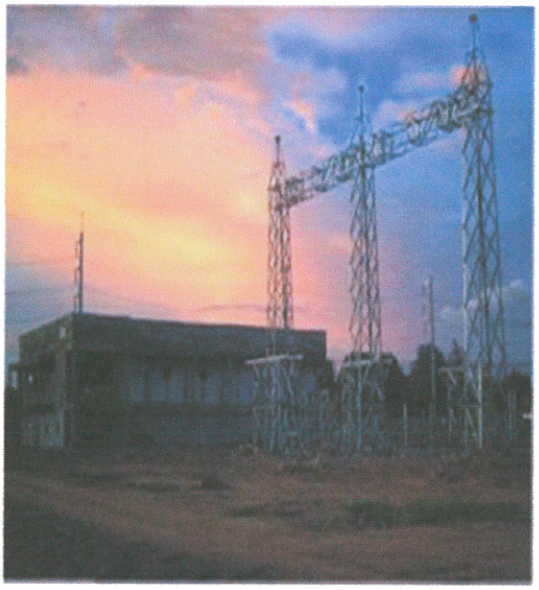
FOR FINAL :

PROVINCIAL ELECTRICITY AUTHORITY

115 /22 kv. PEA Substations



DESIGN CRITERIA

Project : PEA Substation : Control Building
Nakorn Thai Substation

Strength of Materials		
Concrete		
Compressive strength of 28-days Concrete Cylinders	210	ksc
Elastic modulus	230067	ksc
Shear strength		
-Beam type shear	4.20	ksc
-Punching shear	7.68	ksc
Structural Steel (ASTM A-36)		
Elastic modulus	2040000	ksc
Minimum yield strength	2520	ksc
Allowable shear stress	1008	ksc
Allowable tensile stress		
-Pinned end	1134	ksc
-Fixed end	1512	ksc
Reinforcing Steel		
Deformed Bars		
Yield strength	4000	ksc
Allowable tensile strength	1700	ksc
Yield strength	3000	ksc
Allowable tensile strength	1500	ksc
Rounded Bars		
Yield strength	2400	ksc
Allowable tensile strength	1200	ksc
Live Load		
Roof	50	kg/sq.m
Floor		
Capacitor Bank Room	1200	kg/sq.m
Switchgear Room	1200	kg/sq.m
Control Room	1200	kg/sq.m
Battery Room	800	kg/sq.m
Cable Room	600	kg/sq.m
Toilet	300	kg/sq.m
Stair	600	kg/sq.m
Transformer	110	Ton
Wind Load		
H = 10 - 20 m	80	kg/sq.m
H = 0 - 10 m	50	kg/sq.m
Dead Load		
Concrete	2400	kg/cu.m
Steel	7860	kg/cu.m
Ceiling	20	kg/sq.m
Brick Wall (Full Size)	360	kg/sq.m
Brick Wall (Half Size)	180	kg/sq.m
Concrete Block Wall	120	kg/sq.m
Light Weight Concrete Wall	85	kg/sq.m

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1. DESIGN CRITERIA

THE STANDARD DESIGN CRITERIA FOR THE SUBSTATION STEEL STRUCTURES SHALL CONFORM TO **THE AISC MANUAL OF STEEL CONSTRUCTION (EIGHTH EDITION @ 1980)**

2. MATERIALS

2.1 ROLLED SHAPES AND PLATES

ALL MATERIALS SHALL BE HOT-ROLLED OF STRUCTURAL STEEL. THE STRUCTURAL STEEL SHALL CONFORM TO JIS G3101 SS400 OR EQUIVALENT

2.2 CONNECTION BOLTS AND NUTS

BOLTS AND NUTS SHALL CONFORM TO ASTM A394 type 0

ANCHOR BOLTS SHALL CONFORM TO ASTM A307

2.3 HOT-DIP GALVANIZED

A) HOT-DIP GALVANIZED FOR STEEL SHAPES AND PLATES SHALL CONFORM TO ASTM A123.

B) HOT-DIP GALVANIZED FOR BOLTS,NUTS,SPRING WASHERS AND ANCHOR BOLTS SHALL CONFORM TO ASTM A153.

3. STRENGTH OF MATERIALS

JIS G3101 SS400 OR	Fy =	2,500 ksc	t ≤	16 mm
EQUIVALENT	=	2,400 ksc	t >	16 mm
	Fu =	4,100 ksc		
ASTM A394 type 0	Fu =	5,203 ksc		

4. LOADING CONDITION

4.1) WIND LOAD

BASIC WIND PRESSURE = 100 kg/m^2

ACTING ON THE PROJECTED AREA OF ONE FACE OF THE FLAT SURFACE STRUCTURE

ACTING ON 1.75 TIMES THE PROJECTED AREA OF ONE FACE OF THE LATTICED STRUCTURES (175 kg/m^2)

ACTING ON 2/3 TIMES THE PROJECTED AREA OF CIRCULAR SURFACE (67 kg/m^2)

4.2) DEAD LOAD

DEAD LOAD OF EQUIPMENT AND STEEL STRUCTURES ACTING ON THE STRUCTURES AS SHOWN IN THE DESIGN CALCULATION

4.3) SHORT CIRCUIT OR DYNAMIC LOAD (FOR EQUIPMENT SUPPORTING STEEL STRUCTURES)

SHORT CIRCUIT OR DYNAMIC LOAD = 0.2G IN HORIZONTAL DIRECTION AT CENTER OF GRAVITY OF EQUIPMENT (APPROXIMATE) EXCEPT OTHERWISE SHOWN

5. ALLOWABLE UNIT STRESSES

5.1 TENSION

ON THE NET SECTION EXCEPT AT PIN HOLES

Ft = 0.60 Fy

Ft = ALLOWABLE TENSILE STRESS (ksc)

Fy = MINIMUM YIELD POINT (ksc)

ON THE NET SECTION AT PIN HOLES

Ft = 0.45 Fy

5.2 SHEAR

ON THE GROSS SECTION

Fv = 0.40 Fy

Fv = ALLOWABLE SHEARING STRESS (ksc)

5.3 COMPRESSION

A) ON THE GROSS SECTION OF AXIALLY LOADED COMPRESSION MEMBERS WHEN **KL/r < Cc,**

$$Fa = \frac{\left[1 - \frac{(KL/r)^2}{2(Cc)^2}\right] Fy}{\frac{5}{3} + \frac{3(KL/r)}{8(Cc)} - \frac{(KL/r)^3}{8(Cc)^3}}$$ **FORMULA------(AISC 1.5-1)**

WHERE $Cc = \sqrt{\frac{2(\pi)^2 E}{Fy}}$

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Fa = ALLOWABLE COMPRESSIVE STRESS (ksc)

K = IN TRUSS, THE EFFECTIVE LENGTH FACTOR, k FOR THE COMPRESSION MEMBERS SHALL BE TAKEN AS UNITY, UNLESS ANALYSIS SHOW THAT A SMALLER VALUE MAY BE USED.

L = ACTUAL UNBRACED LENGTH

r = GOVERNING RADIUS OF GYRATION

E = MODULUS OF ELASTICITY OF STEEL (2.04×10^6 ksc)

$\pi = 3.14159$

B) ON THE GROSS SECTION OF AXIALLY LOADED COMPRESSION MEMBERS WHEN **KL/r > Cc**

$$Fa = \frac{12(\pi)^2 E}{23(KL/r)^2}$$ **FORMULA---------(AISC 1.5-2)**

C) ON THE GROSS SECTION OF AXIALLY LOADED COMPRESSION MEMBERS WHEN **KL/r > 120**

$$Fas = \frac{Fa(\text{BY FORMULA (1.5-1) OR (1.5-2)})}{1.6 - L/200r}$$ **FORMULA------(AISC 1.5-3)**

HERE k IS TAKEN AS UNITY

Fas = ALLOWABLE COMPRESSIVE STRESS FOR BRACING AND SECONDARY MEMBERS (ksc)

5.4 BENDING

TENSION AND COMPRESSION ON EXTREME FIBERS

Fb = 0.66 Fy

Fb = ALLOWABLE BENDING STRESS (ksc)

5.5 BEARING (ON THE CONTACT AREA)

MILLED SURFACE, INCLUDING BEARING STIFFENERS AND PINS IN REAMED, DRILLED, OR BORED HOLES

Fp = 0.90 Fy

Fp = ALLOWABLE BEARING STRESS (ksc)

WHEN PARTS IN CONTACT HAVE DIFFERENT YIELD STRESS , Fy SHALL BE THE SMALLER VALUE.

5.6 TENSION ON BOLT

Ft = 0.33 Fu

Ft = ALLOWABLE TENSILE STRESS (ksc)

5.7 SHEAR ON BOLTS

Fv = 0.22 Fu

Fv = ALLOWABLE SHEAR STRESS (ksc)

5.8 BEARING ON BOLTS

Fp = 0.60 Fu

Fp = ALLOWABLE BEARING STRESS (ksc)

5.9 ALLOWABLE BEARING STRESS IN CONCRETE

fc = 0.25 fc'

fc = ALLOWABLE BEARING STRESS IN CONCRETE (ksc)

fc' = CYLINDER COMPRESSIVE STRENGTH OF CONCRETE (0.15x0.30) AT 28 DAYS WITH A MINIMUM VALUE OF 175 ksc

5.10 ALLOWABLE BONDING STRESS

ALLOWABLE BONDING STRESS = 10 ksc

5.11 ALLOWABLE SHEARING STRESS OF WELDING

ALLOWABLE SHEARING STRESS OF WELDING fv = 1,260 ksc (AWS E60)

5.12 ALLOWABLE BENDING STRESS ON RECTANGULAR SECTION

Fb = 0.75 Fy

Fb = ALLOWABLE BENDING STRESS **(AISC Sec. 1-5.1.4.3,** base on bending on rectangular section)

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6. COMBINED STRESSES

6.1 AXIAL COMPRESSION AND BENDING STRESSES

MEMBERS SUBJECTED TO BOTH AXIAL COMPRESSION AND BENDING STRESSES SHALL BE PROPORTIONED TO SATISFY THE FOLLOWING REQUIREMENTS:

WHEN fa/Fa > 0.15

$$\frac{fa}{Fa} + \frac{Cmxfbx}{(1-fa/F'ex)Fbx} + \frac{Cmyfby}{(1-fa/F'ey)Fby} \leq 1.000$$ **FORMULA----(AISC 1.6-1a)**

$$\frac{fa}{0.60Fy} + \frac{fbx}{Fbx} + \frac{fby}{Fby} \leq 1.000$$ **FORMULA----(AISC 1.6-1b)**

WHEN fa/Fa < 0.15

$$\frac{fa}{Fa} + \frac{fbx}{Fbx} + \frac{fby}{Fby} \leq 1.000$$ **FORMULA----(AISC 1.6-2)**

7. WIND AND SEISMIC STRESSES (AISC SECTION 1.5.6)

ALLOWABLE STRESSES MAY BE INCREASED 1/3 ABOVE THE VALUES OTHERWISE PROVIDED WHEN PRODUCED BY WIND OR SEISMIC LOADING, ACTING ALONE OR IN COMBINATION WITH THE DESIGN DEAD AND LIVE LOADS, PROVIDED THE REQUIRED SECTION COMPUTED ON THIS BASIS IS NOT LESS THAN THAT REQUIRED FOR THE DESIGN DEAD AND LIVE LOADS AND IMPACT (IF ANY), COMPUTED WITHOUT THE 1/3 STRESS INCREASE, AND FURTHER PROVIDED THAT STRESSES ARE NOT OTHERWISE REQUIRED TO BE CALCULATED ON THE BASIS OF REDUCTION FACTORS APPLIED TO DESIGN LOADS IN COMBINATION.

8. MAXIMUM EFFECTIVE SLENDERNESS RATIO (kl/r)

8.1 kl/r FOR COMPRESSION MAIN LEG MEMBERS AND OTHER COMPRESSION HAVING A CALCULATED STRESS
MAX. KL/r = 200

8.2 kl/r FOR COMPRESSION MEMBERS WITH NO CALCULATED STRESS
MAX. KL/r = 300

9. MINIMUM THICKNESS OF STEEL MEMBERS AND SIZE OF BOLTS

MAIN LEG AND GROUND WIRE PEAK	5 mm
ALL OTHER STRESS MEMBERS AND SECONDARY MEMBERS	4 mm
GUSSET PLATES	4.5 mm
BOLTS AND NUTS	12 mm

10. ALLOWABLE DEFLECTION

10.1 ALLOWABLE VERTICAL DEFLECTION FOR SIMPLE BEAM	L/360
10.2 ALLOWABLE VERTICAL DEFLECTION FOR CANTILEVER BEAM	L/180
10.3 ALLOWABLE HORIZONTAL DEFLECTION FOR SIMPLE BEAM	L/180

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1. DESIGN CRITERIA

THE STANDARD DESIGN CRITERIA FOR THE TAKE OFF STEEL STRUCTURES SHALL CONFORM TO **"GUIDE FOR DESIGN OF STEEL TRANSMISSION TOWERS" ASCE MANUALS AND REPORTS ON ENGINEERING PRACTICE NO. 52 (SECOND EDITION COPYRIGHT @ 1988)**

2. COMPUTER PROGRAM FOR ANALYSIS AND DESIGN

THE CALCULATION OF THE TAKE OFF STRUCTURES IS PERFORMED BY USING A THREE DIMENSIONAL STIFFNESS METHOD ANALYSIS COMPUTER PROGRAM NAMED TOWER VERSION 92. THE SOFTWARE USE THE DESIGN CODE CHECKING ACCORDING TO ASCE MANUALS AND REPORTS ON ENGINEERING PRACTICE NO. 52 (SECOND EDITION COPYRIGHT @ 1988)

3. MATERIALS

3.1 ROLLED SHAPES AND PLATES

ALL MATERIALS SHALL BE HOT ROLLED OF STRUCTURAL STEEL SHALL CONFORM TO JIS G3101 SS400 FOR MILD STEEL AND JIS G3101 SS540 FOR HIGH TENSILE STRENGTH STEEL.

3.2 CONNECTION BOLTS AND NUTS

BOLTS AND NUTS SHALL CONFORM TO ASTM A394 TYPE 0

STEP BOLTS SHALL CONFORM TO ASTM 307

3.3 HOT-DIPED GALVANIZING

a) HOT-DIPED GALVANIZING FOR STEEL SHAPES AND PLATES SHALL CONFORM TO ASTM A123.

b) HOT-DIPED GALVANIZING FOR BOLTS,NUTS,SPRING WASHERS AND ANCHOR BOLTS SHALL CONFORM TO ASTM A153.

4. STRENGTH OF MATERIALS

JIS G3101 SS400 OR	Fy = 2,500 ksc	t ≤ 16 mm
EQUIVALENT	= 2,400 ksc	t > 16 mm
	Fu = 4,100 ksc	
ASTM A394 Type 0	Fu = 5,203 ksc	

5. LOADING CONDITION

5.1) WIND LOAD

WIND PRESSURE ACTING ON THE CONDUCTORS, OHG. WIRES AND STRUCTURES ARE SHOWN ON LOADING DIAGRAM

5.2) DEAD LOAD

DEAD LOAD OF CONDUCTORS, OHG. WIRES, ACCESSORY EQUIPMENTS AND STEEL STRUCTURE ACTING ON THE STRUCTURE AS SHOWN ON LOADING DIAGRAM AND THE DESIGN CALCULATION

5.3 SAFETY FACTOR

OVERLOAD FACTOR = 1.8 FOR NORMAL CONDITION

6. UNIT STRESSES

UNIT STRESSES USED IN DESIGN SHALL BE AS FOLLOWS :

STRESSES	**ULTIMATE STRESSES ALLOWED IN DESIGN**
MEMBERS :	
BUCKLING	SEE ULTIMATE BUCKLING STRESS FORMULA AS DETAIL ATTACHED (PAGE 6)
TENSION ON NET SECTION	1.00 Fy
BEARING	1.80 Fy BUT NOT EXCEED THE ULTIMATE TENSILE STRENGTH
BOLTS :	
SHEAR	0.60 Fu
BEARING	1.00 Fu

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THE SECONDARY MEMBERS OR REDUNDANT MEMBERS ARE CAPABLE OF SUPPORTING AN AXIAL TENSILE OR COMPRESSIVE LOAD OF AT LEAST 2.5 PERCENT OF THE MAXIMUM COMPUTED COMPRESSIVE LOAD IN THE MAIN MEMBER, APPLIED AT EACH NODE IN TURN AND IN THE PLANE OF THE BRACING. THE SECONDARY MEMBERS SHOULD ALSO BE CHECKED SEPERATELY FOR 2.5 % OF LEG LOAD SHARED EQUALLY BETWEEN ALL THE NODE POINTS ALONG THE LENGTH OF THE LEG IN A PANEL, EXCLUDING THE FIRST AND THE LAST, ALL THESE LOADS ACTING TOGETHER AND IN THE SAME DIRECTION.

REMARKS :

INCOMPUTING THE NET SECTION FOR TENSION MEMBERS, THE DIAMETER OF THE BOLT HOLE SHALL BE TAKEN AS 2.5 mm GREATER THAN THE NOMINAL DIAMETER OF THE BOLT, THE DETERMINATION OF NET SECTION AREA SHALL BE AS SPECIFIED IN ASCE, GUIDE FOR DESIGN OF STEEL TRANSMISSION TOWERS.

7. LIMIT OF EFFECTIVE SLENDERNESS RATIO

SLENDERNESS RATIOS FOR MEMBERS SHALL BE LIMITED AS FOLLOWS,

MAIN LEG, STUB, MAIN COMPRESSION MEMBER IN CROSSARM AND GROUND WIRE PEAK	150
OTHER COMPRESSION MEMBERS HAVING COMPUTED STRESSES	200
REDUNADANT MEMBERS	250
MEMBERS SUBJECTED TO TENSION ONLY	375

THE DETERMINATION OF EFFECTIVE SLENDERNESS RATIOS OF ANY MEMBER SHALL STRICTLY CONFORM TO THE REQUIREMENTS IN ASCE, GUIDE FOR DESIGN OF STEEL TRANSMISSION TOWERS.

8. MINIMUM THICKNESS OF STEEL MEMBERS AND SIZE OF BOLTS.

MAIN LEG, MAIN COMPRESSION MEMBER IN CROSSARM AND GROUND WIRE PEAK	5 mm
ALL MEMBERS HAVING COMPUTED STRESSES	4 mm
SECONDARY MEMBERS WITHOUT COMPUTED STRESSES OR REDUNDANT MEMBERS	4 mm
GUSSET PLATES	4.5 mm
BOLTS & NUTS AND STEP BOLTS	12 mm

9. HORIZONTAL MEMBERS

THE MEMBERS WITH AN ANGLE LESS THAN 15 DEGREE BETWEEN HORIZONTAL AXIS ARE VERIFIED LOAD OF 150 KGS ACTING AT MIDSPAN TAKING ACCOUNT THE WEIGHT OF A MAN WITH ACCESSORIES.

10. COMPRESSIVE STRENGTH OF CONCRETE

f'c = THE SPECIFIED CYLINDER COMPRESSIVE STRENGTH OF CONCRETE (0.15x0.30) AT 28 DAYS IS 175 ksc

11. ALLOWABLE BONDING STRESS

ALLOWABLE BONDING STRESS = 10 ksc

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The ultimate buckling stresses permitted on gross section of axially loaded compression members shall not exceed the values given in table 1

TABLE 1 ULTIMATE BUCKLING STRESS FORMULA

b/t	Cc	KL/r	METRIC SYSTEM ULTIMATE BUCKLING STRESS (kg/cm^2)
$b/t < (b/t)_{Lim}$	$\pi\sqrt{\frac{2E}{Fy}}$	$\leq$ Cc	$Fa = [1-1/2\left(\frac{KL/r}{Cc}\right)^2 Fy$
		> Cc	$Fa = \frac{20,108,600}{(KL/r)^2}$
$(b/t)_{Lim} \leq b/t \leq \frac{994}{\sqrt{Fy}}$	$\pi\sqrt{\frac{2E}{Fcr}}$	$\leq$ Cc	$Fa = [1-1/2\left(\frac{KL/r}{Cc}\right)^2 Fcr$
		> Cc	$Fa = \frac{20,108,600}{(KL/r)^2}$ Where $Fcr = Fy\,[1.8-0.8(b/t)]/(b/t)_{Lim}$
$b/t \geq \frac{994}{\sqrt{Fy}}$	$\Pi\sqrt{\frac{2E}{Fcr}}$	$\leq$ Cc	$Fa = [1-1/2\left(\frac{KL/r}{Cc}\right)^2 Fcr$
		> Cc	$Fa = \frac{20,108,600}{(KL/r)^2}$ $Fa = \frac{590,580}{(b/t)^2}$

REMARK

$(b/t)_{Lim} = 663/\sqrt{Fy}$ METRIC SYSTEM

Fa = Ultimate buckling stress permitted on gross sec axially loaded compression member in kg/cm²

Fy = Minimum yield point of steel in kg/cm²

Fcr = Adjusted minimum yield point of steel when Mir yield point of steel in kg/cm

Cc = Column slenderness ratio dividing elastic and i buckling

K = Effective length factor or restraint factor

L = Length of the unsupported panel of member in centimeters

r = Radius of gyration of member in centimeters

b = Distance from the edge of fillet to the extreme fiber of the material in centimeters

t = Thinkness of the material in centimeters

E = Modulus of elasticity of steel in kg/cm²

Lim = Limit

2. The effective slenderness ratios for each member shall be permitted to be adjusted in accordance with table 2

TABLE 2 ADJUSTED SLENDERNESS RATIOS, KL/r FOR DIFFERENT TYPE OF MEMBERS

Case	Description	Effective slenderness ration, KL/r	Measured, L/r
1	For leg sections or part members bolted at connections in both faces	KL/r = L/r	-
2	For members with concentric loading at both ends of the unsupported panel	KL/r = L/r	$0 \leq L/r \leq 120$
3	For members with concentric loading at one end and normal framing eccen- at the other end of the unsupported panel	KL/r = 30+0.75L/r	$0 \leq L/r \leq 120$
4	For members with normal framing eccentricities at both ends of the unsup- ported panel	KL/r = 60+0.50L/r	$0 \leq L/r \leq 120$
5	For members unrestrained against rotation at both ends of the unsupported panel. (c.g. single bolt connection at both ends)	KL/r = L/r	$120 < L/r \leq 200$
6	For members partially restrained against rotation at one end of the unsup- ported panel. (c.g. single bolt connection at one end and multiple bolt con- nection at another end)	KL/r = 26.6+0.762L/r	$120 < L/r \leq 225$
7	For members partially restrained against rotation at bolt ends of the unsup- ported panel. (c.g. multiple bolt connection at both ends)	KL/r = 46.2+0.615L/r	$120 < L/r \leq 250$

REMARKS

1. A single bolt connection shall not be consider to provide restraint against rotation
2. A multiple bolt connection properly detailed to minimize eccentricities shall be considered to offer partial restraint if the connection is to a member having adequate flexural strength to resist rotation of the joint
3. Point of intermediate support shall not be considered as offering restraint to rotation unless the criteria outlined in from 2.met

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MAXIMUM FOUNDATION LOADS /COLUMN

TYPE OF STRUCTURE	MOMENT (KG-M.)	VERTICAL (KG.)	HORIZONTAL (KG.)
1. 115 KV. BUS SUPPORT STRUCTURE	317	350	101
2. 115 KV. CIRCUIT BREAKER STRUCTURE	3,052	2,050	665

MAXIMUM FOUNDATION LOADS /POST

TYPE OF STRUCTURE	COMPRESSION (KG.)	TENSION (KG.)	HORIZONTAL (KG.)
4. 115 KV. LIGHTNING ARRESTER	307	197	109
5. 115 KV. CURRENT TRANSFORMER STRUCTURE	703	228	188
6. 115 KV. CAPACITOR VOLTAGE TRANSFORMER STRUCTURE	619	269	146

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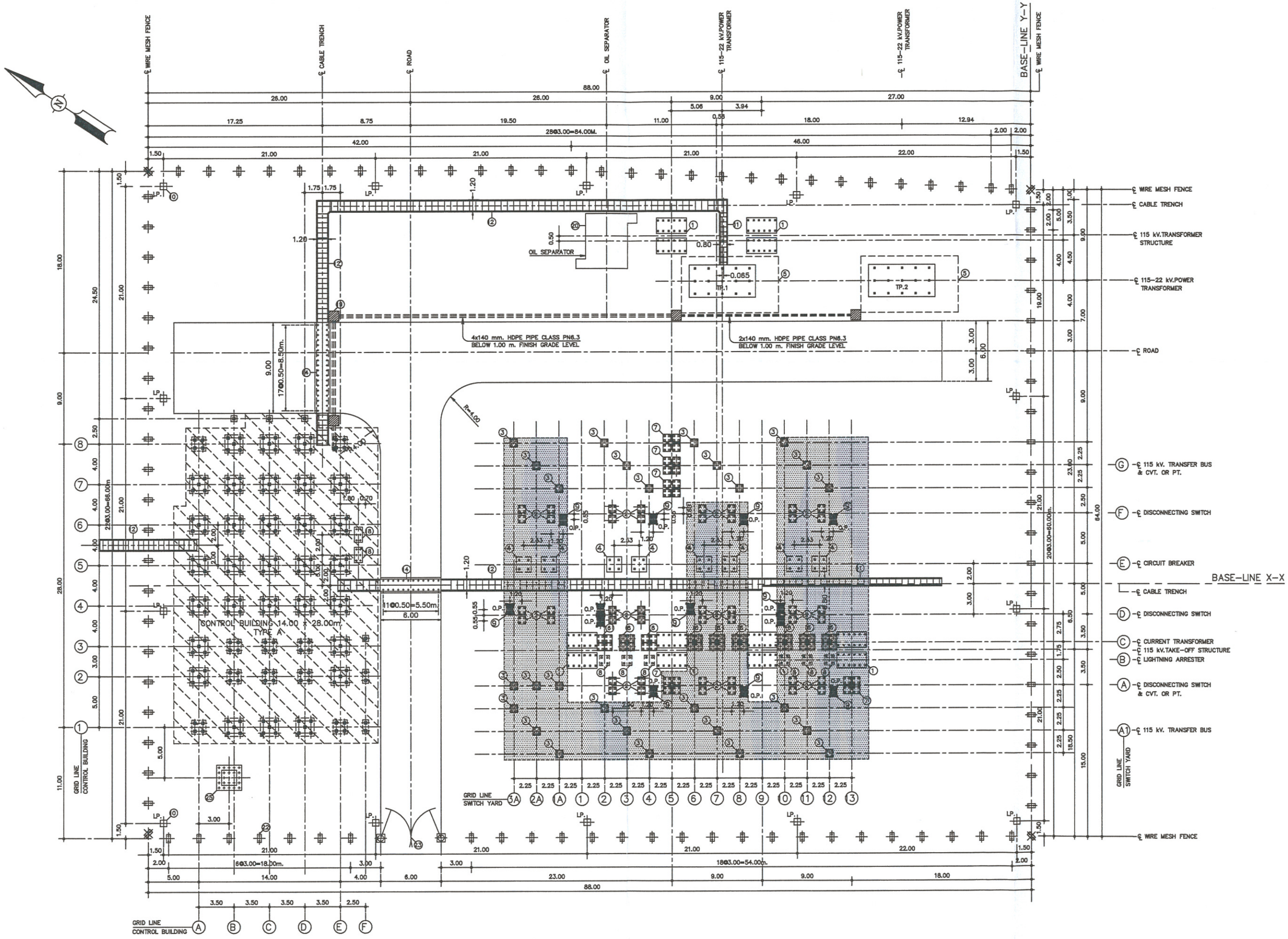
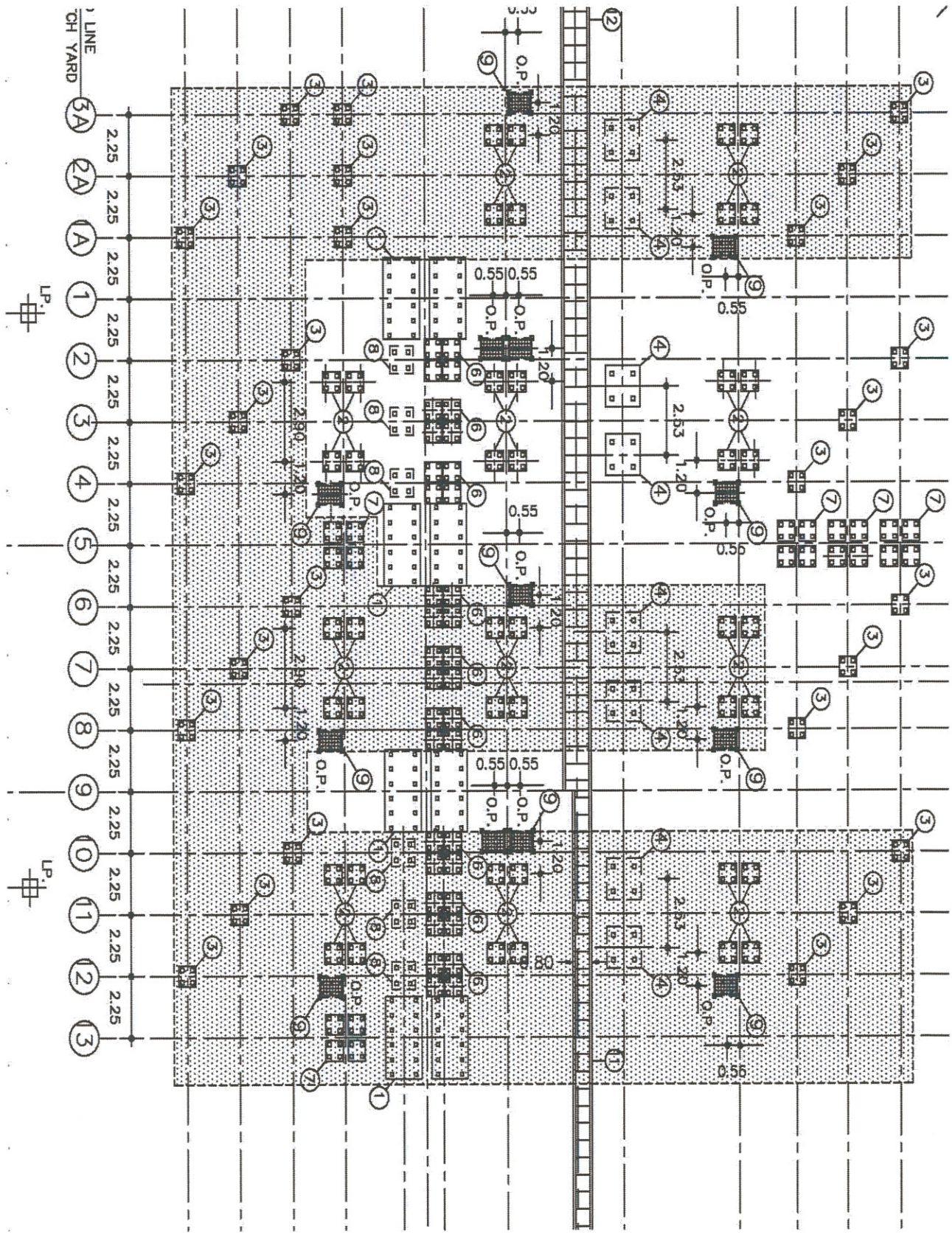


FOUNDATION AND PILING LAYOUT

SCALE 1 : 250

SWITCH YARD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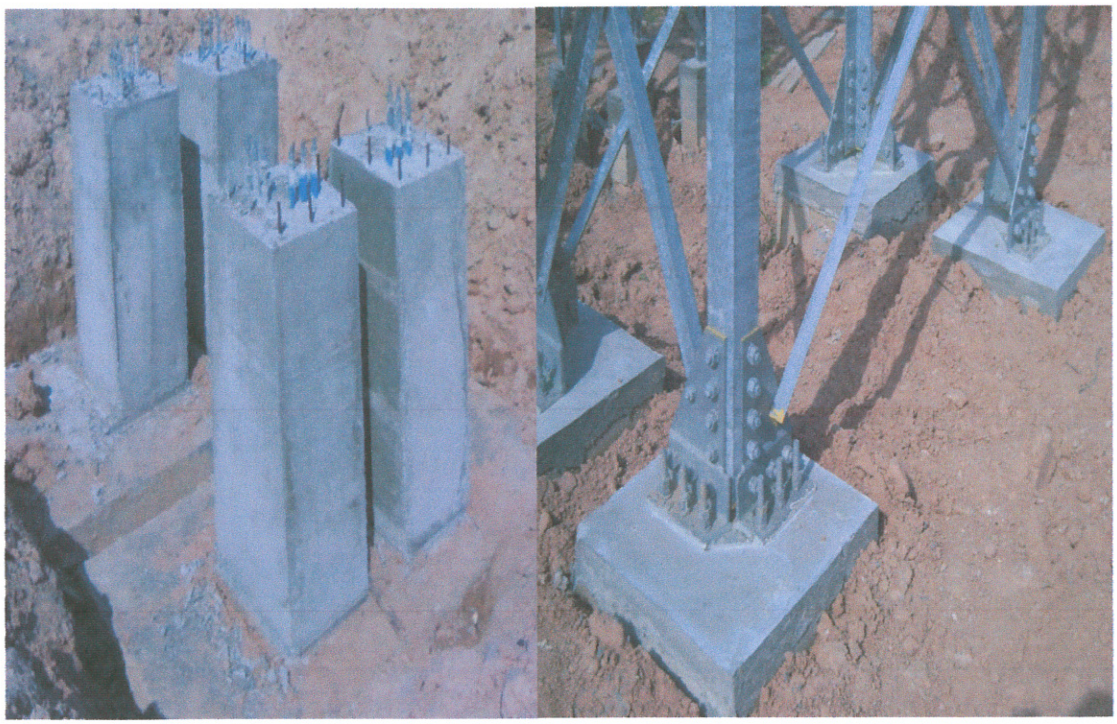
2.90
LP.

BILL OF PILING		QUANTITY				
ITEM	DESCRIPTION	OF FOUNDATIONS		NUMBER OF PILES PER FOUNDATION /TYPE/DIMENSIONS OF PILE	DWG. NO.	PILE TOP LEVEL
		Q'TY	UNIT			
1	115 kV. TAKE-OFF SUPPORT FOUNDATION (1 SET = 2 FOUNDATIONS)	5	SET	24- ⌀0.18x0.18x3.00 m.	IB1-020/23015	-2.20
2	115 kV. DISCONNECTING SWITCH SUPPORT (1 SET = 4 FOUNDATIONS)	3	SET	16- ⌀0.15x0.15x2.00 m.	IB1-020/23016	-1.15
3	115 kV. BUS POLE SOPPORT FOUNDATION (1 SET = 1 FOUNDATION)	6	SET	4- ⌀0.15x0.15x2.00 m.	IB1-017/23011	-1.15
4	115 kV. CIRCUIT BREAKER SUPPORT FOUNDATION (1 SET = 2 FOUNDATIONS)	1	SET	8- ⌀0.18x0.18x3.00 m.	STD-SWY-A-001	-1.15
5	115-22 KV TRANSFORMER FOUNDATION (1 SET = 1 FOUNDATION)	2	SET	15- ⌀0.18x0.18x5.00 m.	STD-SWY-A-002	-0.40
6	115 kV. CURRENT TRANSFORMER SUPPORT FOUNDATION (1 SET = 4 FOUNDATION)	3	SET	16- ⌀0.15x0.15x2.00 m.	IB1-020/23017	-1.15
7	115 kV. CVT OR PT SUPPORT FOUNDATION (1 SET = 4 FOUNDATION)	3	SET	16- ⌀0.15x0.15x4.00 m.	IB1-017/23022	-1.15
8	115 kV. LIGHTNING ARRESTER SUPPORT FOUNDATION (1 SET = 1 FOUNDATION)	3	SET	4- ⌀0.15x0.15x2.00 m.	IB1-020/23018	-1.15
9	OPERATING PLATFORM FOUNDATION TYPE C	4	SET	ON GROUND	IB1-017/23038	-
10	LAMP POST FOUNDATION (1 SET = 1 FOUNDATION)	14	SET	1- ⌀0.15x0.15x2.00 m.	SB3-021/22015	-1.15
11	CABLE TRENCH TYPE A SIZE 0.80 m.	24	m.	ON GROUND	IB2-020/21002	-
12	CABLE TRENCH TYPE A SIZE 1.20 m.	95	m.	ON GROUND	IB2-020/21002	-
13	CABLE TRENCH TYPE B SIZE 0.80 m.	-	m.	-	-	-
14	CABLE TRENCH TYPE B SIZE 1.20 m.	16	m.	2- ⌀0.15x0.15x2.00 m.	IB2-020/21002	-
15	CABLE TRENCH T SHAPE SIZE 1.20 m.	-	m.	-	-	-
16	CABLE TRENCH L SHAPE SIZE 0.80 m.	-	m.	-	-	-
17	CABLE TRENCH L SHAPE SIZE 1.20 m.	2	SET	ON GROUND	IB2-020/21002	-
18	STATION SERVICE TRANSFORMER FOUNDATION (1 SET = 1 FOUNDATION)	2	SET	6- ⌀0.18x0.18x3.00 m.	STD-SWY-A-004	-0.15
19	HAND HOLE	4	SET	ON GROUND	STD-SWY-A-006	-
20	OIL SEPERATOR FOUNDATION (1 SET = 1 FOUNDATION)	1	SET	ON GROUND	STD-SWY-A-005	-
21	CONTROL BUILDING TYPE A	198	PILES	198- ⌀0.26x0.26x4.00 m.	IB3-011/41006	-1.45
22	MESH FENCE FOR SUBSTATION	300	m.	2- ⌀0.15x0.15x2.00 m.	IB2-020/24214	-
23	MESH GATE FOR SUBSTATION	1	SET	8- ⌀0.15x0.15x2.00 m.	IB2-020/24214	-
24	OPERATOR'S HOUSE	-	-	ON GROUND AND EXTENSION STUB TO 2.50 m.	IB2-011/45001	-
25	ANTENNA TOWER FOUNDATION	25	PILES	25- ⌀0.15x0.15x2.00 m.	SA2-017/32032	-1.55



115 KV. TAKE-OFF SUPPORT

SUBJECT : 115 KV. TAKE-OFF STRUCTURE	PAGE
FOUNDATION LOADS	

FOUNDATION LOADS

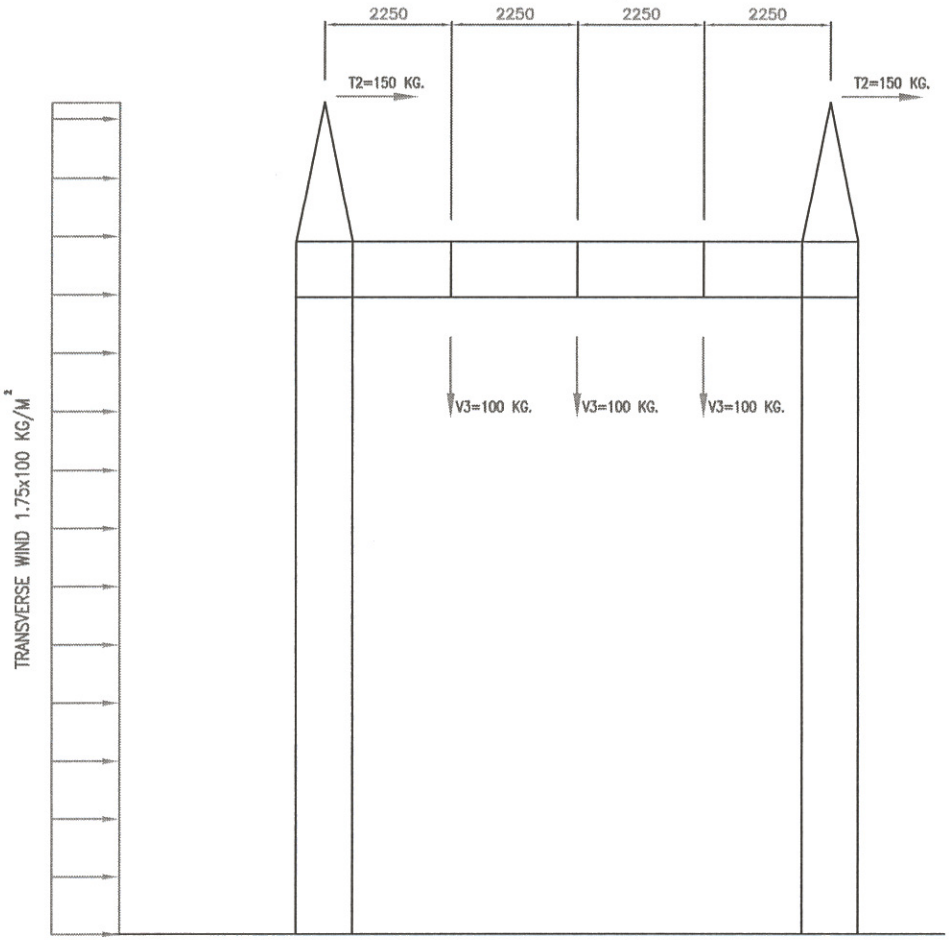
TYPE OF STRUCTURE	MAXIMUM COMPRESSION (KG)	MAXIMUM TENSION (KG)	MAX. HORIZONTAL SHEAR (KG)	
			TRANSVERSE	LONGITUDINAL
115 KV. TAKE-OFF STRUCTURE	18,325	15,693	744	1,115

NOTES

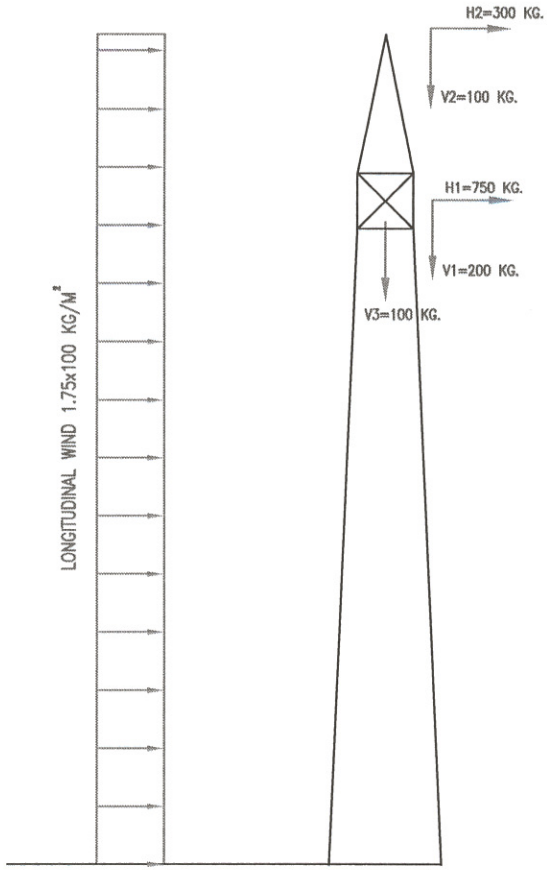
1. ALL LOADS ARE INCLUDED OVERLOAD FACTOR = 1.8
2. ALL LOADS ARE PER ONE LEG

(นายชาย แสงไสว)

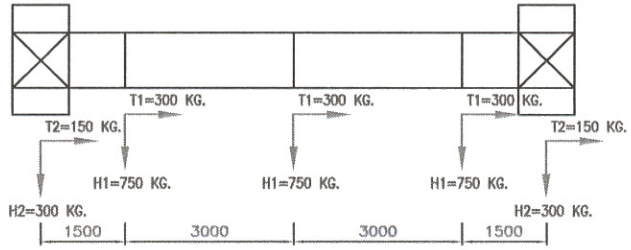
A3:100



FRONT VIEW



SIDE VIEW



TOP VIEW

LOADING CASE

CASE 1. NORMAL CONDITION (LONGITUDINAL WIND)
CASE 2. NORMAL CONDITION (TRANSVERSE WIND)

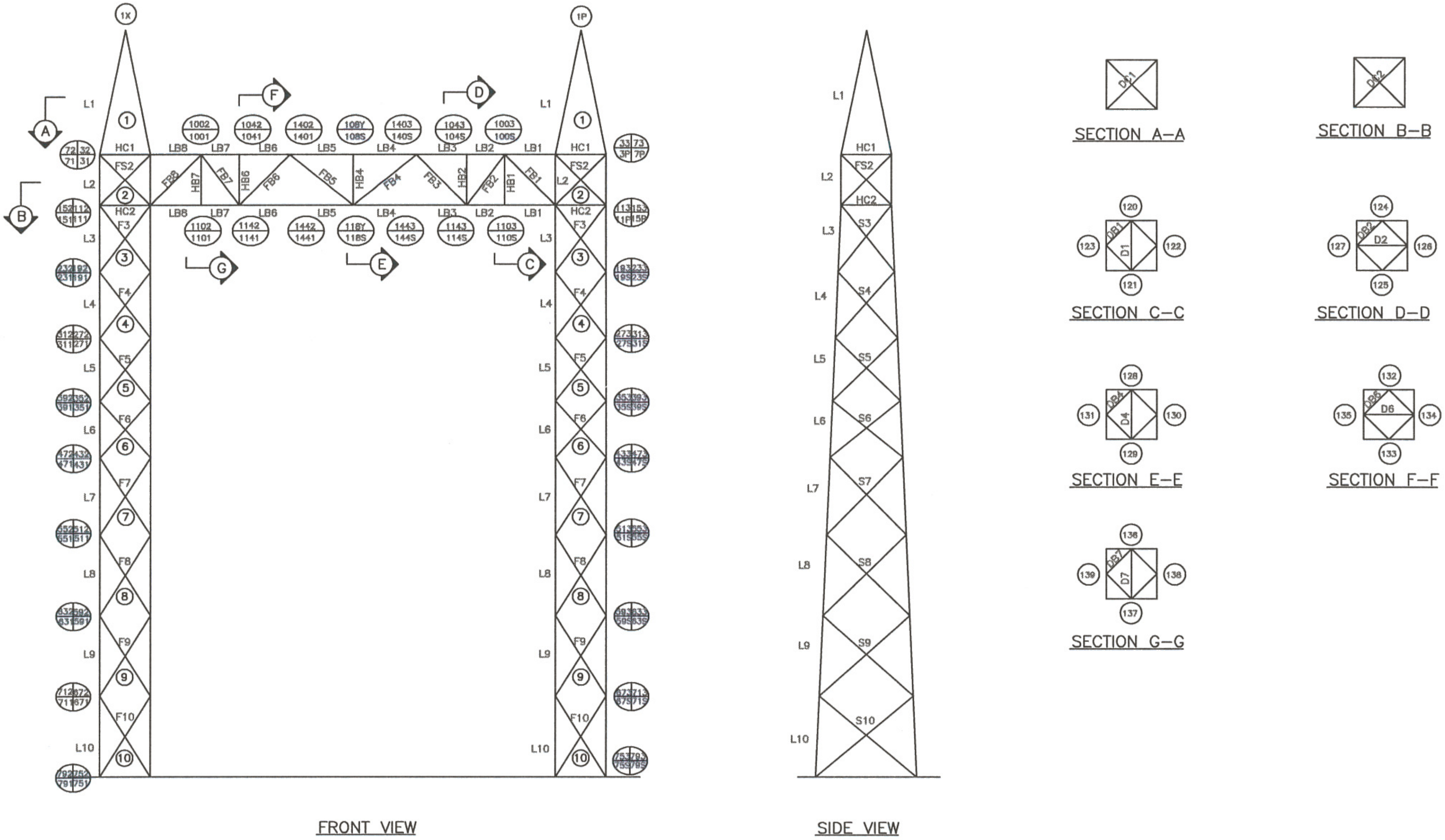
NOTE ALL LOADS EXCLUDING SAFETY FACTOR = 1.8

OWNER : PROVINCIAL ELECTRICITY AUTHORITY

NO.	DATE	REVISION	DESIGNED	DRAWN	CHECKED	APPROVED

PROJECT :	115/22 KV. PEA SUBSTATION
CONTRACT NO. :	PEA-TSD.7.2.P-3.1/2003
TYPE OF STRUCTURE :	115 KV. TAKE-OFF STRUCTURE
TYPE OF DRAWING :	LOADING DIAGRAM
DRAWING NO. :	ST-435
DATE :	22-09-2003
DRAWING NO.	UA-03-ST435-D3
REV	01
	01

A3:100



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PROVINCIAL ELECTRICITY AUTHORITY

PROJECT : 115/22 KV. PEA SUBSTATION

PEA-TSD.7.2.P-3.1/2003

115 KV. TAKE-OFF STRUCTURE

COMPUTER MODEL

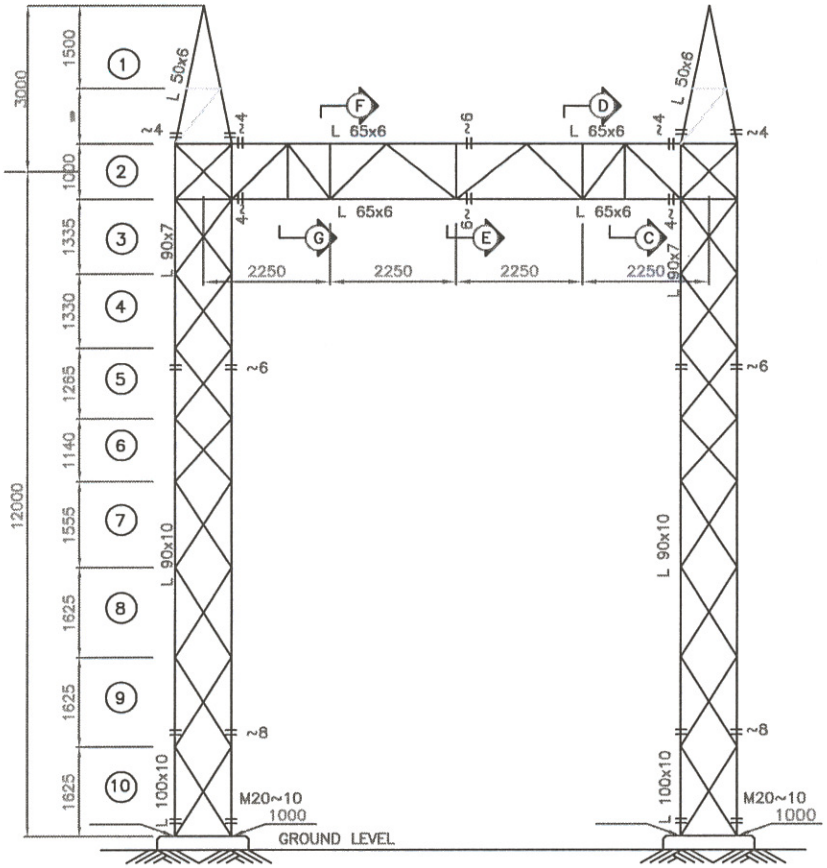
ST-436

22-08-2003

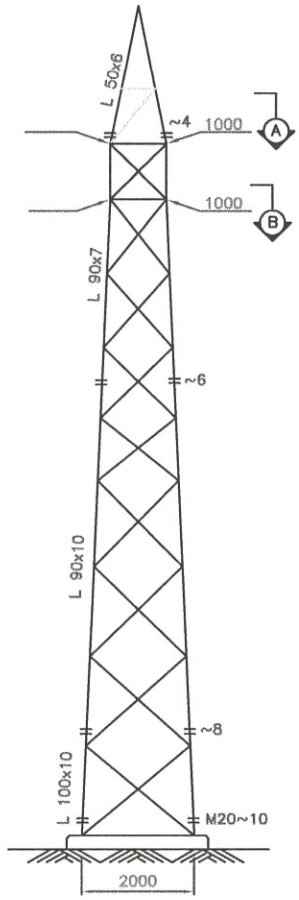
UA-03-ST436-D2

01

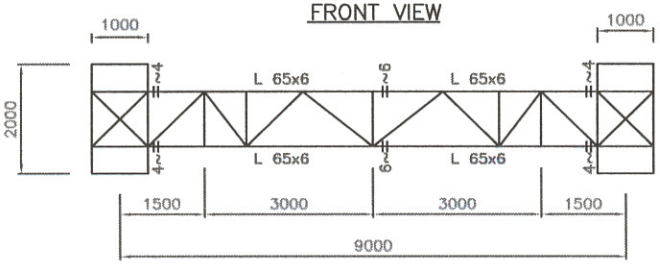
NO.	DATE	REVISION	DESIGNED	DRAWN	CHECKED	APPROVED



FRONT VIEW



SIDE VIEW



TOP VIEW

SECTION A–A

SECTION B–B

SECTION C–C,E–E,G–G

SECTION D–D,F–F

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETERS FROM THE CG. TO CG. OF MEMBERS.
2. ALL BLANK MEMBERS AND BOLTS ARE L50x4 AND M16–1 RESPECTIVELY.
3. ALL BOLTS ARE SIZE M16 EXCEPT OTHERWISE SHOWN, BOLTS MATERIALS CONFORM TO ASTM A394 (TYPE 0)
4. ALL STRUCTURAL STEEL CONFORM TO JIS G3101 SS400 OR EQUIVALENT.
5. ALL MATERIALS SHALL BE HOT DIP GALVANIZED AFTER FABRICATION AND CLEANING , MEMBERS AND PLATES CONFORM TO ASTM A123, BOLTS AND NUTS CONFORM TO ASTM A153
6. ALL BOLT CONNECTIONS ARE SINGLE SHEAR EXCEPT OTHERWISE SHOWN "DS" ARE DOUBLE SHEAR.
7. MINIMUM THICKNESS OF GUSSET PLATES ARE 5 MM.

NO.	DATE	REVISION	DESIGNED	DRAWN	CHECKED	APPROVED

OWNER : PROVINCIAL ELECTRICITY AUTHORITY

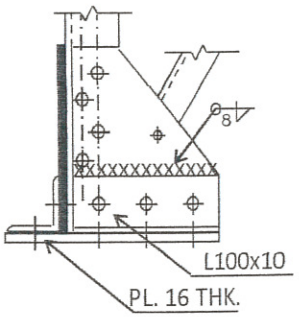
SUPPLIER : THE UA INDUSTRIAL CORPORATION CO., LTD.

DESIGNER : PACIFIC GAS AND CHEMICALS CO., LTD.

PROJECT :	115/22 KV. PEA SUBSTATION
CONTRACT NO. :	PEA-TSD.7.2.P-3.1/2003
TYPE OF STRUCTURE :	115 KV. TAKE-OFF STRUCTURE
TYPE OF DRAWING :	DESIGN DRAWING
DRAWING NO. :	ST-436
DATE :	22-09-2003
DRAWING NO.	UA-01-ST4B3-D1
REV	01
	01

SUBJECT : 115 KV. TAKE-OFF STRUCTURE	PAGE
DESIGN OF BASE PLATE AND ANCHOR BOLT	

DESIGN OF BASE PLATE & ANCHOR BOLT



ULTIMATE COMPRESSION = 18,325 KG

ULTIMATE TENSION = 15,693 KG

WORKING COMPRESSION = 10,181 KG (OLF. = 1.8)

WORKING TENSION = 8,718 KG (OLF. = 1.8)

BEARING AREA OF BASE PLATE = (35x35)-(0.5x23x23)-(0.5x11x11)

= 900.0 CM^2

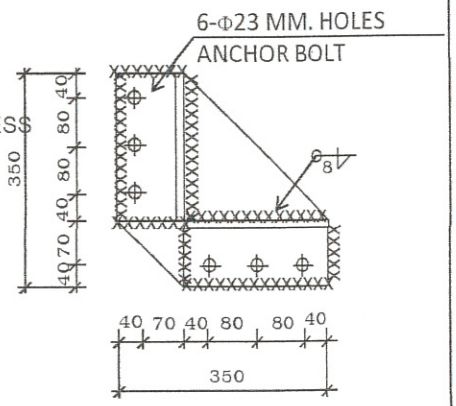
BEARING STRESS ON BASE PLATE = 10,181/900

= 11.31 KG/CM^2

< ALLOWABLE BEARING STRESS

ON CONCRETE = 0.25fc'

= 43.75 KG/CM^2



TENSION = 8,718/2

= 4,359 KG/SIDE

MAX.. MOMENT = 4,359x8.0

= 34,873 KG-CM

MIN.THICKNESS OF BASE PLATE = $\sqrt{6x34.873/(0.75x2,400x24)}$

= 2.20 CM

SO WE USE BASE PLATE 25 MM THICKNESS ⇦

(BASE PLATE 25 MM = 10+15 =L100x10 + BASE PLATE 15 MM)

CHECKING OF ANCHOR BOLT

ASSUME USE ANCHOR BOLTS SIZE 6-M20x712x100 , EMBEDED LENGTH = 60 CM ,

MATERIAL IS JIS G3101 SS400 , Fy =2,500 ksc , Fu =4,100 ksc

ALLOWABLE BONDING STRESS = 10 KSC

BONDING STRENGTH = 6xπx2.0x60x10

= 22,619 KG

> 8,718 KG OK.

TENSILE STRENGTH = 0.33FuxArea

= 0.33x4,100x6xπx$(2.0)^2$/4

= 25,503 KG

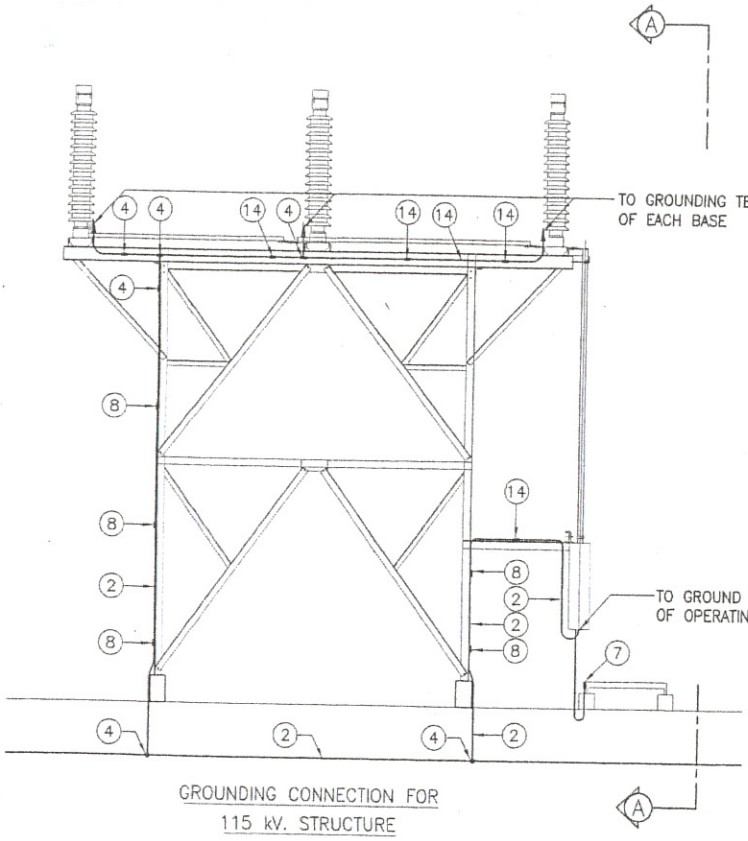
> 8,718 KG OK.

SO WE CAN USE ANCHOR BOLTS SIZE 6-M20x712x100 PER LEG ⇦

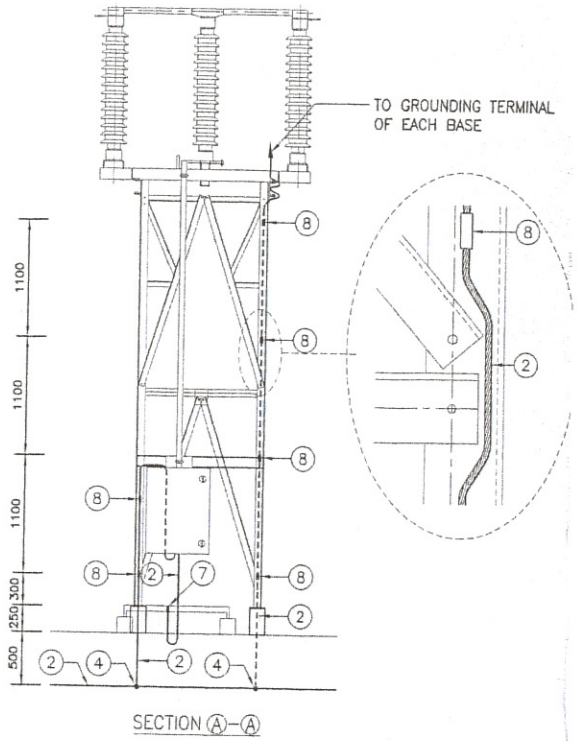
(นายชาย แสงไสว)

115 KV.BUS POLE SUPPORT

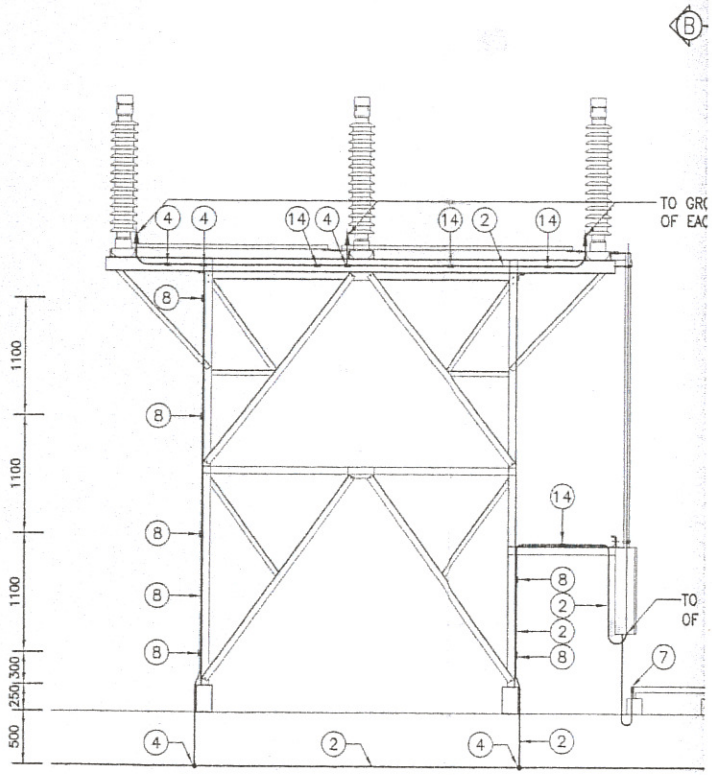
CURRENT TRANSFORMER



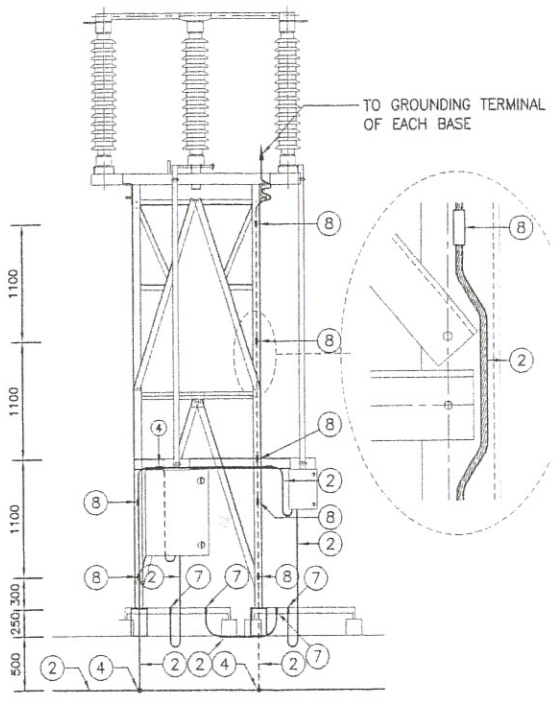
GROUNDING CONNECTION FOR
115 kV. STRUCTURE



SECTION Ⓐ–Ⓐ



GROUNDING CONNECTION FOR
115 kV. STRUCTURE

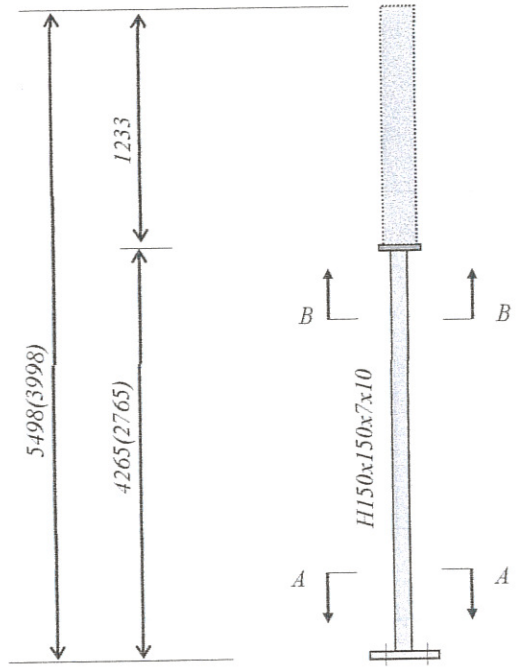


SECTION Ⓑ–Ⓑ

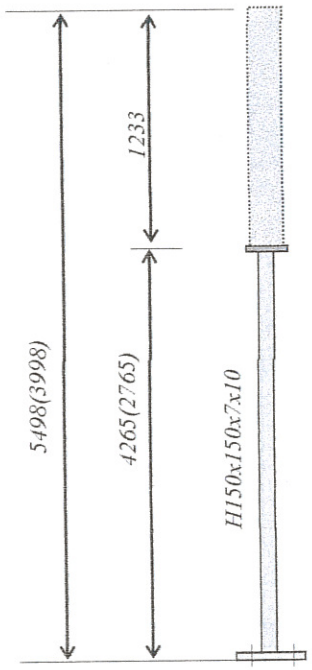
115 KV. DISCONNECTING SWITCH SUPPORT

(นายชาย แสงไสว)

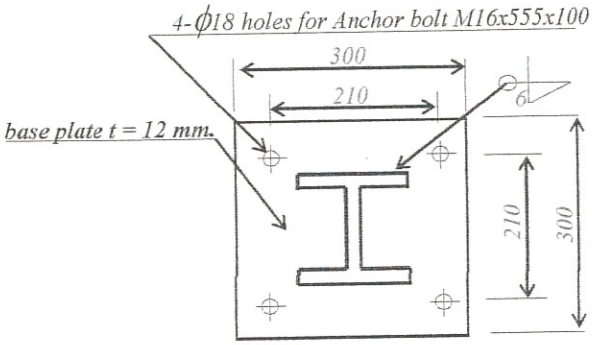
1. Structural design drawing



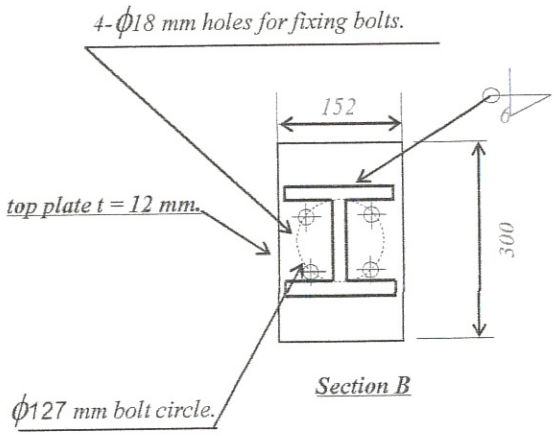
Front view



Side view



Section A



Section B

Total weight of steel structure	=	250	kg.	
Wind load on steel structure	=	64	kg.	
Wind load on equipment	=	1.233x0.2x67		
	=	17	kg.	(App. Diameter=200 mm.)
Weight of equipment	=	100	kg.	
Dynamic load = 0.2G	=	20	kg.	
Center of gravity of equipment	=	617	mm.	

2. Detail of equipment

Item no.	Total height (mm.)	Height of equipment (mm.)	Height of steel structure (mm.)	Weight of Equipment (kg.)
A11.3	5498	1233	4265	100

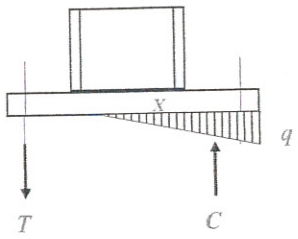
(ชาย แสงไสว)

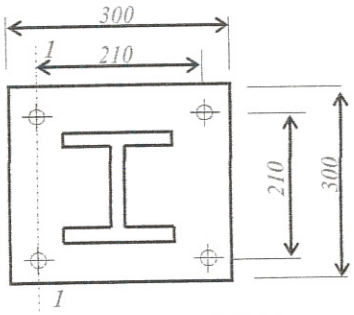
Maximum moment on column	=	(20+17)x(4.265+0.617)+62x4.265/2=		317	kg.-m.
Maximum vertical load on column	=	250+100	=	**350**	kg.

Design column, base plate , anchor bolts and check welding

Assume use column size H150x150x7x10 ,area = 40.14 cm^2 , rx = 6.39 ,ry = 3.75 cm, Zx = 219 Zy = 75.1 cm^4

Base plate 300x300 mm^2





KL/r	=	2.1x426.5/3.75	=	238.84	> Cc =	$(2(\pi)^2E/FY)^{0.5}$	= 126.91
Fa	=	**184** ksc.		**(AISC 1.5-2)**			
fa	=	350/40.14	=	**8.7**	ksc.		
fa/Fa	=	8.7/184	=	0.047	< 0.15		

According to AISC specification for checking of combined axial force and bending moment

fa/Fa	+	fbx/Fbx	<	1.00		**(AISC 1.6-2)**	
0.047	+	317x100/75.1 / 0.66x2,500	=	0.30	<	1.00	**OK.**

Allowable bearing stress on concrete

fc= 0.25fc' = 0.25x175 = 43.75

q = V/A+M/S = 350/(30x30)+317x100x6/(30x30^2)	=	7.4	< 43.75 ksc.	**OK.**

Σ moment around 1-1 = 0

C(25.5-X/3)	=	Vx10.5+M
0.5x7.4x30X(25.5-X/3)	=	350x10.5+317x100
$-37X^2+2830.5X$	=	35375
$37X^2-2830.5X+35375$	=	0
X	=	15.7 cm.
T	=	C-V
	=	0.5x7.4x30x15.7-350
	=	1393 kg.

Maximum moment on base plate M1	=	1393x(21-15)/2	
	=	4179	kg-cm.
Maximum moment on base plate M2	=	7.4x30x7.5x7.5/2	
	=	6244	kg-cm.
Minimum thickness of base plate	=	$(6244x6/(30x0.75x2500))^{0.5}$	
	=	**0.816**	cm.

(ชาย แสงไสว)

Assume use anchor bolt size M16x555x100, Embeded length = 45 cm., JIS G3101 SS400 Fu = 4,100 ksc.

Allowable bonding stress = 10 KSC

Allowable bonding strength = $2x\pi x1.6x45x10$

= 4,522 KG. > 1,393 kg. **OK**

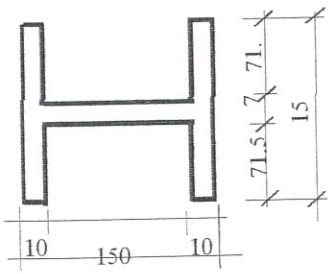
Allowable tensile strength = 0.33xFuxAREA

= $2x\ 0.33x4,100x\pi x(1.6)^2/4$

= 5,438 KG. > 1,393 KG **OK.**

So we can use column size H150x150x7x10, base plate 300x300x12^t and 4-M16x555x100 anchor bolts

Check welding



Assume use 6 mm. weld

Moment inertia $Iy = 2x1/12x1x(15)^3+4(1/12x1x(7.15)^3$
$+4x1x7.15x(3.75^2)+2x1x13x(0.35)^2$
= 1,090 $cm.^4/cm$

Moment inertia $Ix = 2x1/12x1x(13^3)+4x7.15x(6.5^2)$
$+2x15x(7.5)^2$
= 3,262 $cm.^4/cm$

Shearing stress $fv1 = Mc/I$
= 317x100x7.5/1090x0.6x0.707
= 514 KSC.

Allowable shearing stress fv = 1,260 KSC

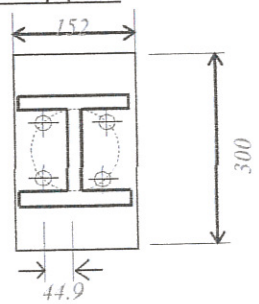
Total horiz. Force = 101 KG. TOTAL WELDING LENGTH = 85 CM

Shearing stress fv3 = 101/85x0.6x0.707 = 2.8 KSC

Combined shearing stress $= \sqrt{(514)^2+(2.8)^2}$ = 514.01 < 1,260 KSC **OK.**

So we can use 6.0 mm. Fillet weld

Design top plate



Maximum moment = (17+20)x0.617 = 23 kg.-m.

Maximum vertical = 100 kg.

Maximum compression on plate
= 23/0.0449+100/2 = 562 kg.

Maximum bending moment on plate
= 562x0.0449/2 = 12.62 kg.-m.

minimum thickness of top plate = $(12.62x100x6/(0.75x2500x15.2))^{0.5}$
= 0.52 cm.

So we can use top plate 12 mm. Thickness

(ชาย แสงไสว)