CHAPTER VI POWER SUPPLY

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6.1 Power Supply System and Execution Organization

Electric power will be supplied from the El Abd substation operated by EEA and located about 35 km north west of the No. 7 Pumping station through two 66 kV transmission lines. The electric power transmitted to the main substation located on the site beside No. 7 Pumping station and it is transformed to 11 kV and distributed to the auxiliary substations in the pump house.

That is, there are four major facilities such as 66 kV transmission lines, 66 kV Main substation, 11 kV Feeder cable lines and auxiliary substations in the power supply system.

6.1.1 66 kV Transmission Lines

All works about the transmission lines will be executed by REA (Rural Electrification Authority) by the requirement of NSDO before the beginning operation of the pump station.

6.1.2 Main Substation

For the main substation, NSDO will require that execution and operation of the main substation at the site provided by NSDO to REA with presenting schematic drawings and documents which shows the technical requirement of NSDO.

Then REA will prosecute detail designing, tendering and construction for the main substation. The construction cost is decided by REA and NSDO will settle a share of the expenses. REA will take management of the main substation continuously.

6.1.3 11 kV Feeder Cable Lines

The cable lines connected from the main substation to the auxiliary substations will be installed by REA.

6.1.4 Auxiliary Substations

Two auxiliary substations will be constructed in each pumping station or construction Stage I and Stage II.
NSDO will execute all of works such as design, tendering, operation and maintenance as one part of the packaged construction contract.
The rate of electric power demanded in the pump station facilities is measuring by the kilo-watt hour meters installed to each 11 kV service feeder and is paid monthly.

6.2 Requirement Capacity of Power Supply

For the main items required to design works of the power supply system such as capacity of the main and auxiliary transformers, short circuit current of the circuit breakers and grounding resistance for protection earth are calculated as shown the following procedure.

6.2.1 Numbers and Unit Capacity of Main Transformer

The main transformer unit capacity is limited as 25 MVA by the standard capacity of REA and the input capacity of main pump motor is 13,000 kW then the starting capacity will be about 33 MVA as shown on the Table 6.2-1.
It means the main transformers must be connected to suit the parallel running.
The required numbers of the transformer is calculated based on the following operational conditions.

(1) Phase-I: 3-Main pumps shall be operated at the time of the auxiliary transformer load is 100 %
(2) Phase-II: 2-Main pumps shall be operated at the time of the auxiliary transformer load is 100 %
(3) Main motors shall be manually operated one by one or never started plural main pumps at the same time.

The data of connecting loads that is main pump motors and station transformer used for calculation is shown on the following tables.

Table 6.2-1 Data of Main Pump Motor

Rated output capacity	A	13,000 (kW)
Rated voltage	B	11 (kV)
Efficiency	C	0.926
Power factor under normal running	D	1.0
Rated current	E=A/B/C/D/1.73	737 (A)
Input capacity under normal running	F=A/C	14,039 (kW)
Voltage tap of starter transformer	G	0.65
Starting current	H=5.5*E	4,054 (A)
Starting capacity	$J=1.73*B*H*G^2$	32,633 (kVA)
Power factor on starting	K	0.2
Starting input capacity (Active power)	L=J*K	6,527 (kW)
Starting input capacity (Reactive power)	M=J*Sin[Cos-1(K)]	31,974 (kVar)

Table 6.2-2 Data of Station Transformer

Capacity	Q	1,000 (kVA)
Power factor of total connecting loads	R	0.8
Total load (Active power)	S=R*Q	800 (kW)
Total load (Reactive power)	T=Q*Sin[Cos-1(R)]	600 (kVar)

(a) Transformer capacity at the construction Stage-1

The required transformer capacity is 48 MVA as shown on the Table 6.2-3 to start the third main pump under the condition of that the station transformer and two other main pumps are under full load operation.

Table 6.2-3 Required Transformer Capacity in Pahse I

Operation Mode		Load	
		Active power (kW)	Reactive power (kVar)
Station transformer	Full load Run	800	600
1st Pump motor	Full load Run	14,039	0
2nd Pump motor	Full load Run	14,039	0
3rd Pump motor	Start	6,527	31,974
4th Pump motor	Standby		
Total		Pa: 35,405	Pr: 32,574
Impedance of Main transformer		Zt: 10 %	
Allowable voltage drop of Motor		Vd: 10 %	
Required Capacity		$Pt = \sqrt{(Pa^2+Pr^2)} * Zt/Vd$ = 48.1 (MVA)	

By same procedure the required transformer capacity is 39 MVA as shown on the Table 6.2-4 to start the second main pump under the condition of that the station transformer and another main pump are under full load operation.

Table 6.2-4 Required Transformer Capacity in Phase II

Operation Mode		Load	
		Active power (kW)	Reactive power (kVar)
Station transformer	Full load Run	800	600
1st Pump motor	Full load Run	14,039	0
2nd Pump motor	Start	6,527	31,974
3rd Pump motor	Standby		
Total		Pa: 21,366	Pr: 32,574
Impedance of Main transformer		Zt: 10 %	
Allowable voltage drop of Motor		Vd: 10 %	
Required Capacity		$Pt = \sqrt{(Pa^2+Pr^2)} * Zt/Vd$ = 39.0 (MVA)	

Then two 25 MVA transformers in parallel operation are required on each construction phase to operate main pumps and station transformer.

Eventually two 25 MVA transformers and two 25 MVA transformers for 100 percent standby on the first construction stage will be installed in the main substation.

For the second construction stage four 25 MVA transformers will be added two are usually use and two is for standby.

6.2.2 Station Transformer Capacity (Main Substation)

For supply power to operate the equipment of power supply systems, protection relays, control systems, building facilities and lighting systems of the main substation the station transformer is provided.
Connecting load is estimated as follows.

- Operation of power supply equipment	100 kVA
- Protection relays/Control system	100 kVA
- Building facilities	100 kVA
- Lighting systems	200 kVA
- Others	100 kVA
Total	600 kVA

Take the demand factor of 70 percent into consideration one 500-kVA transformer as station transformer is installed in the main substation.

6.2.3 Auxiliary Transformer Capacity (Pump Stations)

The auxiliary transformer will supply power to the following consumers in the each pump station as shown on the Table 6.2-5.
To keep reliability of the low voltage distribution system, two auxiliary transformers one is for 100 % standby will be installed in each pump station.

Table 6.2-5 Connecting Consumers in the Pump Station (Stage I)

No.	Consumers	Supply power	Load (kW)
1	Main pump - 1 auxiliary equipment	3-Phase 380 V	7
2	Main pump - 2 auxiliary equipment	3-Phase 380 V	7
3	Main pump - 3 auxiliary equipment	3-Phase 380 V	7
4	Main pump - 4 auxiliary equipment	3-Phase 380 V	(7)
5	Common used equipment – 1	3-Phase 380 V	34
6	Common used equipment – 2	3-Phase 380 V	40
7	Others	3-Phase 380 V	50
8	Lighting & Socket outlets	3-Phase 380/220 V	250
9	Out door lighting	3-Phase 380/220 V	250
	Total of the above items		645
10	Pipe line water filling pump-1	3-Phase 380 V	240
11	Pipe line water filling pump-2	3-Phase 380 V	240
	Total		1125

Note: The data in parenthesis is standby then not calculated for the total.

Table 6.2-6 Connecting Consumers in the Pump Station (Stage II)

No.	Consumers	Supply power	Load (kW)
1	Main pump -1 auxiliary equipment	3-Phase 380 V	7
2	Main pump -2 auxiliary equipment	3-Phase 380 V	7
3	Main pump -3 auxiliary equipment	3-Phase 380 V	(7)
4	Common use equipment – 1	3-Phase 380 V	34
5	Common use equipment – 2	3-Phase 380 V	40
6	Others	3-Phase 380 V	50
7	Lighting & Socket outlets	3-Phase 380/220 V	200
8	Out door lighting	3-Phase 380/220 V	200
	Total of the above items		538
9	Pipe line water filling pump-1	3-Phase 380 V	250
10	Pipe line water filling pump-2	3-Phase 380 V	250
	Total		1038

Note: The data in parenthesis is standby then not calculated for the total.

Then the estimated load is 1,125 kW and 1,038 kW for each pump station.
For the daily connecting load take demand factor (60 %) and power factor (75%) are into consideration then the required capacity of the auxiliary transformer is 1,000 kVA to each pump station.

6.2.4 Short Circuit Capacity

To calculate the short circuit capacity of the circuit breakers the worst fault point in the power supply system is pointed out at branch line to each main pump motor.
Because the other connecting main pump motors under full load operation will effect instantaneously as a generator and additional reverse current flow into this fault point.
At this point the short circuit capacity is calculated 29.3 kA under normal operation and 31.1 kA under starting operation of the motor as shown on the following calculation procedure.
Then the short circuit capacity of the circuit breaker for main pump motor shall be 40 kA.

To calculation of short circuit capacity of the power supply system the percent impedance method by the following procedure will be applied.

- Decide a Basic capacity.
- Calculate the percent impedance based on basic power of main equipment connected to the system.
- Make impedance map of the system.
- Calculate the momentary short circuit current.
- Calculate the short circuit capacity.

(1) Decide a Basic capacity.

This value is used only to calculation then any value is acceptable, usually 10 MVA is adopted.

(2) Calculate the percent impedance based on the basic capacity.

The main equipment connected to the system will be used in deferent voltage then rated percent impedance must be converted to based on the basic capacity.

Convert by one of the following formula (1) or (2).

(a) Conversion by capacity of the equipment

$$\%Z = \frac{Pb}{Pe} x100 \text{ ------------------------------------- } (1)$$

Where,
%Z : Finding percent impedance of the equipment
Pb : Basic capacity (10 MVA)
Pe : Capacity of the equipment

(b) Conversion by rated percent impedance

$$\%Z = \frac{Pb}{Pe} x\%Zo \text{ ----------------------------------- } (2)$$

Where,
%Z : Finding percent impedance of the equipment
Pb : Basic capacity (10 MVA)
Pe : Capacity of the equipment
%Zo : Rated percent impedance of the equipment

On the Figure 6.2-1 System Diagram the short circuit capacity of power source (REA's Substation) is assumed as 2000 MVA then the %Z is 0.5 % as shown the followings.

%Zp = (10x100)/2000 = **0.5 %** by formula (1)

The %Z of the transformer is,

%Zt = (8x10)/25 = **3.2 %** by formula (2)

Where, rating percent impedance of the transformer is: %Zo = 8 %

For the synchronous motor percent impedance is different under constant operation and momentary operation at starting time.

The character of the motor is,

Capacity	: 14 MVA
%Z at constant operation	: 35 %
%Z at momentary operation	: 25 %

The %Z based on basic capacity under normal operation is,

%Zmn = (10x35)/14 = **25.0 %** by formula (2)

%Z based on basic capacity under momentary operation is,

%Zmm = (10x25)/14 = **17.9 %** by formula (2)

(3) Impedance map

By the calculated %Z of equipment make the impedance map based on the basic capacity as shown on the Figure 6.2-2 .
The impedance maps for momentary operation is as shown on the Figure 6.2-3(a) and for constant operation is (b).
For the %Z of transformers and motors (%ZT and %ZM) is composed to the value of parallel connection.

%ZT	= %Zt/2	=	1.6 %
%ZM	= %Zmm/2	=	8.9 % (momentary)
%ZM	= %Zmn/2	=	12.5 % (constant)

The total impedance (%Z) under momentary operation at the fault (see Figure 6.2-1) point is,

$$\frac{1}{\%Z}=\frac{1}{Zp+ZT}+\frac{1}{ZM}=\frac{1}{0.5+1.6}+\frac{1}{8.9}=0.59$$

Then %Z = 1/0.59 = **1.69**

By the same procedure the total impedance under constant operation is,

$$\frac{1}{\%Z}=\frac{1}{0.5+1.6}+\frac{1}{12.5}=0.56$$

Then %Z = 1/0.56 = **1.79**

(4) Calculate the Momentary short circuit current

(a) Momentary short circuit capacity (Rcm)

Rcm = (100x10)/1.69 = 592 MVA

Then the momentary short circuit current is

Icm = 592/(1.73x11) = **31.1 kA**

Asymmetrically peak current (Imax) is,

Imax = 2.5 x Icm = 2.5 x 31.1 = **77.6 kA**

Where, [2.5] is standard constant for synchronous motor.

(b) Short circuit current

The short circuit capacity (Rc) and short circuit current (Ic) under constant operation is,

Rc = (100x10)/1.79 = 559 MVA

Ic = 559/(1.73x11) = **29.3 kA**

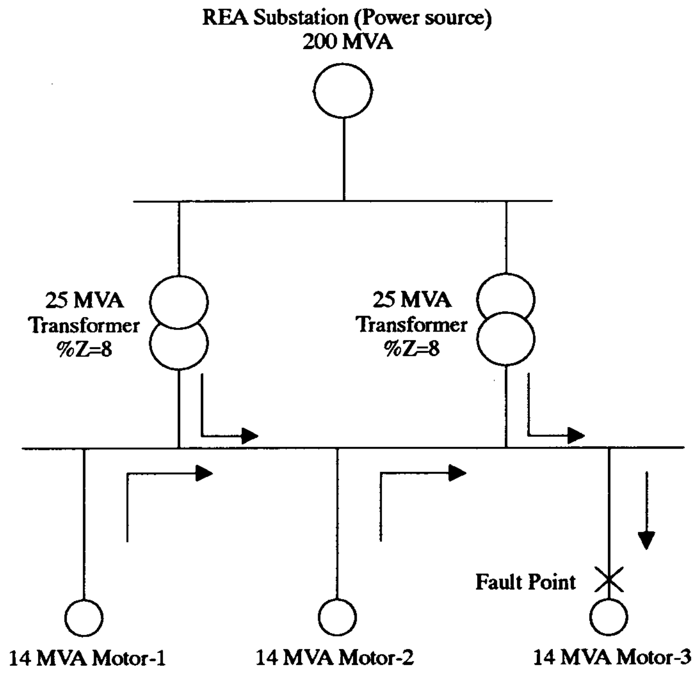


Figure 6.2-1 System Diagram

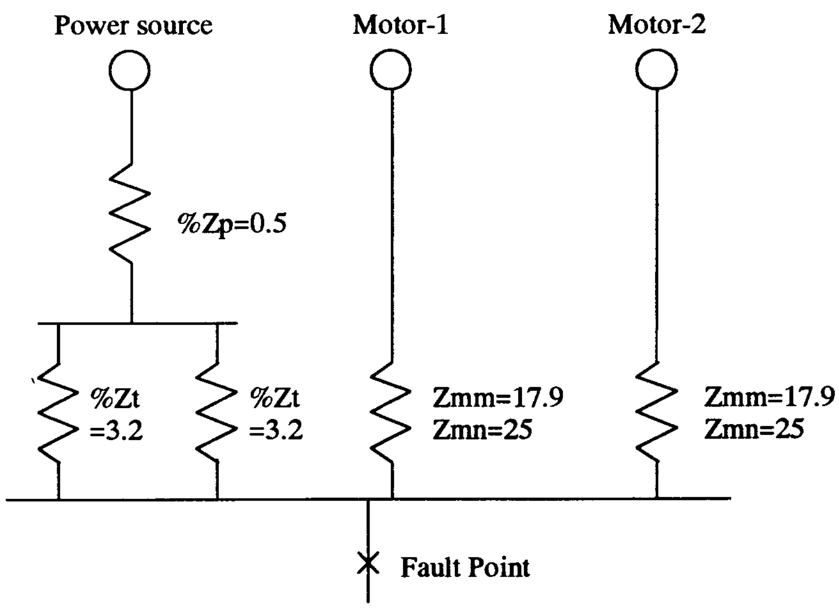
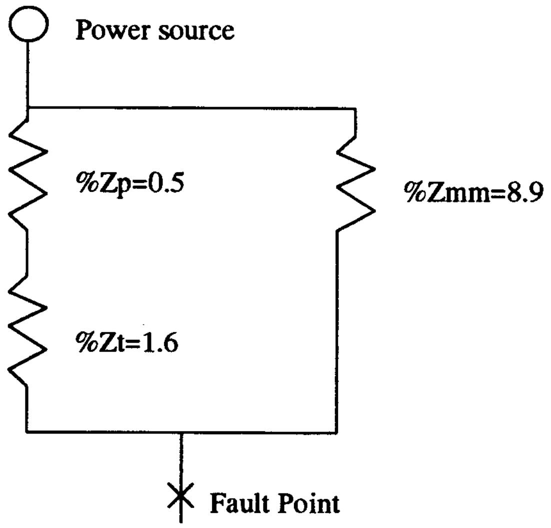
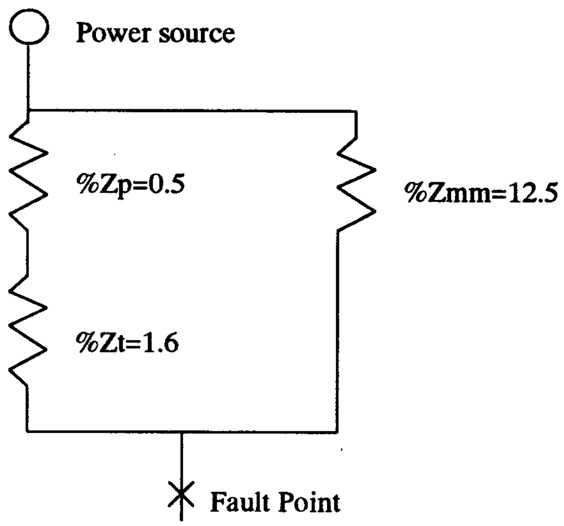


Figure 6.2-2 Impedance Map



(a) Momentary Operation



(b) Constant Operation

Figure 6.2-3 Equivalent Impedance Maps

6.2.5 Protection Earth Resistance

To determine the protection earth resistance of all metallic frames, bodies or fittings of electrical equipment which shall be grounded to protect a human accident by touch to the equipment that is being in electric leakage.

The grounding resistance to keep safe of human body from an electric shock shall be less than 5Ω in the pump station calculated by the following procedures.

(1) Safety current against electric shock

There are several theories about harmless current to human body but generally it is said that 10 mA to 15 mA is minimum current unable to escape from convulsions by electric shock. While, for the minimum current to have ventricle convulsions the following empirical formula is presented.

$mA = \frac{2.18W + 12.8}{\sqrt{T}}$ (Mr. C.F.Dalziel USA) ----- (1)

Where,

mA : Minimum current to had ventricle convulsions 0.5 % of number of the people. (mA)

W : One's weight (kg)

T : Time to contact with leakage point (sec)

Where, it is supposed that the contact time is 9 sec and the weight is 50 kg then the current is calculated as follows.

mA=(2.18 x 50 + 12.8)/3=40.6 (mA): (by the formula 1)

(2) Calculation the maximum voltage of the touch point and ground.

The maximum voltage or limit of voltage safe to human body between touch point and ground is calculated by the following formula.

e = mA x Rh ------------------(2)

Where,

e : Voltage between touch point and ground (V)

mA : Minimum current (A)

Rf: Resistance of the human (Ω)

Table 6.2-7 Human Resistance

Situation of contact to the leakage point and ground	Resistance (Ω)
Dry hand to dry hand	5,000
Wet hand to bare foot on dry concrete floor	3,000
Wet hand to bare foot on dry earthen floor	2,000
Wet hand to bare foot on wet floor	1,300

Actually the situation of contact in the pump station will be wet hand to bare foot on wet floor and the minimum current is 40.6 mA.

Then the maximum voltage (e) is,

$$e = 40.6 \times 10^{-3} \times 1300 = 52.8 \text{ (V)}$$

If the voltage between touch point and ground is over 52.8 V the man will fall into a dangerous situation.

This means that the protection earth resistance shall be meet to get the touch point voltage to be smaller than 52.8 V.

(3) Calculation for the protection earth resistance

The protection earth resistance of the power system is calculated by the following procedure.

- Selection of fault point in the system
- Calculation of ground fault current (Ig) at the fault point.
- Calculation of allowable voltage (e) between the touch point (fault point) and ground.
- Calculation of the protection earth resistance (R).

The earth resistance is calculated by the following formula.

$$R \leq \frac{e}{Ig} \text{ -- (3)}$$

Where,

R : Protection earth resistance (Ω)

e : Voltage of the touch point (V)

Ig : Line to ground fault current (A)

$$Ig = \sqrt{3}\, \omega \text{CE (A) --------------------------------- (4)}$$

Where,

ω : 2πf

f : Frequency: 50 (Hz)

E : Line voltage (V)

C : Total capacitance of the subject circuit in the system (F)

The fault point is selected at one of motor as shown on the Figure 6.2-4 then the maximum grounding resistance is calculated as follows.

For calculation the fault current, calculate the total capacitance of the system. There are 2-service feeders and 3-subject motor branch feeders and 1-fault feeder.

$C = 2C1 + 3C2$

C : Total capacitance

C1 : Capacitance of service feeder

$3 \times 0.83\,\mu F/km \times 0.3\,km = 0.75 \times 10^{-6}\,F$

C2 : Capacitance of motor branch feeder

$3 \times 0.4\,\mu F/km \times 0.05\,km = 0.06 \times 10^{-6}\,F$

Note: Service and branch feeders composed with 3-single core cables then the capacitance shall be three times.

$C = 2C1 + 3C2 = (2 \times 0.75 + 3 \times 0.06) \times 10^{-6} = 1.68 \times 10^{-6}\,F$

System line voltage	: E = 11,000 (V)
System total capacitance	: $C = 0.68 \times 10^{-6}$ (F)
Frequency	: 50 Hz
Touch point voltage required	: e = 52.8 (V)

Then,

$Ig = 1.73 \times 2 \times 3.14 \times 50 \times 1.68 \times 10^{-6} \times 11000 = 10.0\,(A)$

$$R \leq \frac{e}{Ig} = 52.8/10 = 5.3\,(\Omega)$$

Then the protection earth resistance shall be less than 5.3 (Ω).

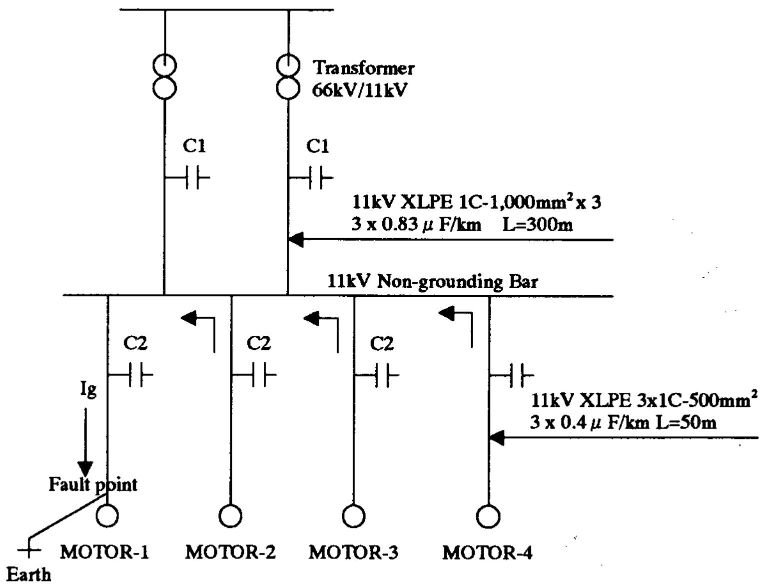


Figure 6.2-4 Earth Fault Current

6.2.6 Earth Resistance

Both of an earth grid system and earth rods system will be adopted for the grounding system of the main substation.
For the grounding system of the auxiliary substations (or pump station) it is possible to consider that the reinforcement iron bars installed in the bottom slab of the pump station is making an earth grid.

(1) Earth resistance of Main substation

Actually it is difficult to precisely calculate the earth resistance of these systems because change of soil resistance by change of ratio of contained water and temperature.

However, it is roughly calculated by the following formulas.

(a) Earth grid system

$$R = \frac{U}{4E}\left(1 - \frac{4D}{\pi E}\right) \ (\Omega) \text{ ----------------------------- } (1)$$

Where,
R: Earth resistance of the grid
U: Soil resistivity (Ω-cm)
D: Installation depth of grid (cm)
E: Equivalent radius of grid area (cm)

E = square root of (A/Ω) (cm)
Where, A: aria of grid (cm^2)

Notes for the grid system:

- Distance of each earth conductor composing the grid is practically have not effect to the earth resistance.
- Numbers of the divided grid section in the site is practically have not effect to the earth resistance, there is another report which insistence the 16-section grid is most economical and more division will bring saturation of the resistance.

(b) Earth rod system

$$R = \frac{U}{2\pi L}\left(2.3\log\frac{4L}{H} - 1\right) \ (\Omega) \text{ -------------------- } (2)$$

Where,

R: Earth resistance of the grid
U: Soil resistivity (Ω-cm)
L: Length of earth rod (cm)
H: Radius of earth rod (cm)

For the case of connecting more than one rod composed resistance is calculated by the following formula.

$$Rt = \frac{K}{\sum_{n} \frac{1}{R}}$$

When all R is equal: Rt = KR/n   n: Number of rod

Where,
Rt : Composed earth resistance of plural rods (Ω)
K : Coefficient of connection by the interval between each rod is shown on the following table.

Interval of rod (m)	0.5	1.0	2.0	3.0	4.0
Coefficient (K)	1.35	1.20	1.15	1.10	1.05

(c) Soil resistivity
An example of the soil resistivity data is as shown on the following table.

Table 6.2-8 Soil Resistivity

Soil	Dry (kΩ-cm)	Wet (kΩ-cm)
Clay	80	80
Sand	400	30
Gravel	400 – 700	60 – 100
Loam	200	80
Shale	20	20
Sandstone	60	30
Conglomerate	80	50
Clay state	50	50
Granite	500	500

By the result of soil test, the soil resistance of the site is 5,000 Ω-cm.

(d) Calculation of the earth resistance of the main substation
(i) Earth grid system
When install a grid earth at the main substation site the resistance is calculated as follows.

- Soil resistivity : U = 5000 (Ω-cm)

- Site scale : X = 100 m, Y = 80 m
- Depth of grid installation : 2 m

A = 10000 (cm) x 8000 (cm) = 8 x 10^7 (cm^2)

$$E = \sqrt{\frac{A}{\pi}} \qquad E = \sqrt{\frac{80000000}{3.14}} = 5048 \text{ (cm)}$$

R = (U/4E)(1-(4D/ΠE))

Hence,
R = (5000/4/5048)(1-(4 x 200/3.14/5048)) = 2.9 x (1-0.05) = **0.24** (Ω)

(ii) Earth resistance of the earth rod

When install the earth rod at the conditioned site resistance is calculated as follows.

- Soil resistivity : U = 5000 (Ω-cm)
- Dimension of the rod : Length: 150 cm
  Radius: 0.014 cm

R=(U/2ΠL)(2.3 log(4L/H)-1)

$$R = \left(\frac{U}{2\Pi L}\right)\left(2.3\log\frac{4L}{H} - 1\right) \quad (\Omega)$$

Hence,
R=(5000/(2/3.14/150)(2.3 log(4x150/0.014)-1) = **56.5** (Ω)

Totally 28 rods connecting to the grid system each rods is separated more than 4 m from the grid then coefficient (K) by interval of rod is 1.05, and the total resistance of all rods is calculated as follow.

Rt = KR/n ∴ Rt = (1.05 x 56.5)/28 = **2.11** (Ω)

(iii) Total earth resistance at the main substation

The total resistance is calculated as a parallel connection of grid and 28 rods will be 0.22 Ω as shown on the following.

$$\frac{1}{R} = \frac{1}{Rg} + \frac{1}{Rr}$$

Where,

R : Total resistance

Rg Resistance of grid system: 0.24 Ω

Rr : Resistance of rods system: 2.11 Ω

R=Rg*Rr/(Rg+Rr) R=0.24 x 2.11/(0.24+2.11) = **0.22** (Ω)

(2) Earth resistance of Auxiliary substation-1

The reinforced iron bars in the bottom slab of the pump station making a grid earth system and the earth resistance will be calculated as follows.

- Soil resistivity : U = 5,000 (Ω-cm)
- Site scale : X = 67 m, Y = 27 m
- Depth of grid installation : 10 m

Note: The depth of bottom slab is about 20 m under the ground level then the average value 10-m is adapted to the calculation.

A = 6700 (cm) x 2700 (cm) = 1.8 x 10^7 (cm^2)

$$E = \sqrt{\frac{A}{\pi}} \qquad E = \sqrt{\frac{18000000}{3.14}} = 2394 \text{ (cm)}$$

R = (U/4E)(1-(4D/ΠE))

Hence,

R = (5000/4/2394)(1-(4 x 1000/3.14/2394)) = 0.52 x 0.47 = **0.25** (Ω)

The calculated earth resistance will be 0.3 Ω.

(3) Earth resistance of Auxiliary substation-2

By the same procedure as Auxiliary substation-1, the calculated resistance will be 0.24 (Ω) as follows.

- Soil resistivity : U = 5,000 (Ω-cm)
- Site scale : X = 58 m, Y = 27 m
- Depth of grid installation : 10 m

A = 5800 (cm) x 2700 (cm) = 1.6 x 10^7 (cm^2)

$$E = \sqrt{\frac{A}{\pi}} \qquad E = \sqrt{\frac{16000000}{3.14}} = 2.257 \text{ (cm)}$$

R = (U/4E)(1-(4D/ΠE))

Hence,

R = (5000/4/2257)(1-(4 x 1000/3.14/2257)) = 0.55 x 0.44 = **0.24** (Ω)

6.3 Basic Design of Substations

There are three substations will be installed supplying power to No. 7 Pumping station namely the Main Substation, Auxiliary Substation-1 and Auxiliary Substation-2.
The main substation will be installed in the separated site located near by the pump station and two auxiliary substations will be installed in the each pump station building.

6.3.1 Main Substation

The main substation will receive 66 kV, 3-Phase and 50 Hz power through two transmission lines and transform to 11 kV, 3-Phase and 50 Hz for supply power to the auxiliary substations.

The main substation will be indoor open type and will consist of the following main equipment or facilities as shown on the attached layout drawings.

The receiving power capacity is suitable supplying to two pump stations or construction Stage I and Stage II.

- 66 kV Power receiving equipment
- 66 kV Power feeder equipment
- Main transformers
- Cable pits
- Grounding system
- End tower of 66 kV Transmission lines
- Buildings

In these items the end tower will be constructed by REA and the buildings will be described in the other section.

(1) The construction Stage I

- Two 66 kV power receiving equipment will be provided each consist of earth switch, disconnect switch, circuit breaker current transformer, disconnect plus earth switch and lightning arrestor.
- One Potential device and 66 kV open bus bars
- Four 66 kV power feeder equipment will be provided each consist of disconnect switch, circuit breaker and current transformer.
- Four main transformers
- The transformers will be installed in the independent transformer booth out side of the building.
- The underground earth conductors will be installed through the site spreading 1 meter outside of boundary fence.
- The indoor earth conductors will be installed through the building area.
- The grounding grid and indoor earth conductor system

(2) The construction Stage II

- Three 66 kV power feeder equipment will be added each consist of disconnect switch, circuit breaker and current transformer.
- Three main transformers will be added in the independent transformer booth out side of the building.
- Extension of the indoor earth conductors to the extension area of the building.

The adopted specification of main equipment is as follows.

(a) Main Transformer

- Type	: Outdoor, Oil-immersed, double winding
- Oil Preservation system	: Diaphragm type conservator
- Cooling system	: ONAF (Oil immersed, air cooling with fan)
- Number of phases	: Three phases
- Capacity	: 25 MVA
- Frequency	: 50 Hz
- Applied standard	: IEC
- Primary Voltage	: 66 kV
- Primary Tap Voltage	: 69 kV, 66 kV, 63 kV and 60 kV
- Tap change	: On Load change system, plus and minus 8 steps of 1.25 %
- Secondary Voltage	: 11 kV
- Connection	: Delta - Star
- Impedance	: 10%
- Accessories	Pressure relief device
	Dial type thermometer

Dial type oil indicator
Buchholtz's relay
Cooling fan
Cable connection box

(b) 66 kV Disconnector

- Type : Air disconnector
- Rated Voltage : 72.5 kV
- Frequency : 50 Hz
- Rated power frequency withstands voltage : 140 kV to earth
- Lightning impulse withstand voltage : 350 kV to earth
- Rated normal current : For power receiving: 1,250 A
  For main transformer: 1,000 A
  For lightning arrester : 800 A
- Rated short time withstands current : 31.5 kA (1 sec)
- Operation method : For power receiving: Electric motor
  For main transformer: Electric motor
  For lightning arrester: Manual

Note: The disconnecting switches installed for power receiving gas circuit breakers shall be provided with self contained earth switch.

(c) 66 kV Earthing switch

- Type : Air disconnector
- Rated Voltage : 72.5 kV
- Frequency : 50 Hz
- Rated power frequency withstands voltage : 140 kV to earth
- Lightning impulse withstand voltage : 350 kV to earth
- Rated normal current : 1,250 A
- Rated short time withstands current : 31.5 kA (1 sec)
- Operation method : Manual

(d) 66 kV Circuit Breakers

- Type (GCB) : Gas insulated, phase segregated type
- Rated voltage : 72.5 kV
- Frequency : 50 Hz
- Rated power frequency withstand voltage : 140 kV
- Lightning impulse withstand voltage : 325 kV
- Rated normal current : For power receiving : 1,250 A
  For main transformer : 800 A
- Rated short circuit breaking current : 31.5 kA

- Rated peak withstands current : 80 kA
- Rated break time of circuit breaker : 3 cycles
- Operation method : Electric motor operating system
- Accessories : SF6 Gas System

(e) 66 kV Surge Arresters
- Type : Series gap type
- Rated voltage : 84 kV
- Rated frequency : 50 Hz
- Rated discharge current : 10,000 A
- Rated discharge voltage by 50 Hz : 126 kV
- Rated discharge voltage by Surge : 256 kV
- Operation times counter : Contained

(f) 66 kV Current Transformer
- Type : Indoor bushing type
- Rated primary current : For power receiving : 1,250 A
  For transformer : 400 A
- Rated secondary current : 5 A
- Ratio of error : ± 1 %
- Maximum voltage : 69 kV
- Rated withstand current : 40 times of rated current
- Rated burden : 60 VA
- Rated frequency : 50 Hz
- Withstand voltage to 50 Hz : 140 kV
- Withstand voltage to surge : 350 kV

(g) Control Panel for 66 kV Substation

The control devices for the main substation will be installed in the steel clad and consist of mimic panel, protection relay panels and DC power unit panel.
- Type : Vertical stand type
- Enclosure : Sheet steel unit type
- Index of protection : IP 51
- Separation of unit enclosure : Sheet steel
- Doors : Front and rear of each unit
- Installation place : In the control building located in the main substation

(h) 66 kV Bus bar Insulators

For the insulators installed suspending or pulling the bus bars two type of insulator will be used or one is suspension type and the other is line post type.

(i) Suspension type insulator

- Type : Disc type suspension insulator
- Connection system : Ball-and socket type
- Diameter of disc : 250 mm
- Power-frequency withstand voltage : 40 kV (wet condition)
- Impulse withstands voltage : 105 kV
- Electro-mechanical failing load : 16,500 kgf
- Power-frequency puncture voltage in oil : 140 kV
- Tensile withstands load : 6,600 kgf

(ii) Line post type insulator

- Type : Line post type insulator
- Power-frequency withstand voltage : 135 kV (wet condition)
- Impulse withstands voltage : 410 kV
- Vending withstand load : 700 kgf
- Dimensions : Diameter: 190 mm, Length: 740 mm

(i) Auxiliary Transformer

- Type : Molded type
- Cooling system : AN (Natural air-cooling)
- Number of phases : Three phases
- Capacity : 1,000 kVA
- Frequency : 50 Hz
- Applied standard : IEC
- Primary Voltage : 11 kV
- Primary Tap Voltage : 12 kV, 11.5 kV, 11 kV and 10.5 kV
- Tap change : No-voltage changing system
- Secondary Voltage : 380-220 V
- Connection : Delta-Star
- Impedance : 4.5 %
- Bushing : Made of porcelain

6.3.2 Auxiliary Substations

The auxiliary substation will be installed in each pump station of construction Stage I and Stage II and they will distribute power to the main pump motors and auxiliary transformers in the manner of 11 kV, 3-Phase, 50 Hz.

The auxiliary transformer supply power to all electrical consumers in the pump station site except the main pump motors in the manner of 380/220 V, 3-phase or single phase through the distribution board or control board.

Type of the auxiliary substations will be indoor metal clad type and they will be installed in the pump motor room of the pump station.

They will consist of the following cubicles as shown on the attached drawings.

The auxiliary substations will consist of the following systems.

- 11 kV Power Cable termination panel
- 11 kV Power receiving panels
- Main pump motor feeder panels
- Auxiliary transformer panels
- Grounding system

(1) The construction Phase-I (Pumping station –1)

- Two power cable termination panels
- Two 11 kV power receiving panels each consist of 11 kV vacuum circuit breaker, current transformers, potential transformers and meters will be provided
- Two voltage transformer panels
- Two Grounding potential transformer panels
- Eight 11 kV main motor feeder each consist of 11 kV vacuum circuit breaker current transformers zero phase current transformers and meters will be provided.
- Two 11 kV station transformer feeders each consist of 11 kV vacuum circuit breaker, current transformer and meters will be provided.
- Two 1000 kVA dry type station transformers will be installed in the cabinets.
- The reinforcement bars in the bottom slab of the pump station will be substituted to earth grid system for the pump station.
- The indoor earth conductors will be installed through the building area.
- All metallic casing or housing of electrical equipment will be connected to grounding system through indoor earth conductor.

The adopted specification of main equipment is as follows.

(a) 11 kV Circuit Breaker

- Type	: Vacuum Circuit Breaker (VCB)
- Rated voltage	: 12 kV
- Frequency	: 50 Hz
- Rated continuous current	: For service power receiving : 3,000 A For branch feeders : 1,250 A
- Lightning impulse withstand voltage	: 75 kV
- Rated power frequency withstands voltage	: 28 kV
- Rated short circuit breaking current	: 40 kA
- Rated peak withstands current	: 63 kA
- Rated break time of circuit breaker	: 3 cycle
- Operation method	: Motor spring charged

(b) 11 kV Current Transformer

-	Rated Primary Current	: For service power receiving	: 3000 A
		For main pump motor feeder	: 1250 A
		For auxiliary transformer feeder	: 100 A
-	Rated Secondary Current	: 5 A	
-	Ratio of Error	: ± 1 %	
-	Maximum Voltage	: 11.5 kV	
-	Rated withstand current	: 40 times of rated current	
-	Rated burden	: 60 VA	
-	Rated frequency	: 50 Hz	
-	Withstand voltage to 50 Hz	: 28 kV	
-	Withstand voltage to surge	: 90 kA	

(c) 11 kV Voltage Transformer

- Rated primary voltage : 11 kV
- Rated secondary voltage : 110 V
- Ratio of error : ± 1.0 %
- Maximum voltage : 11.5 kV
- Rated withstand current : 40 times of rated current
- Rated burden : 50 VA
- Rated frequency : 50 Hz
- Withstand voltage to 50 Hz : 28 kV
- Withstand voltage to surge : 90 kV

(d) 11 kV Zero Phase Current Transformer

- Rated primary current : For main pump motor feeder: 800 A
- Rated secondary current : 5 A
- Rated zero phases primary current : 200 mA
- Rated zero phase secondary current : 1.5 mA
- Ratio of error : ± 1.0 % (used for grounding relays)
- Maximum voltage : 11.5 kV
- Rated withstand current : 40 times of rated current
- Rated burden : 10 Ω
- Rated frequency : 50 Hz
- Withstand voltage to 50 Hz : 28 kV
- Withstand voltage to surge : 90 kV

(e) Metal clad for auxiliary substation

All equipment and devices of the auxiliary will be installed in the steel clad as specified as follows.

- Type : Vertical stand type
- Enclosure : Sheet steel unit type

- Index of protection : IP 51
- Separation of unit : Unit enclosed
- Doors : Front and Rear of each unit

(2) The construction Stage II (Pump station –2)

- Two 11 kV power cable termination panels
- Two 11 kV power receiving panels each consist of 11 kV vacuum circuit breaker, current transformers, potential transformers and meters will be provided.
- Six 11 kV main motor feeder each consist of 11 kV vacuum circuit breaker current transformers zero phase current transformers and meters will be provided.
- Two 11 kV station transformer feeders each consist of 11 kV vacuum circuit breaker, current transformer and meters will be provided.
- Two 1000 kVA dry type station transformers will be installed in the cabinets.
- The reinforcement bars in the bottom slab of the pump station will be substituted to earth grid system for the pump station.
- The indoor earth conductors will be installed through the building area.
- All metallic casing or housing of electrical equipment will be connected to grounding system through indoor earth conductor.

6.3.3 Quantity of Equipment

The substations mentioned above will be constructed separately into two periods or Stage I and Stage II.
The required quantities of main equipment based on the designing on this stage are estimated as shown on the following tables.

Table 6.3-1 Quantity List of Main Equipment for the Main Substation

Equipment	Specification	Stage I	Stage II
1. Transformer (outdoor)	66/11 kV, 25 MVA	4	4
2. Earthing switch	66 kV, 3-Pole, 1,250A	2	
3. Disconnecting switch	66 kV, 3-Pole, 1,250A	4	
4. Disconnecting switch	66 kV, 3-Pole, 800A	4	4
5. GCB for power receiving	66 kV, 2000A, 25 kA	2	
6. GCB for feeder	66 kV, 800A, 25 kA	4	4
7. Surge arrestor	66 kV, 800A, 10 kA	2	
8. Earth switch	66 kV, 3-Pole, 1250A	2	
9. CT	66 kV, 1250/5A - 3 units	2	
10. CT	66 kV, 400/5A - 3 units	4	4
11. Neutral equipment panel	11 kV, 400/5A - 3 units	4	4
12. Cable termination panel	Terminal for 400 mm^2 x 9	4	4
12. VCB panel for secondary of mein transformer	11 kV, 2000A	4	4
13. VCB panel for Pumping station feeder	11 kV, 3000A	2	2
14. VCB panel for station transformer	11 kV, 400A	2	2
15. VCB & Arrestor panel	11 kV, 1000A and arrestor	2	2
16. 11 kV Bus-tie panel	11 kV VCB, 3000A	1	1
17. VCB panel for station tranformer	11 kV VCB, 400A	2	2
18. Station transformer panel	1000 kVA, 11 kV/380-220V	2	2
19. Low voltage distribution panel	Main MCCB: 3P+N 800A x 2 Branch: 3P+N 100A x 10 Bus-tie: 3P+N 800A	1	1
17. Relay Panel		1	1
18. Control/Supervise Panel		1	1
19. Aux. Transformer	11 kV/380-220 V, 500 kVA	1	1
20. DC Power unit	DC 220 V, 500 Ah	1	1

Table 6.3-2 Quantity List of Main Equipment for the Auxiliary Substations

Equipment	Specification	Stage I	Stage II
1. Cable termination panel	11 kV XLPE, 500 mm^2 x 12	2	2
1. Power receiving Panel	12 kV, VCB 3000A, 40 kA	2	2
2. PT Panel	11 kV/110 V	2	2
3. GPT Panel	11 kV GPT - 3	2	2
4. Main pump feeder Panel	12 kV, VCB 1250A, 40 kA	8	6
5. Aux. transformer feeder Panel	12 kV, VCB 1250A, 40 kA	2	2
6. Aux. transformer Panel	11 kV/380-220V, 1000 kVA LV main switch: 1600A	2	2

6.4 Building Works

6.4.1 Architectural Design

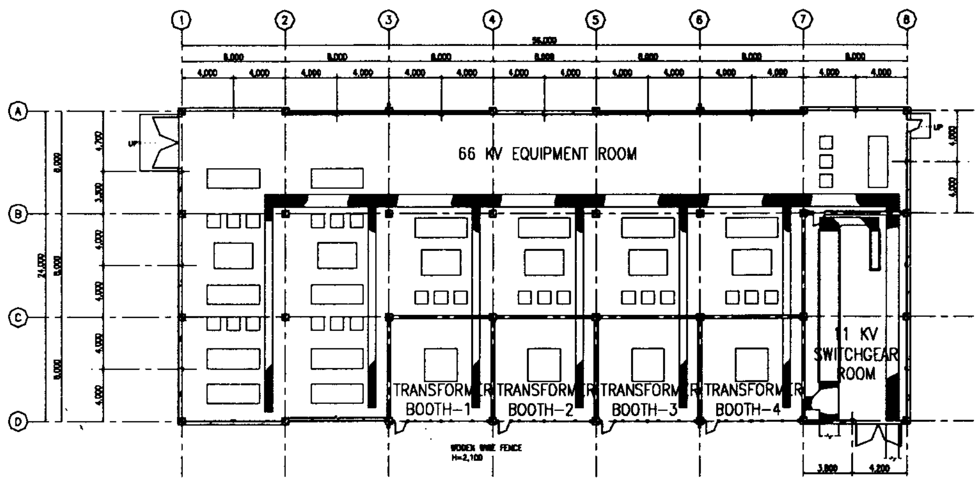
(1) Background

Detailed design of Main Substation (indoor type) and Administration Building has been carried out based on the design concepts and criteria mentioned in the Interim Report (2) Clause 6.4. Detailed data and information required for the Power Supply and Sub-station equipment has been provided and considered in the design of the Main Substation and Administration Building.

(2) Function and Layout

Site for Main Substation and Administration Building shall be located to the north of Pump House at elevation EL+25.00 m in accordance with the site plan. Floor plans, sections and elevations for the Main Substation and Administration Building are defined in the drawings and the following facilities are provided in order to provide adequate spaces for operation and maintenance of all equipment and to allow reasonable working conditions for staff and workers in compliance with the laws and regulations in Egypt.

(a) Main Substation (Total Area: 1,344 m^2)



(i) 66 KV Equipment Room (960 m^2)

Main large access door provided at axis 1 for the delivery and maintenance of the equipment. One ordinary door shall be provided at axis 8. Space for future expansion (Stage II) shall be reserved next to axis 8.

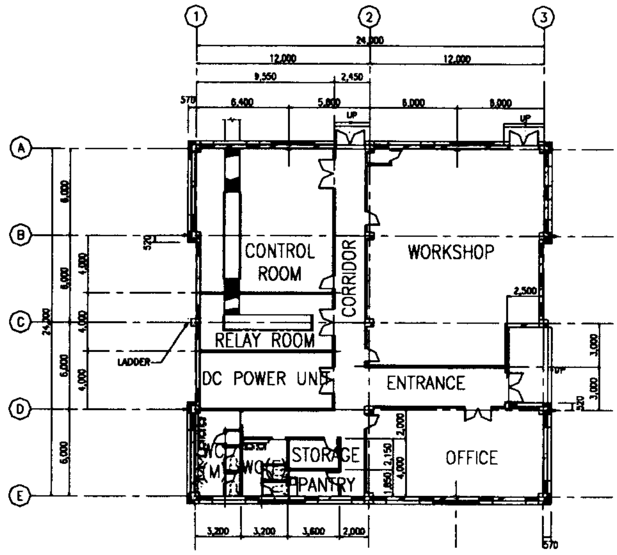
(ii) 11KV Switchgear Room (128 m^2)

Main large access door shall be provided at axisD.

(iii) Transformer Booths 1-4 (256 m^2)

Four Nos. transformer shall be installed in the booths respectively. Each booth shall be partitioned by brick wall construction, however front side at axis D shall be fenced for better natural ventilation.

(b) Administration Building (Total Area : 576 m^2)



(i) Control Room (95.5 m^2)

One large main and one ordinary size doors shall provided for the equipment and staff's access from corridor.

(ii) Relay Room (38.2 m^2)

One large main door shall be provided for the equipment and staff's access from corridor. The room is located between Control Room and DC Power Unit.

(iii) DC Power Unit (38.2 m^2)

One large main door shall be provided for the equipment and staff's access from corridor.

(iv) Workshop (172.5 m^2)

One external large entrance door shall be provided for the equipment's access and two ordinary doors are provided for staff's access from corridor.

(v) Office (72 m^2)

One main large door shall be located near to the main entrance door for staff's easy access. Another door provided to access utility area (toilets, pantry).

(vi) Toilets, Storage and Pantry (46.4 m^2)

Male and female toilets shall be located separately and Storage and Pantry shall be located adjacently.

(vii) Entrance and Corridor (113.2 m^2)

Adequate width to deliver equipment is provided for the corridor. Large size door shall be provided at axis A considering access of equipment.

(3) Building Materials and Architectural Finishes

Based on the criteria mentioned in the Interim Report (2), building materials and architectural finish shall be designed and selected as described hereafter in order to avoid unreasonable heat accumulation in the buildings from natural sun-light, adequate number of openings shall be provided for natural ventilation and insulation will be provided on the roof slab.

(a) Building Materials

Building framing will be of reinforced concrete. Building enclosures will be of masonry brick or block wall construction. Based on the existing main sub-station buildings and where practical, the similar materials, proprietary products and architectural appearance shall be used in order to ensure satisfactory aesthetic design and the use of standard products and dimensions. The interior and external architectural finish for Main Sub-station Building and Administration Building are as defined on the drawings.

(i) External finishes:
- Roof: Bituminous membrane waterproofing with heat insulation material (50 mm thick.) and covered by mortar with tiles.
- Wall: Cement brick (120 x 240 x 60 mm) walling with plastered and painted or sand lime brick (115 x 250 x 60 mm) faced.

(ii) Floors: Unglazed ceramic tiles (150 mm x 150 mm or 200 mm x 200mm with 10mm thick) for all electrical rooms, toilets and pantry. Terrazzo tiles (250 mm x 250 mm with 25mm thick) for office, entrance and corridors.

(iii) Walls: Glazed ceramic tiles (150 mm x 150 mm or 200mm x 200mm with 6mm thick) up to 2 m height from the finished floor level and paint for the area above 2 m on plastered wall for all electrical rooms (except for transformer booths), toilets and pantry. Paint on plastered masonry or RC structure walls for the remaining rooms.

(iv) Ceiling: Generally paint on plastered RC structure. Suspended acoustic ceiling will be applied for Office and Control room.

(v) Doors: Steel doors with paint finish shall be used for mechanical, electrical and workshop rooms. Wooden door with paint finish shall be used for office, toilets and pantry rooms. Sizes of doors are as defined on the drawings.

(vi) Windows: Aluminum framed bottom-hinged glazed windows are generally used and fixed windows are combined where necessary in the rooms of Administration Building. Sizes of windows are as defined on the drawings.

(vii) Gallery Works: Handrails and ladders where required shall be of fabricated steel and painted.

(4) Drawings

The following drawings are prepared for the architectural design.:

(a) General notes, symbols, abbreviations, floor area and finishing schedule.

(b) Floor plans, sections and elevations

(c) Standard and special details

6.4.2 Structural Design

(1) Background

Design has been carried out based on the design criteria and considerations mentioned in the Interim Report (2). Structural design includes structural calculation, general notes, framing plans and standard details and so on for Main Substation and Administration Building. Design coordination with electrical equipment has been carried out and loading data and size of equipment to ensure space and design of supporting structure were provided. Loading data of architectural finish has also been coordinated. The buildings are single storied and the structure shall be of reinforced concrete framing with masonry brick wall construction. Elevated water tank (4t capacity) will be installed on the roof of Administration Building and the loading shall be considered for the design of the buildings.

(2) Codes and Standards

Structural design for buildings shall be carried out in accordance with the latest edition of Egyptian Code of Practice (E.S.S). Any authorized national or local standards and codes in Egypt are considered in the design of the building. Structural calculation will be carried out in accordance with the latest edition of E.S.S with the aid of ACI 318.

(3) Materials

As mentioned in item (1) above, building will be by reinforced concrete framing and materials used for the building structure are summarized as follows:.

(a) Concrete

- Foundation, slab on grade: Fcu=275kg/cm^2
- All other concrete: Fcu=300kg/cm^2

(Fcu: 28days cube compressive strength)

(b) Reinforcing steel

- Round bar: Normal mild steel 24/35 Fy=2400kg/cm^2
- Deformed bar: High grade steel 36/52 Fy=3600kg/cm^2

(c) Other materials

- Other materials are as defined on the drawing No. SBW-411.

(4) Frame Analysis

The Main Substation and Administration Building are both single-story reinforced concrete frame structure. Lateral loads are resisted by bending action in both lateral and longitudinal directions.

(a) Dead Loads

- Weight of reinforced concrete: 2500kg/m^3
- Weight of steel: 7850kg/m^3

(b) Live Loads:

- Roof: 100kg/m^2

(c) Seismic loads

Seismic load will be calculated as follows:

Kh=0.4K C I

Where,
Kh: Seismic horizontal acceleration for design,
K: 1.0 for structural system contains both ductile space frames and shear walls, both to resist the effect of horizontal forces.
C: Factor calculated from following equation:
$C=1/15 \times \sqrt{T}$
T: Fundamental period of vibration of the structure under consideration in seconds.
I: Degree of importance for the structure. 1.5 for structure with special importance.

(d) Soil Condition

Allowable bearing capacity of soil: 20 t/m^2

(e) Frame analysis

Three dimensional frame analysis was carried out for the design of structures, using the STAAD III structural analysis software. The frame models, including joint numbers, member numbers, member properties and analysis results for Main Substation and Administration Building are shown in the APPENDIX C.6.4-1 and C.6.4-2 respectively.

6.4.3 Building Services Design:

(1) Ventilation and Air Conditioning

(a) Description of the System

Ventilation and air conditioning system will be provided for the rooms where required at the Main Substation and Administration Building in order to maintain proper working condition for the equipment and O/M personnel. The 66 KV Equipment Room in the Main Substation building shall be ventilated naturally by providing sufficient number of windows on the wall. The 11 KV Switchgear Room in the Main Sub-staion shall be ventilated by the axial flow exhaust fan and outside fresh air shall be introduced to the space through the intake wall louvers. Workshop in the Administration Building shall be ventilated by the axial flow supply fan and supplied outside air shall be exhausted through the wall louvers. The Control Room, Relay

Room and Office in the Administration Building shall be air conditioned by the window type air conditioners or split type air conditioners. Following type of the ventilation and air conditioning equipment shall be adopted as shown on the Table below.

Building	**Room**	**Ventilation/Airconditioning Equipment**
Main Substation	11KV Switchgear Room	Axial type exhaust fan
	66 KV Equipment Room	Natural ventilation by window
Administration Building	Control Room	Split type air conditioner
	Relay Room	Split type air conditioner
	DC Power Unit	Wall mounted exhaust fan
	Work shop	Axial flow supply fan
	Office	Window type air conditioner
	Toilets	Wall mounted exhaust fan
	Pantry	Wall mounted exhaust fan

(b) Design Conditions and Criteria

The design of ventilation and air conditioning system shall be based on the recommendation of ASHRAE handbook, and the following design conditions and design criteria shall be adopted:

Outdoor Design Temperature	:	37 °CDB, 23 °CWB
Indoor Design Temperature	:	25 ±1 °CDB, 50 ± 10% RH

Ventilation Requirements:

Room		Fresh air changes per hour
Work Shop	;	15
Toilet, Pantry	;	20
11 KV switch gear room	;	15 times air changes or 45 °C whichever larger
DC power unit room	;	30

(2) Plumbing System

The water supply and plumbing system shall be designed in accordance with the rules and regulations of Egypt. Plumbing system shall include provisions of water supply including elevated water tank, drainage, plumbing fixture, septic tank and evaporation pit and appurtenances.

(a) Water Supply System

Water distribution piping with the 50mm diameter gate valve shall be provided at the appropriate location within the boundary by the Second Package Contractor. The water shall be stored in the elevated water tank having a capacity of 4 M^3, being installed on the roof of the Administration Building, and supplied to sanitary fixtures and pantry wherever water is required by gravity flow. A stub-out with the 40mm diameter gate valve shall also be provided by the Second Package Contractor for supplying water to the Pump House.

(b) Drainage System

Soil and wastewater from the plumbing fixtures and pantry shall be collected to the sewer pipe by gravity flow and connected to the wastewater treatment facility. The septic tank and evaporation pit shall be provided at the appropriate location within the area. The treated water from the septic tank will be evaporated in the air through the evaporation pit.

(c) Plumbing Fixtures

The plumbing fixtures shall be provided as shown on the architectural drawings.

(d) Fire Protection System

A fire extinguisher shall be provided for every 100 m2 of the floor area in the building. A floor area less than 100 m2 shall have at least one fire extinguisher. Fire protection system will be designed in compliance with the local regulations, standards and practices applicable to the facility.

(3) Lighting and socket outlet system

(a) General lighting system

All areas or rooms of the main substation building will be equipped with general lighting and systems as mentioned herein after.

(i) System composition

The system will consist of general lighting fixtures, emergency lighting fixtures, distribution boards, control system and wiring.

(ii) General lighting fixtures

The fixtures are classified into four types such as,

Type-A: Ceiling surface mounted type with metallic low brightness louver, for fluorescent lamp, IP 51.

Type-B: Ceiling surface mounted open type for fluorescent lamp, IP 51.

Type-C: Pipe pendant type with metallic reflector for fluorescent lamp, IP 51.

Type-D: High ceiling mounted type with flood type metallic reflector for high-pressure sodium lamp, IP 51.

Type-E: Flood lighting fixture for high-pressure sodium lamp, IP 65.

Type-F: Pole top mounted type area lighting fixture for sodium lamp, IP 65.

(iii) Lighting intensity

Designed lighting intensity and installed fixture type are as shown on the following table.

Schedule for Lighting intensity and fixture

Type of room/area	Lighting Intensity (lux)	Fixture Type
Office	300	A
Control room	300	A
Workshop	300	B
Relay room	200	B
DC Power unit room	200	B
Storage	200	B
Pantry	250	B
Toilet	200	B
Corridor	200	B
66 kV Equipment room	300	D and B
11 kV Switchgear room	300	B
Transformer booth	100	B
Main substation site	50	F

(b) Emergency lighting system

The emergency lighting fixtures are installed into all interior area or rooms of the building to prevent darkness by the general lighting failure.

The emergency lighting fixture is ceiling or wall surface mounted type for incandescent lamp powered by centrifugal battery system.

Designed lighting intensity of the emergency lighting is 50 lux for every escape root in the building.

(c) Control method of the lighting system

The general lighting fixtures installed into the administration building are turned on or off by the local lighting switch in each room.

The general lighting fixtures installed in the main substation building will be turned on or off by the remote control switches located in suitable locations.

Each remote control switch will control a magnetic contact relay installed in branch circuit for the fixtures in distribution board.

(d) Socket outlet system

All interior rooms or areas are equipped with general use socket outlets to power supply for small electrical consumers.

Additionally two types of special purpose socket outlets are installed into main substation building and workshop room.
The general use socket outlet is 2-pole plus earth pole and 220 V, 15 amp, wall surface flush mounted type.
The special purpose socket outlets are specified as follows.
One is single phase 220 V, 30 amp and the other is three phase 380 V, 20 amp and these outlets is set in wall surface mounted metallic cabinet of IP 51.

(e) Distribution board

For supply power to these lighting fixtures and socket outlet the distribution boards will be installed or two into the main substation building and one is into administration building.
The distribution board is composed with main circuit breaker, branch circuit breakers, earth leakage current relays, magnetic contact relays and voltage indication lamps.
The molded case circuit breaker is adopted for main and branch breakers.
To automatic control of exterior site lighting a photocell switch and time switch will be provided to branch circuits of the site lighting fixtures.