No. 37

THE ISLAMIC REPUBLIC OF PAKISTAN

DETAILED DESIGN STUDY
ON
WEST WHARF
THERMAL POWER PLANT PROJECT

FINAL REPORT-I

VOLUME 3

JANUARY 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

THE ISLAMIC REPUBLIC OF PAKISTAN

DETAILED DESIGN STUDY ON WEST WHARF THERMAL POWER PLANT PROJECT

FINAL REPORT-I

VOLUME 3

JANUARY 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

WEST WHARF THERMAL POWER PLANT PROJECT

DETAILED DESIGN STUDY

DRAFT FINAL REPORT - I

VOLUME 1

WEST WHARF THERMAL POWER PLANT PROJECT

DETAILED DESIGN STUDY

DRAFT FINAL REPORT - I

VOLUME 2

TRANSMISSION LINE AND GRID STATION

WEST WHARF THERMAL POWER PLANT PROJECT

DETAILED DESIGN STUDY

DRAFT FINAL PROJECT - I

VOLUME 3

AR-1. Structural Calculation Sheet for Main Powerhouse Superstructure

CONTENTS

I. General

1. Building Dimensions

1) Building Area 4,181.6 m2

2) Floor Area

5th Floor	55.6 m2
4th Floor	1,726.4 m2
Operating Floor	4,181.6 m2
Mezzanine Floor	4,181.6 m2
Ground Floor	4,181.6 m2
Total	14,326.8 m2

3) Building Heught (T/S) GL+27.1 m

4) Building KVolume 102,057.6 m3

2. Structure

1) Main Structure : Steel

2) Foundation : Reinforced concrete mat foundation

3) Slab : Concrete slab and grating floor

4) Wall : Concrete Wall and precast concrete wall

3. Structural Design Method

3.1 Superstructure

1) All frames in longitudinal direction are designed with vertical braced frames.
2) All frames in transverse direction are designed with vertical braced and open frames.
3) The bracing system will utilize x-braces or portal braces and the brace members are designed for compression and tension.
4) Every end joint of every girder is assumed to be a pin joint except that of a roof truss.
5) Every bottom of every column is assumed to be a pin support.
6) Every member including a roof truss is replaced to a line element.
7) Every structural analysis is based on elastic stiffness.

4. Design Criteria and Code

1) "Design Standard for Steel Structure", Architectural Institute of Japan(AIJ), 1970
2) "Standards for Calculation of Reinforced Concrete Structure", AIJ, 1982
3) "Standards for Structural Design of Building Foundation", AIJ, 1974
4) "Manual for Loads of Buildings", AIJ, 1981

5. Structural Materials and Allowable Stresses

1) Qualities of materials

Structural steel : JIS G3101 SS41, JIS G3106 SM41 or equivalent — $F=2400kg/cm^2$

High Strength Bolt : JIS B1186 F10T or equivalent

Concrete : $F=210kg/cm^2$ (compressive strength of 28 days)

Reinforcement : Deformed bar, ASTM A615 Grade 40 or equivalent — $F=2800kg/cm^2$

2) Physical constants of structural steel

Modulus of elasticity $E=2.1\times10^6$ kg/cm^2

3) Allowable stresses

Allowable stresses for each materials are shown in Table 5.1 to 5.7.

Table 5.1 Allowable Unit Stresses of Steel

	Allowable Unit Stress (t/cm^2)
Allowable Tensile Stress f_t	$f_t = \frac{F}{1.5} = 1.6$
Allowable Shear Stress f_s	$f_s = \frac{F}{1.5\sqrt{3}} = 0.92$
Allowable Compressive Stress f_c	when $\lambda \leqq \Lambda$ $f_c = \frac{\{1-0.4(\lambda/\Lambda)^2\}F}{\nu}$ when $\lambda > \Lambda$ $f_c = \frac{0.277F}{(\lambda/\Lambda)^2}$ where $\nu = 3/2 + 2/3 \cdot (\lambda/\Lambda)^2$ $\Lambda = \sqrt{\frac{\pi^2 E}{0.6F}}$: Critical slenderness ratio
Allowable Bending Stress f_b	$f_b = Max(f_{b1}, f_{b2})$, but not more than f_t $f_{b1} = \{1-0.4 \frac{(l_b/i)^2}{C \cdot \Lambda^2}\} f_t$ $f_{b2} = \frac{900}{(l_b \cdot h/A_f)}$ where $C = 1.75-1.05(\frac{M_2}{M_1})^2 + 0.3(\frac{M_2}{M_1})^2$, but not more than 2.3
Allowable Bending Stress of Bearing Plate f_{b3}	$f_{b3} = \frac{F}{1.3} = 1.85$

Notes: 1. Each allowable stress indicated in this table is permanent.

2. Temporary allowable stresses are 1.5 times as much as those in this table.

3. Allowable bending stress f_b is that for a shape steel, a plate girder and another built-up member which are bended around the principal axis of maximum moment of inertia. This is not, however, applied to box section.

4. Symbols in this table are defined as follows:

- λ : Slenderness ratio for compression memeber
- l_b : length of compressive side flange btween supports
- h : Depth of beam(cm)
- Af : Cross sectional area of compressive side flange(cm^2)
- i : Radius of gyration of area of Tee section, comprising compressive side flange and one-sixth of depth of beam, around the axis of web(cm)

Table 5.2 Allowable Unit Stresses in Welded Joints (t/cm^2)

Welding Position	Permanent Stresses					Temporary Stresses
	Groove Weld				Fillet Weld	
	Tension	Compress	Bending	shear		
(1) (2)	1.44 1.20	1.44 1.20	1.44 1.20	0.83 0.70	0.83 0.70	Permanent stresses × 1.5

Notes: (1) Flat or horizontal in the shop
(2) Overhead or vertical in the shop and flat or horizontal in the field

Table 5.3 Allowable Strength per Medium Bolts (SS41)

Bolt Nominal Dia.	Dia. of Bolt Hole (mm)	Bolt Gross Area (cm^2)	Permanent Strength			Temporary Strength (t)
			Shear (t)		Tension (t)	
			Single shear	Double shear		
M12	12.5	1.13	1.02	2.03	1.36	Permanent Stresses x 1.5
M16	16.5	2.01	1.81	3.62	2.41	
M20	20.5	3.14	2.83	5.65	3.77	
M22	22.5	3.80	3.42	6.84	4.56	
M24	24.5	4.52	4.07	8.14	5.42	

Table 5.4 Allowable Strength per High Strength Bolts (F10T)

Bolt Nominal Dia.	Dia. of Bolt Hole (mm)	Bolt Effect. Area (cm^2)	Permanent Strength			Temporary Strength (t)
			Shear (t)		Tension (t)	
			Single shear	Double shear		
M16	17.0	1.57	3.02	6.03	6.23	Permanent Stresses x 1.5
M20	21.5	2.45	4.71	9.42	9.73	
M22	23.5	3.03	5.70	11.4	11.8	
M24	25.5	3.53	6.78	13.6	14.0	

FORM 04

Table 5.5 Allowable Unit Stresses of Concrete (kg/cm^2)

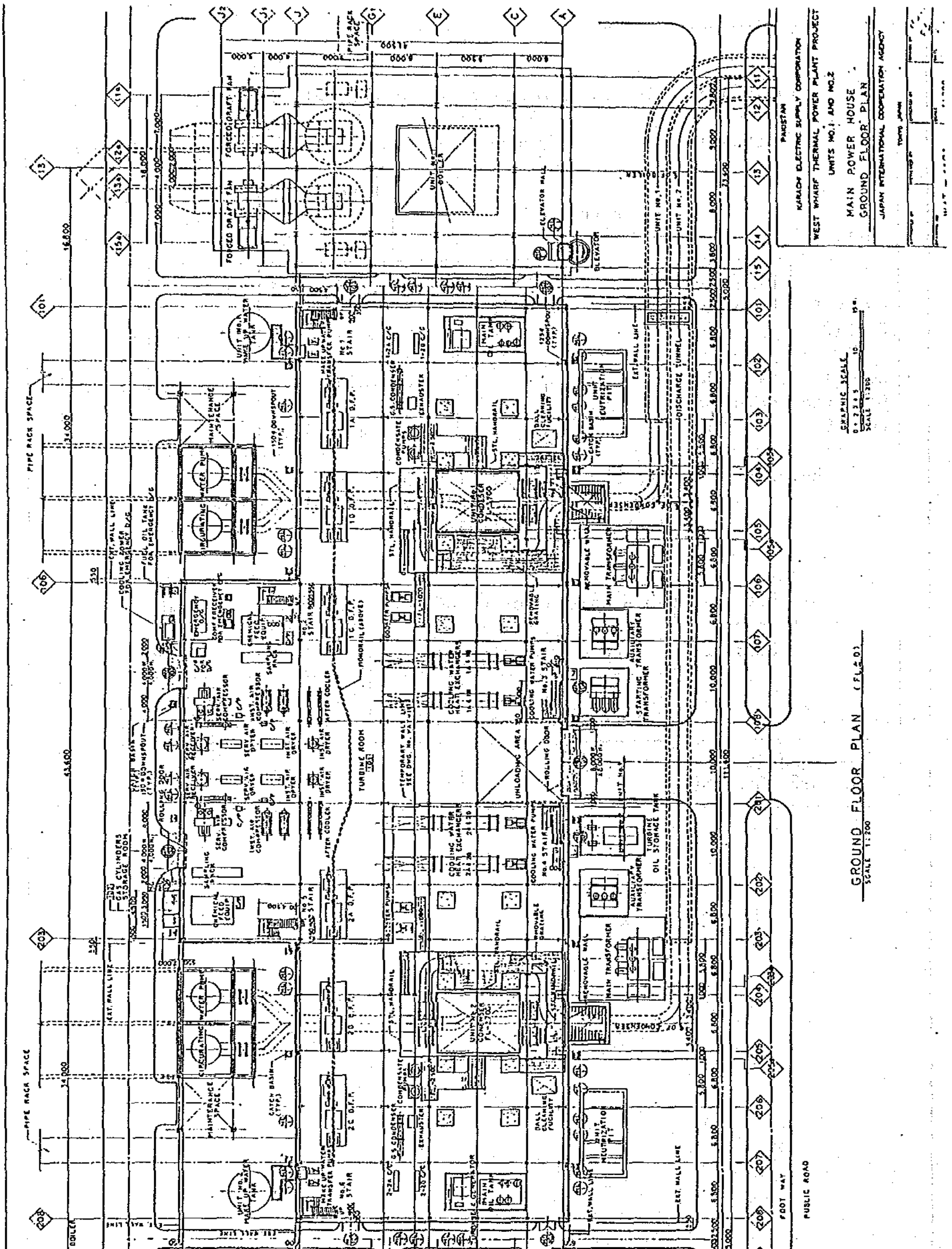
Materials \ Stresses		Permanent Stresses					Temporary Stress	
		Compress	Shear	Bond A	Bond B	Bond C	Compress	Shear Bond
Normal Concrete Fc=210	Plain bar	70	7.0	8.4	12.6	8.4	P.Stress x 2.0	P.S. x 1.5
	Deformed bar			14.0	21.0	14.0		
Normal Concrete Fc=250	Plain bar	80	7.5	9.0	13.5	9.0		
	Deformed bar			15.6	23.5	15.6		

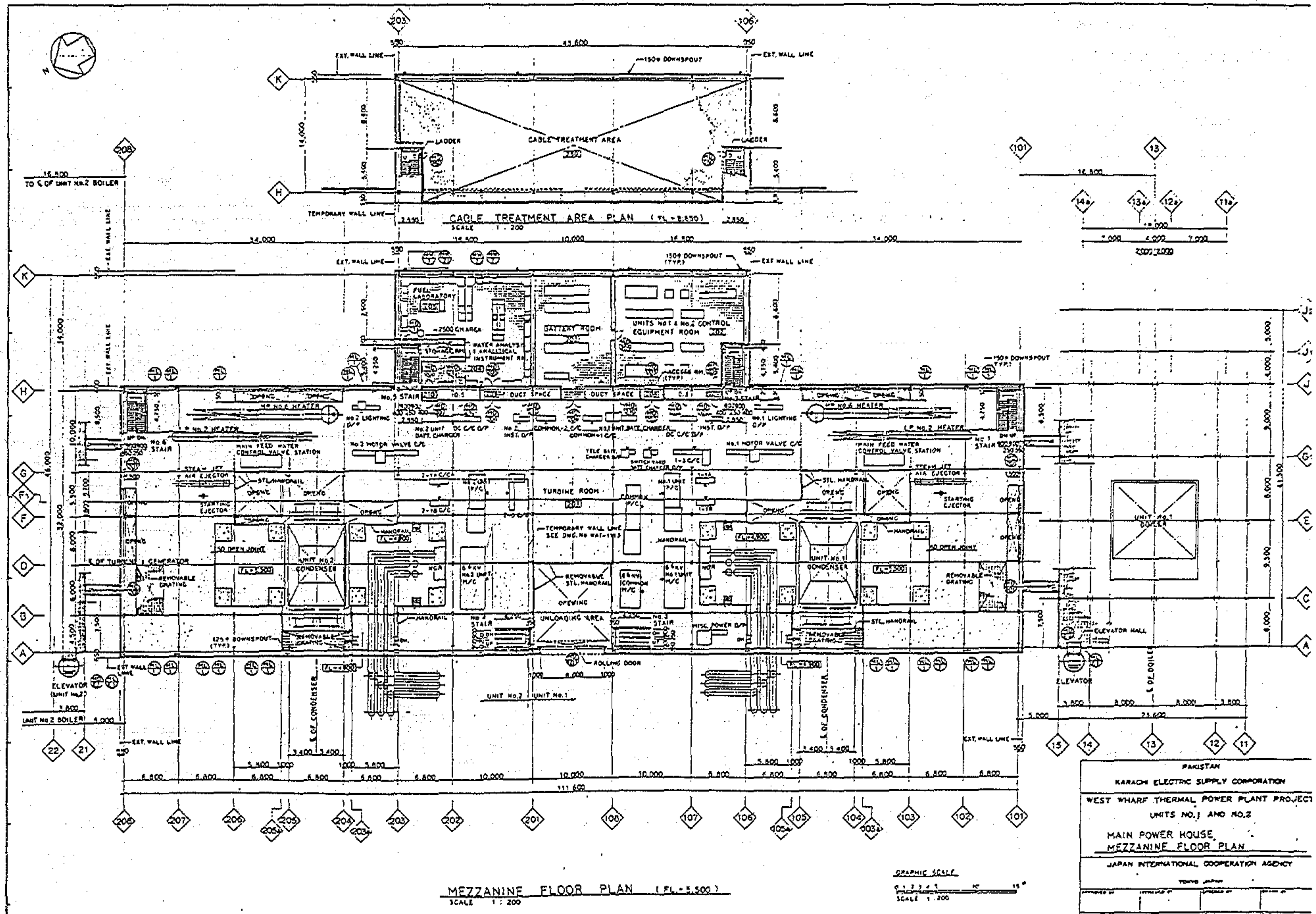
Remarks A : Top bar of flexural members
B : Bar, except "Item A", of flexural members
C : Anchors and lap splices

Table 5.6 Allowable Unit Stresses of Reinforcing Bars (kg/cm^2)

Material \ Stresses	Permanent Stresses		Temporary Stresses	
	Tension Compression	Shear Reinforcement	Tension Compression	Shear Reinforcement
Deformed bar ASTM A615 Grade40	1850	1850	2800	2800

6. General drawing





PAKISTAN

KARACHI ELECTRIC SUPPLY CORPORATION

WEST WHARF THERMAL POWER PLANT PROJECT

UNITS NO.1 AND NO.2

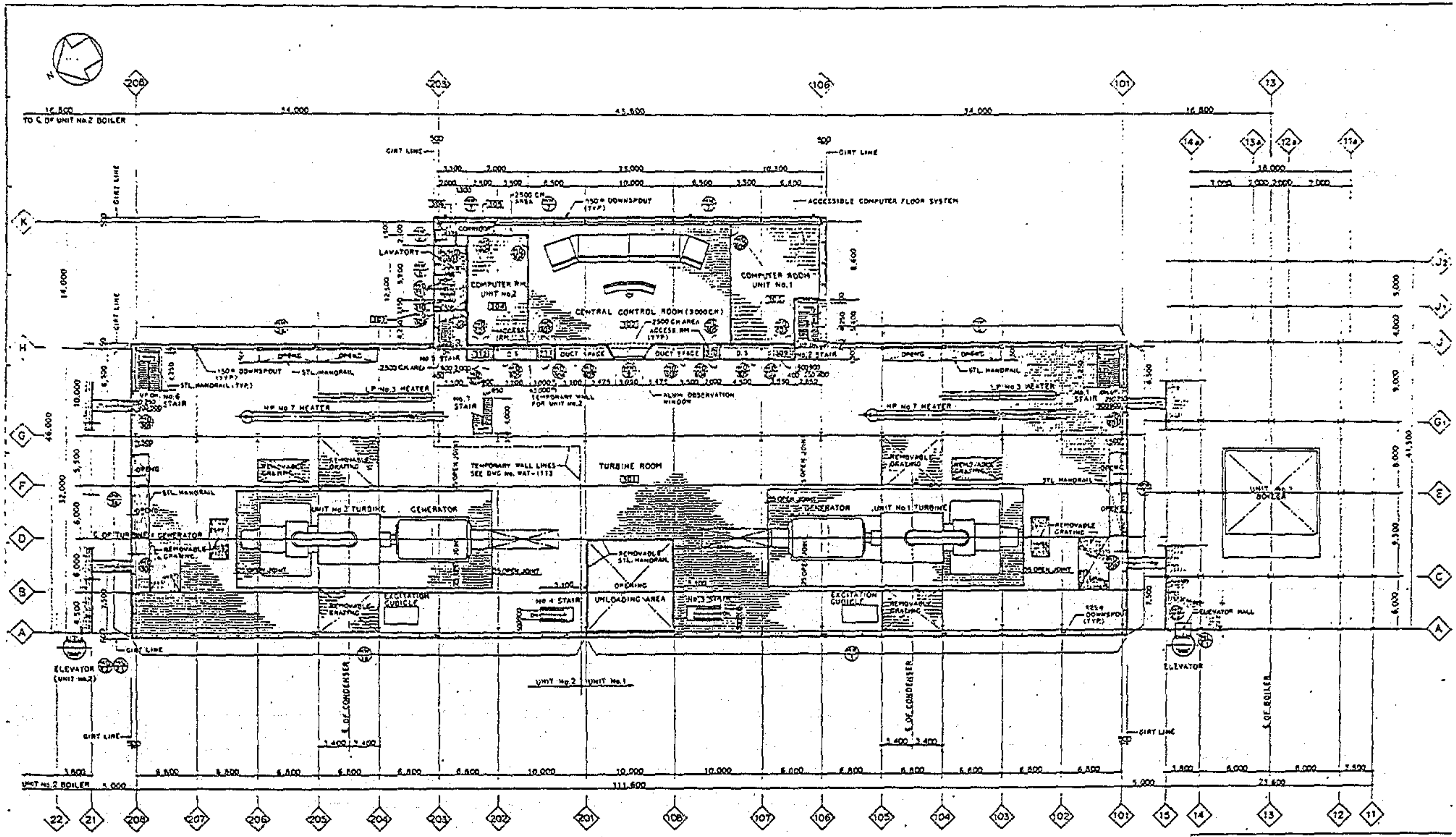
MAIN POWER HOUSE

MEZZANINE FLOOR PLAN

JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO JAPAN

12



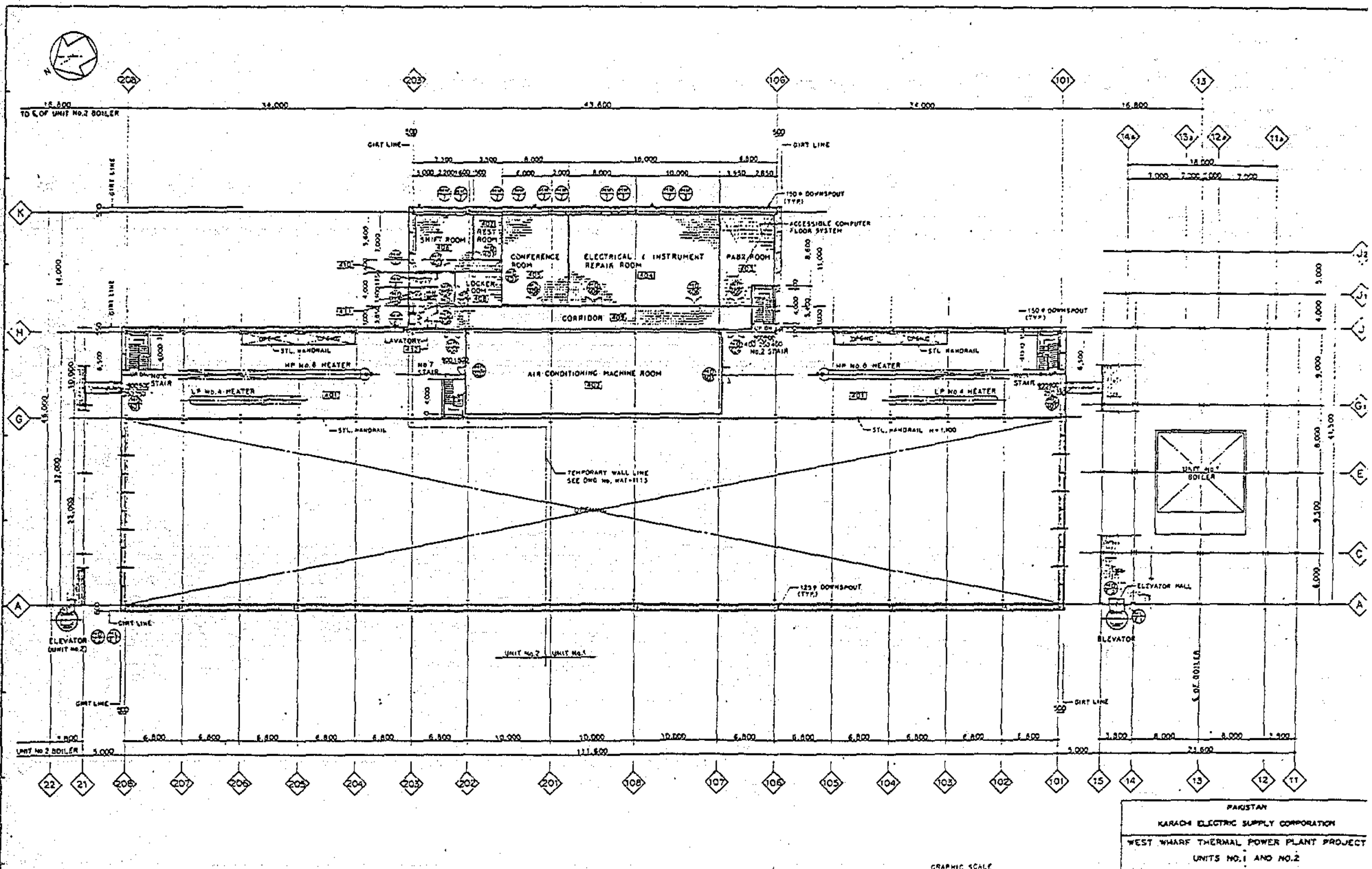
OPERATING FLOOR PLAN (FL +11,000)
SCALE 1 : 200

GRAPHIC SCALE
SCALE 1 : 200

PAKISTAN
KARACHI ELECTRIC SUPPLY CORPORATION
WEST WHARF THERMAL POWER PLANT PROJECT
UNITS NO.1 AND NO.2
MAIN POWER HOUSE
OPERATING FLOOR PLAN
JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO JAPAN

10

13



FORTH FLOOR PLAN (FL.+21,000)

SCALE 1 : 200

PAKISTAN

KARACHI ELECTRIC SUPPLY CORPORATION

WEST WHARF THERMAL POWER PLANT PROJECT

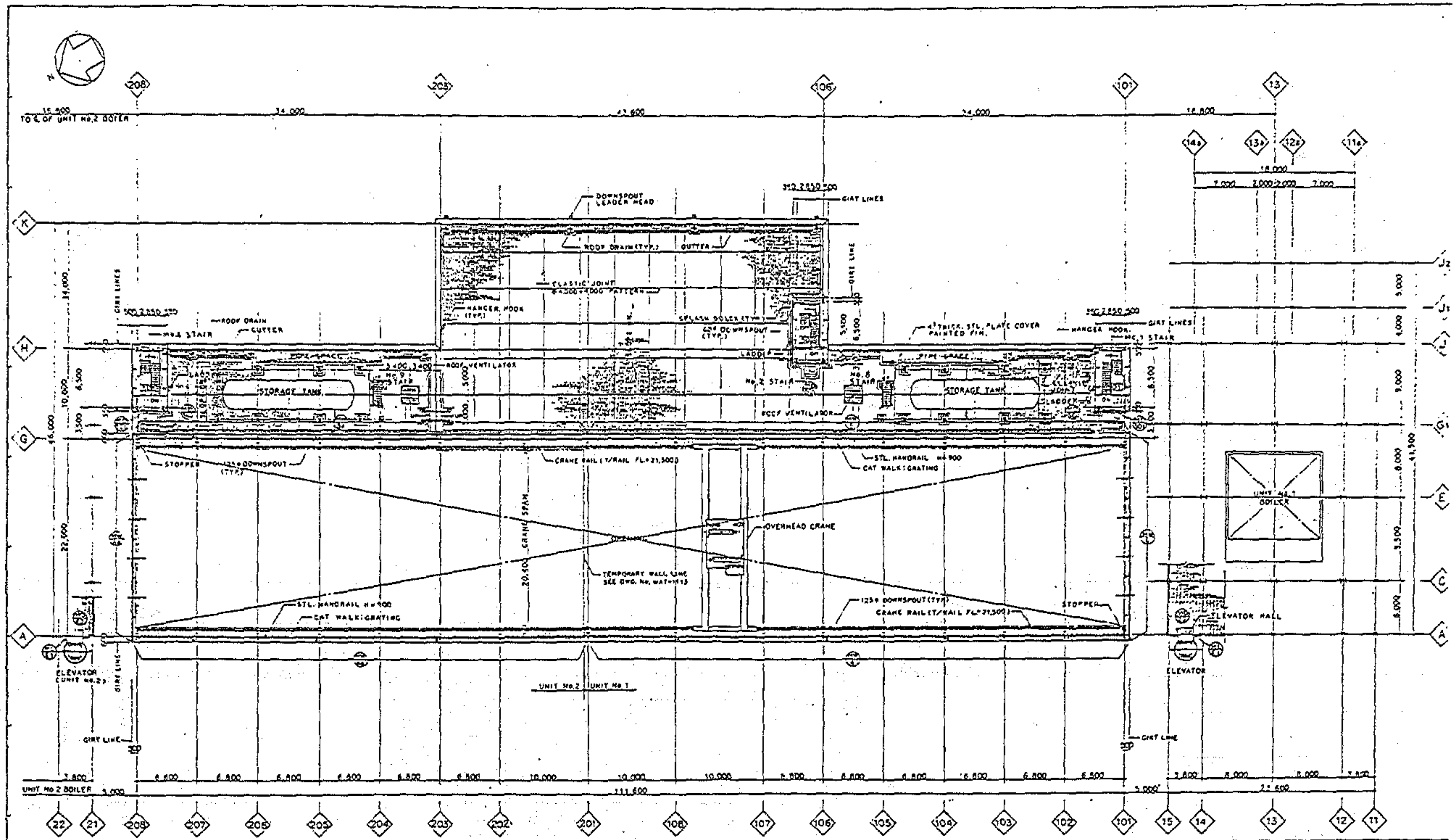
UNITS NO.1 AND NO.2

MAIN POWER HOUSE

FORTH FLOOR PLAN

JAPAN INTERNATIONAL COOPERATION AGENCY

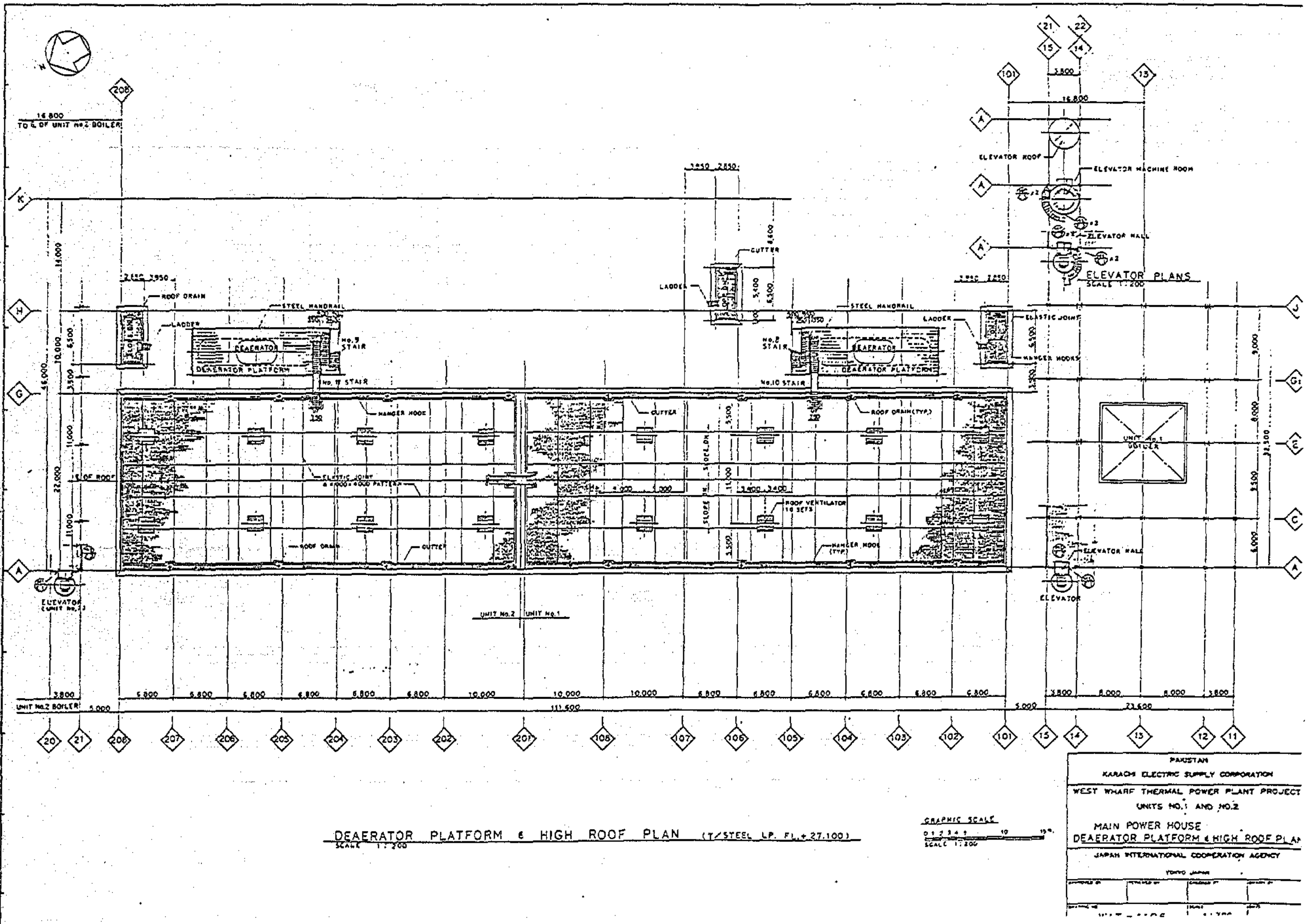
TOKYO JAPAN



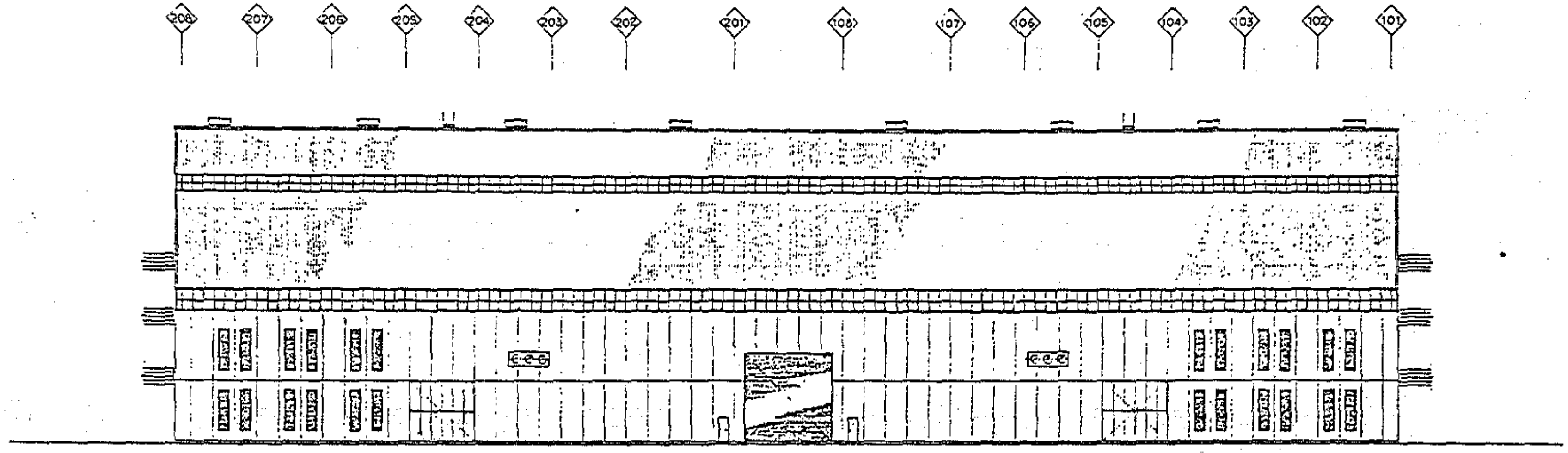
CRANE LEVEL (T/CRANE RAIL FL+21.500) & LOW ROOF (T/STEEL L.P. FL+21.000) PLAN
SCALE 1 : 200

GRAPHIC SCALE
SCALE 1 : 200

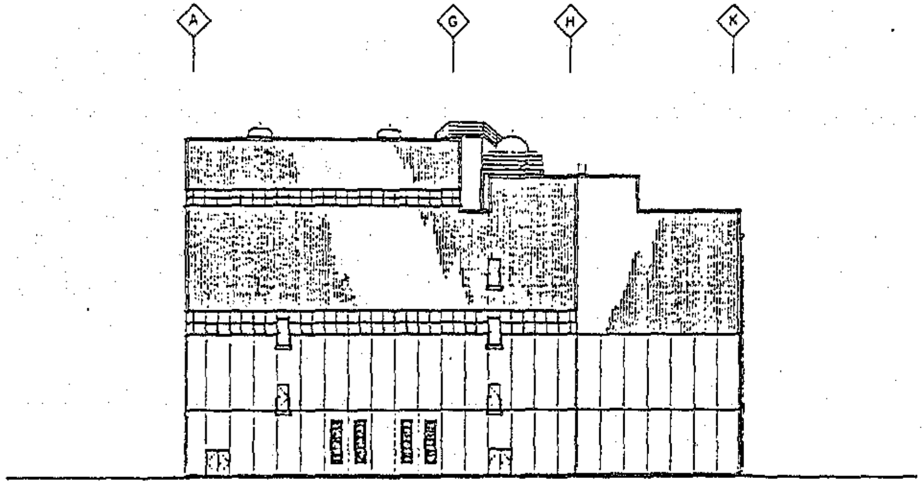
PAKISTAN
KARACHI ELECTRIC SUPPLY CORPORATION
WEST WHARF THERMAL POWER PLANT PROJECT
UNITS NO.1 AND NO.2
MAIN POWER HOUSE
CRANE LEVEL & LOW ROOF PLAN
JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO JAPAN



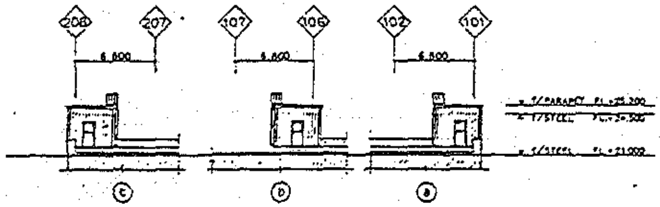
DEAERATOR PLATFORM & HIGH ROOF PLAN (T/STEEL LP. FL. +27.100)
SCALE 1:200



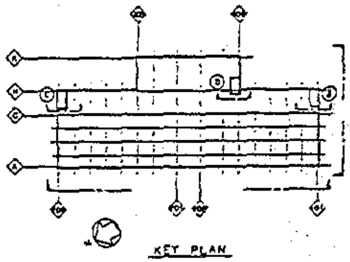
WEST ELEVATION
SCALE 1 : 200



SOUTH ELEVATION
SCALE 1 : 200



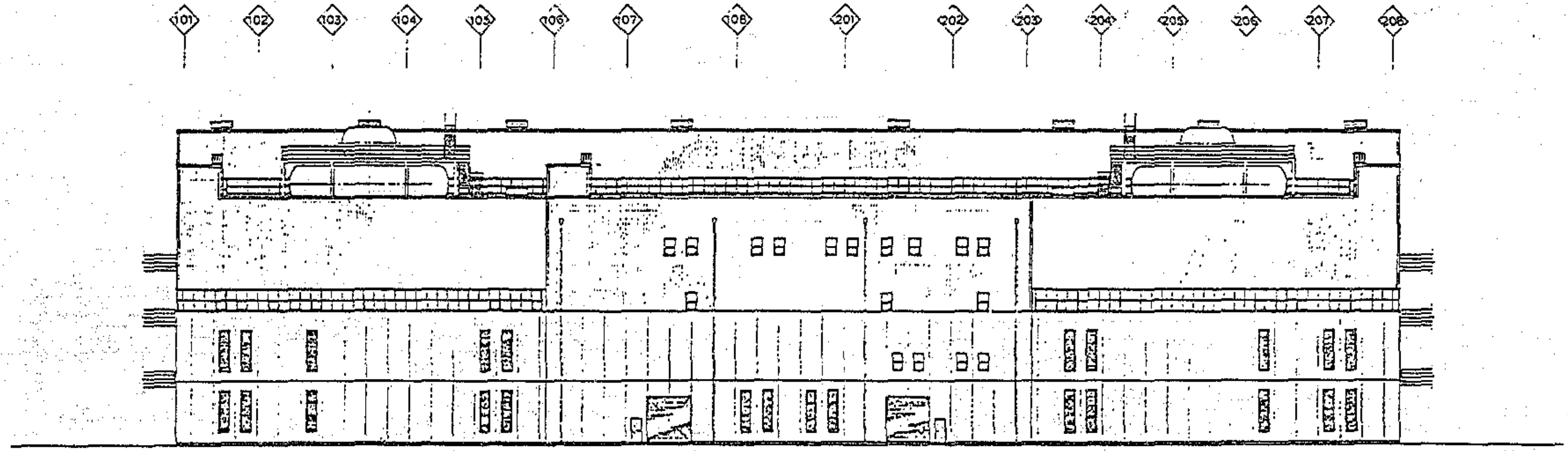
WEST ELEVATIONS (STAIR CASE)
SCALE 1 : 200



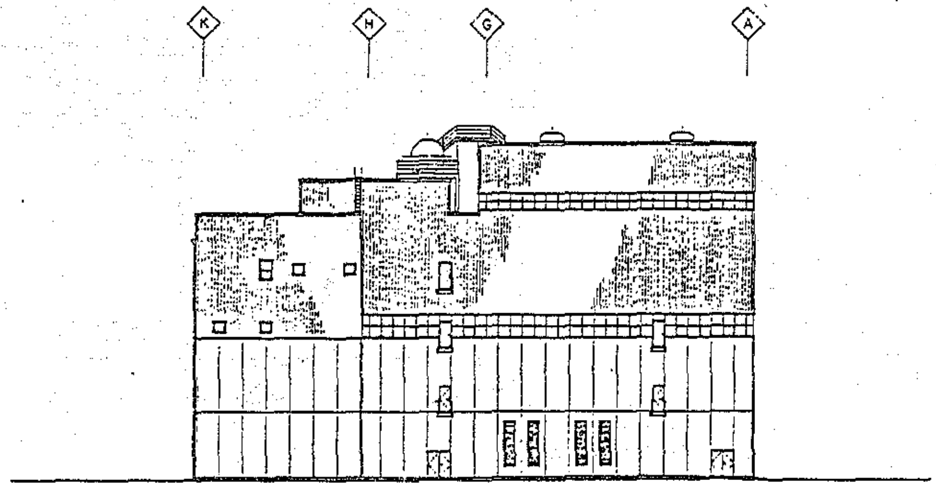
KEY PLAN

GRAPHIC SCALE
0 1 2 3 4 5 10 15 M
SCALE 1 : 200

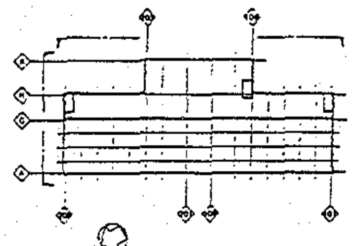
PAKISTAN
KARACHI ELECTRIC SUPPLY CORPORATION
WEST WHARF THERMAL POWER PLANT PROJECT
UNITS NO.1 AND NO.2
MAIN POWER HOUSE
WEST & SOUTH ELEVATIONS
JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO JAPAN



EAST ELEVATION
SCALE 1 : 200



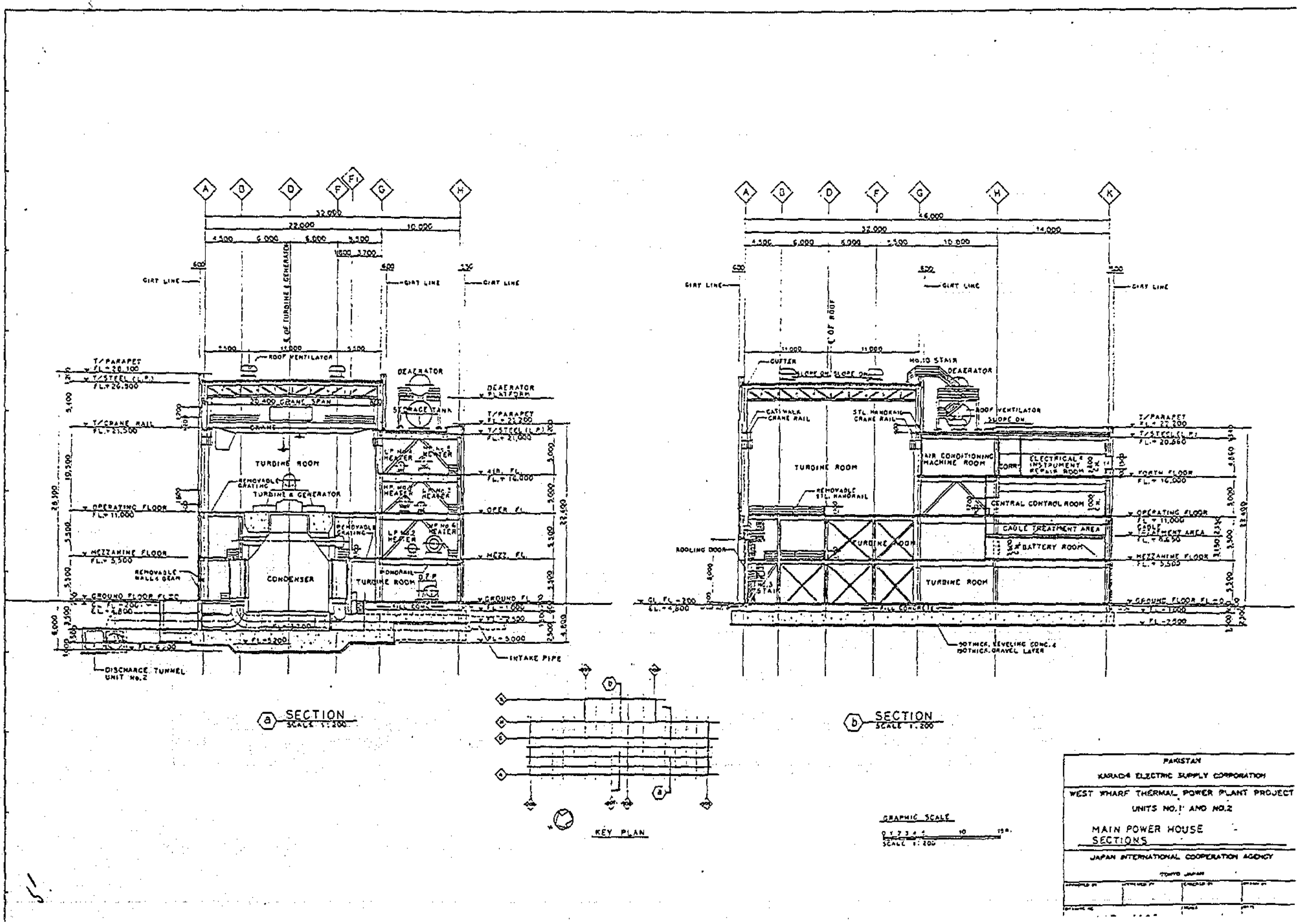
NORTH ELEVATION
SCALE 1 : 200



KEY PLAN

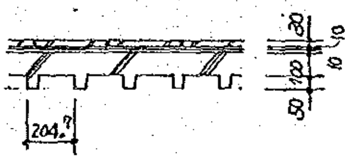
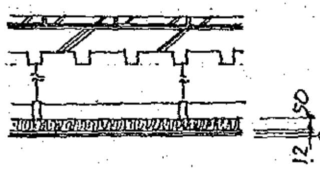
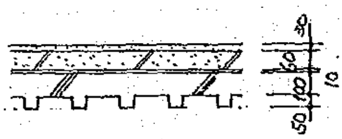
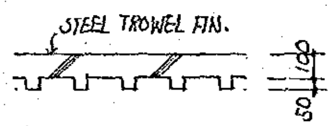
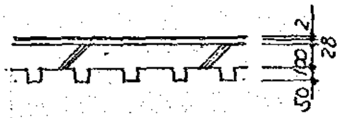
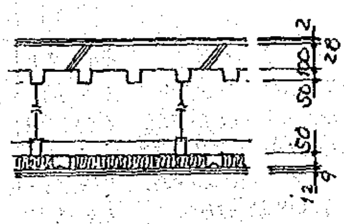
GRAPHIC SCALE
SCALE 1 : 200

PAKISTAN
KARACHI ELECTRIC SUPPLY CORPORATION
WEST WHARF THERMAL POWER PLANT PROJECT
UNITS NO.1 AND NO.2
MAIN POWER HOUSE
EAST & NORTH ELEVATIONS
JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO JAPAN


SECTION a
SCALE 1:200
SECTION b
SCALE 1:200
KEY PLAN
GRAPHIC SCALE
SCALE 1:200
TURBINE ROOM
TURBINE & GENERATOR
CONDENSER
DEAERATOR
STORAGE TANK
DEAERATOR PLATFORM
ROOF VENTILATOR
CRANE
20,400 CRANE SPAN
REMOVABLE GRATING
LP NO.2 HEATER
HP NO.6 HEATER
MONORAIL
GIRT LINE
T/PARAPET
T/STEEL (L.P.)
T/CRANE RAIL
OPERATING FLOOR
MEZZANINE FLOOR
GROUND FLOOR
REMOVABLE WALLS BEAM
DISCHARGE TUNNEL UNIT No.2
INTAKE PIPE
AIR CONDITIONING MACHINE ROOM
ELECTRICAL & INSTRUMENT REPAIR ROOM
CENTRAL CONTROL ROOM
CABLE TREATMENT AREA
BATTERY ROOM
FORTH FLOOR
ROLLING DOOR
CATWALK
CRANE RAIL
STL. HANDRAIL
GUTTER
SLOPE DN
NO.10 STAIR
NO.3 STAIR
FILL CONCRETE
50THICK. LEVELING CONC. & 150THICK. GRAVEL LAYER
PAKISTAN
KARACHI ELECTRIC SUPPLY CORPORATION
WEST WHARF THERMAL POWER PLANT PROJECT
UNITS NO.1 AND NO.2
MAIN POWER HOUSE
SECTIONS
JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO JAPAN

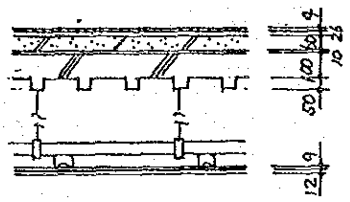
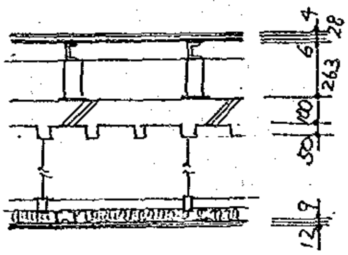
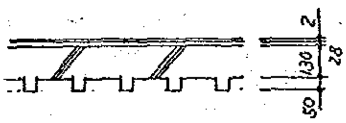
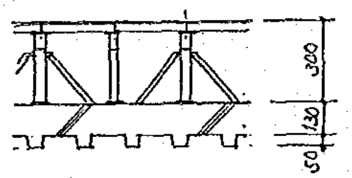
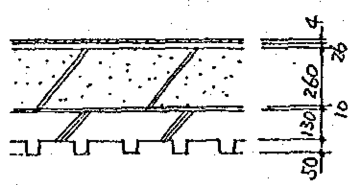
17. Design Load

7-1 DEAD LOAD (1)
[固定荷重]

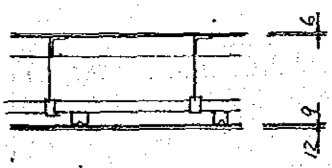
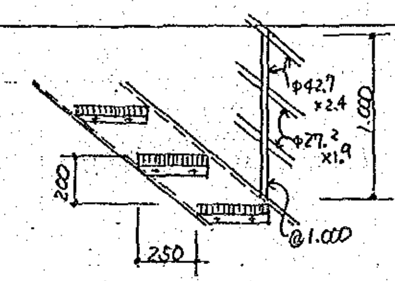
ROOM NAME OR LOCATION	FIGURE (mm)	MATERIALS (THICKNESS-mm)	WEIGHT (kg/m2)	TOTAL (kg/m2)
ROOF TURBINE ROOM A/C MACHINE ROOM		CONCRETE BLOCK (THK=30) SAND (" =10) ASPHALT ROOFING (" =10) CONCRETE SLAB (" =100) DECK PLATE V-50 (" =1.2)	60 20 15 275 13.9 383.5	→ 385
ROOF of ELECTORICAL& INST. REPAIR RM. CONFERENCE ROOM		CONCRETE BLOCK SAND ASPHALT ROOFING CONCRETE SLAB DECK PLATE GLASS WOOL CEILING	383.5 2 25 410.5	→ 415
4TH. FL. A/C MACHINE ROOM		CEMENT MORTAL (" =30) CINDER CONCRETE (" =60) ASPHALT WATER PROOF (" =10) CONCRETE SLAB (" =100) DECK PLATE (" =1.2)	60 120 15 275 13.9 483.9	→ 485
4TH. FL. HP HEATER ROOM		CONCRETE SLAB (THK=100) DECK PLATE (" =1.2)	275 13.9 288.9	→ 290
~~LABORATORY ROOM~~		VINYL ASBESTOS TILE (THK=2.0) CEMENT MORTAL (" =28) CONCRETE SLAB (" =100) DECK PLATE (" =1.2)	4 56 275 13.9 348.9	→ 350
4TH. FL. ELECTORICAL& INST. REPAIR RM CORRIDOR		VINYL ASBESTOS TILE (THK=2.0) CEMENT MORTAL (" =28) CONCRETE SLAB (" =100) DECK PLATE (" =1.2) GLASS WOOL CEILING	348.9 2 25 375.9	→ 380

2P

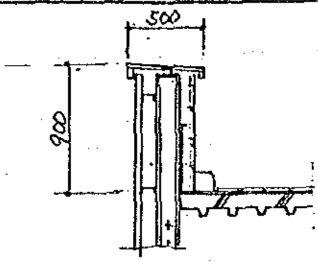
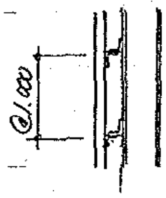
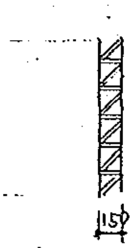
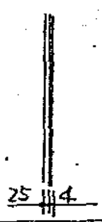
DEAD LOAD (2)
[固定荷重]

ROOM NAME OR LOCATION	FIGURE (mm)	MATERIALS (THICKNESS-mm)	WEIGHT (kg/m2)	TOTAL (kg/m2)
4TH. FL. LAVATORY		MOSAIC TILE (THK=4) CEMENT MORTAL (〃=26) CINDER CONCRETE (〃=60) ASPHALT WATER PROOF (〃=10) CONCRETE SLAB (〃=100) DECK PLATE (〃=1.2) CEILING	8 52 120 15 275 13.9 25 508.9	→ 510
~~LABORATORY ROOM PABX ROOM~~		VYNYL ASBESTOS TILE (THK=2.0) CEMENT MORTAL (〃=28) CONCRETE SLAB (〃=100) DECK PLATE (〃=1.2) GLASS WOOL CEILING STEEL PLATE (THK=6.0) STEEL FRAME FLOOR	375.9 47.1 40 463	→ 465
OPE. FL. TURBINE RM.		VINYL ASBESTOS TILE (THK=2.0) CEMENT MORTAL (〃=28) CONCRETE SLAB (〃=130) DECK PLATE (〃=1.2)	4 56 347 13.9 420.9	→ 425
OPE. FL. CENTRAL CONTROL ROOM	… Ditto.			425
OPE. FL. COMPUTER ROOM		FREE FLOOR CONCRETE SLAB (THK=130) DECK PLATE (〃=1.2)	60 347 13.9 420.9	→ 425
OPE. FL. LAVATORY		MOSAIC TILE (THK=4) CEMENT MORTAL (〃=26) CINDER CONCRETE (〃=260) ASPHALT WATER PROOF (〃=10) CONCRETE SLAB (〃=130) DECK PLATE (〃=1.2)	8 52 520 15 347 13.9 955.9	→ 960

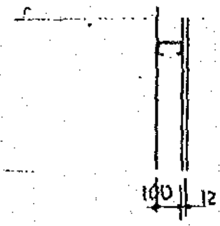
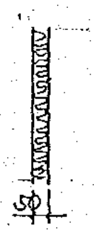
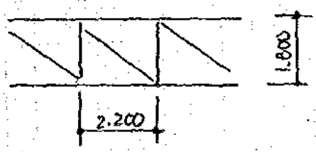
DEAD LOAD (3)
[固定荷重]

ROOM NAME OR LOCATION	FIGURE (mm)	MATERIALS (THICKNESS-mm)	WEIGHT (kg/m2)	TOTAL (kg/m2)
MEZ. FL. TURBINE RM	SAME AS OPE. FL. TURBINE FL.			425
MEZ. FL. CONTROL EQUIP. ROOM BATTERY ROOM LABORATORY ROOM	Ditto.			425
GRATING FLOOR		GRATING	44.4	→ 45
CHECKERED PLATE FLOOR		CHECKERED PLATE (THK=6) L-65×65×6 CEILING	48.8 20 25 93.8	→ 95
STAIR		L-250×90×9×13 ×2 GRATING HAND RAIL φ42.7 (1.0+1.4)×2 φ27.2 1.4×2 ×2	97.8 33 18.7 13.6 163.1	→ 165 kg/m

DEAD LOAD (4)
[固定荷重]

ROOM NAME OR LOCATION	FIGURE (mm)	MATERIALS (THICKNESS~mm)	WEIGHT (kg/m2)	TOTAL (kg/m2)
PARAPET		WEATHER PROOF METAL (THK=1.0) L-30x30x2 @500 GIRT L-50x50x4 @500 VERTICAL GIRT C-100x50 @2000 BEND PLATE A=0.7 (THK=6.0) ASPHALT ROOFING (〃=5.0) WEATHER PROOF METAL (〃=1.0) CONCRETE BLOCK 150x120	5 3 6.1 4.7 34.2 7.5 7 43 110.5	→ 120 kg/m
METAL SIDING		METAL SIDING (THK=1.0) FRAME (L-50x50x6, H=250)	18 25 43	→ 45
CONCRETE BLOCK WALL		CONCRETE BLOCK (THK=150)	300	→ 300
MORTAL FIN		MORTAL (THK=25)	50	→ 50
TILE FIN		MOSAIC TILE (THK=4) MORTAL (THK=25)	8 50 58	→ 60
PRECAST CONCRETE PANEL		PRECAST CONC. PANEL (THK=120)	288	→ 290

DEAD LOAD (5)
[固定荷重]

<table>
<tr><th>ROOM NAME OR LOCATION</th><th>FIGURE (mm)</th><th>MATERIALS (THICKNESS-mm)</th><th>WEIGHT (kg/m2)</th><th>TOTAL (kg/m2)</th></tr>
<tr><td>WALL (SINGLE SIDE)</td><td></td><td>FRAME C-100 @450
PLASTER BOAD (THK=12)</td><td>15
10.2
25.2</td><td>→ 26</td></tr>
<tr><td>WALL (DOUBLE SIDE)</td><td></td><td>FRAME C-100 @450
PLASTER BOAD (THK=12)</td><td>15
20.4
35.4</td><td>→ 36</td></tr>
<tr><td>GLASS WOOL</td><td></td><td>GLASS WOOL (THK=50)</td><td>2</td><td>→ 2</td></tr>
<tr><td>TRUSS</td><td></td><td>H-350 49.4×4.4
H-250 92.4×4.4
POST 2L-130²×15 57.6×1.8×2
BRACE 57.6×2.85×2</td><td>= 243.6</td><td>→ 250 kg/m</td></tr>
<tr><td>FENCE</td><td></td><td></td><td></td><td>→ 110 kg/m</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
</table>

24

NOTE: DL --- DEAD LOAD　PHL --- PIPE HANGER LOAD
LL --- LIVE LOAD　TL --- TOTAL FLOOR LOAD

FLOOR LOAD
[設計用床荷重]

Unit: kg/m2

FLOOR	ROOM NAME	SLAB			GIRDER				BEAM				COLUMN & FOUND.				SEISMIC			
		DL	LL	TL	DL	LL	PHL	TL	DL	LL	PHL	TL	DL	LL	PHL	TL	DL	LL	PHL	TL
ROOF	T/G ROOM	385	90	475	535	60	—	595	535	60	—	595	535	60	—	595	535	—	—	535
5TH FL.	COOLING TOWER ROOF	415	200	615	565	200	—	765	565	200	—	765	565	200	—	765	565	100	—	665
& ROOF	A/C MACHINE ROOM ROOF	385	100	485	535	100	—	635	535	100	—	635	535	100	—	635	535	—	—	535
GL+21.0	DEAERATOR ROOF	385	500	885	535	500	250	1,285	535	500	250	1,285	535	350	150	1,035	535	80	75	690
4TH FL	CONFERENCE ROOM	380	300	680	530	180	—	710	530	180	—	710	530	180	—	710	530	80	—	610
GL+16.0	ELECTORICAL & INS. REPAIR ROOM	380	500	880	530	500	—	1,030	530	500	—	1,030	530	350	—	880	530	350	—	880
	HP HEATER ROOM	290	1000	1,290	440	1000	250	1,690	440	1000	250	1,690	440	700	150	1,290	440	*150	75	665
	LAVATORY	510	130	640	660	130	—	790	660	130	—	790	660	130	—	790	660	60	—	720
	A/C MACHINE ROOM	485	500	985	635	500	—	1,135	635	500	—	1,135	635	350	—	985	635	350	—	985
OPE FL	T/G ROOM (OVERHAUL)	425	2,000	2,425	575	2,000	250	2,825	575	2,000	250	2,825	575	1,500	150	2,225	575	150	75	800
GL+11.0	" (OTHER)	425	1,000	1,425	575	1,000	250	1,825	575	1,000	250	1,825	575	700	150	1,425	575	700	75	1,350
	CENTRAL CONTROL ROOM	425	300	725	575	180	250	1,005	575	180	250	1,005	575	180	150	905	575	80	75	730
	COMPUTER ROOM	425	500	925	575	500	—	1,075	575	500	—	1,075	575	350	—	925	575	350	—	925
	LAVATORY	960	130	1,090	1110	130	—	1,240	1110	130	—	1,240	1110	130	—	1,240	1110	60	—	1,170
MEZ.FL	T/G ROOM	425	800	1,225	575	800	250	1,625	575	800	250	1,625	575	500	150	1,225	575	500	75	1,150
GL+5.5	CONTROL EQUIPMENT ROOM	425	500	925	575	500	150	1,225	575	500	150	1,225	575	350	100	1,025	575	350	50	975
	BATTERY ROOM	425	500	925	575	500	150	1,225	575	500	150	1,225	575	350	100	1,025	575	350	50	975
	LABORATORY ROOM	425	300	725	575	180	150	905	575	180	150	905	575	180	100	855	575	80	50	705
COMMON	GRATING FLOOR	—	—		195	*130	—	*325	195	*130	—	*325	195	*130	—	*325	195	*60	—	*255
	STAIR	—	—		300	*130	—	*430	300	*130	—	*430	300	*130	—	*430	300	*60	—	*360
	CHECKERED PLATE FLOOR	95	100	195	95	100	—	195	95	100	—	195	95	100	—	195	95	100	—	195

24

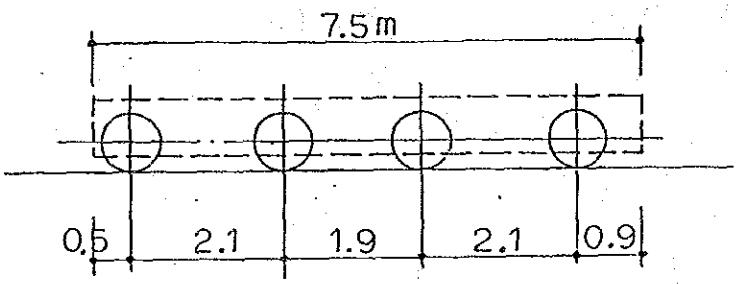
7.3 Crane Load

1. Design Condition

1.1 Overhead crane

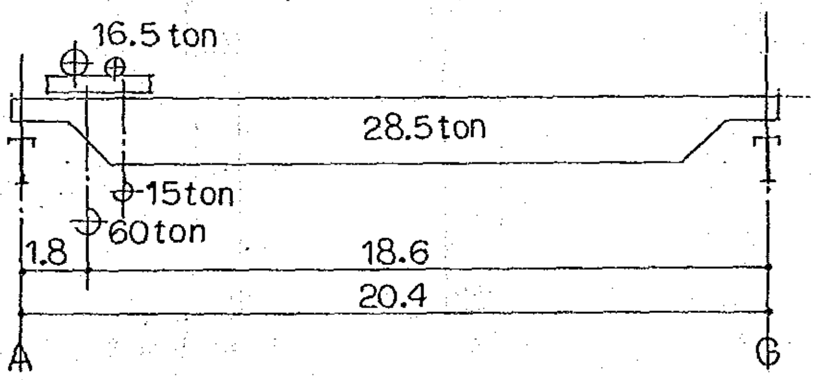
Dead load : 45.0 ton (including 16.5 ton trolley)
Main hook : 60.0 ton
Auxiliary hook : 15.0 ton

The wheel span is assumed to be as illustrated in the following diagram according to the experience.



1.2 The beam for the crane girder will be a simple beam each for 6.8 m span and 10.0 m span.

1.3 Maximum wheel load (P)
Crane span , $l = 20.4$ m



When

$$R_A = (60.0 + 16.5) \times \frac{18.6}{20.4} + \frac{1}{2} \times 28.5 = 84.0 \text{ ton}$$

$$R_B = (60.0 + 16.5) \times \frac{1.8}{20.4} + \frac{1}{2} \times 28.5 = 21.0 \text{ ton}$$

The maximum wheel load (A) per wheel becomes 84.0/4 = 21.0 ton. Since the impact factor is 120%, the design wheel load is 21 × 1.2 = 25.2 ton / wheel.

7.2 WIND LOAD

$F_w = A \cdot C \cdot q$

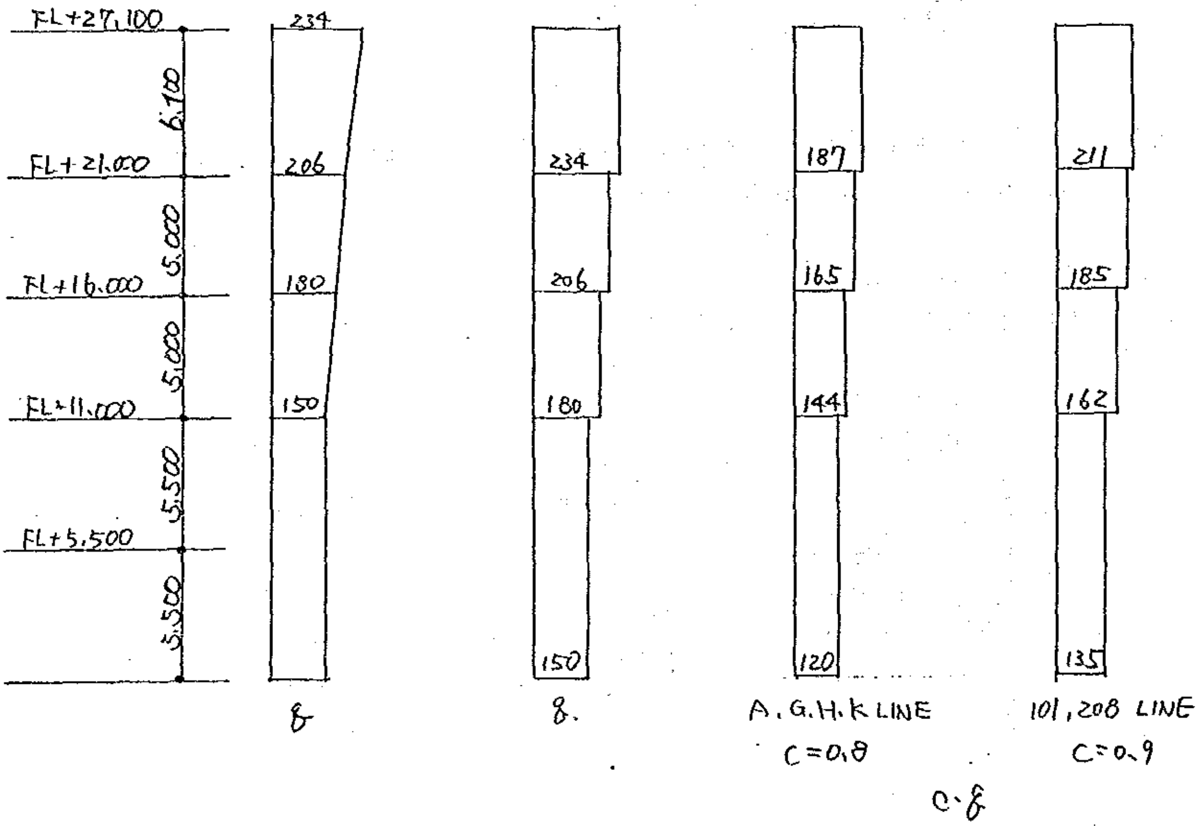
A: Projected area of structure (m^2)

C: Shape factor

H: Height (m)

$q = 150\ kg/m^2 \qquad H \leq 10m$

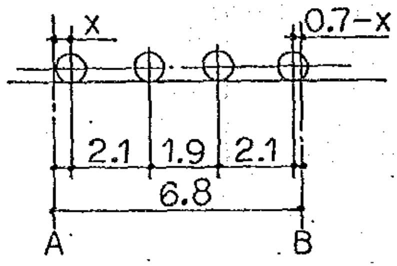
$q = 45\sqrt{H} \qquad H > 10m$



2. Stress analysis

2.1 6.8m span

The stress becomes maximum in the case of the following diagram (four wheels are located on 6.8m span).



the stress of beam due to crane operation on simple beam "AB" becomes :

$$R_A = \frac{P}{6.8}(15.0 - 4X)$$

$$R_B = \frac{P}{6.8}(12.2 + 4X)$$

and the maximum bending moment becomes :

$$M_{max} = \left\{ \frac{15.0-4X}{6.8}(2.1+X) - 2.1 \right\} P$$

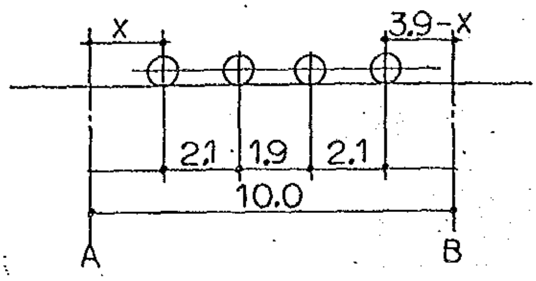
$$= -0.588(X^2 - 0.97X - 4.31)P$$

M becomes maximum when $X = 0.485$ and P is 25.2 ton. Then, the maximum bending moment of beam becomes 67.3 t·m (vertical) and 5.6 t·m (horizontal), respectively.

2n

2.2 10.0 m span

The stress becomes maximum in the case of the following diagram (four wheels are located on 10.0m span).



The stress of beam due to crane operation on simple beam "AB" is:

$$R_A = \frac{P}{10}(27.8-4X) \quad , \quad R_B = \frac{P}{10}(12.2+4X)$$

$$M_{max} = \left\{ \frac{27.8-4X}{10.0}(2.1+X) - 2.1 \right\} P$$

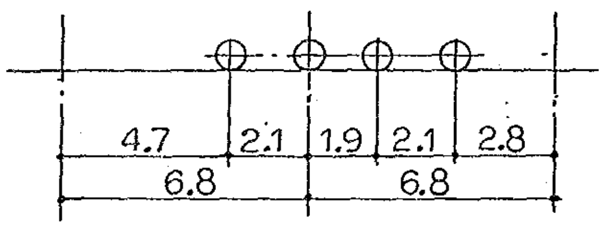
$$= -0.5(X^2 - 2.24X - 12.76) P$$

Therefore, the bending moment becomes maximum when $X = 2.425$, and the maximum vertical moment becomes 155.1 t·m (vertical) and 12.9 t·m (horizontal), respectively.

2.3 Maximum reaction against column due to wheel load

(1) In case of 6.8 m span

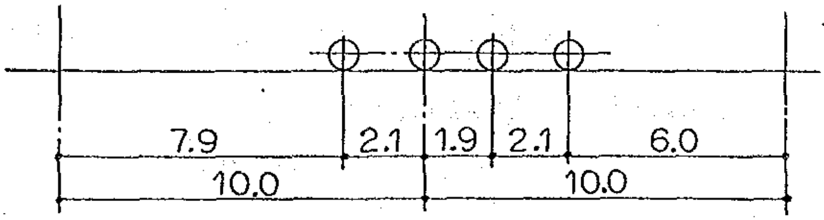
The reaction becomes maximum in the case of the following diagram:



$$N = \frac{P}{6.8} \times (4.7 + 6.8 + 4.9 + 2.8)$$

$$= 2.824 \times P$$

(2) In case of 10.0m span
The reaction becomes maximum in the case of the following diagram:



$$N = \frac{P}{10.0}(7.9 + 10.0 + 8.1 + 6.0)$$

$$= 3.2 \times P$$

2.4 Reaction against column due to dead load

$$R_A = 16.5 \times \frac{18.6}{20.4} + \frac{1}{2} \times 28.5 = 29.3 \text{ ton}$$

$$R_B = 16.5 \times \frac{1.8}{20.4} + \frac{1}{2} \times 28.5 = 15.7 \text{ ton}$$

(1) In case of 6.8m span

Reaction for foundation design:

$P_A = 2.824 \times \frac{29.3}{4} = 20.7$ ton , $P_B = 2.824 \times \frac{15.7}{4} = 11.1$ ton

Reaction for column design (vertical):

$20.7 \times 1.2 = 24.8$ ton , $11.1 \times 1.2 = 13.3$ ton

Reaction for column design (horizontal):

$20.7 \times 0.1 = 2.1$ ton , $11.1 \times 0.1 = 1.1$ ton

Force in travelling direction:

$20.7 \times 0.15 = 3.1$ ton $11.1 \times 0.15 = 1.7$ ton

(2) In case of 10.0m span

Reaction for foundation design:

$P_A = 3.2 \times \frac{29.3}{4} = 23.4$ ton, , $P_B = 3.2 \times \frac{15.7}{4} = 12.6$ ton

FORM 04

Reaction for column design (vertical) :

23.4 × 1.2 = 28.1 ton , 12.6 × 1.2 = 15.1 ton

Reaction for column design (horizontal):

23.4 × 0.1 = 2.3 ton , 12.6 × 0.1 = 1.3 ton

Force in travelling direction :

23.4 × 0.15 = 3.5 ton , 12.6 × 0.15 = 1.9 ton

2.5 Reaction against column due to lifted load

(1) In case of 6.8 m span

Reaction for foundation design :

$P_A = 2.824 \times \frac{84.0}{4} = 59.3$ ton, $P_B = 2.824 \times \frac{21.0}{4} = 14.8$ ton

Reaction for column design (vertical):

59.3 × 1.2 = 71.2 ton, 14.8 × 1.2 = 17.8 ton

Reaction for column design (horizontal):

59.3 × 0.1 = 5.9 ton , 14.8 × 0.1 = 1.5 ton

Force in travelling direction :

59.3 × 0.15 = 8.9 ton , 14.8 × 0.15 = 2.2 ton

(2) In case of 10.0 m span

Reaction for foundation design :

$P_A = 3.2 \times \frac{84.0}{4} = 67.2$ ton, $P_B = 3.2 \times \frac{21.0}{4} = 16.8$ ton

Reaction for column design (vertical):

67.2 × 1.2 = 80.6 ton , 16.8 × 1.2 = 20.2 ton

Reaction for column design (horizontal):

67.2 × 0.1 = 6.7 ton , 16.8 × 0.1 = 1.7 ton

Force in travelling direction :

67.2 × 0.15 = 10.1 ton 16.8 × 0.15 = 2.5 ton