## 4.7 No.7 Pumping Station

### (1) Dimension of Pump Room

The following dimensions of pump room were decided based on the basic dimension of pumping station which was discussed in the Interim Report (2).

(a) Width of Pump House

The width of the pump house consists of following A and B. (Refer to Figure 4.7-1)

A : pump unit pitch = 9.0 m

Pump unit pitch is decided by motor maximum dimension 7.20m plus 1.80m of passage width between motors.

B : space of maintenance area = 20.0 m

Necessary space of service area is depend on occupied area of pump and motor parts overhauled such as motor rotor, pump casing cover, impeller, shafts and truck to board these parts considering traveling crane working area. ( Refer to Figure 4.7-2 )

Therefore the width of the pump house will be 67.0 m (= 9.0 x 3 + 20.0 x 2 ).

(b) Length of Pump House

The length of the pump house consists of C, D, E, F & G. ( Refer to Figure 4.7-3)

C : width of valve gallery = 7.0 m

D : 1st. embedded concrete wall thickness = 1.0 m

E : block out of pump house = max. dimension of pump casing plus installation working area=7.0 m

F : passage = 1.5 m

G : wall thickness or column depth of pump house = 2.0 m

Therefore the length of pump house will be 21.5 m ( = 7.0 + 1.0 x 2 + 7.0 + 1.5 +2.0 x 2 ).

(c) Height of Pump House ( Building )

The height of pump house consists of H, I, J & K. ( Refer to Figure 4.7-3 )

H : height of motor with exciter removed = 5.3 m

I : height of rotor = 6.0 m

J : space of lifting gear = 2.1 m

K : distance between highest level of crane hock to ceiling = 5.4 m

Therefore the height of pump house will be 18.8 m ( = 5.3 + 6.0 + 2.1 + 5.4 ).

(d) Depth of Pump House

The depth of pump house consists of L, & M. ( Refer to Figure 4.7-3 )

L : depth between motor floor and pump impeller = EL13.70-EL1.60 = 12. 1m

The elevation of motor floor will be decided elevation 13.7 m, higher than 0.3 m from around the ground elevation of the pumping station of 13.4 m.

Installated elevation of pump impeller will be decided by the study on the cavitation. It's elevation is 1.6 m of which deducted suction head Hs =7.0 m from lowest suction water level LSWL 8.6m at the mouth of suction pipe.

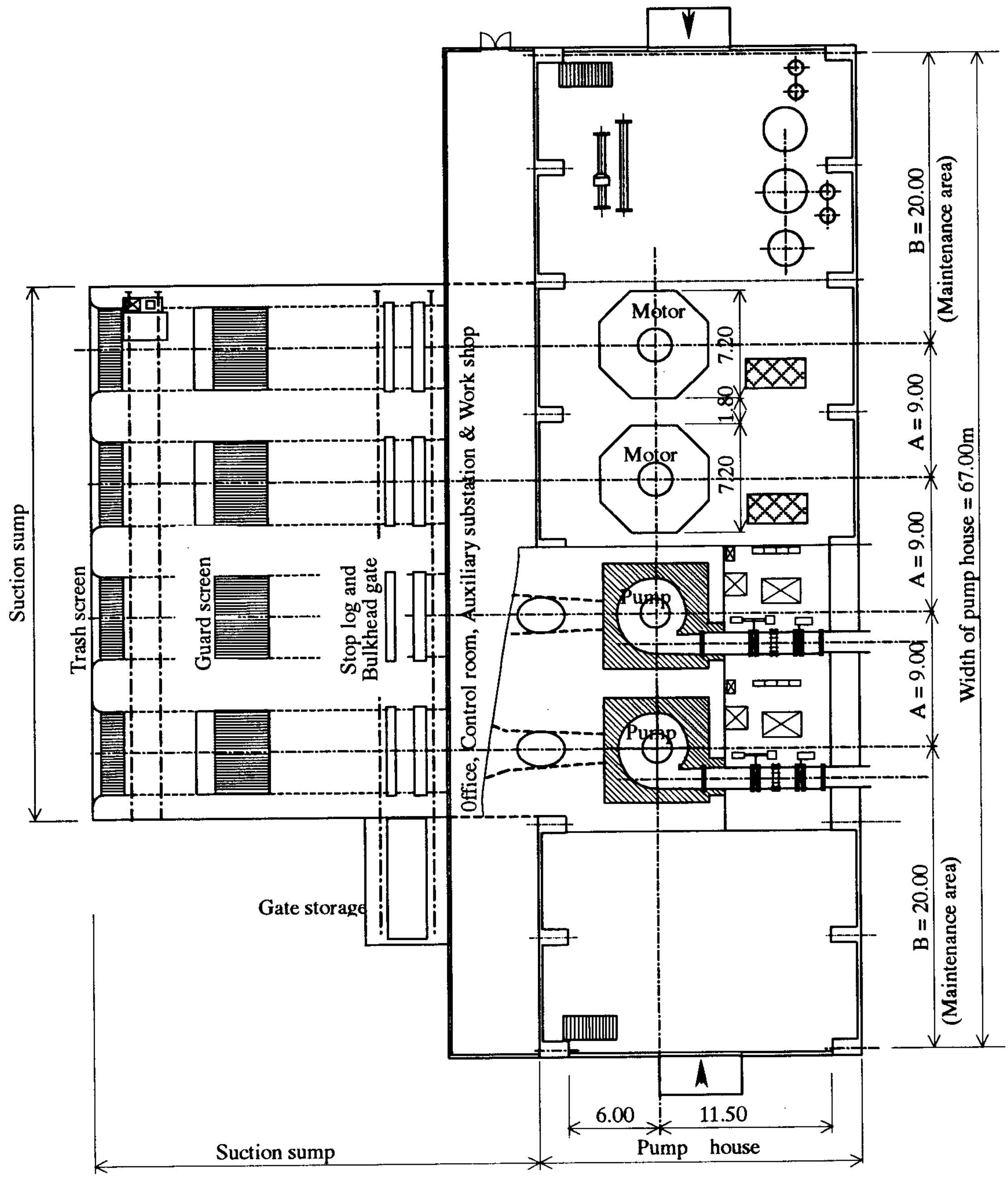



**Figure 4.7-1 Width of Pump House**

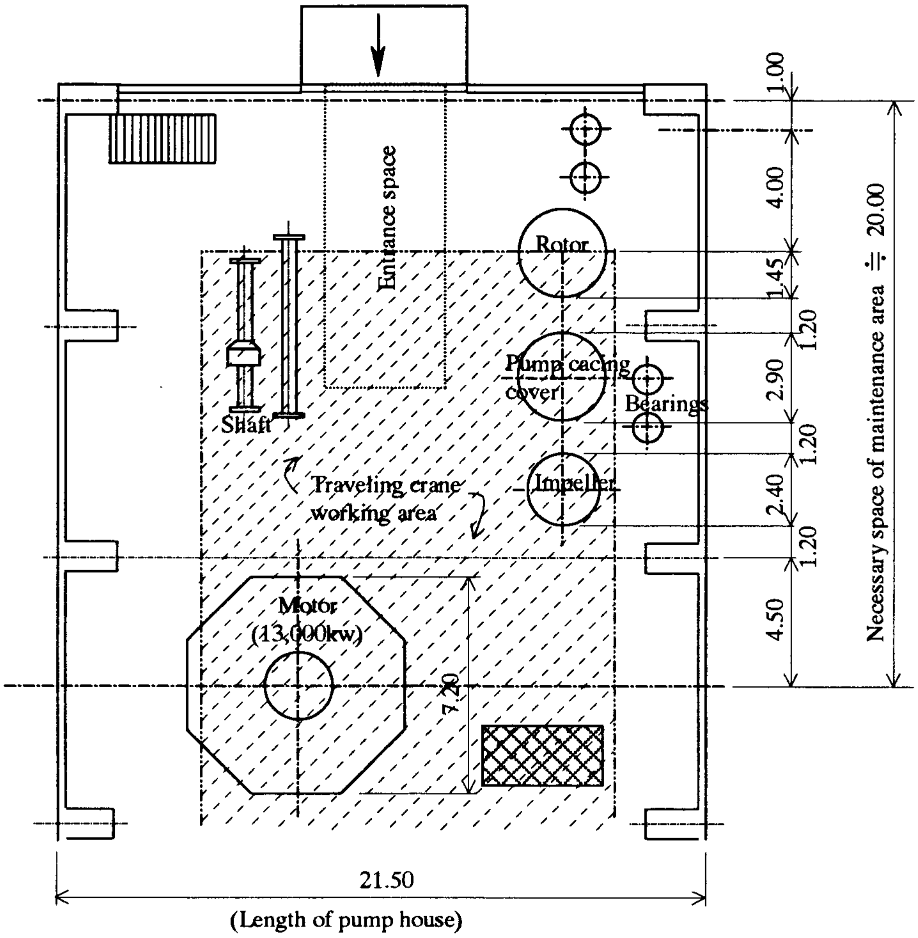



**Figure 4.7-2 Necessary Space of Maintenance Area**

M : depth between pump impeller and bottom of block out of pump house = 6.5 m
This depth consists of dimension of pump casing from impeller and necessary space to install pump suction pipe. ( 5.5 + 1.0 = 6.5 m)

Therefore, the depth of pump house will be 18.6 m. ( = 12.1 + 6.5 )

(e) Location of Auxiliary Equipment

The location of auxiliary equipment which is necessary for operating main pump, will be under the maintenance area, showing in Figure 4.7-4.

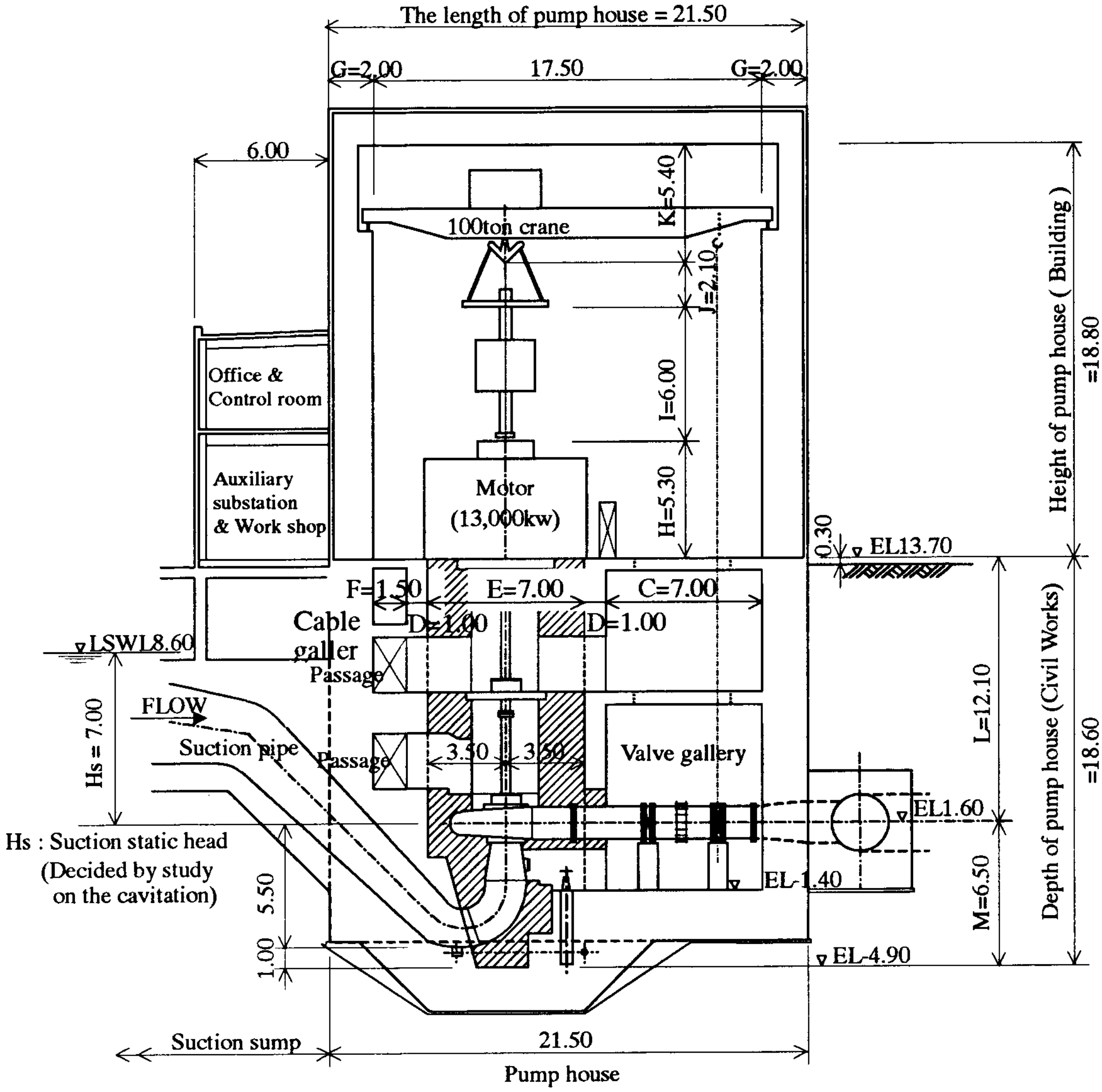



**Figure 4.7-3 Width, Height and Depth of Pump House**

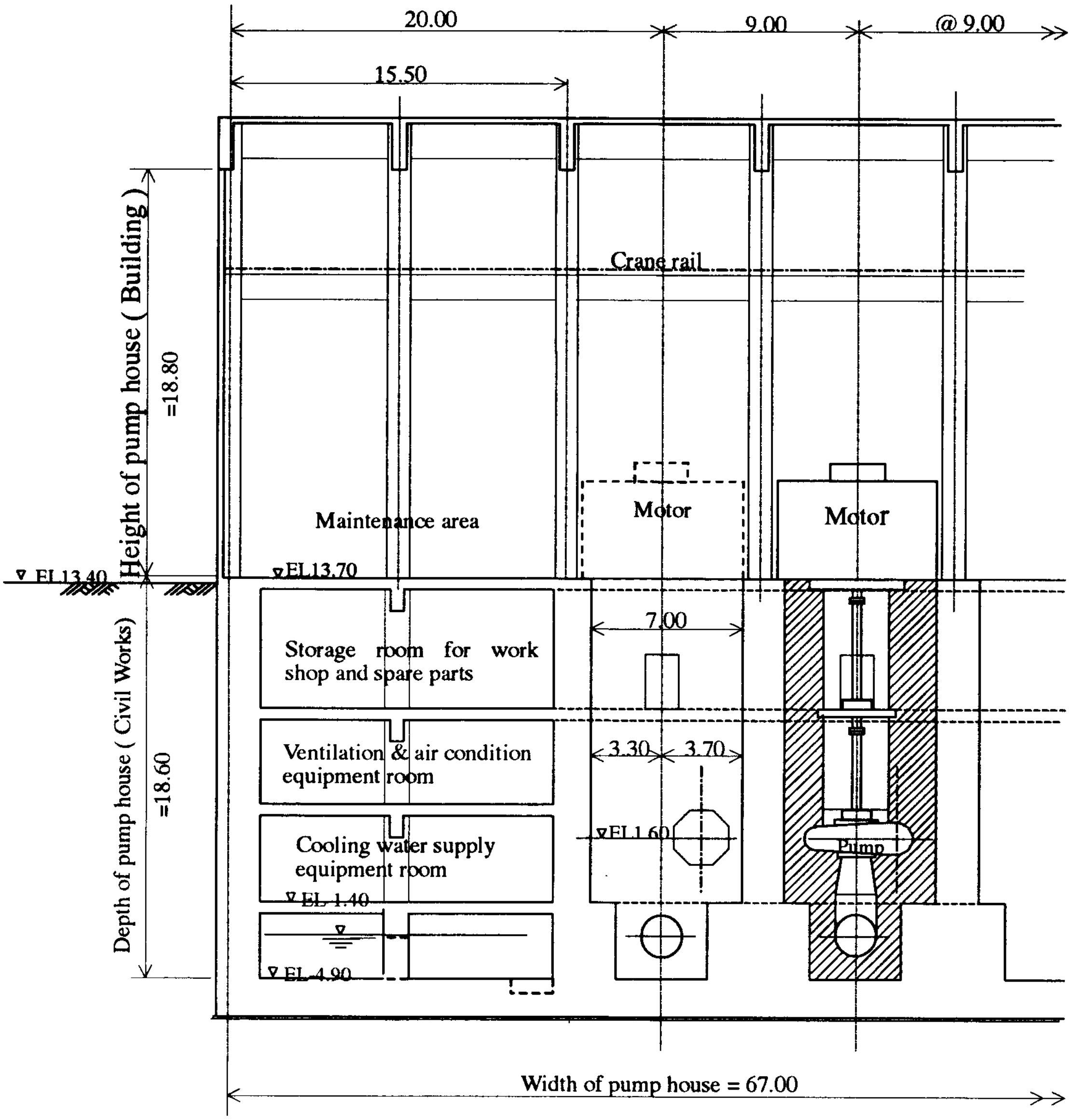



**Figure 4.7-4 Location of Auxiliary Equipment**

(f) Capacity computation of sump pit volume

(i) Prospected discharges to be collected and/or stored in the sump pit

| | |
|---|---|
| -Condensed water adhered motor cooler surface (3 nits) | : 6.0 $m^3$/hr |
| -Leakage water from main pump stuffing box (3 units) | : 6.0 $m^3$/hr |
| -Leakage water from valve shaft (0.005x3,600x2x3 units) | : 5.4 $m^3$/hr |
| -Leakage water from pump room | : 5.0 $m^3$/hr |
| -Other miscellaneous (20% of the above) | : 4.5 $m^3$/hr |
| Total | 26.9 $m^3$/hr = 30 $m^3$/hr |

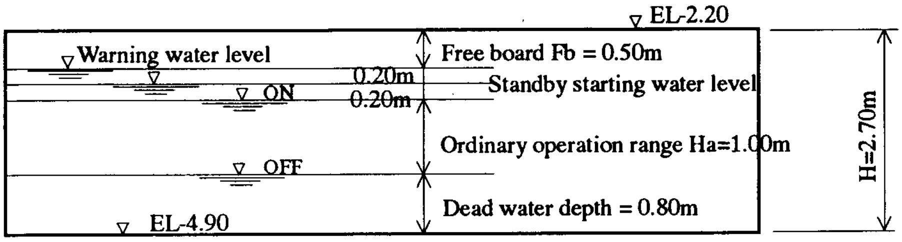



**Figure 4.7.5 Cross Section of Sump Pit**

Effective storage water volume of the sump pit are estimated based on two hours continuous non operation of the pit water drainage pump under the maximum discharge water(30 $m^3/hr$) mentioned above.

From the above mentioned conditions and proposed cross section of sump pit, required area for both effective depth (1.00m) and free board depth (0.50m) can be calculated as follows ;

$A_1 = Q \times T / Ha = 30 \times 2 / 1.00 = 60\ m^2,\ V_1 = 60\ m^3$
$A_2 = Q \times T / Fb = 30 \times 1 / 0.50 = 60\ m^2,\ V_2 = 30\ m^3$

Actual effective design capacity of the pit under the B3F floor is as follows ;

$Aa = ( 6.75 + 6.15 ) \times 5.00 = 64.50\ m^2$ and $Va = 64.50 \times 1.00 = 64.50\ m^3$

**(2) Structural Analysis**

(a) General

No.7 pumping station consists of the intake canal (suction sump) , pump room, valve chamber and flow meter chamber. These structures have the following types, and the major structural analyses have been made for these structures using personal computers.

| | |
|---|---|
| • Intake canal ------------------ | Flume structure |
| | Box type rahmen structure |
| | Retaining wall of Inverted L-shape type |
| | Retaining wall of Gravity type |
| • Pump room ------------------- | Column/Beam frame type rahmen structure |
| | Beam of two (2) sides fixed |
| | Slab/wall of four (4) sides fixed plate |
| • Valve/flow-meter chamber | Box type rahmen structure |
| | Beam of tow (2) sides fixed |
| | Wall of four (4) sides fixed plate |

(b) Intake Canal

The structural analysis of the intake canal was made for retaining wall, flume structure and box type rahmen with seven (7) cells composed of upper plates, bottom plates, side walls and middle wall. In this section, the following three (3) case study for flume and box type rahmen are examined showing below table of load condition and Appendix C.4.7-2 as example, and other detailed was explained in the Appendix C.4.7-1 and C.4.7-2.

( i ) Cases of Analysis

The structural analysis shall be made in the following three (3) cases.

| Case | Combination of Loads |
|---|---|
| • Case 1: Empty in all Cell box | Dead weight, Earth pressure, Trash-car load, Crowd load, Live load, Ground reaction |
| • Case 2: Filled in by Water except 1 cell box | Dead weight, Earth pressure, Internal water pressure, Trash-car load, Crowd load, Live load, Ground reaction |
| • Case 3: Filled in 4 cell Box by water | Dead weight, Earth pressure, Internal water pressure, Trash-car load, Crowd load, Live load, Ground reaction |

( ii ) Structural Analysis of Intake Canal

The structural analyses of the intake canal was carried out as shown in Appendix C.4.7-1 and C.4.7-2 and necessary reinforcements of the flume section is shown on Figure 4.7-6.

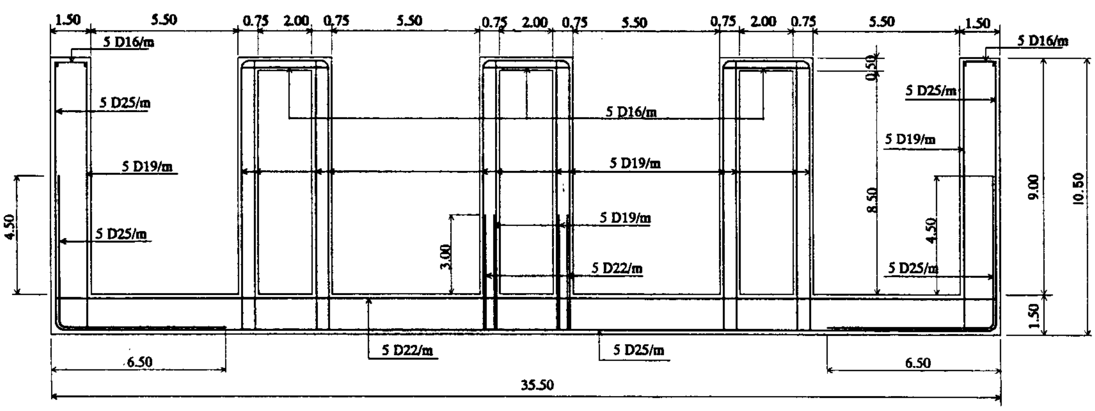



**Figure 4.7-6 Arrangement of Reinforcement for Intake Canal**

(Flume Section)

(c) Pump Room

( i ) Load conditions for the analysis

The structural analysis of the main frame in the pump room shall be made by rahmen structure with load of axial force acting to the building columns and main pumps/motors. The major loads of pump room are summarized in the Table 4.7-1.

**Table 4.7-1 Major Load of Pump Room**

| Description | Unit | Axial Force | Remarks |
|---|---|---|---|
| Main pump | tf/unit | 99.6 | Dead load including water x 1.2 |
| Main motor | tf/unit | 224 | Dead load x 1.2 + axial thrust |
| Intermediate shaft bearing | tf/unit | 13.2 | Dead load x 1.2 |
| Suction pipe | tf/unit | 188 | Dead load including water x 1.2 |
| Header pipe | tf | 678 | Dead load including water x 1.2 |
| Discharge valve | tf/unit | 15.6 | Dead load including water x 1.2 |
| Isolating valve | tf/unit | 18 | Dead load including water x 1.2 |
| Gantry crane | tf/wheel | 17 | 4 wheels |
| | | | |

( ii ) Case of analysis

Structures of the main pump room with building work are rather complicate for structure analysis. Steps of the calculation process are firstly, computation of representative main frame (Rahmen structures) i.e. No. 2 Lane, No.4- No.6 Lane, No.8 Lane and middle section of A – B Lane, and secondly, calculation of beam with slab which mainly extended from the main girder for each floors. The results of overall calculation were compiled in the Table 3,4,5 and 6 of the Appendix A.4.7-3 and Annex C. Structure Design as the output data.

In this paragraph, the result of computation on bending moment and shearing force for main frame (⑧−⑧ Lane) was shown in the Figure 4.7-7 and Figure 4.7-8, and necessary reinforcements was also shown in Figure 4.7-9 as a sample.

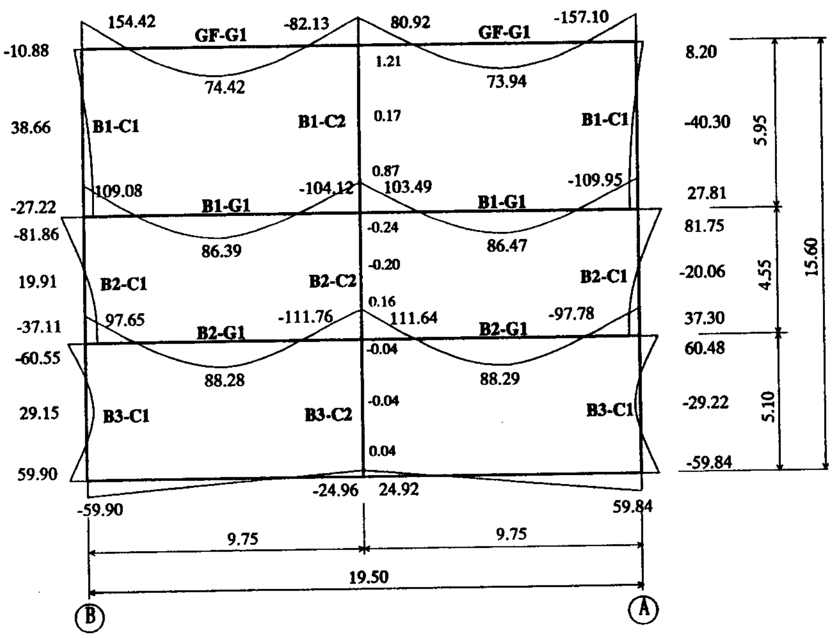



**Figure 4.7-7 Bending Moment Diagram of Main Frame** (tf·m)

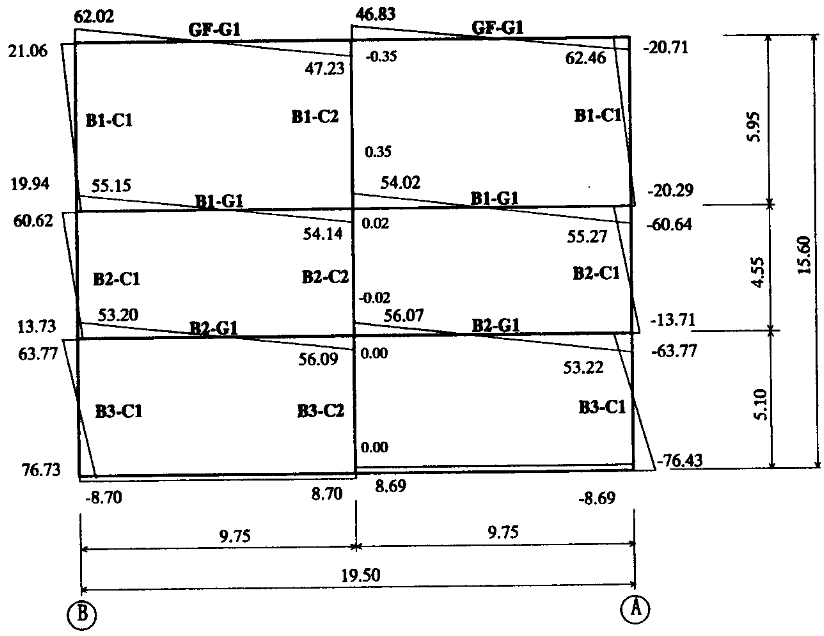



**Figure 4.7-8 Shearing Force Diagram of Main Frame (tf)**

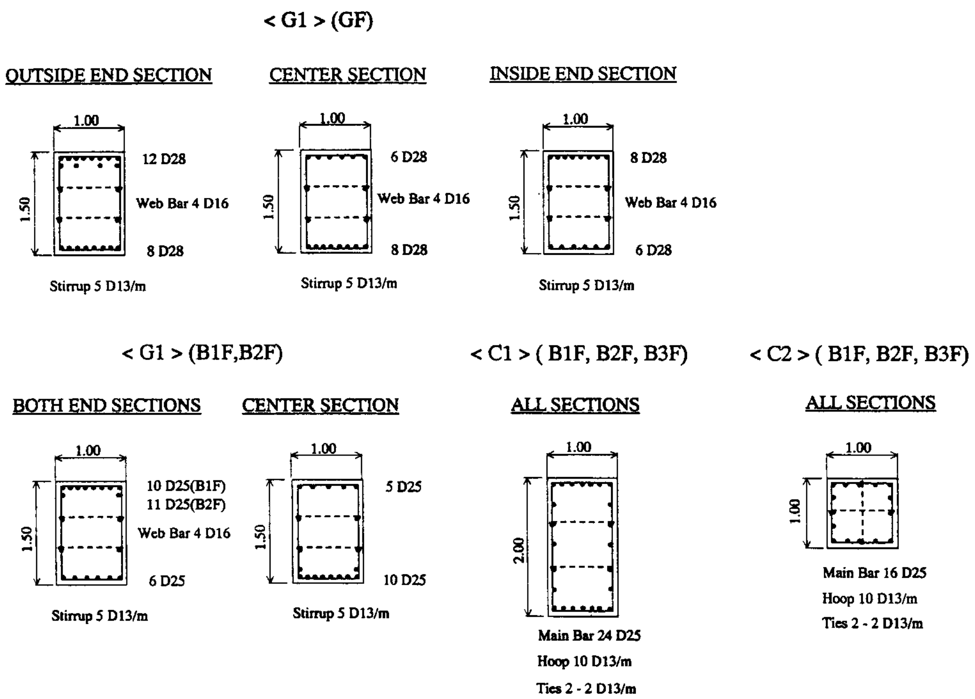



**Figure 4.7-9 Arrangement of Reinforcement for Main Beam/Column**

(d) Valve and Flow Meter Chamber

The structural analyses of valve and flow meter chambers shall be made by box type rahmen structure with one (1) cell composed of upper plate, bottom plate and side wall. And the walls of not-rahmen direction shall be made by four (4) sides fixed plate. In this paragraph, necessary reinforcements are shown on Figure 4.7-10 and Figure 4.7-11.

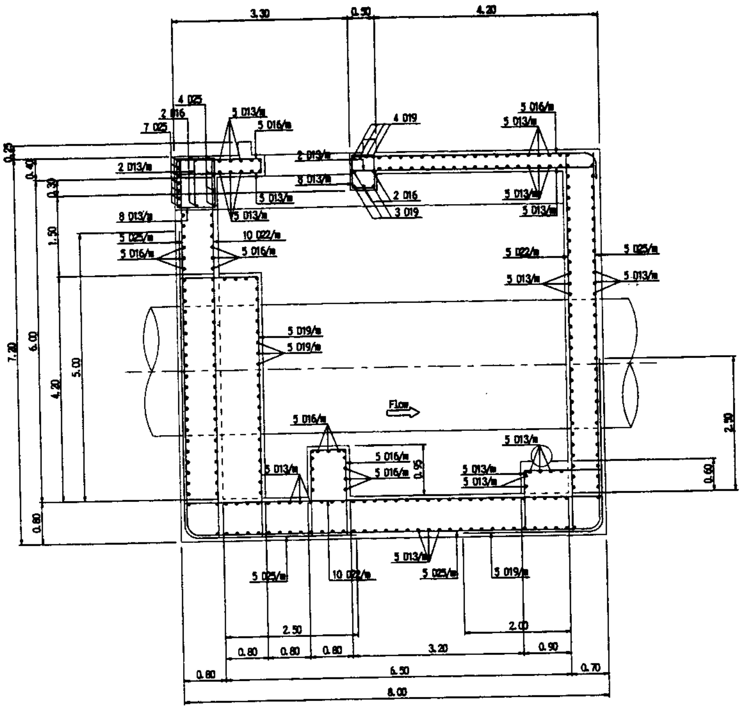



Figure 4.7-10 Arrangement of Reinforcement for Valve Chamber

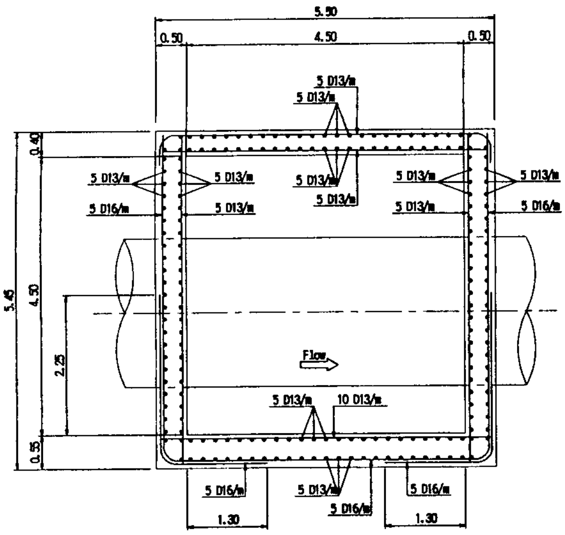



Figure 4.7-11 Arrangement of Reinforcement for Flow Meter Chamber

## 4.8 Discharge Tank

The structural analysis of the discharge tank was made by flume type structure with four (4) sells composed of bottom plates, side walls and intermediate walls. The walls and bottom plates of the flume are supported by cantilevers to secure stability against earth or hydraulic pressure and soil reaction.

### (1) Cases of Analysis

The structural analysis shall be made in the following three (3) cases.

| Case | Combination of Loads |
|---|---|
| • Case 1: Empty in box | Dead weight, earth pressure, gate weight, hoist weight, crowd load, live load, ground reaction |
| • Case 2: Filled in 1 sell box by water | Dead weight, earth pressure, internal water pressure, gate weight, hoist weight, crowd load, live load, ground reaction |
| • Case 3: Filled in 2 sell box by water | Dead weight, earth pressure, internal water pressure, gate weight, hoist weight, crowd load, live load, ground reaction |

### (2) Structural Analysis of Discharge Tank

The structural analysis of the discharge tank was carried out as shown in Appendix C.4.8-1 and necessary reinforcements are shown on Figure 4.8-1.

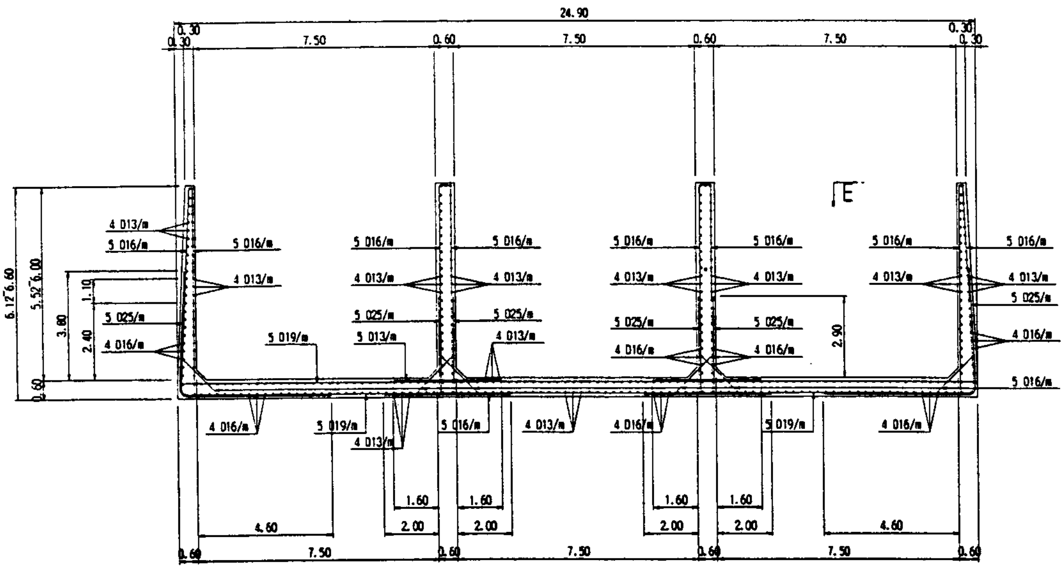



**Figure 4.8-1 Arrangement of Reinforcement for Discharge Tank**

## 4.9 Building Works

### 4.9.1 Architectural Design

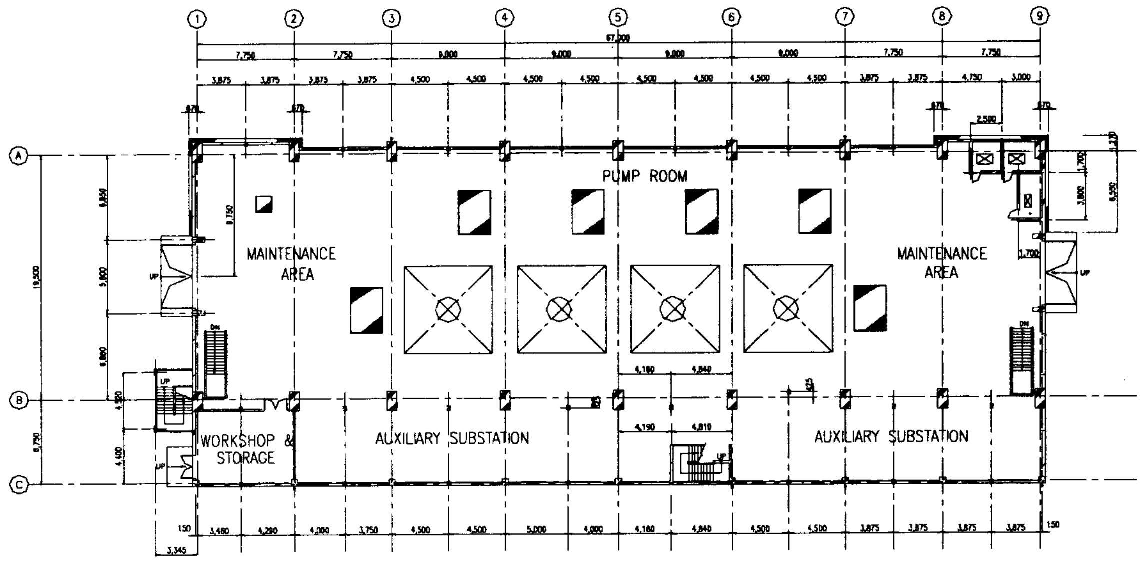
#### (1) Background

As to the architectural design, it was confirmed by NSDO that no monument is required to be provided but improvement on the building facades design. Information and/or data as to overhead travelling crane obtained. Design coordination done with below ground structures, mechanical and electrical equipment.

#### (2) Function and Layout

Floor plans, sections and elevations for the Pump Houses are defined in the drawings and the following facilities are provided in the building in order to allow proper installation, operation and maintenance of all equipment required and, to allow reasonable working conditions for staff and workers in compliance with the laws and regulations in Egypt:

(a) Ground Floor (1,759 $m^2$):




(i) Pump Room and Maintenance Area (1,307 $m^2$)

Space for four (4) units of pumps at axis between 3 – 7, and two (2) Maintenance Area at axis 1-3 and 7-9 provided. Two (2) main access doors with built-in man door, shall be provided at axis 1 and axis 9. Two (2) staircases to the basement level are provided near to axis 1 and 9. Ladder shall be provided at axis B/2 which is accessible from 1st Floor corridor level (EL. 19.50).

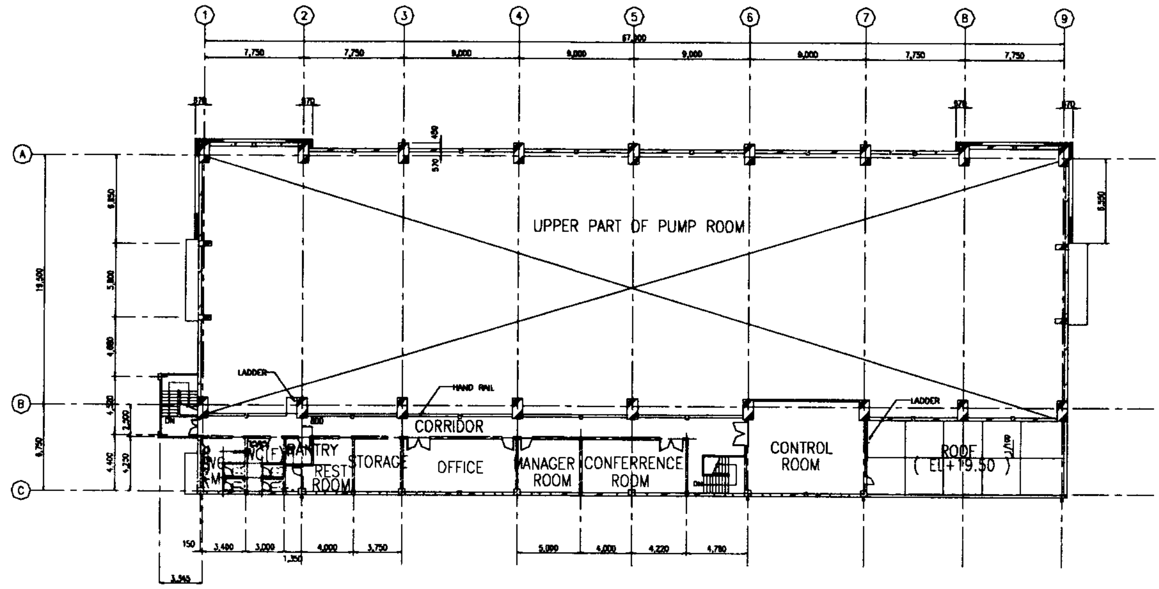
(ii) Auxiliary Substation (400 $m^2$)

The room shall be located adjacent to the Pump Room for Auxiliary Substation equipment. In this area internal staircase accessible to the first floor office area and basement area provided. No partition wall shall be provided between pump room and auxiliary substation.

(iii) Workshop & Storage (52 $m^2$)

The room shall be located at the corner of axis 1 and C. The area is accessible both from outside and pump room..

(b) First Floor (348 $m^2$):




The following facilities are provided on the first floor level of the pump house at axis B-C/1-7.

(i) Control Room (61 $m^2$)

One service door shall be provided to access roof level (EL;19.50 m) for the purpose of maintenance of the adjacent roof levels and upper levels roof. Glazed windows shall be provided to the pump room side to have a view of Pump Room.

(ii) Office (38 $m^2$)

One each large double and ordinary size doors shall be provided to the corridor side.

(iii) Manager's Room (21 $m^2$)

One ordinary size door shall be provided to the corridor side.

(iv) Conference Room (35 $m^2$)

One large double size door shall be provided to the corridor side.

(v) Rest Room and Pantry (39 $m^2$)

One ordinary size door shall be provided to the corridor side for Rest Room. A pantry is provided to prepare tea and/or light meals.

(vi) Male and Female Toilets (25 $m^2$)

Toilets are provided for male and female separately.

(vii) Corridor & Stairs (127 $m^2$)

Handrails shall be provided to the pump room side. Internal corridor is provided to have an easy access to the downstair's Auxiliary Substation and Pump Room areas.

### (3) Building Materials and Architectural Finishes

(a) Building Materials

Building shall be of reinforced concrete framing with masonry brick wall construction. However roof beams and crane girders are substituted to structural steel construction. Appropriate materials shall be used in order to ensure satisfactory aesthetic design and the use of standard products and dimensions and building materials are designed and selected based on the criteria and considerations mentioned in the Interim Report (2):

(b) Architectural finishes

The interior and external architectural finish for the Pump Houses are defined on the Drawings.

(i) External finishes:

- Roof: Bituminous water proofing membrane with heat insulation material (50mm thick) and covered by mortar with tiles.
- Wall: Cement brick (120 x 240 x 60mm) wall construction with plastered and painted or facing with sand lime brick (115 x 250 x 60mm) construction.

(ii) Interior Finishes:

Floors:

- Ceramic tiles (150 mm x 150 mm or 200 mm x 200mm, with 10 mm thick) are used for Pump Room and Auxiliary Substation as well as Toilets and Pantry.
- Terrazzo tiles (250 mm x 250 mm, with 25 mm thick) for administrative area such as Office, Manager's Room and Conference Room.

Walls:

- Ceramic tiles (150 mm x 150 mm or 200 mm x 200 mm, with 6 mm thick) up to 2 m height from the finished floor level and paint for the remaining area above 2 m on plastered wall, for Pump Room, Auxiliary Substation, Control Room, toilets and pantry.
- Paint on plastered masonry or RC structure walls for the remaining rooms.

Ceiling:

- Generally paint on RC structure with cement sand repairing where necessary.

(iii) Doors and Windows:

Main access door: Double swing steel door (5 m wide and 5.5 m high and provided with built-in man door, 750 mm wide and 1900 mm high) with paint finish

Windows: All windows in the Pump Room and Auxiliary Substation areas shall be modular sized aluminum framed bottom hinged windows which can easily opened by handle. Windows shall be located at 2 levels, i.e. 2 m above floor level and in the area between crane girder and the ceiling.

(iv) Miscellaneous steel and metal works:

- Handrail: Steel (using flat bars for staircase handrail and pipes for corridor handrail) with oil paint.

- Ladder: Steel pipe and re-bars assembly (using flat bars for cages) with oil paint
- Trench covers: Steel checkered plate with oil paint.
- Down pipe: Cast iron pipes with oil paint.

#### (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

### 4.9.2 Structural Design

#### (1) Background

Design has been carried out based on the design criteria and considerations as mentioned in the Interim Report (2). Structural design includes structural calculation, general notes, framing plans and standard details and so on. Design coordination with below ground structure, electrical and mechanical equipment has been carried out. Loading data and sizes of overhead travelling crane have been provided to design crane girders and space required. Roof beams originally proposed reinforced concrete, are substituted to structural steel trusses in consideration of 19.5 m span and easier construction.

#### (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, however roof beams shall be of structural steel trusses. Materials used for the building 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) Structural steel

- Structural steel shall conform to JIS G3101 SS400, ASTM A36 or equivalent.

(d) Other materials

- Other materials are as defined on the drawing No. PSB-214.

**(4) Frame Analysis**

The Pump House structure will be of a reinforced concrete frame which is moment-resisting in both longitudinal and transverse directions. The roof is supported by steel trusses, the span of which is 19.5 m. Loading data for the structure is described as follows:

(a) Dead Loads

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

(b) Live Loads:

- Roof: 100kg/$m^2$
- Office area 300kg/$m^2$

(c) Crane loads:

- Lifting load capacity: 95 ton
- Maximum load capacity: 38 ton
- Number of wheels 8

- Vertical impact load: 25% of maximum wheel load
- Lateral impact load: 10% of wheel load
- Longitudinal impact load 10% of wheel load

(d) Seismic loads

Seismic load will be calculated as follows:

Kh=0.4K C I

Where,

| | | |
|---|---|---|
| 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 x $\sqrt{T}$ |
| | 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. |

(e) Frame analysis

Three-dimensional frame analysis was carried out for the design of the structure, using the STAAD III structural design software. Frame model, loading diagram and analysis results at Axis 5 are as shown in the APPENDIX C.4.9.

### 4.9.3 Building Services Design

#### (1) Ventilation and Air-conditioning

(a) Description of the System

Ventilation and air conditioning system shall be provided for the rooms where required in order to maintain proper working condition for the equipment and O/M personnel. The ground floor (EL+13.7) will be naturally ventilated by providing a sufficient number of the windows on the exterior wall, but the auxiliary substation area will be provided with the propeller type exhaust fans to avoid the accumulation of the heat dissipated from the electrical appliances. Toilet and work shop will be ventilated by the wall mounted propeller fan. Office, manager room, conference, rest room and control room at the Level of EL+19.5 will be air conditioned by the window type air conditioners or the split type air conditioners. Following type of the ventilation and air conditioning equipment shall be adopted as shown in the table below:

| Building | Room | Level | Ventilation/Airconditioning Equipment |
|---|---|---|---|
| Pump House | Maintenance area | EL+13.7 | Natural Ventilation |
| | Work shop | EL+13.7 | Wall mounted exhaust fan |
| | Auxiliary substation | EL+13.7 | Wall mounted exhaust fans |
| | Office, Manager room, Conference, Rest room | EL+19.5 | Window type air conditioners |
| | Control room | EL+19.5 | Split type air conditioner |
| | Toilets | EL+19.5 | 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 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 | : | 20 |
| Toilets | : | 20 |
| Auxiliary Substation Area | : | 15 times air changes or 45 °C whichever larger |

### (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 water supply pumps, water reservoir, filtration and chlorination facility, drainage, plumbing fixtures, septic tank and evaporation pit and other appurtenances.

(a) Water Supply

Two submersible water feed pumps will be provided in the suction sump located at axis 5 to obtain the water from the channel. A water reservoir having a capacity of 4 $M^3$ as one day water consumption will also be provided together with the filtration and chlorination facilities at the outside of the pump house which maintain the water quality for drinking purpose. After treatment of water, water will be supplied to the elevated water tank, which is located on the roof of the administration building by the submersible water supply pumps provided in the water reservoir. Water from the elevated water tank will be distributed to the sanitary fixtures and pantry by gravity flow for both main pump house and administration building. The elevated water tank on the administration building will be provided by the Fourth Package Contractor. The water supply piping and distribution piping to the administration building shall be terminated with the 50mm and 40mm diameter gate valves respectively at the appropriate location within the power supply sub-station boundary.

The design of the filtration and chlorination facilities shall be based on the raw water and treated water qualities table below:

| Item | Unit | Raw Water* | Treated Water (WHO) |
|---|---|---|---|
| TDS | mg/l | 1351 – 2472 | 1000 |
| Turbility | NTU | 45 – 100 | 25 |
| pH | - | 6.7 – 6.8 | 6 – 9.5 |
| Hardness as $CaCO_3$ | mg/l | 348 – 463 | 500 |
| Calcium ion | mg/l | 83 – 88 | 200 |
| Chloride | mg/l | 591 - 1152 | 600 |
| Sulphate | mg/l | 146 – 198 | 400 |
| Iron | mg/l | 0.23 – 0.45 | 0.3 |
| Manganeese | mg/l | < 0.01 | 0.1 |
| Silica | mg/l | 8 – 12.8 | 25 |

* Source: March 1999

(b) Drainage

Soil and wastewater from the plumbing fixtures and pantry will be collected to the sewer pipe by gravity flow and connected to the sewage treatment facility. The septic tank will be provided at the appropriate location within the site area, and treated wastewater will be evaporated in the atmosphere through the evaporated pit. The septic tank and evaporation pit shall be designed based on the requirements of codes and practices of Egypt.

(c) Plumbing Fixtures

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

(d) Fire Protection System

A fire extinguisher will be provided for every 100 $m^2$ of the floor area in the building. A floor area of less than 100 $m^2$ will 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 pumping station 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 |
| Conference room | 300 | A |
| Manager room | 300 | A |
| Rest room | 200 | A |
| Control room | 300 | A |
| Workshop | 300 | B |
| Pump room/maintenance area | 250 | D and B |
| Toilet | 200 | B |
| Corridor | 200 | B |
| Electrical room/area | 300 | B |
| Mechanical room/area | 150 | B or C |
| Cable chamber | 100 | B |
| Gate area | 150 | E |
| Pumping station 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 separate room are turned on or off by the local lighting switch in each room.

The other general lighting fixtures or fixtures installed in pump room, mechanical or electrical rooms, public rooms such as corridor or toilet, basement and exterior area are 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 pump house, maintenance area, workshop and basement.

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 lighting distribution board is installed in each floor of the 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.

## 4.10 Mechanical Design

### 4.10.1 Suction and Delivery Pipes of the Main Pump

#### (1) Design of the suction pipe

For large pumping units, closed type suction pipe should be used to provide proper hydraulic flow and reduce the construction costs. This type suction shape prevents entrance of air by vortexes because there is no free surface in the sump. Therefore, the required depth of submergence can be decreased in comparison with a suction sump having a free water surface.

Drawing PSM-201 shows neat line of the suction pipe to be designed in this project. And also Figure 4.10-1 shows profile of the suction pipe.Table 4.10-1 shows relative dimensions of suction pipe which referred from some design standards and dimensions adopted for No.7 Pumping Station (PS).

**Table 4.10-1 Comparison of suction pipe dimension**

| Dimension | D1 | D2 | L1 | L2 | L3 | L4 | R1 |
|---|---|---|---|---|---|---|---|
| USBR | 1.284 D | 1.4 D | 1.35 D | 2.2 D | 3.55 D | 4.0 D min | 1.5D |
| A | 1.284 D | 1.4 D | 1.35 D | 2.2 D | 3.55 D | 4.0 D min | - |
| B | 1.2 D | 1.4 D | 1.35 D | 2.2 D | 3.55 D | 4.0 D min | 1.5D |
| C | 1.284 D | 1.4 D | 1.35 D | 2.2 D | 3.55 D | 4.0 D min | - |
| No.7 P/S | 1.284 D | 1.4 D | 1.35 D | 2.2 D | 3.55 D | 4.0 D min | 1.5D |

Note: 1) D2 means pump suction inlet diameter.

2) A,B, and C present leading pump manufacturer in Japan.

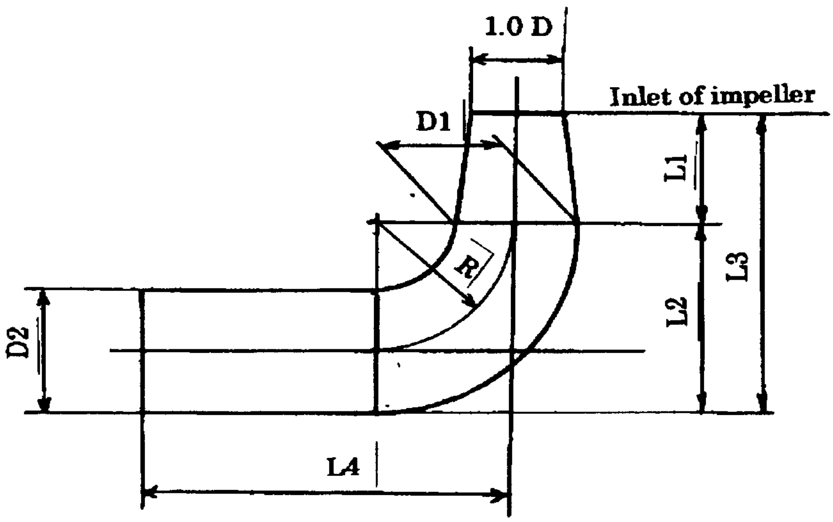



**Figure 4.10- 1 Profile of suction pipe**

**(2) Design of the discharge header**

The discharge header should be designed and constructed with the following objectives:

-To achieve smooth uniform flow into the header by providing gradual expansion for the connecting pipe.
-To minimize the water head loss.
-To minimize the forces due to internal flow in the header.

Diameter of the discharge header is designed to keep flow speed within 1 m/s considering the above, and decided about 3,800 mm

Each discharge pipes and delivery pipes are provided flared pipe to match the header pipe and diameter of the pipe is as follow :

- Discharge pipe : 1,500 mm
- Delivery pipe : 2,400 mm

With pressure determined, the wall thickness of discharge header is found using equation :

$t \geqq (pd / 2\sigma_{al}\eta) + C$
Where:
t = wall thickness (cm)
p = a pressure when water hammer is occurred ($kgf/cm^2$)
d = inside diameter of pipe (cm)
$\sigma_{al}$= allowable stress ($kgf/cm^2$)
$\eta$ = joint efficiency
C = additional thickness against corrosion and erosion.

The wall thickness of branch pipes is calculated from the following formula :

$$t \geqq (pd / 2\sigma_{al}\cos\theta) + C$$

Where:
$\theta$ = angle of enlargement or contraction of pipe

At the joint of branch pipe and the main pipe, a complicated and substantial force is applied created by the composite force of hoop tension, and the longitudinal force working on the conical part. For this reason, such part is required to have increased shell plate thickness or reinforcement so as to be provided with sufficient strength and rigidity.

The type of reinforcement can be determined by the magnitude of the pressure-diameter and the ratio of the branch diameter to the main pipe diameter d/D. This time, the ring girder reinforcement is adopted because ratio of d/D is large. In the analysis of ring girder reinforcement, it is assumed that the curved girder acts as if it lay in one plane, that the loads in both directions are uniformly distributed, and that the ring is circular. For the stress analysis, the ring dimensions must first be assumed. Computations will be simplified by using a ring of constant cross section. Drawing PSM-204 shows result of study.

### 4.10.2 Valves

#### (1) Design of the Discharge Valve

The type of valve selected for any given installation will depend primarily on service conditions to be encountered. And it also depends on the initial cost, and cost of maintenance.
In this project, the bi-plane type butterfly valve is selected for purpose stopping water, reverse flow prevention and water hammer prevention but not intend to control flow rate because pumps are operating by unit number control methods. Figure 4.10-2 shows the cylinder/counter weight driven bi-plane valve to be used as discharge valve and check valve.

The valve is normally open by the hydraulic cylinder and closed by the counter weight in time of aprox.120 second. When the pump is accidentally stopped such as power failure and back flow starts, the valve is first closed to prevent most water from backward then slowly closed by the hydraulic cylinder (acting as dash pot) while releasing some of the water. The closing time of the valve is controlled by the hydraulic cylinder (acting as dash pot) after the optimum time has been determined by analyzing the transients of the water hammer according to pipeline conditions.

Figure 4.10-3 shows the motor operating bi- plane valve to be used as the isolating valve and pipeline valve. And figure 4.10-4 shows detail of construction of the bi-plane valve.
As shown in figure 4.10-5, aim of selection is on the initial cost, and cost of maintenance because the bi-plane valve have a characteristic of lower friction loss coefficient than one of the lens type butterfly valve and lower cost than the spherical valve.
The bi-plane valve can be used under maximum static head of 300 meter.

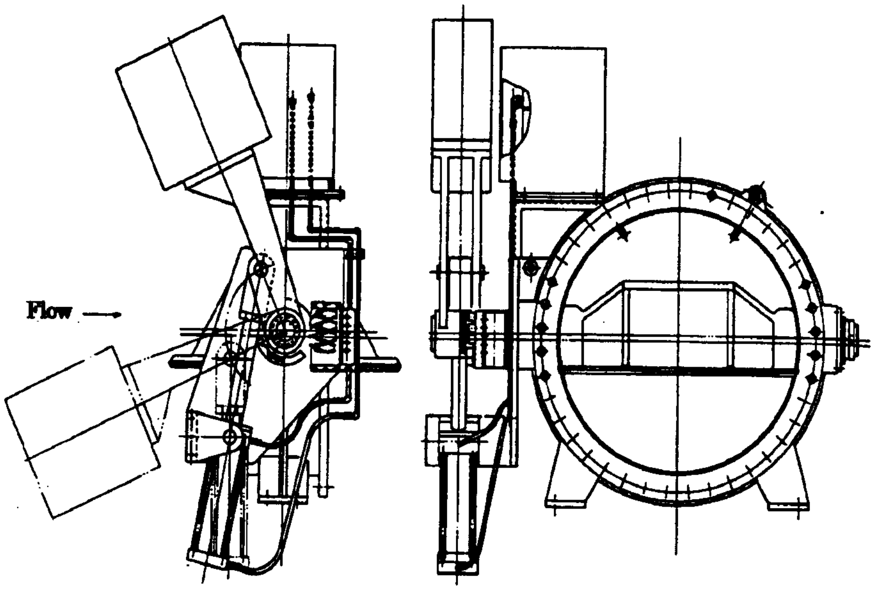



**Figure 4.10-2 Bi-plane Valve cylinder/counter weight operating type(Typical)**

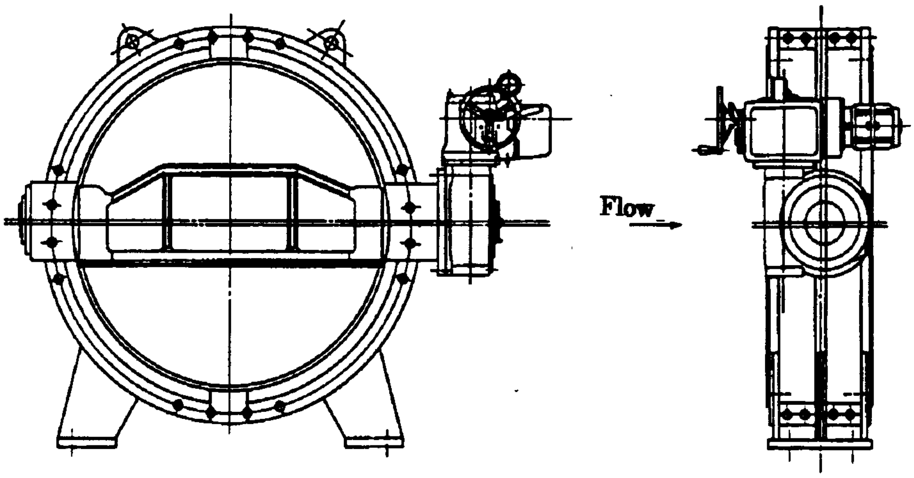



**Figure 4.10-3 Bi-plane Valve Motor operating type(Typical)**

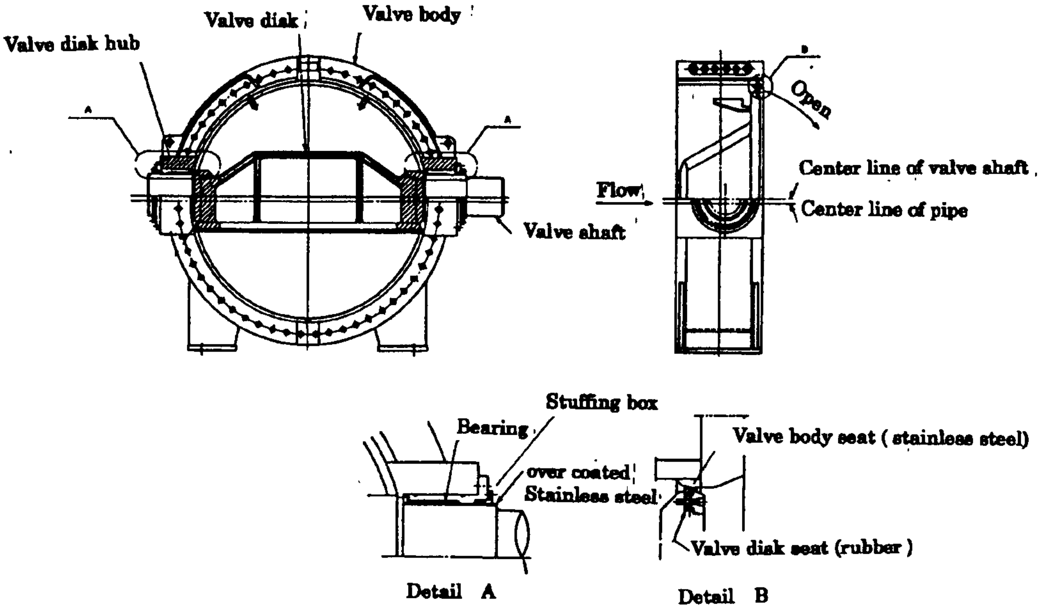



Figure 4.10-4 Structure of bi-plane valve ( Typical)

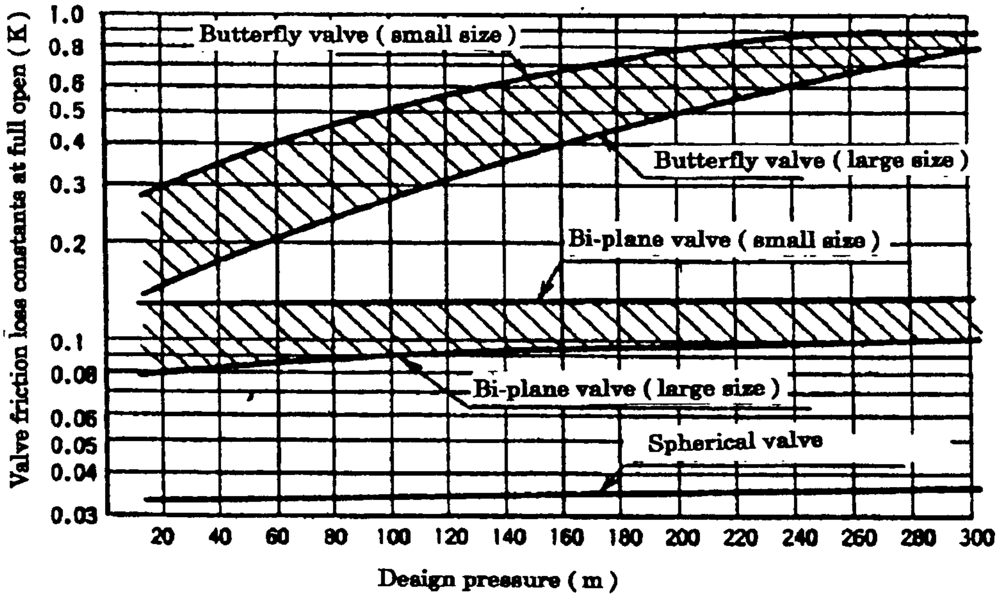



Figure 4.10-5 Friction loss for different valve

### 4.10.3 Gates

#### (1) Design of Bulkhead Gate for Suction Sump

The arrangement of the bulkhead gate is shown on the drawing PSM-208. The gate is designed for the following conditions.

| | | | |
|---|---|---|---|
| -Water load : | Head water at elevation | ( m ) | 11.94 |
| | Sill beam at elevation | ( m ) | 4.40 |

-Type of hoist : Lifting by gantry crane

The gate is raised under non pressure difference between up and down stream sides of the gate after the suction pipe has been refilled by using dewatering valves in the pumping station. And also the gate will be lowered under balanced head condition.

#### (2) Design of Stop-log for Suction Sump

The arrangement of the stop log is shown on the drawing PSM-209. The gate is designed for the following conditions.

| | | | |
|---|---|---|---|
| -Water load : | Head water at elevation | ( m ) | 11.94 |
| | Sill beam at elevation | ( m ) | 4.40 |

-Type of hoist : Lifting by gantry crane

#### (3) Design of Gantry Crane

The crane is designed to hoist and travel with a bulkhead gate having a weight of 13 tons which will be heaviest load imposed by the lifting beam with a gate or stop log attached. And also, the hoist shall be capable of starting and lifting the heaviest unit against the friction force for which the unit has been designed under water load.

The crane shall be statically stable by itself under all operating conditions, without temporary ballasting or tiedowns. Specification of the gantry crane is described in chapter5.

#### (4) Design of Trash Screen

The arrangement of the trash screen is shown on the drawing PSM-210. The screen is designed for the following conditions.

-For weed screen (upstream side)

| | |
|---|---|
| Clear span : | 5.50 m |
| Height of rack : | 9.00 m |
| Installation angle : | 75 degree |
| Water load : | Differential head of 1.0 m |
| Bar pitch : | 50 mm |
| Bar element : | Flat bar 90mm x 9 mm |

-For Guard screen (downstream side)

Clear span : 5.50 m
Height of rack : 9.00 m
Installation angle : 60 degree
Water load : Differential head of 0.5 m
Bar pitch : 100 mm
Bar element : Flat bar 75mm x 9mm

**(5) Design of Trash Rake**

Type of rake : Mobile weed screen cleaning machine

Number of unit : 1 set
Rake length : 2,000 mm
Hoisting speed : 10 m/min
Raking capacity per unit : 0.5 $m^3$
Travelling speed 10 m/min

**(6) Design of Radial Gate for Spillway**

The arrangement of the radial gate is shown on the drawing SPW-110.

The gate is designed under the following conditions.

Water load
Head water at elevation ( m ) 11.94
Sill beam at elevation ( m ) 7.60
Type of hoist : Lifting by manual head-stock

The gate is raised under pressure difference between up and down stream sides of the gate, and be lowered by own weight.

**(7) Design of Stop-log for Spillway**

The arrangement of the stop logs is shown on the drawing SPW-111.

The stop log is designed under the following conditions.

Water load
Head water at elevation ( m ) 10.91
Sill beam at elevation ( m ) 7.60
Height of stop log ( m ) 1.20
Type of hoist Lifting by chain block

The gate consists of three blocks, and be raised under water load of 1.2 m between up and down stream sides of the gate, and be lowered by own weight.

### (8) Design of Stop-logs at Inlet and Outlet of Box Culvert Canal

The arrangement of the stop logs is shown on the drawing CCL-168.

The stop log is designed under the following conditions.

| | | |
|---|---|---|
| Water load | ( m ) | 3.35 |
| Height of stop log | ( m ) | 1.20 |

Type of hoist : Lifting by the track crane

The gate consists of three blocks, and be raised under water load of 1.2 m between up and down stream sides of the gate, and be lowered by own weight.

### (9) Design of Screen at Inlet of Box Culvert Canal

The arrangement of the screen is shown on the drawing CCL-171.

The screen is designed under the following conditions.

| | |
|---|---|
| Clear span : | 3.70m |
| Height of screen : | 4.00 m |
| Installation angle : | vertical |
| Water load : | Differential head of 0.1 m |
| Bar pitch : | 300 mm |
| Bar element : | 60 mm dia.steel pipe |

The screen consists of three blocks, and be fixed to a concrete structure.

### (10) Design of Roller Gate for Sand Settling Basin

The arrangement of the roller gate is shown on the drawing SSB-204. The gate is designed for the following conditions.

Water load

| | | |
|---|---|---|
| Head water at elevation | ( m ) | 10.90 |
| Sill beam at elevation | ( m ) | 7.40 |
| Type of hoist | | Lifting by motor operated winch. |

The gate is raised under pressure difference between up and down stream sides of the gate, and be lowered by own weight.

## 4.11 Electrical Design

### (1) Design Standards

All electrical equipment shall be designed, manufactured and tested in accordance with the latest IEC Standards (International Electro-Technical Commission) and/or the equivalent standards in the country of Manufacture. This was agreed by MED. The following specific standards shall be used for the design of all electrical equipment.

(a) Main pump motor

| | |
|---|---|
| IEC-34 | Rotating Electrical Machine |
| IEC-72/72A | Dimensions and Output ratings |
| IEC-85 | Recommendations for the classification of insulating materials in relation to their thermal stability in service. |

(b) Power supply equipment

| | |
|---|---|
| IEC-76 | Specifications for transformers and reactors |
| IEC-298 | A.C. Metal-enclosed switchgear and control-gear for rated voltages above 1KV |
| IEC-439 | Low-voltage switchgear and controlgear assemblies |
| IEC-470 | High-voltage alternating current contactors |
| IEC-632 | High-voltage motor starters |
| IEC-694 | Specification for A.C. switchgear for voltages above 1KV |
| IEC-947 | Low-voltage switchgear and controlgear |

### (2) Design Conditions

(a) Service conditions

All electrical equipment shall be suitable for operation in No.7 pumping station, which is located in, hot, humid and tropical atmosphere polluted by wind-drift sand.

The service conditions in the pumping station shall be as follows:

| | |
|---|---|
| Maximum ambient air temperature: | 45°C |
| Minimum ambient air temperature: | 5°C |
| Maximum relative humidity: | 85% |
| Maximum altitude above sea level: | 1,000m below |

(b) Features of major equipment

Features of the major electrical equipment and required quantities are described in Table 4.11-1. The detailed technical description for each item of electrical equipment is described in Chapter 5, Clause 5.3 "Electrical Equipment".

**Table 4.11-1 Number of Major Equipment for Main Pump Unit**

| Equipment | Specification | Per pump unit | Total |
|---|---|---|---|
| 1. Main pump motor | 13MW, 11KV, 375 rpm, 50Hz | 1 | 4 |
| 2. Main motor starting panel | Vacuum circuit breaker (VCB) | 3 | 12 |
| | - VCB-1, 11KV, 1200A | (1) | (4) |
| | - VCB-2, 11KV, 1200A | (1) | (4) |
| | - VCB-3, 11KV, 1200A | (1) | (4) |
| 3. Exciter transformer panel | 20KVA, 11KV/380V, 1Ph | 1 | 4 |
| 4. Exciter panel | AC exciter | 1 | 4 |
| 5. Main pump unit control panel | | 2 | 8 |
| | - Programmable controller panel | (1) | (4) |
| | - Relay panel | (1) | (4) |
| 6. Auto-transformer | 11KV, 57000KVA, 3 minutes rating | 1 | 4 |
| 7. D.C power source | Battery and charger | - | 1 |
| 8. Load Center | 380/220V, 3Ph, 4W | - | 1 |
| 9. Motor control center (MCC) | for main pump | 1 | 4 |
| 10. MCC | for common A | - | 1 |
| 11. MCC | for common B | - | 1 |
| 12. Central control panel | Desk type | - | 1 |
| 13. Printer desk | | - | 1 |
| 14. Uninterrupting power supply unit (ups) | 5KVA, 220V, 1Ph | - | 1 |
| 15. Emergency diesel generator set | 100KVA, 380/220V, 3Ph, 4W 1500 rpm, 50Hz | - | 1 |
| 16. Generator control panel | | - | 1 |
| 17. Power change-over switch panel | | - | 1 |

**(3) Main Pump Unit Operation**

(a) Location of the operation

The main pump units shall be operable from the following positions:

(i) Main Pump Unit Control Panel – Located in beside the auxiliary substation

(ii) Central Control Panel (desk type) – Located in the Control room of the No. 7 Pumping Station.

(b) Operation Mode

(i) Manual (Individual) operation mode

In this method, the main pumps and the auxiliary machines (such as the discharge valves and related equipment) shall be operated individually by an operator.

(ii) Linking Operation (One-man Control)

In this method, operator controls only start or stop switches for the main pumps and all auxiliary machines (such as the discharge valves and related equipment) will be operated by the sequence control system linked to the start or stop switches.

The outline of the main pump operation procedure is shown in Chapter 5, Clause 5.3.6.