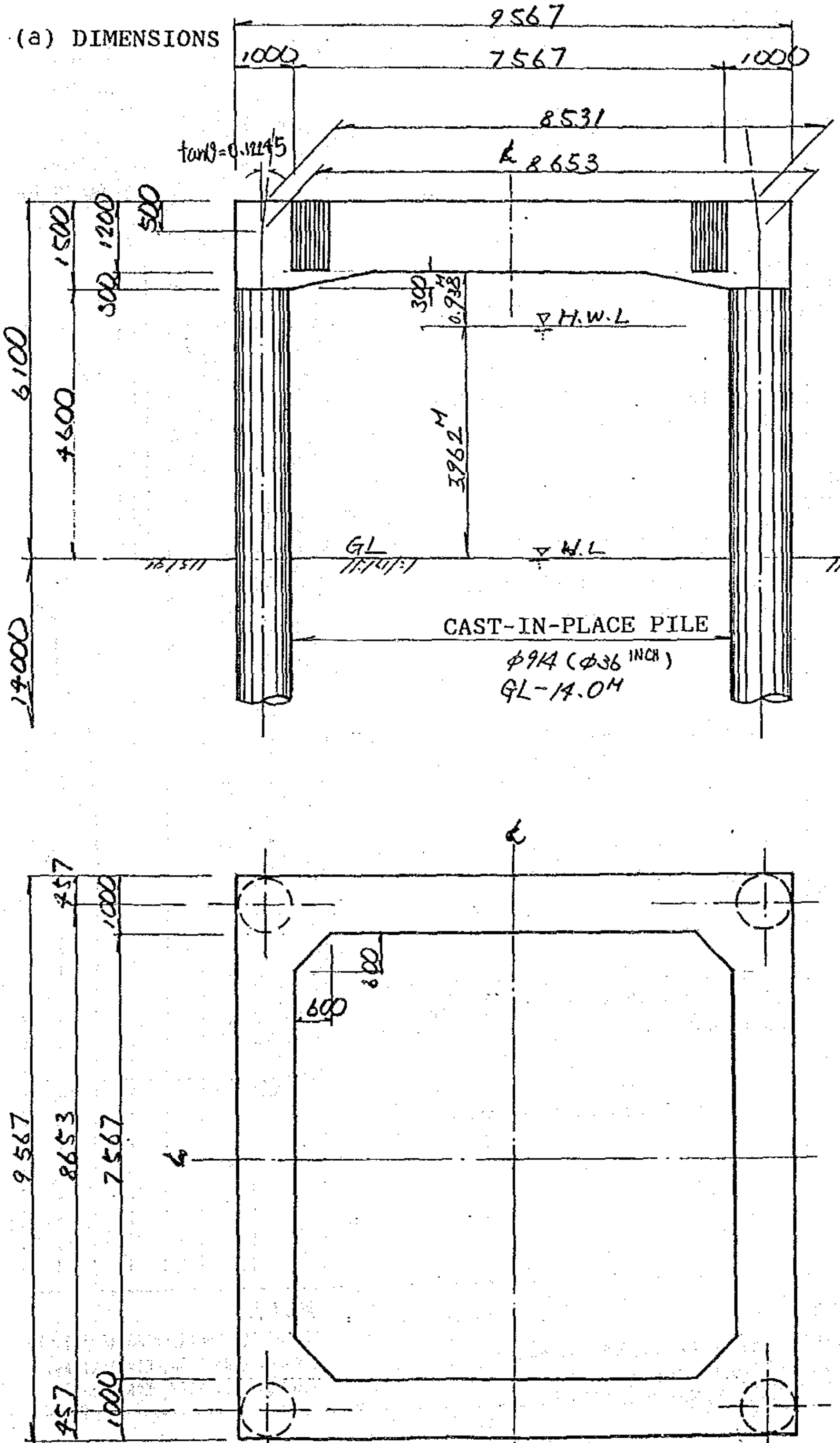
WC+WS+N*WP= 58.261 TON >TO= 2.290 TON =OK=

2)With Buoyancy

WC+WS+N*WP'= 34.176 TON >TO= 2.290 TON =OK=

(5). AL-R

(a) DIMENSIONS



(b) Computation of Bearing Capacity of Ground

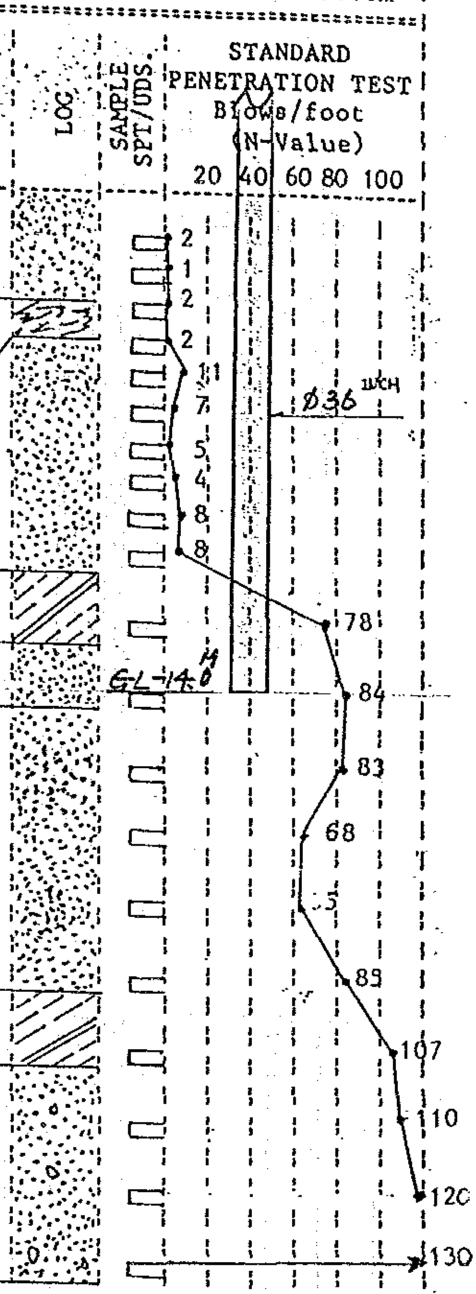
KESC WEST WHARF - Transmission Line.

BORE HOLE NO: TL-1

BORE LOG

Date: 28.5.89 to 30.5.89 Ground Elev: 3.066m Ground Water Table: 3.00m

DEPTH (m)	THICKNESS (m)	SOIL NAME/DESCRIPTION
3.00	3.00	Brown, very loose, fine SAND.
4.00	1.00	Dark brown, decayed, soft wooden pieces.
10.50	6.50	Grey, loose, fine SAND with traces of shell fragments.
12.50	2.00	Grey, hard, Silty CLAY.
14.50	2.00	Grey, very dense, fine SAND.
22.50	8.00	Brown, very dense, fine to medium, SAND with traces of coarse SAND.
24.50	2.00	Brownish grey, hard, Silty CLAY.
30.50	6.00	Brownish grey, fine to medium, very dense SAND with traces of coarse sand and gravel.
		Borehole completed.



SPT Sample: ▭

NB: Ground Water Table reported in all Borecharts indicate depth of water below the existing ground level.

PGEL
PENCON GEO-ENGINEERING (PVT.) LTD.
9 Sunny Side Road, Civil Lines,
P.O. Box No: 3969, KARACHI-4

No.	Stratum No.	N-Value(N)	Thickness(L)	N*L
1	1	1(1)	3.00 M	3.000(3.000)
2	2	3(3)	1.00 M	2.500(2.500)
3	1	7(7)	6.50 M	45.500(45.500)
4	2	16(6)	2.00 M	32.000(12.000)
5	1	50(50)	1.50 M	75.000(75.000)

Sand (total)....................NS*LS= 123.500 TON
(123.500)
Clay (total)....................QU*LC= 34.500 TON
(14.500)

WATER TABLE.......................WL=- 0.000

N-VALUE OF BEARING STRATUM.........N = 46

PILE CONDITION

Diameter of Pile...................D = 0.914 M
Length of Pile.....................L = 14.000 M
Unit Weight (without buoyancy)......G1= 1.575 TON/M
Unit Weight (with buoyancy).........G2= 0.919 TON/M
Blockade Ratio.....................R = 1.000

LIMIT OF PILE CAPACITY

Comp. Side.......................QCA= 334.000 TON/UNIT
Uplift Side......................QTA= 131.000 TON/UNIT

PILE CAPACITY

Comp. Side...QCY=15*R*N*π*D^2/4+((NS*LS)/5+(QU*LC)/2)*π*D)/1.5-2*WP
= 334.000 TON/UNIT —— 330 t

Uplift Side..QTY=((NS*LS)/5+(QU*LC)/2)*π*D+1.5WP')/1.5
= 74.027 TON/UNIT ——> 74 t

WEIGHT OF PILE

Without Buoyancy......................WP= 22.050 TON/UNIT
With Buoyancy.........................WP'= 12.866 TON/UNIT

3

(c) Coefficient of Lateral Subgrade Reaction

The coefficient of lateral subgrade reaction should be calculated using the following formula, dividing the ground into five layers.

$$ko = \alpha Eo D^{-3/4}$$

where,

ko : coefficient of lateral subgrade reaction (kg/cm³)

α : coefficient for computation of Eo (α = 0.2) (Eo is estimated using the N-value of 28N.)

Eo : deformation modulus of ground (kg/cm²)

D : effective pile diameter (91.4 cm)

Stratigraphy \ Types	α	E_0 (kg/cm²)	D (cm)	k_0 (kg/cm³)	k (kg/cm²)	Remarks
Fine sand	0.2	28	91.4	0.189	17.3	
Humus	〃	56	〃	0.379	34.6	
Fine sand	〃	196	〃	1.326	121.2	
Silty clay	〃	1400	〃	9.472	865.7	
Fine sand	〃	1400	〃	9.472	865.7	

Note : k = ko·D

(d) Axial Spring Constant of Pile

The axial spring constant of the pile should be computed using the following formula.

$$kv = a \cdot \frac{Ap \cdot Ep}{\ell}$$

where,

kv : axial spring constant of pile (kg/cm)

Ap : net sectional area of pile (cm^2)

Ep : elastic modulus of pile body (kg/cm^2)

(= 270,000 kg/cm^2)

ℓ : pile length (cm)

a : $a = 0.022(\ell/D) - 0.05$

(cast-in-place pile)

$$K_v = \left(0.022 \times \frac{1400}{91.4} - 0.05\right) \times \frac{91.4^2 \times \pi/4 \times 270000}{1400}$$

$= 363137$ kg/cm

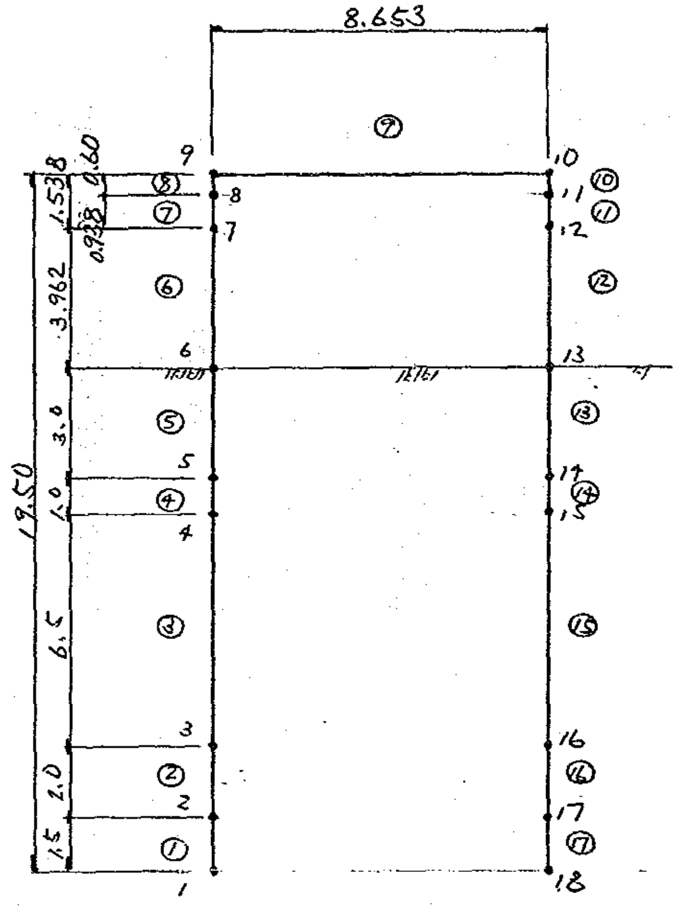
$= 36300$ t/m

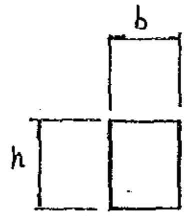
5

(e) Load Combination

Types \ Cases		Stationary	Abnormal	Oblique Wind	Oblique Wind	Earthquakes	Floods	E Load
Design Load		○	○	○	○	○	○	○
Water Flow Pressure							○	
Temperature Changes					○			
Wind Pressure		○	○	○	○		○	
Dead Weight of Tower						○		
Design Load	C	55.06	43.68	57.95	57.95	= E load	= Stationary	19.29
	T	37.28	31.77	40.17	40.17			2.29
	Q	11.28	40.17	6.89	6.89			2.05
Comparison Cases				※	※	※	※	※
Additional Rate of Stress	Foundation Body	1.0	1.5	1.0	1.15	1.5	1.5	1.0
	Pile Body	1.0	1.5	1.0	1.0	1.5	1.5	1.0
Remarks				CASE 1~3	CASE 13~15	CASE 4~6	CASE 7~9	CASE 10~12

(f) Skeleton Diagram



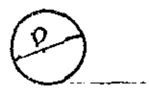


$$A = b \cdot h$$

$$= 1.00 \times 1.20 = 1.20 \; m^2$$

$$I = \frac{b \cdot h^3}{12}$$

$$= \frac{1.0 \times 1.2^3}{12} = 0.1440 \; m^4$$



$$A = \frac{\pi \cdot D^2}{4}$$

$$= \frac{\pi \times 0.914^2}{4} = 0.656 \; m^2$$

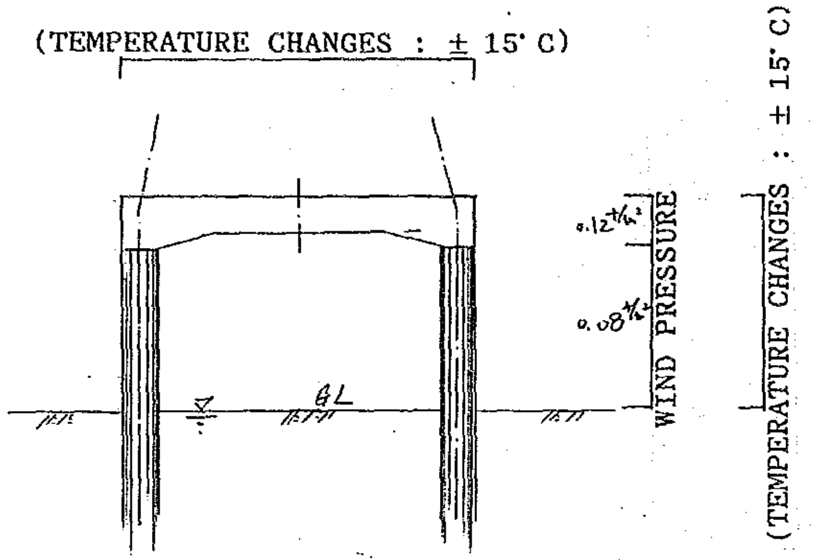
$$I = \frac{\pi \cdot D^4}{64}$$

$$= \frac{\pi \times 0.914^4}{64} = 0.0343 \; m^4$$

7

(9) Oblique Wind (taking account of temperature changes)

Load Computation



o Design Loads

$C = 57.95^{t}$

$T = 40.17$ "

$Q = 5.032 + 1.852 = 6.89^{t}$

o Dead Weight of Foundation

$w_1 = 1.00 \times 1.20 \times 2.4^{t/m^3} = 2.88^{t/m}$

$p_1 = (1/2 \times 9.567 \times 1.20 \times 1.00 + 1.00^2 \times 0.30) \times 2.4 = 14.50^{t}$

$p_2 = 1/2 \times 0.30 \times 1.50 \times 1.00 \times 2 \times 2.4 = 1.08$ "

$p_3 = 1/2 \times 0.60^2 \times 1.20 \times 2.4 = 0.52$ "

$P_1 = 16.10^{t}$

o Wind Pressure

$$P_{H1} = \{1/2 \times 9.567 \times 1.20 + 1/2 \times (1.00 + 2.50) \times 0.30\} \times 0.12^{t/m^2}$$

$$= 0.75^{t}$$

$$g_{H1} = 0.914 \times 0.08^{t/m^2} = 0.07^{t/m}$$

o Without Water Flow Pressure

o Dead Weight of Pile

In the air $g_1 = \pi/4 \times 0.914^2 \times 2.4^{t/m^3} = 1.57^{t/m}$

In the water $g_2 =$ 〃 1.4 〃 $= 0.92$ 〃

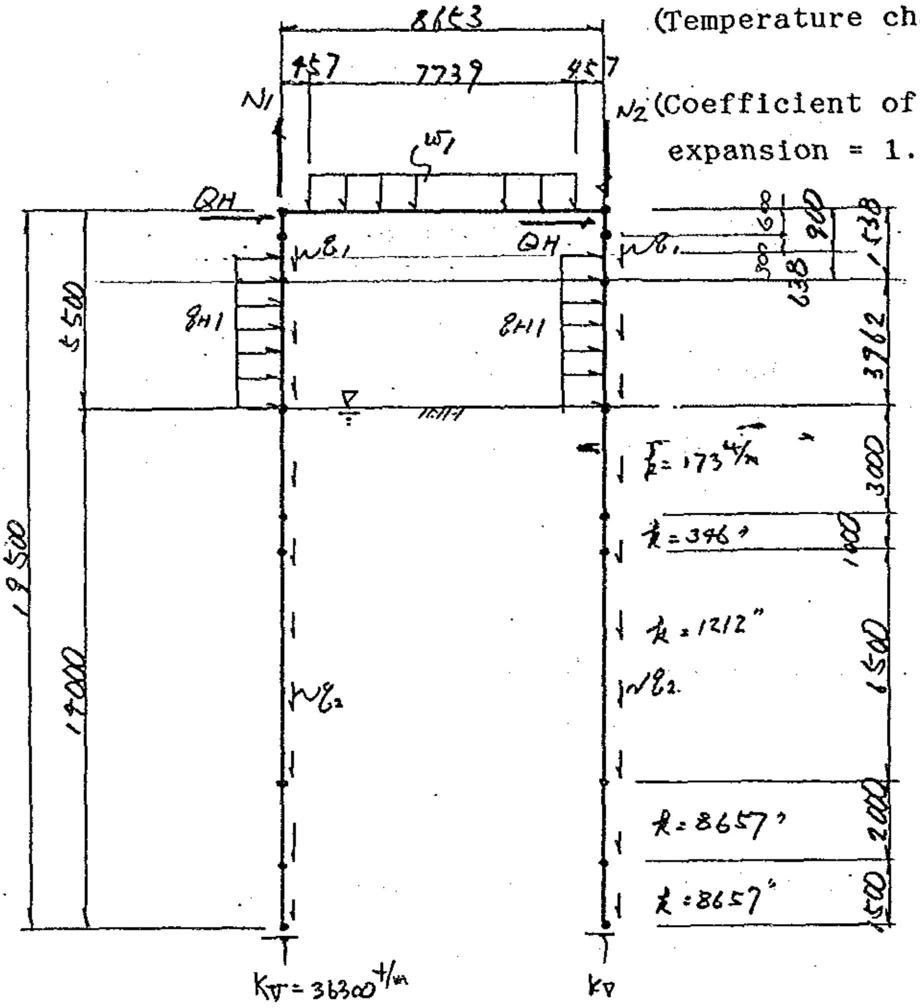
(Temperature changes)

± 15° C

(Coefficient of linear expansion)

Concrete $1.0 \times 10^{-5} = EPS$

Load Diagram (at oblique wind : C-T) CASE 1
(CASE 13)
Temperature changes



(Temperature changes : ± 15° C)
(Coefficient of linear expansion = 1.0 × 10^{-5})

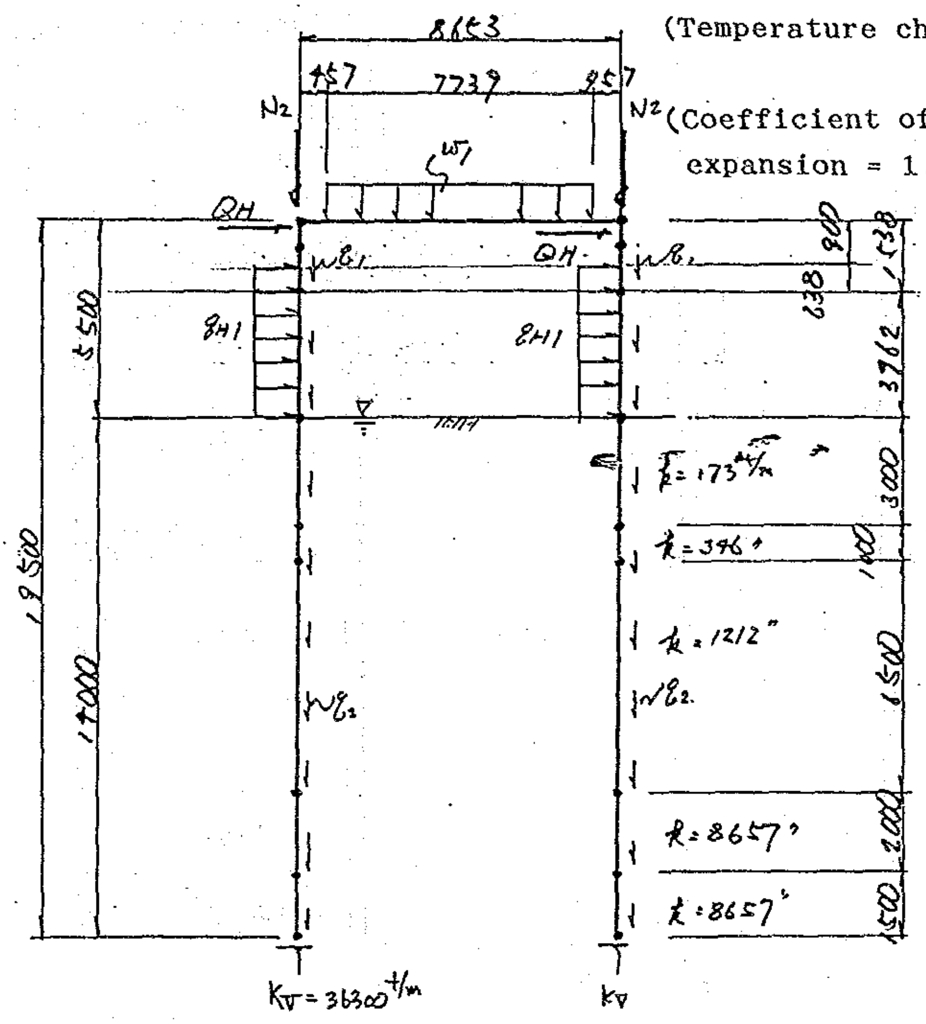
$N_1 = P_1 - T = 16.10 - 40.17$
$= -24.07^t$

$N_2 = P_1 + C = 16.10 + 57.95$
$= 74.05^t$

$Q_H = Q + P_{H1} = 6.89 + 0.75$
$= 7.64^t$

Load Diagram (at oblique wind : C-C) CASE 2
(CASE 14)
Temperature changes

(Temperature changes : ± 15°C)
(Coefficient of linear expansion = 1.0 × 10^{-5})



$N_2 = 74.05^t$

$QH = Q + P_{H1} = 6.89 + 0.75$
$= 7.64^t$

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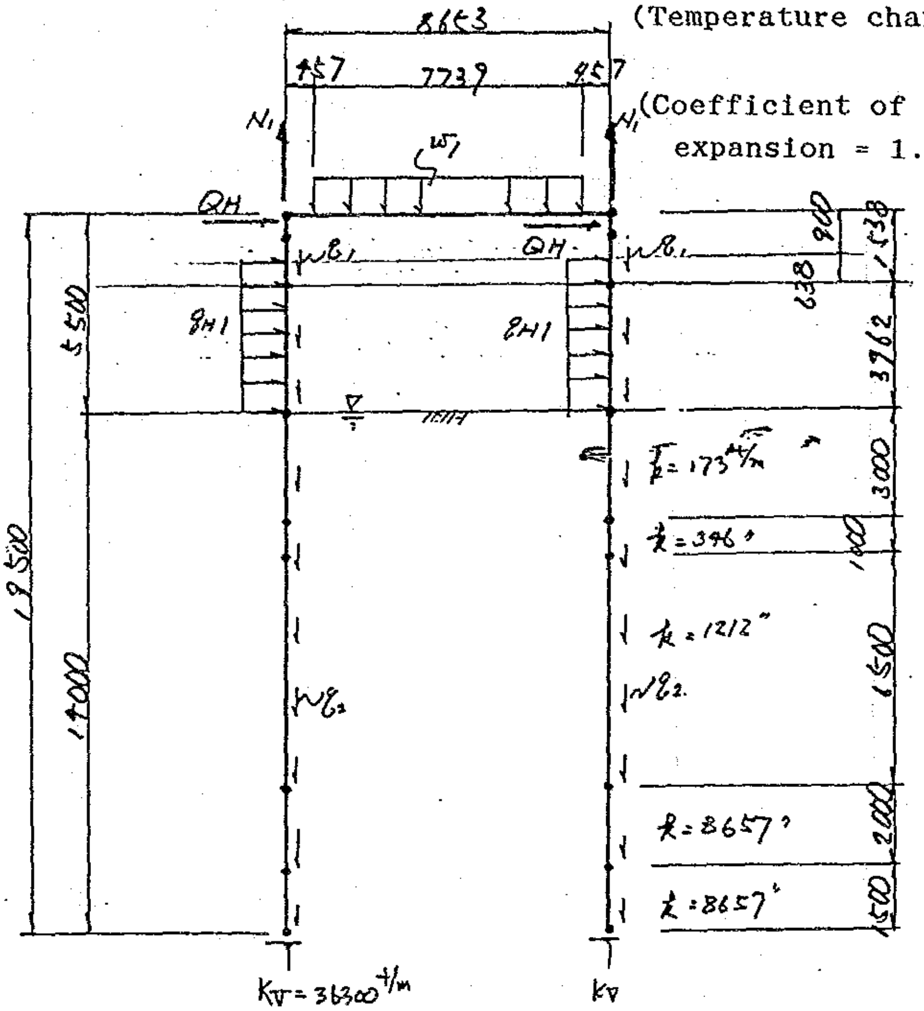
Load Diagram (at oblique wind : T-T) CASE 3
(CASE 15)
Temperature changes

(Temperature changes : ± 15°C)
(Coefficient of linear expansion = 1.0 × 10^{-5})

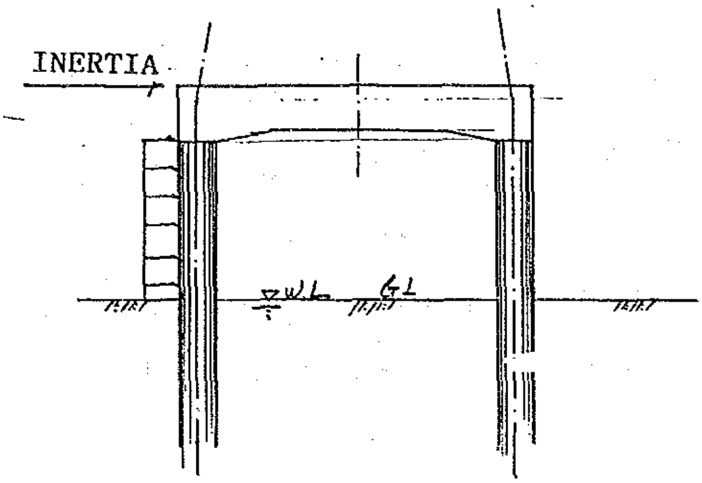


$N_1 = -24.07$

$Q_H = Q + P_{H1} = 6.89 + 0.75$
$= 7.64^t$

(h) During Earthquakes

Load Computation



o Design Loads

$C = 19.29^t$

$T = 22.82^t$

$Q = 1.341 + 0.704 = 2.05^t$

o Dead Weight of Foundation

$w_1 = 2.88\ t/m$

$P_1 = 14.50^t$ (Beam)

$P_2 = 1.08^t$ (Haunch)

$P_3 = 0.52^t$ (Horizontal haunch)

$P_i = 16.10^T$

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o Wind and Water Flow Pressures

Not taken into account

o Lateral Seismic Load

Lateral seismic coefficient $k_H = 0.1$

Beam $(1/2 \times 9.567 \times 1.00 \times 1.20 \times 2.4\,t/m^3 + 1/2 \times 7.567 \times 1.00 \times 1.20 \times 2.4) \times 0.1 = 2.47^t$

Beam $1.00^2 \times 0.30 \times 2.4 \times 0.1 = 0.07$ "

Haunch $1/2 \times 1.50 \times 0.30 \times 1.00 \times 2.4 \times 2 \times 0.1 = 0.11$ "

Haunch $1/2 \times 0.60^2 \times 1.20 \times 2.4 \times 0.1 = 0.05$ "

$P_{H1} = 2.70^t$

Pile $g_{H1} = \pi/4 \times 0.914^2 \times 2.40\,t/m^3 \times 0.1 = 0.16\,t/m$

o Dead Weight of Pile

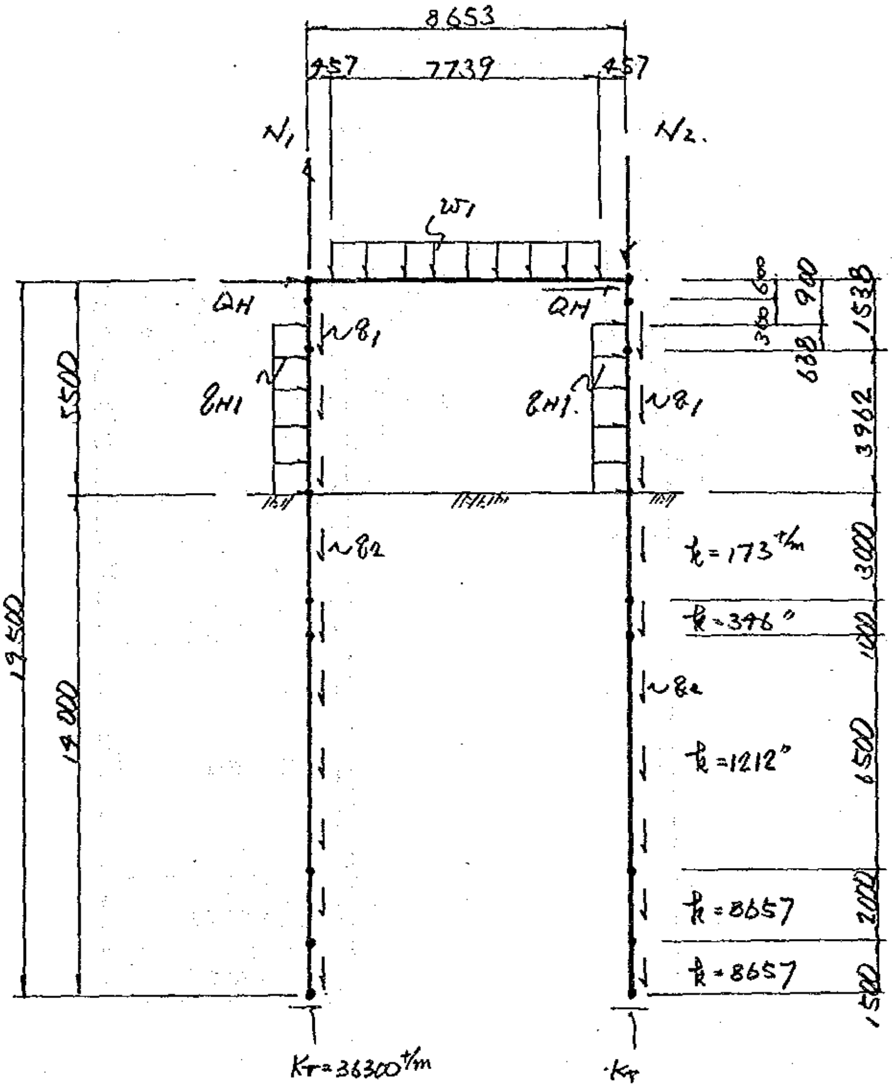
In the air $g_1 = \pi/4 \times 0.914^2 \times 2.4\,t/m^3 = 1.57\,t/m$

In the water $g_2 =$ " 1.4 " $= 0.92$ "

o Lateral Force on Tower $(k_H = 0.1)$

$P_{H2} = 26.54 \times 0.1 = 2.65^t$

Load Diagram (during earthquakes C-T)   CASE 4



$N_1 = P_1 - T = 16.10 - 22.82$

$= -6.72^t$

$N_2 = P_1 + C = 16.10 + 19.29$

$= 35.39^t$

$Q_H = Q + P_{H1} + P_{H2} = 2.05 + 2.70 + 2.65$

$= 7.40^t$

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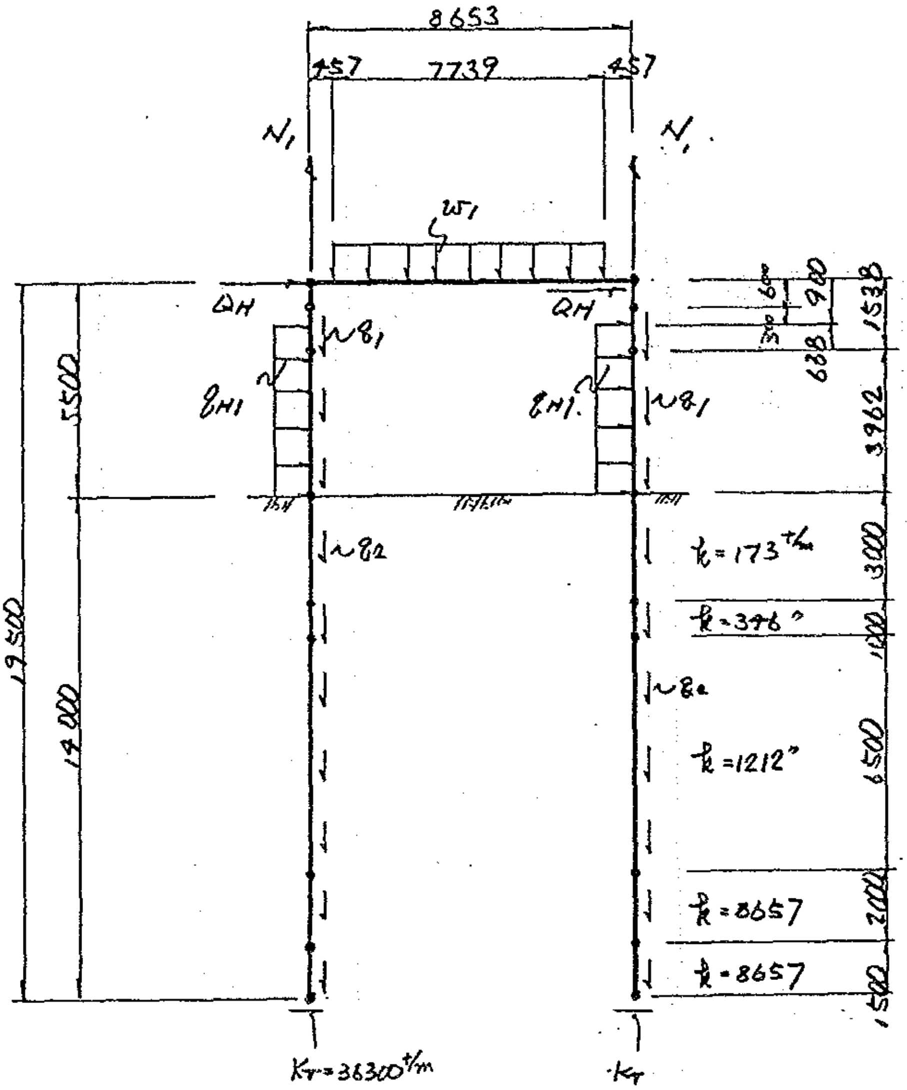
Load Diagram (during earthquakes T-T) CASE 5

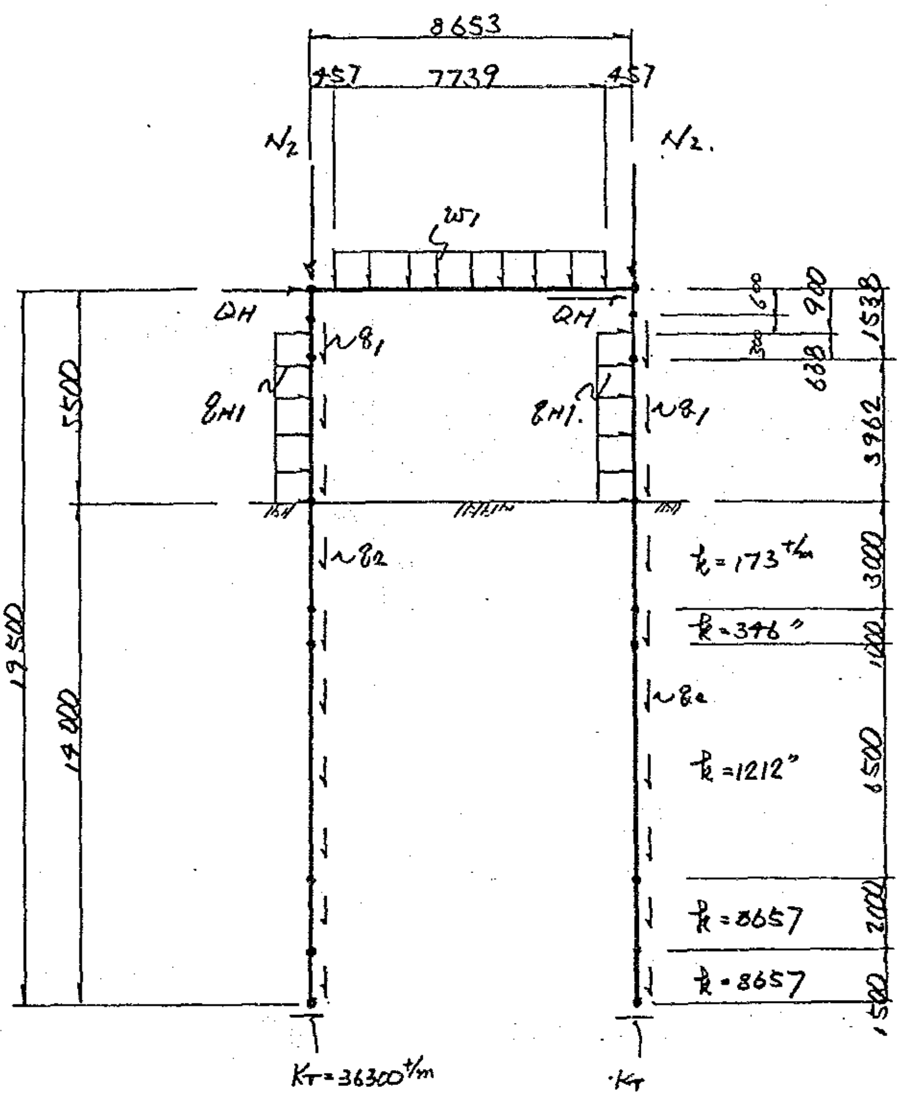


$N_1 = -6.72^t$

$Q_H = Q + P_{H1} + P_{H2} = 2.05 + 3.98 + 2.70$

$= 7.40$

Load Diagram (during earthquakes C-C) CASE 6



$N_2 = 35.39^t$

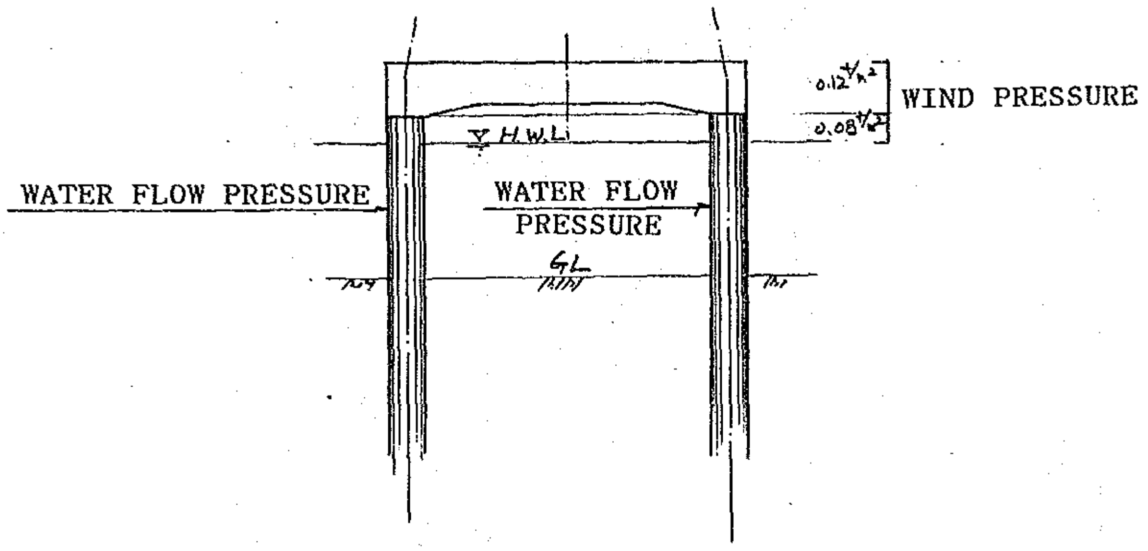
$Q_H = Q + P_{H1} = 2.05 + 2.70 + 2.65$

$= 7.40^t$

17

(i) During Floods

Load Computation



o Design Load

$C = 55.06^t$

$T = 37.28^t$

$Q = 6.783 + 4.489 = 11.28^t$

o Dead Weight of Foundation

$w_1 = 2.88^{t/m}$

$p_1 = 14.50^t$

$p_2 = 1.08$ "

$p_3 = 0.52$ "

$P_1 = 16.10^t$

o Wind Pressure

$$P_{H1} = \{1/2 \times 9.567 \times 120 + 1/2 \times (1.00 + 2.50) \times 0.30\} \times 0.12 \ t/m^2$$

$$= 0.75^t$$

$$g_{H1} = 0.914 \times 0.08 \ t/m^2 = 0.07 \ t/m$$

o Water Flow Pressure

The water flow pressure is calculated using the following formula.

$$P_{H2} = K \cdot A \cdot V^2 \ (+)$$

where,

K : coefficient of sectional shape (circular section = 0.04)

A : vertical projected area of pile

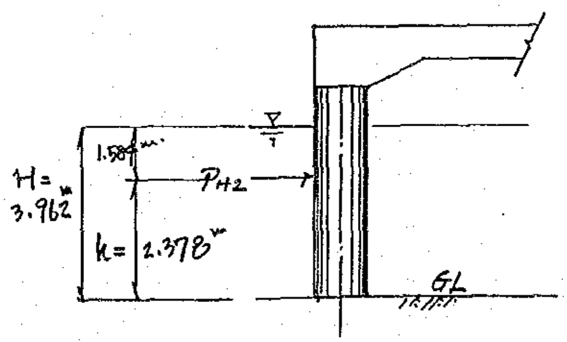
V : flow velocity (v = 1.83 m/s)

H : depth of water (= 3.962 m)

The application point of the water flow pressure is 0.6H above ground level.

$$\therefore P_{H2} = 0.04 \times 0.914 \times 1.83^2 \times 3.962 = 0.49^t$$

Application point (h) = 3.962 × 0.6 = 2.378 m



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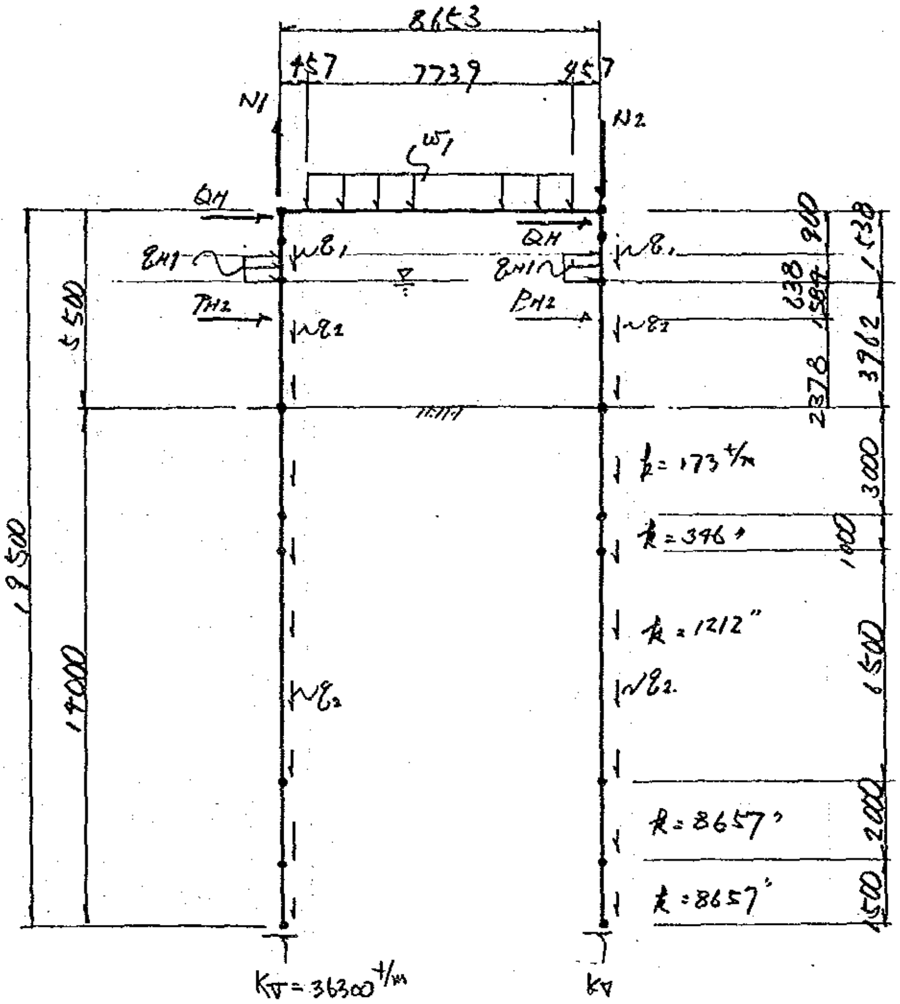
o Dead Weight of Pile

In air $\gamma_1 = 1.57$ t/m

In water $\gamma_2 = 0.92$ "

Load Diagram (during floods C-T) CASE 7



$N1 = P_1 - T = 16.10 - 55.06 = -38.96^t$

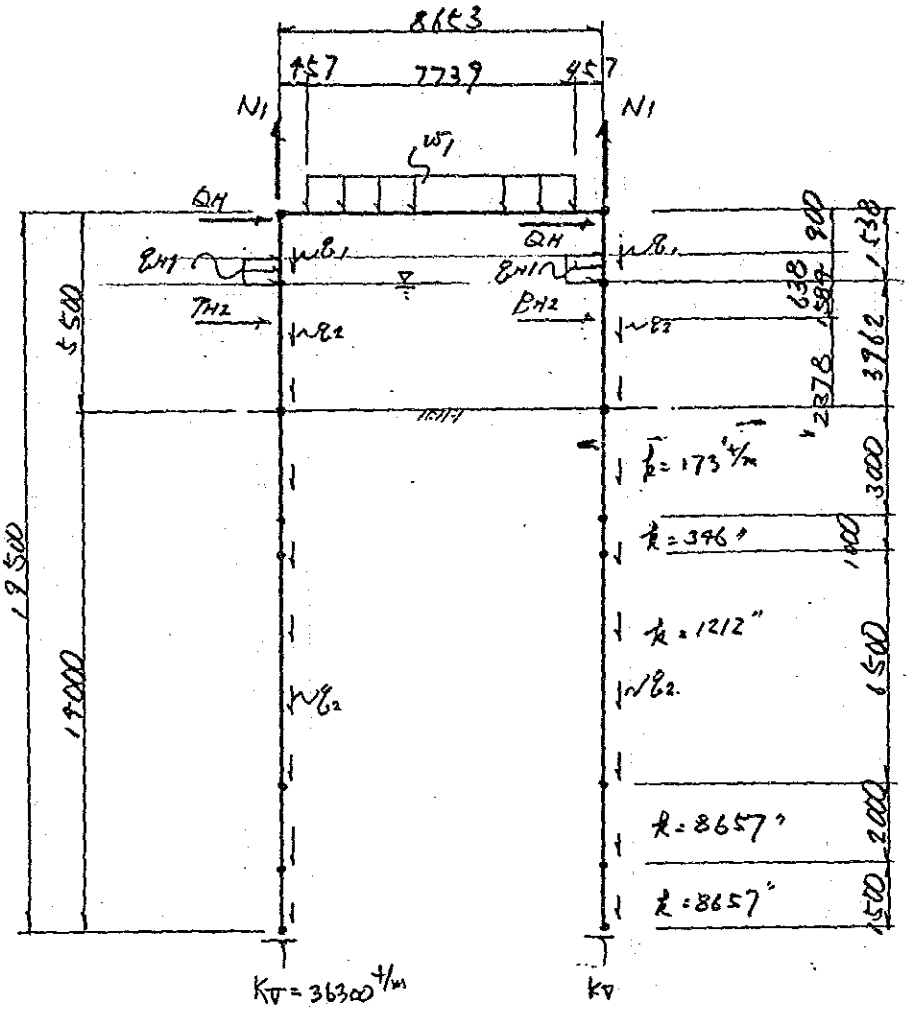
$N2 = P_1 + C = 16.10 + 37.28 = 53.38^t$

$Q_H = Q + P_{H1} = 11.28 + 0.75 = 12.03^t$

$P_{H2} = 0.49^t$

21

Load Diagram (during floods T-T) CASE 8

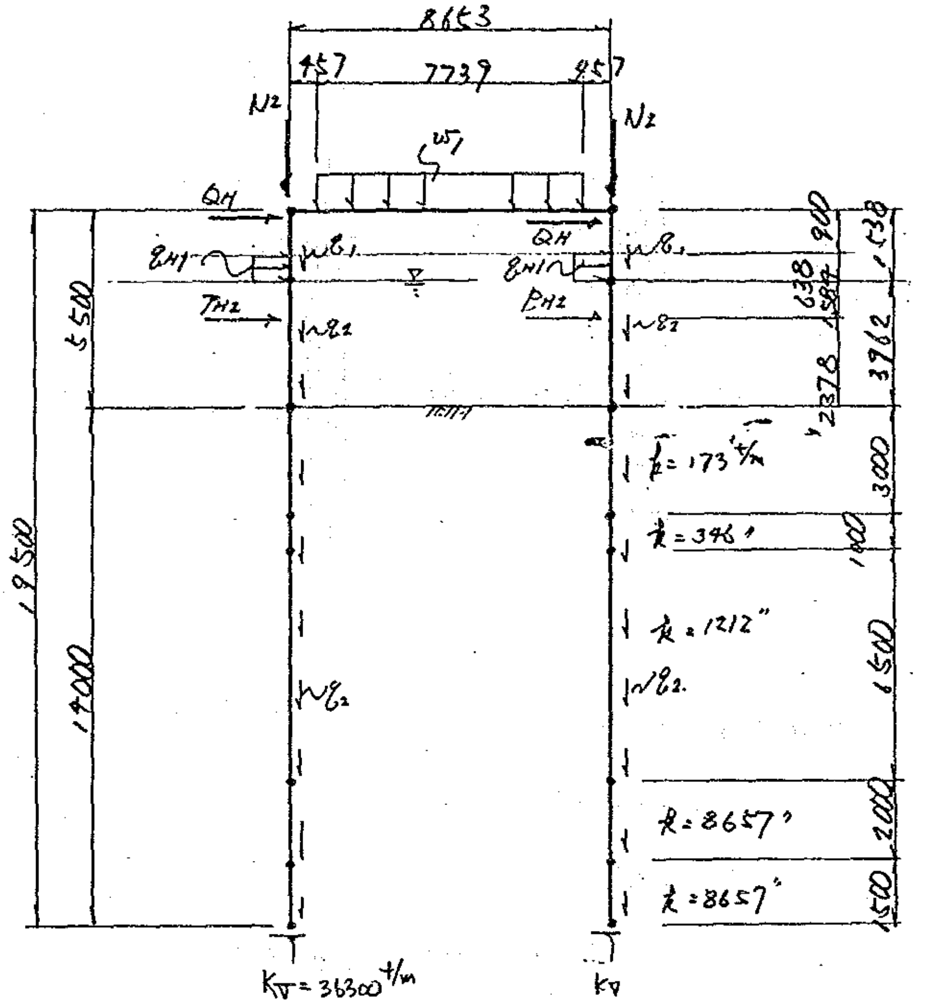


$N_1 = -38.96^t$

$Q_H = Q + P_{H1} = 11.28 + 0.75 = 12.03^t$

$P_{H2} = 0.49^t$

Load Diagram (during floods C-C) CASE 9



$N_2 = 53.38^t$

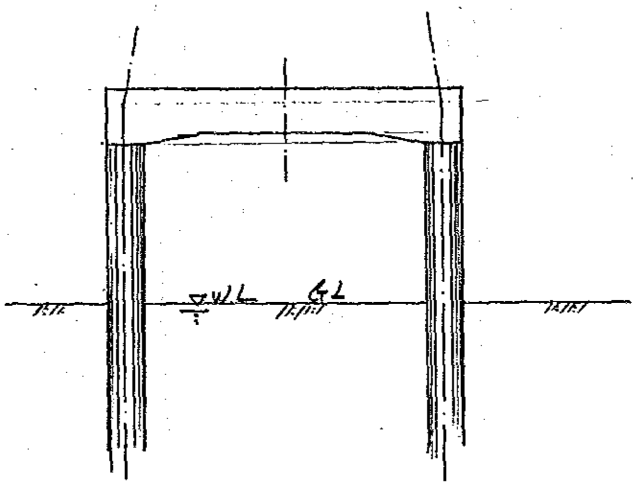
$Q_H = Q + P_{H1} = 11.28 + 0.75 = 12.03^t$

$P_{H2} = 0.49^t$

23

(j) During Load E

, Load Computation



o Design Loads

$C = 19.29^t$

$T = 22.82^t$

$Q = 1.341 + 0.704 = 2.05^t$

o Dead Weight of Foundation

$w_1 = 2.88\ ^t/m$

$p_1 = 14.50\ ^t$ (Beam)

$p_2 = 1.08\ ^t$ (Haunch)

$p_3 = 0.52\ ^t$ (Horizontal haunch)

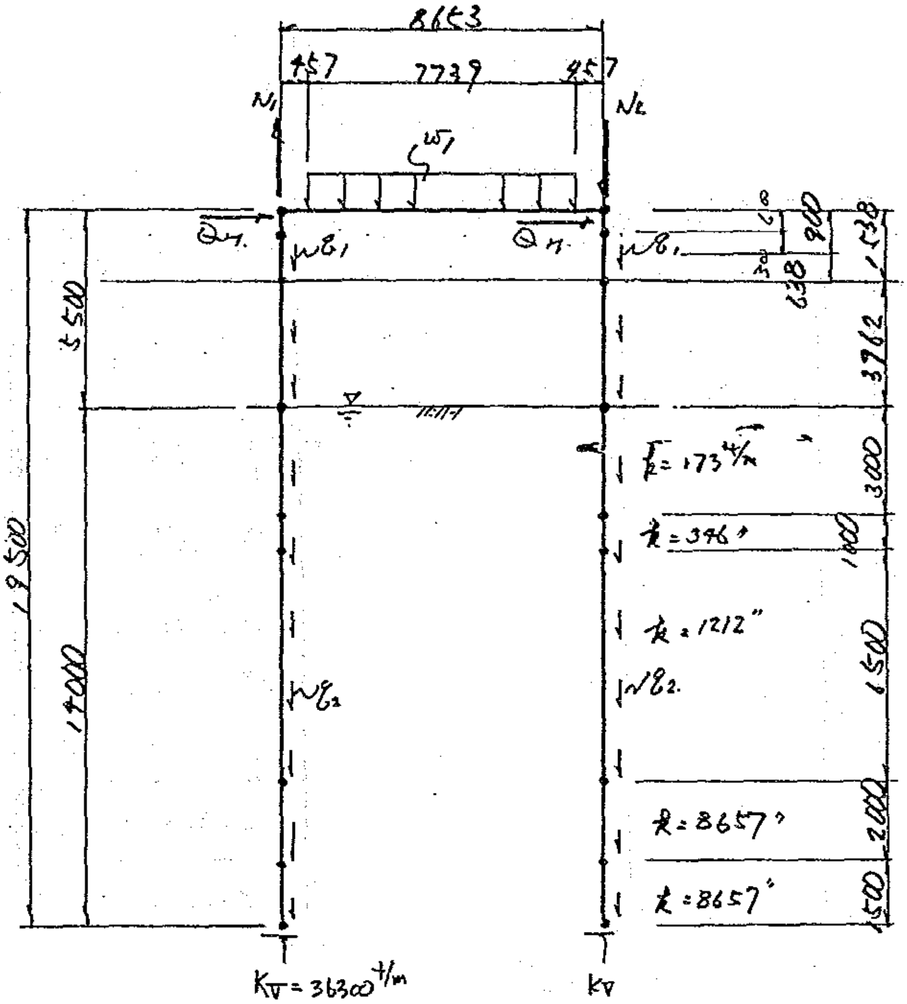
$P = 16.10^T$

o Pile Weight

In air $g_1 = 1.57\ ^t/m$

In water $g_2 = 0.92$ "

Load Diagram (during load E C-T) CASE 10

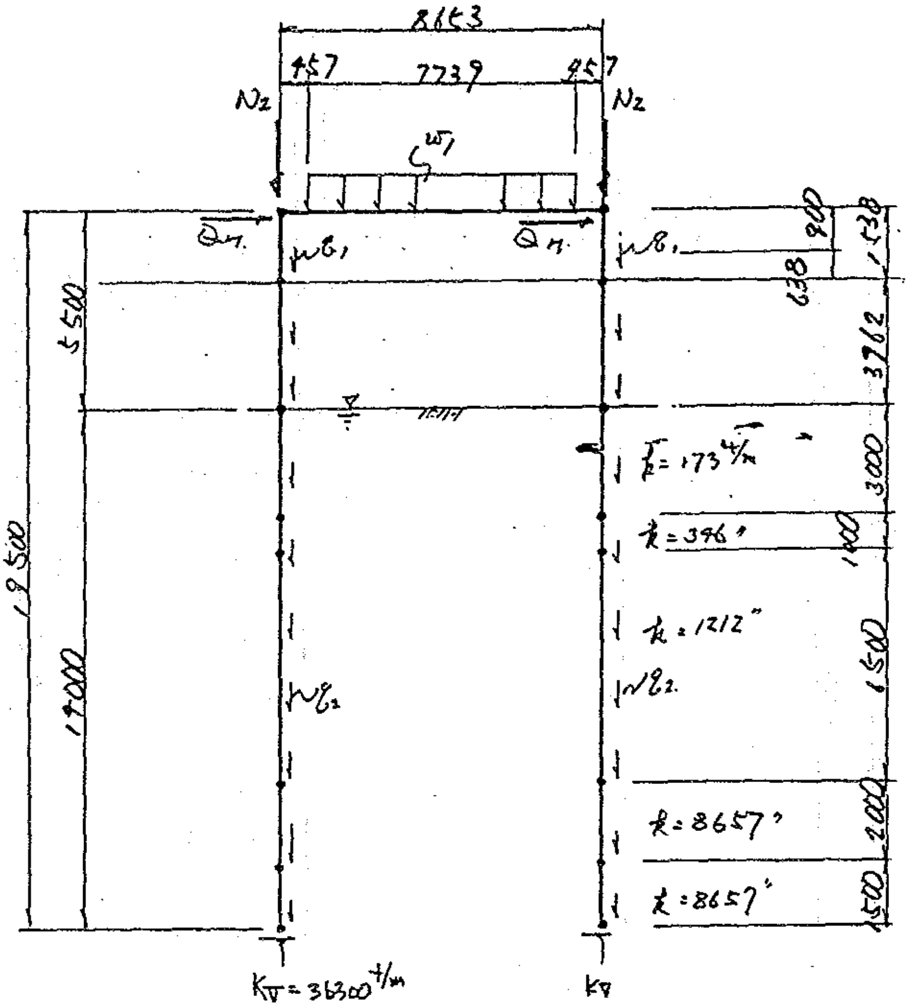


$N_1 = P_1 - T = 16.10 - 22.82 = -6.72^t$

$N_2 = P_1 + C = 16.10 + 19.29 = 35.39^t$

$Q_H = Q = 2.05^t$

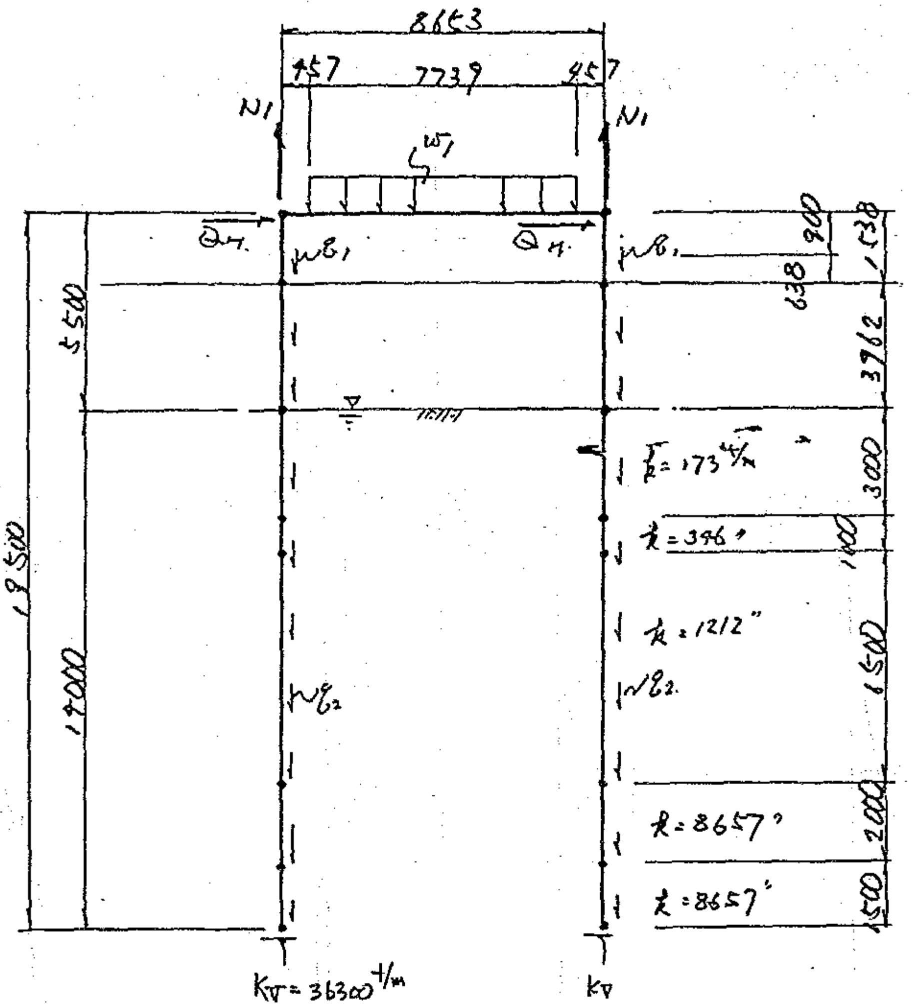
Load Diagram (during load E C-C) CASE 11



$N_2 = 35.39^t$

$Q_H = Q = 2.05^t$

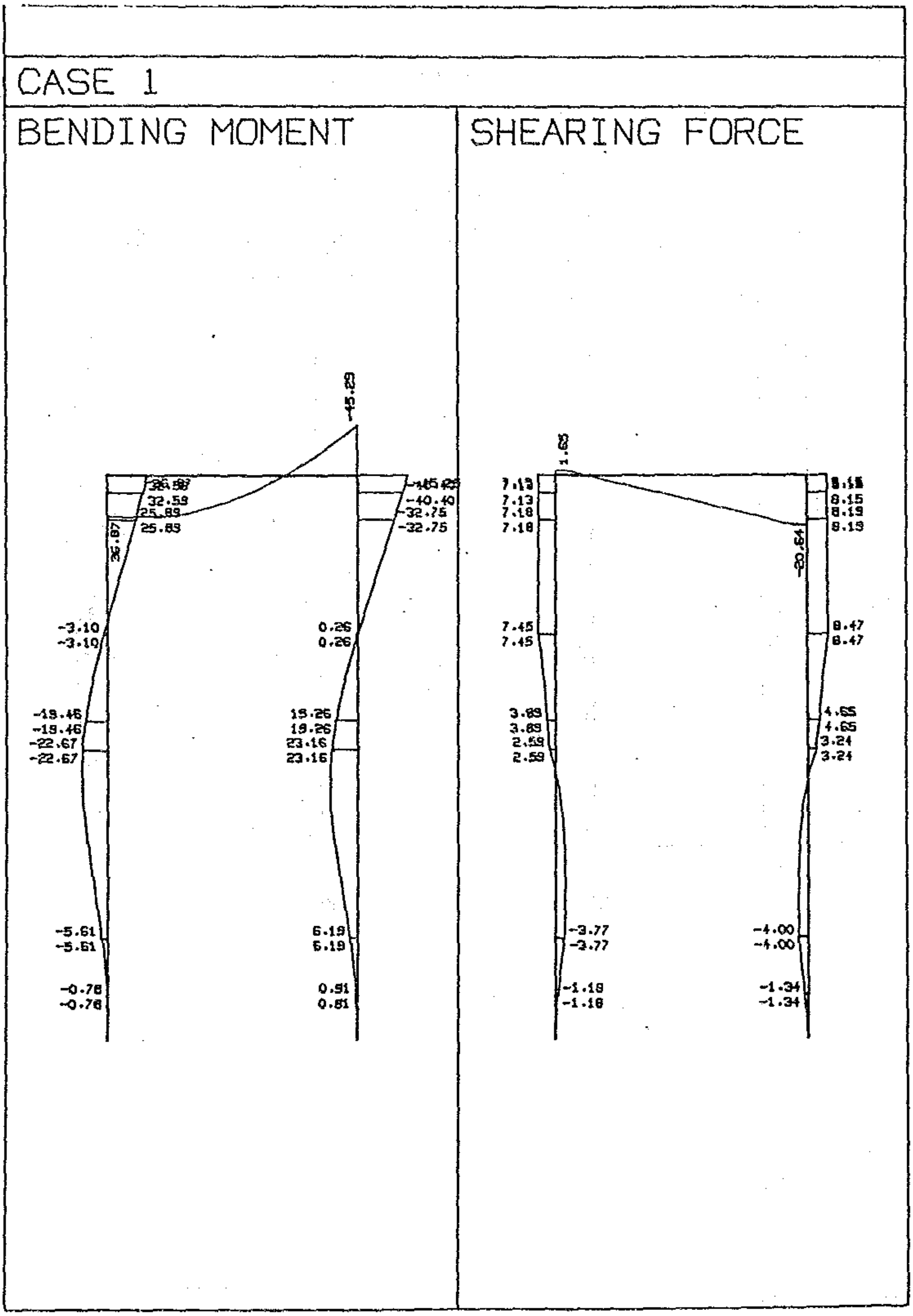
Load Diagram (during load E T-T) CASE 12



$N_1 = -6.72^t$

$Q_H = Q = 2.05^t$

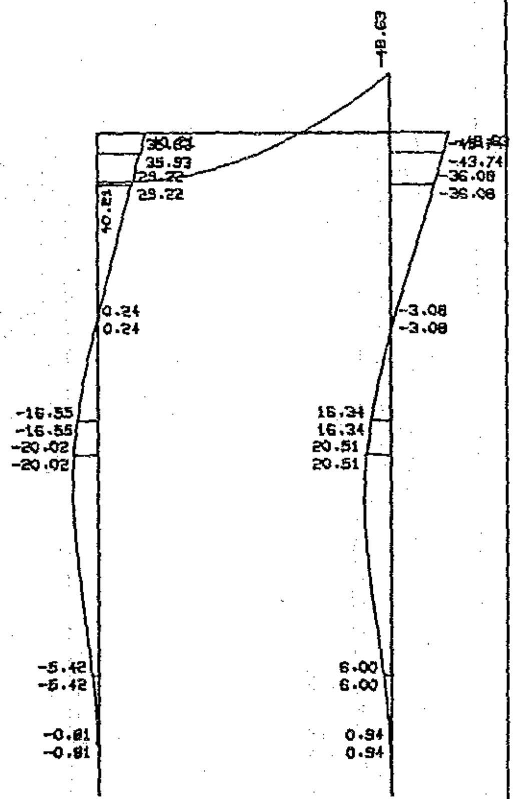
(k) OUT PUT



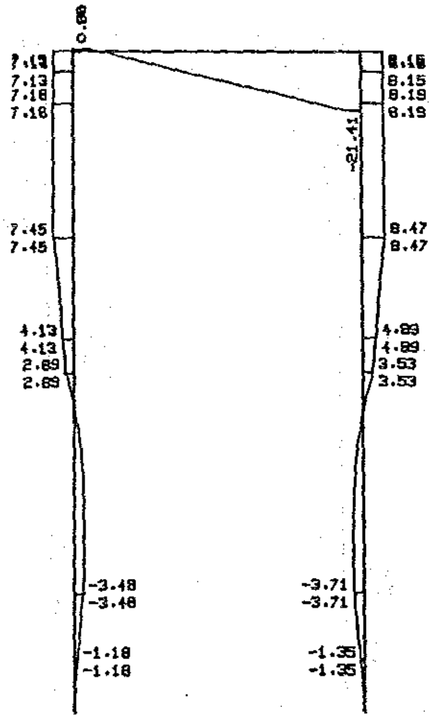
8

CASE 2

BENDING MOMENT



SHEARING FORCE



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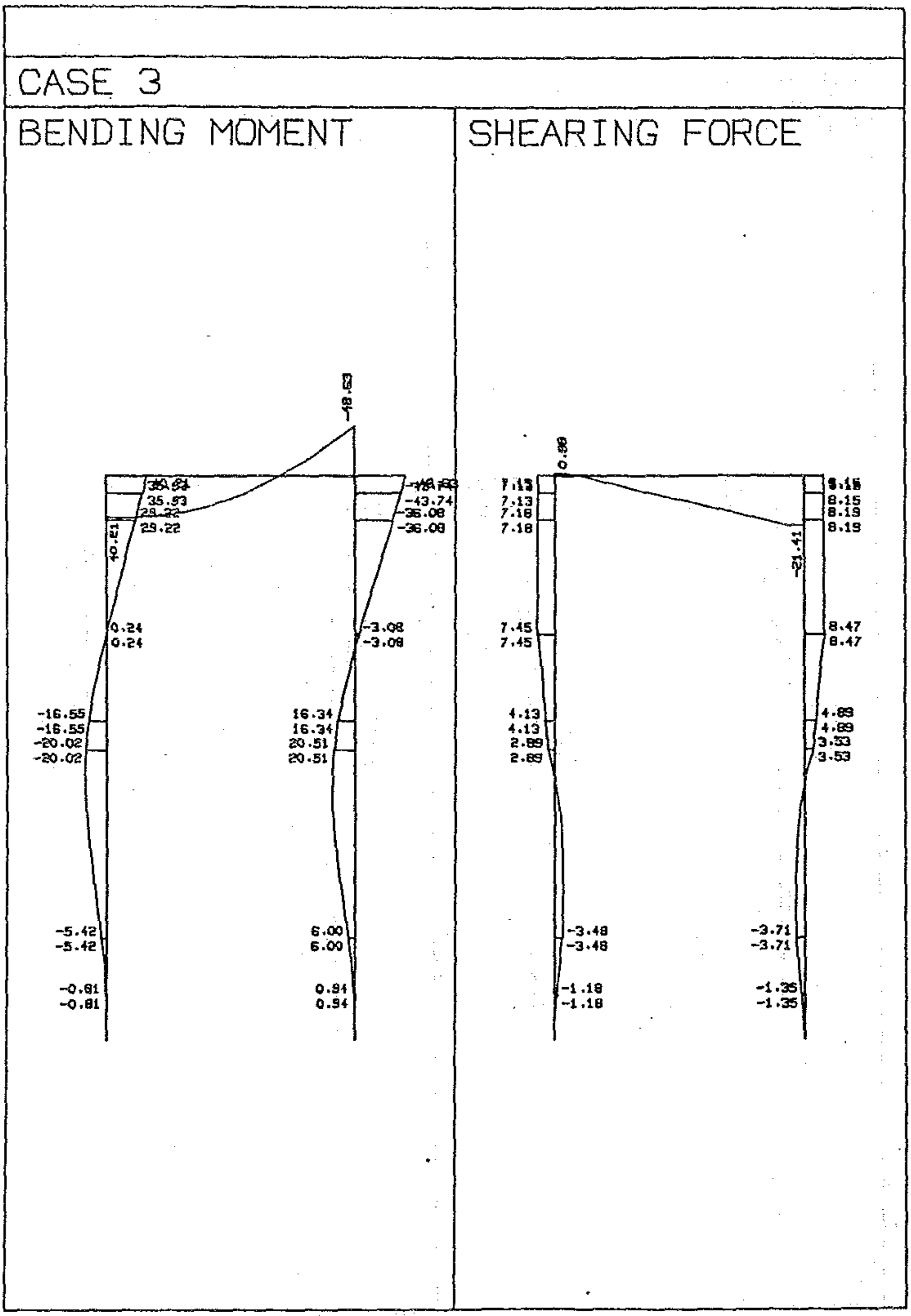
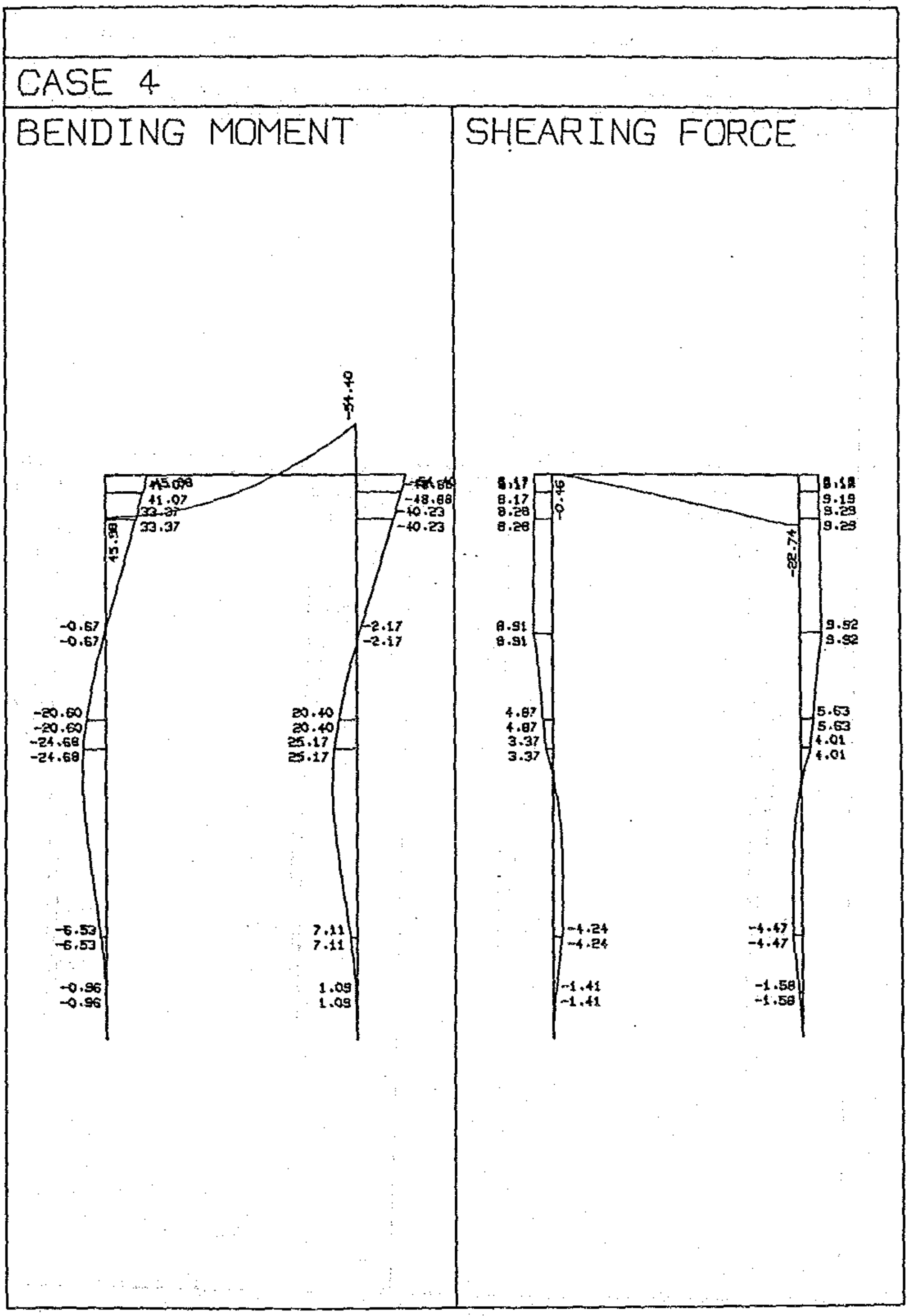
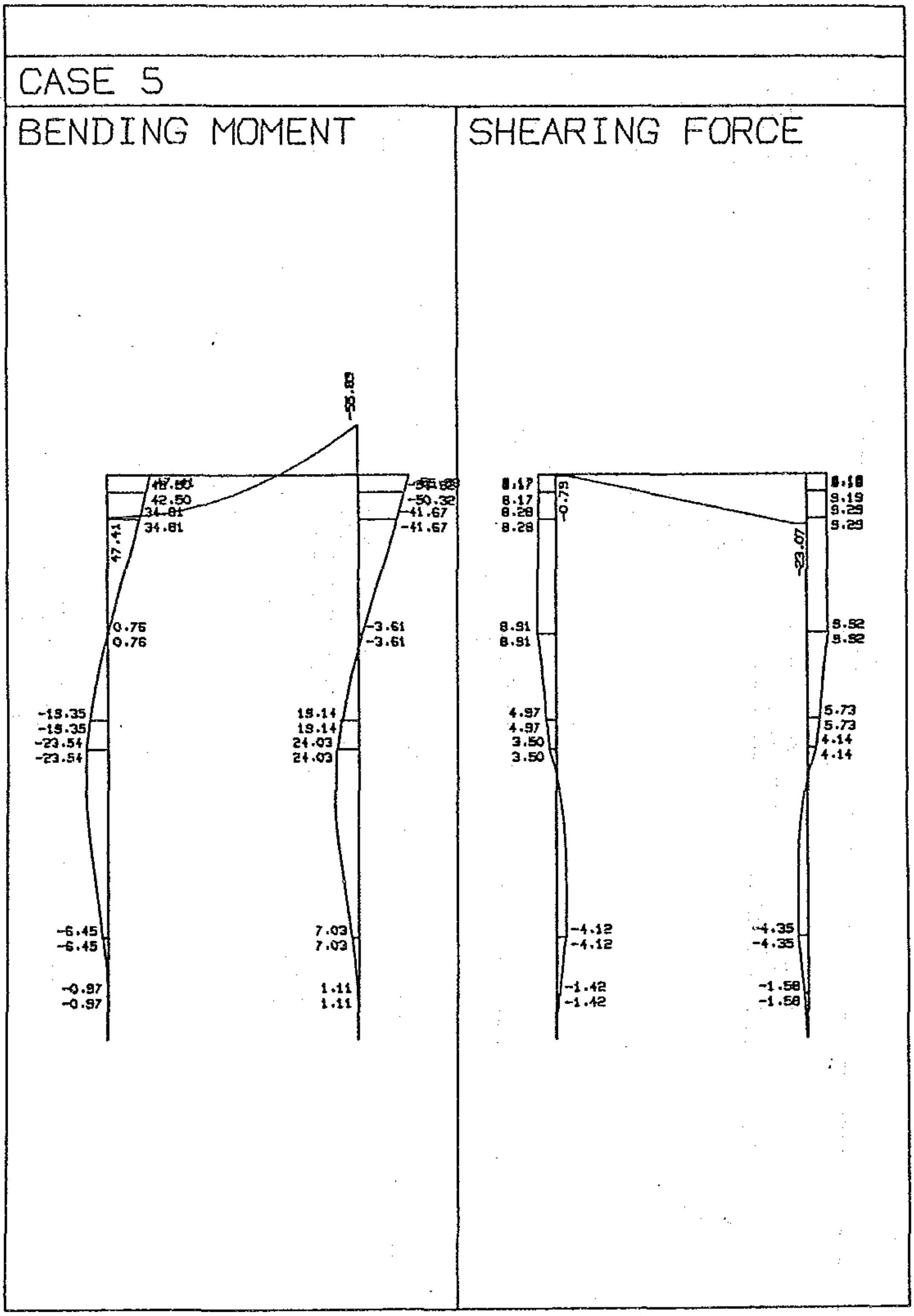

CASE 3
BENDING MOMENT
SHEARING FORCE
35.93
29.22
-43.74
-36.08
0.24
-3.08
-16.55
-20.02
16.34
20.51
-5.42
6.00
-0.81
0.94
7.13
7.18
8.15
8.19
-21.41
7.45
8.47
4.13
2.89
4.89
3.53
-3.48
-3.71
-1.18
-1.35

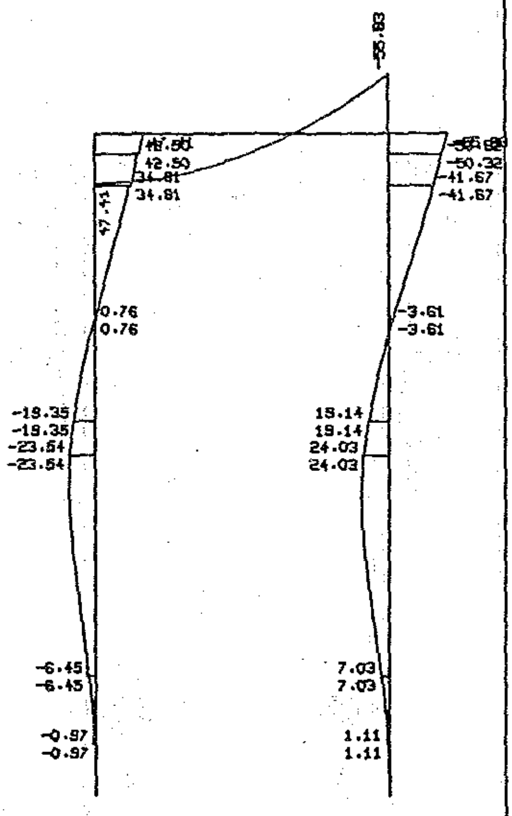

CASE 4
BENDING MOMENT
SHEARING FORCE
-54.40
41.07
33.37
-48.88
-40.23
45.98
-0.67
-2.17
-20.60
-24.68
20.40
25.17
-6.53
7.11
-0.96
1.09
-0.46
8.17
8.28
9.19
9.28
-22.74
8.91
9.92
4.87
3.37
5.63
4.01
-4.24
-4.47
-1.41
-1.58

31

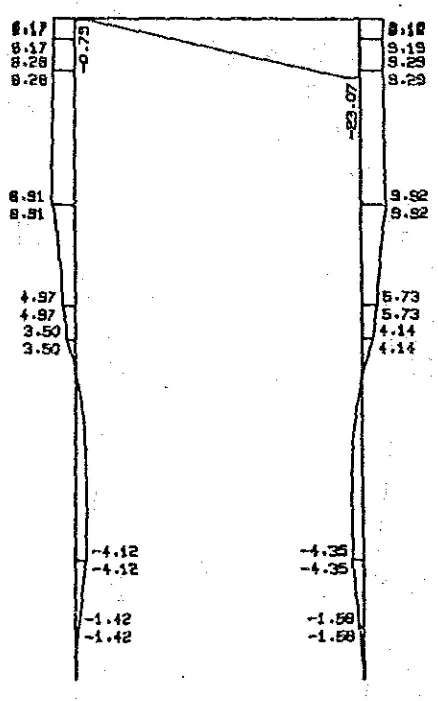

CASE 5
BENDING MOMENT
SHEARING FORCE
42.50
34.81
47.41
-50.32
-41.67
0.76
-3.61
-19.35
-23.54
19.14
24.03
-6.45
-0.97
7.03
1.11
8.17
8.28
-0.79
9.19
9.29
-23.07
8.91
8.92
4.97
3.50
5.73
4.14
-4.12
-1.42
-4.35
-1.58

CASE 6

BENDING MOMENT



SHEARING FORCE



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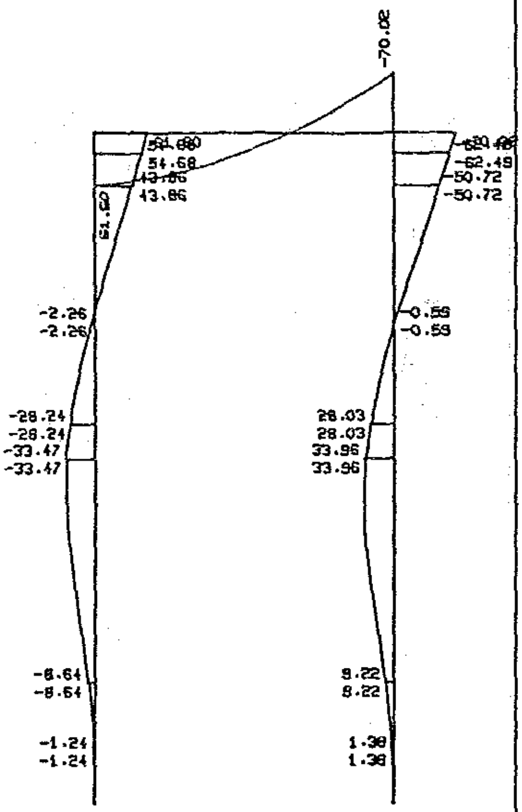
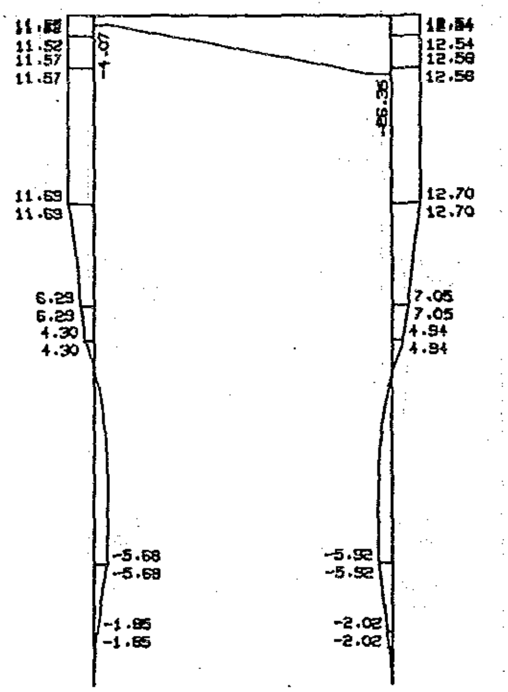
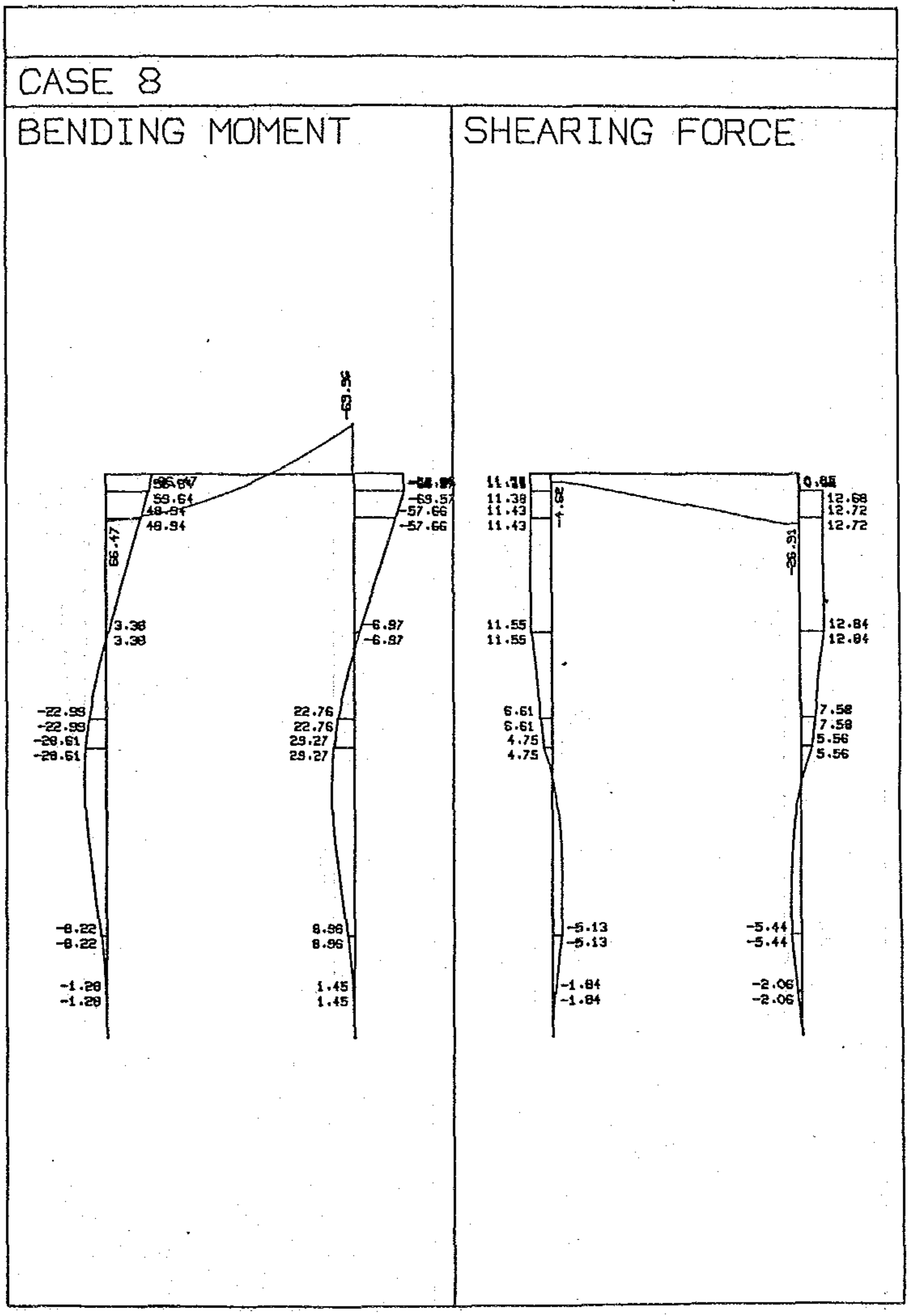
CASE 7

BENDING MOMENT

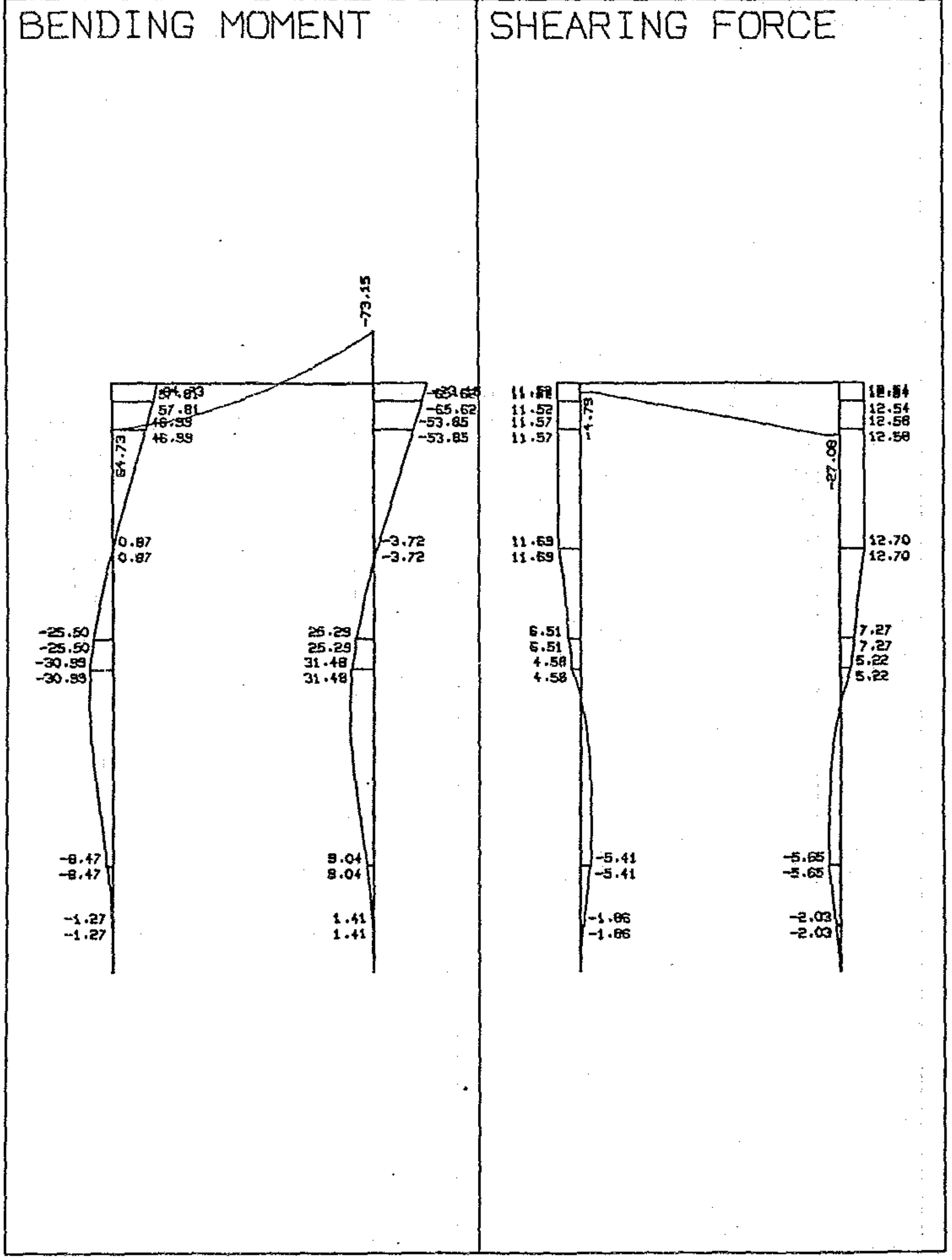


SHEARING FORCE



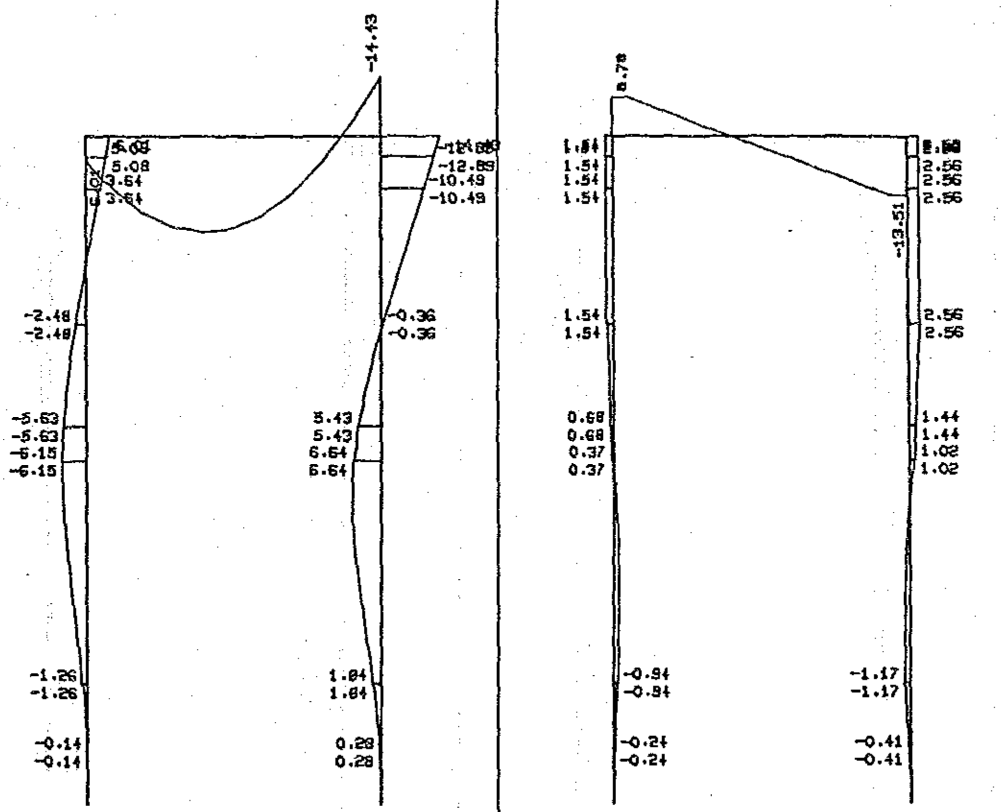

CASE 8
BENDING MOMENT
SHEARING FORCE
59.64
48.94
48.94
-69.57
-57.66
-57.66
3.38
3.38
-6.97
-6.97
-22.99
-22.99
-28.61
-28.61
22.76
22.76
29.27
29.27
-8.22
-8.22
8.96
8.96
-1.28
-1.28
1.45
1.45
11.38
11.43
11.43
12.68
12.72
12.72
11.55
11.55
12.84
12.84
6.61
6.61
4.75
4.75
7.58
7.58
5.56
5.56
-5.13
-5.13
-5.44
-5.44
-1.84
-1.84
-2.06
-2.06

CASE 9


BENDING MOMENT
SHEARING FORCE
-73.15
57.81
46.99
46.99
64.73
0.87
0.87
-65.62
-53.85
-53.85
-3.72
-3.72
-25.50
-25.50
-30.99
-30.99
25.29
25.29
31.48
31.48
-8.47
-8.47
9.04
9.04
-1.27
-1.27
1.41
1.41
11.52
11.57
11.57
-4.73
12.54
12.58
12.58
-27.08
11.69
11.69
12.70
12.70
6.51
6.51
4.58
4.58
7.27
7.27
5.22
5.22
-5.41
-5.41
-5.65
-5.65
-1.86
-1.86
-2.03
-2.03

CASE 10

BENDING MOMENT | SHEARING FORCE



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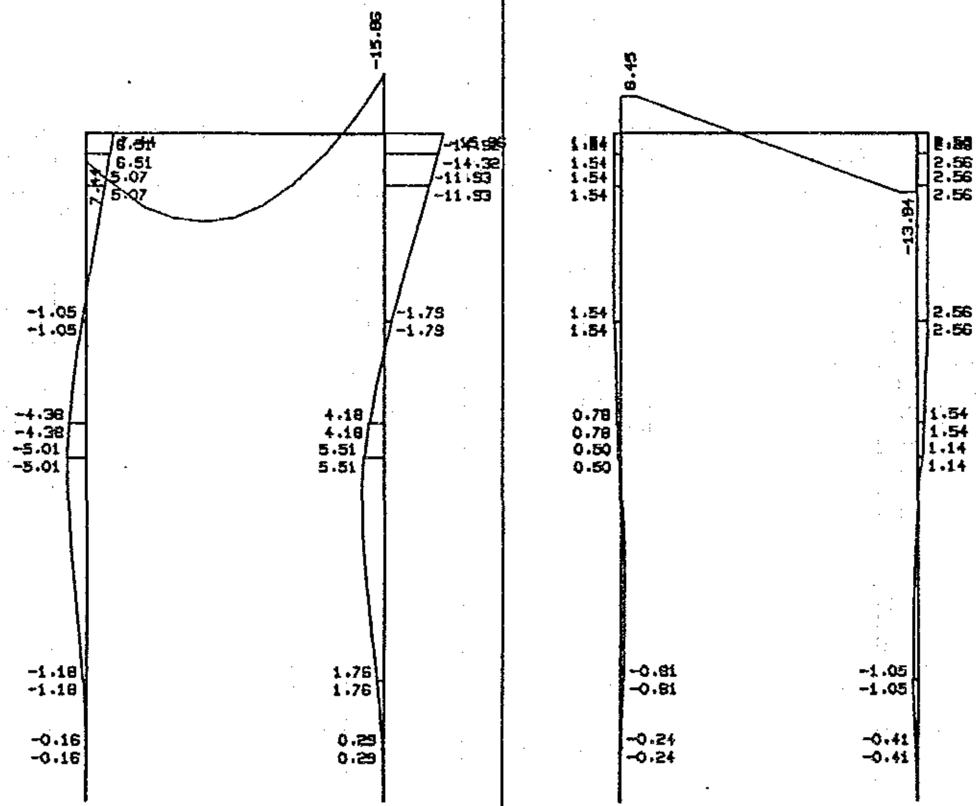
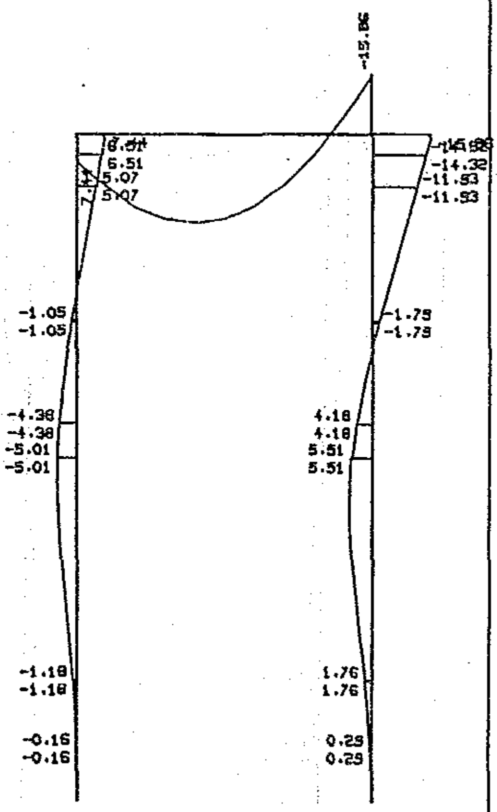
CASE 11

BENDING MOMENT | SHEARING FORCE

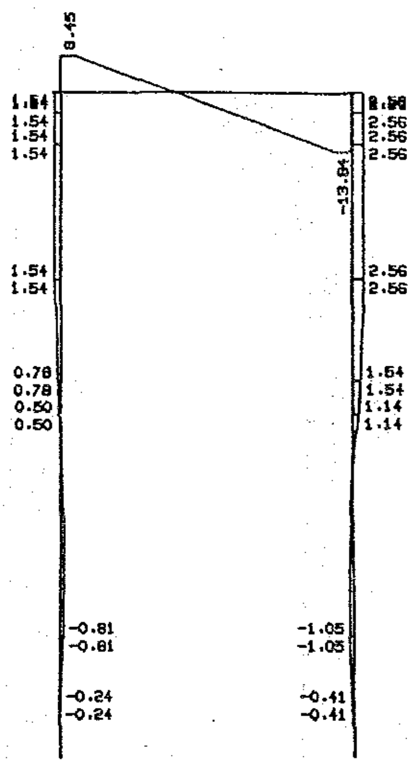


CASE 12

BENDING MOMENT

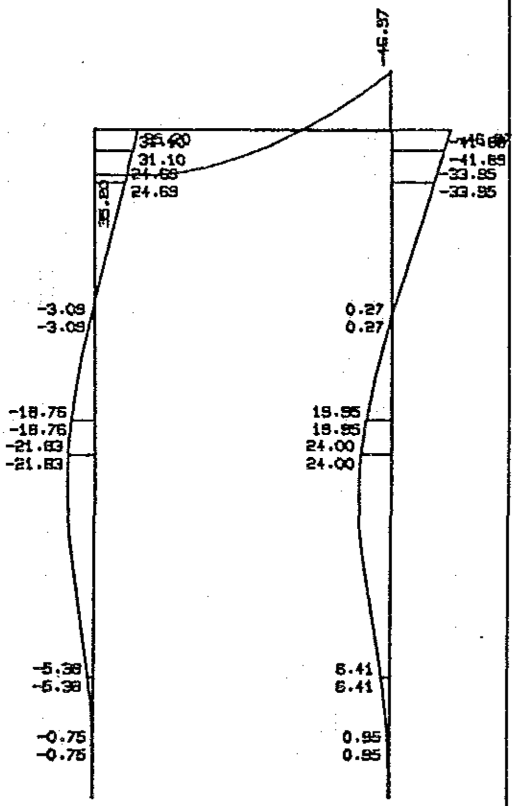


SHEARING FORCE

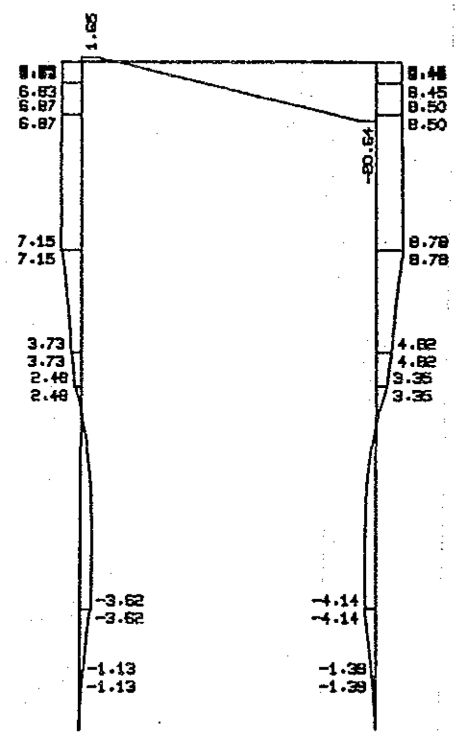


CASE 13 (TEMPERATURE CHANGES)

BENDING MOMENT

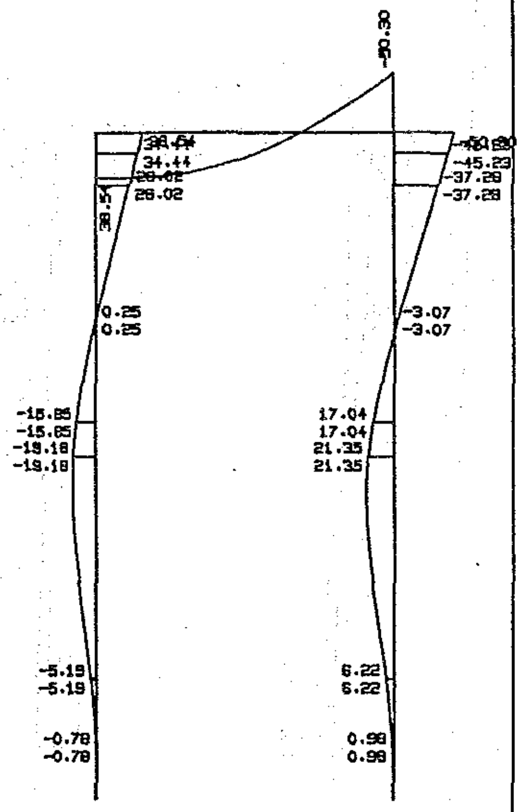


SHEARING FORCE

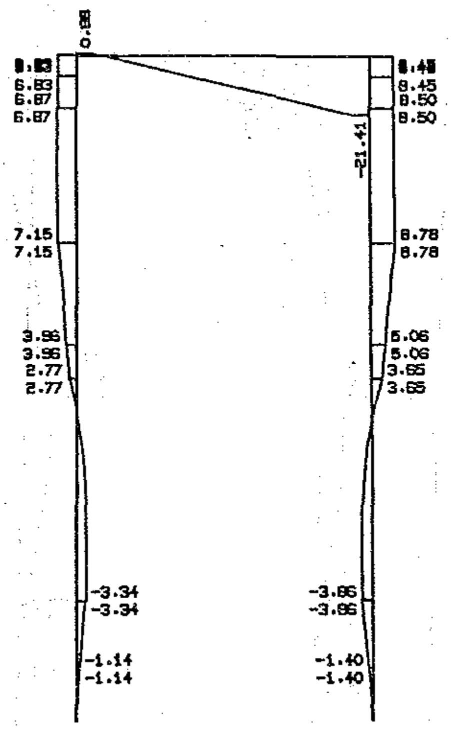


CASE 14 (TEMPERATURE CHANGES)

BENDING MOMENT

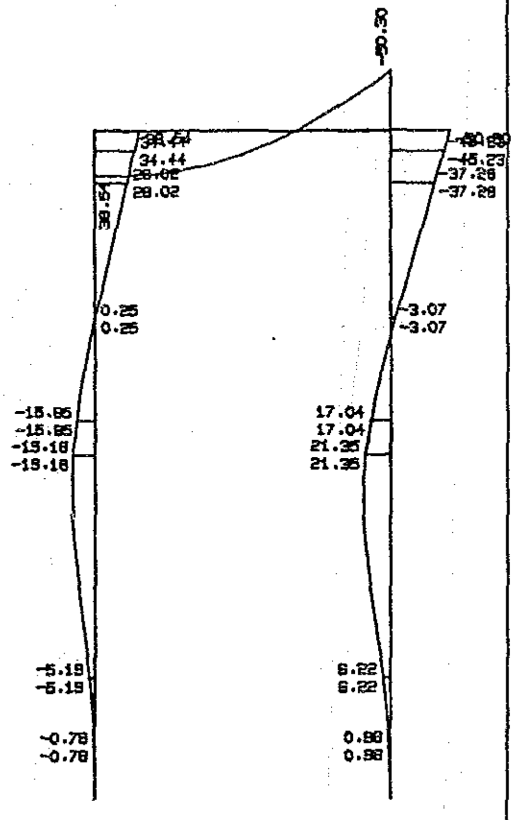


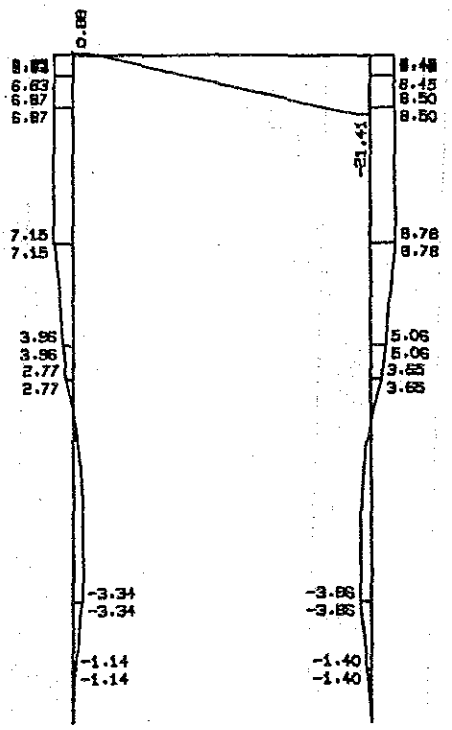
SHEARING FORCE



CASE 15 (TEMPERATURE CHANGES)

BENDING MOMENT	SHEARING FORCE





(↓) Pile Reaction

Types / Cases	C − T		T − T		C − C		Displacement (mm)	
	N_{max} (+)	N_{min} (+)	N_{max} (+)	N_{min} (+)	N_{max} (+)	N_{min} (+)	Top	Top of G.L.
Oblique Wind	116.20	13.79	18.86	14.56	116.98	—	19.7	10.9
Oblique Wind	116.20	13.79	18.86	14.56	116.98	—	20.4	11.2
Earthquakes	79.65	—	37.87	—	79.98	—	21.3	12.1
Floods	98.40	36.97	1.44	44.95	99.40	—	28.8	15.9
Load E	70.41	—	28.63	—	70.74	—	5.7	3.5

Safety Factor

Types / Cases	Q_{ca}	Q_{ta}	SF_c	SF_t	SF_a
Oblique Wind	330	74	2.82	5.08	2.00
Oblique Wind	〃	〃	2.82	5.08	2.00
Earthquakes	〃	〃	4.12	Non Tension	1.33
Floods	〃	〃	3.31	1.64	1.33
Load E	〃	〃	4.66	Non Tension	2.00

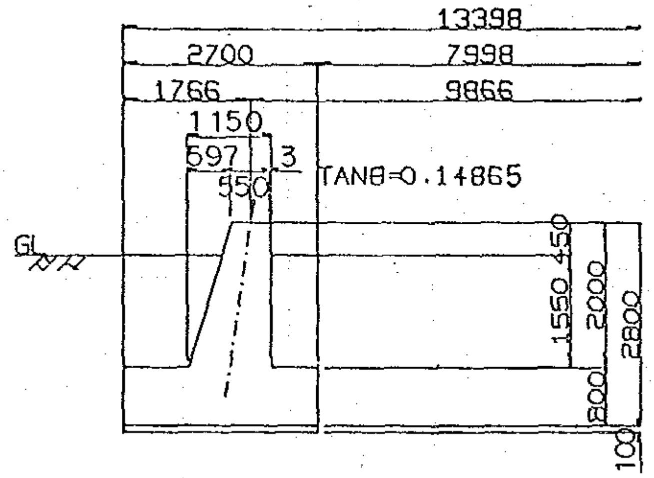
→ O.K

(6). B-D-I

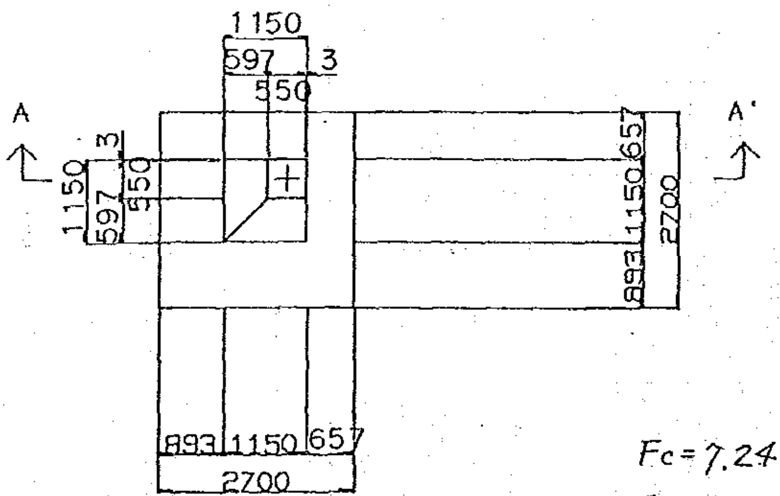
C = 55.84 t
T = 41.65
Q = 4.13
Q_B = 1.49

S=1/100

PROFILE



A-A' SECTION



Fc = 7.24 > 2.00
Ft = 2.07 > 2.00

PLAN

INDIVIDUAL TYPE TOWER FOUNDATION (I , II)

-------------------------------INPUT DATA---------------------------------------

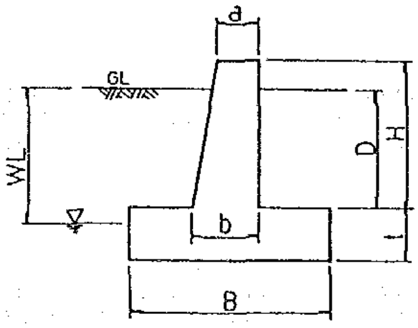
TOWER NAME............NO. B-D-I

(1)LOAD CONDITION

```
Comp. Load....................C =  55.84 TON
Uplift Load...................T =  41.65 TON
Hori. Load....................Q =   4.13 TON
Hori. Load....................QB=   1.49 TON
E-Load........................TO=   9.85 TON
```

(2)DIMENSION OF FOUNDATION

```
a =    0.550 M
b =    1.150 M
B =    2.700 M
t =    0.800 M
H =    2.000 M
D =    1.550 M
WL=- 10.000 M
γ =    2.40 TON/M^3
```



(3)SOIL CONDITION

```
Unit Weight of Soil (beneath the foundation)......S1=  1.800 TON/M^3
Unit Weight of Soil (on the foundation)...........S2=  1.440 TON/M^3
Cohesion (beneath the foundation)................C1=  0.000 TON/M^2
Cohesion (on the foundation).....................C2=  0.000 TON/M^2
Angle of Internal Friction (on the foundation)....φ = 40.000 °
Bearing Capacity Factor..N1= 95.700 N2=114.000 N3= 83.200 ( φ =40 °)
```

(4)FOUNDATION TYPE

Foundation Type (shallow type...1,deep type...2)... 2

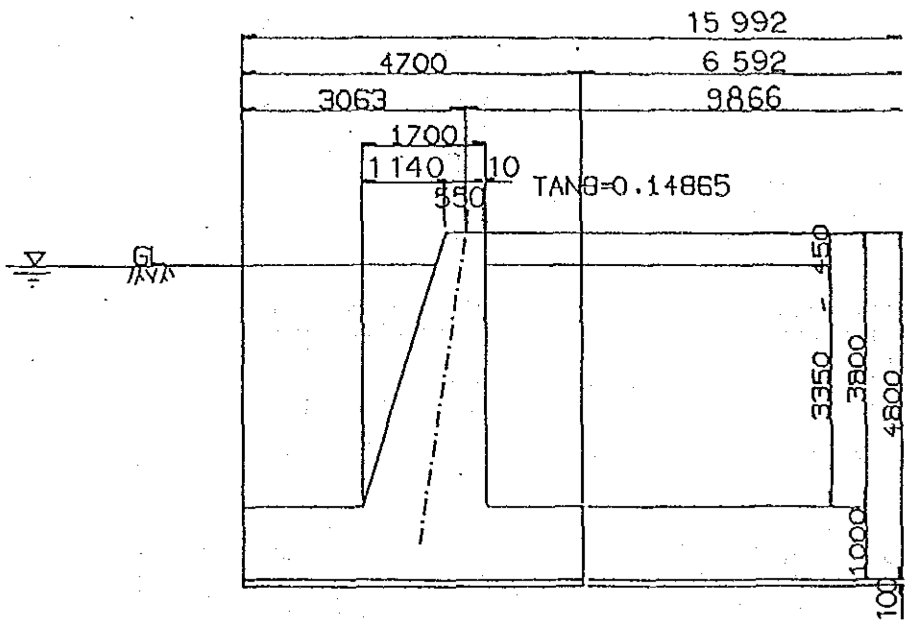
```
-------------------------------RESULT-------------------------------------

(5)VERTICAL LOAD

   Weight of concrite...........................WC=   17.609 TON
   Weight of Soil...............................WS=   17.940 TON
   Weight of Column and a part under Column...WC'=    6.151 TON
   Vertical Load......................P=C+WC+WS=   91.389 TON

(6)PILE CAPACITY

   Comp. Side.................................QCY= 100.000 TON/M^2
   Uplift Side................................QTY=  86.588 TON/M^2
   Hori. Side.................................QHY=  40.000 TON/M^2
                                                              Upper Limit
(7)SOIL REACTION

  1)Comp. Side

   Eccentricity....E=QB*(H+T')/P=  0.046 M <= B/6=  0.450 M
   Incremental Rate...................MU=1+6*E/B=  1.101
   Max. Soil Reaction................Qmax=P/A*MU= 13.808 TON/M^2

  2)Uplift Side

   Eccentricity...................E=QB*H/(T-WC')=  0.084 M
   Reduction Rate.........K=1/(1+6*E*B/(B^2+b^2))=  0.864

(8)HORIZONTAL SOIL REACTION

   Max. Horizontal soil Reaction....QHmax=Q/(B*t)=  1.912 TON/M^2

(9)SAFETY FACTOR

   Comp. Side.......................SFC=QCY/Qmax=  7.242 >=  2.00 =OK=
   Uplift Side........................SFT=QTY/T=  2.078 >=  2.00 =OK=
   Hori. Side......................SFH=QHY/QHmax= 20.920 >=  2.00 =OK=

(10)E-LOAD                                      From Upper Limit

   WC+WS'=   31.961 TON >= TO=    9.850 TON =OK=
      (WS'=WS*0.8)
```

(7). B- C -I

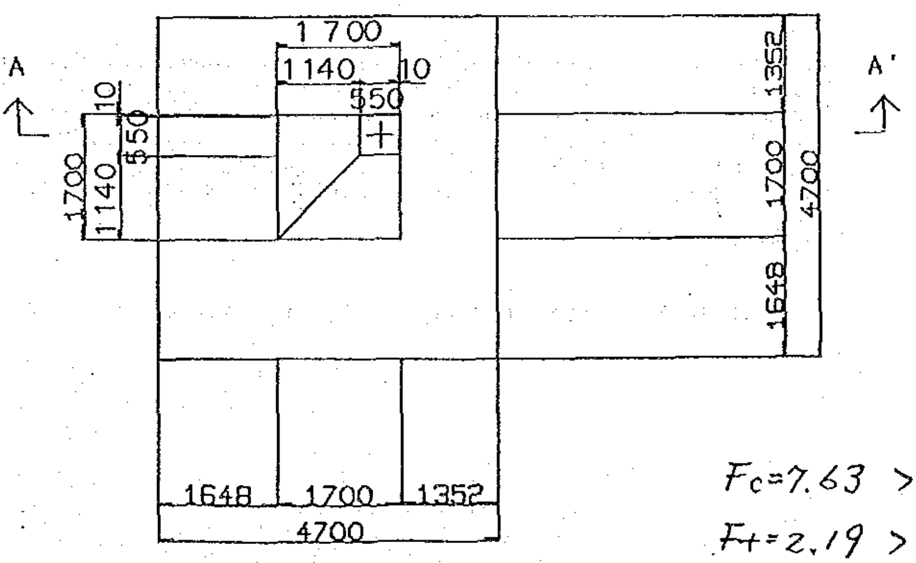
$C = 55.84^{t}$
$T = 41.65$
$Q = 4.13$
$Q_A = 1.49$

S=1/100

PROFILE



A-A' SECTION



$F_c = 7.63 > 2.00$
$F_t = 2.19 > 2.00$

PLAN

INDIVIDUAL TYPE TOWER FOUNDATION (I , II)

--------------------------------INPUT DATA--

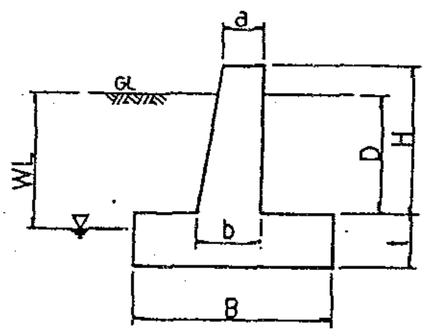
TOWER NAME............NO. B-C-I

(1)LOAD CONDITION

Comp. Load....................C = 55.84 TON
Uplift Load...................T = 41.65 TON
Hori. Load....................Q = 4.13 TON
Hori. Load....................QB= 1.49 TON
E-Load........................TO= 9.85 TON

(2)DIMENSION OF FOUNDATION

a = 0.550 M
b = 1.700 M
B = 4.700 M
t = 1.000 M
H = 3.800 M
D = 3.350 M
WL=- 0.000 M
γ = 2.40 TON/M^3



(3)SOIL CONDITION

Unit Weight of Soil (beneath the foundation)......S1= 1.800 TON/M^3
Unit Weight of Soil (on the foundation)...........S2= 1.440 TON/M^3
Cohesion (beneath the foundation).................C1= 0.000 TON/M^2
Cohesion (on the foundation)......................C2= 0.000 TON/M^2
Angle of Internal Friction (on the foundation)....ϕ = 35.000 °
Bearing Capacity Factor..N1= 35.400 N2= 23.400 N3= 27.800 (ϕ =35 °)

(4)FOUNDATION TYPE

Foundation Type (shallow type...1,deep type...2)... 2

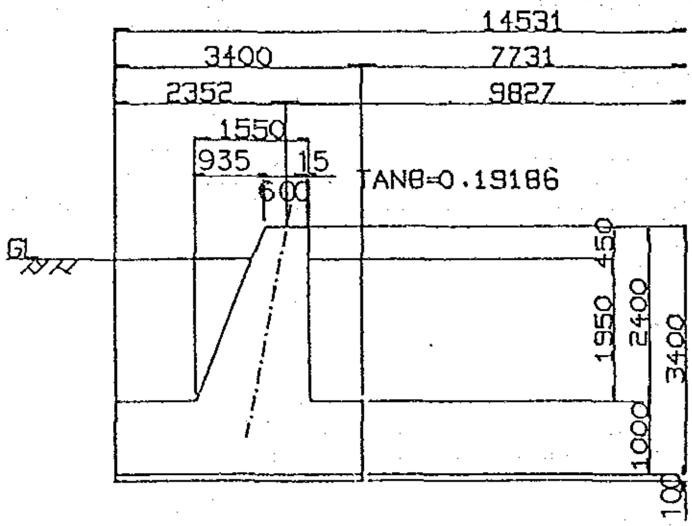
```
-----------------------------------RESULT--------------------------------------
(5)VERTICAL LOAD

   Weight of concrite........................WC=   65.564 TON
   Weight of Soil............................WS=  124.103 TON
   Weight of Column and a part under Column...WC'=  11.538 TON
   Vertical Load.......................P=C+WC+WS=  245.506 TON

(6)PILE CAPACITY

   Comp. Side...............................QCY=  87.958 TON/M^2
   Uplift Side..............................QTY=  91.537 TON/M^2
   Hori. Side...............................QHY=  35.183 TON/M^2

(7)SOIL REACTION

  1)Comp. Side

   Eccentricity....E=QB*(H+T')/P=  0.029 M <= B/6=  0.783 M
   Incremental Rate....................MU=1+6*E/B=  1.037
   Max. Soil Reaction.................Qmax=P/A*MU= 11.527 TON/M^2

  2)Uplift Side

   Eccentricity...................E=QB*H/(T-WC')=  0.188 M
   Reduction Rate.........K=1/(1+6*E*B/(B^2+b^2))=  0.825

(8)HORIZONTAL SOIL REACTION

   Max. Horizontal soil Reaction....QHmax=Q/(B*t)=  0.879 TON/M^2

(9)SAFETY FACTOR

   Comp. Side.......................SFC=QCY/Qmax=  7.630 >=  2.00 =OK=
   Uplift Side.........................SFT=QTY/T=  2.197 >=  2.00 =OK=
   Hori. Side......................SFH=QHY/QHmax= 40.039 >=  2.00 =OK=

(10)E-LOAD

   WC+WS'=   68.754 TON >= TO=    9.850 TON =OK=
      (WS'=WS*0.8)
```

(8). D-D-I

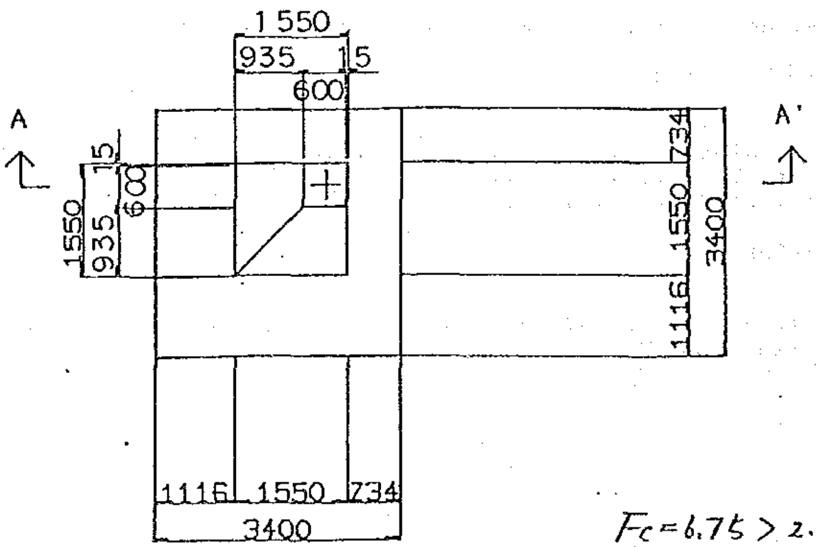
$C = 95.63^{t}$
$T = 80.88$
$Q = 3.58$
$Q_{\theta} = 0.84$

S=1/100

PROFILE



A-A' SECTION



$Fc = 6.75 > 2.00$

$Ft = 2.02 > 2.00$

PLAN

INDIVIDUAL TYPE TOWER FOUNDATION (I , II)

------------------------------INPUT DATA------------------------------

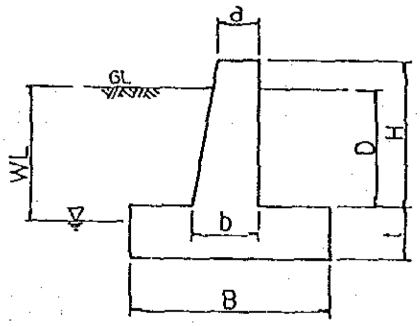
TOWER NAME............NO. D-D-I,C-D-I

(1)LOAD CONDITION

Comp. Load....................C = 95.63 TON
Uplift Load...................T = 80.88 TON
Hori. Load....................Q = 3.58 TON
Hori. Load....................QB= 0.84 TON
E-Load........................TO= 34.04 TON

(2)DIMENSION OF FOUNDATION

a = 0.600 M
b = 1.550 M
B = 3.400 M
t = 1.000 M
H = 2.400 M
D = 1.950 M
WL=- 10.000 M
γ = 2.40 TON/M^3



(3)SOIL CONDITION

Unit Weight of Soil (beneath the foundation)......S1= 1.800 TON/M^3
Unit Weight of Soil (on the foundation)...........S2= 1.440 TON/M^3
Cohesion (beneath the foundation)................C1= 0.000 TON/M^2
Cohesion (on the foundation)....................C2= 0.000 TON/M^2
Angle of Internal Friction (on the foundation)....φ = 40.000 °
Bearing Capacity Factor..N1= 95.700 N2=114.000 N3= 83.200 (φ =40 °)

(4)FOUNDATION TYPE

Foundation Type (shallow type...1,deep type...2)... 2

------------------------------------RESULT------------------------------------

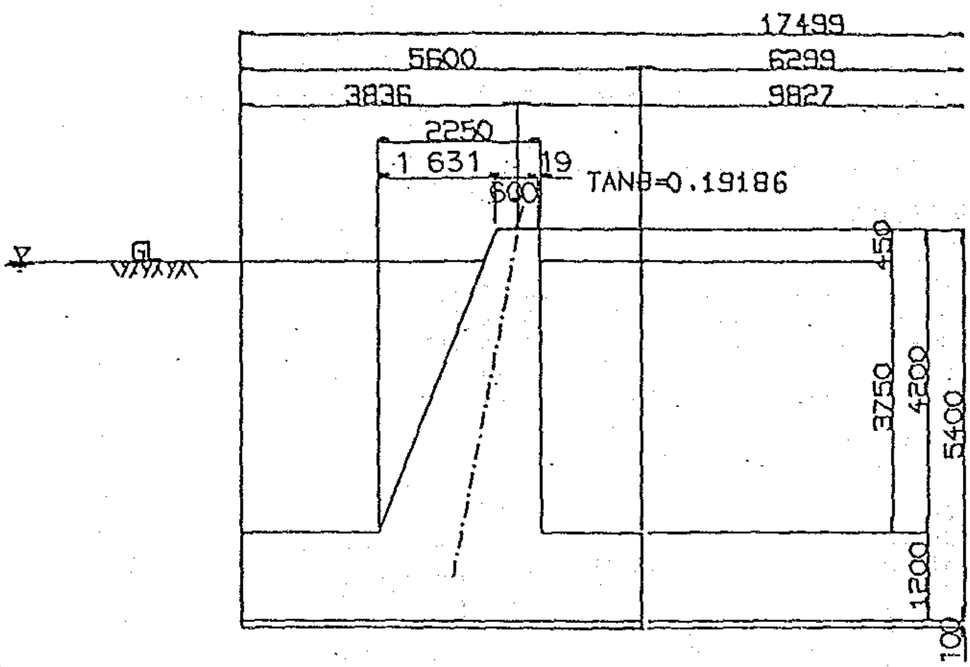
```
(5)VERTICAL LOAD

    Weight of concrite..........................WC=   34.834 TON
    Weight of Soil..............................WS=   35.645 TON
    Weight of Column and a part under Column...WC'=   12.856 TON
    Vertical Load.........................P=C+WC+WS=  166.109 TON

(6)PILE CAPACITY

    Comp. Side..................................QCY= 100.000  TON/M^2
    Uplift Side.................................QTY= 163.487  TON/M^2
    Hori. Side..................................QHY=  40.000  TON/M^2
                                                                      Upper Limit
(7)SOIL REACTION

  1)Comp. Side

    Eccentricity....E=QB*(H+T')/P=  0.017 M <= B/6=  0.567 M
    Incremental Rate....................MU=1+6*E/B=  1.030
    Max. Soil Reaction..................Qmax=P/A*MU= 14.805 TON/M^2

  2)Uplift Side

    Eccentricity.....................E=QB*H/(T-WC')=  0.030 M
    Reduction Rate.........K=1/(1+6*E*B/(B^2+b^2))=  0.958

(8)HORIZONTAL SOIL REACTION

    Max. Horizontal soil Reaction....QHmax=Q/(B*l)=  1.053 TON/M^2

(9)SAFETY FACTOR

    Comp. Side.......................SFC=QCY/Qmax=  6.754 >=  2.00 =OK=
    Uplift Side.........................SFT=QTY/T=  2.021 >=  2.00 =OK=
    Hori. Side......................SFH=QHY/QHmax= 37.986 >=  2.00 =OK=

(10)E-LOAD                                     From Upper Limit

    WC+WS'=    63.350 TON >= TO=    34.040 TON =OK=
      (WS'=WS*0.8)
```

(9). D-C -I, C-C -I

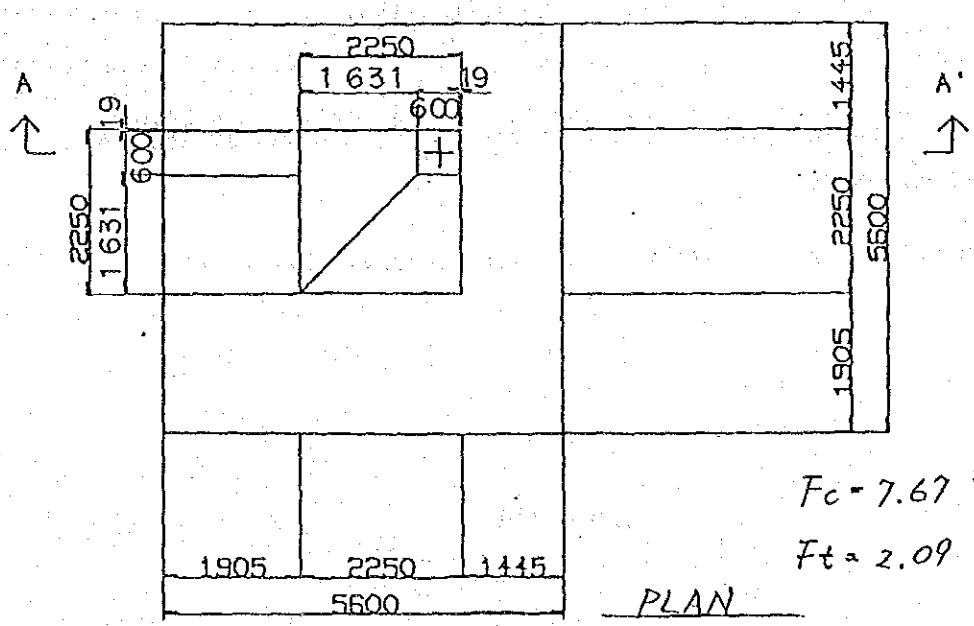
C = 95.63 t
T = 80.88
Q = 3.58
Q_B = 0.84

PROFILE

S=1/100



A-A' SECTION



PLAN

Fc = 7.67 > 2.00

Ft = 2.09 > 2.00

INDIVIDUAL TYPE TOWER FOUNDATION (I , II)

------------------------------INPUT DATA------------------------------------

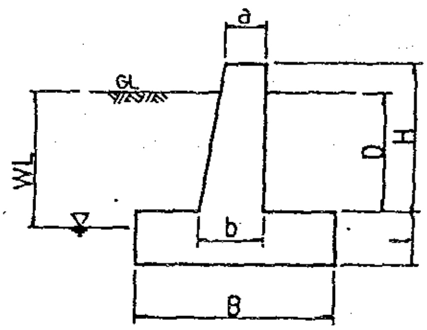
TOWER NAME............NO. D-C-I, C-C-I

(1)LOAD CONDITION

```
Comp. Load...................C =  95.63 TON
Uplift Load..................T =  80.88 TON
Hori. Load...................Q =   3.58 TON
Hori. Load...................QB=   0.84 TON
E-Load.......................TO=  34.04 TON
```

(2)DIMENSION OF FOUNDATION

```
a  =   0.600 M
b  =   2.250 M
B  =   5.600 M
t  =   1.200 M
H  =   4.200 M
D  =   3.750 M
WL=-   0.000 M
γ  =   2.40 TON/M^3
```



(3)SOIL CONDITION

```
Unit Weight of Soil (beneath the foundation)......S1=  1.800 TON/M^3
Unit Weight of Soil (on the foundation)...........S2=  1.440 TON/M^3
Cohesion (beneath the foundation).................C1=  0.000 TON/M^2
Cohesion (on the foundation)......................C2=  0.000 TON/M^2
Angle of Internal Friction (on the foundation)....φ = 35.000 °
Bearing Capacity Factor..N1= 35.400 N2= 23.400 N3= 27.800 ( φ =35 °)
```

(4)FOUNDATION TYPE

Foundation Type (shallow type...1,deep type...2)...   2

----------------------------------RESULT----------------------------------

(5)VERTICAL LOAD

```
Weight of concrite...........................WC=  113.072 TON
Weight of Soil...............................WS=  194.999 TON
Weight of Column and a part under Column...WC'=   21.994 TON
Vertical Load........................P=C+WC+WS=  403.702 TON
```

(6)PILE CAPACITY

```
Comp. Side..................................QCY= 100.000 TON/M^2
Uplift Side.................................QTY= 169.594 TON/M^2
Hori. Side..................................QHY=  40.000 TON/M^2
```

Upper Limi

(7)SOIL REACTION

1)Comp. Side

```
Eccentricity....E=QB*(H+T')/P=  0.011 M <= B/6=  0.933 M
Incremental Rate...................MU=1+6*E/B=  1.012
Max. Soil Reaction...............Qmax=P/A*MU= 13.028 TON/M^2
```

2)Uplift Side

```
Eccentricity...................E=QB*H/(T-WC')=  0.060 M
Reduction Rate.........K=1/(1+6*E*B/(B^2+b^2))=  0.948
```

(8)HORIZONTAL SOIL REACTION

```
Max. Horizontal soil Reaction....QHmax=Q/(B*t)=  0.533 TON/M^2
```

(9)SAFETY FACTOR

```
Comp. Side.......................SFC=QCY/Qmax=  7.675 >=  2.00 =OK=
Uplift Side.........................SFT=QTY/T=  2.096 >=  2.00 =OK=
Hori. Side......................SFH=QHY/QHmax= 75.046 >=  2.00 =OK=
```

(10)E-LOAD

From Upper Limit

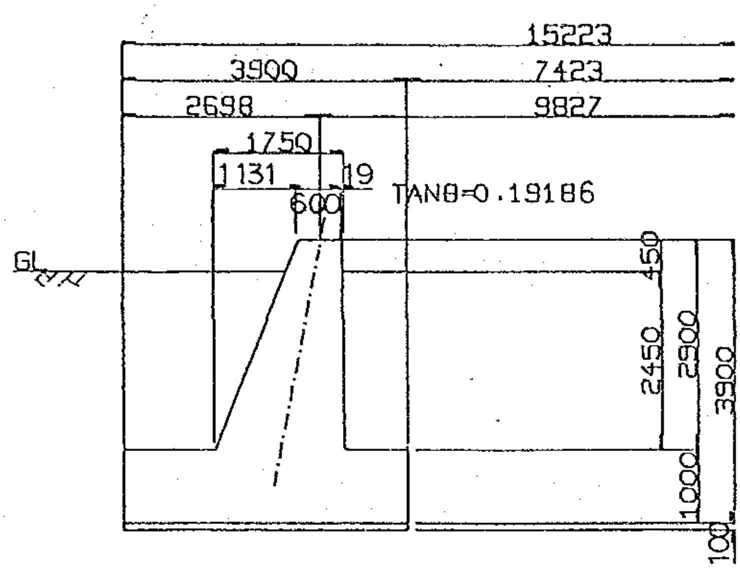
```
WC+WS'=  113.840 TON >= TO=   34.040 TON =OK=
   (WS'=WS*0.8)
```

(10), DR-D-I

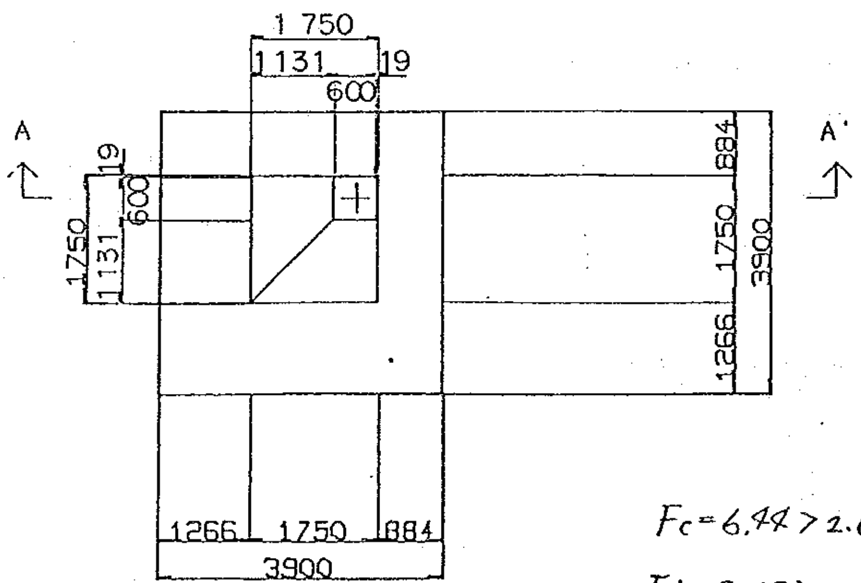
C = 124.05[+]
T = 107.47
Q = 3.67
Q_B = 0.87

PROFILE

S=1/100



A – A' SECTION



F_c = 6.44 > 2.00

F_t = 2.08 > 2.00

PLAN

INDIVIDUAL TYPE TOWER FOUNDATION (I , II)

------------------------------INPUT DATA--------------------------------------

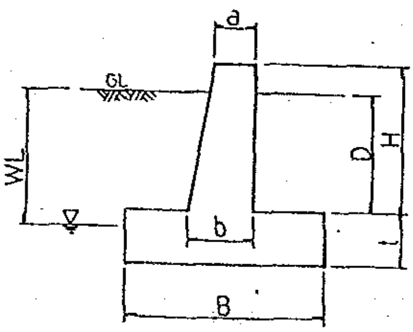
TOWER NAME............NO. DR-D-I

(1)LOAD CONDITION

Comp. Load....................C = 124.05 TON
Uplift Load...................T = 107.47 TON
Hori. Load....................Q = 3.67 TON
Hori. Load....................QB= 0.87 TON
E-Load.........................TO= 48.35 TON

(2)DIMENSION OF FOUNDATION

a = 0.600 M
b = 1.750 M
B = 3.900 M
t = 1.000 M
H = 2.900 M
D = 2.450 M
WL=- 10.000 M
γ = 2.40 TON/M^3



(3)SOIL CONDITION

Unit Weight of Soil (beneath the foundation)......S1= 1.800 TON/M^3
Unit Weight of Soil (on the foundation)...........S2= 1.440 TON/M^3
Cohesion (beneath the foundation)................C1= 0.000 TON/M^2
Cohesion (on the foundation).....................C2= 0.000 TON/M^2
Angle of Internal Friction (on the foundation)....φ = 40.000 °
Bearing Capacity Factor..N1= 95.700 N2=114.000 N3= 83.200 (φ =40 °)

(4)FOUNDATION TYPE

Foundation Type (shallow type...1,deep type...2)... 2

-----------------------------------RESULT-----------------------------------

(5)VERTICAL LOAD

```
Weight of concrite...........................WC=   46.880 TON
Weight of Soil...............................WS=   59.681 TON
Weight of Column and a part under Column...WC'=   17.726 TON
Vertical Load.........................P=C+WC+WS=  230.611 TON
```

(6)PILE CAPACITY

```
Comp. Side...................................QCY= 100.000 TON/M^2
Uplift Side..................................QTY= 224.264 TON/M^2
Hori. Side...................................QHY=  40.000 TON/M^2
```

(7)SOIL REACTION   Upper Limit

1)Comp. Side

```
Eccentricity....E=QB*(H+T')/P=  0.015 M <= B/6=  0.650 M
Incremental Rate.....................MU=1+6*E/B=  1.023
Max. Soil Reaction..................Qmax=P/A*MU= 15.505 TON/M^2
```

2)Uplift Side

```
Eccentricity.....................E=QB*H/(T-WC')=  0.028 M
Reduction Rate.........K=1/(1+6*E*B/(B^2+b^2))=  0.965
```

(8)HORIZONTAL SOIL REACTION

```
Max. Horizontal soil Reaction....QHmax=Q/(B*t)=  0.941 TON/M^2
```

(9)SAFETY FACTOR

```
Comp. Side........................SFC=QCY/Qmax=  6.449  >=  2.00 =OK=
Uplift Side.........................SFT=QTY/T=  2.086  >=  2.00 =OK=
Hori. Side.......................SFH=QHY/QHmax= 42.507  >=  2.00 =OK=
```

(10)E-LOAD   From Upper Limit

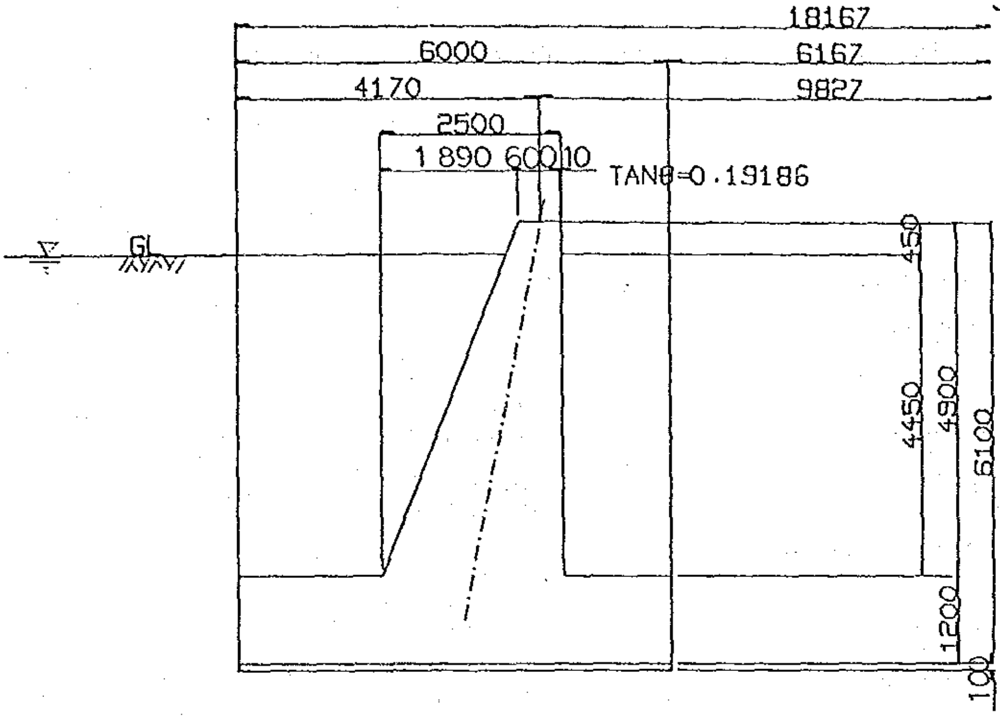
```
WC+WS'=    94.625 TON >= TO=    48.350 TON =OK=
   (WS'=WS*0.8)
```

(11). DR- C -I

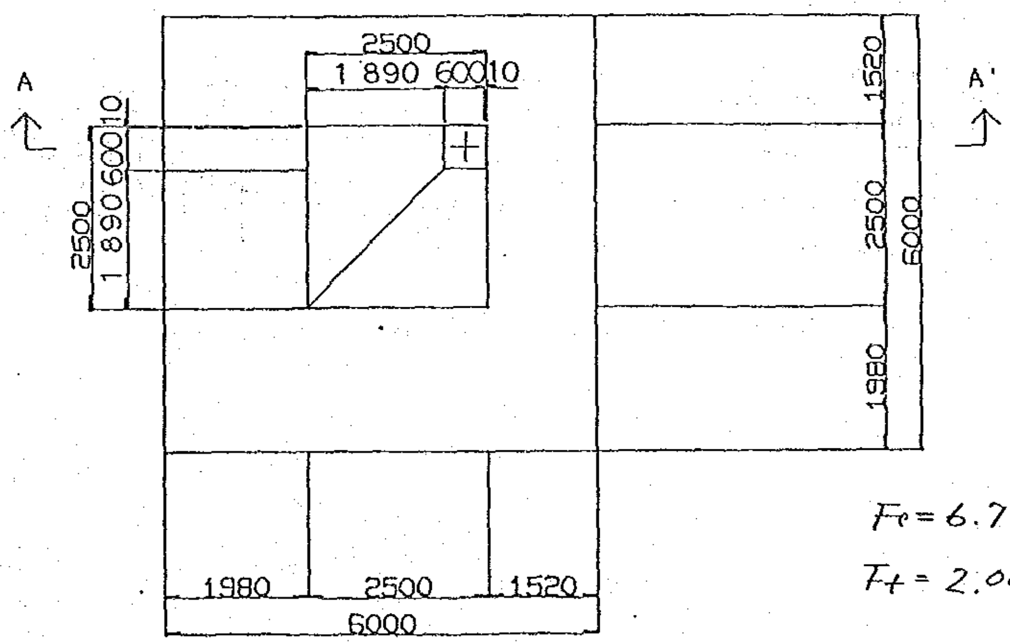
PROFILE

C=124.05t
T=107.47
Q= 3.67
Q_B= 0.87

S=1/100



A - A' SECTION



F_c = 6.79 > 2.00

F_t = 2.08 > 2.00

PLAN

INDIVIDUAL TYPE TOWER FOUNDATION (I , II)

--------------------------------INPUT DATA--------------------------------------

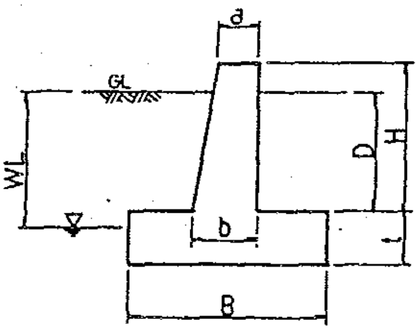
TOWER NAME............NO. DR-C-I

(1)LOAD CONDITION

Comp. Load.....................C = 124.05 TON
Uplift Load...................T = 107.47 TON
Hori. Load....................Q = 3.67 TON
Hori. Load....................QB= 0.87 TON
E-Load........................TO= 48.35 TON

(2)DIMENSION OF FOUNDATION

a = 0.600 M
b = 2.500 M
B = 6.000 M
t = 1.200 M
H = 4.900 M
D = 4.450 M
WL=- 0.000 M
γ = 2.40 TON/M^3



(3)SOIL CONDITION

Unit Weight of Soil (beneath the foundation)......S1= 1.800 TON/M^3
Unit Weight of Soil (on the foundation)...........S2= 1.440 TON/M^3
Cohesion (beneath the foundation).................C1= 0.000 TON/M^2
Cohesion (on the foundation)......................C2= 0.000 TON/M^2
Angle of Internal Friction (on the foundation).... φ = 35.000 °
Bearing Capacity Factor..N1= 35.400 N2= 23.400 N3= 27.800 (φ =35 °)

(4)FOUNDATION TYPE

Foundation Type (shallow type...1,deep type...2)... 2

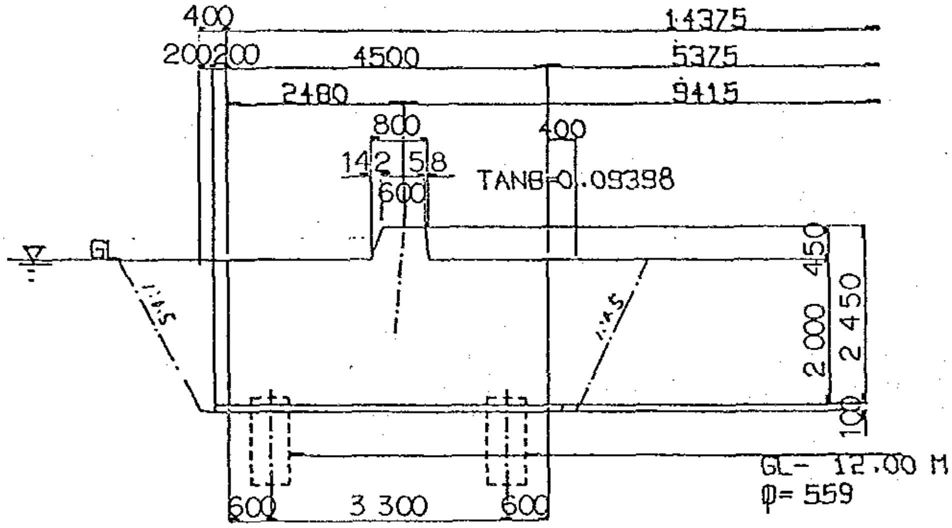
```
-------------------------------RESULT-------------------------------------
(5)VERTICAL LOAD

   Weight of concrite...........................WC=  135.471 TON
   Weight of Soil...............................WS=  264.901 TON
   Weight of Column and a part under Column...WC'=    29.259 TON
   Vertical Load.......................P=C+WC+WS=  524.422 TON

(6)PILE CAPACITY

   Comp. Side.................................QCY= 100.000 TON/M^2
   Uplift Side................................QTY= 224.478 TON/M^2
   Hori. Side.................................QHY=  40.000 TON/M^2
                                                                    Upper Limit
(7)SOIL REACTION

  1)Comp. Side

   Eccentricity....E=QB*(H+T')/P=  0.010 M <= B/6=  1.000 M
   Incremental Rate...................MU=1+6*E/B=  1.010
   Max. Soil Reaction................Qmax=P/A*MU= 14.715 TON/M^2

  2)Uplift Side

   Eccentricity..................E=QB*H/(T-WC')=  0.055 M
   Reduction Rate.........K=1/(1+6*E*B/(B^2+b^2))=  0.956

(8)HORIZONTAL SOIL REACTION

   Max. Horizontal soil Reaction....QHmax=Q/(B*t)=  0.510 TON/M^2

(9)SAFETY FACTOR

   Comp. Side......................SFC=QCY/Qmax=  6.795  >=   2.00 =OK=
   Uplift Side.......................SFT=QTY/T=  2.088  >=   2.00 =OK=
   Hori. Side....................SFH=QHY/QHmax= 78.431  >=   2.00 =OK=
                                                     From Upper Limit
(10)E-LOAD

   WC+WS'=  143.992 TON >= TO=   48.350 TON =OK=
      (WS'=WS*0.8)
```

(12). A4-S-Ⅲ

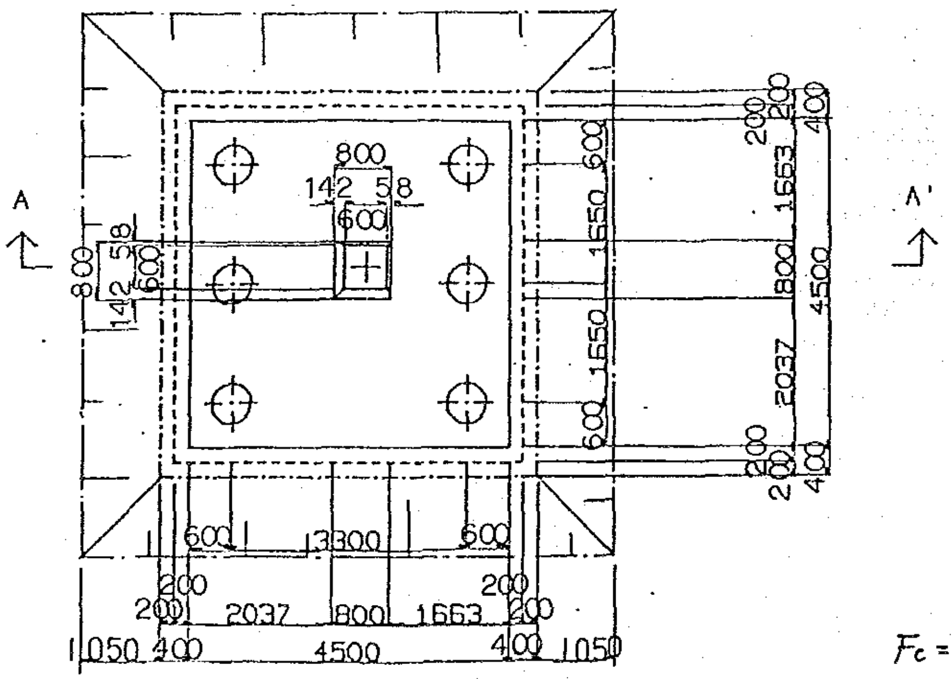
C = 110.95 t
T = 84.56
Qa = 2.34

PROFILE

S=1/100



A-A' SECTION



PLAN

TLG-1-236

Fc = 2.40 > 2.00
Ft = 2.04 > 2.00

PILE TYPE TOWER FOUNDATION (Ⅲ)

--------------------------------INPUT DATA--------------------------------

TOWER NAME.....NO. A4-S-Ⅲ

(1)LOAD CONDITION

Comp. Load.........................C = 110.95 TON
Uplift Load........................T = 84.56 TON
Hori. Load.........................Q = 9.24 TON
Hori. Load.........................QB= 2.34 TON
E-Load.............................TO= 7.60 TON

(2)STRATUM DATA

No.	Stratum No.	N-Value(N)	Thickness(L)	N*L
1	1	0(0)	2.00 M	0.000(0.000)
2	1	1(1)	1.00 M	1.000(1.000)
3	2	3(3)	1.00 M	2.500(2.500)
4	1	7(7)	6.50 M	45.500(45.500)
5	2	16(6)	1.50 M	24.000(9.000)

Sand (total)....................NS*LS= 46.500 TON
(46.500)
Clay (total)....................QU*LC= 26.500 TON
(11.500)

(3)WATER TABLE......................WL=- 0.000

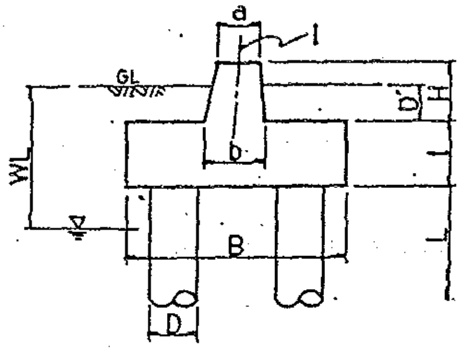
(4)N-VALUE OF BEARING STRATUM........N = 29

(5)BULK DENSITY

Concrete...........................γ = 2.400 TON/M^3
Soil (on the foundation)...........S2= 0.000 TON/M^3

(6)DIMENSION OF FOUNDATION

a = 0.600 M
b = 0.700 M
B = 4.500 M
t = 2.000 M
H = 0.450 M
D'= 0.000 M
I = 0.09398



(7)PILE TYPE (driven pile...1,cast in place conc. pile...2).... 2

(8)PILE CONDITION

Diameter of Pile....................D = 0.559 M
Length of Pile......................L = 12.000 M
Unit Weight (without buoyancy)......G1= 0.589 TON/M
Unit Weight (with buoyancy).........G2= 0.344 TON/M
Blockade Ratio......................R = 1.000

(9)LIMIT OF PILE CAPACITY

Comp. Side........................QCA= 124.000 TON/UNIT
Uplift Side.......................QTA= 49.000 TON/UNIT

(10)CONFIGURATION

Row of pile	Number(UNIT)	Distance(M)
1	2	1.650
2	2	0.000
3	2	-1.650

Eccentricity.......................E= 0.000 M

```
-----------------------------------RESULT-----------------------------------

(11)VERTICAL LOAD

  1)Without Buoyancy

  Weight of Concrete....................WC=   97.657 TON
  Weight of Soil (on the foundation)....WS=    0.000 TON
  Vertical Load.................P=C+WC+WS=  208.607 TON

  2)With Buoyancy

  Weight of Concrete....................WC=   57.157 TON
  Weight of Soil (on the foundation)....WS=    0.000 TON
  Vertical Load.................P=C+WC+WS=  168.107 TON

(12)PILE CAPACITY

  Comp. Side...QCY=15*R*N*π*D^2/4+((NS*LS)/5+(QU*LC)/2)*π*D)/1.5-2*WP
               =  85.793 TON/UNIT

  Uplift Side..QTY=((NS*LS)/5+(QU*LC)/2)*π*D+1.5WP')/1.5
               =  21.060 TON/UNIT

(13)OVERTURNING MOMENT

  1)Without Buoyancy

  Comp. Side..............MC=QB*(H+t)+P*E=     5.733 TON-M
  Uplift Side....MT=QB*(H+t)+|T-WC-WS|*E=     5.733 TON-M

  2)With Buoyancy

  Comp. Side..............MC=QB*(H+t)+P*E=     5.733 TON-M
  Uplift Side....MT=QB*(H+t)+|T-WC-WS|*E=     5.733 TON-M

(14)WEIGHT OF PILE

  Without Buoyancy......................WP=    5.890 TON/UNIT
  With Buoyancy........................WP'=    3.440 TON/UNIT
```

132

(15)LOAD DISTRIBUTIVE

Without Buoyancy......................KA= 0.436
With Bouyancy........................KA= 0.311

(16)PILE REACTION

1)Comp. Side

Row of pile	Without Buoyancy (TON/UNIT)	With Buoyancy (TON/UNIT)
1	35.637	28.887
2	34.768	28.018
3	33.899	27.149

2)Uplift Side

Row of pile	Without Buoyancy (TON/UNIT)	With Buoyancy (TON/UNIT)
1	8.440	10.302
2	7.950	9.704
3	7.460	9.106

(17)SAFETY FACTOR

1)Without Buoyancy

Comp. Side.................SFC=QCY/NCmax= 2.407 >= 2.0 =OK=
Uplift Side................SFT=QTY/NTmax= 2.495 >= 2.0 =OK=

2)With Buoyancy

Comp. Side.................SFC=QCY/NCmax= 2.970 >= 2.0 =OK=
Uplift Side................SFT=QTY/NTmax= 2.044 >= 2.0 =OK=

(18)E-LOAD

1)Without Buoyancy

WC+WS+N*WP= 132.997 TON >TO= 7.600 TON =OK=

2)With Buoyancy

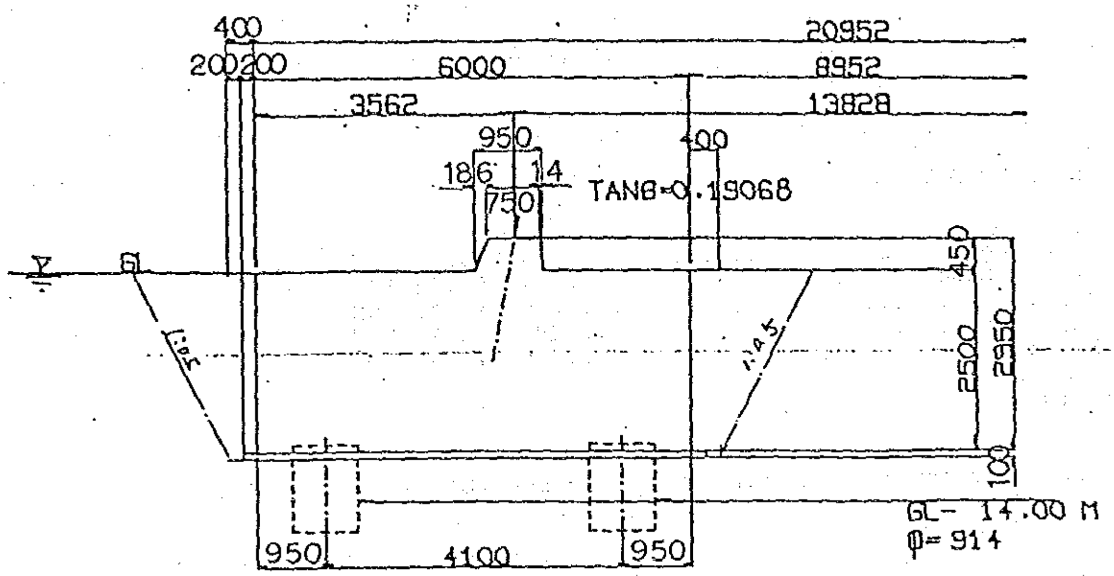
WC+WS+N*WP'= 77.797 TON >TO= 7.600 TON =OK=

(13) DR4 - S -Ⅲ , D4-'S -Ⅲ

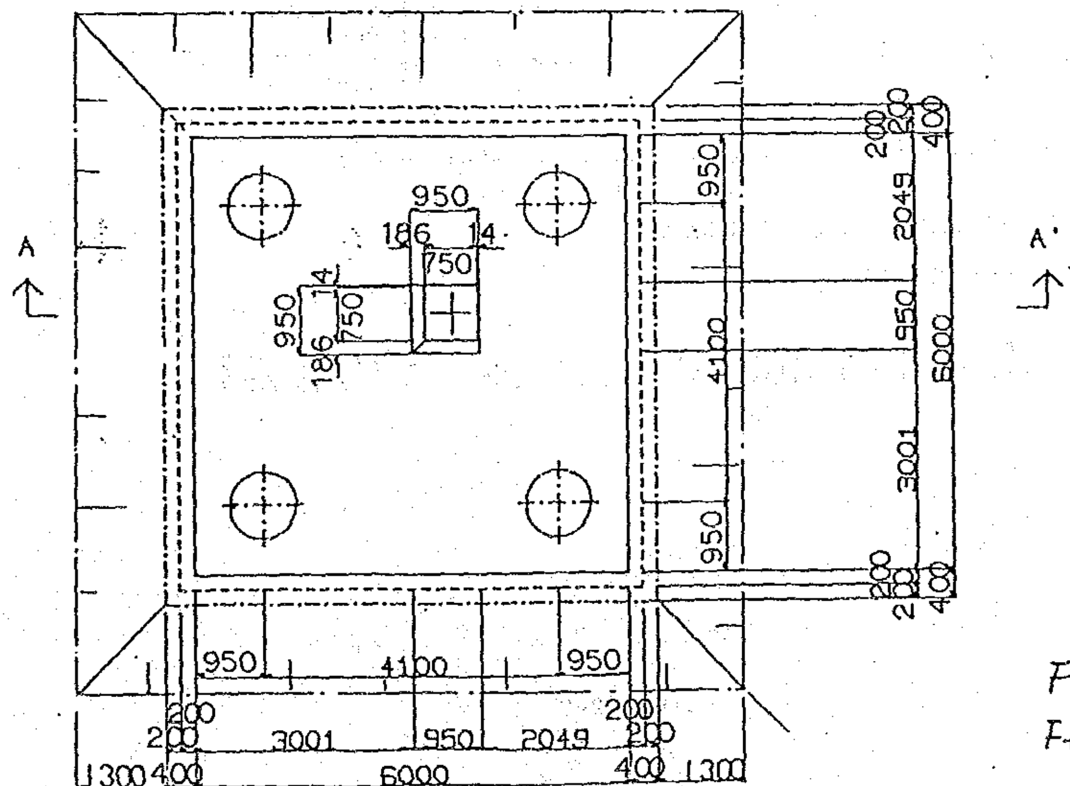
C = 245.32[t]
T = 201.88
Q_a = 0.78

S=1/100

PROFILE



A-A' SECTION



F_c = 2.88 > 2.00
F_t = 2.01 > 2.00

PLAN

TLG-1-241

PILE TYPE TOWER FOUNDATION (Ⅲ)

---------------------------------INPUT DATA---------------------------------

TOWER NAME.....NO. DR4-S-Ⅲ, D4-S-Ⅲ

(1)LOAD CONDITION

Comp. Load..........................C = 245.32 TON
Uplift Load.........................T = 201.88 TON
Hori. Load..........................Q = 12.37 TON
Hori. Load..........................QB= 0.78 TON
E-Load..............................TO= 76.67 TON

(2)STRATUM DATA

No.	Stratum No.	N-Value(N)	Thickness(L)	N*L
1	1	0(0)	2.50 M	0.000(0.000)
2	1	1(1)	0.50 M	0.500(0.500)
3	2	3(3)	1.00 M	2.500(2.500)
4	1	7(7)	6.50 M	45.500(45.500)
5	2	16(6)	2.00 M	32.000(12.000)
6	1	50(50)	1.50 M	75.000(75.000)

Sand (total)....................NS*LS= 121.000 TON
(121.000)
Clay (total)....................QU*LC= 34.500 TON
(14.500)

(3)WATER TABLE........................WL=- 0.000

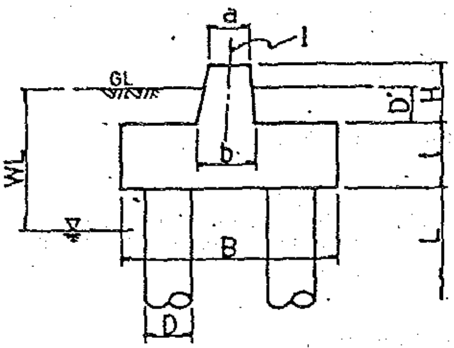
(4)N-VALUE OF BEARING STRATUM.........N = 46

(5)BULK DENSITY

Concrete............................ γ = 2.400 TON/M^3
Soil (on the foundation)............S2= 0.000 TON/M^3

(6)DIMENSION OF FOUNDATION

```
a  =  0.750 M
b  =  0.950 M
B  =  6.000 M
t  =  2.500 M
H  =  0.450 M
D'=  0.000 M
I  =  0.19068
```



(7)PILE TYPE (driven pile...1,cast in place conc. pile...2).... 2

(8)PILE CONDITION

```
Diameter of Pile....................D =   0.914 M
Length of Pile......................L =  14.000 M
Unit Weight (without buoyancy)......G1=   1.575 TON/M
Unit Weight (with buoyancy).........G2=   0.919 TON/M
Blockade Ratio......................R =   1.000
```

(9)LIMIT OF PILE CAPACITY

```
Comp. Side........................QCA= 334.000 TON/UNIT
Uplift Side.......................QTA= 131.000 TON/UNIT
```

(10)CONFIGURATION

Row of pile	Number(UNIT)	Distance(M)
1	2	2.050
2	2	-2.050

```
Eccentricity......................E=  0.000 M
```

------------------------------------RESULT------------------------------------

(11)VERTICAL LOAD

1)Without Buoyancy

```
Weight of Concrete....................WC=  216.784 TON
Weight of Soil (on the foundation)....WS=    0.000 TON
Vertical Load.................P=C+WC+WS=  462.104 TON
```

2)With Buoyancy

```
Weight of Concrete....................WC=  126.784 TON
Weight of Soil (on the foundation)....WS=    0.000 TON
Vertical Load.................P=C+WC+WS=  372.104 TON
```

(12)PILE CAPACITY

Comp. Side...QCY=15*R*N*π*D^2/4+((NS*LS)/5+(QU*LC)/2)*π*D)/1.5-2*WP
= 334.000 TON/UNIT

Uplift Side..QTY=((NS*LS)/5+(QU*LC)/2)*π*D+1.5WP')/1.5
= 70.773 TON/UNIT

(13)OVERTURNING MOMENT

1)Without Buoyancy

```
Comp. Side...............MC=QB*(H+t)+P*E=     2.301 TON-M
Uplift Side....MT=QB*(H+t)+|T-WC-WS|*E=     2.301 TON-M
```

2)With Buoyancy

```
Comp. Side...............MC=QB*(H+t)+P*E=     2.301 TON-M
Uplift Side....MT=QB*(H+t)+|T-WC-WS|*E=     2.301 TON-M
```

(14)WEIGHT OF PILE

```
Without Buoyancy......................WP=    18.113 TON/UNIT
With Buoyancy........................WP'=    10.569 TON/UNIT
```

(15)LOAD DISTRIBUTIVE

Without Buoyancy......................KA= 0.434
With Bouyancy.........................KA= 0.309

(16)PILE REACTION

1)Comp. Side

Row of pile	Without Buoyancy (TON/UNIT)	With Buoyancy (TON/UNIT)
1	115.807	93.307
2	115.245	92.745

2)Uplift Side

Row of pile	Without Buoyancy (TON/UNIT)	With Buoyancy (TON/UNIT)
1	28.741	35.052
2	28.423	34.665

(17)SAFETY FACTOR

1)Without Buoyancy

Comp. Side................SFC=QCY/NCmax= 2.884 >= 2.0 =OK=
Uplift Side...............SFT=QTY/NTmax= 2.462 >= 2.0 =OK=

2)With Buoyancy

Comp. Side................SFC=QCY/NCmax= 3.579 >= 2.0 =OK=
Uplift Side...............SFT=QTY/NTmax= 2.019 >= 2.0 =OK=

(18)E-LOAD

1)Without Buoyancy

WC+WS+N*WP= 289.234 TON >TO= 76.670 TON =OK=

2)With Buoyancy

WC+WS+N*WP'= 169.058 TON >TO= 76.670 TON =OK=

11. LEDGER FOR INDIVIDUAL TOWER

LEDGER FOR INDIVIDUAL TOWER

West Wharf P/S — b c / a d — Baldia G/S

Circuit Voltage : 220 kV
No. of Circuit : 2 cct.
Conductor : ACSR/AS 330 mm^2
Ground Wire : OPGW 190/90 mm^2

Tower No.	Span (m)	Wind Span (m)	Daviation Angle	Tower Type	Tower Extention	Ground Level Difference (m)	Formation Level (m)	Cond. Support Height (m)	Cond. Support Level Difference (m)	h/S h1/S1	h/S h2/S2	h/S Σh/S	Catenary Ang. (°) For side	Catenary Ang. (°) Back side	Catenary Ang. (°) Total	Insulator Class	Insulator Type	Type of Foundation	Remarks Crossing	Remarks Land Item
G1	15			Gantry	+0	0.0	0.0	9.0								12t*1	—	PILE FOUND.		Factory Area
G2	35			Gantry	+0	-0.2	0.0	9.0								12t*1	—	PILE FOUND.		
1	320	185		D4	-3	-0.1	0.0	39.2	32.57	0.6514	-0.0102	0.6412	36	7	43	12t*1 12t*2	— =	D4-S		
2	330	325		A4	+0	0.0	0.0	42.5	3.28	0.0102	0.0095	0.0198	6	6	12	12t*2	V	A4-S	Road	
3	276	303		A4	-3	-0.2	0.0	39.5	-3.15	-0.0095	0.0006	-0.0090	5	5	10	12t*2	V	A4-S	Road, Mosque	
4	350	313	L 70° 48'	DR4	-3	0.1	0.0	39.2	-0.16	-0.0006	0.0556	0.0550	7	11	18	12t*2	=,=	DR4-S	Sea Water Houses, Boat Manuf.	Trees
5	380	365		A	+0	-2.9	0.0	22.5	-19.45	-0.0556	-0.0277	-0.0833	3	5	8	12t*2	V	[illegible]-S	Sea Water	Sea Water
6	500	440		AL	+6	0.7	0.0	32.5	10.53	0.0277	-0.0034	0.0243	8	8	16	12t*2	V	AL-S	Sea Water, House	Enchroachment Area
7	460	480		AL	+7.5	0.1	0.0	34.0	1.72	0.0034	0.0175	0.0210	9	9	18	12t*2	V	AL-S	Fish Yard, River	River
8	430	445		AL	+0	-0.5	0.0	26.5	-8.06	-0.0175	0.0016	-0.0159	7	7	14	12t*2	V	AL-R	Layari River	River
9	333	382		A	+3	0.3	0.0	25.5	-0.70	-0.0016	0.0055	0.0039	7	6	13	12t*2	V	A-R	Layari River, Bund	Water Lodging
10	290	312	L 36° 42'	C	+0	1.4	0.0	22.2	-1.84	-0.0055	0.0293	0.0238	8	9	17	12t*2	==	C-C	Katcha Road Water Lodging	
11	225	258		AS	+0	-0.8	0.0	14.5	-8.50	-0.0293	-0.0024	-0.0317	3	4	7	12t*2	V	AS-C	ater Lodging	
12	220	223	L 44° 39'	D	-3	0.8	0.0	14.2	0.53	0.0024	0.0010	0.0033	6	6	12	12t*2	=,=	D-C		Broken Area
13	220	220		AS	+0	-0.5	0.0	14.5	-0.21	-0.0010	-0.0059	-0.0068	4	3	7	12t*2	V	AS-C		
14	220	220		AS	+0	1.3	0.0	14.5	1.29	0.0059	-0.0048	0.0011	4	3	7	12t*2	V	AS-C		
15	220	220		AS	+0	1.1	0.0	14.5	1.05	0.0048	0.0019	0.0066	4	4	8	12t*2	V	AS-C		
16	180	200		AS	+0	-0.8	0.0	14.5	-0.41	-0.0019	-0.0053	-0.0072	4	3	7	12t*2	V	AS-C	KMC Boundary, Market	
17	170	175	R 4° 49'	B	-6	-0.6	0.0	16.2	1.11	0.0053	0.0163	0.0216	6	6	12	12t*2	==	B-C	H.T Line	Salt Area
18																				

West Wharf P/S — [b c / a d] — Baldia G/S

LEDGER FOR INDIVIDUAL TOWER

Circuit Voltage : 220 kV
No. of Circuit : 2 cct.
Conductor : ACSR/AS 330 mm^2
Ground Wire : OPGW 190/90 mm^2

Tower No.	Span (m)	Wind Span (m)	Daviation Angle	Tower Type	Tower Extention	Ground Level Difference (m)	Formation Level (m)	Cond. Support Height (m)	Cond. Support Level Difference (m)	h1/S1	h2/S2	Σh/S	Catenary Ang. (°) For side	Catenary Ang. (°) Back side	Catenary Ang. (°) Total	Insulator Class	Insulator Type	Type of Foundation	Remarks: Crossing	Remarks: Land Item
18	245	208		AS	+0	-1.0	0.0	14.5	-2.74	-0.0161	0.0000	-0.0161	2	4	6	12t*2	V	AS-C	Old Salt Area	Old Salt Area
19	245	245		AS	+0	0.0	0.0	14.5	0.00	0.0000	-0.0004	-0.0004	4	4	8	12t*2	V	AS-C	Old Salt Area Katcha Road	
20	220	233		AS	+0	0.0	0.0	14.5	0.10	0.0004	0.0023	0.0027	4	4	8	12t*2	V	AS-C		
21	200	210		AS	+0	-0.5	0.0	14.5	-0.50	-0.0023	0.0000	-0.0023	3	3	6	12t*2	V	AS-C	Sea Water	Sea Water
22	200	200		AS	+0	0.0	0.0	14.5	0.00	0.0000	0.0005	0.0005	3	3	6	12t*2	V	AS-C	Sea Water, Nala	
23	230	215		AS	+0	-0.1	0.0	14.5	-0.10	-0.0005	0.0004	-0.0001	3	4	7	12t*2	V	AS-C	Sea Water	
24	220	225		AS	+0	-0.1	0.0	14.5	-0.10	-0.0004	0.0014	0.0009	4	4	8	12t*2	V	AS-C	Sea Water	
25	240	230		AS	+0	-0.3	0.0	14.5	-0.30	-0.0014	-0.0148	-0.0161	4	3	7	12t*2	V	AS-C	Bund, Sea Water	
26	180	210	L 12°27'	B	-6	1.8	0.0	16.2	3.54	0.0148	0.0180	0.0328	7	6	13	12t*2	==	B-C	Sea Water	
27	180	180		AS	+0	-1.5	0.0	14.5	-3.21	-0.0178	-0.0051	-0.0230	2	3	5	12t*2	V	AS-C	Sea Water, Bushes	
28	180	180		AS	+0	0.9	0.0	14.5	0.92	0.0051	0.0067	0.0118	3	3	6	12t*2	V	AS-C	Sea Water	
29	160	170	R 71°22'	DR	-3	-1.0	0.0	14.2	-1.21	-0.0067	-0.0015	-0.0083	5	5	10	12t*2	=ǀ=	DR-C	Marin Academy, Road	
30	240	200		AS	+0	-0.0	0.0	14.5	0.25	0.0015	-0.0013	0.0002	3	4	7	12t*2	V	AS-C	Sea Water	
31	240	240		AS	+0	0.3	0.0	14.5	0.32	0.0013	0.0038	0.0052	4	4	8	12t*2	V	AS-C	Sea Water	Salt Area
32	240	240		AS	+0	-0.9	0.0	14.5	-0.92	-0.0038	-0.0037	-0.0075	4	4	8	12t*2	V	AS-C	Sea Water, Salt Area	
33	250	245		AS	+0	0.9	0.0	14.5	0.88	0.0037	-0.0005	0.0032	4	4	8	12t*2	V	AS-C	Salt Area	
34	240	245		AS	+0	0.1	0.0	14.5	0.12	0.0005	0.0006	0.0011	4	4	8	12t*2	V	AS-C	Salt Area	
35	250	245		AS	+0	-0.1	0.0	14.5	-0.14	-0.0006	-0.0004	-0.0010	4	4	8	12t*2	V	AS-C		
36	180	215	R 52° 7'	D	-3	0.4	0.0	14.2	0.10	0.0004	-0.0004	-0.0000	6	5	11	12t*2	==	D-C		
37																				

West Wharf P/S — b c ⊠ a d — Baldia G/S

LEDGER FOR INDIVIDUAL TOWER

Circuit Voltage : 220 kV
No. of Circuit : 2 cct.
Conductor : ACSR/AS 330 mm²
Ground Wire : OPGW 190/90 mm²

Tower No.	Span (m)	Wind Span (m)	Daviation Angle	Tower Type	Tower Extention	Ground Level Diffe-rence (m)	Formation Level (m)	Cond. Support Height (m)	Cond. Support Level Diffe-rence (m)	h/S h1/S1	h/S h2/S2	h/S Σh/S	Catenary Ang. (°) For side	Catenary Ang. (°) Back side	Catenary Ang. (°) Total	Insulator Class	Insulator Type	Type of Foun-dation	Remarks Crossing	Remarks Land Item
37	169	175		AS	+0	-0.2	0.0	14.5	0.08	0.0004	-0.0054	-0.0050	3	2	5	12t*2	V	AS-C		Salt Area
38	140	155	L 45°27'	D	-3	1.2	0.0	14.2	0.91	0.0054	0.0088	0.0142	5	5	10	12t*2	=ᵢ=	D-C	Road, H.T Line Old Salt Area	
39	220	180		AS	+0	-1.5	0.0	14.5	-1.23	-0.0088	0.0002	-0.0086	2	4	6	12t*2	V	AS-C	Sea Water	
40	240	230		AS	+0	-0.1	0.0	14.5	-0.05	-0.0002	-0.0020	-0.0022	4	4	8	12t*2	V	AS-C	Sea Water	Sea Water
41	240	240		AS	+0	0.5	0.0	14.5	0.47	0.0020	0.0019	0.0039	4	4	8	12t*2	V	AS-C	Sea Water	
42	240	240		AS	+0	-0.5	0.0	14.5	-0.46	-0.0019	-0.0011	-0.0030	4	4	8	12t*2	V	AS-C	Sea Water	
43	240	240		AS	+0	0.3	0.0	14.5	0.27	0.0011	-0.0034	-0.0023	4	4	8	12t*2	V	AS-C		Open Area
44	155	198		AS	+0	0.8	0.0	14.5	0.82	0.0034	0.0058	0.0093	4	3	7	12t*2	V	AS-C		
45	150	153		B	-6	-0.1	0.0	14.5	-0.91	-0.0058	-0.0084	-0.0142	2	2	4	12t*2	⊥=	B-C	Nala, Road, H.T Line	
46	230	190		B	-6	1.6	0.0	14.5	1.04	0.0084	-0.0055	0.0029	3	3	6	12t*2	==	B-C		
47	250	240		AS	+0	1.0	0.0	14.5	1.26	0.0055	0.0001	0.0056	4	4	8	12t*2	V	AS-C	Road under const.	
48	250	250		AS	+0	-0.2	0.0	14.5	-0.02	-0.0001	-0.0318	-0.0319	4	2	6	12t*2	V	AS-C		
49	230	240	R 38°18'	C	+0	-0.1	0.0	22.2	7.64	0.0318	0.0311	0.0630	8	8	16	12t*2	==	C-C	Road under const.	
50	230	230		AS	+0	0.6	0.0	14.5	-7.16	-0.0311	-0.0043	-0.0354	2	4	6	12t*2	V	AS-D		
51	230	230		AS	+0	1.0	0.0	14.5	0.99	0.0043	-0.0040	0.0003	4	4	8	12t*2	V	AS-D	Trees & Bushies	
52	196	213		AS	+0	0.9	0.0	14.5	0.91	0.0040	-0.0046	-0.0007	4	3	7	12t*2	V	AS-D	Trees & Bushies	Bushes
53	224	210		AS	+0	0.9	0.0	14.5	0.97	0.0046	-0.0058	-0.0012	4	3	7	12t*2	V	AS-D	Road under const.	Bushes
54	210	217		AS	+0	1.3	0.0	14.5	1.22	0.0058	-0.0031	0.0027	4	3	7	12t*2	V	AS-D		Open Area
55	210	210		AS	+0	0.7	0.0	14.5	0.66	0.0031	-0.0055	-0.0024	4	3	7	12t*2	V	AS-D	Bushies	Bushies
56																				Bushies

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West Wharf P/S — b c ⊠ a d — Baldia G/S

LEDGER FOR INDIVIDUAL TOWER

Circuit Voltage : 220 kV
No. of Circuit : 2 cct.
Conductor : ACSR/AS 330 mm^2
Ground Wire : OPGW 190/90 mm^2

Tower No.	Span (m)	Wind Span (m)	Daviation Angle	Tower Type	Tower Extention	Ground Level Diffe-rence (m)	Forma-tion Level (m)	Cond. Support Height (m)	Cond. Support Level Diffe-rence (m)	h / S h1/S1	h / S h2/S2	h / S Σh/S	Catenary Ang. (°) For side	Catenary Ang. (°) Back side	Catenary Ang. (°) Total	Insulator Class	Insulator Type	Type of Foun-dation	Remarks Crossing	Remarks Land Item
56		205		AS	+0	1.2	0.0	14.5	1.16	0.0055	-0.0048	0.0008	4	3	7	12t*2	V	AS-D		
	200																		Bushies	
57		200		AS	+0	1.0	0.0	14.5	0.95	0.0048	-0.0031	0.0017	4	3	7	12t*2	V	AS-D		
	200																			
58		208		AS	+0	0.6	0.0	14.5	0.61	0.0031	-0.0041	-0.0010	3	3	6	12t*2	V	AS-D		
	215																			
59		208	R 56°51'	D	-3	1.1	0.0	14.2	0.87	0.0041	-0.0063	-0.0023	6	5	11	12t*2	= =	D-D		Open Area
	200																		Road	
60		220		AS	+0	1.0	0.0	14.5	1.27	0.0063	-0.0035	0.0028	4	4	8	12t*2	V	AS-D		
	240																			
61		225		AS	+0	0.9	0.0	14.5	0.85	0.0035	-0.0057	-0.0021	4	3	7	12t*2	V	AS-D		
	210																			
62		210		AS	+0	1.2	0.0	14.5	1.19	0.0057	-0.0049	0.0008	4	3	7	12t*2	V	AS-D		
	210																			
63		210		AS	+0	1.0	0.0	14.5	1.02	0.0049	-0.0072	-0.0024	4	3	7	12t*2	V	AS-D		
	210																			
64		210		AS	+0	1.5	0.0	14.5	1.52	0.0072	-0.0075	-0.0003	4	3	7	12t*2	V	AS-D		
	210																			
65		210		AS	+0	1.6	0.0	14.5	1.58	0.0075	-0.0001	0.0074	4	4	8	12t*2	V	AS-D		Open Area
	210																		Nala, Trees & Bushes	
66		210		AS	+0	0.0	0.0	14.5	0.02	0.0001	-0.0019	-0.0018	4	4	8	12t*2	V	AS-D		
	210																		Bushes, Nala	
67		250		AS	+0	0.4	0.0	14.5	0.39	0.0019	-0.0363	-0.0345	4	3	7	12t*2	V	AS-D		
	290																		Bushes	
68		345		A	+1.5	1.0	0.0	24.0	10.53	0.0363	-0.0020	0.0343	7	6	13	12t*2	V	A-D		Bushes
	400																		Bushes, Rail Way	
69		395		A	+1.5	0.8	0.0	24.0	0.79	0.0020	0.0064	0.0084	7	7	14	12t*2	V	A-D		
	390																		Bushes, Nala	
70		375		A	+0	-1.0	0.0	22.5	-2.51	-0.0064	-0.0032	-0.0096	6	6	12	12t*2	V	A-D		
	360																		Sparco Building Wall	
71		355		A	+0	1.1	0.0	22.5	1.14	0.0032	-0.0066	-0.0035	6	5	11	12t*2	V	A-D		
	350																			
72		350		A	+0	2.3	0.0	22.5	2.32	0.0066	-0.0075	-0.0008	6	5	11	12t*2	V	A-D		
	350																			
73		330	R 17°37'	C	+0	2.9	0.0	22.2	2.61	0.0075	0.0082	0.0156	9	8	17	12t*2	= =	C-D		
	310																			
74																				

West Wharf P/S — b c / a d — Baldia G/S

LEDGER FOR INDIVIDUAL TOWER

Circuit Voltage : 220 kV
No. of Circuit : 2 cct.
Conductor : ACSR/AC 330 mm^2
Ground Wire : OPGW 190/90 mm^2

Tower No.	Span (m)	Wind Span (m)	Daviation Angle	Tower Type	Tower Extention	Ground Level Difference (m)	Formation Level (m)	Cond. Support Height (m)	Cond. Support Level Difference (m)	h/S h1/S1	h/S h2/S2	h/S Σh/S	Catenary Ang. (°) For side	Catenary Ang. (°) Back side	Catenary Ang. (°) Total	Insulator Class	Insulator Type	Type of Foundation	Remarks Crossing	Remarks Land Item
74	310	310		A	-3	0.2	0.0	19.5	-2.53	-0.0082	-0.0023	-0.0104	5	5	10	12t*2	V	A-D		
75	310	310		A	-3	0.7	0.0	19.5	0.70	0.0023	-0.0111	-0.0088	5	5	10	12t*2	V	A-D	Poultry Forme	
76	390	350	R 27° 0'	C	+0	0.7	0.0	22.2	3.44	0.0111	-0.0006	0.0105	8	9	17	12t*2	= =	C-D		
77	390	390		A	+0	-0.0	0.0	22.5	0.24	0.0006	0.0011	0.0017	7	7	14	12t*2	V	A-D	Poultry Forme	
78	378	384		A	+0	-0.4	0.0	22.5	-0.44	-0.0011	-0.0032	-0.0044	7	6	13	12t*2	V	A-D		
79	267	323		A	+0	1.2	0.0	22.5	1.22	0.0032	-0.0346	-0.0314	7	4	11	12t*2	V	A-D	Cattle Farm	
80.	163	215	L 27° 47'	C	+12	1.1	0.0	34.2	12.81	0.0346	-0.0081	0.0265	11	5	16	12t*3	= =	C-D	Wall, 132kV Line, Tel Line Road, H.t Line	
81	435	299	R 3°00'	A	+12	1.0	0.0	34.5	1.26	0.0081	0.0365	0.0446	3	9	12	12t*2	V	A-D	Nala	
82	350	393		A	-3	0.4	0.0	19.5	-14.60	-0.0365	-0.0131	-0.0496	5	5	10	12t*2	V	A-D	Nala	
83	344	347		A	+0	1.6	0.0	22.5	4.60	0.0131	0.0115	0.0246	7	6	13	12t*2	V	A-D		
84	273	309	L 89° 3'	DR	+0	1.2	0.0	17.2	-3.96	-0.0115	-0.0051	-0.0166	8	7	15	12t*2	=|=	DR-D		
85	390	332	R 90° 8'	DR	+0	1.4	0.0	17.2	1.36	0.0050	-0.0517	-0.0467	7	6	13	12t*2	=|=	DR-D	Road, 132kV Line	
86	410	400		A	+12	2.9	0.0	34.5	20.17	0.0517	0.0045	0.0562	10	7	17	12t*2	V	A-D	Road	Urban Area
87	390	400		A	+4.5	5.7	0.0	27.0	-1.83	-0.0045	-0.0106	-0.0151	7	6	13	12t*2	V	A-D	Road	
88	323	357		A	+3	5.6	0.0	25.5	4.13	0.0106	0.0072	0.0178	7	7	14	12t*2	V	A-D	Road	
89	200	262	R 89° 4'	DR	+0	5.6	0.0	17.2	-2.68	-0.0072	0.0110	0.0037	8	7	15	12t*2	=|=	DR-D	Nala	
90	199	200		AS	+0	0.5	0.0	14.5	-2.19	-0.0110	0.0066	-0.0043	3	4	7	12t*2	V	AS-D		
91	110	155	R 90° 0'	DR	-6	1.9	0.0	11.2	-1.32	-0.0066	0.0357	0.0291	5	6	11	12t*2	=|=	DR-D	Boundary Wall, Road, Nala	
92	30	70		D	-3	-6.9	0.0	14.2	-3.93	-0.0357	0.1033	0.1676	2	21	23	12t*2 12t*1	= –	D-D		
G3				Gantry	+0	-0.9	0.0	12.0	-3.10							12t*1	–|	MONO BLOCK FOUNDATION		

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