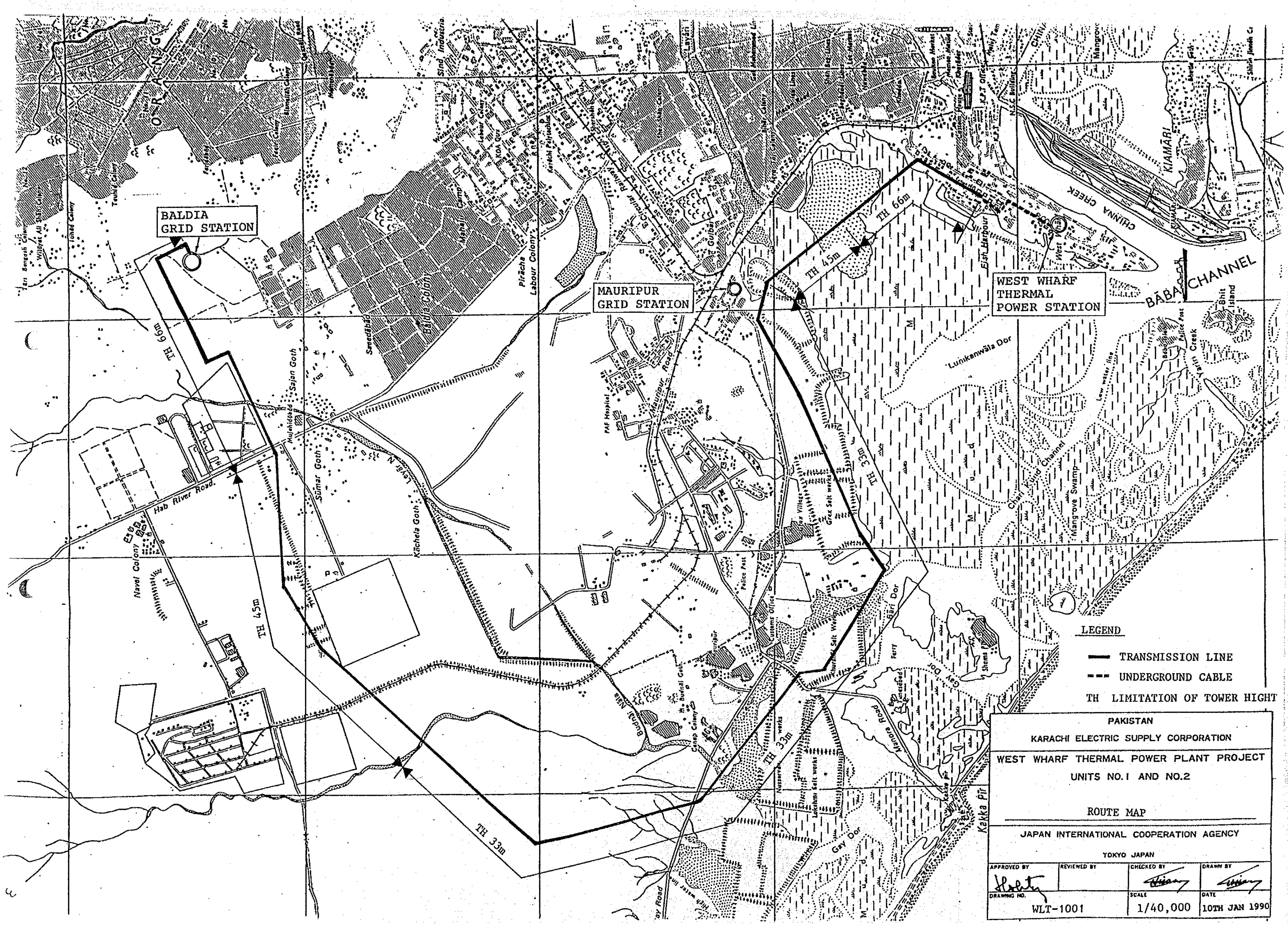
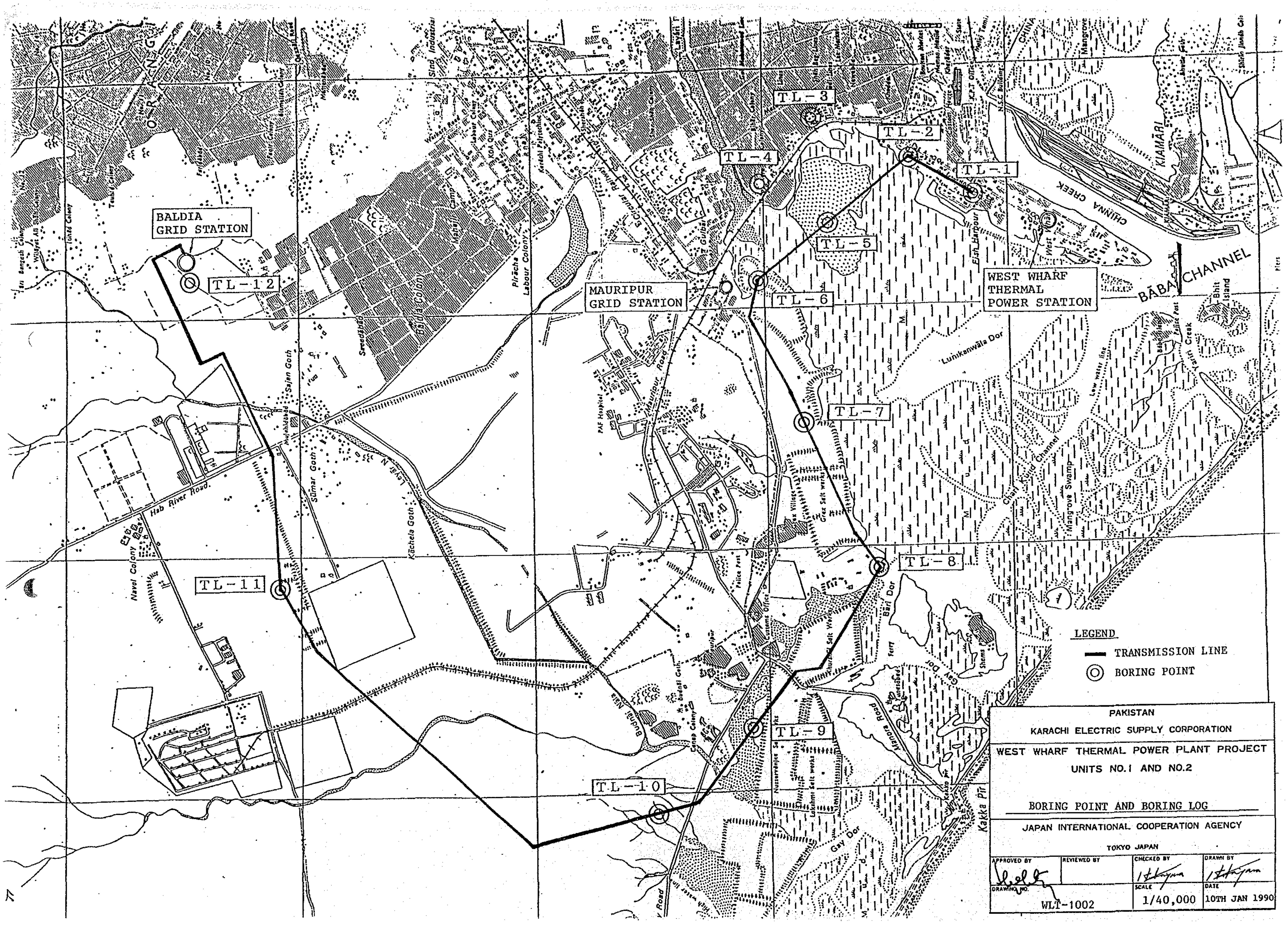
12. DRAWINGS

	DRAWING NO.	DESCRIPTION
1.	WLT-1001	ROUTE MAP
2.	WLT-1002	BORING POINT AND BORING LOG
3.	WLT-1101	SKELETON OF TOWER (1)
4.	WLT-1102	SKELETON OF TOWER (2)
5.	WLT-1103	SKELETON OF TOWER (3)
6.	WLT-1104	CONFIGURATION AT THE PLACE OF TOWER NO. 1
7.	WLT-1105	PLAN AT THE PLACE OF TOWER NO. 1
8.	WLT-1106	ARRANGEMENT OF 220 KV INCOMING LINES AT TOWER NO. 1
9.	WLT-1107	CLEARANCE DIAGRAM (1)
10.	WLT-1108	CLEARANCE DIAGRAM (2)
11.	WLT-1109	CLEARANCE DIAGRAM (3)
12.	TLT-01	SKELETON OF TOWER AS
13.	TLT-02	SKELETON OF TOWER A
14.	TLT-03	SKELETON OF TOWER AL
15.	TLT-04	SKELETON OF TOWER B
16.	TLT-05	SKELETON OF TOWER C
17.	TLT-06	SKELETON OF TOWER D & DR
18.	TLT-07	SKELETON OF TOWER A4
19.	TLT-08	SKELETON OF TOWER D4
20.	TLT-09	SKELETON OF TOWER DR4
21.	WLT-1201	220 KV V-SUSPENSION INSULATOR STRING
22.	WLT-1202	220 KV SINGLE TENSION INSULATOR STRING
23.	WLT-1203	220 KV DOUBLE TENSION INSULATOR STRING
24.	WLT-1204	220 KV JUMPER SUPPORT INSULATOR STRING
25.	WLT-1205	132 KV SINGLE SUSPENSION INSULATOR STRING
26.	WLT-1206	132 KV SINGLE TENSION INSULATOR STRING

	DRAWING NO.	DESCRIPTION
27.	WLT-1207	132 KV DOUBLE TENSION INSULATOR STRING
28.	WLT-1208	132 KV JUMPER SUPPORT INSULATOR STRING
29.	WLT-1209	132 KV TIE DOWN INSULATOR STRING
30.	WLT-1210	FOG TYPE SUSPENSION INSULATOR
31.	WLT-1601	INDIVIDUAL TYPE TOWER FOUNDATION (I-DRY, I-WET)
32.	WLT-1602	PILE TYPE TOWER FOUNDATION (1/2)
33.	WLT-1603	PILE TYPE TOWER FOUNDATION (2/2)
34.	WLT-1604	RIGID FRAME TOWER FOUNDATION (AL-R)



BALDIA
GRID STATION
MAURIPUR
GRID STATION
WEST WHARF
THERMAL
POWER STATION
TH 66m
TH 45m
TH 33m
BABA CHANNEL
CHINA CREEK
KIAMARI
Hab River Road
Maripur Road
Mangrove Swamp
LEGEND
TRANSMISSION LINE
UNDERGROUND CABLE
TH LIMITATION OF TOWER HIGHT
PAKISTAN
KARACHI ELECTRIC SUPPLY CORPORATION
WEST WHARF THERMAL POWER PLANT PROJECT
UNITS NO.1 AND NO.2
ROUTE MAP
JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO JAPAN
APPROVED BY
REVIEWED BY
CHECKED BY
DRAWN BY
DRAWING NO.
WLT-1001
SCALE
1/40,000
DATE
10TH JAN 1990


BALDIA GRID STATION
MAURIPUR GRID STATION
WEST WHARF THERMAL POWER STATION
TL-1
TL-2
TL-3
TL-4
TL-5
TL-6
TL-7
TL-8
TL-9
TL-10
TL-11
TL-12
CHINA CREEK
KIAMARI
BABA CHANNEL
Hab River Road
Mauripur Road
Baldia Colony
Lunikanwala Dor
Mangrove Swamp
Bari Dor
Gay Dor
Manora Road
Kakka Pir
Naval Colony
LEGEND
TRANSMISSION LINE
BORING POINT
PAKISTAN
KARACHI ELECTRIC SUPPLY CORPORATION
WEST WHARF THERMAL POWER PLANT PROJECT
UNITS NO.1 AND NO.2
BORING POINT AND BORING LOG
JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO JAPAN
APPROVED BY
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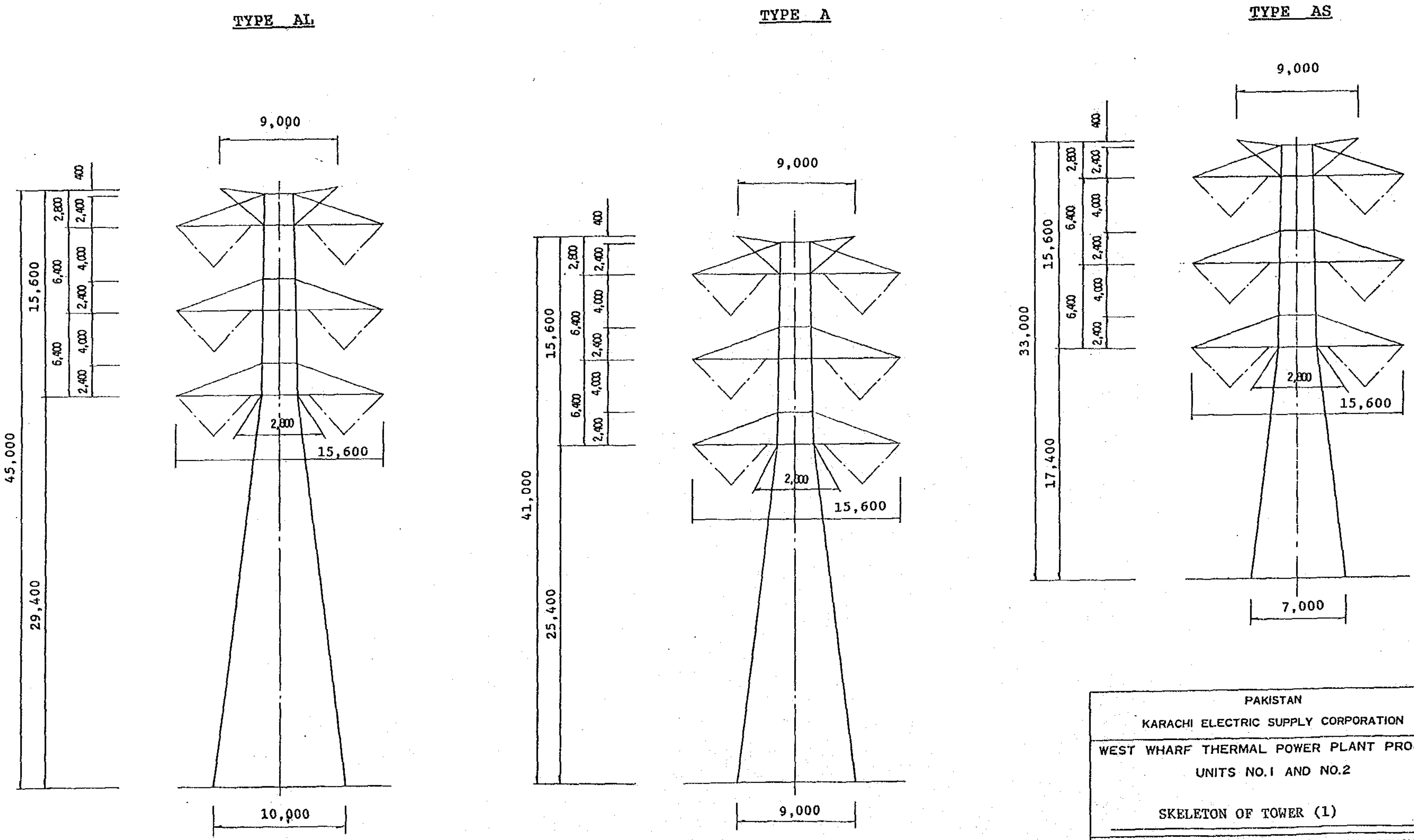
CHECKED BY
DRAWN BY
DRAWING NO.
WLT-1002
SCALE
1/40,000
DATE
10TH JAN 1990



PAKISTAN

KARACHI ELECTRIC SUPPLY CORPORATION

WEST WHARF THERMAL POWER PLANT PROJECT

UNITS NO.1 AND NO.2

SKELETON OF TOWER (1)

JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO JAPAN

APPROVED BY	REVIEWED BY	CHECKED BY	DRAWN BY
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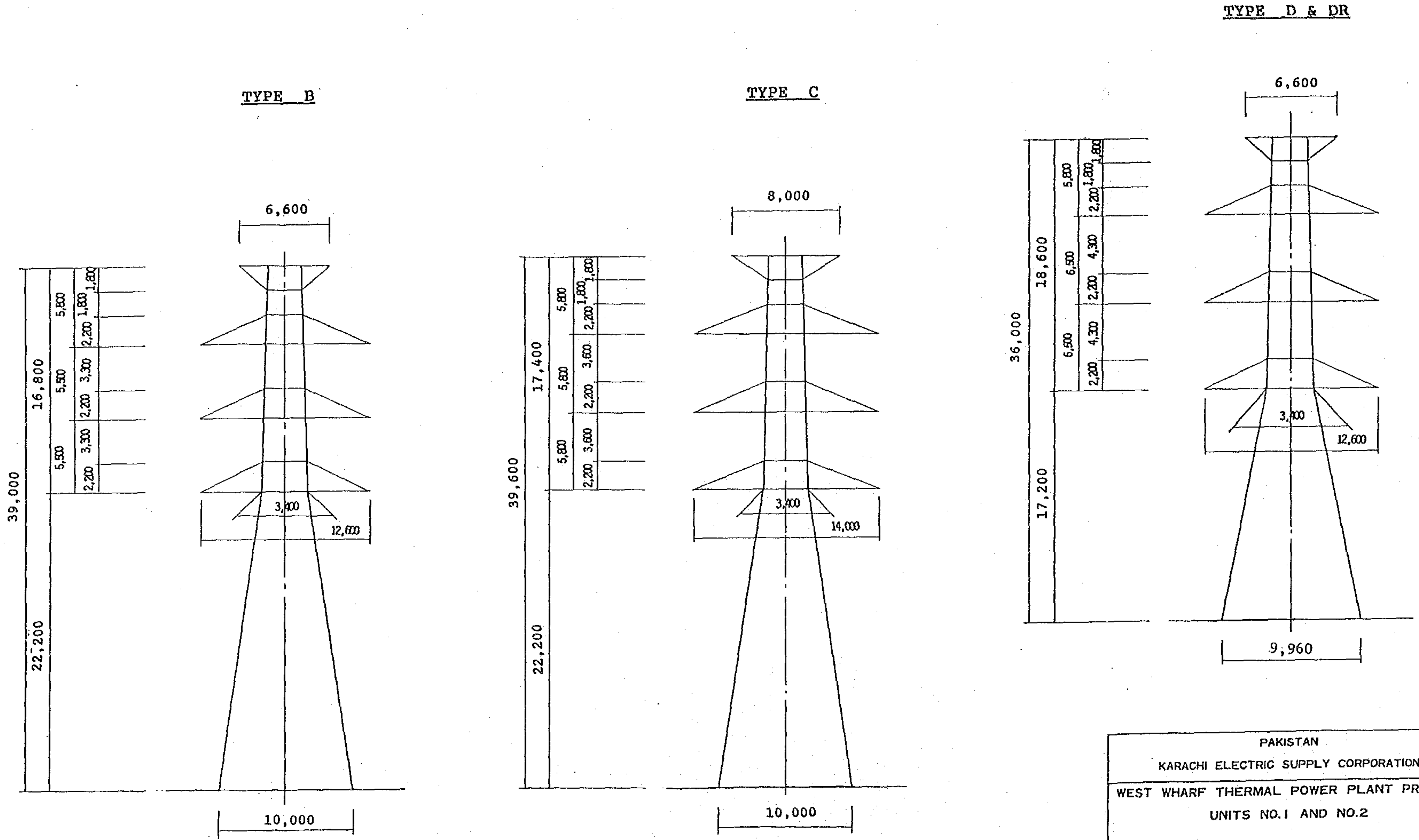

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KARACHI ELECTRIC SUPPLY CORPORATION

WEST WHARF THERMAL POWER PLANT PROJECT

UNITS NO.1 AND NO.2

SKELETON OF TOWER (2)

JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO JAPAN

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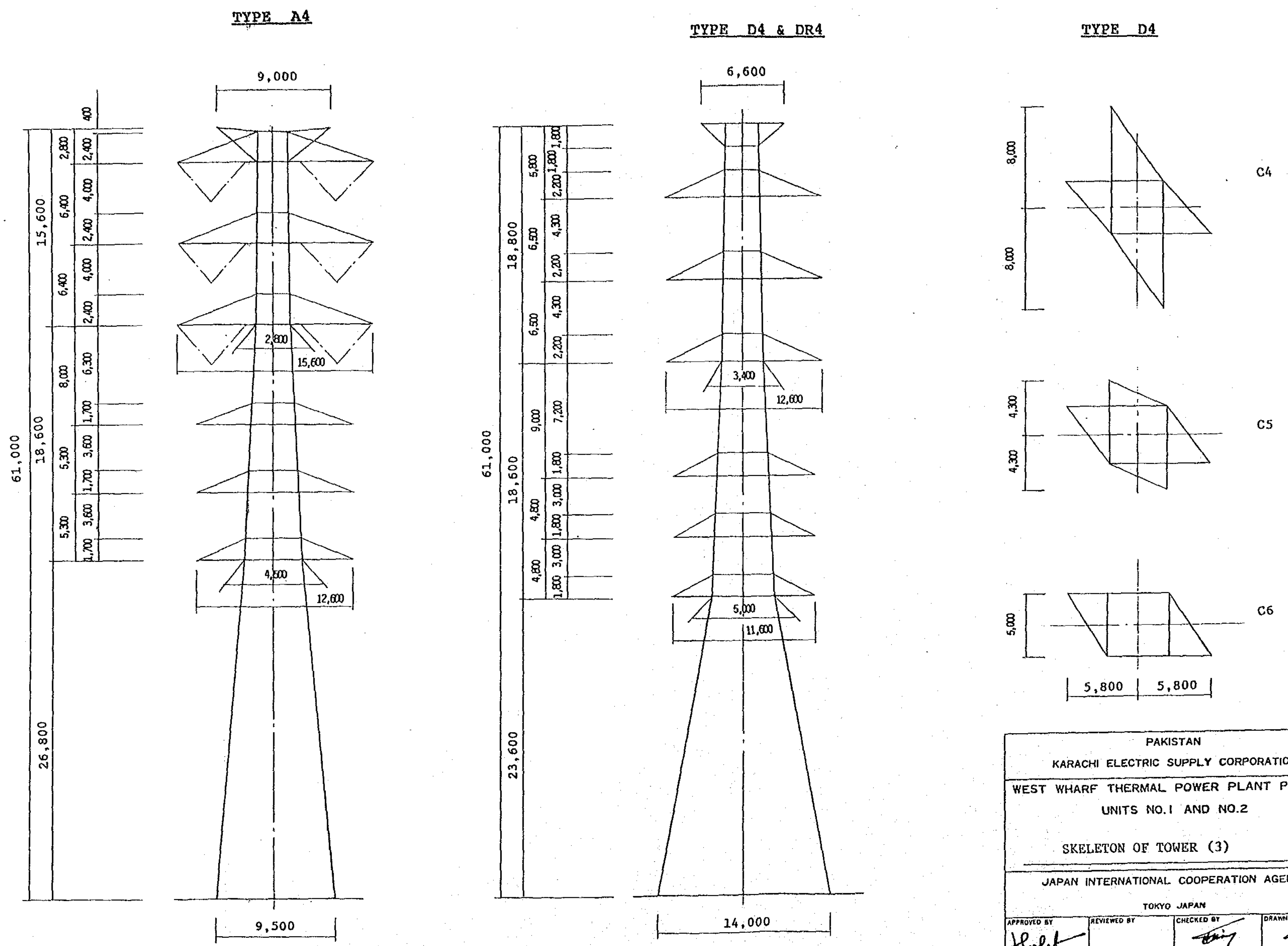

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KARACHI ELECTRIC SUPPLY CORPORATION

WEST WHARF THERMAL POWER PLANT PROJECT

UNITS NO.1 AND NO.2

SKELETON OF TOWER (3)

JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO JAPAN

APPROVED BY	REVIEWED BY	CHECKED BY	DRAWN BY
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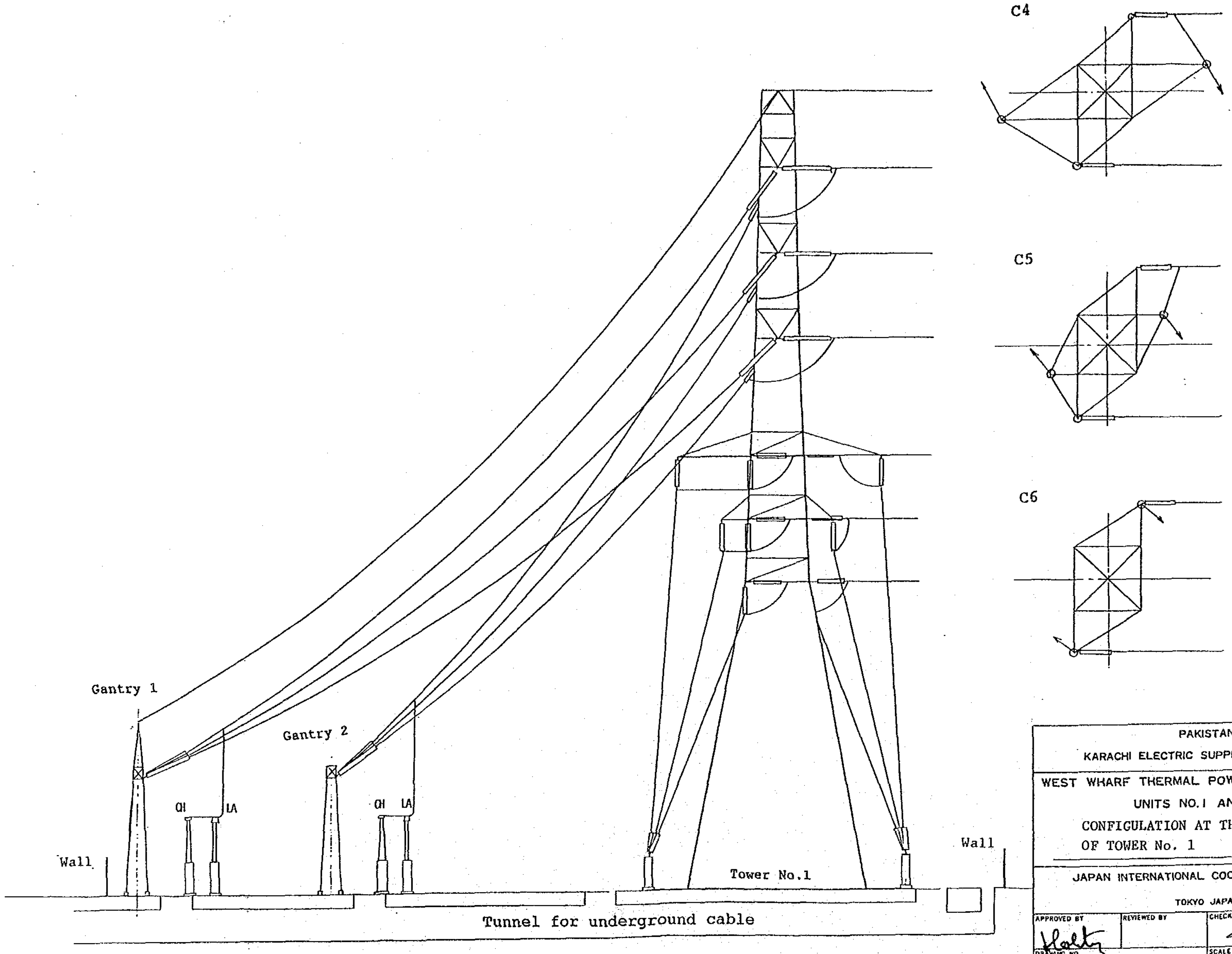

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KARACHI ELECTRIC SUPPLY CORPORATION

WEST WHARF THERMAL POWER PLANT PROJECT

UNITS NO.1 AND NO.2

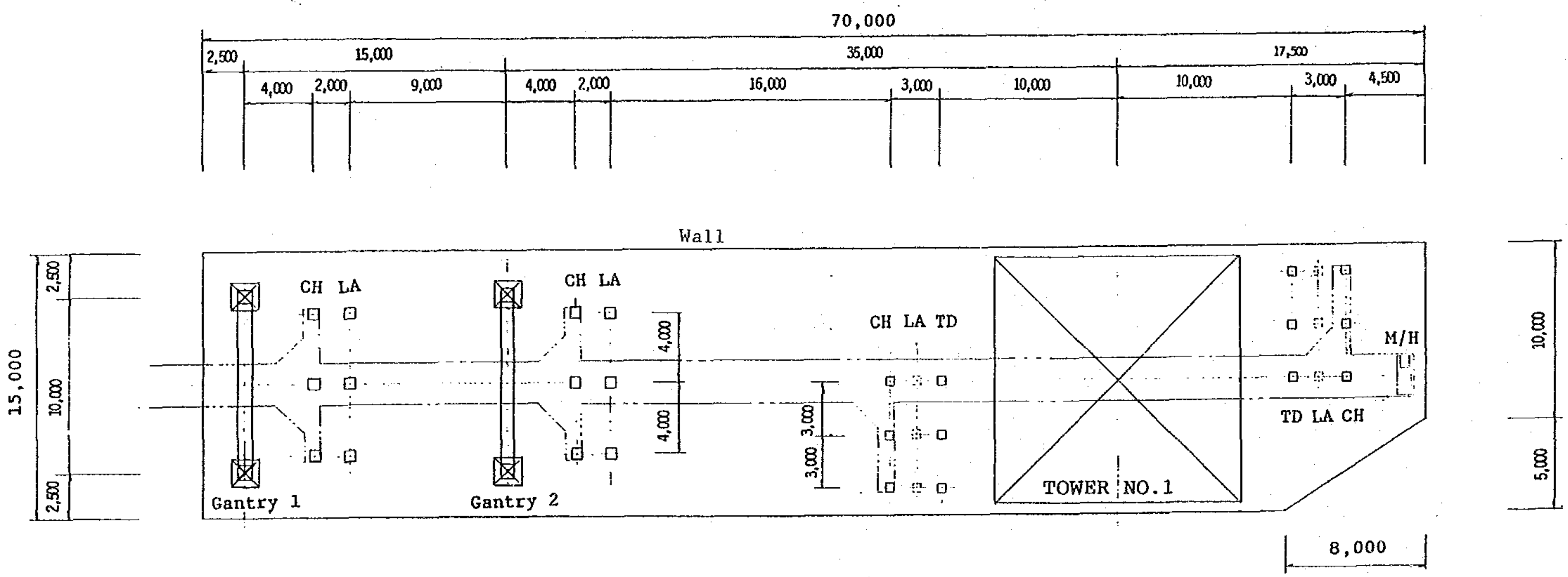
CONFIGULATION AT THE PLACE OF TOWER No. 1

JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO JAPAN

APPROVED BY	REVIEWED BY	CHECKED BY	DRAWN BY
[signature]		[signature]	[signature]

DRAWING NO.	SCALE	DATE
WLT-1104	1/300	10TH JAN 1990



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KARACHI ELECTRIC SUPPLY CORPORATION

WEST WHARF THERMAL POWER PLANT PROJECT
UNITS NO.1 AND NO.2

PLAN AT THE PLACE OF TOWER No.1

JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO JAPAN

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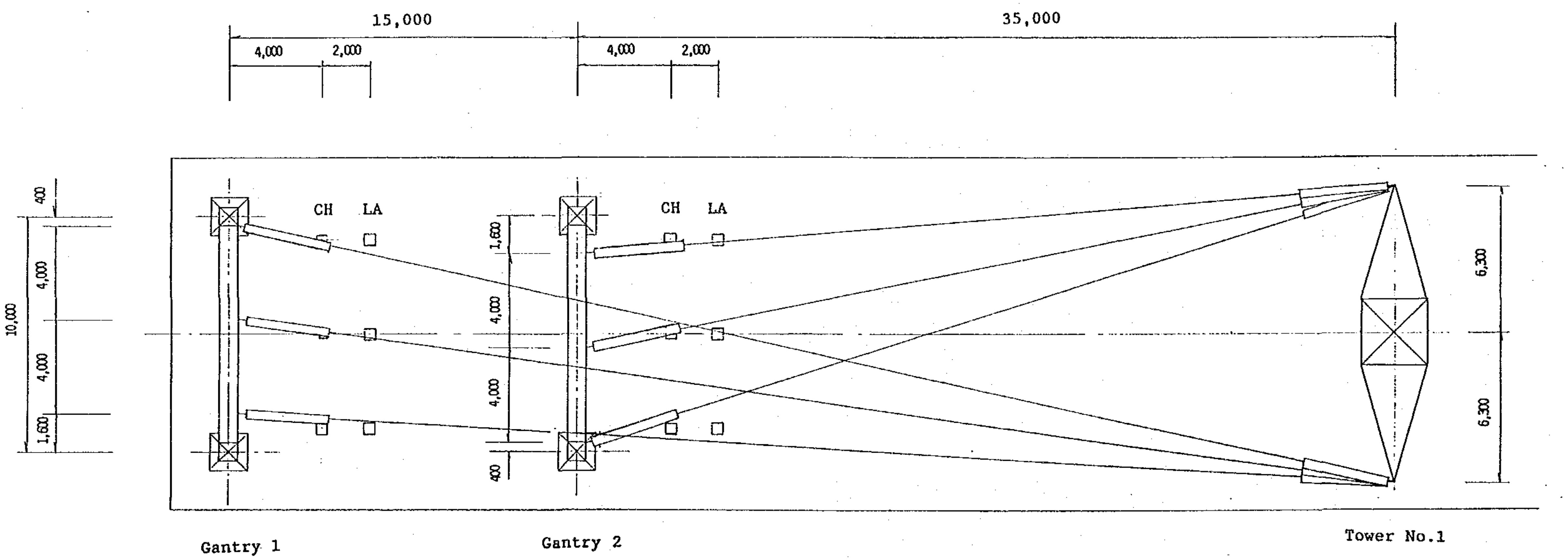
[signature]		[signature]	[signature]
DRAWING NO. WLT-1105		SCALE 1/300	DATE 10TH JAN 1990



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KARACHI ELECTRIC SUPPLY CORPORATION

WEST WHARF THERMAL POWER PLANT PROJECT

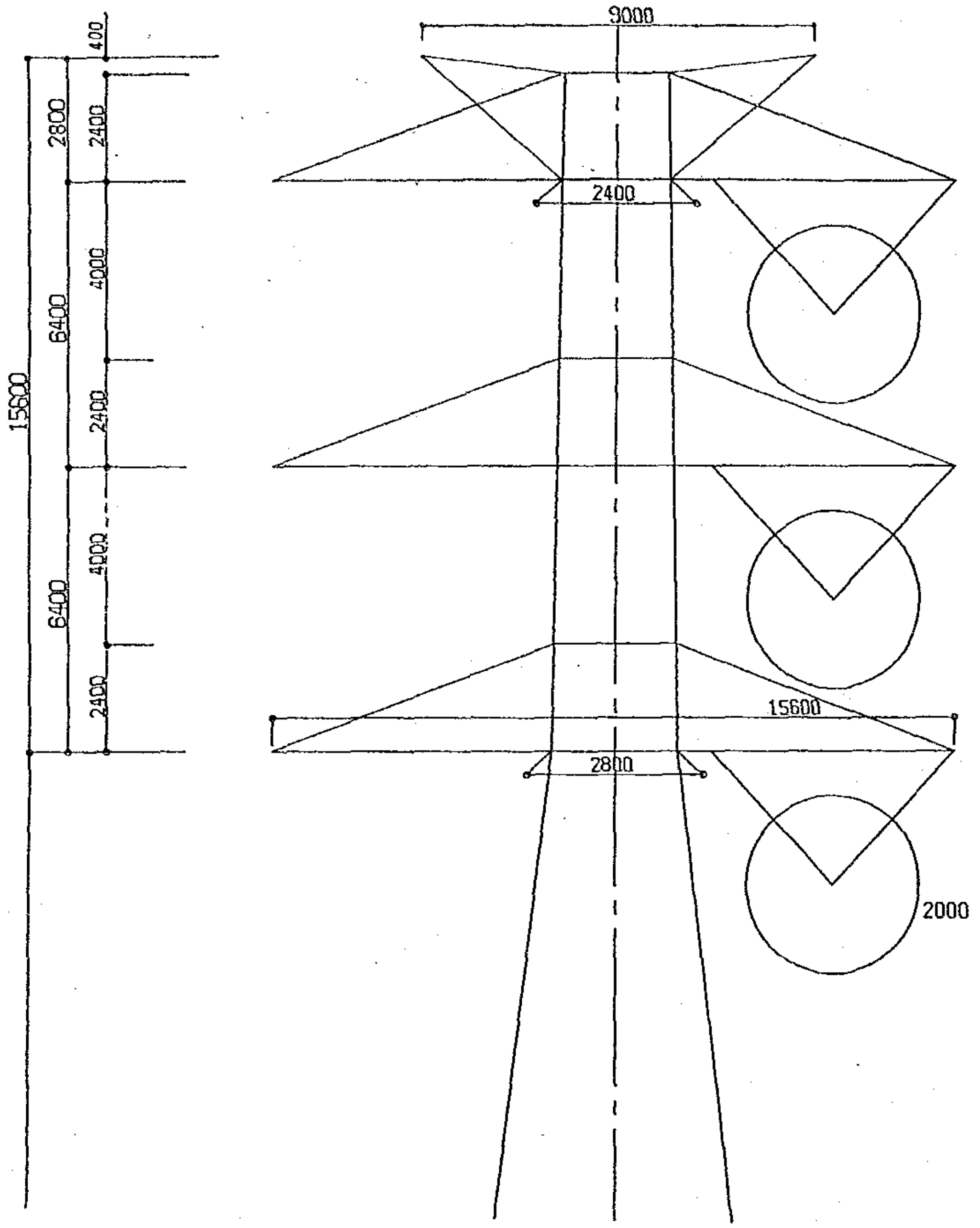
UNITS NO.1 AND NO.2

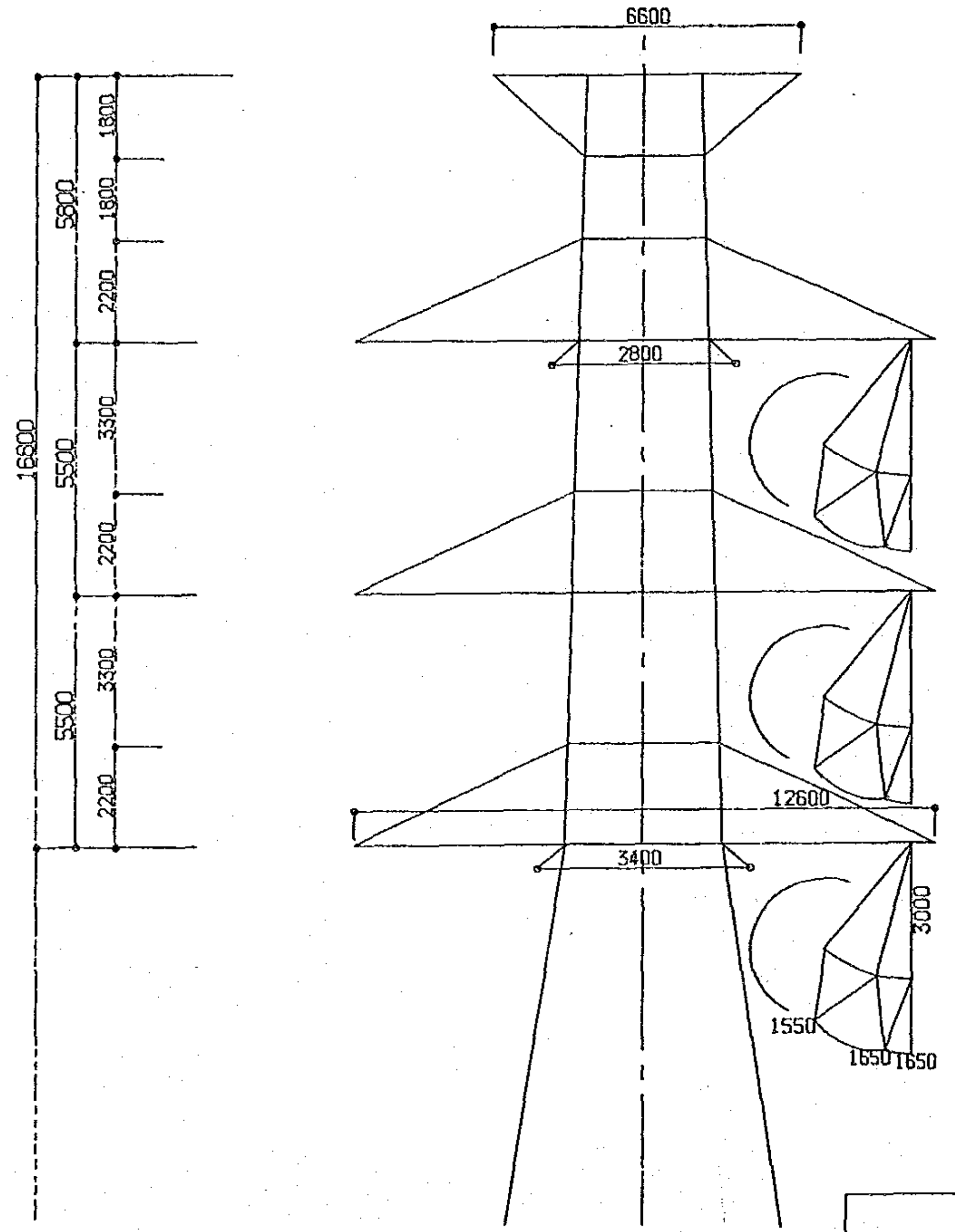
ARRANGEMENT OF 220 kV INCOMING LINES AT TOWER No.1

JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO JAPAN

APPROVED BY	REVIEWED BY	CHECKED BY	DRAWN BY
DRAWING NO. WLT-1106		SCALE 1/200	DATE 10TH JAN 1990





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KARACHI ELECTRIC SUPPLY CORPORATION

WEST WHARF THERMAL POWER PLANT PROJECT
UNITS NO.1 AND NO.2

CLEARANCE DIAGRAM (1)

JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO JAPAN

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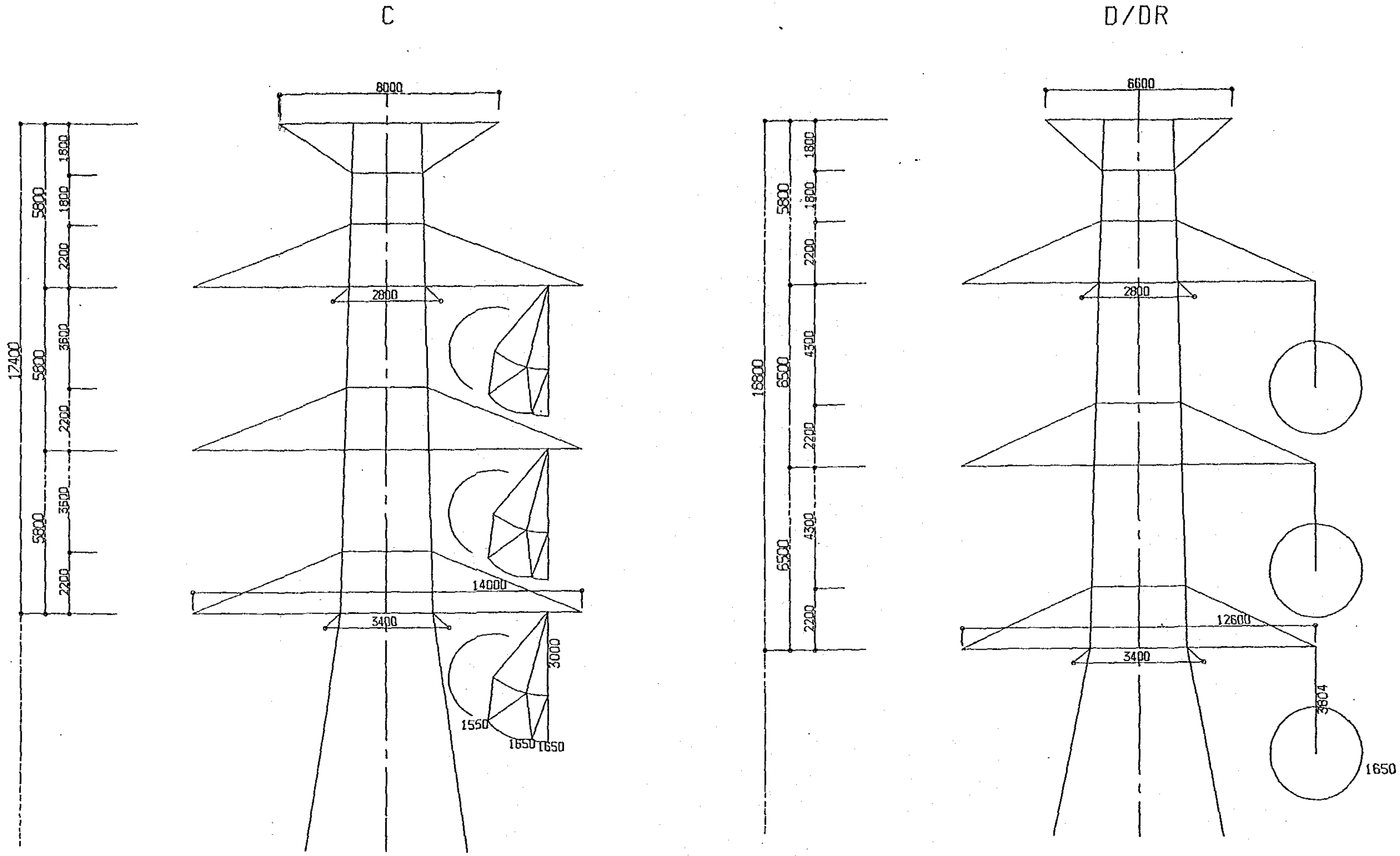
DRAWING NO WLS-1107		SCALE	DATE 10TH JAN 1990



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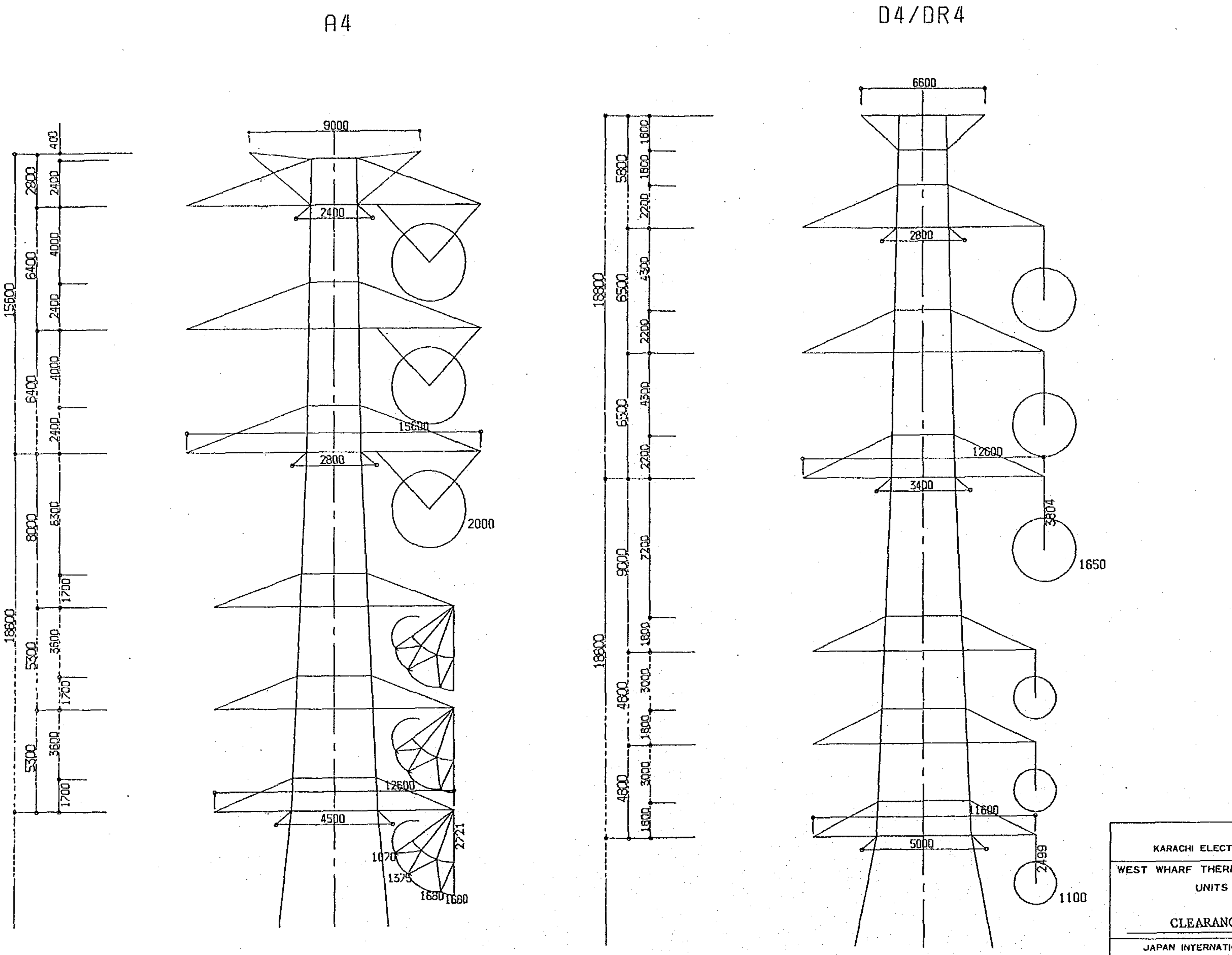
KARACHI ELECTRIC SUPPLY CORPORATION

WEST WHARF THERMAL POWER PLANT PROJECT
UNITS NO.1 AND NO.2

CLEARANCE DIAGRAM (2)

JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO JAPAN

APPROVED BY	REVIEWED BY	CHECKED BY	DRAWN BY
DRAWING NO. WLT-1108		SCALE	DATE 10TH JAN 1990



PAKISTAN
KARACHI ELECTRIC SUPPLY CORPORATION

WEST WHARF THERMAL POWER PLANT PROJECT
UNITS NO.1 AND NO.2

CLEARANCE DIAGRAM (3)

JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO JAPAN

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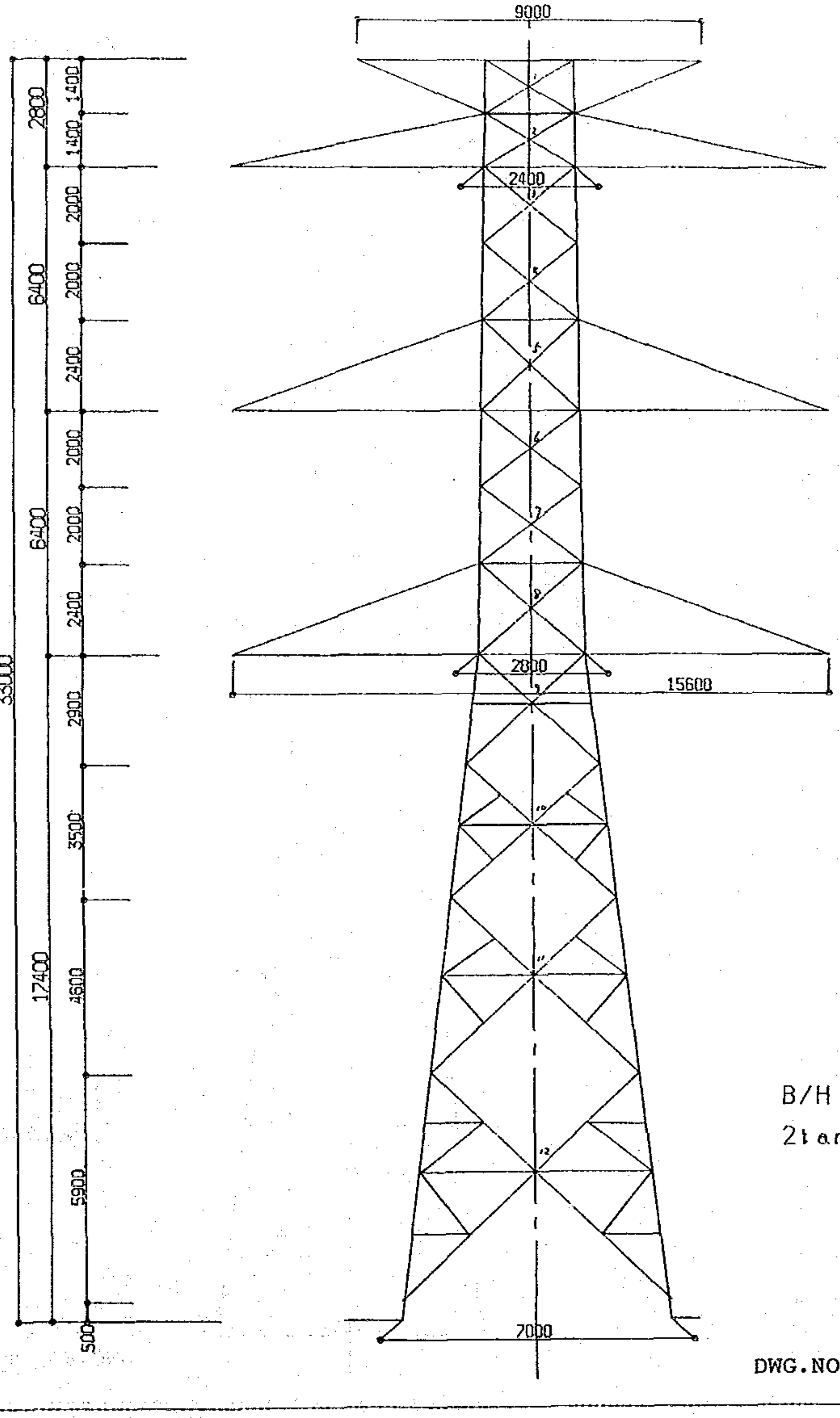
DRAWING NO WLT-1109		SCALE	DATE 10TH JAN 1990

As

S=1 / 150



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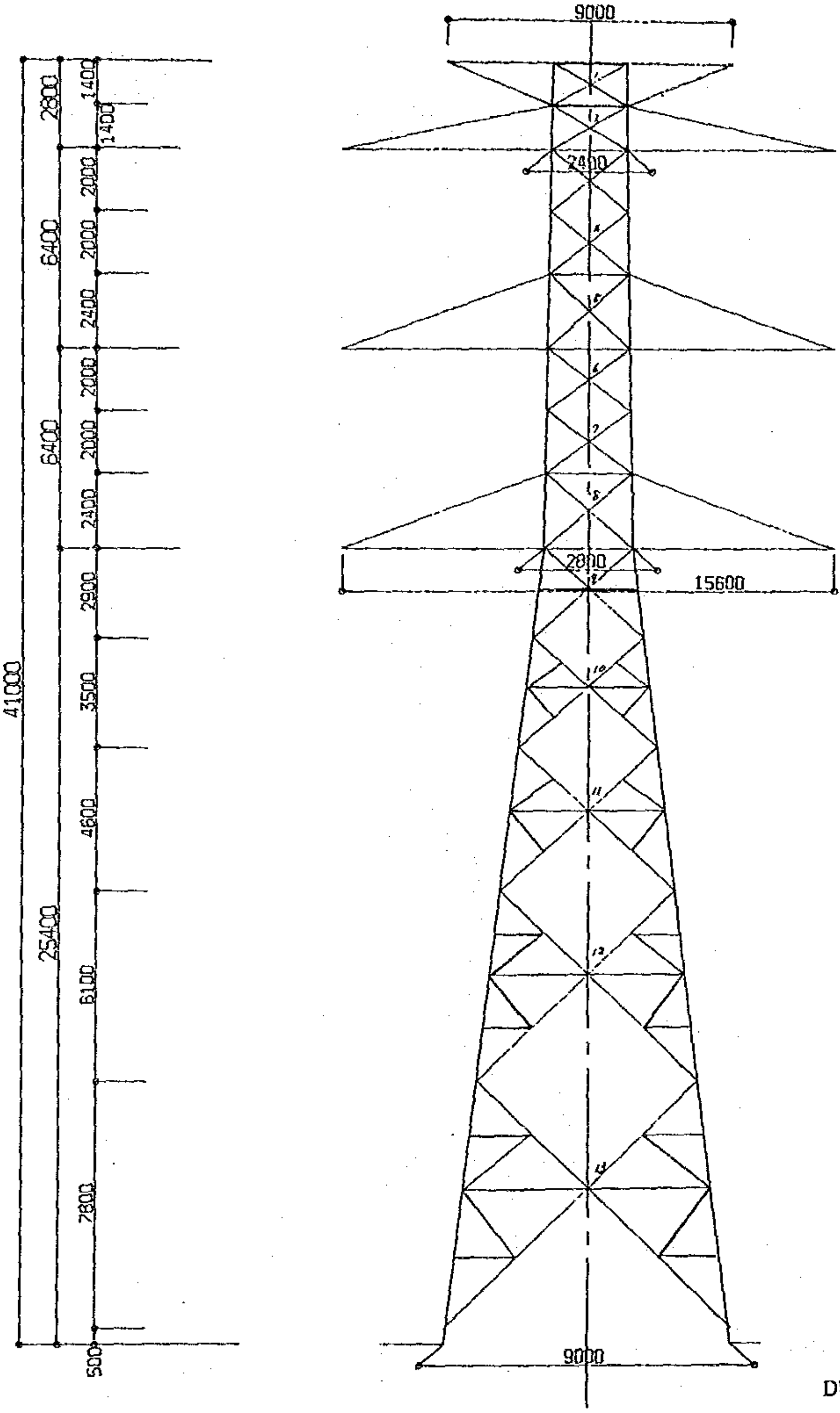
2tanθ= .241

DWG.NO. TLT-01

A

S=1 / 200



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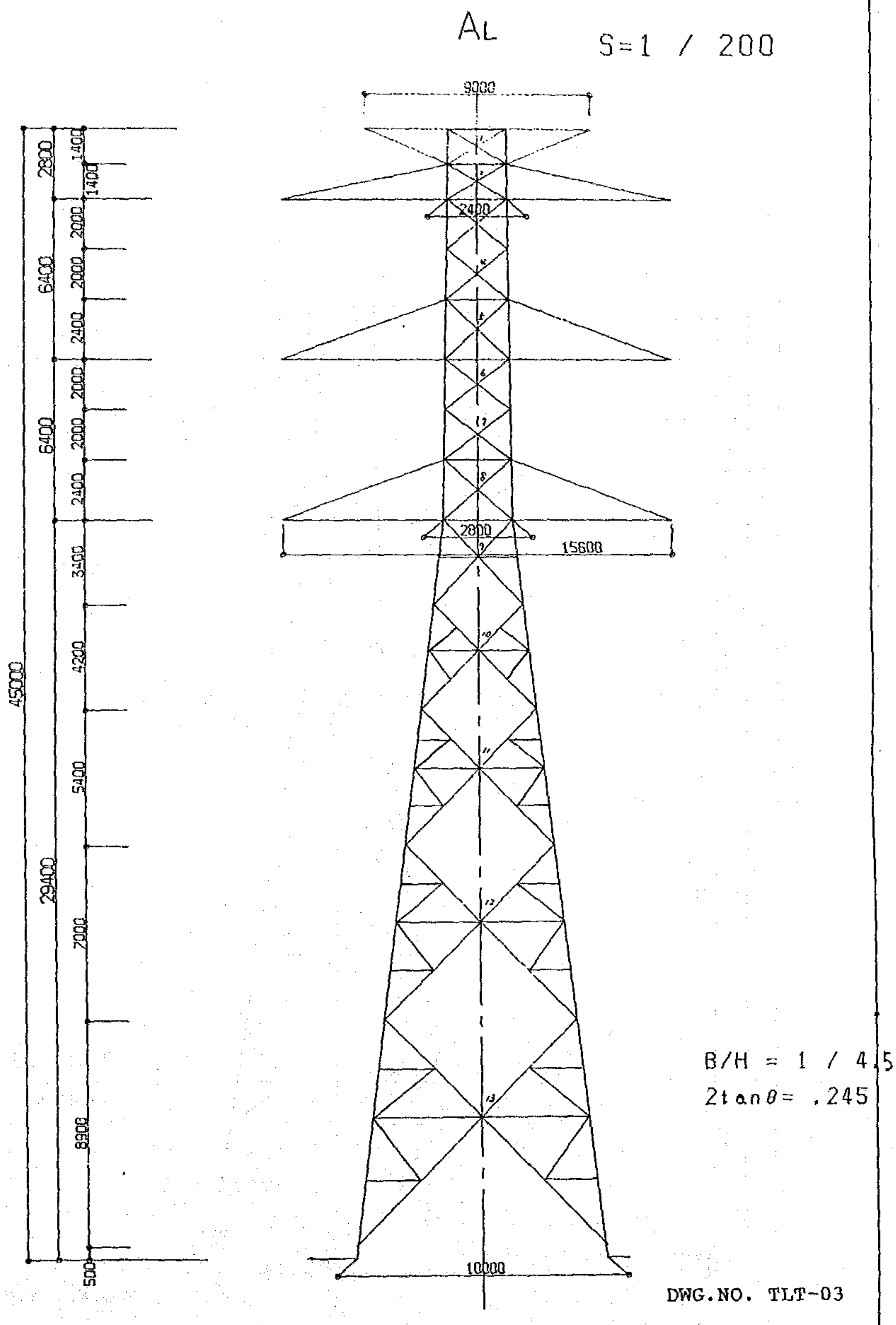
$2\tan\theta = .244$

DWG.NO. TLT-02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2000
2000
2400
2000
2000
2400
3400
4200
5400
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8900
500
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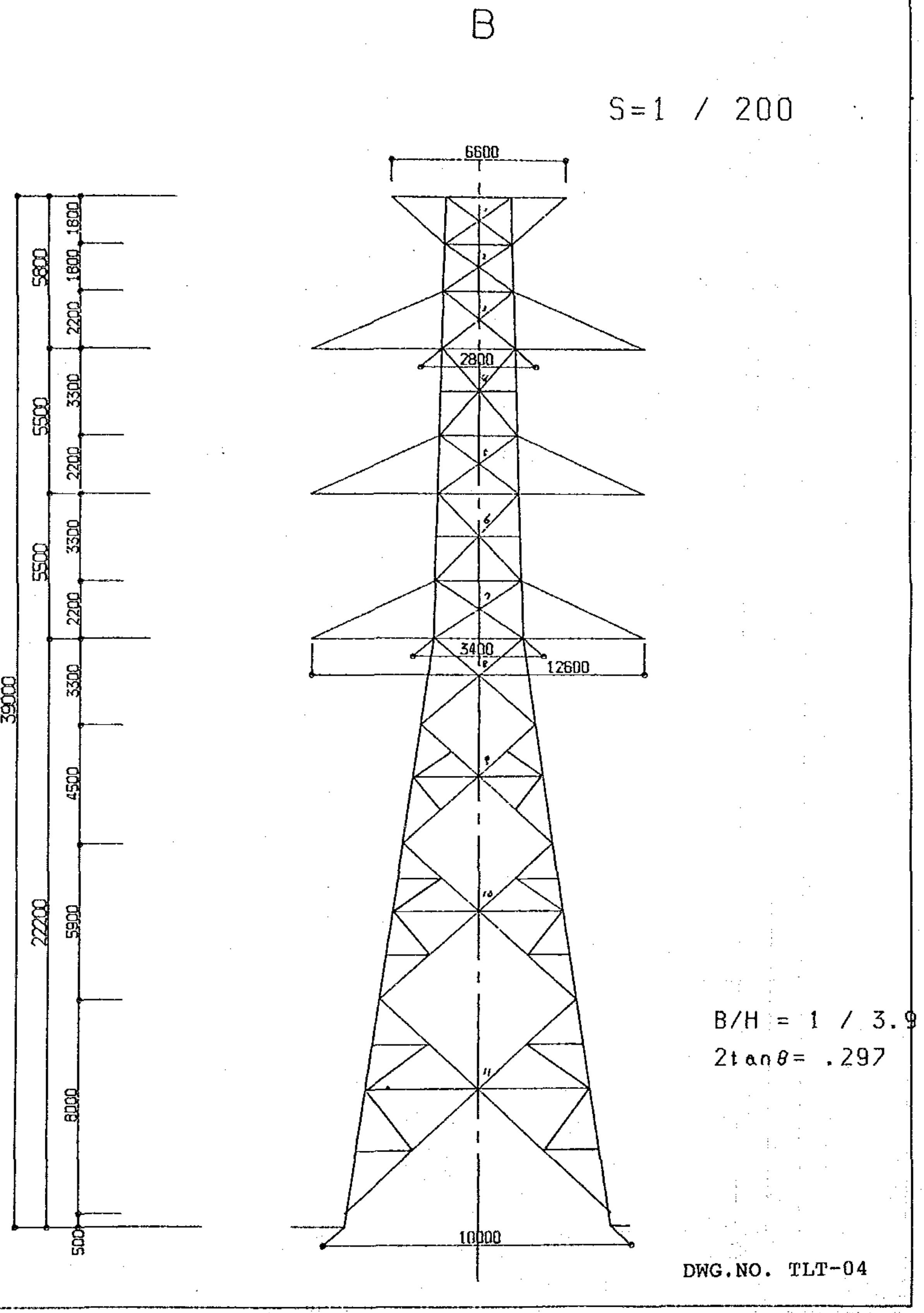
2tanθ= .245

DWG.NO. TLT-03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8000
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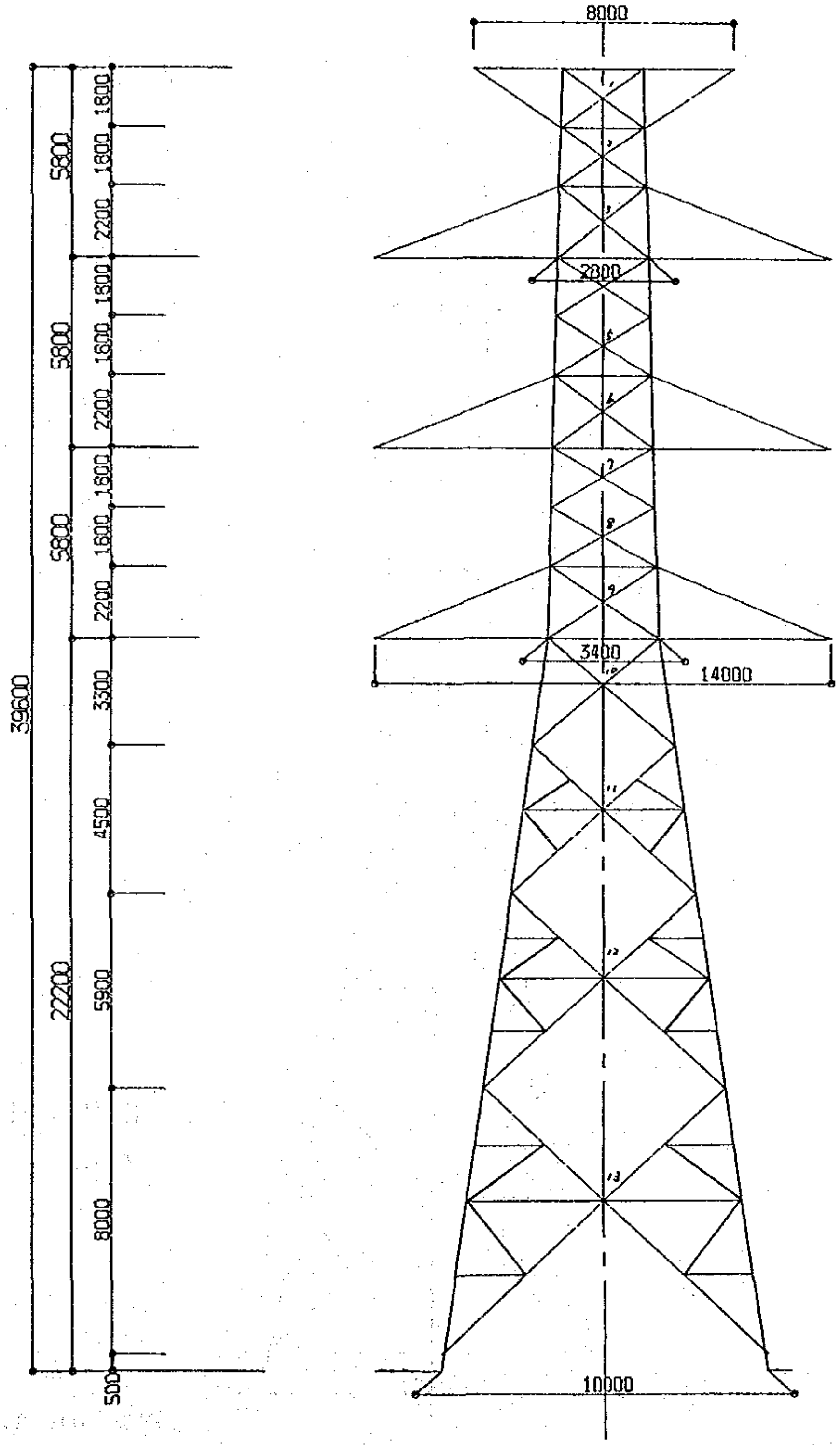
39000
B/H = 1 / 3.9
2tanθ= .297

DWG.NO. TLT-04

C

S=1 / 200

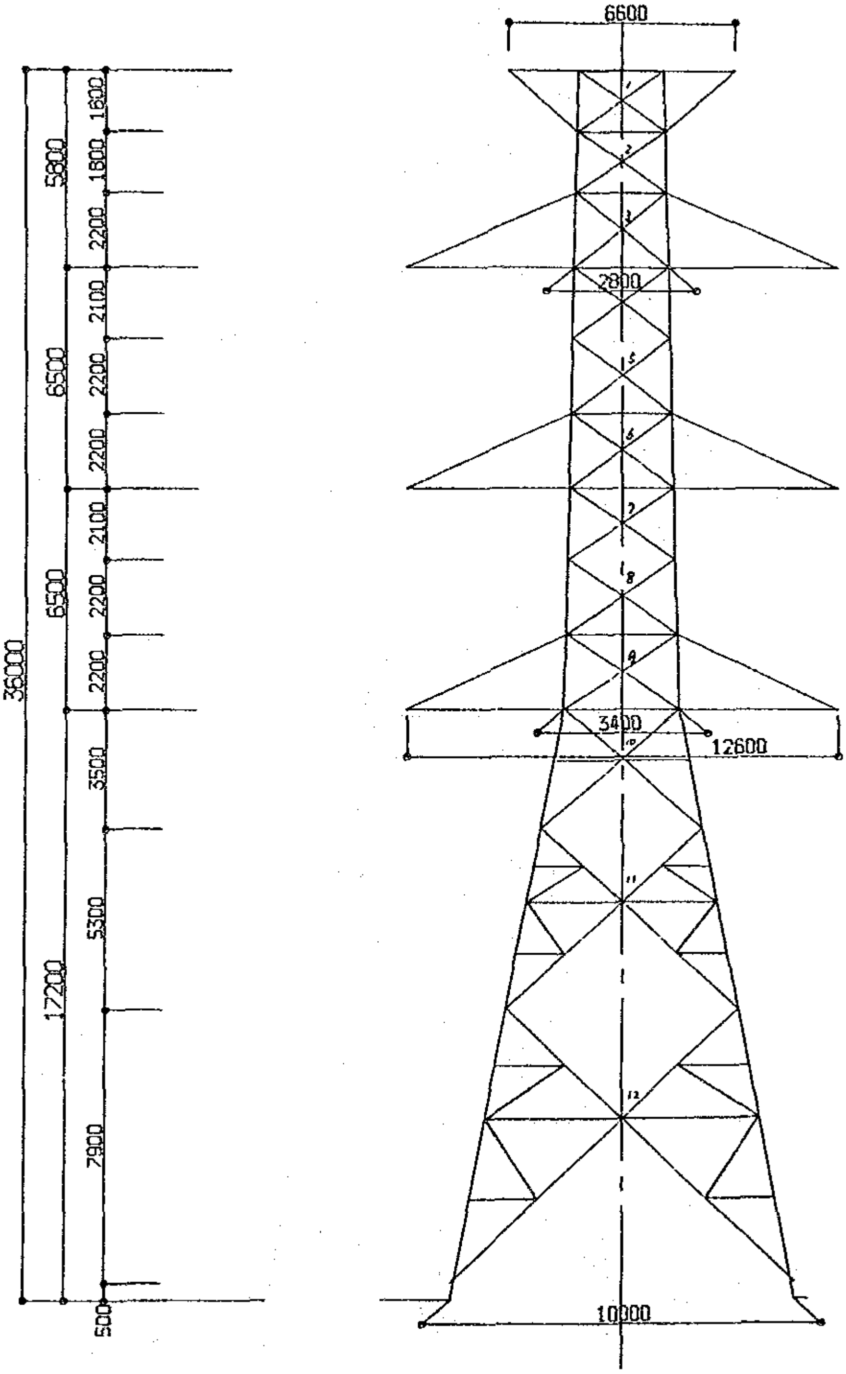


B/H = 1 / 3.96
2tanθ= .297

DWG.NO. TLT-05

D / DR

S=1 / 200

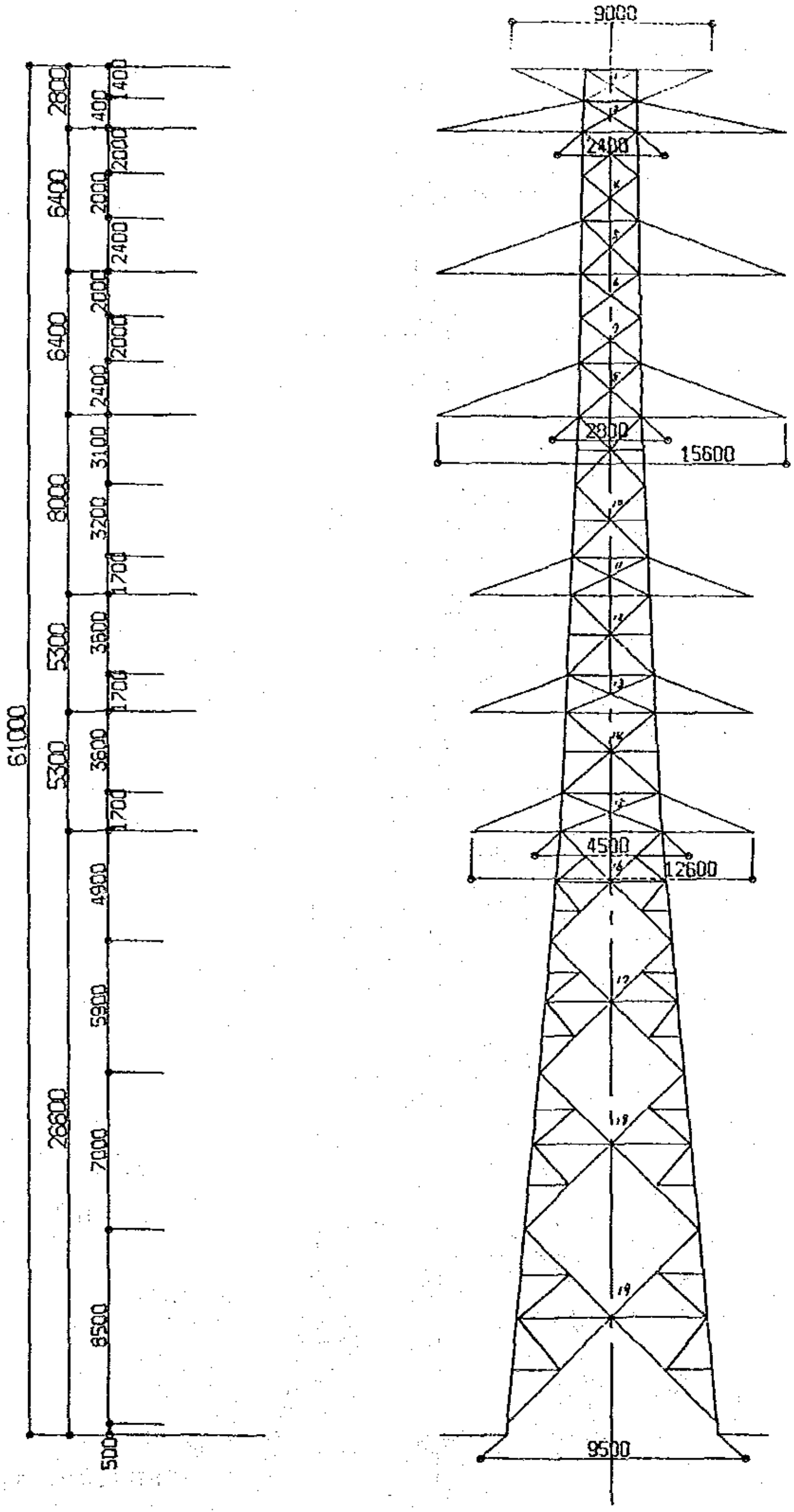


B/H = 1 / 3.6
$2\tan\theta = .384$

DWG.NO. TLT-06

A4

S=1 / 300

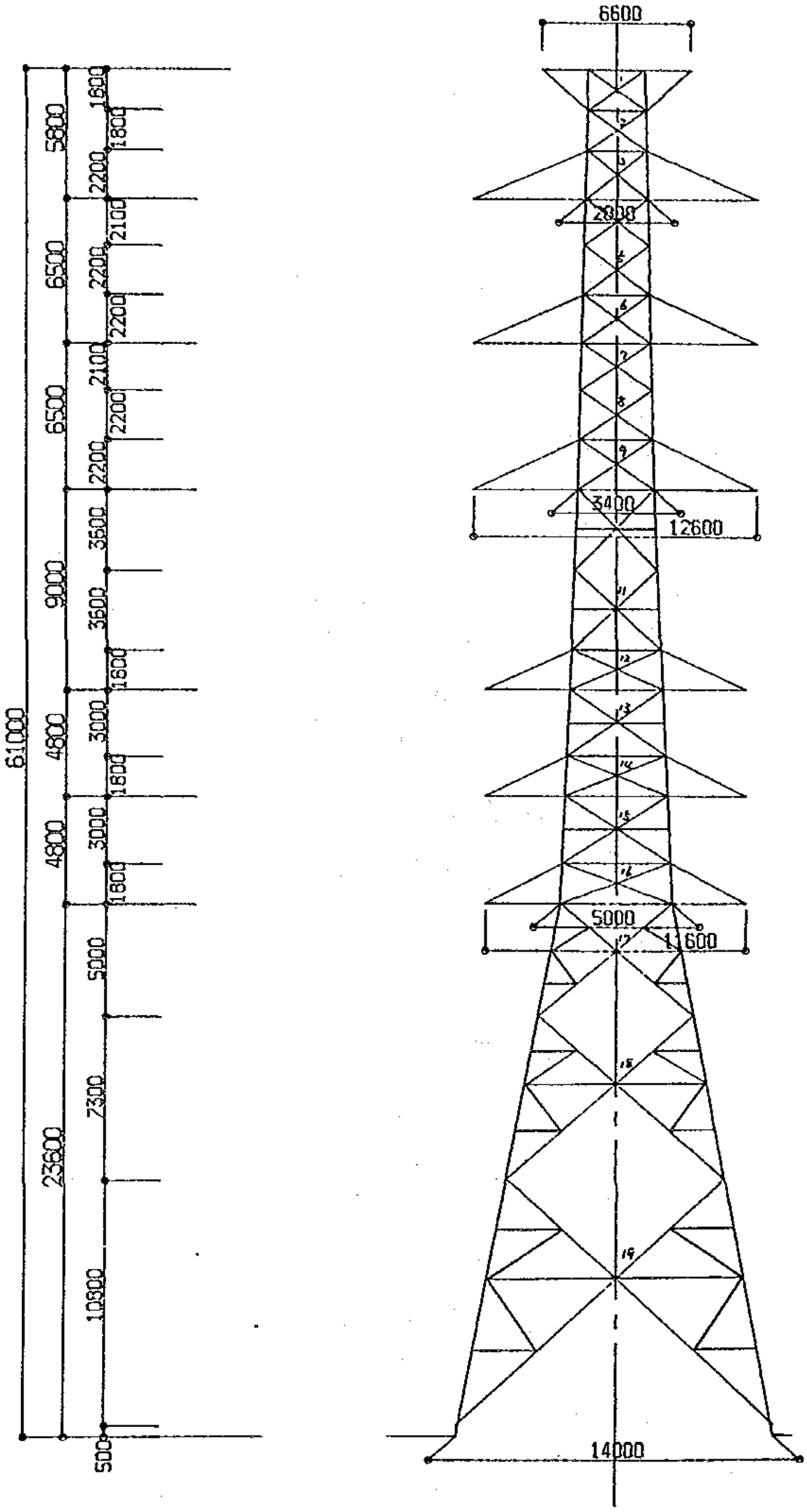


B/H = 1 / 6.42
$2\tan\theta = .187$

DWG.NO. TLT-07

D4

S=1 / 300



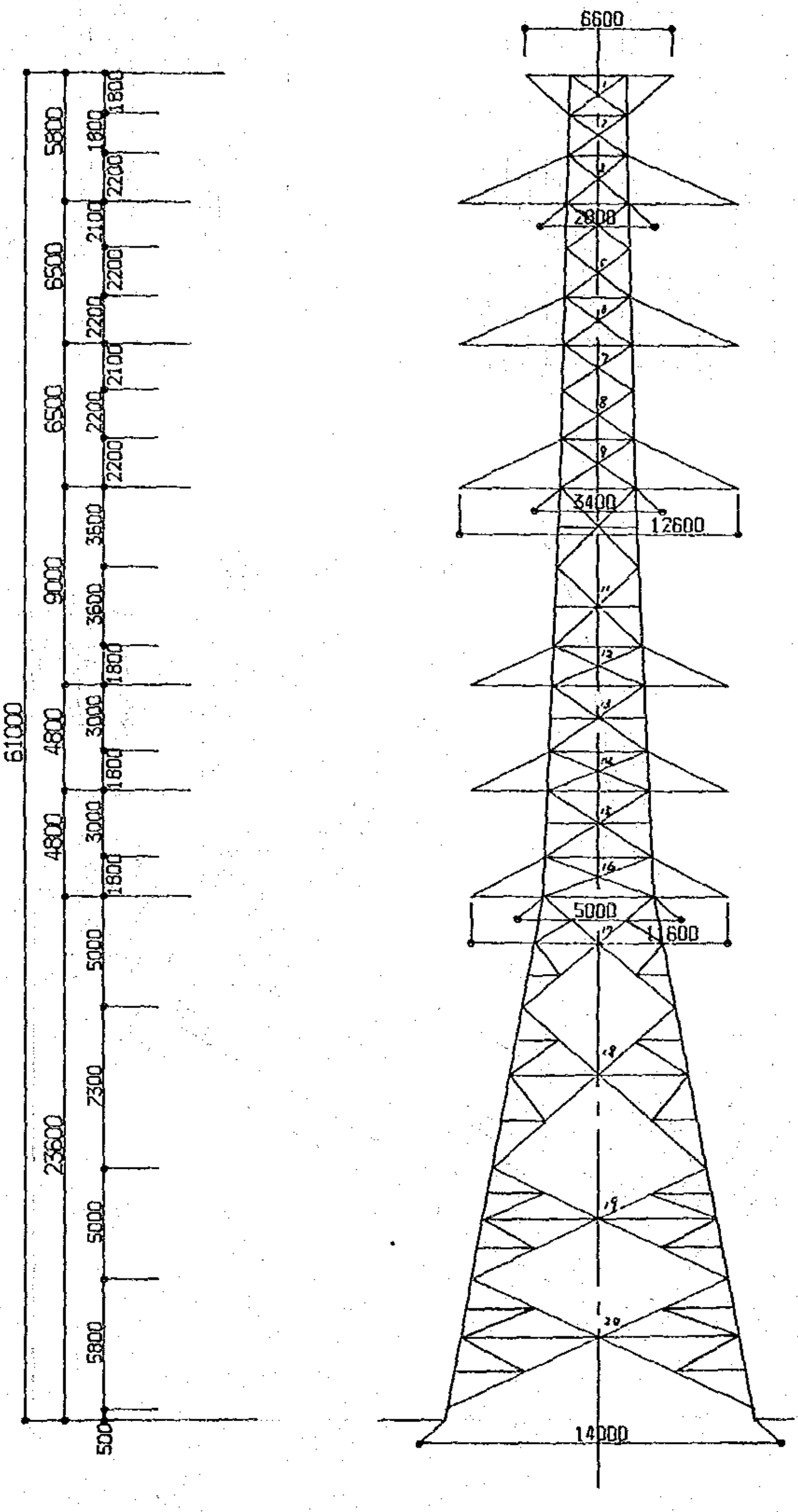
B/H = 1 / 4.36

2tanθ= .381

DWG.NO. TLT-08

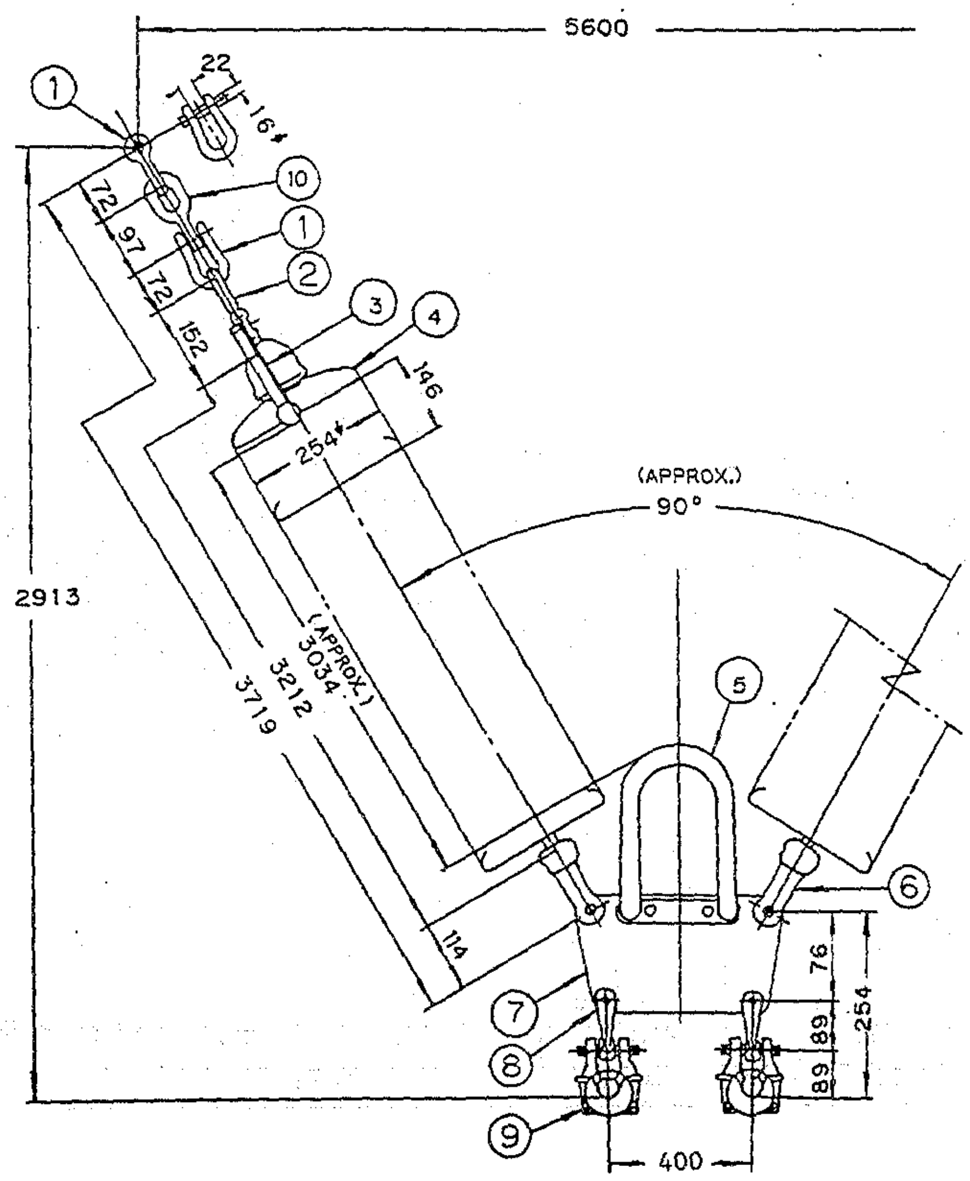
DR4

S=1 / 300



B/H = 1 / 4.36
2tanθ= .381

DWG.NO. TLT-09



ITEM	DESCRIPTION	MAIN MATERIAL	REQD.
1	ANCHOR SHACKLE	HIGH TENSION STEEL	4
2	HORN HOLDER BALL EYE	HIGH TENSION STEEL	2
3	ARCING HORN	STEEL	2
4	SUSPENSION INSULATOR	PORCELAIN	22×2
5	ARCING HORN	STEEL	1
6	SOCKET CLEVIS	DUCTILE IRON	2
7	YOKE	STEEL	1
8	CLEVIS EYE	STEEL	2
9	SUSPENSION CLAMP	ALUMINIUM ALLOY	2
10	EYE LINK	HIGH TENSION STEEL	2
MIN. BREAKING STRENGTH OF STRING		12000kg	
SUITABLE CONDUCTOR SIZE OF CLAMP		39.3ϕ~44.3ϕ	
TYPE OF BALL AND SOCKET PARTS		IEC 16mm A	

PAKISTAN

KARACHI ELECTRIC SUPPLY CORPORATION

WEST WHARF THERMAL POWER PLANT PROJECT

UNITS NO.1 AND NO.2

220 kV V-SUSPENSION INSULATOR STRING

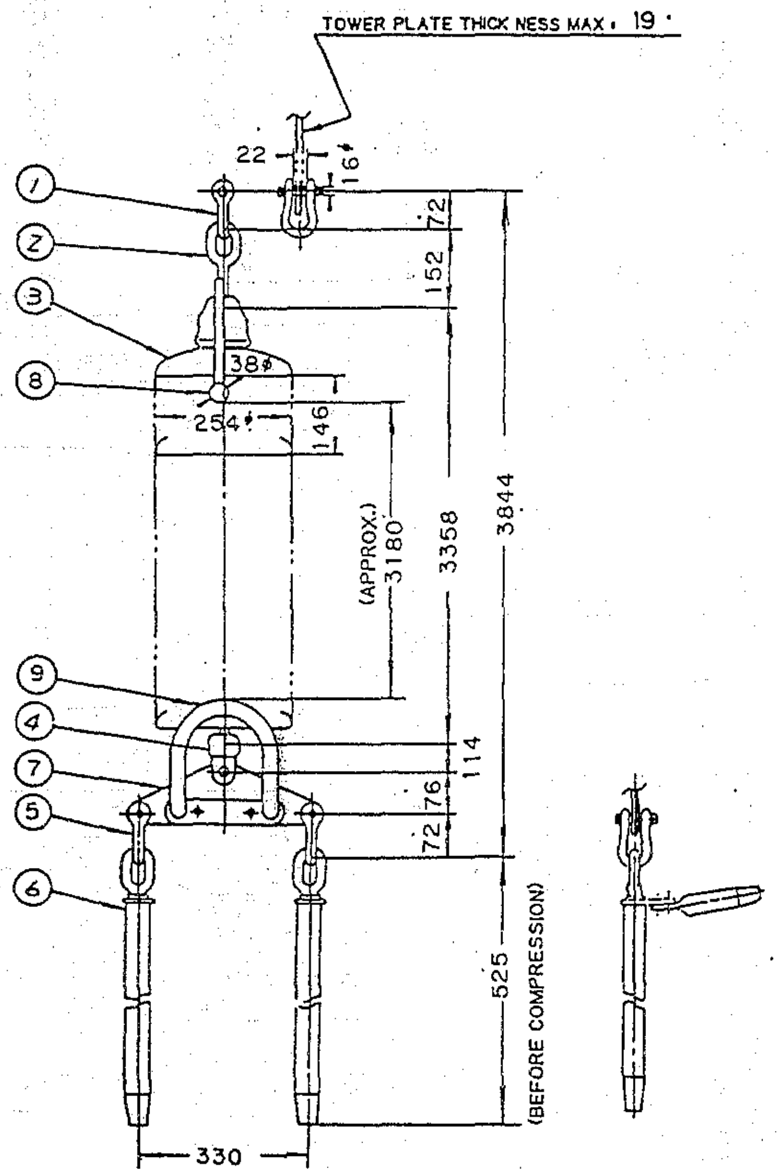
JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO JAPAN

APPROVED BY	REVIEWED BY	CHECKED BY	DRAWN BY
[signature]		[signature]	N. [signature]
DRAWING NO. WLT-1201		SCALE	DATE 10TH JAN 1990

FORM 04

23



ITEM	DESCRIPTION	MAIN MATERIAL	REQD.
1	ANCHOR SHACKLE	HIGH TENSION STEEL	1
2	HORN HOLDER BALL EYE	HIGH TENSION STEEL	1
3	SUSPENSION INSULATOR	PORCELAIN	23
4	SOCKET CLEVIS	DUCTILE IRON	1
5	ANCHOR SHACKLE	HIGH TENSION STEEL	2
6	COMPRESSION CLAMP	ALUMINIUM	2
7	YOKE	STEEL	1
8	ARCING HORN	STEEL	1
9	ARCING HORN	STEEL	1

SUITABLE CONDUCTOR SIZE OF CLAMP	ACSR/AS 330mm²
* MIN. BREAKING STRENGTH OF STRING EXCEPT COMPRESSION CLAMP	12000kg
TYPE OF BALL AND SOCKET PARTS	IEC 16mm A

PAKISTAN

KARACHI ELECTRIC SUPPLY CORPORATION

WEST WHARF THERMAL POWER PLANT PROJECT

UNITS NO.1 AND NO.2

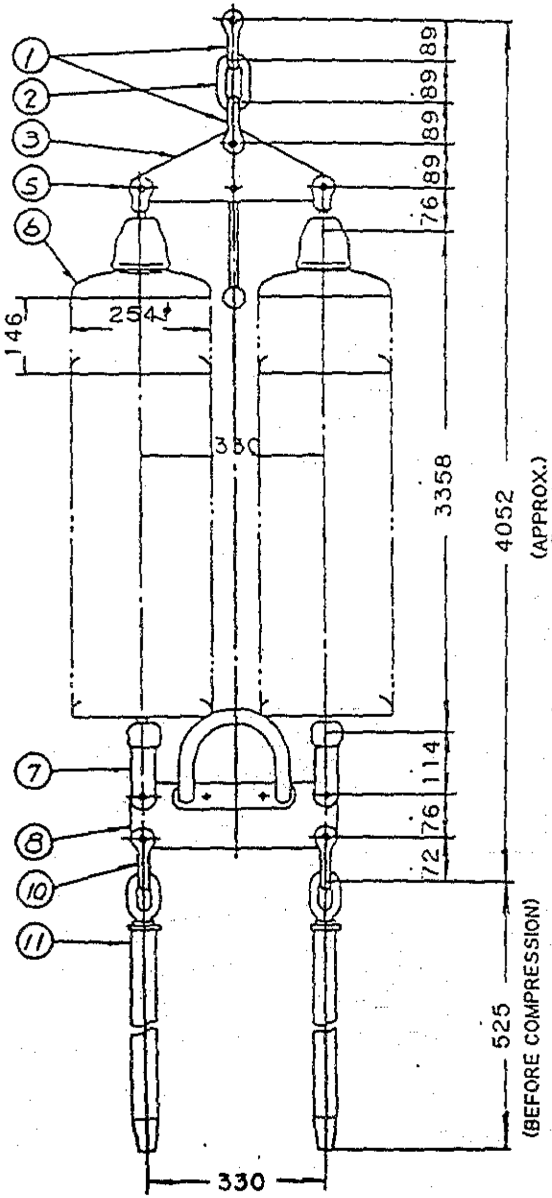
220 kV SINGLE TENSION INSULATOR STRING

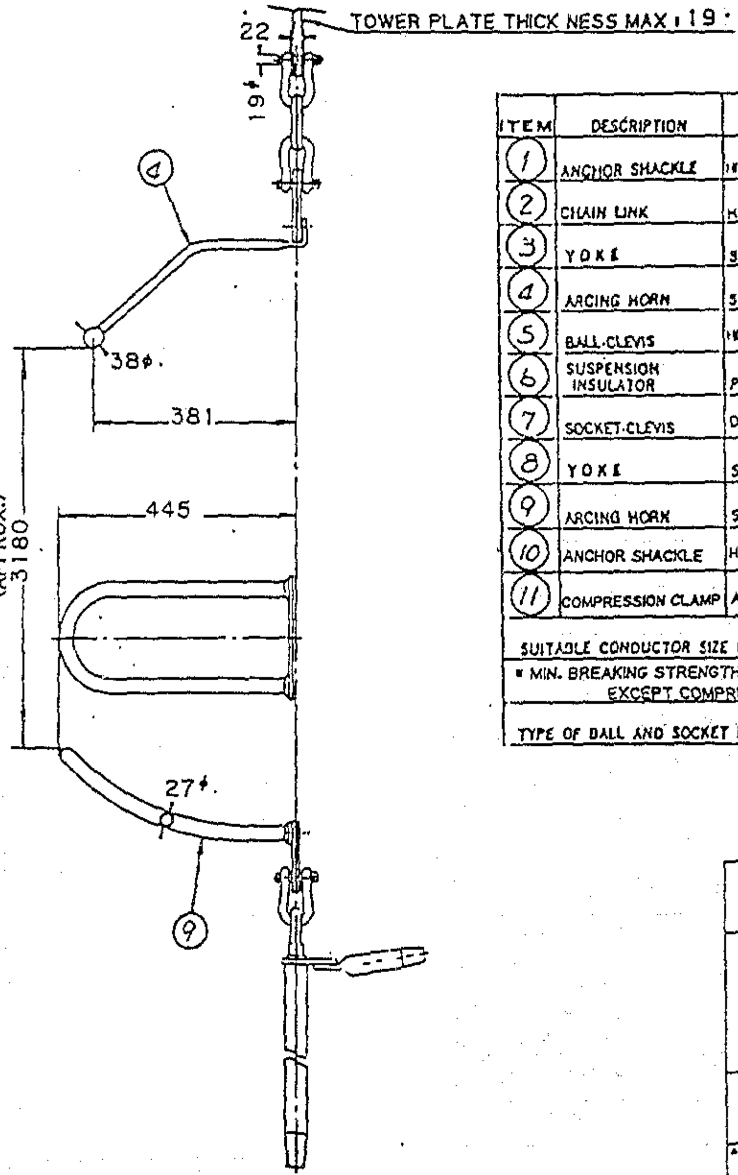
JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO JAPAN

APPROVED BY	REVIEWED BY	CHECKED BY	DRAWN BY
[signature]		[signature]	N. Inoue
DRAWING NO. WLT-1202		SCALE	DATE 10TH JAN 1990

FORM 04





ITEM	DESCRIPTION	MAIN MATERIAL	REQ'D.
1	ANCHOR SHACKLE	HIGH TENSION STEEL	2
2	CHAIN LINK	HIGH TENSION STEEL	1
3	YOKE	STEEL	1
4	ARCING HORN	STEEL	1
5	BALL-CLEVIS	HIGH TENSION STEEL	2
6	SUSPENSION INSULATOR	PORCELAIN	23×2
7	SOCKET-CLEVIS	DUCTILE IRON	2
8	YOKE	STEEL	1
9	ARCING HORN	STEEL	1
10	ANCHOR SHACKLE	HIGH TENSION STEEL	2
11	COMPRESSION CLAMP	ALUMINIUM	2

SUITABLE CONDUCTOR SIZE OF CLAMP	ACSR/AS 330mm²
* MIN. BREAKING STRENGTH OF STRING EXCEPT COMPRESSION CLAMP	24000kg
TYPE OF BALL AND SOCKET PARTS	IEC 16mm A

PAKISTAN

KARACHI ELECTRIC SUPPLY CORPORATION

WEST WHARF THERMAL POWER PLANT PROJECT

UNITS NO.1 AND NO.2

220 kV DOUBLE TENSION INSULATOR STRING

JAPAN INTERNATIONAL COOPERATION AGENCY

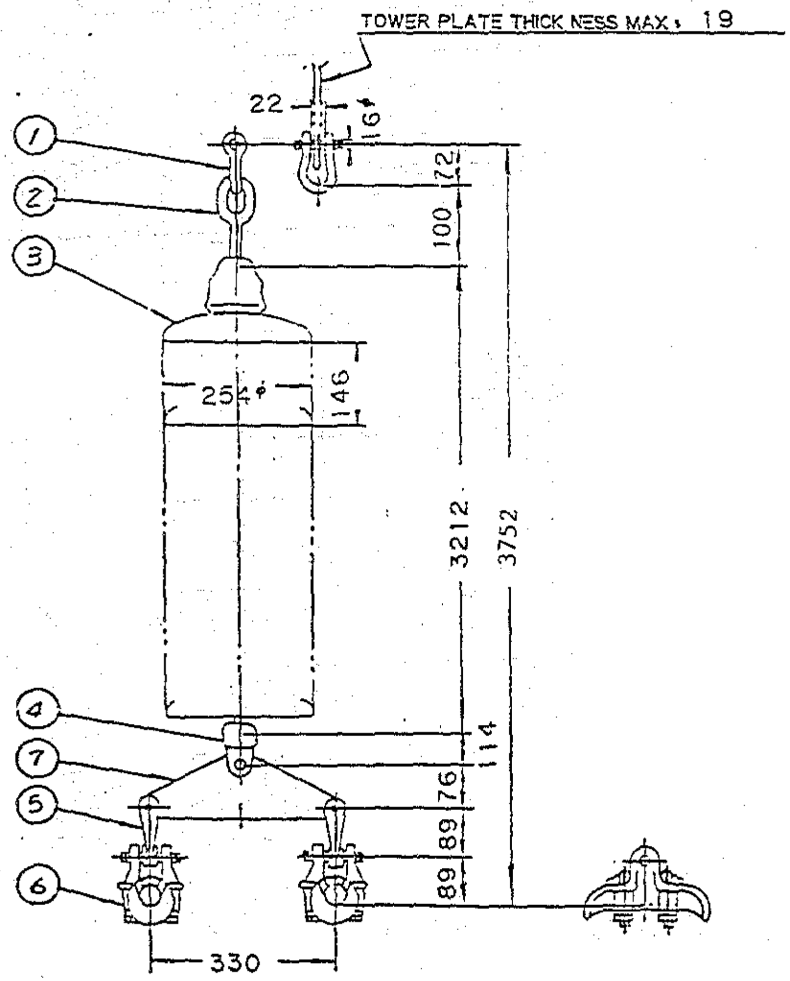
TOKYO JAPAN

APPROVED BY	REVIEWED BY	CHECKED BY	DRAWN BY
[signature]		[signature]	N. Inoue
DRAWING NO. WLT-1203		SCALE	DATE 10TH JAN 1990

FORM 04

25

9c



ITEM	DESCRIPTION	MAIN MATERIAL	REQ'D
1	ANCHOR SHACKLE	HIGH TENSION STEEL	1
2	BALL EYE	HIGH TENSION STEEL	1
3	SUSPENSION INSULATOR	PORCELAIN	22
4	SOCKET CLEVIS	DUCTILE IRON	1
5	CLEVIS EYE	STEEL	2
6	SUSPENSION CLAMP	ALUMINIUM ALLOY	2
7	YOKE	STEEL	1

SUITABLE CONDUCTOR SIZE OF CLAMP	39.3φ ~44.3φ
MIN. BREAKING STRENGTH OF STRING	12000kg
TYPE OF BALL AND SOCKET PARTS	IEC 16mm A

PAKISTAN

KARACHI ELECTRIC SUPPLY CORPORATION

WEST WHARF THERMAL POWER PLANT PROJECT

UNITS NO.1 AND NO.2

220 kV JUMPER SUPPORT INSULATOR STRING

JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO JAPAN

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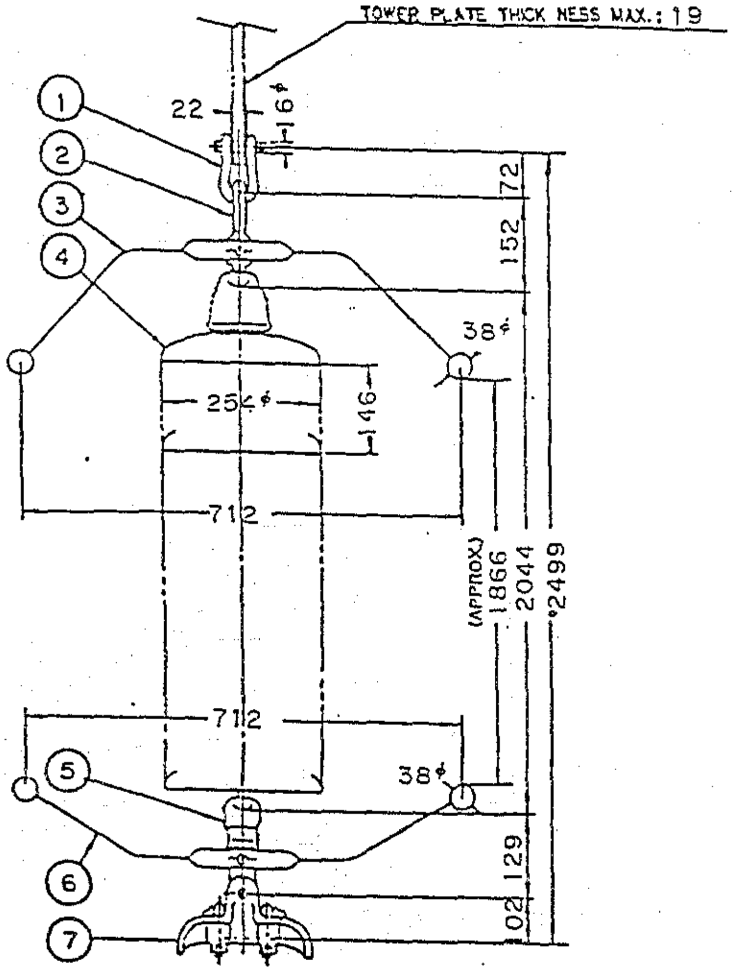
DRAWING NO. WLT-1204		SCALE	DATE 10TH JAN 1990

FORM 04



ITEM	DESCRIPTION	MAIN MATERIAL	REQ'D
1	ANCHOR SHACKLE	HIGH TENSION STEEL	1
2	HORN HOLDER BALL EYE	HIGH TENSION STEEL	1
3	ARCING HORN	STEEL	1
4	SUSPENSION INSULATOR	PORCELAIN	14
5	HORN HOLDER SOCKET-EYE	MALLEABLE IRON OR DUCTILE IRON	1
6	ARCING HORN	STEEL	1
7	SUSPENSION CLAMP	ALUMINIUM ALLOY	1

SUITABLE CONDUCTOR SIZE OF CLAMP	43.2φ ~57.1φ
MIN. BREAKING STRENGTH OF STRING	12000kg
TYPE OF BALL AND SOCKET PARTS	IEC 16mm A

PAKISTAN

KARACHI ELECTRIC SUPPLY CORPORATION

WEST WHARF THERMAL POWER PLANT PROJECT

UNITS NO.1 AND NO.2

132 kV SINGLE SUSPENSION INSULATOR STRING

JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO JAPAN

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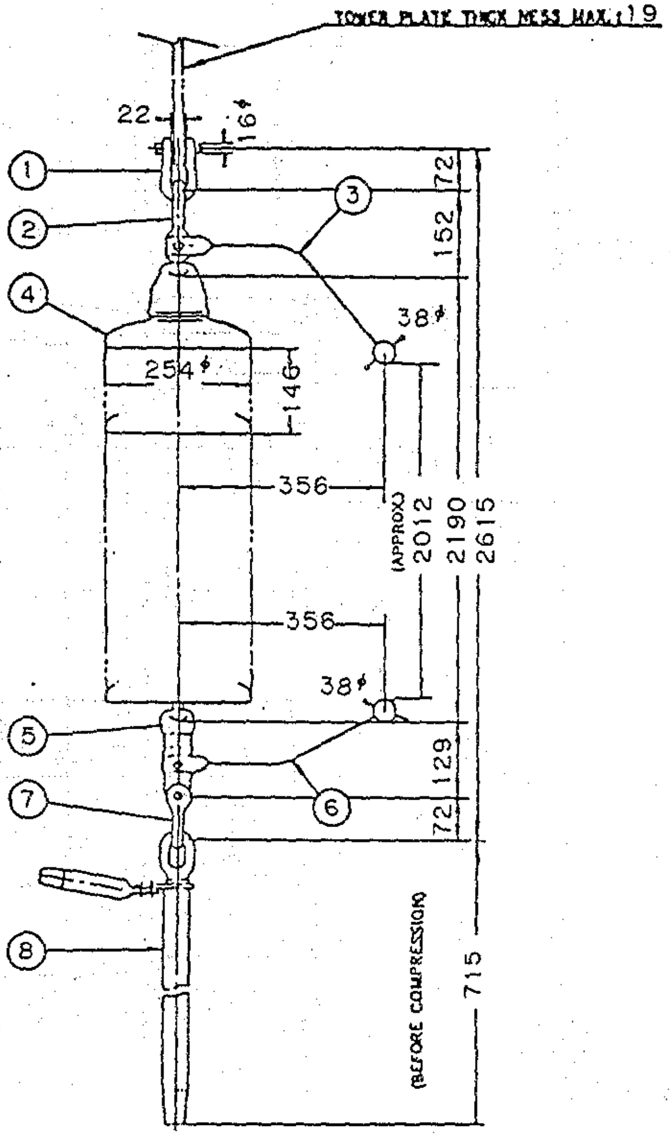
[signature]		[signature]	N. Inoue
DRAWING NO. WLT-1205		SCALE	DATE 10TH JAN 1990

FORM 04

27



ITEM	DESCRIPTION	MAIN MATERIAL	REQD
1	ANCHOR SHACKLE	HIGH TENSION STEEL	1
2	HORN HOLDER BALL EYE	HIGH TENSION STEEL	1
3	ARCING HORN	STEEL	1
4	SUSPENSION INSULATOR	PORCELAIN	15
5	HORN HOLDER SOCKET - EYE	MALLEABLE IRON OR DUCTILE IRON	1
6	ARCING HORN	STEEL	1
7	ANCHOR SHACKLE	HIGH TENSION STEEL	1
8	COMPRESSION CLAMP	ALUMINIUM	1

SUITABLE CONDUCTOR SIZE OF CLAMP	ACSR/AS 680mm²
※ MIN. BREAKING STRENGTH OF STRING EXCEPT COMPRESSION CLAMP	12000Kg
TYPE OF BALL AND SOCKET PARTS	IEC 16mm A

PAKISTAN

KARACHI ELECTRIC SUPPLY CORPORATION

WEST WHARF THERMAL POWER PLANT PROJECT

UNITS NO.1 AND NO.2

132 kV SINGLE TENSION INSULATOR STRING

JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO JAPAN

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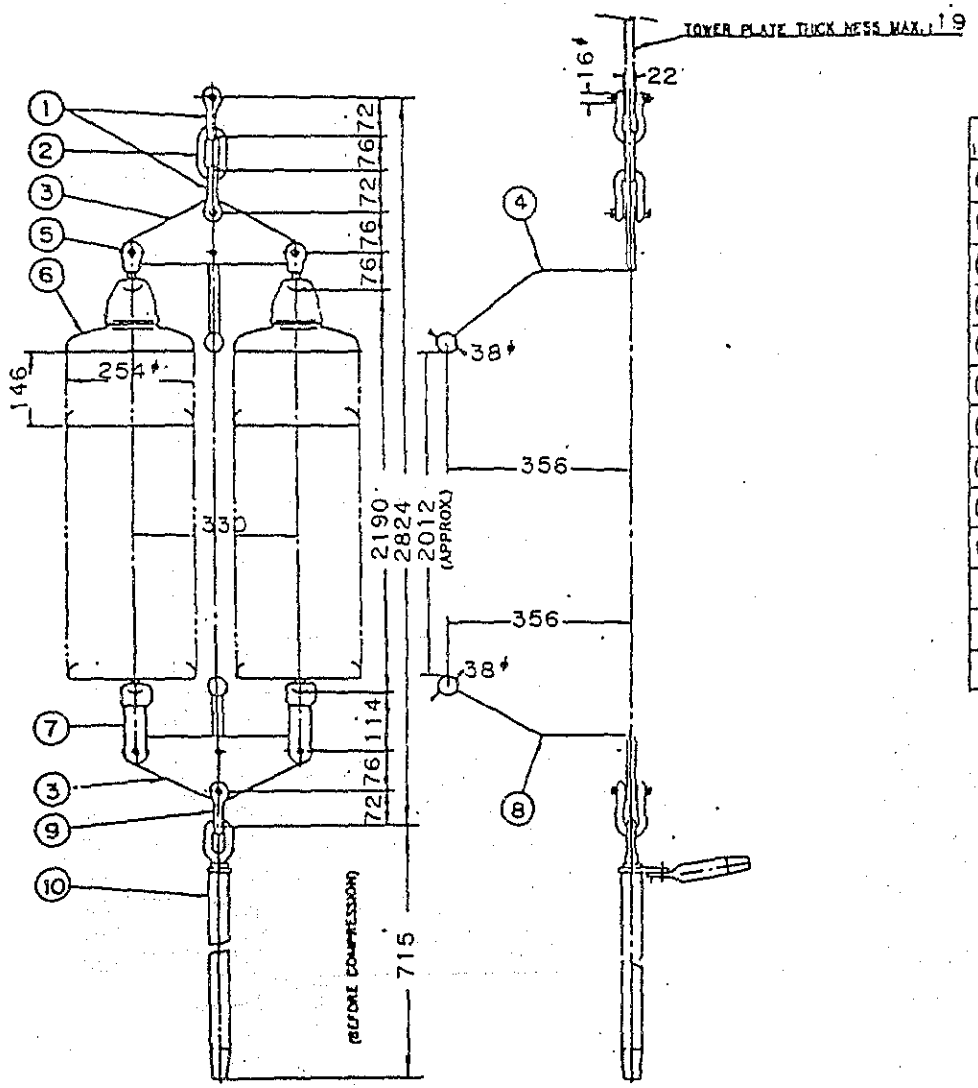
(signature)		(signature)	N. Inoue
DRAWING NO. WDT-1206		SCALE	DATE 10TH JAN 1990



ITEM	DESCRIPTION	MAIN MATERIAL	REQD.
1	ANCHOR SHACKLE	HIGH TENSION STEEL	2
2	CHAIN LINK	HIGH TENSION STEEL	1
3	YOKE	STEEL	2
4	ARCING HORN	STEEL	1
5	BALL-CLEVIS	HIGH TENSION STEEL	2
6	SUSPENSION INSULATOR	PORCELAIN	15×2
7	SOCKET-CLEVIS	MALLEABLE IRON OR DUCTILE IRON	2
8	ARCING HORN	STEEL	1
9	ANCHOR SHACKLE	HIGH TENSION STEEL	1
10	COMPRESSION CLAMP	ALUMINIUM	1

SUITABLE CONDUCTOR SIZE OF CLAMP	ACSR/AS 680mm²
MIN. BREAKING STRENGTH OF STRING ※ EXCEPT COMPRESSION CLAMP	12000kg
TYPE OF BALL AND SOCKET PARTS	IEC 16mm A

PAKISTAN

KARACHI ELECTRIC SUPPLY CORPORATION

WEST WHARF THERMAL POWER PLANT PROJECT

UNITS NO.1 AND NO.2

132 kV DOUBLE TENSION INSULATOR STRING

JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO JAPAN

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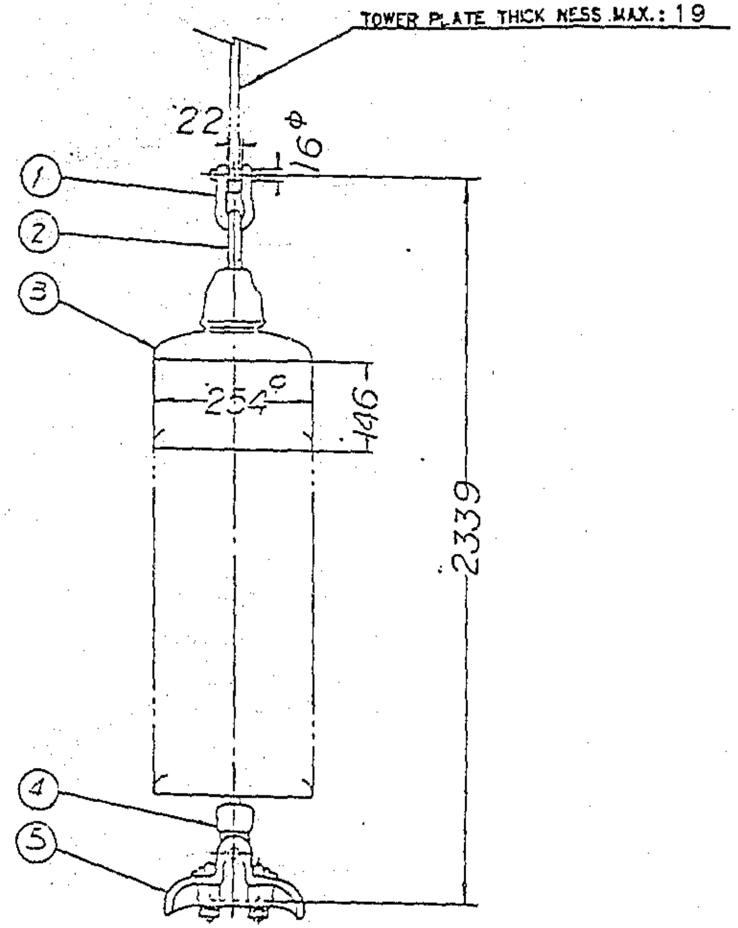
FORM 04



ITEM	DESCRIPTION	MAIN MATERIAL	REQD
1	ANCHOR SHACKLE	HIGH TENSION STEEL	1
2	BALL EYE	HIGH TENSION STEEL	1
3	SUSPENSION INSULATOR	PORCELAIN	14
4	SOCKET-EYE	MALLEABLE IRON OR SPHEROIDAL GRAPHITE IRON (DUCTILE IRON)	1
5	SUSPENSION CLAMP	MALLEABLE IRON OR DUCTILE IRON	1

SUITABLE CONDUCTOR SIZE OF CLAMP	43.2φ ~57.1φ
MIN. BREAKING STRENGTH OF STRING	12000kg
TYPE OF BALL AND SOCKET PARTS	IEC 16mm A

PAKISTAN

KARACHI ELECTRIC SUPPLY CORPORATION

WEST WHARF THERMAL POWER PLANT PROJECT

UNITS NO.1 AND NO.2

132 kV JUMPER SUPPORT INSULATOR STRING

JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO JAPAN

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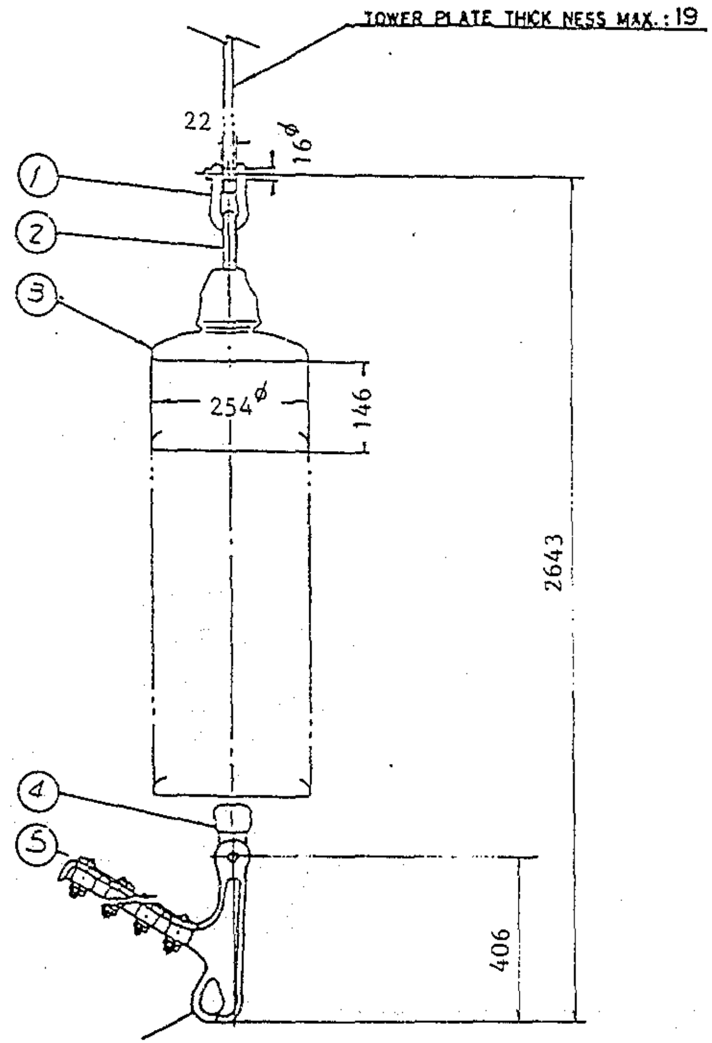
DRAWING NO. WLT-1208		SCALE	DATE 10TH JAN 1990

FORM 04



ITEM	DESCRIPTION	MAIN MATERIAL	REQD
1	ANCHOR SHACKLE	HIGH TENSION STEEL	1
2	BALL EYE	HIGH TENSION STEEL	1
3	SUSPENSION INSULATOR	PORCELAIN	14
4	SOCKET-EYE	MALLEABLE IRON OR DUCTILE IRON	1
5	STRAIN CLAMP	ALUMINIUM ALLOY	1

SUITABLE CONDUCTOR SIZE OF CLAMP	30.5φ~43.2φ
MIN. BREAKING STRENGTH OF STRING	12000kg
TYPE OF BALL AND SOCKET PARTS	IEC 16mm A

PAKISTAN KARACHI ELECTRIC SUPPLY CORPORATION			
WEST WHARF THERMAL POWER PLANT PROJECT UNITS NO.1 AND NO.2 132KV TIE DOWN INSULATOR STRING			
JAPAN INTERNATIONAL COOPERATION AGENCY TOKYO JAPAN			
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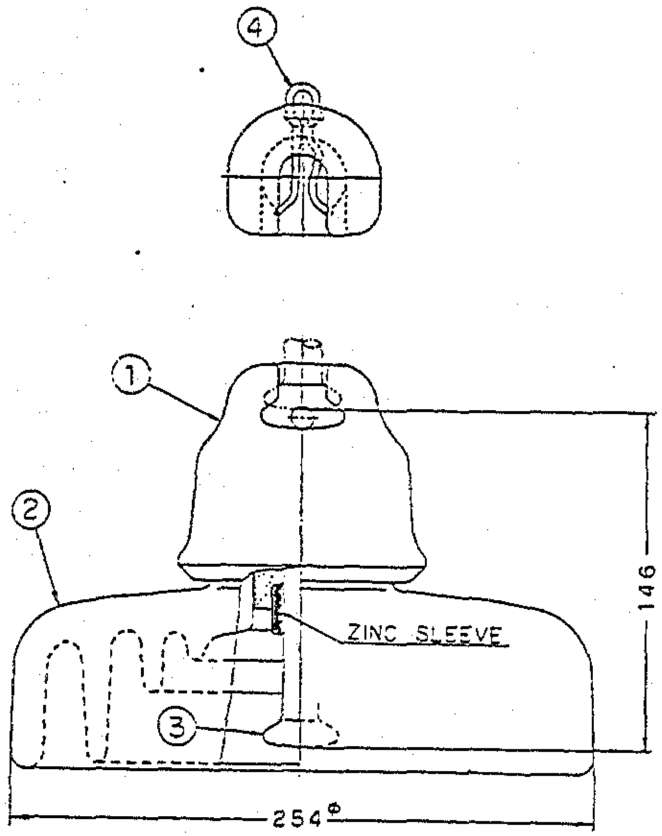
DRAWING NO. WLD-1209		SCALE	DATE 10TH JAN 1990

FORM 04

31



TECHNICAL DATA

SPECIFICATION APPLIED : IEC Pub. 383-1983

Characteristics	Rating
1. Type of ball and socket coupling	IEC 16mm A
2. Creepage distance (mm)	432
3. Electro-mechanical failing load (kN)	120
4. Dry lightning impulse withstand voltage (kV)	125
5. Wet power-frequency withstand voltage (kV)	45
6. Power-frequency puncture voltage (kV)	130

ITEM	MATERIAL
①	DUCTILE IRON
②	PORCELAIN
③	HIGH TENSION STEEL
④	STAINLESS STEEL

PAKISTAN
KARACHI ELECTRIC SUPPLY CORPORATION

WEST WHARF THERMAL POWER PLANT PROJECT
UNITS NO.1 AND NO.2

FOG TYPE SUSPENSION INSULATOR

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TOKYO JAPAN

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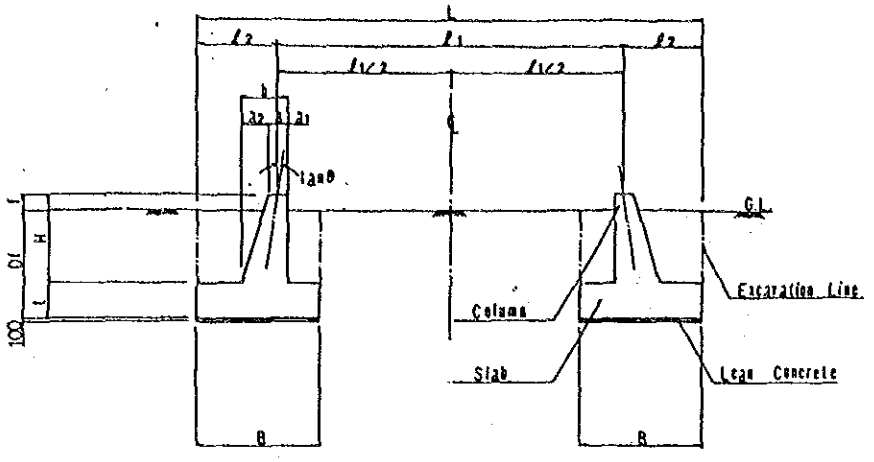
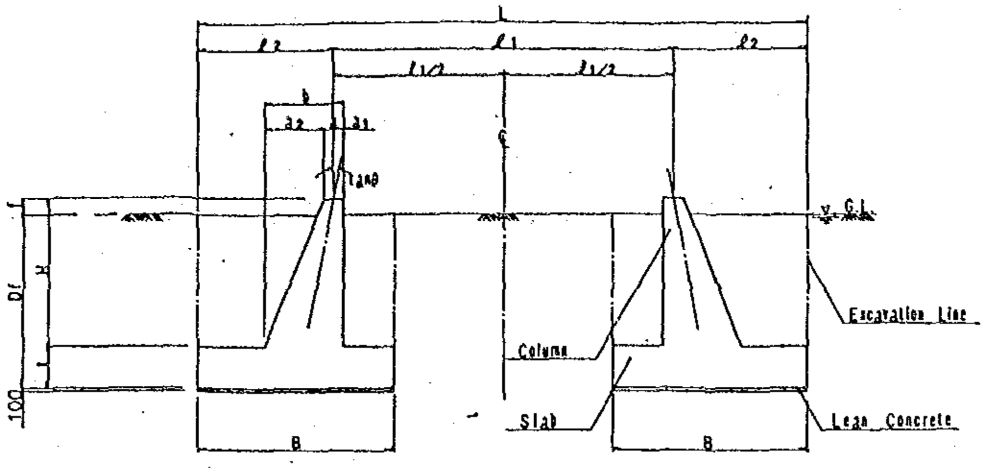
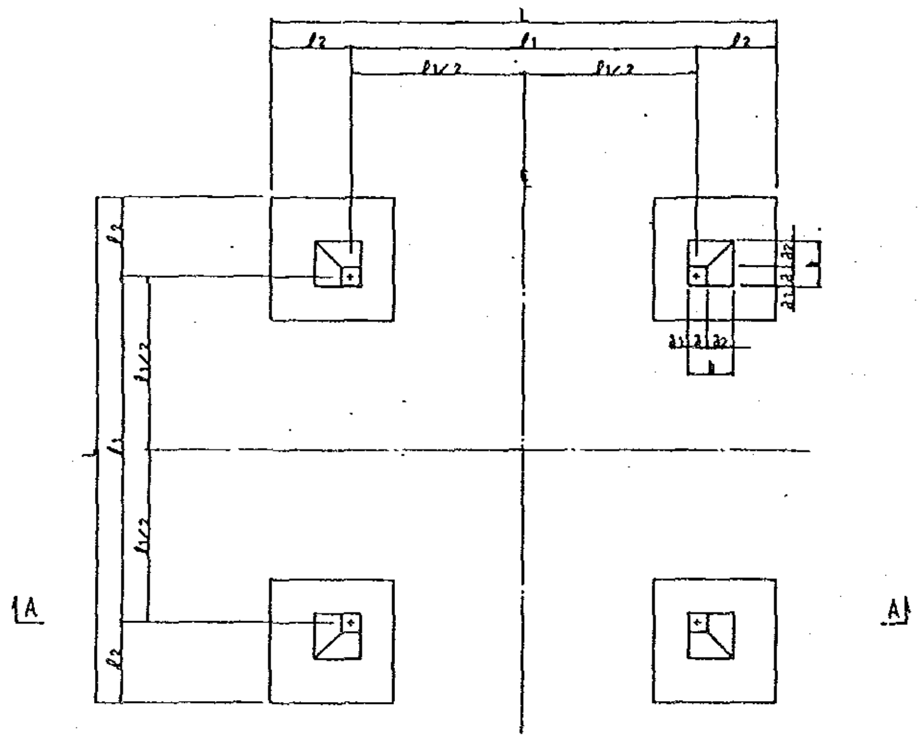
FORM 04



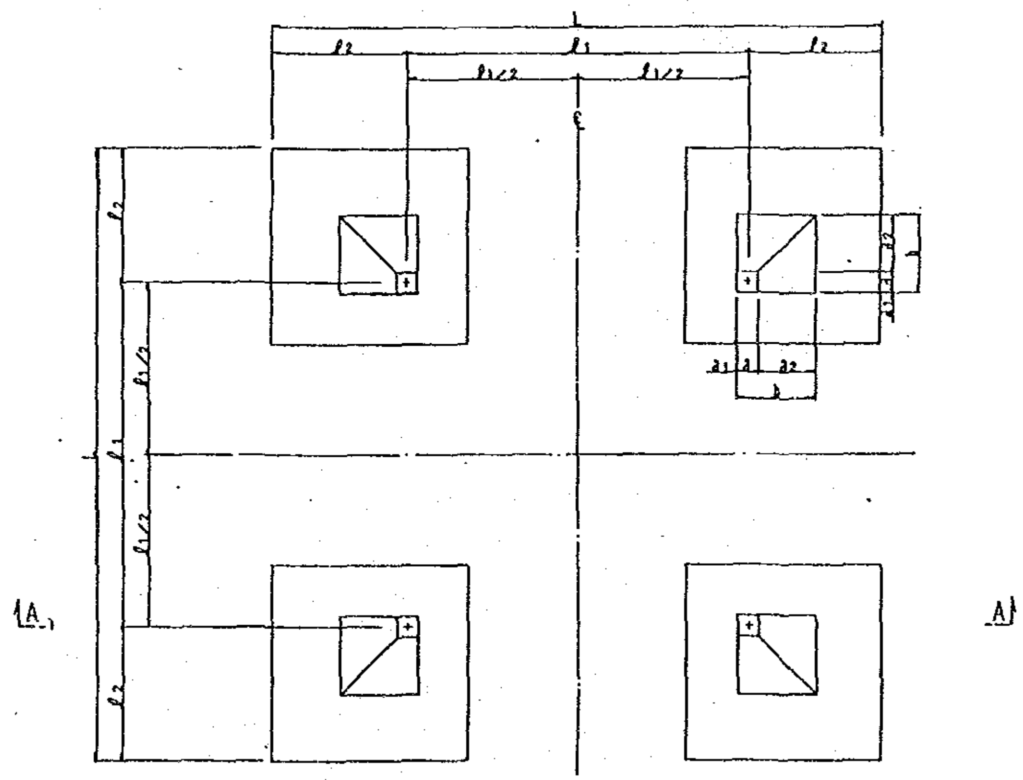
SECTION A - A



SECTION A - A



FOUNDATION PLAN



FOUNDATION PLAN

(UNIT : m)

TOWER TYPE	B	H	t	f	Df	a	a_1	a_2	b	$\tan\theta$	ℓ_1	$\ell_1/2$	ℓ_2	L	ANGLE SIZE
As-D-I	2.200	1.800	0.800	0.450	2.150	0.450	0.008	0.442	0.900	0.12069	6.891	3.4455	1.4135	9.718	L-150×12
A-D-I	2.300	2.000	0.800	0.450	2.350	0.550	0.006	0.494	1.050	0.12204	8.890	4.4450	1.4915	11.873	L-175×12
B-D-I	2.700	2.000	0.800	0.450	2.350	0.550	0.003	0.597	1.150	0.14865	9.866	4.9330	1.7660	13.398	L-175×12
C-D-I	3.400	2.400	1.000	0.450	2.950	0.600	0.015	0.935	1.150	0.14865	9.866	4.9330	2.2055	14.277	L-200×15
D-D-I	3.400	2.400	1.000	0.450	2.950	0.600	0.015	0.935	1.150	0.19186	9.827	4.9135	2.3520	14.531	L-200×20
DR-D-I	3.900	2.900	1.000	0.450	3.450	0.600	0.019	1.131	1.750	0.19186	9.827	4.9135	2.6980	15.223	L-200×25

INDIVIDUAL TYPE TOWER FOUNDATION (I - DRY)

(UNIT : m)

TOWER TYPE	B	H	t	f	Df	a	a_1	a_2	b	$\tan\theta$	ℓ_1	$\ell_1/2$	ℓ_2	L	ANGLE SIZE
As-C-I	4.000	3.000	1.000	0.450	3.550	0.450	0.013	0.737	1.200	0.12069	6.891	3.4455	2.4825	11.856	L-150×12
B-C-I	4.700	3.800	1.000	0.450	4.350	0.550	0.010	1.140	1.700	0.14865	9.866	4.9330	3.0630	15.992	L-175×12
C-C-I	5.600	4.200	1.200	0.450	4.950	0.600	0.020	1.630	2.250	0.14865	9.866	4.9330	3.6025	17.071	L-200×15
D-C-I	5.600	4.200	1.200	0.450	4.950	0.600	0.019	1.631	2.250	0.19186	9.827	4.9135	3.8360	17.499	L-200×20
DR-C-I	6.000	4.900	1.200	0.450	5.650	0.600	0.010	1.890	2.500	0.19186	9.827	4.9135	4.1700	18.167	L-200×25

INDIVIDUAL TYPE TOWER FOUNDATION (I - WET)

PAKISTAN

KARACHI ELECTRIC SUPPLY CORPORATION

WEST WHARF THERMAL POWER PLANT PROJECT

UNITS NO.1 AND NO.2

INDIVIDUAL TYPE TOWER FOUNDATION (I-DRY, I-WET)

JAPAN INTERNATIONAL COOPERATION AGENCY

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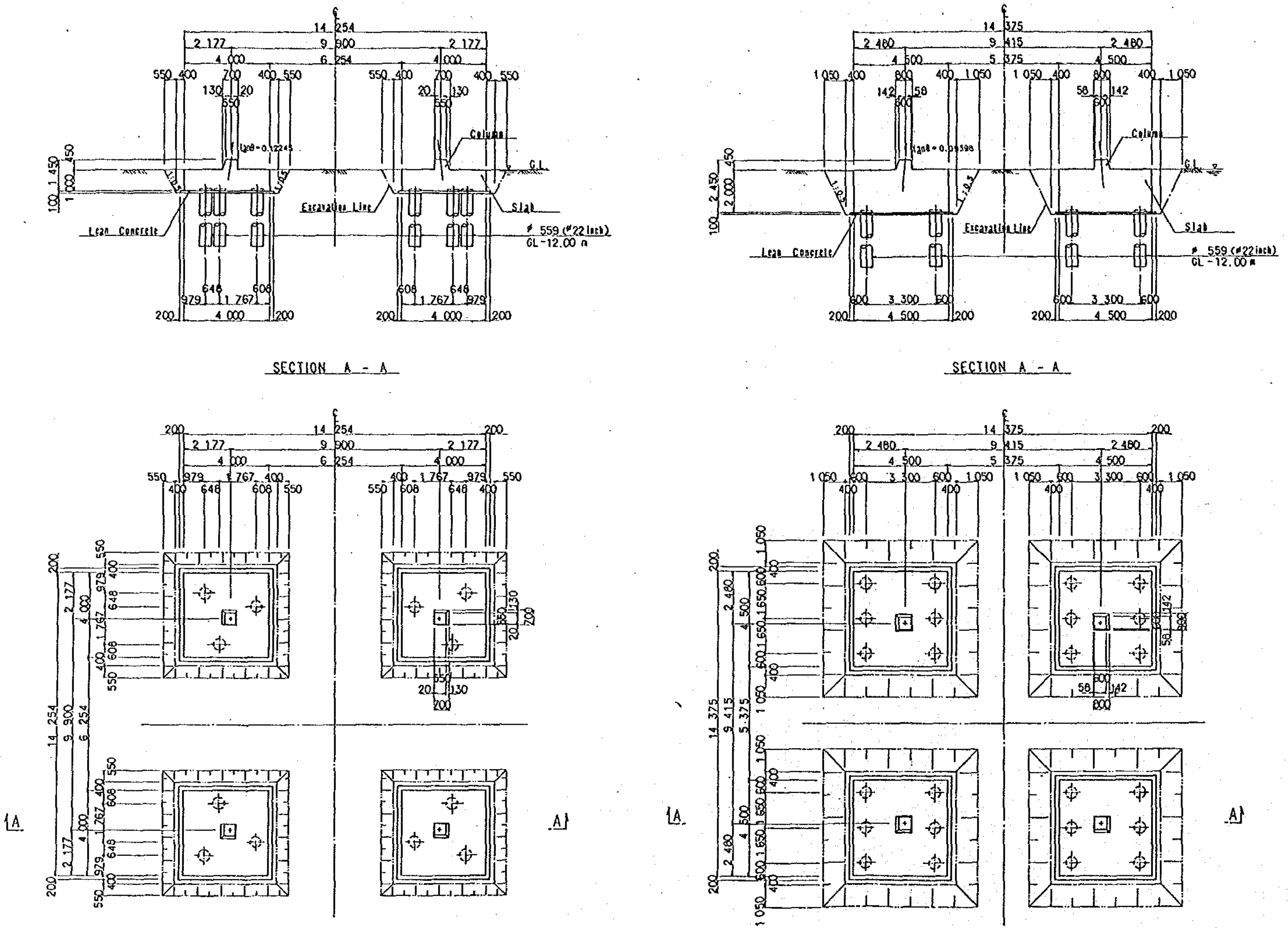

SECTION A - A

SECTION A - A

FOUNDATION PLAN
(AL - S - Ⅲ)

FOUNDATION PLAN
(A4 - S - Ⅲ)

PILE TYPE TOWER FOUNDATION (1/2)

PAKISTAN
KARACHI ELECTRIC SUPPLY CORPORATION
WEST WHARF THERMAL POWER PLANT PROJECT
UNITS NO.1 AND NO.2
PILE TYPE TOWER FOUNDATION (1/2)

JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO JAPAN

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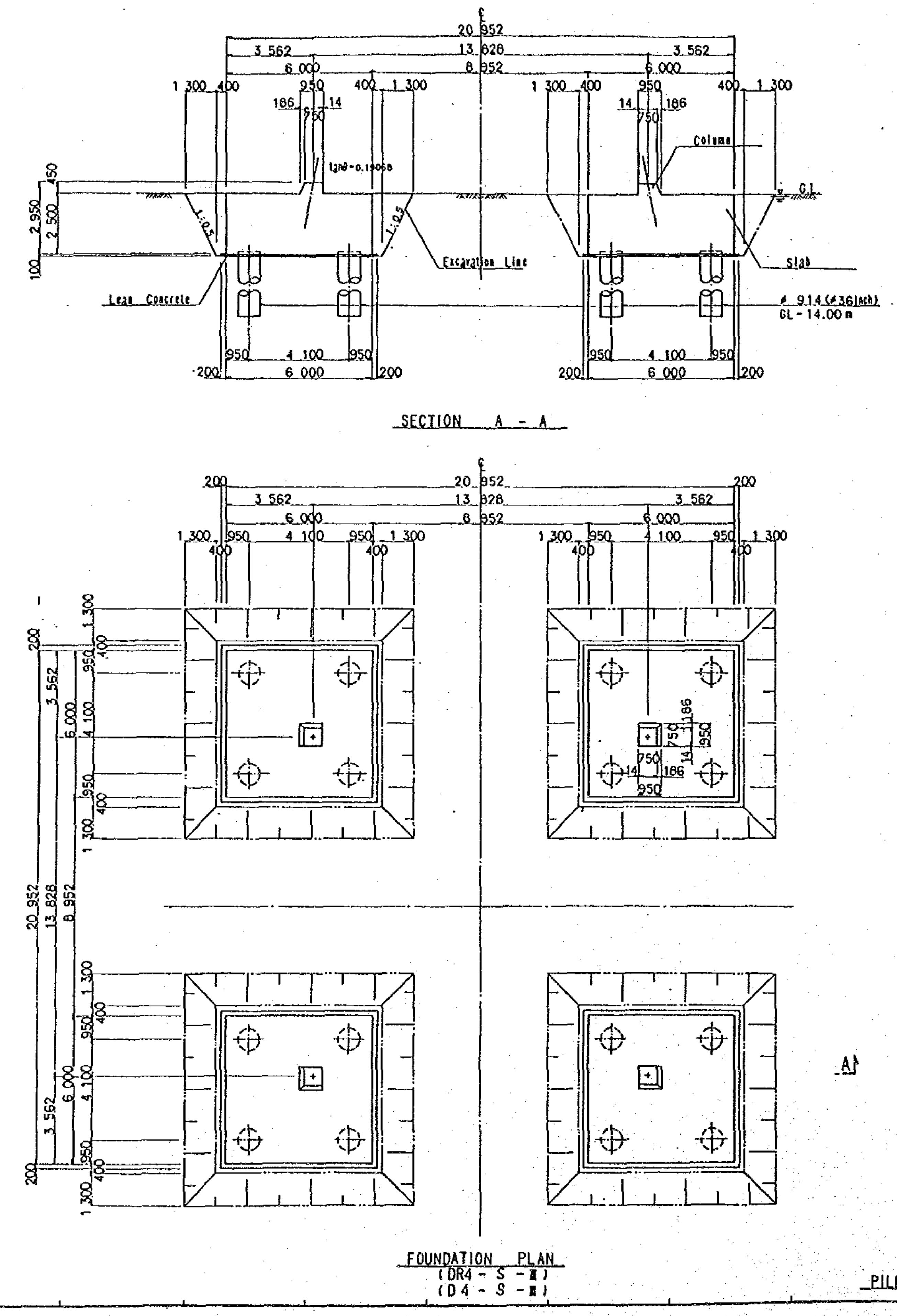

PILE TYPE TOWER FOUNDATION (2/2)

PAKISTAN			
KARACHI ELECTRIC SUPPLY CORPORATION			
WEST WHARF THERMAL POWER PLANT PROJECT UNITS NO.1 AND NO.2 PILE TYPE TOWER FOUNDATION (2/2)			
JAPAN INTERNATIONAL COOPERATION AGENCY TOKYO JAPAN			
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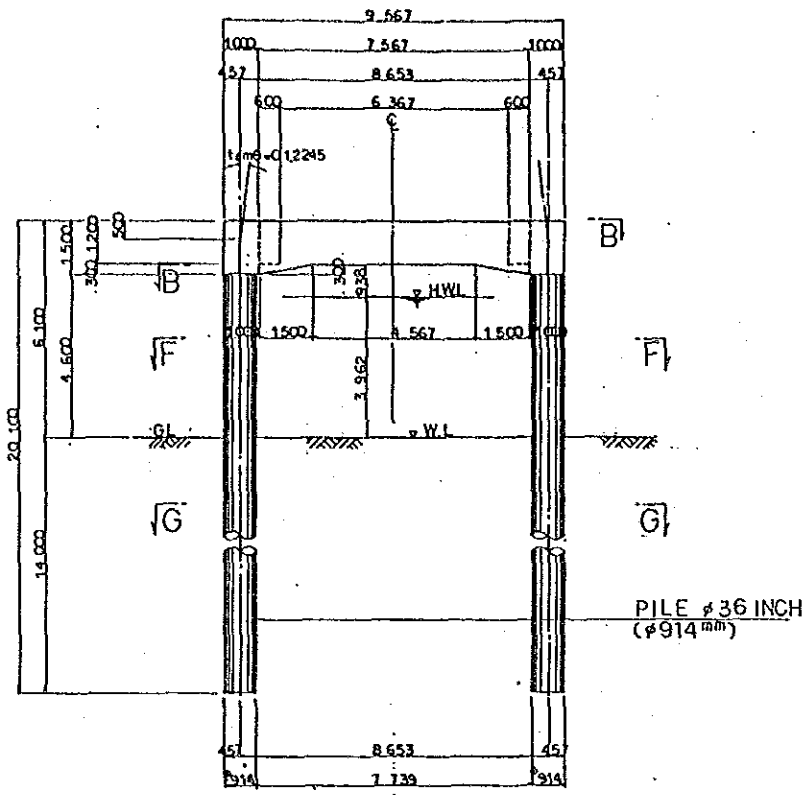
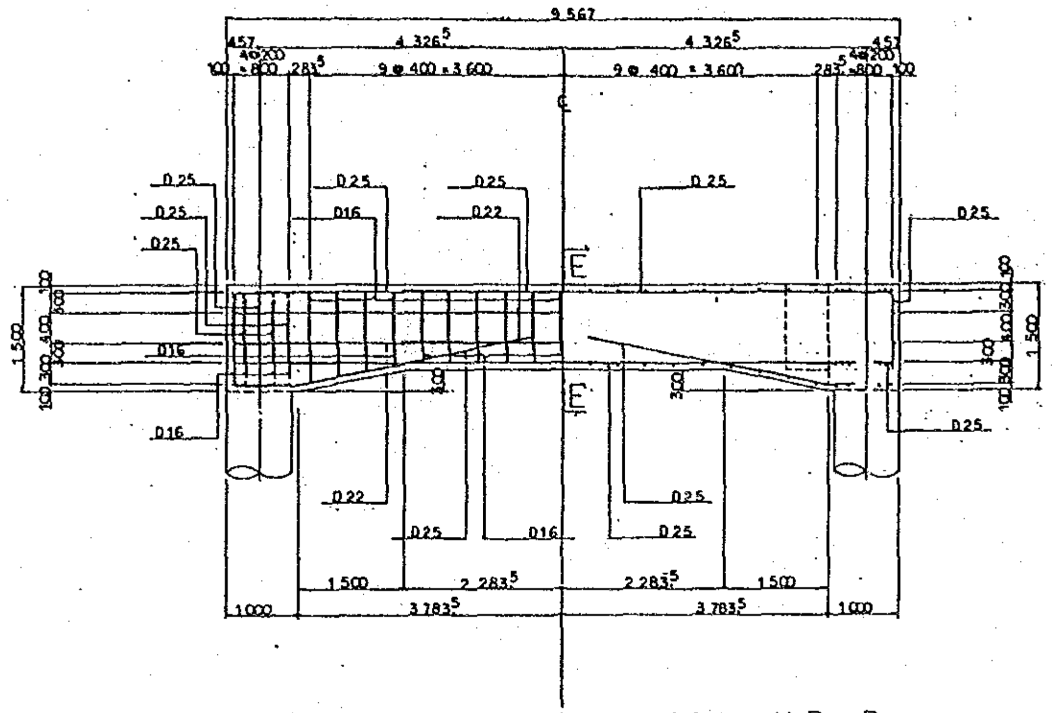
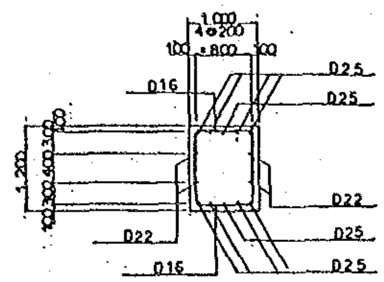
DRAWING NO. WLT-1603		SCALE	DATE 10TH JAN 1990



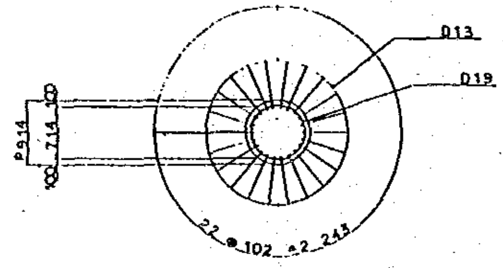
SECTION A-A S=1/100



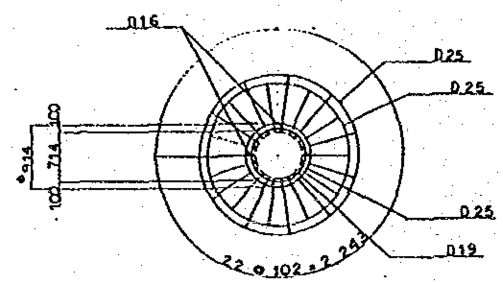
SECTION C-C S=1/50 SECTION D-D S=1/50



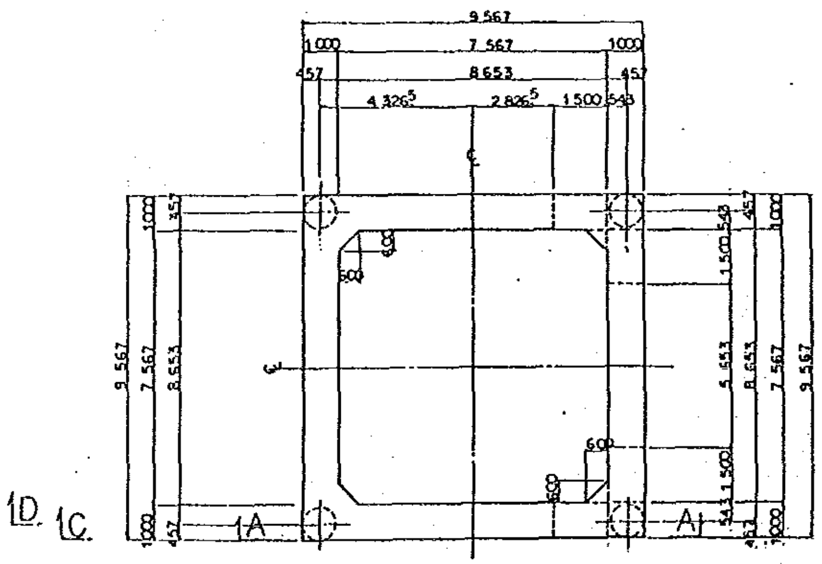
SECTION E-E S=1/50



SECTION F-F S=1/50



SECTION G-G S=1/50



SECTION B-B S=1/100

RIGID FRAME TOWER FOUNDATION (AL-R)

PAKISTAN
KARACHI ELECTRIC SUPPLY CORPORATION
WEST WHARF THERMAL POWER PLANT PROJECT UNITS NO.1 AND NO.2
RIGID FRAME TOWER FOUNDATION (AL-R)
JAPAN INTERNATIONAL COOPERATION AGENCY TOKYO JAPAN

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DRAWING NO. WLT-1604		SCALE	DATE 10TH JAN 1990

TLG-2

UNDERGROUND CABLE

TLG-2 UNDERGROUND CABLE

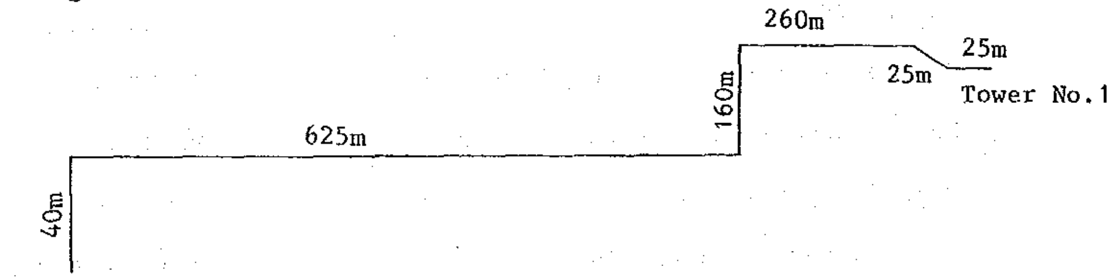
TLG-2 UNDERGROUND CABLE

1. Route of Underground Cable

The route of 220 kV underground cable, starting from the West Wharf Thermal Power Plant and ending at Tower No. 1, is as shown in Fig. 1.

Total length will be approximately 1.1 km.

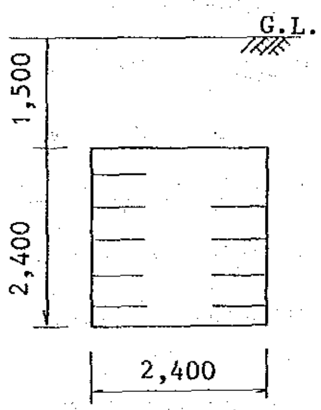
Fig. 1



2. Cross Section of Tunnel

The cross section of tunnel for underground cable is shown in Fig. 2.

Fig. 2



3. Cable Size

According to calculations made for the overhead conductor, the required current carrying capacity is 1,200 A and 720 A for 220 kV and 132 kV lines, respectively.

The cable size will be 1,200 mm^2 and 500 mm^2 for 220 kV and 132 kV, respectively.

The specifications of the cable shall be as follows.

220 kV 1,200 mm^2 OFAZV

Six sector hollow copper cable	
Rdc at 20°C	0.0151 Ω/km
Thermal resistance ratio of insulation	4.5°C m/W
Max. allowable temperature of insulation	85°C
Relative permittivity of insulation	ε = 3.45
Loss factor of insulation	tan δ = 0.0023
Inside diameter of conductor	12.0 mm
Outside diameter of conductor	43.6 mm
Outside diameter of binder	44.1 mm
Outside diameter of conductor cover	44.7 mm
Insulation thickness	15.2 mm
Outside diameter of core	76.8 mm
Height of aluminium wave of sheath	4.8 mm
Thickness of aluminium sheath	2.1 mm
Outside diameter of sheath	91.1 mm
Outside diameter of jacket	101.1 mm
Material of jacket	PVC

132 kV 500 mm^2 OFAZV

Self support copper cable	
Rdc at 20°C	0.0366 Ω/km

Thermal resistance ratio of insulation	4.5°C m/W
Max. allowable temperature of insulation	85°C
Relative permittivity of insulation	ε = 3.45
Loss factor of insulation	tan δ = 0.0023
Inside diameter of conductor	12.0 mm
Outside diameter of conductor	27.9 mm
Outside diameter of conductor cover	28.5 mm
Insulation thickness	9.1 mm
Outside diameter of core	48.4 mm
Height of aluminium wave of sheath	3.8 mm
Thickness of aluminium sheath	1.6 mm
Outside diameter of sheath	59.7 mm
Outside diameter of jacket	68.7 mm
Material of jacket	PVC

Note: The allowable current has been calculated in accordance with IEC 287 and the results are shown in Table 1 and Table 2.

Table 1. ALLOWABLE CURRENT OF 220KV CABLE

DESCRIPTION	VALUE
(1) Installation Conditions	
220 kV 1 x 1,200 mm2 OFAZV	
(a) Max. conductor temperature	85 °C
(b) Ambient temperature	50 °C
(c) Relative permittivity of insulation material (ε)	3.45
(d) Dielectric loss factor of insulation material (tan δ)	0.0023
(2) D.C. resistance of conductor at 20 °C	0.0151×10^{-3} Ω/m
(3) A.C. resistance of conductor at 85 °C (R)	0.0197×10^{-3} Ω/m
(4) Ratio of losses in metallic sheath to total losses in conductors of cable (λ1)	0.1768
(5) Ratio of losses in armour to total losses in conductors of cable (λ2)	------
(6) Thermal resistance of :	
(a) Insulation (T1)	0.445 K.m/W
(b) Separation sheath (T2)	----- K.m/W
(c) Outer sheath (T3)	0.151 K.m/W
(d) Surrounding of cable in air (T4)	0.341 K.m/W
(7) Permissible conductor temperature rise above ambient (Δθ)	35 °C
(8) Max. dielectric losses (Wd)	4.65 W/m
(9) Max capacitance (C)	399 pF/m
(10) Continuous current carrying capacity per conductor (I)	1255 Amps.

Table 2. ALLOWABLE CURRENT OF 132KV CABLE

DESCRIPTION	VALUE
(1) Installation Conditions	
132 kV 1 x 500 mm^2 OFAZV	
(a) Max. conductor temperature	85 °C
(b) Ambient temperature	5Ø °C
(c) Relative permittivity of insulation material (ε)	3.45
(d) Dielectric loss factor of insulation material ($\tan\delta$)	Ø.ØØ23
(2) D.C. resistance of conductor at 2Ø °C	Ø.Ø366 x $1Ø^{-3}$ Ω/m
(3) A.C. resistance of conductor at 85 °C (R)	Ø.Ø469 x $1Ø^{-3}$ Ω/m
(4) Ratio of losses in metallic sheath to total losses in conductors of cable ($\lambda 1$)	Ø.Ø315
(5) Ratio of losses in armour to total losses in conductors of cable ($\lambda 2$)	------
(6) Thermal resistance of :	
(a) Insulation (T1)	Ø.455 K.m/W
(b) Separation sheath (T2)	----- K.m/W
(c) Outer sheath (T3)	Ø.197 K.m/W
(d) Surrounding of cable in air (T4)	Ø.471 K.m/W
(7) Permissible conductor temperature rise above ambient ($\Delta\theta$)	35 °C
(8) Max. dielectric losses (Wd)	1.76 W/m
(9) Max capacitance (C)	419 pF/m
(1Ø) Continuous current carrying capacity per conductor (I)	79Ø Amps.

4. Ventilation in Tunnel

4.1 Calculation base

Maximum power to be transferred through 220 kV and 132 kV cables is considered to be 480 MW, which is 20% more than the generating capacity of West Wharf Thermal Power Plant.

Calculation shall be carried out on the bases of 2 cct of 1,200 mm^2 of 220 kV cables and 7 cct of 500 mm^2 of 132 kV cables.

4.2 Calorific power of cable and the temperature in tunnel

Temperature in tunnel ΔT:

$$\Delta T = \sum_{i=1}^{n} Wi \cdot Rt + To \qquad (^{o}C)$$

Wi : Calorific power of cable (W/cm)

R_T : Heat resistance of tunnel (^{o}C.cm/W)

To : Base temperature ($30^{o}C$)

$$Wi = Ii^2 \, r_{aci} \, (1 + Pi) \cdot Lfi + Wdi$$

Ii : Current (A)

r_{aci}: AC resistance of conductor (Ω/cm)

Pi : Ratio of eddy-current loss in metallic sheath

Lfi: Ratio of loss

Wdi: Dielectric loss (W/cm)

$$R_T = \frac{g \cdot n}{2\pi} \log_e \left\{ \frac{2L}{D} + \sqrt{\left(\frac{2L}{D}\right)^2 - 1} \right\} = 13.85 \ ^{o}C.cm/W$$

g : Specific heat resistance of soil ($200^{o}C$.cm/W)

η : Decreasing ratio of heat resistance by underground Water (0.3)

L : Depth up to center of tunnel (270 cm)

D : Equivalent diameter of tunnel

$D = \sqrt{\text{Height x Width}} = 240$ cm

(a) Normal condition

Assuming the current flow as 320 A and 200 A for 220 kV and 132 kV cables respectively, the following equations are used.

$$P = (220 \times 0.35 \times 2 + 132 \times 0.2 \times 7) \times \sqrt{3} \times 0.85 = 479 \text{ (MW)}$$

$$W_1 = 350^2 \times 0.0190 \times 10^{-5} (1+0.177) \times 1.0 + 4.65 \times 10^{-2}$$

$$= 0.0739 \text{ (W/cm)}$$

$$W_2 = 200^2 \times 0.0451 \times 10^{-5} (1+0.0315) \times 1.0 + 1.76 \times 10^{-2}$$

$$= 0.0362 \text{ (W/cm)}$$

$$\sum_{i=1}^{9} W_i = (W_1 \times 2 + W_2 \times 7) \times 3 = 1.204 \text{ (W/cm)}$$

(b) All power in 1cct of 220 kV and 4 cct of 132 kV

Assuming the current flow as 600 A and 370 A for 220 kV and 132 kV cables respectively, the following equations are used.

$$P = (200 \times 0.6 + 132 \times 0.37 \times 4) \times \sqrt{3} \times 0.85 = 482 \text{ (MW)}$$

$$W_1 = 600^2 \times 0.0190 \times 10^{-5} (1+0.177) \times 1.0 + 4.65 \times 10^{-2}$$

$$= 0.127 \text{ (W/cm)}$$

$$W_2 = 370^2 \times 0.0451 \times 10^{-5} (1+0.0315) \times 1.0 + 1.76 \times 10^{-2}$$

$$= 0.0813 \text{ (W/cm)}$$

$$\sum_{i=1}^{9} W_i = (W_1 + W_2 \times 4) \times 3 = 1.357 \text{ (W/cm)}$$

The temperature in tunnel will be

$$\Delta T = 1.357 \times 13.85 + 30 = 48.8 < 50 \text{ (}^{\circ}\text{C)}$$

Therefore, no cooling system will be required. However, it is advantageous to install one exhaust chimney so that the natural flow of air will prevent any toxic inhalation by maintenance personnel.

5. Oil Pressure Tank

5.1 Volume of insulation oil

Since the level differences are very small through the route, the PT-PT system is preferable. Standard and variation volumes of insulation oil by fluctuation of temperature of each portion are as follows.

		Standard volume of oil	Fluctuation of temperature	Q'ty	Valiation of volume of oil
Cable	Conductor and 1/2 insulator	1,100 ℓ/km	60 (85-25)	1.1 km	58.1 ℓ
	Others	1,600 ℓ/km	50 (75-25)	1.1 km	70.4 ℓ
IJB		60 ℓ/each	60 (85-25)	2	5.8 ℓ
CH in air		180 ℓ/km	35 (60-25)	2	10.0 ℓ
P.T		12 ℓ/cell	20 (45-25)	N cell	0.192 N ℓ

Therefore, total variation of oil volume becomes:

144.3 + 0.192 Nℓ.

5.2 Temperature of insulation oil at shutdown of load

Temperature of conductor

$$Tc = \frac{I^2 . R_{20} . Rth \; . \; n \; (1-20\alpha) + Te + Td'}{1 - I^2 \; . \; R_{20} \; . \; Rth \; . \; n}$$

$$= \frac{1,200^2 \times 0.0157 \times 10^{-5} \times 70.4 \times 1 \times (1 - 20 \times 0.00393) + 25 + 2.1}{1 - 1,200^2 \times 0.0157 \times 10^{-5} \times 70.4 \times 1 \times 0.00393}$$

$= 44.6$ (^{o}C)

Temperature of sheath

$$Ts = I^2.R_{20} \{1 + \alpha(Tc - 20)\} (Rth - T_1).n + Te + Td'$$

$$= 1,200^2 \times 0.0157 \times 10^{-5} \{1 + 0.00393 (44.6 - 20)\} (70.4 - 44.5)$$

$$+ 25 + 2.1 = 33.5 \ (^oC)$$

Temperature of insulation oil

$$Toil \ (Tc + Ts)/2 = (44.6 + 33.5)/2 = 39.1 \ (^oC)$$

Where;

I : Current (A)

R_{20}: AC resistance of conductor at 20^oC (Ω/cm)

Rth: Total thermal resistance (^oC.cm/W)

n : Number of conductor

α : Constant mass temperature coefficient at 20^oC per Kelvin

Te : Minimum earth temperature (^oC)

Td': Temperature rise by dielectric losses (^oC)

T_1 : Thermal resistance of insulation (^oC.cm/W)

5.3 Oil demand

$$a = a_o.W = a_o.n \ (I^2R + Wd)$$

$$= 24 \times 1 \times [1,200^2 \times 0.0157 \times 10^{-5} \times \{1 + 0.00393 (39.1 - 20)\} + 0.0465]$$

$$= 6.96 \times 10^{-5} \ (cm^3/cm.sec)$$

where;

a_o : Oil demand per unit loss (cm^3/cm.sec.W)

W : Load loss at shut down (W/cm)

R : AC resistance at temperature of oil (Ω/cm)

Wd : Dielectric losses (W/cm)

5.4 Resistance of oil flow

$$b = 0.815 \times \frac{\eta}{n.\pi.r^4} \times 10^{-4}$$

$$= 0.815 \times \frac{7.4}{1 \times \pi \times 0.6^4} \times 10^{-4} = 14.81 \times 10^{-4} \ (g.sec/cm^3)$$

where;

η : Viscosity of insulation oil (Cp)

r : Radius of oil hollow (cm)

n : Number of oil hollow

5.5 Transient valiation of oil pressure

See Fig. 4

$$\Delta P = \frac{1}{2} abL^2$$

$$= \frac{1}{2} \times 6.96 \times 10^{-5} \times 14.81 \times 10^{-4} \times \left(\frac{1.1 \times 10^5}{2}\right)^2 \times 10^{-3} = 0.16 \ (kg/cm^2)$$

$$P_{minB} = P_s + h_1\rho + \Delta P$$

$$= 0.2 + (4 - 1) \times 0.087 + 0.16 = 0.62 \ (kg/cm^2.G)$$

$$= 1.65 \ (kg/cm^2.abs)$$

$$P_{minA} = P_{minB} + h_2\rho$$

$$= 0.68 + (4 - 1.5) \times 0.087 = 0.9 \quad (kg/cm^2.G)$$

$$= 1.93 \quad (kg/cm^2.abs)$$

$$P_{maxA} = P_M - h_3\rho$$

$$= 4.5 - (4 - 1.5) \times 0.087 = 4.28 \quad (kg/cm^2.G)$$

$$= 5.31 \quad (kg/cm^2.abs)$$

$$P_{maxB} = P_{maxA} - h_4\rho$$

$$= 4.28 - (1.5 + 1) \times 0.087 = 4.06 \quad (kg/cm^2.G)$$

$$= 5.09 \quad (kg/cm^2.abs)$$

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where;

ΔP : Transient alteration of oil pressure (kg/cm^2)

P_{minA}: Minimum oil pressure of oil tank A

P_{minB}: Minimum oil pressure of oil tank B

P_{maxA}: Maximum oil pressure of oil tank A

P_{maxB}: Maximum oil pressure of oil tank B

L : Length of the cable route for one oil tank (cm)

P_S : Surplus of minimum oil pressure ($kg/cm^2.G$)

P_M : Maximum allowable pressure of oil pressure tank ($kg/cm^2.G$)

ρ : Specific gravity of oil

h_1, h_2, h_3, h_4: Level difference (m)

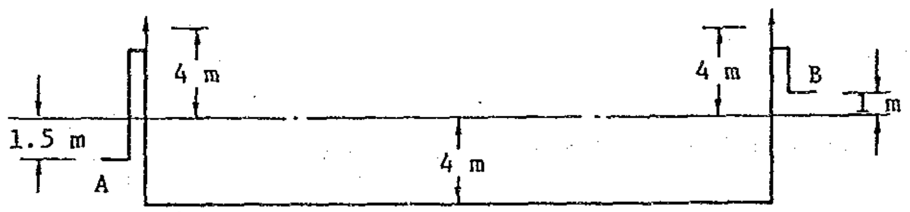


Fig. 4

5.6 Required number of cells

Absorption capacity of transient valiation of oil pressure per cell is as follows.

$$Pa = Cg \left(\frac{K_{25}}{Pmin} - \frac{K_{45}}{Pmax} \right) - \Delta C$$

Cg : Gas constant of pre pressure ratio 1.5

K_{25}: Absolute temperature of 25°C

K_{45}: Absolute temperature of 45°C

ΔC : Variation of oil volume per cell

$$P_{aA} = 0.0646 \left(\frac{298}{1.93} - \frac{318}{5.31} \right) - 0.192 = 5.91 \ (\ /\text{cell})$$

$$P_{aB} = 0.0646 \left(\frac{298}{1.65} - \frac{318}{5.09} \right) - 0.192 = 7.44 \ (\ /\text{cell})$$

$$N > \frac{167.6 + 100}{5.91 + 7.44} = 20$$

$$N = 25$$

Dimensions of tank are shown in Fig. 5.

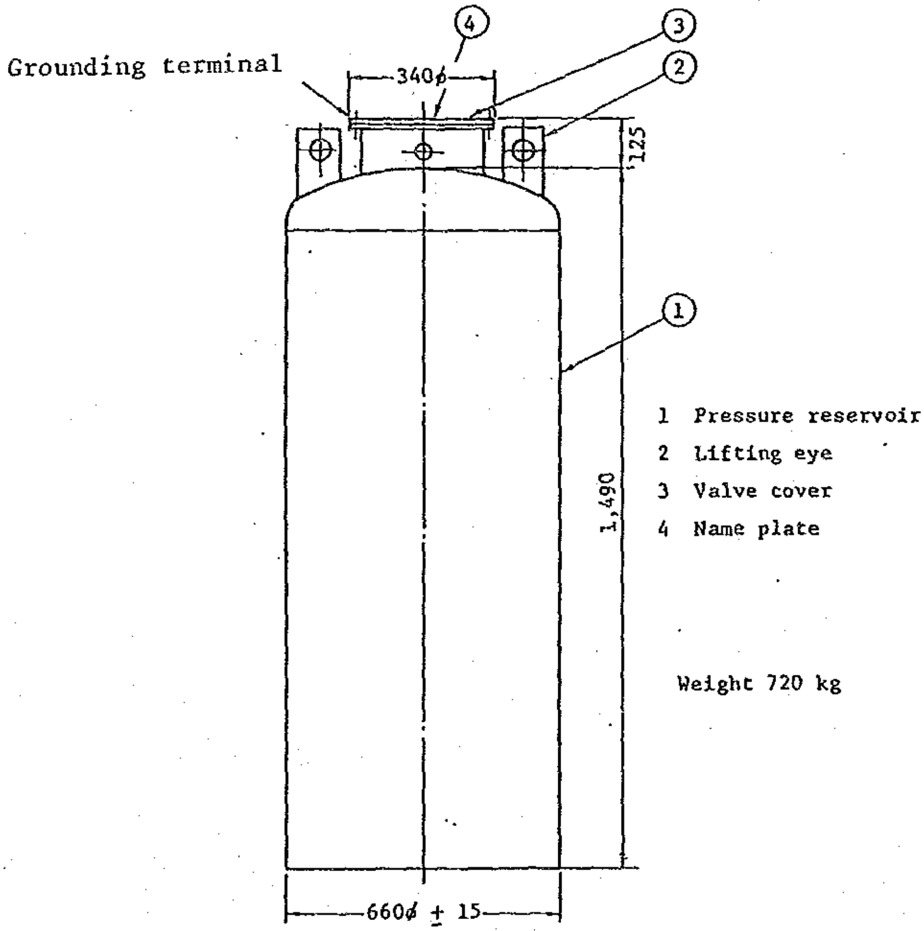


Fig. 5 Pressure Tank (Buried Type)
(Prepressure ratio 1.0 - 1.5)

TLG-3

CABLE TUNNEL

TLG-3 CABLE TUNNEL

1. Tunnel Structure

1-1 Design conditions

Tunnel dimensions (inside)	(B) x (H) = 2.4 m x 2.4 m (refer to Fig. 1)
Haunch	150 mm x 150 mm
Depth (ground surface to top of structure)	1.5 (typical) m
Allowable unit stress	
Reinforcing steel bars	According to the Standards of
Reinforcing concrete	Japanese Society of Civil Engineers
	Japanese Society of Civil Engineers
Dead weight (traffic) max.	20 ton (trailer-vehicle)

Note: Pavement weight should be included in the calculation.

Water level	Assuming as up to the surface for safety side
Soil properties	Soil properties shall be referred to the result of geological investigation in this project

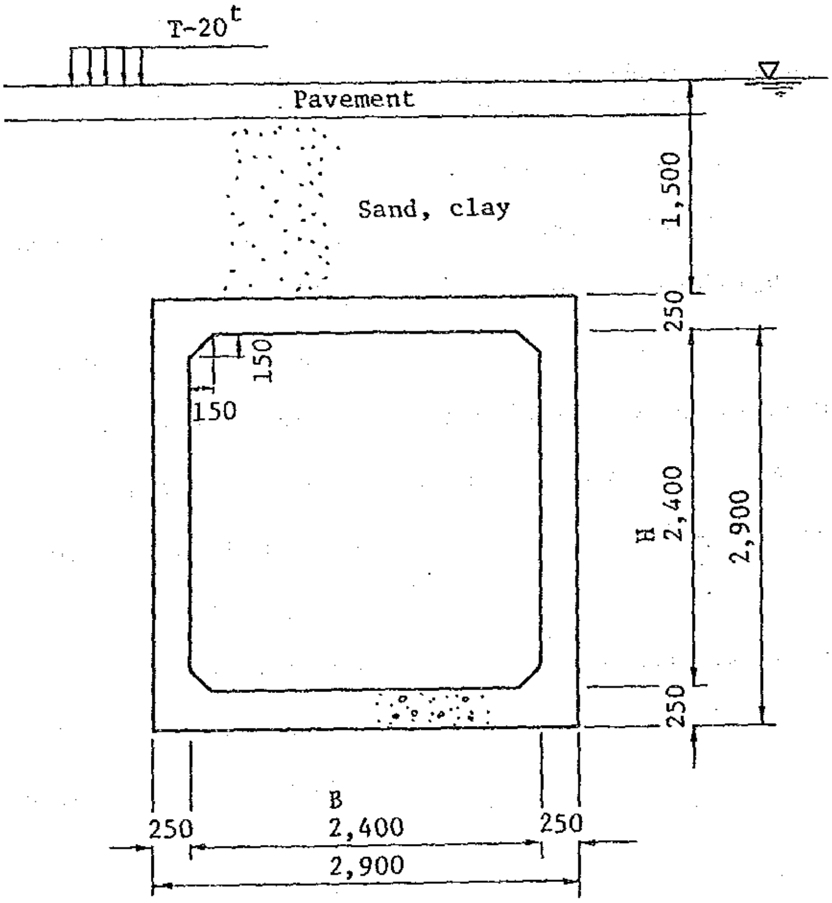
1-2 Load

(1) Traffic load 2.75 ton/m^2 (refer to Table 1)

Table 1

Depth (m)	1.0	1.5	2.0	2.5	3.0	3.5	4.5	9.0	10.0
Traffic load (ton/m^2)	4.50	2.75	2.05	1.50	1.20	1.15	1.10	1.05	0.95

Fig. 1



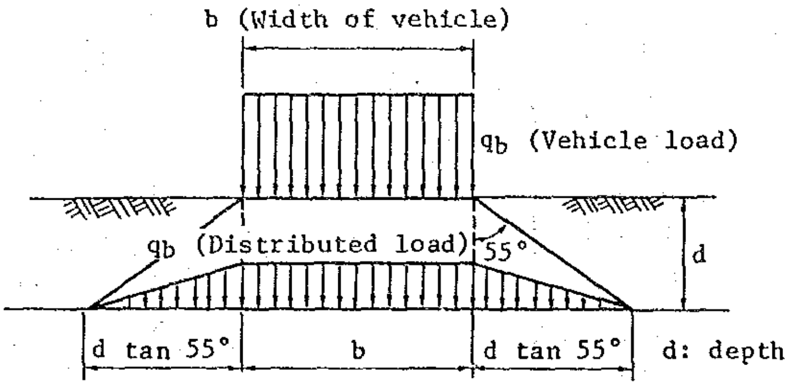
Note:

The loads indicated in the Table 1 are derived with the following assumptions.

(a) Traffic load is derived by applying a trailer load of 20 ton.

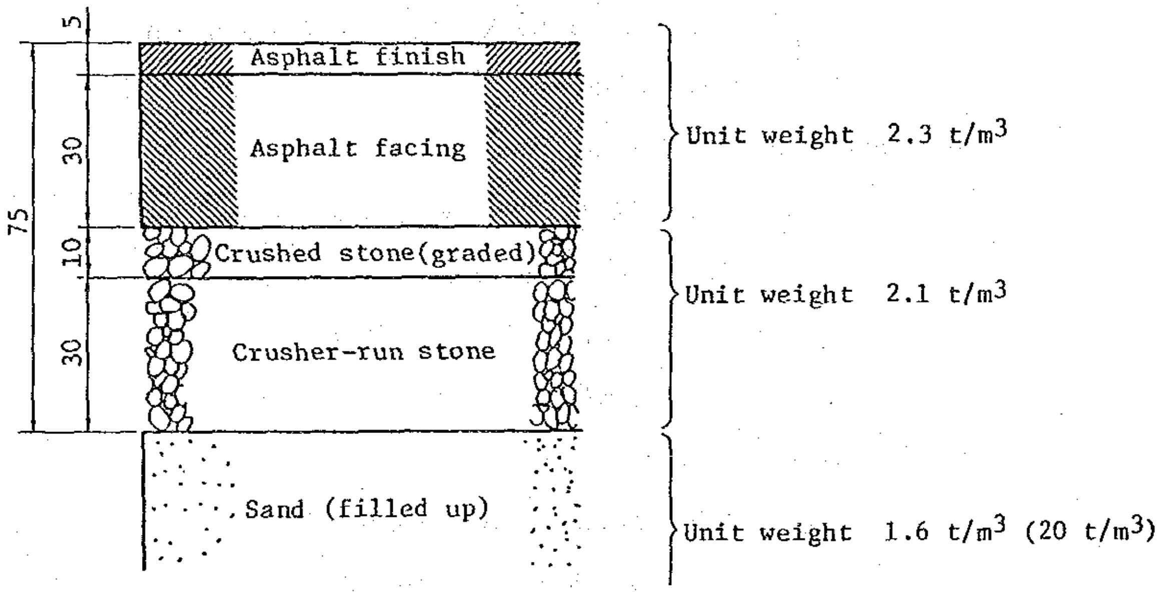
(b) Vehicle load is calculated by Kögler method with the following load distribution inside soil (Fig. 2)

Fig. 2



(2) Weight of pavement

Weight of pavement is calculated as indicated in Fig. 3.



(3) Soil and water pressure

Unit weight of soil

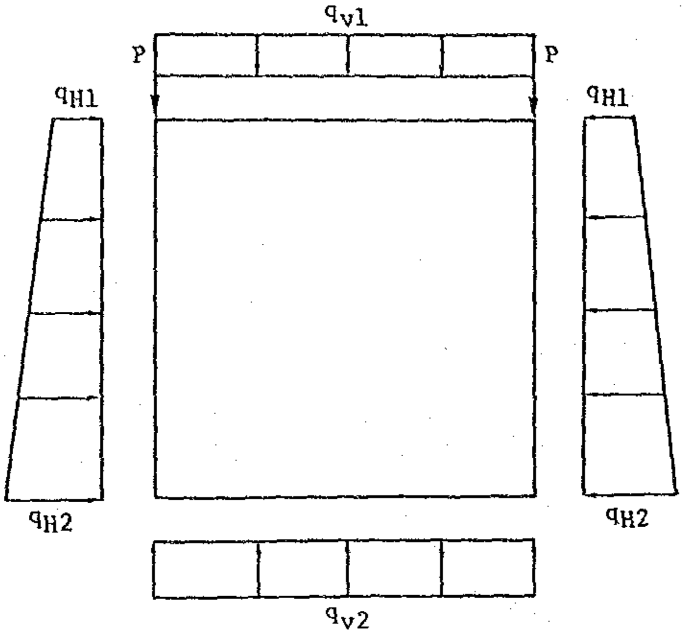
Back filled soil = 2.0 ton/m^3

Soil (sand, silt) = 2.0 ton/m^3, Ko = 0.5

= 1.1 ton/m^3

(4) Imposed loads used for the structural calculation are derived as follows.

Fig. 4



(a) Vertical soil pressure

$$q_{ve} = 2.75 + 2.3 \times 0.35 + 2.1 \times 0.4 + 2.0 \times 0.75$$
$$= 5.895 \text{ ton/m}^2$$

(b) Horizontal soil pressure

$$q_{He1} = 0.5 \times (2.75 + 2.3 \times 0.35 + 2.1 \times 0.4 + 1.1 \times 0.875) = 2.679 \text{ ton/m}^2$$

$$q_{He2} = 2.679 + 0.5 \times (1.1 \times 2.65)$$
$$= 4.137 \text{ ton/m}^2$$

(c) Horizontal water pressure

$$q_{HW1} = 1.0 \times 1.625 = 1.625 \text{ ton/m}^2$$
$$q_{HW2} = 1.0 \times 4.275 = 4.275 \text{ ton/m}^2$$

(d) Dead weight

Ceiling plate

$$q_g = 2.5 \times 0.25 = 0.625 \text{ ton/m}^2$$

Side wall

$$P = 2.5 \times 0.25 \times 2.65 = 1.656 \text{ ton/m}^2$$

(e) Reaction force to bottom plate

$$q_{vz} = q_{ve} + q_g + 2 \times P/2.65 = 7.770 \text{ ton/m}^2$$

(f) Imposed load (summary)

$$q_{v1} = q_{ve} + q_g = 6.520 \text{ ton/m}^2$$

$$q_2 = 7.770 \text{ ton/m}^2$$

$$q_{H1} = q_{He1} + q_{HW1} = 4.304 \text{ ton/m}^2$$

$$q_{H2} = q_{He2} + q_{HW2} = 8.412 \text{ ton/m}^2$$

$$P = 1.625 \text{ ton/m}^2$$

1-3 Section force (calculation result)

(1) Side wall

	M (TON-M)	Q (TON)	N (TON)		
0-	3.6200	-7.2674	-10.2950	1	Support (face)
1-	2.7457	-6.7172	-10.2950	2	Haunch (starting point)
2-	2.5792	-6.6043	-10.2950		
3-	1.7896	-6.0251	-10.2950		
4-	-0.1749	-4.0758	-10.2950		
5-	-1.6301	-0.2038	-10.2950	3	Center
6-	-0.2947	4.3486	-10.2950		
7-	1.9599	7.3267	-10.2950		
8-	2.9386	8.3370	-10.2950		
9-	3.1496	8.5420	-10.2950	4	Haunch (starting point)
10-	4.2820	9.5813	-10.2950	5	Support

(2) Bottom plate

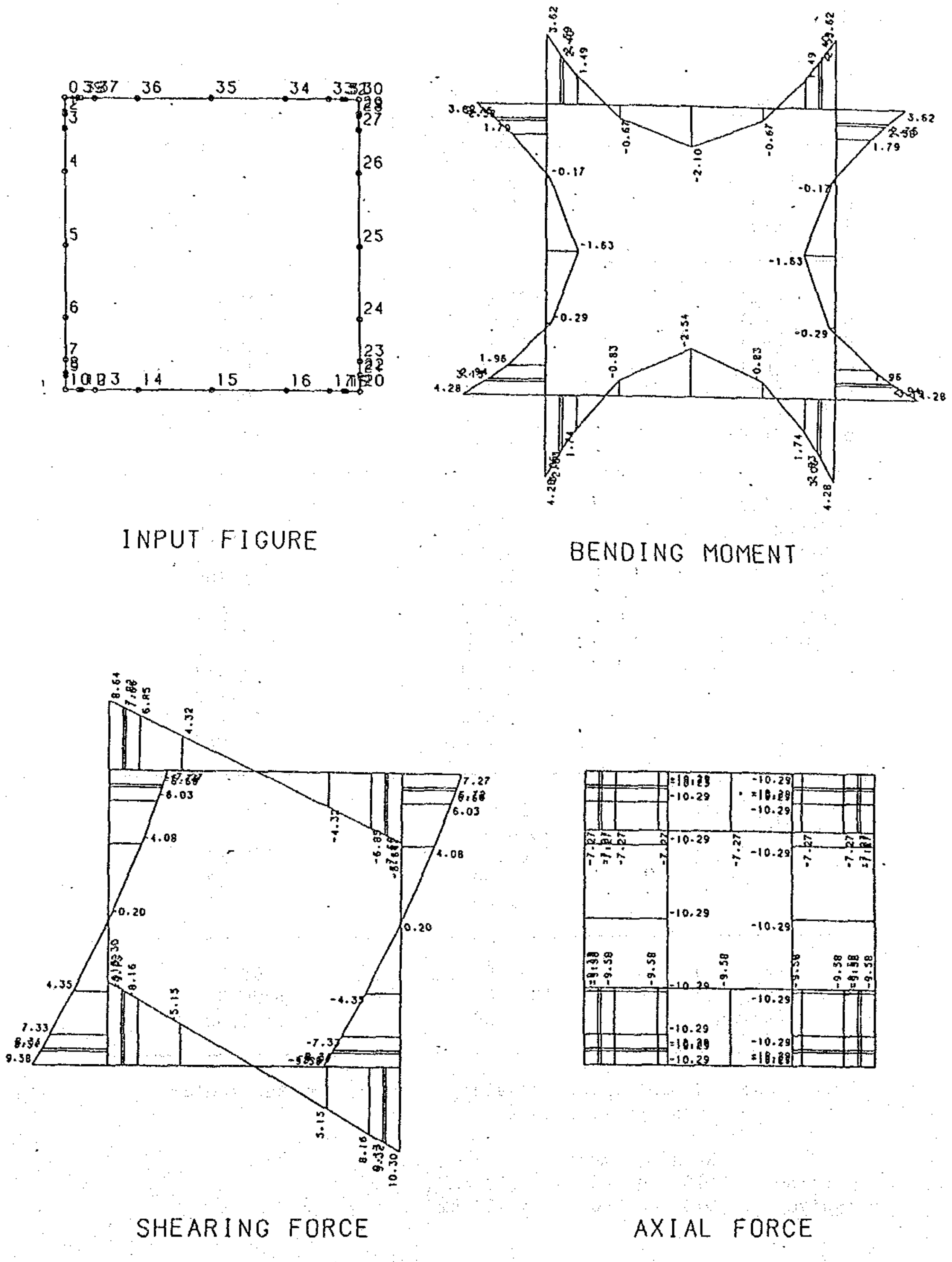
	M (TON-M)	Q (TON)	N (TON)		
10-	4.2820	-10.2953	-9.5813	1	Support (face)
11-	3.0558	-9.3240	-9.5813	2	Haunch (starting point)
12-	2.8252	-9.1297	-9.5813		
13-	1.7446	-8.1585	-9.5813		
14-	-0.8334	-5.1476	-9.5813		
15-	-2.5386	0.0000	-9.5813	3	Center
16-	-0.8334	5.1476	-9.5813		
17-	1.7446	8.1585	-9.5813		
18-	2.8252	9.1297	-9.5813		
19-	3.0558	9.3240	-9.5813		
20-	4.2820	10.2952	-9.5813		

(3) Ceiling plate

	M (TON-M)	Q (TON)	N (TON)		
30-	3.6200	-8.6390	-7.2674	1	Support (face)
31-	2.5911	-7.8240	-7.2674	2	Haunch (starting point)
32-	2.3975	-7.6610	-7.2674		
33-	1.4908	-6.8460	-7.2674		
34-	-0.6725	-4.3195	-7.2674		
35-	-2.1033	0.0000	-7.2674	3	Center
36-	-0.6725	4.3195	-7.2674		
37-	1.4908	6.8460	-7.2674		
38-	2.3975	7.6610	-7.2674		
39-	2.5911	7.8240	-7.2674		
0-	3.6200	8.6390	-7.2674		

M: Bending moment
Q: Shearing force
N: Axial force

Fig. 5



1-4 Stress (calculation result)

(1) Side wall

Section No.		Upper 1-(1) support (face)	Upper 1-(2) haunch starting point)
M	(t.m)	3.62	2.75
N	(t)	10.30	10.30
S	(t)	6.72	6.60
b	(cm)	100.0	100.0
h	(cm)	30.0	25.0
d	(cm)	25.0	20.0
d'	(cm)	10.0	5.0
As	(cm2)	6.620	6.620
As'	(cm2)	4.223	4.223
n =	Es/Ec	15.00	15.00
P=As/(b*d)	(%)	0.265	0.331
u=d-h/2	(cm)	10.000	7.500
f=M/N+u	(cm)	45.163	34.170
f/d		1.807	1.709
d'/d		0.400	0.250
As'/As		0.638	0.638
M'=M+N*u	(t.m)	4.650	3.518
x	(cm)	8.268	7.073
C		0.000	6.137
S		0.000	11.216
Z		0.000	1.082
c	(kg/cm2)	51.7	54.0
s	(kg/cm2)	1568.6	1479.6
s'	(kg/cm2)	162.3	237.3
	(kg/cm2)	0.00	3.57
m	(kg/cm2)	2.69	3.30
ca	(kg/cm2)	90.0	90.0
sa	(kg/cm2)	1800.0	1800.0
a	(kg/cm2)	4.50	4.50

Note: σs; (-) denotes compression, σs'; (-) denotes tenior
m: mean shear stress

	Reinforcement
Outside	D16 @ 300 = 6.62 cm^2
Insiee	D13 @ 300 = 4.223 cm^2

Section No.		1-(3) Center	1-(4) Bottom haunch (starting point)	1-(5) Bottom support (face)
M	(t.m)	1.70	3.15	4.28
N	(t)	10.30	10.30	10.30
S	(t)	0.00	8.34	8.54
b	(cm)	100.0	100.0	100.0
h	(cm)	25.0	25.0	30.0
d	(cm)	20.0	20.0	25.0
d'	(cm)	5.0	5.0	10.0
As	(cm2)	4.223	10.843	10.843
As'	(cm2)	6.620	4.223	4.223
n =	Es/Ec	15.00	15.00	15.00
P=As/(b*d)	(%)	0.211	0.542	0.434
u=d-h/2	(cm)	7.500	7.500	10.000
f=M/N+u	(cm)	24.013	38.094	51.593
f/d		1.201	1.905	2.064
d'/d		0.250	0.250	0.400
As'/As		1.568	0.389	0.389
M'=M+N*u	(t.m)	2.472	3.922	5.312
x	(cm)	7.310	8.138	9.424
C		5.805	5.405	0.000
S		10.077	7.878	0.000
Z		1.012	1.114	0.000
c	(kg/cm2)	35.9	53.0	51.9
s	(kg/cm2)	934.2	1158.5	1285.7
s'	(kg/cm2)	170.1	306.5	47.5
	(kg/cm2)	0.00	4.64	0.00
m	(kg/cm2)	0.00	4.17	3.42
ca	(kg/cm2)	90.0	90.0	90.0
sa	(kg/cm2)	1800.0	1800.0	1800.0
a	(kg/cm2)	4.50	4.50	4.50

Note: σs; (-) denotes compression, σs'; (-) denotes tension
m: mean shear stress

Reinforcement

Outside D16, D13 alternately @ 150 = 10.843 cm^2

Inside D13 @ 300 = 4.223 cm^2

(2) Bottom plate

Section No.		2-(1) Support (face)	2-(2) Haunch (starting point)	2-(3) Center
M	(t.m)	4.28	3.06	2.54
N	(t)	9.58	9.58	9.58
S	(t)	9.32	9.13	0.00
b	(cm)	100.0	100.0	100.0
h	(cm)	30.0	25.0	25.0
d	(cm)	25.0	20.0	20.0
d'	(cm)	10.0	5.0	5.0
As	(cm2)	10.843	10.843	6.620
As'	(cm2)	6.620	6.620	10.843
n =	Es/Ec	15.00	15.00	15.00
P=As/(b*d)	(%)	0.434	0.542	0.331
u=d-h/2	(cm)	10.000	7.500	7.500
f=M/N+u	(cm)	54.691	39.393	33.995
f/d		2.188	1.970	1.700
d'/d		0.400	0.250	0.250
As'/As		0.611	0.611	1.638
M'=M+N*u	(t.m)	5.240	3.774	3.257
x	(cm)	9.314	7.965	6.876
C		0.000	5.361	5.923
S		0.000	8.101	11.304
Z		0.000	1.119	1.089
c	(kg/cm2)	52.0	50.6	48.2
s	(kg/cm2)	1312.5	1146.6	1380.7
s'	(kg/cm2)	57.4	282.4	197.4
	(kg/cm2)	0.00	5.11	0.00
m	(kg/cm2)	3.73	<u>4.56</u>	0.00
ca	(kg/cm2)	90.0	90.0	90.0
sa	(kg/cm2)	1800.0	1800.0	1800.0
a	(kg/cm2)	4.50	4.50	4.50

Reinforcement

Outside D16, D13 alternately @ 150 = 10,843 cm^2

Inside D16 @ 300 = 6.62 cm^2

Reinforcement with strirrup is applied because of an excess shear stress at original point of the haunch.

(3) Ceiling plate

Section No.		3-(1) Support (face)	3-(2) Haunch (starting point)	3-(3) Center
M	(t.m)	3.62	2.59	2.10
N	(t)	7.27	7.27	7.27
S	(t)	7.82	7.66	0.00
b	(cm)	100.0	100.0	100.0
h	(cm)	30.0	25.0	25.0
d	(cm)	25.0	20.0	20.0
d'	(cm)	10.0	5.0	5.0
As	(cm2)	6.620	6.620	4.223
As'	(cm2)	4.223	4.223	6.620
n =	Es/Ec	15.00	15.00	15.00
P=As/(b*d)	(%)	0.265	0.331	0.211
u=d-h/2	(cm)	10.000	7.500	7.500
f=M/N+u	(cm)	59.812	43.154	36.442
f/d		2.392	2.158	1.822
d'/d		0.400	0.250	0.250
As'/As		0.638	0.638	1.568
M'=M+N*u	(t.m)	4.347	3.136	2.648
x	(cm)	7.660	6.572	5.811
C		0.000	6.579	7.332
S		0.000	13.442	17.903
Z		0.000	1.092	1.061
c	(kg/cm2)	52.3	51.6	48.5
s	(kg/cm2)	1776.7	1580.9	1778.0
s'	(kg/cm2)	239.7	185.1	101.6
	(kg/cm2)	0.00	4.18	0.00
m	(kg/cm2)	3.13	3.83	0.00
ca	(kg/cm2)	90.0	90.0	90.0
sa	(kg/cm2)	1800.0	1800.0	1800.0
a	(kg/cm2)	4.50	4.50	4.50

Note: σs; (-) denotes compression, $\sigma s'$; (-) denotes tension
m: mean shear stress

Reinforcement

Outside D16 @ 300 = 6.62 cm^2

Inside D13 @ 300 = 4.223 cm^2

1-5 Stirrup

Required cross sectional area req. Av

$S_c = 1/2 \times 4.5 \times 100 \times 0.875 \times 20 \times 10^{-3} = 3.938$ t

$S_v = 9.13 - 3.938 = 5.192$ t

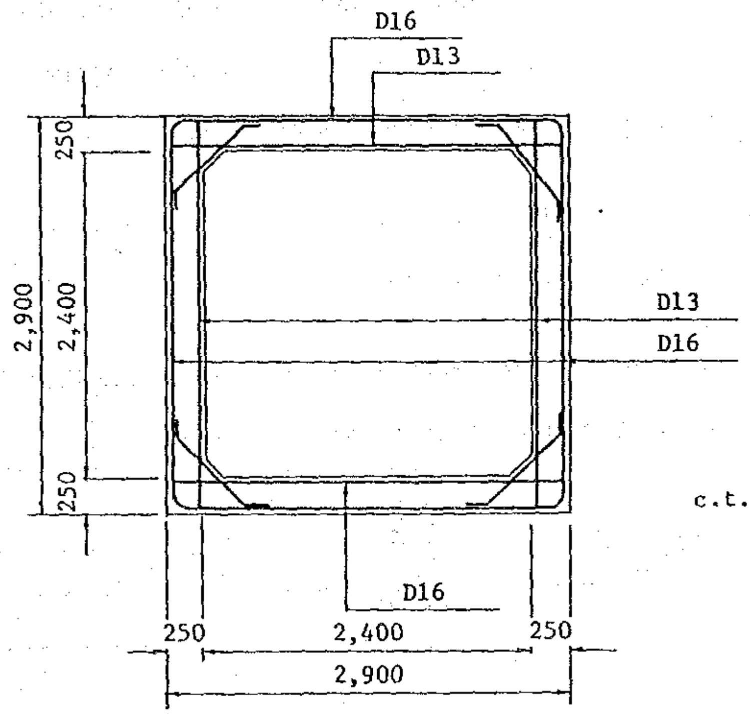
$$\text{req Av} = \frac{Sv.s}{sa.j.d} = \frac{5.192}{1800} \frac{x}{x} \frac{10^3}{0.875} \frac{x}{x} \frac{15}{20}$$

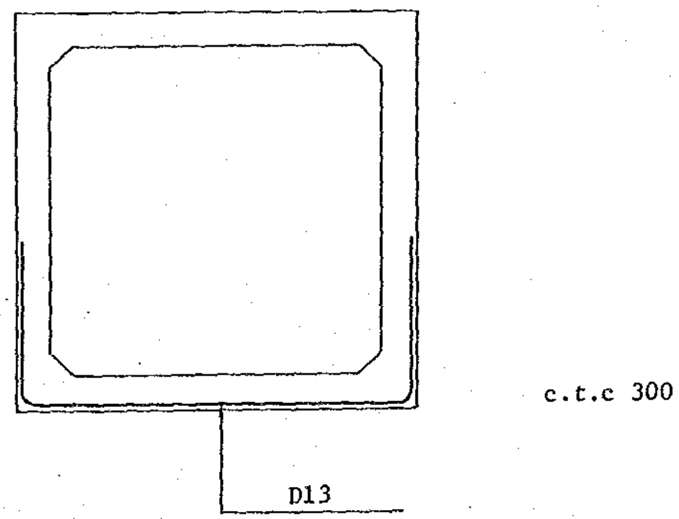
$$= 2.472 \text{ cm}^2 < \text{D13 @ 300} = 4.223 \text{ cm}^2$$

Therefore, stirrups (D13) are placed with 15 cm space in a section and 300 cm axial pitch.

1-6 Summary

The wall thicknesses and reinforcement bars decided by the above calculation are shown in Fig. 6.





The wall thickness is decided as 250 mm with above reinforcement according to the calculation.

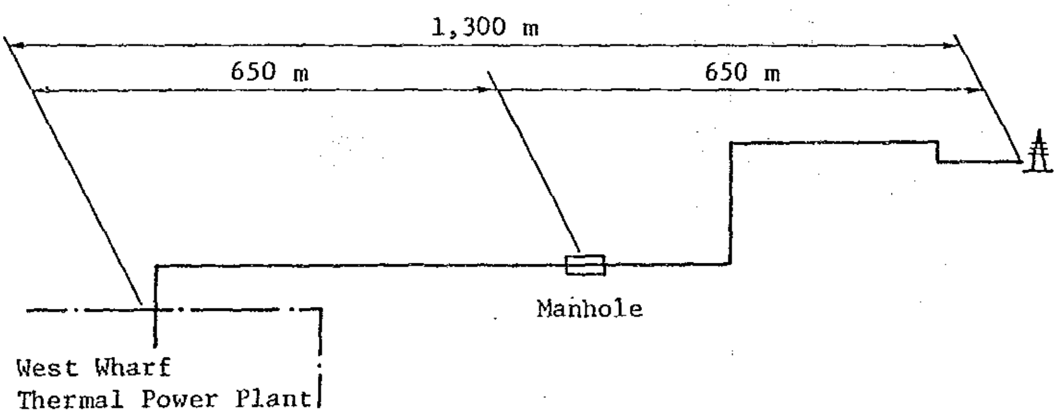
2. MANHOLE

2-1 Location of Manhole

Manholes should be positioned according to the available cable length and other locational conditions, such as public trafic, location of existing structures, facilities, etc.

At present, max. 1,300 m long cables are available, so, no manhole is needed along the underground cable.

However, in case that any manhole is needed in the West Wharf Project, the location will be planned as in Fig. 7.



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2-2 Dimensions of the Manhole

The dimensions of the manhole is as shown in Fig. 8 and Fig. 9 below.

The dimensions are decided considering of the size of cable joints and the allowable curvertures of the cables.

Fig. 8

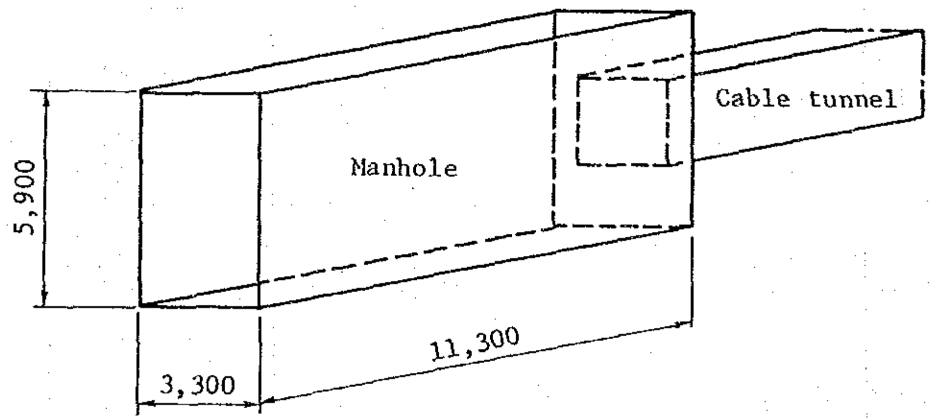


Fig. 9 Location of Cables inside Tunnel

Cable voltages: 275 kV, 154 kV

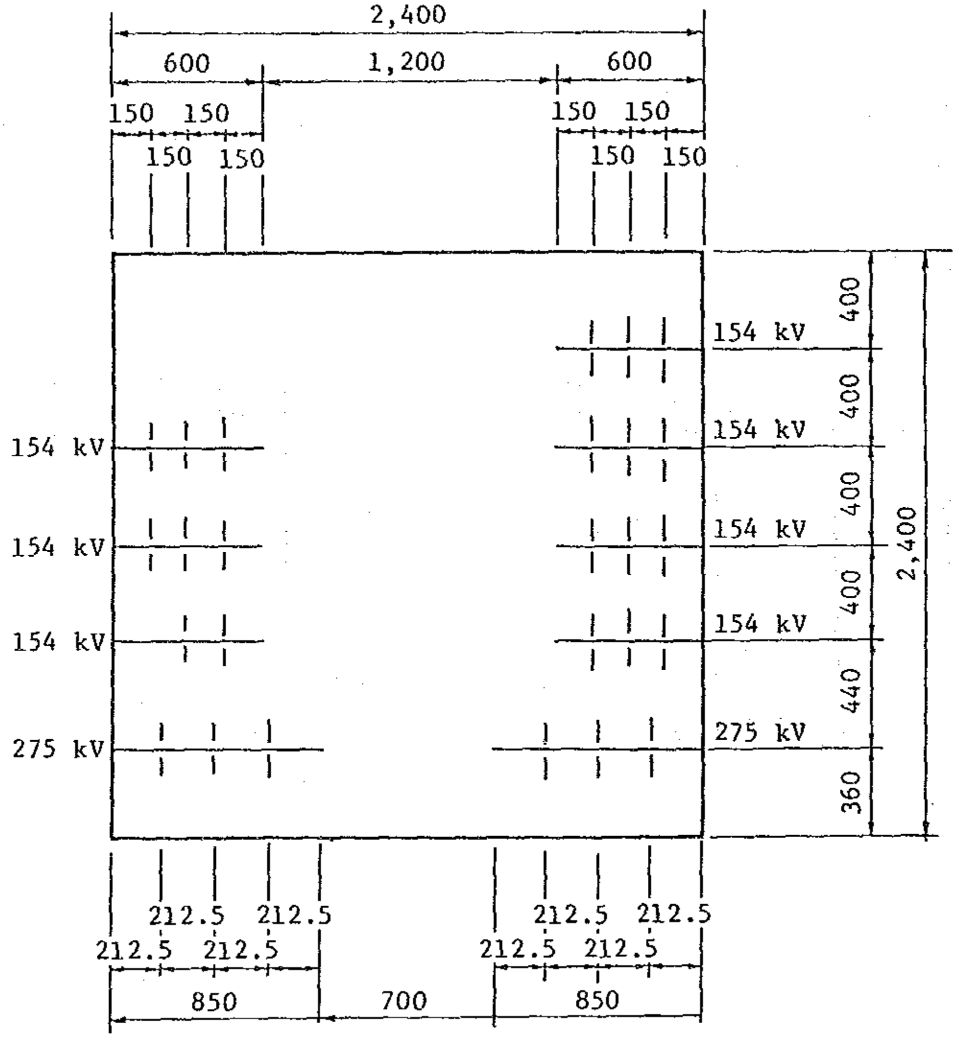
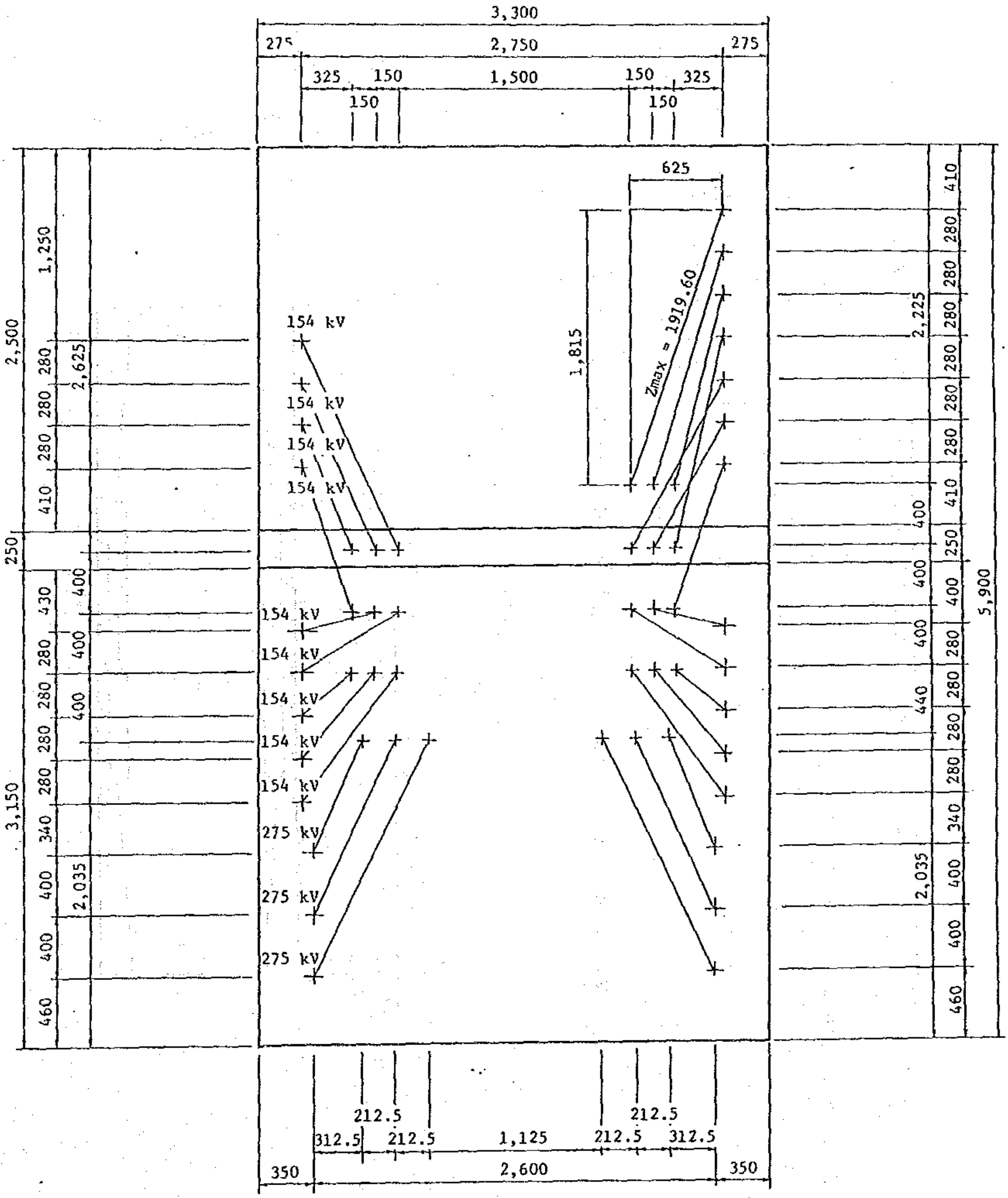


Fig. 10 Cable Offset inside Manhole

Note: Cable arrangement inside manhole.



$$Z_{max} = 0.625^2 + 1.815^2 = 1.9196$$
(154 kV)

Fig. 11 $\ell_o = \sqrt{Z\ max \cdot (4R - Z\ max)} = \sqrt{1.9196 \cdot (4 \times 1.50 - 1.9196)} = 2.80$ m

Manhole length $L = 2\ (\ell_o + \alpha_1) + (2\ \ell_1 + 0.70) + \alpha_2$

$= 2\ (2.80 + 0.40) + (2 \times 2.10 + 0.70) + \alpha_2$

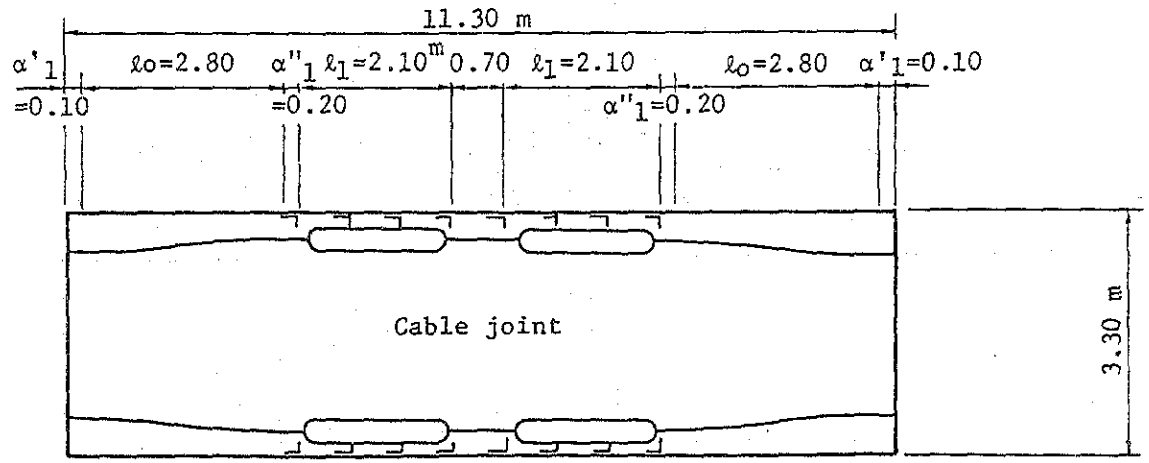
$= 11.30$ m * α_2 = adjusted value = 0

R: Design radius of curverture

154 kV ...... 1.50 m
275 kV ...... 1.80 m

α'_1 = straight line length α''_1 = joint bonding length

Plan Location



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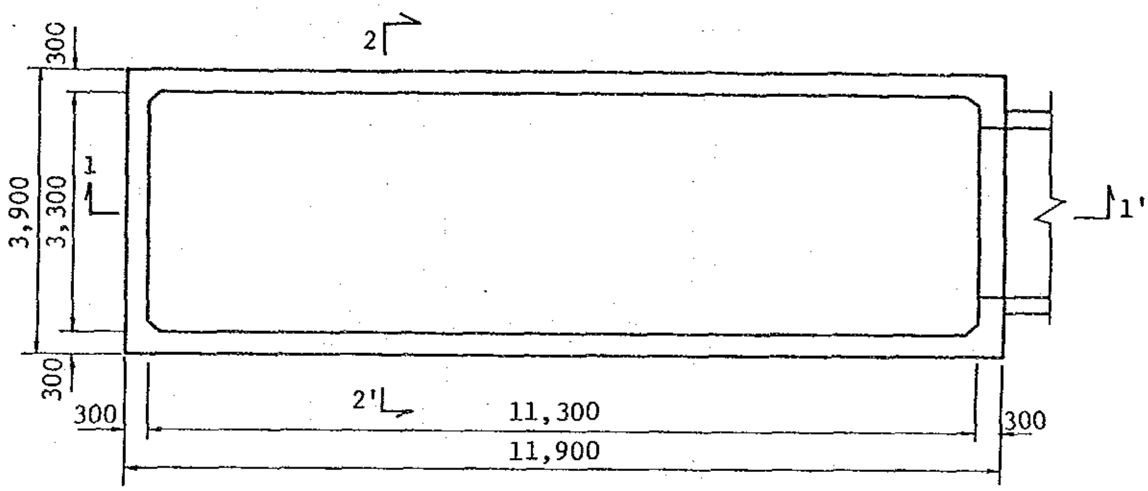
2-3 Manhole Structure

2-3-1 Design condition

Same as the cable tunnel (Fig. 12)



1 - 1' Section

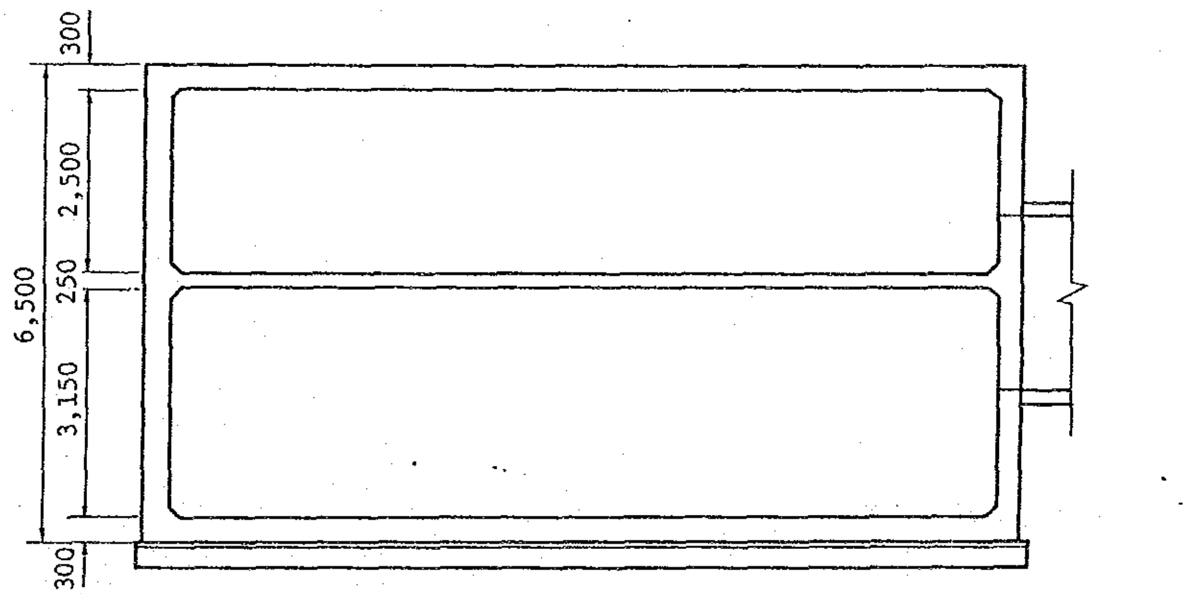
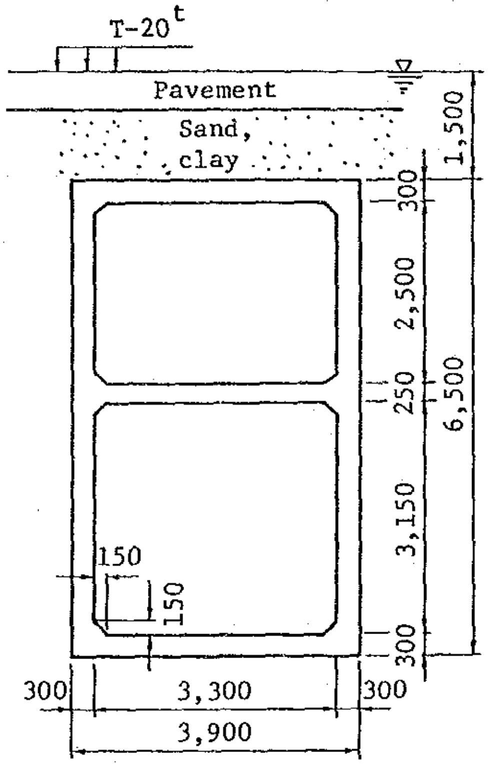


Fig. 13

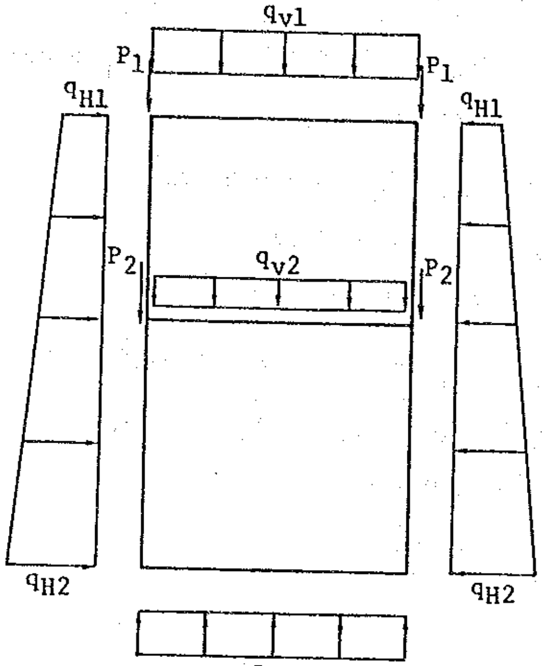
2-2' Section (Structural section)



2-3-2 Load

Imposed loads are culculated same as that of the tunnel.

Fig. 14



(a) Vertical pressure

$$q_{ve} = 2.75 + 2.3 \times 0.35 + 2.1 \times 0.4 + 2.0 \times 0.75$$
$$= 5.895 \ t/m^2$$

(b) Horizontal pressure

$$q_{He1} = 0.5 \times (2.75 + 2.3 \times 0.35 + 2.1 \times 0.4 + 1.1 \times 0.9)$$
$$= 2.693 \ t/m^2$$

$$q_{He2} = 2.693 + 0.5 \times (1.1 \times 6.2) = 6.103 \ t/m^2$$

(c) Horizontal water pressure

$$q_{Hw1} = 1.0 \times 1.65 = 1.65 \ t/m^2$$

$$q_{Hw2} = 1.0 \times 7.85 = 7.85 \ t/m^2$$

(d) Dead weight

Ceiling plate $q_{g1} = 2.5 \times 0.3 = 0.75 \ t/m^2$

Middle floor $q_{g2} = 2.5 \times 0.25 = 0.625\ t/m^2$

Side wall (upper) $P_1 = 2.5 \times 0.3 \times 2.775 = 2.081\ t$

Side wall (lower) $P_2 = 2.5 \times 0.3 \times 3.425 = 2.569\ t$

(e) Reaction force to the bottom plate

$$q_{v3} = q_{ve} + q_{g1} + q_{g2} + 2 \times (P_1 + P_2)/3.6 = 9.853\ t/m^2$$

(f) Imposed load (summary)

$q_{v1} = q_{ve} + q_{g1} = 6.645\ t/m^2$

$q_{v2} = q_{g2} = 0.625\ t/m^2$

$q_{v3} = 9.853\ t/m^2$

$q_{H1} = q_{He1} + q_{HW1} = 4.343\ t/m^2$

$q_{H2} = q_{He2} + q_{HW2} = 13.953\ t/m^2$

$P_1 = 2.081\ t$

$P_2 = 2.569\ t$

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2-3-3 Section force (calculation result)

(1) Side wall (upper)

	M (TON-M)	Q (TON)	N (TON)	
1-	5.7654	-7.7697	-14.0420	(1) Support (face)
2-	4.6497	-7.1008	-14.0420	(2) Haunch (starting point)
3-	3.6369	-6.3971	-14.0420	
4-	1.5065	-4.3838	-14.0420	
5-	-0.0978	-0.8141	-14.0420	
6-	-0.1446	-0.2518	-14.0420	(3) Center
7-	-0.1416	0.3223	-14.0420	
8-	1.3297	4.6261	-14.0420	
9-	3.9494	7.9315	-14.0420	
10-	5.0056	8.9709	-14.0420	
11-	5.2325	9.1817	-14.0420	(4) Haunch(starting point)
12-	6.4467	10.2501	-14.0420	(5) Support (face)

(2) Side wall (lower)

	M (TON-M)	Q (TON)	N (TON)	
12-	8.0349	-16.8229	-17.7360	(1) Support (face)
13-	6.0001	-15.7302	-17.7360	(2) Haunch (starting point)
14-	5.6096	-15.5088	-17.7360	
15-	3.7408	-14.3871	-17.7360	
16-	-3.0387	-8.8530	-17.7360	
17-	-6.7806	-0.7295	-17.7360	
18-	-6.8016	0.2532	-17.7360	(3) Center
19-	-6.7360	1.2478	-17.7360	
20-	-2.2807	10.4959	-17.7360	
21-	5.5554	17.7588	-17.7360	
22-	8.3718	19.7994	-17.7360	(4) Haunch (face)
23-	11.4970	21.8749	-17.7360	(5) Support (starting point)

M: Bending moment

Q: Shear force

N: Axial force

(3) Bottom Plate

	M (TON-M)	Q (TON)	N (TON)		
23-	11.4970	-17.7354	-21.8749	(1)	Support (face)
24-	8.9475	-16.2574	-21.8749	(2)	Haunch (starting point)
25-	6.6197	-14.7795	-21.8749		
26-	-0.4744	-8.8677	-21.8749		
27-	-4.4649	0.0000	-21.8749	(3)	Center
28-	-0.4744	8.8677	-21.8749		
29-	6.6197	14.7795	-21.8749		
30-	8.9475	16.2575	-21.8749		
31-	11.4970	17.7354	-21.8749		

(4) Ceiling plate

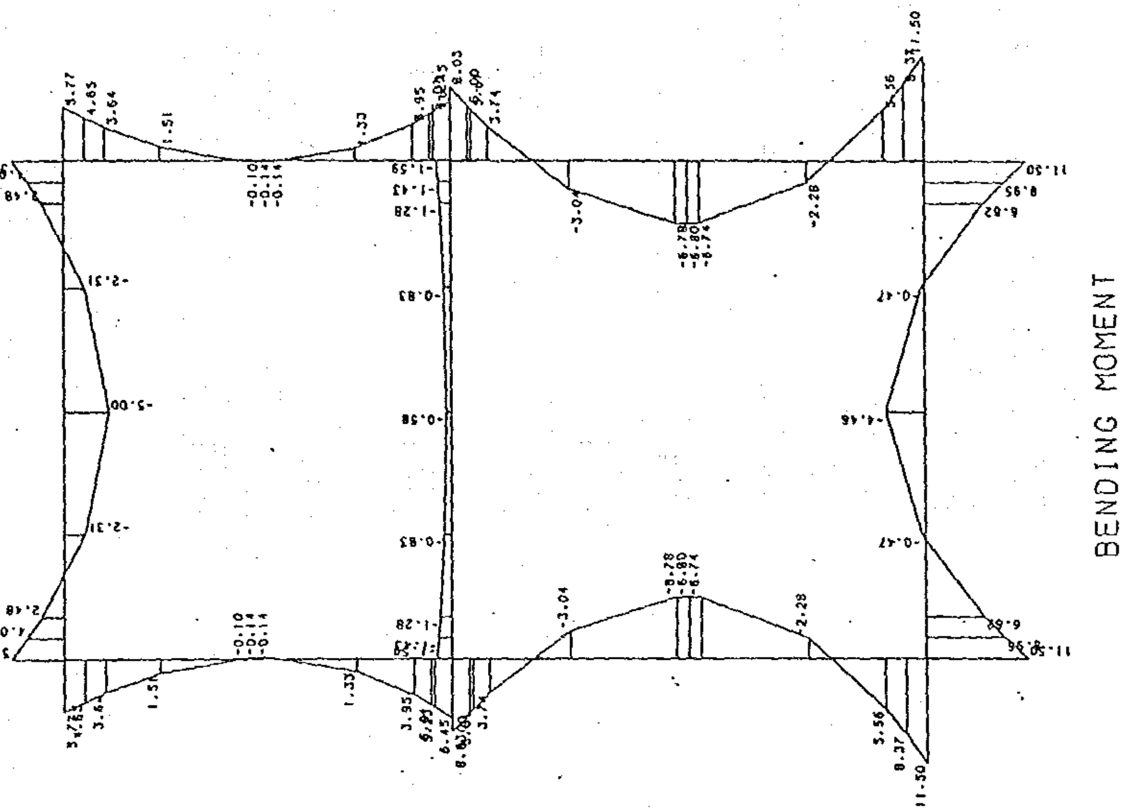
	M (TON-M)	Q (TON)	N (TON)		
53-	5.7654	-11.9610	-7.7697	(1)	Support (face)
54-	4.0460	-10.9642	-7.7697	(2)	Haunch (starting point)
55-	2.4761	-9.9675	-7.7697		
56-	-2.3083	-5.9805	-7.7697		
57-	-4.9995	0.0000	-7.7697	(3)	Center
58-	-2.3083	5.9805	-7.7697		
59-	2.4761	9.9675	-7.7697		
60-	4.0460	10.9643	-7.7697		
1-	5.7654	11.9610	-7.7697		

(5) Middle floor

	M (TON-M)	Q (TON)	N (TON)		
12-	-1.5882	1.1250	-27.0730	(1)	Support (face)
61-	-1.4264	1.0313	-27.0730	(2)	Haunch (starting point)
62-	-1.2788	0.9375	-27.0730		
63-	-0.8288	0.5625	-27.0730		
64-	-0.5757	0.0000	-27.0730		
65-	-0.8288	-0.5625	-27.0730		
66-	-1.2788	-0.9375	-27.0730		
67-	-1.4264	-1.0312	-27.0730		
42-	-1.5882	-1.1250	-27.0730		

M: Bending moment
Q: Shear force
N: Axial force

Fig. 15



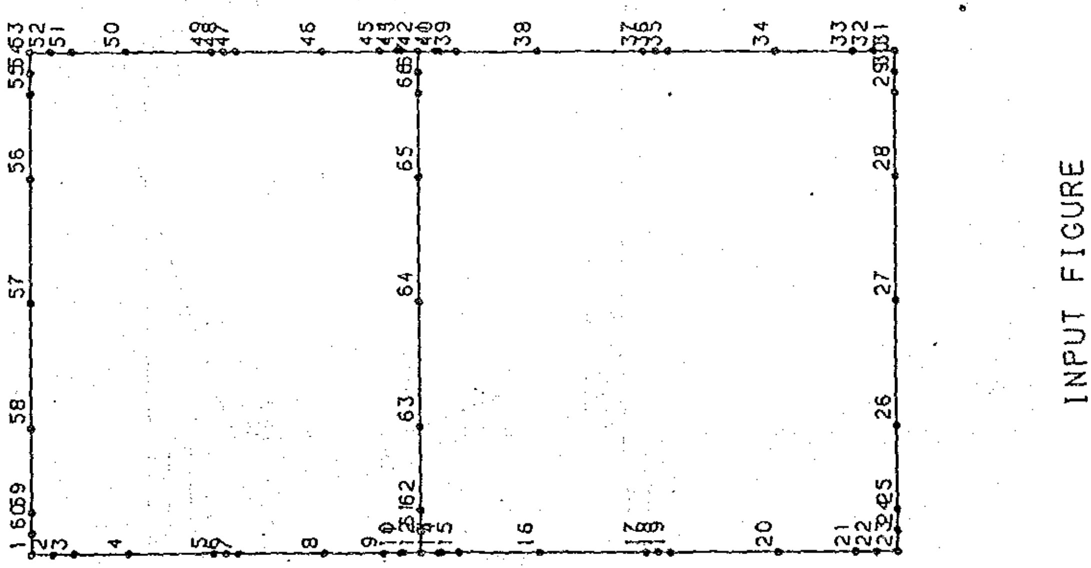
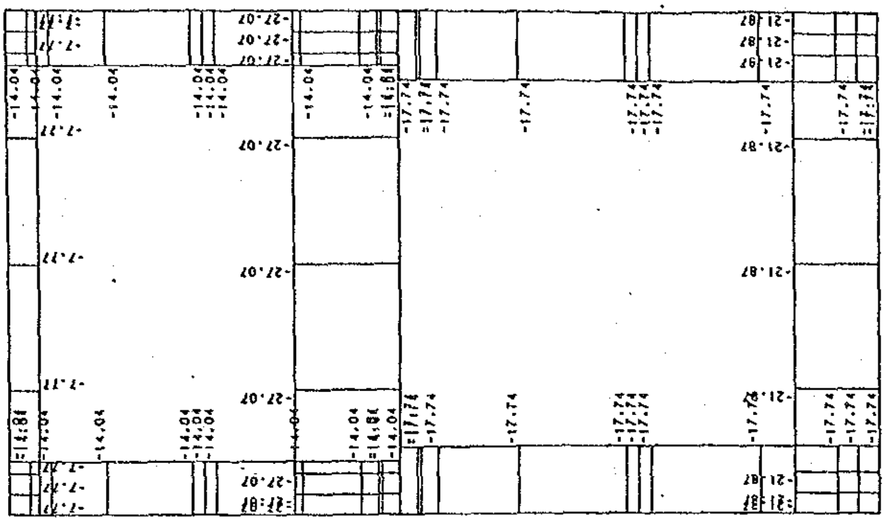
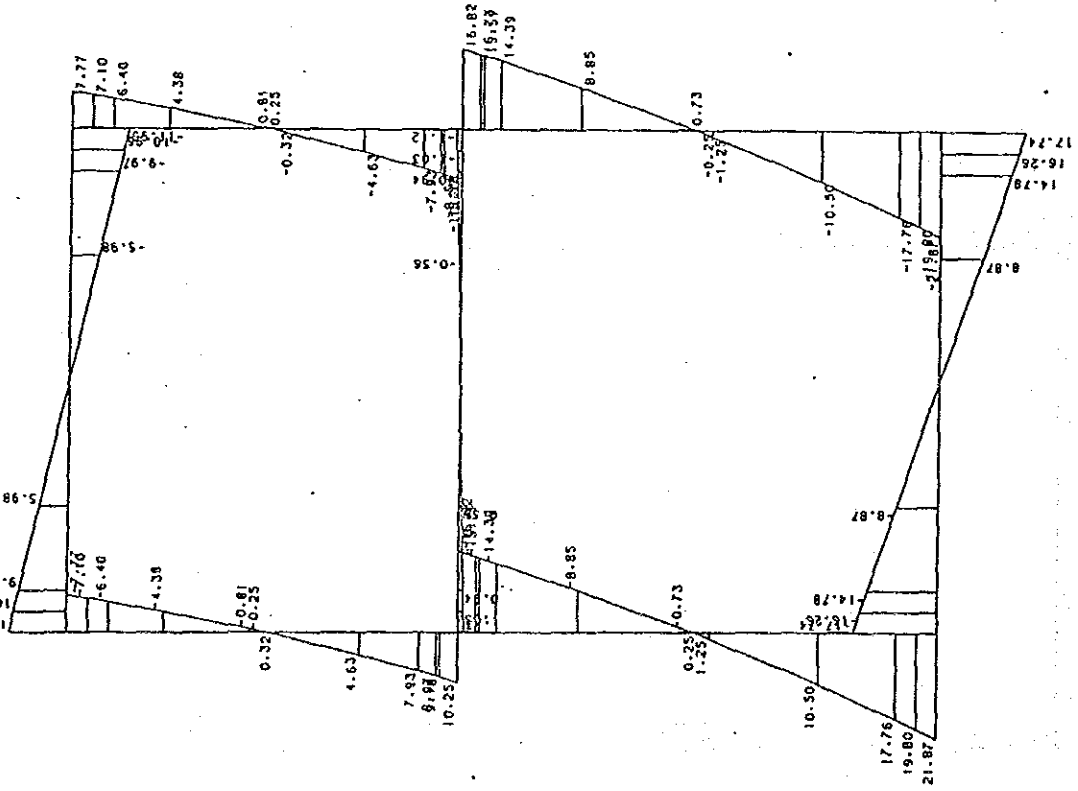


Fig. 16



AXIAL FORCE



SHEARING FORCE

2-3-4 Stress calculation result

(1) Side wall (upper)

Section No.		1-(1) Upper support (face)	1-(2) Upper haunch (starting point)	1-(3) Center
M	(t.m)	5.77	4.65	0.15
N	(t)	14.04	14.04	14.04
S	(t)	7.10	6.40	0.00
b	(cm)	100.0	100.0	100.0
h	(cm)	35.0	30.0	30.0
d	(cm)	30.0	25.0	25.0
d'	(cm)	10.0	5.0	5.0
As	(cm2)	10.843	10.843	4.223
As'	(cm2)	4.223	4.223	10.843
n =	Es/Ec	15.00	15.00	15.00
P=As/(b*d)	(%)	0.361	0.434	0.169
u=d-h/2	(cm)	12.500	10.000	10.000
f=M/N+u	(cm)	53.558	43.113	11.068
f/d		1.785	1.725	0.443
d'/d		0.333	0.200	0.200
As'/As		0.389	0.389	0.568
M'=M+N*u	(t.m)	7.521	6.054	1.554
x	(cm)	10.969	9.699	0.000
C		6.181	5.595	0.000
S		10.725	8.827	0.000
Z		1.079	1.095	0.000
c	(kg/cm2)	51.7	54.2	5.0
s	(kg/cm2)	1344.3	1282.4	-58.6
s'	(kg/cm2)	68.4	393.9	71.6
	(kg/cm2)	2.55	2.80	0.00
m	(kg/cm2)	2.37	2.56	0.00
ca	(kg/cm2)	90.0	90.0	90.0
sa	(kg/cm2)	1800.0	1800.0	1800.0
a	(kg/cm2)	4.50	4.50	4.50

Note: σs; (-) denotes compression, $\sigma s'$; (-1) denotes tension
m: mean shear stress

Reinforcement

Outside	D13, D16 alternately @ 150 = 10,843 cm^2	
Inside	D13 @ 300 = 4.223 cm^2	

Section No.	1-(4) Lower haunch (starting point)	1-(5) Lower support (face)
M (t.m)	5.23	6.45
N (t)	14.04	14.04
S (t)	8.97	9.18
b (cm)	100.0	100.0
h (cm)	30.0	35.0
d (cm)	25.0	30.0
d' (cm)	5.0	10.0
As (cm2)	10.843	10.843
As' (cm2)	4.223	4.223
n = Es/Ec	15.00	15.00
P=As/(b*d) (%)	0.434	0.361
u=d-h/2 (cm)	10.000	12.500
f=M/N+u (cm)	47.263	58.410
f/d	1.891	1.947
d'/d	0.200	0.333
As'/As	0.389	0.389
M'=M+N*u (t.m)	6.637	8.202
x (cm)	9.403	10.671
C	5.748	6.343
S	9.533	11.490
Z	1.100	1.083
c (kg/cm2)	61.0	57.8
s (kg/cm2)	1518.5	1570.7
s' (kg/cm2)	428.7	54.5
(kg/cm2)	3.95	3.32
m (kg/cm2)	3.59	3.06
ca (kg/cm2)	90.0	90.0
sa (kg/cm2)	1800.0	1800.0
a (kg/cm2)	4.50	4.50

Note: σs; (-) denotes compression, $\sigma s'$; (-1) denotes tension
m: mean shear stress

Reinforcement

Outside D13, D16 alternately @ 150 = 10,843 cm^2

Inside D13 @ 300 = 4.223 cm^2

(2) Side wall (lower)

Section No.		2-(1) Upper support (face)	2-(2) Upper haunch (starting point)	2-(3) Center
M	(t.m)	8.03	6.00	6.90
N	(t)	17.74	17.74	17.74
S	(t)	15.73	15.51	0.00
b	(cm)	100.0	100.0	100.0
h	(cm)	35.0	30.0	30.0
d	(cm)	30.0	25.0	25.0
d'	(cm)	10.0	5.0	5.0
As	(cm2)	13.240	13.240	13.240
As'	(cm2)	13.240	13.240	13.240
n =	Es/Ec	15.00	15.00	15.00
P=As/(b*d)	(%)	0.441	0.530	0.530
u=d-h/2	(cm)	12.500	10.000	10.000
f=M/N+u	(cm)	57.803	43.830	48.904
f/d		1.927	1.753	1.956
d'/d		0.333	0.200	0.200
As'/As		1.000	1.000	1.000
M'=M+N*u	(t.m)	10.252	7.774	8.674
x	(cm)	11.359	9.895	9.560
C		5.858	4.921	5.073
S		9.614	7.512	8.193
Z		1.094	1.116	1.120
c	(kg/cm2)	66.7	61.2	70.4
s	(kg/cm2)	1642.7	1401.5	1705.5
s'	(kg/cm2)	119.8	454.1	503.7
	(kg/cm2)	5.73	6.92	0.00
m	(kg/cm2)	5.24	6.20	0.00
ca	(kg/cm2)	90.0	90.0	90.0
sa	(kg/cm2)	1800.0	1800.0	1800.0
a	(kg/cm2)	4.50	4.50	4.50

Note: σs; (-) denotes compression, σs'; (-1) denotes tension
m: mean shear stress

Reinforcement

Outside	D16 @ 150	= 13.24 cm^2
Inside	D16 @ 150	= 13.24 cm^2

Reinforcement with stirrup is applied because the upper shear stresses exceed the allowable stress.

Section No.		1-(4) Lower haunch (starting point)	1-(5) Lower support (face)
M	(t.m)	8.37	11.50
N	(t)	17.74	17.74
S	(t)	17.76	19.80
b	(cm)	100.0	100.0
h	(cm)	30.0	35.0
d	(cm)	25.0	30.0
d'	(cm)	5.0	10.0
As	(cm2)	22.453	22.453
As'	(cm2)	13.240	13.240
n =	Es/Ec	15.00	15.00
P=As/(b*d)	(%)	0.898	0.748
u=d-h/2	(cm)	10.000	12.500
f=M/N+u	(cm)	57.202	77.323
f/d		2.288	2.577
d'/d		0.200	0.333
As'/As		0.590	0.590
M'=M+N*u	(t.m)	10.145	13.714
x	(cm)	11.123	12.738
C		4.455	5.215
S		5.559	7.068
Z		1.151	1.144
c	(kg/cm2)	72.3	79.5
s	(kg/cm2)	1353.6	1615.5
s'	(kg/cm2)	597.2	256.2
	(kg/cm2)	8.17	7.55
m	(kg/cm2)	7.10	6.60
ca	(kg/cm2)	90.0	90.0
sa	(kg/cm2)	1800.0	1800.0
a	(kg/cm2)	4.50	4.50

Note: σs; (-) denotes compression, σs'; (-) denotes tension
m: mean shear stress

	Reinforcement
Outside	D19, D22 alternately @ 150 = 22.453 cm^2
Inside	D16 @ 150 = 13.24 cm^2

Reinforcement with stirrup is applied because the shear stresses at lower side exceed the allowable stress.

(3) Bottom plate

Section No.		3-(1) Support (force)	3-(2) Haunch (original point)	3-(3) Center
M	(t.m)	11.50	8.95	4.46
N	(t)	21.87	21.87	21.87
S	(t)	16.26	14.78	0.00
b	(cm)	100.0	100.0	100.0
h	(cm)	35.0	30.0	30.0
d	(cm)	30.0	25.0	25.0
d'	(cm)	10.0	5.0	5.0
As	(cm2)	22.453	22.453	13.240
As'	(cm2)	13.240	13.240	22.453
n =	Es/Ec	15.00	15.00	15.00
P=As/(b*d)	(%)	0.748	0.898	0.530
u=d-h/2	(cm)	12.500	10.000	10.000
f=M/N+u	(cm)	65.058	50.903	30.411
f/d		2.169	2.036	1.216
d'/d		0.333	0.200	0.200
As'/As		0.590	0.590	1.696
M'=M+N*u	(t.m)	14.231	11.135	6.652
x	(cm)	13.150	11.415	11.393
C		5.058	4.362	3.941
S		6.481	5.191	4.707
Z		1.141	1.147	1.081
c	(kg/cm2)	80.0	77.7	42.0
s	(kg/cm2)	1537.2	1387.3	751.5
s'	(kg/cm2)	287.4	655.1	353.1
	(kg/cm2)	6.18	6.78	0.00
m	(kg/cm2)	5.42	5.91	0.00
ca	(kg/cm2)	90.0	90.0	90.0
sa	(kg/cm2)	1800.0	1800.0	1800.0
a	(kg/cm2)	4.50	4.50	4.50

Note: σs; (-) denotes compression, σs'; (-) denotes tension
m: mean rear stress

Reinforcement

Outside D19, D22 alternately @ 150 = 22.453 cm^2

Inside D16 @ 150 = 13.24 cm^2

Reinforcement with stirrup is applied because of the shear stresses at the end points exceed the allowable stress.

(4) Ceiling plate

Section No.		4-(1) Support (force)	4-(2) Hanch (starting point)	4-(3) Center
M	(t.m)	5.77	4.05	5.00
N	(t)	7.77	7.77	7.77
S	(t)	10.96	9.97	0.00
b	(cm)	100.0	100.0	100.0
h	(cm)	35.0	30.0	30.0
d	(cm)	30.0	25.0	25.0
d'	(cm)	10.0	5.0	5.0
As	(cm2)	10.843	10.843	10.843
As'	(cm2)	10.843	10.843	10.843
n =	Es/Ec	15.00	15.00	15.00
P=As/(b*d)	(%)	0.361	0.434	0.434
u=d-h/2	(cm)	12.500	10.000	10.000
f=M/N+u	(cm)	86.704	62.074	74.346
f/d		2.890	2.483	2.974
d'/d		0.333	0.200	0.200
As'/As		1.000	1.000	1.000
M'=M+N*u	(t.m)	6.737	4.823	5.776
x	(cm)	9.789	8.471	8.196
C		3.953	5.827	6.013
S		4.754	11.372	12.327
Z		1.083	1.115	1.117
c	(kg/cm2)	51.8	45.0	55.6
s	(kg/cm2)	1602.9	1316.3	1709.0
s'	(kg/cm2)	16.7	276.4	325.1
	(kg/cm2)	0.00	4.45	0.00
m	(kg/cm2)	3.65	3.99	0.00
ca	(kg/cm2)	90.0	90.0	90.0
sa	(kg/cm2)	1800.0	1800.0	1800.0
a	(kg/cm2)	4.50	4.50	4.50

Note: σs; (-) denotes compression, σs'; (-) denotes tension
m: mean shear stress

Reinforcement

Outside D13, D16 alternately @ 150 = 10.843 cm^2

Inside D13, D16 alternately @ 150 = 10.843 cm^2

(5) Middle floor

Section No.		5-(1)	5-(2)
M	(t.m)	1.59	1.43
N	(t)	27.07	27.07
S	(t)	1.03	0.94
b	(cm)	100.0	100.0
h	(cm)	40.0	30.0
d	(cm)	30.0	25.0
d'	(cm)	10.0	5.0
As	(cm2)	4.223	4.223
As'	(cm2)	4.223	4.223
n =	Es/Ec	15.00	15.00
P=As/(b*d)	(%)	0.141	0.169
u=d-h/2	(cm)	10.000	10.000
f=M/N+u	(cm)	15.866	15.269
f/d		0.529	0.611
d'/d		0.333	0.200
As'/As		1.000	1.000
M'=M+N*u	(t.m)	4.296	4.134
x	(cm)	0.000	29.406
C		0.000	0.000
S		0.000	0.000
Z		0.000	0.000
c	(kg/cm2)	12.4	17.7
s	(kg/cm2)	-54.8	-39.7
s'	(kg/cm2)	142.0	220.0
	(kg/cm2)	0.00	0.00
m	(kg/cm2)	0.34	0.38
ca	(kg/cm2)	90.0	90.0
sa	(kg/cm2)	1800.0	1800.0
a	(kg/cm2)	4.50	4.50

Note: σs; (-) denotes compression, σs'; (-1) denotes tension
m: mean shear stress

Reinforcement

Outside D13 @ 300 = 4.223 cm^2

Inside D13 @ 300 = 4.223 cm^2

2-3-5 Sirrup

(1) Side wall (lower side) - upper ends

Required cross sectional area   req Av

$Sc = 1/2 \times 4.5 \times 100 \times 0.875 \times 25 \times 10^{-3} = 4.922$ t

$sv = 15.51 - 4.922 = 10.588$ t

$$\text{req } Av = \frac{Sv.s}{sa.j.d} = \frac{10.588 \times 10^{3}\ 15}{1{,}800 \times 0.875 \times 25}$$

$$= 4.034 \text{ cm}^2 > D13\ @\ 300 = 4.223 \text{ cm}^2$$

Therefore, stirrups (D13) are placed with 15 cm space in a section and 300 cm axial pitch.

(2) Side wall (lower side) - lower ends

$Sc = 4.922$ t

$Sv = 17.76 - 4.922 = 12.838$ t

$$\text{req } Av = \frac{12.838 \times 10^{3} \times 15}{1{,}800 \times 0.875 \times 25} = 4.891 \text{ cm}^2 < D13\ @\ 150$$

$$= 8.447 \text{ cm}^2$$

Therefore, stirrups (D13) are placed with 15 cm space in a section and 150 mm axial pitch.

(3) Bottom plate

$Sc = 4.922$ t

$Sv = 14.78 - 4.922 = 9.858$ t

$$\text{req } Av = \frac{9.858 \times 10^{3} \times 15}{1{,}800 \times 0.875 \times 25} = 3.755 \text{ cm}^2 < D13\ @\ 300$$

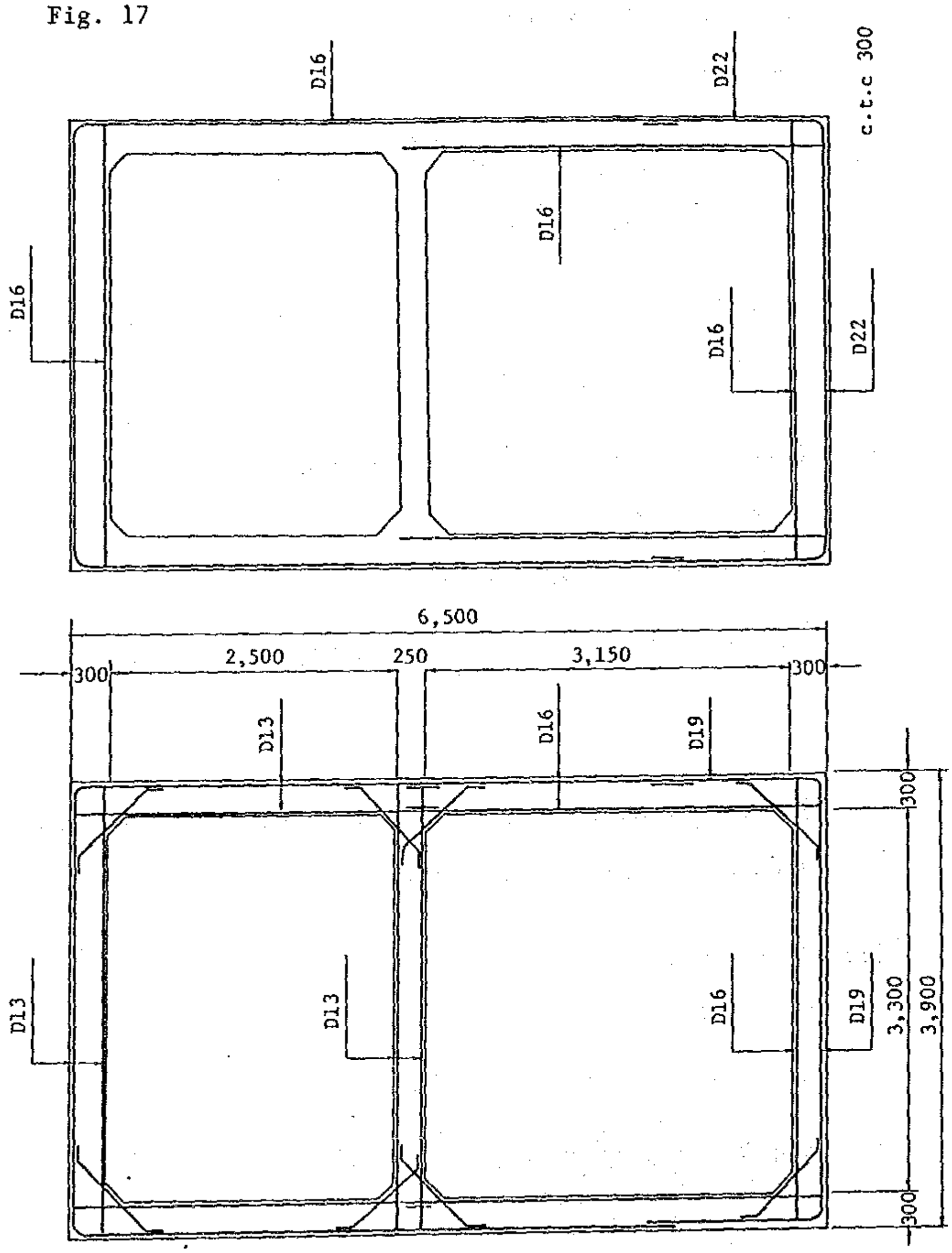
$$= 4.223 \text{ cm}^2$$

Therefore, stirrups (D13) are placed with 15 cm space in a section and 300 mm axial pitch.

2-3-6 Summary

The wall thicknesses and reinforcement bars decided by the above calculations are shown in Fig. 17 below.

Fig. 17



The wall thickness is decided as 300 mm with above reinforcement according to the calculation.

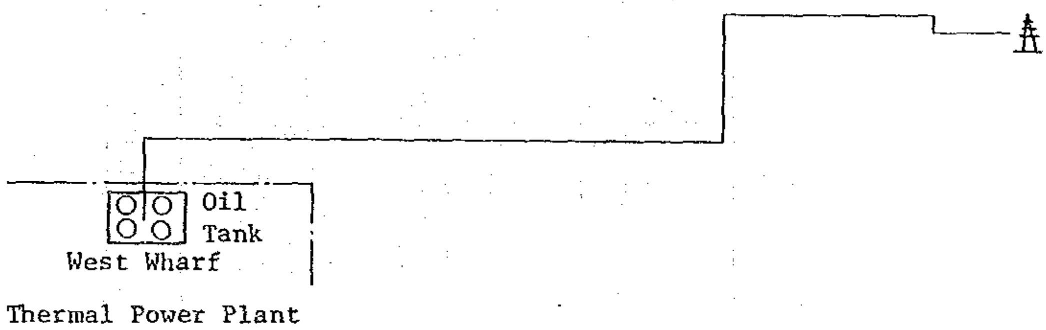
3. Oil Tanks

3-1 Location of the Oil Tanks

Oil tank for oil filled cable can be located at the end of the cable, in case that the cable length is about 1.3 km or less.

Oil tanks preferably be located at the station side for the convenience of maintenance and be put on the roof of the switchyard building in order to have oil pressure, thus eliminating any oil pump installation.

Fig. 18



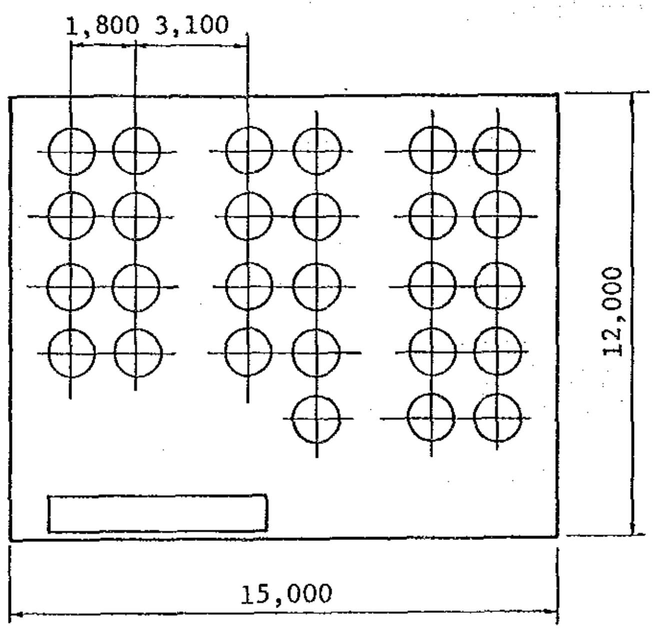
3-2 Oil Tank Yard

One oil tank is needed for one cable.

Therefore, in the case of the West Wharf Power Plant Project, 27 units are necessary.

One oil tank having about 500 capacity (1.2 m diameter x 1.7 m height) will be sufficient.

Fig. 19

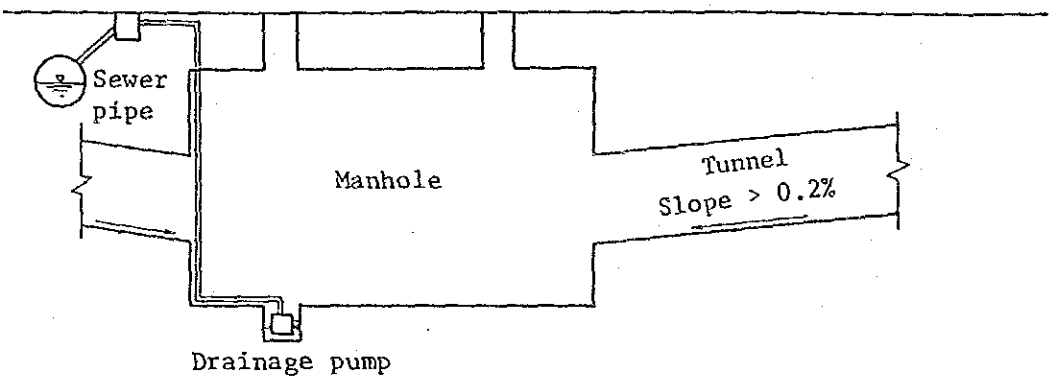


Oil tank area A = 180 m^2 200 m^2

4. Drainage

Water leaked into the tunnel will be collected in a drain pit inside the manhole and pumped up to a sewer pipe or other discharge way. Cable tunnel should have a slope of 0.2% and more for better drainage.

Fig. 20



TLG-4

GRID STATION FACILITIES

TLG-4 GRID STATION FACILITIES

1. General

Two (2) numbers of 220 kV transmission bays will be extended with existing facilities of the 220 kV Baldia grid station in order to receive electrical power from the West Wharf thermal power station Units No. 1 and No. 2.

2. Basic Requirement

The layout of equipment, facilities and basic specification of the 220 kV Baldia Grid Station extension plan of the Project will be in complete harmony with the existing equipment, facilities and the future extension plan of the Baldia Grid Station.

The current carrying capacity of power receiving facilities for the new 220 kV transmission line from the West Wharf Thermal Power Plant will be 1,250 Ampere based on the output of 400 MW (2 units of 200 MW).

3. Design concept

(1) Specification of switchgear

Type of switchgear	:	Indoor, SF6 Gas Insulated switchgear
Bus configuration	:	Double bus system
Rated voltage	:	220 kV
Highest system voltage	:	245 kV
Rated frequency	:	50 Hz

Insulation level

Impulse withstand voltage (1.2/50 wave): 950 kV (peak)

Power frequency withstand voltage : 395 kV

Max. asymmetric three-phase short-circuit withstand current : 100 kA (peak)

Short-time current (1 sec) : 40 kA

(2) Grounding system

(a) 150 mm^2 bare annealed copper wire shall be connected to the 220 kV equipment and steel structure.

(b) Grid (mesh) grounding wire shall be 100 mm^2 bare annealed copper wire which shall be connected to the existing grid (mesh) grounding wire.

(c) Grounding wire for control & protection panels, auxiliaries equipment and building facilities shall conform to the existing grounding wires.

(3) Control cables

(a) Since 220 kV system adopts the direct grounding method, control cables shall be PVC insulated and PVC sheathed control cables with copper tape electrostatic shielding (CVV-S).

(b) Voltage class: 600V grade

(c) Cable laying method: Racks in trench

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(4) Steel structure and pedestals of equipment

Design of the steel structure and pedestals of equipment shall conform to the existing structure.

(5) Relay and control system

(a) Power system frequency : 50 Hz

(b) PT secondary rating : $100/\sqrt{3}$ V

(c) CT secondary rating : 1 A

(d) AC auxiliary power supply : 380 V

(e) DC auxiliary power supply : 220 V

(f) Interlock conditions

Between circuit breaker and isolators

between circuit breaker and high speed earthing switch

between isolator and working earthing switch

(g) Synchronizing switch: Transmission line and bus

(h) Protection system of transmission line

Main: Directional distance relay with transfer trip by P.L.G. system
(Single and/or three phase reclosing)

Backup: Directional distance relay and time delay nondirectional overcurrent relay

(6) 220 kV switchgear

(a) Common features

- Type : Indoor, 220 kV SF6 Gas Insulated Metalclad Switchgear

- Standards : IEC

- Rated voltage : 220 kV
- Maximum system voltage : 245 kV
- Rated frequency : 50 Hz
- Rated short-circuit current: 40 KA
- Insulation medium : SF6
- Materials of enclosures : Aluminum
- Impulse withstand voltage
  - at nominal gas pressure : 950 kV (peak)
  - at minimum gas pressure : 950 kV (peak)
- Power frequency withstand voltage
  - at nominal gas pressure : 395 kV
  - at minimum gas pressure : 395 kV
- Rated short-time withstand current (1 sec): 40 kA
- Rated peak short-circuit current : 100 kA

(b) Bus bar

- Rated normal current at 48°C ambient: 3,150 A
- Bus bar cross section : 3,140 mm^2
- Bus bar materials : Aluminium
- Bus bar enclosed tubing : Single-phase
- Tubing diameter : 315/305 mm
- Density of SF6 in the switchgear : 33.4 kg/m^3
- Rated pressure of SF6 insulation at 20°C: 5.5 bar
- Max. and min. admissible pressure at SF6: 6.5/5.0 bar insulation at 20°C

(c) Circuit breaker

- Standards : IEC

- Rated voltage : 245 kV
- Rated current : 1,250 A
- Rated short circuit breaking current: 40 kA
- Rated short circuit making current : 100 kA
- Impulse withstand voltage (peak) : 950 kV
- Power frequency withstand voltage : 395 kV
- Total opening time at minimum supply voltage and specified gas pressure : 50 m.sec
- Total closing time at minimum supply voltage and specified gas pressure : 80 m.sec
- Driving mechanism
  . type : Motorop.spring
  . rated supply voltage : D.C. 220 V
  . rated of driving motor : 800/900 VA
- Auto-reclose : Single-phase and three-phase
- Rated operating sequence : 0-0.3sec.-CO-3min.-CO
- Number of trip coils : 2
- Arc quenching medium : SF6
- Rated arc quenching pressure of SF6 insulation at 20°C : 6.5 bar
- Max. and min. admissible pressure of SF6 insulation at 20°C : 7.7/6.0 bar

(d) Isolator
- Standards : IEC
- Rated normal current at 48°C ambient : 1,250 A

- Rated short-time withstand current : 40 kA
- Rated peak short-circuit current : 100 kA
- Impulse withstand voltage (peak) : 950 kV
- Power frequency withstand voltage : 395 kV
- Operating mechanism : Motor drive and hand-operated
  . Motor voltage : DC 220 V
  . Rating of driving motor : 375 VA

(e) High speed earthing switch

- Standards : IEC
- Rated making current : 40 kA
- Rated peak short-circuit current : 100 kA
- Impulse withstand voltage (peak) : 950 kV
- Power frequency withstand voltage : 395 kV
- Operating mechanism : Motor drive and hand-operated
  . Motor voltage : DC 220 V
  . Rating of driving motor : 375 VA

(f) Working earthing switch

- Standards : IEC
- Rated making current : 40 kA
- Impulse withstand voltage (peak) : 950 kV
- Power frequency withstand voltage : 395 kV
- Operating mechanism : Handoperated

(g) Current transformer

- Standards : IEC, BS
- Rated primary current : 700, 1,250, 3,000 A
- Rated secondary current : 1 A

- Accuracy class
  - . Measuring : CL 0.2
  - . Protection 1 : 5P 30
  - . Protection 2 : 5P 30
  - . Differential protection : CL X(BS 3938)
- Rated output
  - . Measuring : 20 VA
  - . Protection 1 : 40 VA
  - . Protection 2 : 40 VA
  - . Differential protection : CL X(BS 3938)
- Saturation factor
  - . Measuring : FS < 10 n
  - . Protection 1 : 30 n
  - . Protection 2 : 30 n
  - . Differential protection : Vknee 500 V
- Rated short-time withstand current : 100 kA
- Impulse withstand voltage (peak) : 900 kV
- Power frequency withstand voltage : 395 kV
- Insulation materials : Epoxy/SF6

(h) Voltage transformer

- Standards : IEC
- Rated primary voltage : $220/\sqrt{3}$ kV
- Rated secondary voltage : $100/\sqrt{3}$ V
- Rated tertiary voltage : $100/\sqrt{3}$ V
- Accuracy class : 1.0
- Rated output
  - . Secondary : 200 VA

. Tertiary : 50 VA

- Impulse withstand voltage (peak) : 900 kV

- Power frequency withstand voltage : 395 kV

(7) Outdoor 200 kV equipment

(a) Bushing

- Standards : IEC

- Rated voltage : 245 kV

- Rated current : 1,250 A

- Impulse withstand voltage (peak) : 950 kV

- Power frequency withstand voltage : 395 kV

- Specified creepage distance : 3.5 cm/kV

- Conductor : Aluminium

(b) Lightning arrester

- Standards : IEC

- Rated voltage : 220 kV

- Maximum system voltage : 245 kV

- Rating of arrester : 198 kV

- Rated discharge current : 10 kA
- Maximum residual voltage : 649 kV

- Impulse withstand voltage (peak) : 950 kV

- Power frequency withstand voltage : 395 kV

(8) Power line carrier system

(a) Capacitor voltage transformer

- Type : Outdoor, CCPD

- Standards : IEC

- Rated primary voltage : $220/\sqrt{3}$ kV
- Rated secondary voltage : $100/\sqrt{3}$ V
- Rated tertiary voltage : $100/\sqrt{3}$ V
- Accuracy class : 1.0
- Rated output
  . Secondary : 200 VA
  . Tertiary : 50 VA
- Capacitance : 0.002 μF
- Impulse withstand voltage (peak) : 900 kV
- Power frequency withstand voltage : 395 kV

(b) Line trap

- Standards : IEC
- Rated current : 1,250 A
- Rated short-time current : 31.5 kA
- Rated frequency : 50 Hz
- Frequency band : 100 - 500 kHz
- Inductance : 0.2 mH
- Method of mounting : Mounting on the capacitor voltage transformer

(c) Coupling filter

- Nominal impedance
  . PLC side : Z2 = 75/125 ohm (unbalance)
  . Line side : Z1 = 240/320 ohm
- Range of coupling capacitance : 1.5 to 13 nF
- Composite loss within passband : less than 1.0 dB
- Return loss within passband : more than 12 dB
- Crossover attenuation of hybrid : more than 20 dB

- Average continuous power : 200 W
- Nominal peak power
  . at 50 kHz : less than 400W
  . at 100 kHz : less than 1,000W
- Protection devices
  . Drain coil
  . Earthing switch
  . Lightning arrester

(d) Power line carrier equipment

- Type : Single-sideband with reduced carrier
- RF range : 24 to 500 kHz
- Nominal bandwidth : 4 kHz
- RF system impedance : 50, 75, 125 ohm unbalanced or 150 ohm balanced
- Useful AF bandwidth : 300 to 3,480 Hz
- Ambient conditions
  . Temperature : 0 - 55°C
  . Humidity : < 95%

(Transmitter data)

  . RF output power : 20W
  . AF input (Speech) : 600 ohm balanced
  . Signalling : External contact keys pilot oscillator at 50 baud max.
  . Teleoperations : 5 decoupled and individually adjustable input, 600 ohm balanced

(Receiver data)

. RF sensitivity

at carrier frequency 24 kHz : -38 dBm

at carrier frequency 496 kHz: -24 dBm

. Selectivity

from 4 kHz carrier band

$\geq$ 0.3 kHz	:	62 dB
$\geq$ 4 kHz	:	120 dB

Image rejection

$\leq$ 400 kHz	:	80 dB
$\geq$ 400 kHz	:	70 dB
I.F. rejection	:	$\leq$ 80 dB
. AF output (Speech)	:	600 ohm balanced
. Signalling	:	Potential-free contact

(Power supplies)

. Main	:	A.C. 220 V $\pm$ 15% 50 Hz
. Battery	:	D.C. 48 V

(e) Protection signalling equipment

- Transmission time

. Blocking application	:	< 14 ms
. Permissive tripping	:	< 14 ms
. Direct tripping	:	< 16 ms
- Alarm output	:	20 VA
- Power supply	:	Stabilized voltage from PLC set - 40 $\pm$ 2.5 V
- Current consumption	:	160 - 450 mA
- Ambient temperature	:	0 to 55^{o}C

(Transmitter data)

. Separate starting input per command input

Interface 1

Command initiated by	:	Potential-free contact
Input relay supply	:	from - 40 V
Max. contact current	:	4mA

Interface 2

Command initiated by	:	Contact + battery
Battery voltage	:	220, 125, 110, 60, 48 V
Max. input current	:	4mA

. Command frequency

1st command A	:	1,300 ± 10 Hz
2nd command B	:	1,700 ± 10 Hz
Both command (A + B)	:	1,500 ± 10 Hz

. Signal boost in PLC set : 10 to 16 dB

(Receiver data)

. Receiver input	:	Matched to PLC set 20 dB level reserve
. Command outputs		
1 main contact per command	:	either N/C or N/O
Contact rating	:	100VA, 250V D.C. 1A 10VA, 500V, 0.5A
. Auxiliary output	:	1 normally open contact per command Rating: 50VA, 250V D.C. 1A

(f) High frequency coaxial cable for PLC

- Type : Armoured coaxial cable
- Impedance : 120 ± 5% ohm
- Capacitance : 36 pF/m
- Resistance of conductor : ≤ 37 ohm/km
- Attenuation
  - . at 40 kHz : 0.15 dB/100m
  - . at 500 kHz : 0.38 dB/100m
- Conductor : Copper single core 0.8 mmø

4. Bill of Quantity

No.	Description		Quantity
	(220 kV SF6 Gas Insulated Switchgear)		
1.	Bus bar	220 kV, 3,150 A, Single-phase Type	1 lot
2.	Circuit Breaker	3ϕ, 220 kV, 1,250 A, 40 kA	2 sets
3.	Isolator	3ϕ, 220 kV, 1,250 A, 40 kA mechanism	8 sets
4.	High Speed Earthing Switch	3ϕ, 220 kV, 40 kA with motor operated mechanism	2 sets
5.	Working Earthing Switch	3ϕ, 220 kV, 40 kA with handoperated mechanism	4 sets
6.	Current Transformer	Bushing Type No. 1 core 700 - 1,250/1A No. 2 core 700 - 1,250/1A No. 3 core 700 - 1,250/1A No. 4 core 3,000/1A	6 sets
7.	Voltage Transformer	1ϕ, $\frac{220}{\sqrt{3}}/\frac{0.10}{\sqrt{3}}/\frac{0.10}{\sqrt{3}}$ kV 200 VA, 50 VA	6 sets
8.	Bushing	Outdoor type, 1ϕ, 245 kV 1,250 A, 40 kA	6 sets
	(220 kV Outdoor Equipment)		
9.	Lightning Arrester	1ϕ, 198 kV, 10 kA	6 sets
	(Power Line Carrier System)		
10.	Capacitor Voltage Transformer	1ϕ, $\frac{220}{\sqrt{3}}/\frac{0.10}{\sqrt{3}}/\frac{0.10}{\sqrt{3}}$ kV 200 VA, 50 VA	2 sets

No.		Description	Quantity
11.	Line Trap	1,250 A, 0.2mH mounting on the C.V.T.	2 sets
12.	Coupling Filter	75/125 ohm	2 sets
13.	Power Line Carrier Equipment	24 to 500 kHz Single-sideband with reduced carrier	2 sets
14.	Protection Signalling Equipment		2 sets
15.	Coaxial Cable for PLC (Others)		1 lot
16.	Grounding System		1 lot
17.	Steel Structure and Pedestals		1 lot
18.	Control Cables		1 lot
19.	Control Panel	For two (2) circuits of 220 kV transmission line	1 lot
20.	Relay Panel	For two (2) circuits of 220 kV transmission line	1 lot