# CHAPTER 5 ROUGH ESTIMATION OF CONSTRUCTION COST

## 5.1 Summary

Construction of AFL system the mainly consists of installation of electrical equipments that are manufactured by stipulated specifications. So, estimation of AFL construction cost can be carried out using manufacturer's estimate after specication of the electrical equipments are finalized to some extend, which has different characteristic from estimation of civil construction cost. Since detail design and specification are not completed, accurate estimation as required for Japan Grant is quite difficult at this time. Thus, we estimate the construction for 1997 tender base cost referring similar some projects in past time.

We wish estimate the cost more accurate in final report, because the specifications will be finalized in this time and we can collect many estimates from manufacturers. If delivery time and specification can comply with the requirements of this project, materials and equipment on the local markets will be applied as much as possible. Some kind of lights, 10 kV and low voltage switchgears; transformer and construction materials including some kind of cable will be available from the local markets.

## 5.2 Rough Estimation Project Cost

Cost estimation of AFL system except the AFL-substation is about 13.067 billion yen and the items of cost as below.

| Item | Cost (Million Yen) |
|---|---|
| 1. Direct construction cost | 8,767 |
| 2. In-direct construction cost | 2,032 |
| Total Cost (Construction Cost) | 10,799 |
| 3. Design and Supervision fee | 1,080 |
| 4. Contingency | 1,188 |
| Grand Total (Project cost) | 13,067 |

Imported materials and equipments deem as duty free and other expenses than the direct construction cost are applied to followings.

In-Direct cost:

- Temporary works cost : 3.16% of the direct construction cost from Japanese Construction Works Guide
- Works at site cost : 10% of the direct construction cost is applied from our experience (In general, it is applied among 10 ~ 20%)
- General management cost : 10% of direct construction cost is applied from Japanese Grant guide-line (JICA).

Design and Supervision fee is 10% of the total cost and contingency is 10% of the project cost (the construction cost plus the design and supervision fee) is applied. Total project cost including the AFL substation is 13.358 billion yen.

## 5.3 Project Implementation

This project will be implemented under OECF loan, and an independent tender of AFL system will be carried out. Construction schedule of this AFL system is closely connected to civil works, pavement works, terminal building, thus coordination work shall be necessary.

Procurement by international competitive bit (tender) is confirmed with Chinese experts. We strongly recommend Chinese experts to apply a turn-key contract due to the AFL system is essential facility, consistence of design and installation, and observance of construction schedule are required. It is found that following four (4) companies which are authorized as first class by China Airport Construction Corporation (CACC) only can engage in construction works for airports in China.

- SICHUAN Installation Corporation
- GUANDONG Installation Corporation
- NEIMENGGU Installation Corporation
- BEIJING Air Force

## 5.4 Estimate of Construction Cost in China

In China, owner achieved the estimation of construction cost for airport construction work using "Estimation of Construction Cost Standards" issued by the CAAC. It is a complex construction cost covering from man-power, material fee and machine-use fee that is similar to Japanese one. Nevertheless adopted price cost is old 1993 year base and each construction costs (man-power, material and machine-use fee) shall be adjusted to construction site condition, which shall be issued by Shanghai City Construction Department. We have requested China to submit those data. Furthermore, following difference and subjects are discovered comparing with Japanese construction standards

(Ministry of Transport and Ministry of Construction).

(1) Common labour fee is only applied.

In Japan, an electro-technican and a surveying engineer, etc. are applied.

In China, average data (3 degree) of common labour only adopted, in final stage this cost will be adjusted to site accordingly but adjustment data of Shanghai City are not available yet.

(2) Estimated working day in China standard is short.

(3) Performance and efficiency of machine in China standard is inferior to Japanese one. Cost for operator in China is cheaper than Japan.

(4) No estimation standards for facilities such as a Mechanical and Electrical Work of building in China.

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

SCIENCE AND TECHNOLOGY COMMISSION OF
SHANGHAI MUNICIPAL PEOPLE'S GOVERNMENT,
PEOPLE'S REPUBLIC OF CHINA

# DETAILED DESIGN OF SHANGHAI PUDONG INTERNATIONAL AIRPORT FINAL REPORT

## VOLUME I
## MAIN REPORT

### PART II - 3
### BASID DESIGN OF FUEL SUPPLY SYSTEM

SEPTEMBER 1997

**NIPPON KOEI CO., LTD.**
**NIKKEN SEKKEI LTD.**

# CHAPTER 1 DESIGN SCOPE AND DESIGN SUMMARY

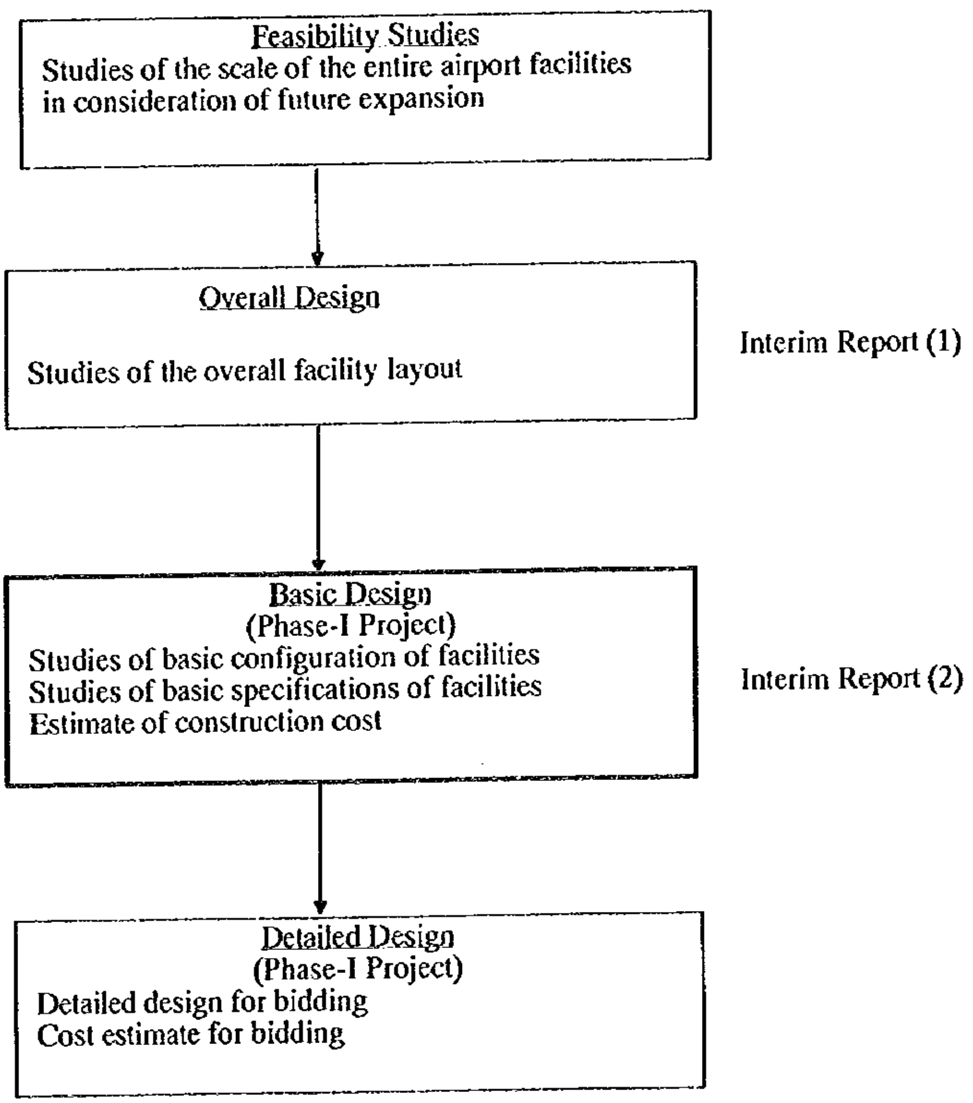
## 1.1 Design Scope

This Report covers the results of basic design of the aircraft fueling facilities, based on detailed design surveys at the Shanghai Pudong International Airport site, which were carried out by the Japanese Survey Mission of JICA.

The aircraft fueling facilities to be designed include the fuel storage facilities to be installed within the site in the Phase-I Project, the hydrant system, and also ancillary facilities required for these fuel storage and hydrant facilities.

Receiving facilities and pipelines for aircraft fuel, in connection with the fuel storage facilities, are outside the basic design scope.

The details of the basic design are identified as follows:



## 1.2 Design Summary

### 1.2.1 Basic Design Policy

The basic design policy of the aircraft fueling facilities for Shanghai Pudong International Airport is as follows:

- Facilities are designed to be of high standard, meeting international codes and standards.
- Foreign advanced technologies are incorporated in the design.
- Future expansion of facilities is taken into consideration.
- The important sections of the facilities are duplicated, thus making them highly reliable.
- The design should be economical and safe.

### 1.2.2 Facilities to be Designed

Basic design was conducted for the following aircraft fueling facilities:

- Fuel receiving facilities:

  The fuel receiving facilities will receive fuel from a transfer system outside the airport, via a pipeline.

- Fuel storage facilities:

  The fuel storage facilities will store fuel.

- Hydrant system:

  The hydrant system consists of hydrant pumps and piping.

- Refueler loading system:

  The refueler loading system will supply fuel to facilities other than the hydrant system.

- Slop facilities:

  The slop facilities will store and transfer slop oil generated by fuel storage tanks.

- Drain facilities:

  The drain facilities will recover sample oil from storage tanks, filters, etc.

- Servicer test system:

  The servicer test system will be used to test servicers.

- Hydrant valve test system:

  The hydrant valve test system will be used to test hydrant valves.

- Fire fighting system:

The fire fighting system includes foam and water fighting systems.

- Electrical system:

    The electrical system will cover all the aforementioned facilities.

- Instrumentation/control system

    The instrumentation/control system will cover all the aforementioned facilities.

- Water supply system:

    The water supply system will supply water within the aircraft fueling facilities.

- Oily water drainage system:

    The oily water drainage system will treat oily water produced in the aircraft fueling facilities.

# CHAPTER 2 DESIGN CONDITIONS

## 2.1 Design Target Year

Phase-1 Project:2005

## 2.2 Applicable Laws/Regulations and Standards

<China>

- Chinese National Code
- Chinese Industrial Standards

<Countries other than China>

- API (American Petroleum Institute)
- ASTEM (American Society for Testing and Materials)
- ANSI (American National Standards Institute)
- NFPA (National Fire Protection Association, USA)
- IEC (International Electrochemical Commission)
- JIS (Japanese Industrial Standards)
- Fire Service Law, Japan

## 2.3 Fuel Conditions

(1) Standard : Chinese standard GB 6537-86

(2) Fuel name : RP3

(3) Density (20°C): 0.775 - 0.83 g/cm$^3$ (design value; 0.78)

(4) Flash point : 38°C or higher

(5) Kinetic viscosity (20°C) : 1.25 mm$^2$/s

(6) Kinetic viscosity (-20°C) : 8 mm$^2$/s (design value:4mm$^2$/s)

(7) Electric conductivity : 50-350 Ps/m

(8) Vapor pressure: 0.0007 MPa

## 2.4 Climatic Conditions

(The values given in the final Report on Basic Design of Shanghai Pudong International Airport are referred to.)

Source: Observation records of the Shanghai Chuan Sha Observatory

(1) Wind velocity : Max. 33.1 m/s (maximum value between 1915 and 1990)

(2) Atmospheric temperature

- Average temperature: 15.5℃
- .Highest temperature: 38.0℃
- .Lowest temperature : -9.6℃

(3) Rainfall

- Yearly average rainfall : 1109.4 mm
- Number of yearly average rainfall days : 130.9 days

(4) Snowfall

- Max. snow depth : 15 cm
- Number of 5-cm or higher depth snowfall days : 5 days (1977 record)

(5) Earthquake

- Basic seismic intensity : 7 (on Chinese seismic scale)
  5 (on Japanese seismic scale)

(6) Lightning

- Number of yearly average lightning days: 29.1 days

## 2.5 Soil Conditions

Soil conditions as described in "Soil Data" prepared separately.

## 2.6 Fuel Receiving Flow Rate

Maximum flow rate : 360 $m^3/h$

## 2.7 Fuel Storage Capacity

Eight 10,000 $m^3$-capacity tanks will be installed. The total fuel storage capacity will be 80,000$m^3$.

## 2.8 Hydrant Discharge Flow Rate

The discharge flow rate of the hydrant two-piping system was set at max. 2,000 $m^3/h$.

## 2.9 Refueler Loading Rate

The loading rate of the refueler loading system to be installed within the fuel supply depot was set at 80 $m^3/h$.

## 2.10 Power Receiving Conditions

- Receiving point : Electric room within the fuel storage depot
- Receiving voltage : 3-phase 10 kV and 3-phase 400 V
- Receiving line : Two lines

## 2.11 Water Receiving Conditions

The line will be branched from the main city water line buried under the trunk road north of the fuel farm. The bore diameter of the line was set at Dg100. Pressure at the branch point was set at 0.2 MPa as the minimum requirement.

## 2.12 Oily Water Discharge Criteria

According to Chinese criteria, discharge of fuel oil in water should be 10 ppm or under.

# CHAPTER 3 FUEL RECEIVING/STORAGE FACILITIES

## 3.1 Basic Layout of Fuel Storage Depot

### 3.1.1 Basic Concept of General Plot Plan for Fuel Storage Depot

The principles of layout of the fuel storage depot are as follows:

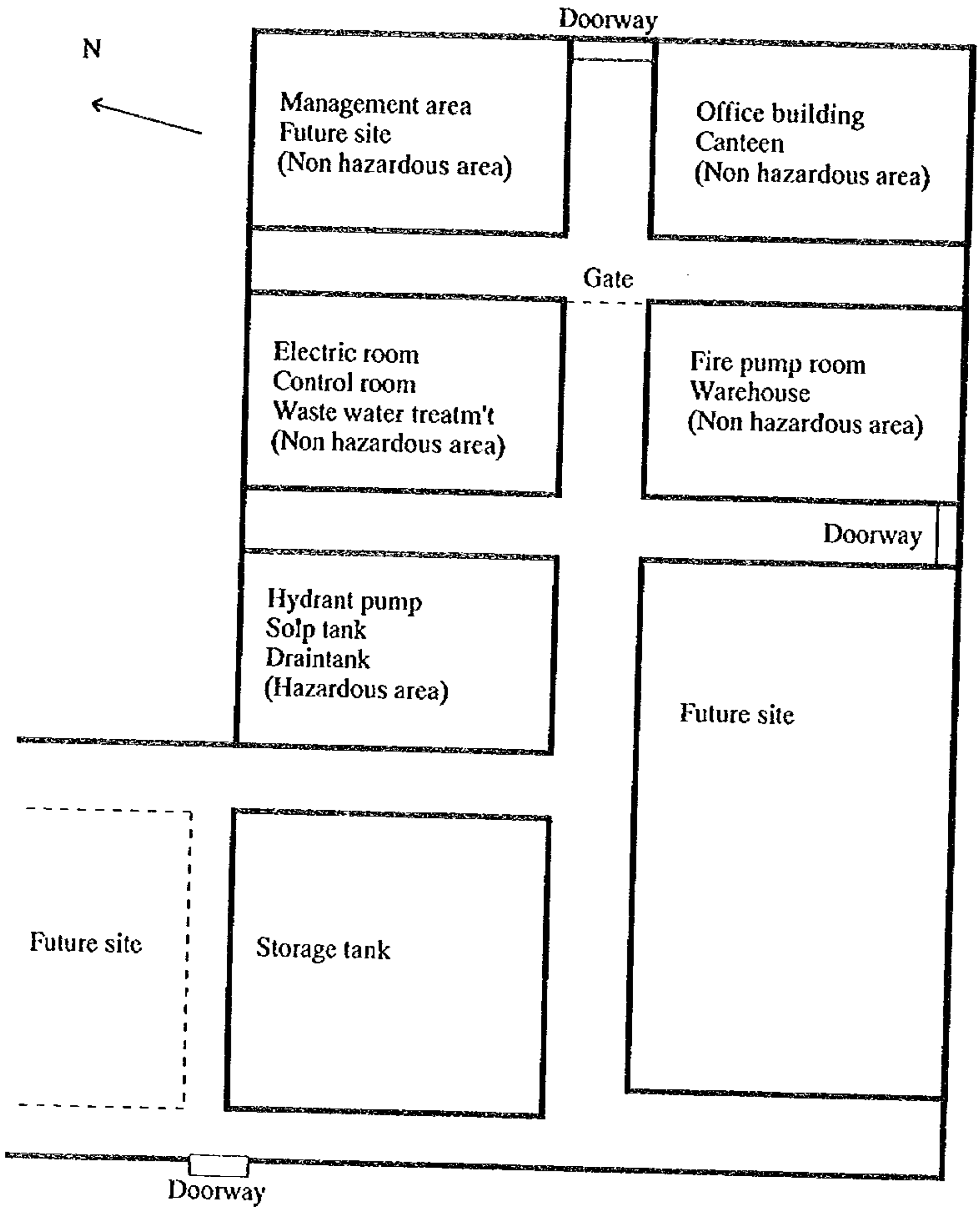
The zones where hazardous materials will be stored and handled, will be separated from other zones.

The zones where hazardous materials will be stored and handled will be enclosed by dikes.

The management zone and the fuel storage zone will be separated by a security fence.

The layout of each facility in the fuel storage depot is as shown in FigureII3-3.1.1 "Fuel Storage Depot General Plot Plan".

**FigureII3-3.1.1 Fuel Storage Depot General Plot Plan**



## 3.2 Fuel Receiving Facilities

The facilities receiving fuel from outside areas via the pipeline will be installed next to the discharge pump within the fuel storage depot. One receiving filter will be installed to remove foreign matters transported by piping, and then one filter separator will be installed to remove foreign matters and free water.

The specifications of the receiving filter are as follows:

| | | |
|---|---|---|
| Design flow rate | : | 360 m3/h |
| Design pressure | : | 1 MPa |
| Material | : | Steel |
| Screen material | : | Stainless steel (200 mesh) |

The specifications of the filter separator are as follows:

| | | |
|---|---|---|
| Design flow rate | : | 360 m3/h |
| Performance | : | According to API 1581 Group II Class B |
| Material | : | Steel |
| Accessories | : | Air eliminator<br>Differential pressure gauge<br>Safety valve<br>Water level indicator<br>Water slug control valve (with flow limiters)<br>Automatic water drain valve |

## 3.3 Fuel Storage Facilities

### 3.3.1 Capacity and Number of Tanks

Eight 10,000 $m^3$ storage capacity tanks will be installed based on feasibility studies in the Phase-1 Project.

### 3.3.2 Tank Layout

Tanks will be laid out according to the Chinese plan. Four tanks will basically be laid out in two rows (a total of eight tanks) in one zone. A future tank expansion area will be provided north of the Phase-1 Project tank area (refer to Fig.II3-3.1.1 "Fuel Storage Depot General Plot Plan").

### 3.3.3 Storage Tanks

The Chinese standards GBJ74 and SH3046, international standard API650, and Japanese standard JISB8501 will be adopted for the design and fabrication of tanks. Vertical and cylindrical tanks, which are of steel dome roof type, will be installed. These tanks are a very general type and do not require columns inside the tanks. A tank has diameter of, 21.282 m and a heights of 14 m.

# CHAPTER 4 HYDRANT SYSTEM

## 4.1 Hydrant Fuel Supply Scope

The aircraft parking spots where fuel will be supplied by the hydrant system include 28 passenger terminal spots, 8 cargo spots, and 11 open spots (a total of 47 spots). The refueler system will supply fuel to other spots.

## 4.2 Hydrant Pumps

Hydrant pumps will be installed to refuel aircraft. Ten large-capacity pump units and two small-capacity pump units will be provided in combination. These pumps will be manufactured by internationally experienced manufacturers, based on API610.

The specifications of the hydrant pumps are as follows:

| | | |
|---|---|---|
| Pump type | : | Centrifugal pump |
| Material | : | Cast steel |
| Flow rate | : | 200 $m^3/h$ |
| Pressure | : | 1.0 MPa |
| Motor capacity | : | 110 kW |

The specifications of the pressure pumps are as follows:

| | | |
|---|---|---|
| Pump type | : | Centrifugal pump |
| Material | : | Cast steel |
| Flow rate | : | 50 $m^3/h$ |
| Pressure | : | 1.0 MPa |
| Motor capacity | : | 30 kW |

The system to control the pumps will be adopted to automatically increase/reduce the number of pumps in operation, in proportion to the number of aircraft to be refueled.

## 4.3 Filter Separator

One filter separator will be installed for each pump (a total of 10 sets).

The specifications of the filter separators are as follows:

| | | |
|---|---|---|
| Design flow rate | : | 50 $m^3/h$ |
| Material | : | Steel (the inside surface is epoxy-painted) |
| Performance | : | According to API 1581 Group II Class B |

| | | |
|---|---|---|
| Accessories | : | Air eliminator<br>Differential pressure gauge<br>Safety valve<br>Water level indicator<br>Water slug control valve (with flow limiters)<br>Automatic water drain valve |

### 4.4 Hydrant Pits

Two hydrant pits will be provided for each aircraft. They will be located underground near the refueling port of aircraft in the aircraft parking spot on the apron. The covers of the hydrant pits will be made of aluminum alloy. These pits will be water-sealed to prevent underground water from entering the pits.

### 4.5 Hydrant Valves

Hydrant valves, which are widely used and can be manufactured by an internationally experienced manufacturer, will be installed inside the pits. The design flow rate of these valves will be equivalent to 1,000 gpm.

### 4.6 Piping System

A loop hydrant piping system will be adopted. Buried piping will be sloped. The buried depth of the hydrant piping will be 1.2 m or more under the apron, 1.5 m or more under paved roads, and 1.0 m or more under unpaved roads. Two ports will be installed for future expansion of the hydrant piping, in consideration of expansion of the future passenger terminal.

### 4.7 Bore Diameter of Hydrant Piping

Two main hydrant pipelines will be installed. The bore diameter of each pipeline was set at Dg600, in consideration of a maximum flow rate of 1,000 $m^3$ per pipeline. The bore diameter of the branch line was established at Dg300.

### 4.8 Piping Material

Steel pipes, which conform to ASTM Gr. B or SY5036 Q235, will be used as the hydrant piping material. The inside surface of the piping will be epoxy-painted, and the outside surface will be coated with polyethylene resin or equivalent corrosion-proof substances.

## 4.9 Header Pit and Valve Box

One header pit or valve box will be provided in the aircraft parking spots 4 - 6 in order to install branch and shutoff valves of the embedded pipelines.

## 4.10 Emergency Shutdown Buttons

Emergency shutdown buttons will be provided at adequate points on the apron and within the hydrant system.

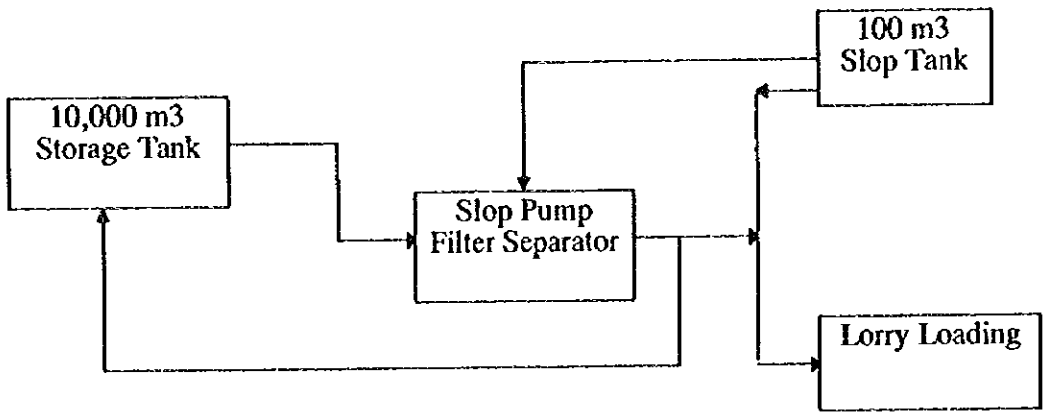
# CHAPTER 5 ANCILLARY FACILITIES

## 5.1 Slop Facilities

### 5.1.1 Summary

Slop facilities will be installed to recover slop produced from the 10,000 $m^3$ tanks. These facilities consist of two slop tanks, two shift pumps, two filter separators, and connecting piping.

The slop transfer schematic flow diagram is shown below:




### 5.1.2 Slop Tanks

Two 100 $m^3$ CRT tanks will be installed to recover slop.

### 5.1.3 Slop Shift Pumps

Two centrifugal slop shift pumps will be installed and operated simultaneously. The capacity of one pump is 60 $m^3/h$, the total pressure is 0.5 MPa, and motor's capacity is 22 kW.

## 5.2 Drainage Facilities

### 5.2.1 Summary

One drain will be installed in each fuel storage depot and each fuel supply depot (a total of two drains), in order to sample fuel, and also to recover the small amount of fuel emitted from safety valves.

### 5.2.2 Drain Drums

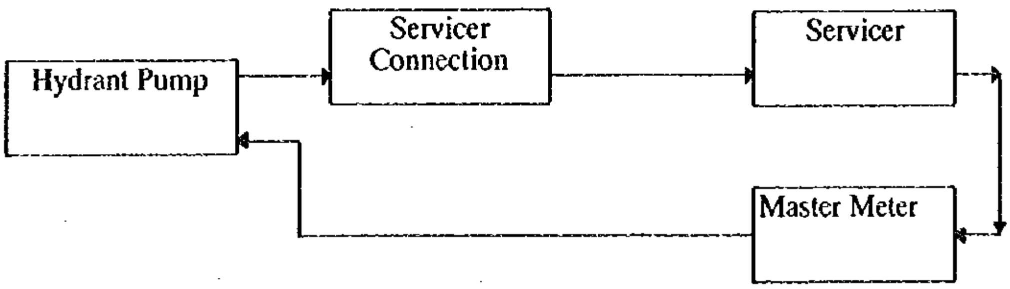
Drain drums will be of underground, horizontal cylindrical type, made of steel. The 20 $m^3$ drum has an in inside diameter of 2.2 m and a length, of 3.6 m, and the 5 $m^3$ drum has an inside diameter of 1.3 m, and a length of 2.2 m.

## 5.3 Refueler Loading System

A loading system will be installed to load fuel into two refuelers simultaneously within the fuel supply depot. The loading capacity of one train system is 80 $m^3/h$, and two train systems will be installed.

## 5.4 Servicer Test System

The servicer test system will be installed to periodically check the performance of the servicer and also the accuracy of the master meter. One train system will be installed, and the maximum test flow rate is 227 $m^3/h$. The system will be as follows:




## 5.5 Hydrant Valve Test System

The hydrant valve test system will be installed to check the operation of hydrant valves and leakage from these valves.

# CHAPTER 6 FIRE FIGHTING AND WATER SUPPLY/DRAINAGE SYSTEMS

## 6.1 Fire Fighting System

### 6.1.1 Summary

A fluorinated protein-foam fire fighting system whose application effects have been confirmed, will be adopted, because this system conforms to the Chinese laws and regulation and has been widely used internationally. Also, a tank drencher system will be installed to prevent a storage tank fire from spreading, and a water fire fighting system will also be installed to fight fires which other facilities may suffer. The fire fighting system will be started up and shut down from the central fire fighting control panel at the operator's discretion, after he/she confirms an alarm issued by a fire detector and the conditions of the fire. This fire fighting system control panel will be used to operate and control the foam fire fighting system, tank drencher system, and water fire fighting system.

### 6.1.2 Foam Fire Fighting System

A bottom foam injection system will be adopted as a fixed foam fire fighting system for tanks. Four 1,600 l/min. foam discharge points will be provided according to the Chinese standard. In addition, foam fire fighting hydrants will be installed around the periphery of the dike. Tanks for the release of foam will be selected on the fire fighting control panel. Three 330 $m^3$/h-capacity foam fire fighting pumps will be installed; one pump will be used as a standby.

### 6.1.3 Water Fire Fighting System

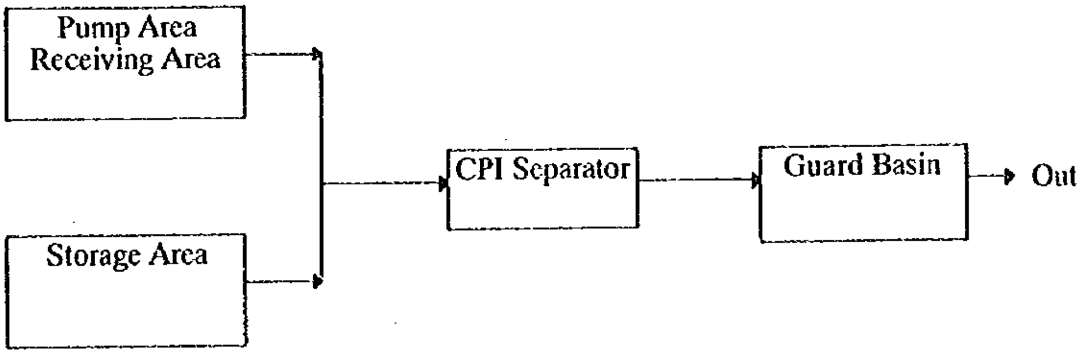
Against the case where a tank may suffer fire, a tank drencher system will be installed to prevent fire from spreading to other tanks around this tank. Three 290 $m^3$/h-capacity water fire fighting pumps will be installed; one pump will be used as a standby.

## 6.2 Water Supply System

The water supply system will supply water for the fueling facilities. The facilities requiring water in the fuel storage depot are the office building, canteen, fire water tanks, fire pump room, fuel pump room, waste water treatment system, and greenbelt sprinkler system.

## 6.3 Oily Water Drainage System

The oily water drainage system will collect oily waste water produced in the fuel storage depot for treatment, and discharge this water outside the depot according to the environmental criteria. The basic waste water treatment flow is as follows:



# CHAPTER 7 ELECTRICAL AND INSTRUMENTATION SYSTEMS

## 7.1 Electrical System

### 7.1.1 Power Receiving/Distribution System

A power source of 10,000V, 3 phase, 50 hz will be supplied from the airport power grid thorough two independent lines for the purpose of keeping highest reliability. The said power will then be transformed to service voltage (400 V,3-phase, 50 hz) and distributed to users by a distribution panel. The transformer capacity is 1,500KVA x two sets. The motor control panel will be of an independent control type. The distributed control system (DCS) will be adopted for the operation and monitoring of motors. Power for the DCS will be supplied by the UPS. An outdoor cabling system to fuel hydrant pumps, etc. will be of direct buried type using armored cables. The cabling system in the sections crossing the roads will be of a duct bank type, for cable protection and expansion.

### 7.1.2 Lightning Protection System

A lightning protection system will be installed to protect the fuel storage depot against damage (fire) due to thunderbolts.

### 7.1.3 Lighting System

A lighting system will be installed to ensure safety during night operation and maintenance in the fuel storage depot.

The illumination in each area will be as follows, according to the Chinese illumination criteria:

| | | | |
|---|---|---|---|
| Tank area | : | 30 | lux |
| Pump yard | : | 100 | lux |
| Roads | : | 30 | lux |

### 7.1.4 Cathodic Protection System

A cathodic protection system will be provided for the hydrant piping to protect is against electrolytic corrosion. A galvanic anode system using magnesium anodes will be used. The design life of the magnesium anodes will be 20 years.

### 7.1.5 ITV Monitoring System

Four TV cameras will be installed in the storage tank yard, pump yard and at the gate, along with one ITV monitor in the control room, in order to ensure security in these areas:

- Number of TV cameras : Two sets in the storage tank yard
  One set in the pump yard
  One set at the gate
- Number of ITV monitors : One set

## 7.2 Instrumentation System

### 7.2.1 Control System

A DCS will be adopted as a control system, and will comprise a control panel, PLC, operator's console, and data printer. This DCS will control the number of pumps, fuel minimum flow, emergency shutdown, and monitor the fuel flow rate, pressure, and temperature.

The DCS will basically transmit optical signals using glass fiber cables.

### 7.2.2 Fuel Storage Tank Level Monitoring System

Highly reliable displacement type level indicators or float type level detectors will be provided to measure the fuel levels in fuel tanks.

A CRT monitor will be installed in the office building to monitor the tank levels. The signals of tank levels will be transmitted to the master station via optical fiber cables.

### 7.2.3 Flight Information

A airport flight information will be input into the computerized system in the control room, for use for the start/stop of refueling during each flight service day.

# CHAPTER 8 CIVIL AND ARCHITECTURAL FACILITIES

## 8.1 Civil Facilities

Tank foundations will be designed based on the Chinese standard, with reference to the Fire Service Law of Japan. Civil designs other than for tanks will be implemented in the detailed design.

## 8.2 Architectural Facilities

Architectural designs will be carried out in the detailed design based on the information prepared in the basic design. The architectural facilities will be the following:

<Fuel storage depot>

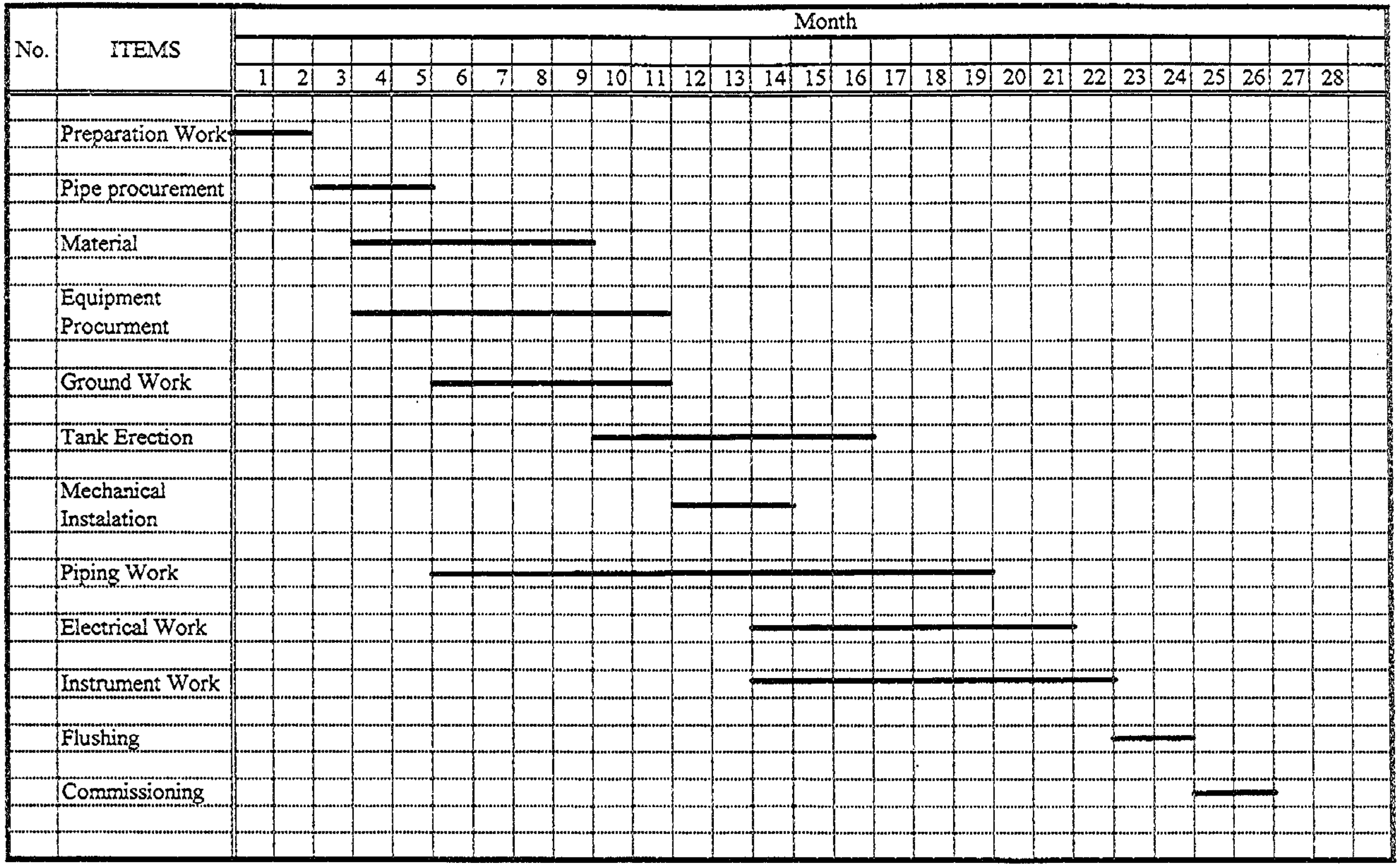
- Office building
- Canteen
- Gate-house
- Fire pump room
- Electrical room
- Workshop
- Warehouse
- Laboratory
- Fuel pump room
- Hazardous material warehouse

<Fuel supply depot>

- Office building
- Motor vehicle service shop
- Refueler, servicer warehouse
- Refueler loading shed
- Hydrant valve testing shed

# CHAPTER 9 CONSTRUCTION SCHEDULE AND ROUGH ESTIMATE OF CONSTRUCTION COST

# CONSTRUCTION SCHEDULE



## SHANGHAI PUDONG INTERNATIONAL AIRPORT

US$1 = 8.31 RMB

| No. Item | Description | Unit | Quantity | Foreign Cost Component US$ | | Local Cost Component RMB | | Combined Cost RMB | | Remarks (Yen) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Rate | Amount | Rate | Amount | Rate | Amount | |
| | **FUEL SUPPLY SYSTEM** | | | | | | | | | |
| | DIVISION 1-MAIN EQUIPMENT | | | | 8,122,000 | | 47,048,000 | | 114,541,820 | 1,603,585,480 |
| | DIVISION 2-PIPING | | | | 4,557,310 | | 91,545,000 | | 129,416,250 | 1,811,827,500 |
| | DIVISION 3-ELECTRICAL | | | | 2,723,000 | | 6,661,874 | | 29,290,004 | 410,060,056 |
| | DIVISION 4-INSTRUMENT | | | | 4,382,000 | | 5,465,000 | | 41,879,420 | 586,311,880 |
| | DIVISION 5-CIVIL | | | | | | 32,000,000 | | 32,000,000 | 448,000,000 |
| | DIVISION 6-BUILDING | | | | | | 7,200,000 | | 7,200,000 | 100,800,000 |
| | DIVISION 7-VEHICLES | | | | 5,050,000 | | 9,600,000 | | 51,565,500 | 721,917,000 |
| | Total cost | | | | 24,834,310 | | 199,519,874 | | 405,892,994 | 5,682,501,916 |
| | Indirect Cost (Div.1-6 :40%) | | | | 7,913,724 | | 75,967,950 | | 141,730,998 | 1,984,233,972 |
| | Grand total | | | | 32,748,034 | | 275,487,824 | | 547,623,992 | 7,666,735,888 |

FUEL SUPPLY SYSTEM

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

SCIENCE AND TECHNOLOGY COMMISSION OF
SHANGHAI MUNICIPAL PEOPLE'S GOVERNMENT,
PEOPLE'S REPUBLIC OF CHINA

# DETAILED DESIGN
# OF
# SHANGHAI PUDONG INTERNATIONAL
# AIRPORT
# FINAL REPORT

## VOLUME I
## MAIN REPORT

### PART II - 4
### BASID DESIGN
### OF
### FIRE FIGHTING AND RESCUE FACILITIES

SEPTEMBER 1997

**NIPPON KOEI CO., LTD.**
**NIKKEN SEKKEI LTD.**

# CHPTER 1 FIRE DEFENCE AND RESCUE PLAN

## 1.1 Basic Policy

### 1.1.1 Basic Guidelines on Fire-Defence and Rescue System

(1) Policy of the plan

The system of fire defence and rescue in China is different from that in Japan in the following points.

・The main work of the airport fire defence is fire fighting at runways, but it also covers all the buildings within the airport perimeter. For this purpose the Main Fire Station holds a facility for night-duty to manage 24-hour operation system, a tower for training on building fire fighting, and a training site.

・An emergency centre deals with the first aid for aircraft accidents in the airport and also provides medical day-care to the airport staff. It deals with the medical demands of many thousands of the airport staff and the demands of insurance businesses.

This administrative operating system for airports is based on the regulations of both ICAO and the General Administration of Civil Aviation of China.

・As to Shanghai Pudong International Airport, it should to conform to the standards of China. Also, considering from the present circumstances and the development process, it is supposed to take time before a hospital and fire stations are operating around the airport. Therefore, the project is to be based on the policy of the plan in the feasibility study by the China side.

(2) Organization system

At present, the fire defence organization of Shanghai Hongqiao International Airport is administered by the Public Peace Department of Shanghai City and the emergency centre by Hongqiao International Airport Authorities. As to Shanghai Pudong International Airport, the fire defence and emergency centre will be jointly administered by the Airport Authorities as one organization.

### 1.1.2 Categories of ICAO

From the forecast frequency of take offs and landings of large aircraft in the year 2005, the plan will be focused on Category 9 of ICAO. As to Category 10 which deals with future large aircraft, ICAO is supposed to establish new standards now, consequently, these alterations will be taken into consideration in the plan.

### 1.1.3 Design Standard

The plan shall conform to the standards of ICAO and domestic standards of China. The main standards are:

| | |
|---|---|
| ICAO-ANNEX14 | Annex 14, International Civil Aviation Treaty of International Civil Aviation Organization |
| MH7002-94 | Standard of equipment in the fire-fighting station of Civil Aviation Transportation Airport |
| MH7003-95 | Construction standards of security and protection installation of Civil Aviation Transportation Airport |
| GBJ16-87 | Fire defence code for architectural design of the People's Republic of China |

## 1.2 Facility Layout Plan

### 1.2.1 Fire Station

Based on the layout plan of the whole airport, the layout plan of fire station shall be made to satisfy the recommendation by ICAO, that is, response should be made within 3 minutes or, if possible, 2 minutes.

For the layout, the adjustment between Phase 1 plan and the whole plan should be taken into consideration. In the Phase 1 plan, the site for that phase should be kept as small as possible to make efficient land use.

About the location of the Main Fire Station, it is to be near to the apron side of the Administration Zone in order to deal with the fire defence of the area including the buildings inside the airport. Sub fire stations shall be laid out about the centre of each runway to shorten the arriving time. The study on facility layout and response time is shown in FigureII4-1.2.1. Two facilities are required under the Phase 1 Plan ,namely the Main Fire Station and a sub station to deal with the Phase 1 runway on the west side.

### 1.2.2 Emergency Centre

The first aid centre will be laid out in the Administrative Zone next to the Main Fire Station, because it deals with medical treatment of the airport staff as well as aircraft accidents.

## 1.3 Plans of Staff Arrangement and Facility Scale

### 1.3.1 Fire Fighting Facilities

(1) Staff arrangement

Staff will be arranged in three shifts for 24 hours and the number of personnel will be planned in accordance with the arrangement of fire-fighting vehicles. The fixed number of regular staffs for fire engines is 50, based on the regulation of "Standard of equipment in the fire fighting station of Civil Aviation Transportation Airport (MH9002-94)". Among them, 39 are for the Main Fire Station and 11 for substations (for details, refer to 2.1 Fire Fighting Vehicles Arrangement Plan). According to the feasibility study made by China, the number of administrative staffs, engineers, and supporters is fixed at 20% of the fire fighting staff, so, the total staff arrangement is set as shown in TableII4-1.3.1.

**TableII4-1.3.1 Number of Fire Defence Staffs**

| | Main station | Substation | Total |
|---|---|---|---|
| Fire fighting staff | 117 | 33 | 150 |
| Administrative staff | 24 | 6 | 30 |
| Total | 141 | 39 | 180 |

(2) Facility scale

The scales of facilities are decided by the standard of building area for fire stations, which is based on "Standard of equipment in the fire fighting station of Civil Aviation Transportation Airport (MH9002-94)". The design standard figures of the Main Fire Station and substations are indicated in TableII4-1.3.2 and TableII4-1.3.3.

### TableII4-1.3.2 Design Standards of the Main Fire Station

| No | Facilities | Number of facilities | Area per facility ($m^2$) | Gross floor area ($m^2$) | Note |
|---|---|---|---|---|---|
| 1 | Garage | 13 | 90 | 1170 | extra space for 1 car, 90m |
| 2 | Chemical feeding warehouse | 1 | 120 | 120 | |
| 3 | Night-duty staff room | 1 | 40 | 40 | |
| 4 | Class room<br>Conference room | 1 | 150 | 150 | |
| 5 | Library | 1 | 40 | 40 | |
| 6 | Reception room | 1 | 50 | 50 | |
| 7 | Office & lodging for executives | 10 | 28 | 280 | 14m²/person |
| 8 | Lodging for firemen | 21 | 42 | 882 | 7m²/person |
| 9 | Battery charger room | 1 | 15 | 15 | |
| 10 | Maintenance room | 1 | 30 | 30 | |
| 11 | Dry room | 1 | 40 | 40 | |
| 12 | Cleaning room | 1 | 20 | 20 | |
| 13 | Bedding & clothing | 1 | 30 | 30 | |
| 14 | Bath room, changing room | 1 | 80 | 80 | |
| 15 | Training room | 1 | 80 | 80 | |
| 16 | Mechanical equipment | 1 | 80 | 80 | |
| 17 | Instrument store room | 1 | 30 | 30 | |
| 18 | Kitchen | 1 | 120 | 120 | |
| 19 | Dining room | 1 | 150 | 150 | |
| 20 | Warehouse<br>Lodging for cooks | 2 | 60 | 120 | |
| 21 | Hot water supply room | 2 | 10 | 20 | |
| 22 | Lavatory | 2 | 45 | 90 | |
| | Total | | | 3637 | Rounded to 3600 m² |

### TableII4-1.3.3 Design Standards of Sub Fire Station

| No | Facilities | Number of facilities | Area per facility ($m^2$) | Gross floor area ($m^2$) | Note |
|---|---|---|---|---|---|
| 1 | Garage | 3 | 90 | 270 | |
| 2 | Extra space for garage | 1 | 90 | 90 | |
| 3 | Chemical feeding | 1 | 40 | 40 | |
| | Preservation room | 1 | | | |
| 4 | Night-duty staff room | 3 | 20 | 20 | |
| 5 | Office & lodging for executives | 6 | 28 | 84 | 14 $m^2$/person |
| 6 | Lodging for firemen | 1 | 42 | 252 | 7 $m^2$/person |
| 7 | Battery charger room | 1 | 15 | 15 | |
| 8 | Maintenance room | 1 | 15 | 15 | |
| 9 | Dry room | 1 | 15 | 15 | |
| 10 | Cleaning room | 1 | 10 | 10 | |
| 11 | Bedding & clothing | 1 | 15 | 15 | |
| 12 | Bath room, changing room | 1 | 20 | 20 | |
| 13 | Training room | 1 | 40 | 40 | |
| 14 | Mechanical equipment | 1 | 25 | 25 | |
| 15 | Instrument storeroom | 1 | 10 | 10 | |
| 16 | Hot water supply room | 1 | 10 | 10 | |
| 17 | Lavatory | 1 | 45 | 45 | |
| | Total | | | 976 | |

(3) Affiliated facilities

The subsidiary facilities based on the feasibility study made by China are as indicated below.

- 4-storey training tower : 1
- Training space : 3,000 $m^2$
  (a runway of 100 m long and 5 m wide is prepared in the training space)
- Outdoor car wash space : for two cars

• Hydrants for training or a water tank for fire fighting use with a capacity of 20 m³.

### 1.3.2 Emergency and First-Aid Facilities

(1) First-aid centre

Emergency and first-aid centres are composed of a facility for first-aid to deal with aircraft accidents, one for day-care of the airport staff at normal time, and another for hygienic services. The emergency centre to deal with unexpected aircraft accidents is planned to be established jointly with the medical centre which also deals with outpatients and other general first aid. The plan should take into consideration that those facilities will be effectively utilized both for the training of rescue/medical activities and for the welfare of the staff. As hygienic service centre and first aid centre compose one-body organization in China, and also they are firmly connected to each other on services, the hygienic centre will be planned to be located in one building jointly with first aid centre. The scale of the facility will be decided according to the feasibility study made by China.

**TableII4-1-3.4 Scale of First-Aid Centre**

| Facilities | Contents of Facility | Area | Note |
|---|---|---|---|
| Facility for treatment and examination (including first aid) | Treatment room for day-care (6 departments)<br>Furst aid treatment room<br>X-ray room<br>Pharmacist's office<br>Office, Conference room<br>Dining room, Kithen<br>Administrative rooms | 2,000 m² | |
| Facility for emergency | Emergency hall<br>Storage space for first-aid equipment | 400 m² | 40% of the number of passengers of the largest aircraft at present (B747-400) |
| | Storage space for first-aid medicine | 100 m² | →Space for about 190 peopel |
| Facility for hygiene | Office (examination room)<br>→ 7 rooms<br>Conference room<br>Sterilizing room | 250 m² | |

(2) Affiliated facilities

The following facilities will be planned as affiliated to the first-aid centre.

- Garage for ambulances for 8 cars 250 $m^2$ (6 ambulances + 1 extra +maintenance space)
- Outdoor emergency training ground 35 m × 45 m

# CHAPTER 2 VEHICLE ARRANGEMENT PLAN

## 2.1 Arrangement Plan of Fire Engines

### 2.1.1 Fire Extinguishing Capability

TableII4-2.1.1 shows the minimum amounts of fire extinguishing water and the ratio of foam solution discharge of chemical fire extinguishing foam, according to ICAO standards.

**TableII4-2.1.1 Minimum Required Amount of Chemical Fire Extinguishing Foam**

| Aircraft Category | Chemical foam corresponding to special A class | | Chemical foam corresponding to special B class | | Supplymentary chemicals | | |
|---|---|---|---|---|---|---|---|
| Category | Water (L) | Discharge ratio of a fom solution (min/L) | Water (L) | Discharge ration of a foam solution (min/L) | Dry chemicals (kg) | or Halon (kg) | or CO2 (kg) |
| ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ | ⑧ |
| 1 | 350 | 350 | 230 | 230 | 45 | 45 | 90 |
| 2 | 1,000 | 800 | 670 | 550 | 90 | 90 | 180 |
| 3 | 1,800 | 1,300 | 1,200 | 900 | 135 | 135 | 270 |
| 4 | 3,600 | 2,600 | 2,400 | 1,800 | 135 | 135 | 270 |
| 5 | 8,100 | 4,500 | 5,400 | 3,000 | 180 | 180 | 360 |
| 6 | 11,800 | 6,000 | 7,900 | 4,000 | 225 | 225 | 450 |
| 7 | 18,200 | 7,900 | 12,100 | 5,300 | 225 | 225 | 450 |
| 8 | 27,300 | 10,800 | 18,200 | 7,200 | 450 | 450 | 900 |
| 9 | 36,400 | 13,500 | 24,300 | 9,000 | 450 | 450 | 900 |
| *10 | 48,200 | 16,600 | 32,300 | 11,200 | 450 | 450 | 900 |

To establish the extinguishing capability, the chemical fire extinguishing foam corresponding to special B class was considered, according to recommendation by ICAO and examples in other airports.

*The figures of Category 10 are subject to change due to the new standard which is being established by ICAO.

### 2.1.2 Arrangement Plan of Vehicles

(1) Number of cars to be arranged

TableII4-2.1.2 shows the arrangement of vehicles of Category 9 according to the Standard of Civil Aviation Transportation Airport MH7002-94. This satisfies the minimum number of fire engines fixed by provisions of ICAO, and is also a standard to keep the required fire extinguishing capability. Therefore, for the vehicle arrangement for this project, we set the number of cars based on Chinese standards.

**TableII4-2.1.2 Arrangement of Fire Engines and Fixed Number of Staffs**

| No | Kinds of vehicles | Number of cars to be arranged | Number of staffs per car | Total number of staffs |
|---|---|---|---|---|
| 1 | High-speed fire engine (import) | 1 | 3 | 3 |
| 2 | Main chemical fire engine (import) | 4 | 3 | 12 |
| 3 | Fire engine for powder extinguisher | 1 | 3 | 3 |
| 4 | Large chemical fire engine | 1 | 6 | 6 |
| 5 | Large water supply car | 2 | 5 | 10 |
| 6 | Chemical foam sprinkler (import) | 1 | 2 | 2 |
| 7 | Lighting car | 1 | 3 | 3 |
| 8 | Communication/Control car | 1 | 2 | 2 |
| 9 | Disaster rescue car (import) | 1 | 5 | 5 |
| 10 | Rear support car | 1 | 2 | 2 |
| 11 | Undiluted foam solution transport car | 1 | 2 | 2 |
| TOTAL | | 15 | | 50 |

(2) Outline specifications of vehicles

The outline specifications of fire fighting vehicles, are established referring to the past records of airports both in China and overseas. Based on the feasibility study made by China, high-speed fire engines, main chemical fire fighting vehicles, fire engines for powder extinguisher and disaster rescue cars are imported and others are locally manufactured. The outline specifications including fire extinguishing capability and external dimensions are determined as described in TableII4-2.1.3 and form the basis for formulation of the Facility Plan. The final decision on selection of fire fighting vehicles will be made by the General Administration of Civil Aviation of China or by the airport authorities of Shanghai City, but the detailed specifications should be decided taking into consideration the adjustment with the Facility Plan.

## TableII4-2.1.3 Outline Specifications of Fire Fighting Vehicles

| Vehicles | Vehicle size (m) | | | Total weight (kg) | Water (l) | Chemi- Emi- fluid (l) (l/min) | | |
|---|---|---|---|---|---|---|---|---|
| | Total length | Total width | Total height | | | | | |
| High-speed fire engine | 9.970 | 2.960 | 3.900 | 33,000 | 5,000 | 600 | 6,000 | |
| Main chemical fire-fighting vehicles (4 cars) | 11.570 | 2.960 | 3.900 | 38,000 | 10,000 | 1,200 | 6,000 | 2 at sub station |
| Fire engine for powder extinguisher | 7.050 | 2.460 | 3.210 | 9,080 | | | | |
| Large chemical fire engine | 7.708 | 2.520 | 3.340 | 15,400 | 4,500 | 1,500 | 50 | |
| Large water supply car (2 cars) | 8.407 | 2.560 | 3.330 | 17,000 | 7,000 | | 60 | 1 at sub station |
| Chemical foam sprinkler | Assumed to be the same size as large chemical fire engine. | | | | | | | |
| Lighting car | 5.380 | 1.920 | 2.700 | 3,195 | | | | |
| Communication/Control car | 4.290 | 1.790 | 2.720 | 2,160 | | | | |
| Disaster rescue car | 5.000 | 2.250 | 3.150 | 7,200 | | | | |
| Rear support car | Assumed to be the same size as large chemical fire engine. | | | | | | | |
| Undiluted foam solution transport car | Assumed to be about the same size as large chemical fire engine. | | | | | | | |

## 2.2 Emergency Vehicles

In the main airports of Japan, the rescue and first-aid activity is to deal with the accidents near the scene with large emergency vehicles for medical works. However, in this project, as an emergency hall is planned in the first-aid centre according to the emergency and first-aid system of China, transporting vehicles for rescue activities will be highly required. Also, in the first-aid centre, the vehicle arrangement has to deal with the emergency medical treatment for the district as well. The number of cars to be arranged based on the feasibility study made by China is indicated in TableII4-2.2.1.

**TableII4-2.2.1 Arrangement of Emergency Vehicles**

| No. | Vehicles | Number of cars | Note |
|---|---|---|---|
| 1 | Ambulance (import) | 2 | A garage is prepared (for 6 cars) |
| 2 | Ambulance (domestic) | 3 | |
| 3 | Emergency control car (import) | 1 | |
| 4 | Middle sized bus | 2 | |
| 5 | Small bus | 10 | |
| TOTAL | | 18 | |

# CHAPTER 3 FACILITY PLAN

## 3.1 Fire Defence Facilities

### 3.1.1 Building Plan

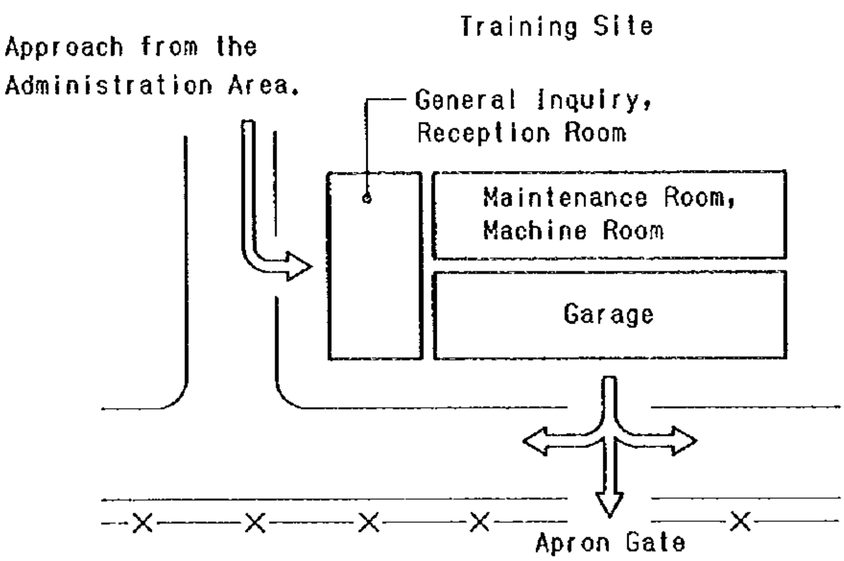
(1) Design policy

Airport fire defence facilities are required to be quick by available and mobile to deal with aircraft accidents. They also deal with fire fighting within the airport perimeter, and require a number of fire fighting staffs according to the organization system of China. Therefore, the design policy is as follows taking into consideration the training and living conditions of firemen.

- Functionality and mobility shall be stressed in the plan.
- The living conditions of firemen shall be considered in the plan.

(2) Building layout plan

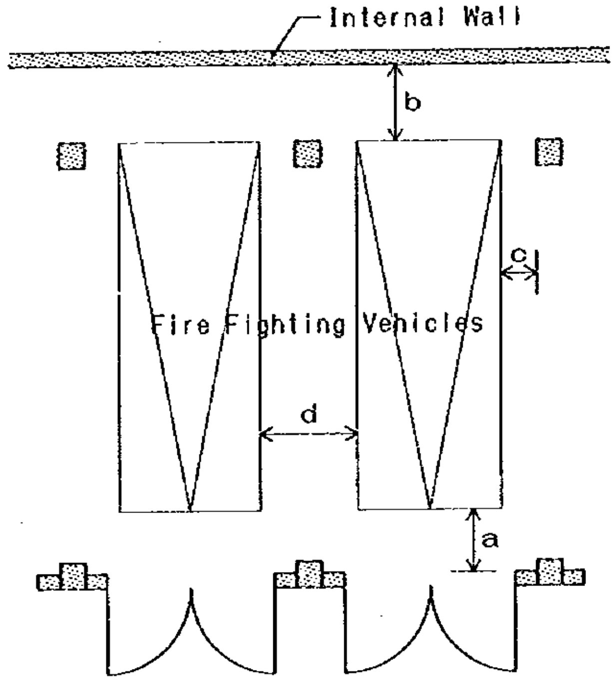
The location of the Main Fire Station in the airport and the layout of buildings relating to the apron are indicated in FigureII4-3.1.1.




**FigureII4-3.1.1. Conceptual Layout of Buildings**

(3) Composition and general layout of facilities

On the first floor, there are a garage for fire engines including an extra space with a maintenance room and a mechanical equipment storage room affiliated to it; a dining room; and a bath room. The lodgings for firemen and executives will be laid out on the second floor above the garage in order to keep functionality at the time of mobilization. Rooms for study and training such as conference rooms and library will be in the Main Fire Station so that they can be contributed to the spare time of firemen. The spans between pillars at the open side are decided by the size of fire engines. Also economy on other structural matters should be taken into consideration. The spaces for fire-fighting vehicles will be as indicated in FigureII4-3.1.2 in accordance with the Chinese standard MH7003-95.




a : Clearance in front of vehicles≧1.0 m

b : Clearance behind vehicles≧2.5 m

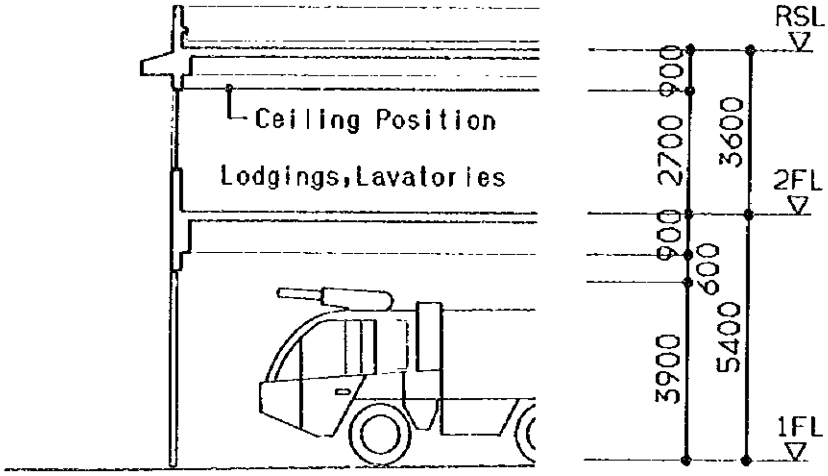
c : Clearance at the side of vehicles≧1.0 m

d : Clearance between vehicles≧2.0 m

**FigureII4-3.1.2 Dimensions of the Space for Fire Engines**

(4) Sectional plan

The floor level and ceiling level of each floor are established as described in FigureII4-3.1.3 taking into consideration the dimensions of fire engines and the living conditions of the rooms.




**FigureII4-3.1.3 Establishment of Floor Levels**

(5) Interior/exterior finish plan

Taking into consideration the domestic materials and construction methods in China and the past records of other airports, the main interior/exterior finishes will be as follows.

Exterior General external walls : porcelain tile, partially architectural concrete finishing

General windows : aluminum sash (partially sound proof sash with double glazing)

Furnishings of garage: steel hinged door

Interior Floor: Garage, machinery room, warehouse, etc. : concrete covering with hardner on surface

Lodging, conference room, etc. : covered with marble

Wall: mortar trowel finishing

Ceiling: plaster board painting finishing (rooms with air conditioning, lavatories and bath rooms)

concrete direct ceiling, painting finishing

### 3.1.2 Structural Design

(1) Design Standards

The design standards are in accordance with the codes of the People's Republic of China and Shanghai City as follows.

| | |
|---|---|
| GBJ 7-89 | The People's Republic of China standard foundation design code |
| JGJ 3-91 | The People's Republic of China standard design code for reinforced concretetall buildings |
| DBJ 08-11-89 | Shanghai standard foundation design code |
| DBJ 08-31-91 | Shanghai tube structure design code for reinforced concrete tall buildings |
| DBJ 08-9-92 | Shanghai aseismic design code for buildings |

(2) Design guidances

1) Foundation work

• In the construction site, poor subsoil in the former water channel is to be replaced by sands and roller-compacted.

• The foundation is strip footing system. If soil bearing capacity is estimated insufficient to support the building according to the result of site investigation, pile foundation system could be used together.

• Distribution of the vertical loads is to be equalized as much as possible in order to prevent differential settlements.

• Materials to be used are C20 concrete and Grade 1&2 steel bar in accordance with the codes of the People's Republic of China.

2) Structural work

• Structural material is reinforced concrete and structural system consists of rigid frames.

• Aseismic design grade of the buildings is #7 and the importance of design grade is 乙.

• Materials to be used are C25 or C30 concrete and Grade 1&2 steel bar in accordance with the codes of the People's Republic of China. Interior and exterior walls are stone masonry or brick masonry.

**Expansion joints are to be located every approximately 50 m.**

### 3.1.3 Mechanical and Electrical Plan

(1) Plumbing system

1) Design codes

Plumbing system will be designed based on the following codes.

| | |
|---|---|
| MH7003-95 | Civil aviation transportation airport standard |
| GNJ1-81 | Building design standard for fire stations |
| GBJ15-88 | Code for water supply and drainage design of buildings |
| GBJ16-87 | Fire defence code for architectural design |
| GBJ67-84 | Fire defence code for garage design |

2) Water supply system

For the Main Fire Station, a volume of 30 $m^3$/day of water will be tapped from the main water supply pipe in the airport premises (pressure of the main pipe : 0.25-0.30 MPa), and for the sub-stations 8$m^3$/day. Water will be supplied directly to the facilities in each building.

3) Hot water distribution system

As the heat source of hot water distribution for kitchens and bathrooms, the Main Fire Station uses the hot water (90 ℃) from the district heating and cooling facilities in the airport, and supplies it to each place through the heat exchanger installed in the machinery room. For sub fire stations, gas instantaneous water heaters will be installed in the kitchens. Both for the Main station and substations, local electric water heaters will be installed for tea preparation.

4) Plumbing fixtures

Chinese-made plumbing fixtures will be used.

5) Drainage system

Drainage inside buildings will be ensured by five systems, that is, sanitary sewage, miscellaneous drainage, kitchen drainage, machine drainage and storm drainage. Grease traps will be set in the kitchens, and drainage will be done after oil and fat are removed.

6) Gas supply system

LP gas will be supplied from the gas station in the airport for use in the kitchens.

7) Fire-protection system

For the fire-protection system, indoor hydrants and fire extinguisher (building construction work) will be installed to conform to "Fire defence code for garage design (GBJ67-84)" and "Fire defence code for architectural design (GBJ16-87)". Hydrants for training will be installed outdoors according to "Civil aviation transportation airport standard (MH7003-95)".

(2) Heating, ventilation and air conditioning system

1) Design code

Air conditioning and ventilation systems will be designed based on the following codes.

| | |
|---|---|
| MH7003-95 | Civil aviation transportation airport standard |
| GNJ1-81 | Building design standard for fire stations |
| GBJ16-87 | Fire defence code for architectural design |

2) Heating system

Heating is needed in every room in winter but only some rooms need air-conditioning in summer. So, only hot water will be tapped from the district heating and cooling facilities in the airport, in accordance with "Civil aviation transportation airport standard (MH7003-95)". Supposed capacities of hot water (90℃) to be supplied are as follows:

Main Fire Station : 3,300m 2 ×90kcal/h=297,000 kcal/h

Sub fire stations : 1,000m 2 ×90kcal/h= 90,000 kcal/h

Supply pressure (10k or less) will be kept on the receiving side of each building so as to spare the use of.

3) Piping and valves

Hot water piping will be in reverse-return method by floors and manual valves are set to each convector.

4) Air conditioning system

Convectors will be installed in all rooms. Also, air-cooled-heat-pump air source heatpomp package will be installed in the rooms mentioned below :

Main Fire Station : small dining room, library, conference and lecture room, reception room,officer's office and lodgings, duty room.

Sub fire stations : officer's office and lodgings, duty room.

• Outside condition

Summer : 34.0 degrees CDB, 28.2 degrees CWB, wind velocity 3.2 m/s
Winter : -2.0 degrees CDB, 75%RH, wind velocity 3.1 m/s

• Indoor condition when air-conditioned or heated (target values)

Summer : 26 degrees CDB
Winter : 18 degees CDB
*Humidity will not be controlled.

Convectors will be installed in garages to keep the atmospheric temperature at 10℃ or higher in winter to conform to "Civil aviation transportation airport standard (MH7003-95)".

5) Ventilation system

Architecturally, natural ventilation will be utilized as much as possible but ventilation facilities will be installed in the rooms which need forced ventilation. Methods and air volume of ventilation are as follows:

| | | | |
|---|---|---|---|
| *Ventilation type 1 | kitchen | 40-50 | Air changes /hour |
| | electric room | 4 | Air changes /hour |
| | machine room | 5 | Air changes /hour |
| *Ventilation type 3 | training room | 10 | Air changes /hour |
| | storage | 5 | Air changes /hour |
| | bathroom, changing room | 5 | Air changes /hour |
| | hot water supply room | 10 | Air changes /hour |
| | lavatory | 10 | Air changes /hour |
| | dry room | 5 | Air changes /hour |
| | garage | 5 | Air changes /hour |

note) ventiation type 1: Supply fan and exhaust fan system
ventiation type 3: Exhaust fan system

Ceiling fans will be installed in each living room

(3) Electrical system

1) Design standards

Electrical system will be designed based on the following codes and standards.

GBJ52-83 Code for industrial and civil electrical supply system design
JGJ/T 16-92 Code for electrical design of civil buildings
GBJ16-87 Fire defence code for architectural design
GNJ1-81 Building design standard for fire stations
GBJ116-88 Code for automatic fire alarm system design
IEC, JIS, standards, etc.

2) Classes of systems

・Power source system

According to 3.1 of "Code for electrical design of civil buildings (JGJ/T 16-92)", these fire defence facilities correspond to the first level load as that of the international airport of Shanghai City. Therefore power will be distributed through a service system consisting of two lines from two systems.

3) Space power sources

・Power service system

Power is received by a 3$\phi$4W 0.4kV system from the airport substation. The service system will have 2 separate lines connected to the two transformers of the substation to ensure reliability of the power source. Each line will have a full load capacity, assuming the case when one line is cut off.

According to the result of discussion with the Chinese side, generator system will be installed, because the power souce is already backed up by the two-line service system.

・Power receiving and distribution system

a)Main Fire Station

Both of the above mentioned two lines are to be main lines to receive power through a power receiving board to be installed in the electric room on the first floor. When one line is cut off, switching to the other will be done by a breaker set on the low voltage bus. The power supply to each installed load will be taken from a low voltage distribution board. For effective use of space, the power receiving/distribution board will be of metal clad type. The installed load of the system is roughly supposed as follows:

Main Fire Station about 100VA/ $m^2 \times 4,000\ m^2 = 400$kVA

b) Sub fire stations

The distribution system will consist of two lines: one normal and one stand-by line, and power will be received through a power receiving/distribution board to be installed in the electric room on the first floor. At normal time, power is supplied by one line of the service system, and when power is cut off by an accident, switching to the other line will be done by a breaker set on the low voltage bus. The power supply to each installed load will be operated by a low voltage distribution board. For effective use of space, the power receiving/distribution board will be of metal clad type. The installed load of the system is roughly supposed as follows:

Sub fire stations about $100VA/m^2 \times 1,200\ m^2 = 120kVA$

・DC battery and charger system

This will be installed in the electric room on the first floor for control and indications of the power receiving/distribution board. The battery will be of lead-acid type (HS).

・Supply voltage

lights, socket outlets  1 φ 2 W 220 V + grounding line

power laod  3 φ 3 W 380 V + grounding line

・Power mains

The power mains will be installed by kind as indicated below.

air-conditioning power power mains: 3 φ 4W 380/220

power mains for socket outlets for lighting: 3 φ 4W 380/220

4) Earthing system

・Method of Earthing

Earthing system will be arranged based on "14 Grounding and safety" of "Code for electrical design of civil buildings (JGJ/T 16-92)". For Earthing, reinforcing bars of buildings and piles will be utilized and lines will be connected synthetically.

5) Load system

・General lighting system

Lighting will be planned to conform to Chinese codes, JIS, and purpose of the use. On-and-off switching will be done by remote control switches and can be operated throughout the each fire station simultaneously from the night-duty room. The lighting plan must take into consideration the lighting on glass so that runways can be seen from the night-duty room at night without obstacle. The lightings of main rooms of the Main Fire Station and sub fire stations are shown in TableII4-3.1.1 and TableII4-3.1.2.

・Emergency light, guidance light systems

These systems will be arranged to conform to Chapter 5 of "Building design standard for fire stations (GNJ1-81)". The emergency lights will be built-in nickel-cadmium battery type and be off at normal time and on at power-off time. The guidance light system will also be of the same type as that of the emergency lights and will be on at both normal time and power-off time.

· Socket outlet system

Socket outlets for diesel engine heaters of fire engines, for battery chargers, etc. will be installed where necessary.

· Motor control system

Motor control panel will be installed for air-conditioning, hygiene and general power load. So that power can be distributed to each power load.

**TableII4-3.1.1 List of Lightings for Main Fire Station**

| Room | Luminance (JGJ/T16-92)* | Lighting Fixture | Note |
|---|---|---|---|
| Garage | 200 | Surface-mounted-type fluorescent lamp, floodlight projector | |
| Lodging for firemen | 100 | Surface-mounted-type fluorescent lamp | |
| Office & lodging for executives | 500 | Recessed-mounted-type fluorescent lamp with cover | |
| Class room/ conference room | 500 | Recessed-mounted-type fluorescent lamp open at bottom | Dimmer |
| Dining room | 200 | Recessed-mounted-type fluorescent lamp open at bottom | |
| Office | 500 | Recessed-mounted-type fluorescent lamp with louver | |

* Refer to JIS, IEC, etc.

**TableII4-3.1.2 List of Lightings for Sub Fire Stations**

| Room | Luminance (JGJ/T16-92)* | Lighting Fixture | Note |
|---|---|---|---|
| Garage | 200 | Surface-mounted-type fluorescent lamp, floodlight projector | |
| Lodging for firemen | 100 | Surface-mounted-type fluorescent lamp | |
| Office & lodging for executives | 500 | Recessed-mounted-type fluorescent lamp with cover | |
| Dining room | 200 | Recessed-mounted-type fluorescent lamp open at bottom | |

* Refer to JIS, IEC, etc.

6) Communication and information systems

• Telephone and information conduiting systems

a) Main Fire Station

• Conduiting for general telephones

Conduits will be laid in the building to accommodate 20 lines. Conduits shall be so arranged that telephones can be installed where necessary. Installation of telephones and wiring will not be included in the scope of work under this project.

• Conduiting for telephones of exclusive use

Conduits will be laid in order to install telephones for the exclusive use of the control tower, emergency control centre, fire fighting and rescue department of local authority and sub fire stations, inside the night-duty room. Installation of telephones for exclusive use and wiring will not be included in the scope of work under this project.

• Space to install radio-communication system for fire engines

Appropriate space shall be provided for installation of the radio-communication system for fire engines and power sources in the night-duty room. Installation of the radio comminication system will not be included in the scope of work under this project.

• Conduuiting for airport information system

Conduits will be arranged in the building so that information such as monitored pictures of runways, apron information, flight information, guidance to runways, etc. can be received in the night-duty room. Installation of equipments and wiring related to the information system will not be included in the scope of work under this project.

b) Sub fire stations

• Conduiting for general telephones

Conduits will be laid in the building to accommodate 6 lines. They shall so arranged that telephones can be installed where necessary. Installation of telephones and wiring will not be included in the scope of work under this project.

• Conduits for telephones of exclusive use

Conduits will be laid in order to install telephones for the exclusive use of the Main Fire Station inside the night-duty room. Installation of telephones for exclusive use and wiring will not be included in the scope of work under this project.

・Space to install radio-communication system for fire engines

Appropriate space shall be provided for installation of the radio-communication system for fire engines and power sources in the night-duty room. Installation of the radio communication system will not be included in the scope of work under this project.

・Conduiting for airport information system

Conduits will be arranged in the building so that information such as monitored pictures of runways, apron information flight information, guidance to runways, etc. can be received in the night-duty room. Installation of equipments and wiring related to the information system will not be included in the scope of work under this project.

・Public address system

An emergency public address system (also used for general broadcasting), covering the whole airport will be installed for exclusive use within each fire station, based on " 24.4 Fire and accident broadcast" of " Code for electrical design of civil buildings (JGJ/T 16-92)". Amplifier and channel selector will be installed in the night-duty room.

・Master antenna television system

A TV antenna will be mounted on the rooftop, and connected to the TV terminals in the reception, dining and class/conference rooms.

・Intercom system

An intercom system will be installed. The master station will be placed in the night-duty room and terminal sets at receptionist's counter, reception room, class/conference room, training room, garage, dining room, lodgings, library, etc.

7) Indicator system

・Emergency indicator system

An indicator system will be installed to conform to Chapter 5 of "Building design standard for fire stations (GNJ1-81)". Emergency lights, and buzzers will be installed in each room and the garage. The main station will be installed in the fire night-duty room. This system will also be used to inform accidents to the staff.

8) Fire prevention system

• Fire alarm system

An automatic fire alarm system will be installed to conform to "24 Fire alarm and fire fighting interlocking device" of "Code for electrical design of civil buildings (JGJ/T 16-92)". The system will be a concentrated system. The control panel is to be of P-type and installed in the night-duty room. A signal contact will be installed in the control panel so as to transfer important signals to the airport fire command room.

## 3.2 Emergency and First-Aid Centre

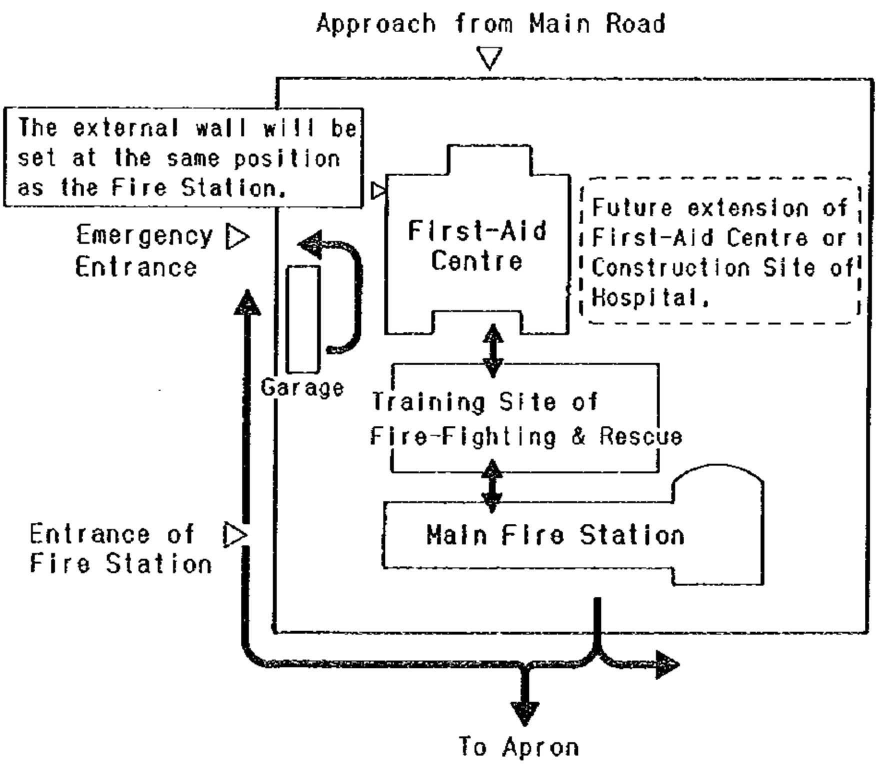
### 3.2.1 Building Plan

(1) Basic guidance

For designing the first-aid centre, scrupulous adjustment with the organization to operate it (doctors, nurses, etc.) is required. However, as even the organization system of the airport authority has not been established yet at present, we cannot decide the details of the plan. Therefore when designing, it should be planned to keep clear zoning and flexibility, and simultaneously to take into consideration the space for future expansion.

(2) Building layout plan

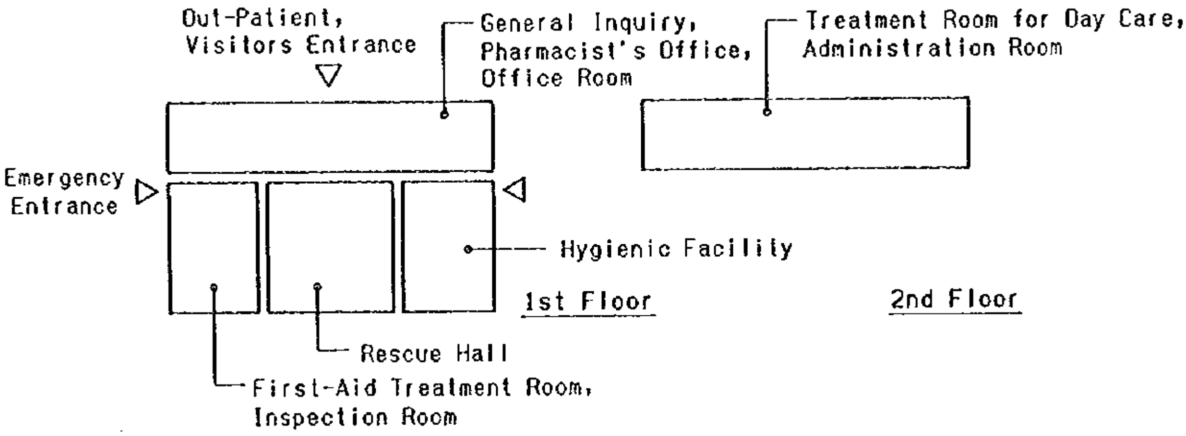
The layout of the first-aid centre shall be so planned as appropriate for single-unit work with fire stations in an emergency, and also for cooperative emergency training. Besides, from an aesthetic viewpoint, the external wall of the Main Fire Station and the first-aid centre should be arranged in a straight line.




**FigureII4-3.2.1 Conceptual Layout of First Aid Centre**

(3) Composition of facilities

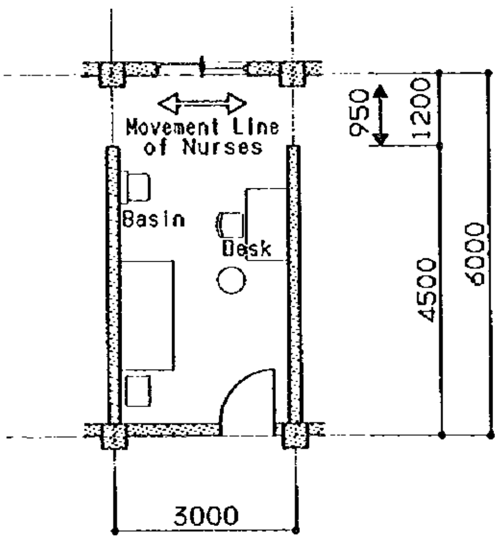
The first-aid centre will be zoned by functions as indicated in FigureII4-3.2.2, and the movement lines of visitors and staff should be taken into consideration in determining the facility composition. The emergency hall will be arranged in the center of the first floor to facilitate the approach from other facilities, thus ensuring the convenience of multiple purposes. Furthermore, setting this centre next to the training ground of the fire station would be more effective in the event of emergencies.




**FigureII4-3.2.2 Zoning of Facilities of the First-aid Centre**

(4) General layout plan

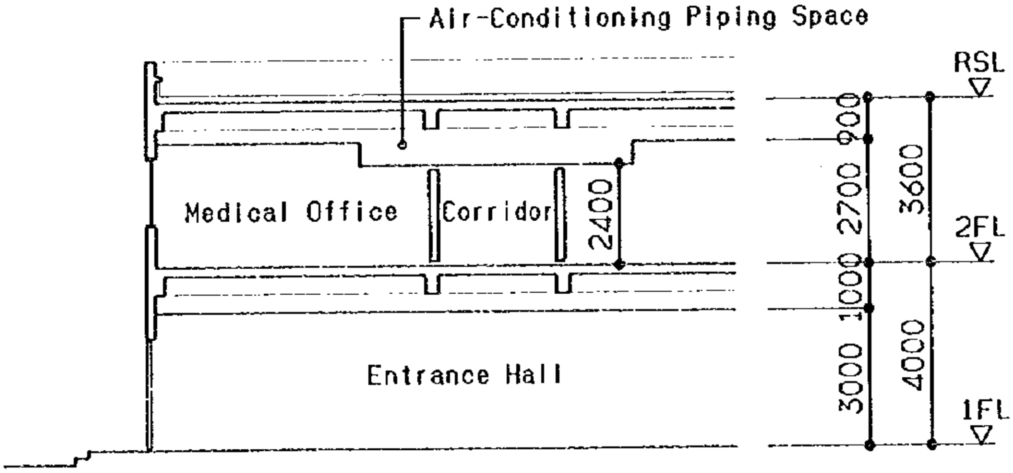
The spans of pillars that determine the plan of each room are established taking into consideration the standard dimensions of the medical office and examination room, that is, 6 m ×6 m. This determination has been based on the dimensions of the medical office of Hongqiao international first-aid centre and the dimensions of medical apparatuses such as X-ray equipment.




**FigureII4-3.2.3 Medical Unit**

(5) Sectional plan

The floor level and ceiling level of each floor are established as described in FigureII4-3.2.4, taking into consideration the functionality of each room. As to the emergency hall, a part of the ceiling is to be raised to keep a suitable height for more space and also for improving the inferior by allowing more natural light from high side windows.




**FigureII4-3.2.4 Establishment of Levels**

(6) Interior/exterior design plan

Taking into consideration the domestic materials and construction methods in China and the adjustment with other facilities, the key interior/exterior design will be as follows:

Exterior General external walls: porcelain tile, partially architectural concrete finishing
General windows : aluminum sash
Door of main entrance/exit : tempered-glass automatic sliding door
Door of emergency night entrance, etc. : steel framed door

Interior Floor: Office, medical office, rescue hall: marble covering

Warehouse, machinery room, etc.: concrete covering with hardener on surface
Lavatory: porcelain tile
Wall : mortar trowel finishing
Ceiling : rock wool with sound absorbing board

### 3.2.2 Structural design

(1) Design standards

The design standards are in accordance with the codes of the People's Republic of China and Shanghai City as follows.

| | |
|---|---|
| GBJ 7-89 | The People's Republic of China standard foundation design code |
| JGJ 3-91 | The People's Republic of China standard design code for reinforcedconcreteall buildings |
| DBJ 08-11-89 | Shanghai standard foundation design code |
| DBJ 08-31-91 | Shanghai tube structure design code for reinforced concrete tall buildings |
| DBJ 08-9-92 | Shanghai aseismic design code for buildings |

(2) Design guidances

1) Foundation work

· In the construction site, poor subsoil in the former water channel is to be replaced by sands and roller-compacted.

· The foundation is strip footing system. If soil bearing capacity is estimated insufficient to support the building aaccording to the result of site investigation, pile foundation system could be used together.

· Distribution of the vertical loads is to be equalized as much as possible in order to prevent differential settlements.

· Materials to be used are C20 concrete and Grade 1&2 steel bar in accordance with the codes of the People's Republic of China.

2) Structural work

· Structural material is reinforced concrete and structural system consists of rigid frames.

· Aseismic design grade of the building is #7 and the importance of design grade is 乙.

· Materials to be used are C25 or C30 concrete and Grade 1&2 steel bar in accordance with the codes of the People's Republic of China. Interior and exterior walls are stone masonry or brick masonry.

· No expansion joints are used in this building. If necessary, rigidity of the foundation beams is to be improved in accordance with the structural calculation results in order to prevent differential settlements.

### 3.2.3 Mechanical and Electrical Plan

(1) Plumbing system

1) Design codes

Plumbing system will be designed based on the following codes.

GBJ15-88 Code for water supply and drainage design of buildings

GBJ16-87 Fire defence code for architectural design

2) Water supply system

A volume of 28 $m^3$/day of water will be tapped from the main water supply pipe in the airport premises (pressure of the main pipe : 0.25-0.30 MPa)and will be supplied directly to each facility in the building.

3) Hot water distribution system

A gas instantaneous water heater will be installed in the kitchen and an local electric water heater will be installed in hot water room and washing room for tea preparation.

4) Plumbing fixtures

Chinese-made plumbing fixtures will be used. For the rooms which are concerned with medical and hygiene/quarantine works, wash basins will be installed.

5) Drainage system

Drainage inside the building will be ensured by six systems, that is, sanitary sewage, miscellaneous drainage, kitchen drainage, medical waste water, machine drainage and storm drainage. Grease traps will be set in the kitchen, and drainage will be done after oil and fat are removed.

6) Waste water treatment system

Waste water from medical special drainage will be treated to conform to the standard of "Code for water supply and drainage design of buildings (GBJ15-88)", and discharged to the main drainage in the airport premises.

7) Gas supply system

LP gas will be supplied from the gas station in the airport for use in the kitchen.

8) Fire-protection system

Indoor hydrants and fire extinguishers (building construction work) will be installed for the fire-protection system in conformity with "Fire defence code for architectural design (GBJ16-87)".

(2) Heating, ventilation and air conditioning system

1) Design codes

Air conditioning and ventilation systems will be designed based on "GBJ16-87 Fire defence code for architectural design".

2) Heating and cooling system

As this facility needs both air-conditioning and heating in every room, chilled water for cooling and hot water for heating will be tapped from the the district heating and cooling facilities in the airport. Supposed capacities of chilled water (7 ℃) and hot water (90 ℃) to be drawn in are as follows:

Chilled water: 2,700 m²×105 kcal/h =283,500 kcal/h

Hot water: 2,700 m²× 90 kcal/h =243,000 kcal/h

Supply pressure (10k or less) will be kept on the receiving side so as to spare the use of pumps.

3) Piping and valves

Piping will be in reverse-return method by floors, two-pipe type of chilled and hot waters. Switching of valves will be performed by the receiving facilities for the need of air-conditioning and heating, to supply chilled/hot water to each place.

4) Air conditioning system

A fan coil unit of sealing mounted type will be installed in each room.

· Outside condition

Summer: 34.0 degrees CDB, 28.2 degrees CWB, wind velocity 3.2 m/s

Winter : -2.0 degrees CDB, 75% RH, wind velocity 3.1 m/s

· Indoor condition when air-conditioned or heated (target values)

Summer : 26 degrees CDB

Winter : 22 degrees CBD,

*Humidity will not be controlled.

5) Ventilation system

Basically natural ventilation will be utilized in the rooms like in offices, but wall-type ventilation fans with heat exchanger will be installed, if necessary, in the medical office, treatment room, examination room, and medical apparatus storage room. Methods and air volume of ventilation are as follows:

| | | | |
|---|---|---|---|
| • Ventilation type 1 : | kitchen | 40-50 | Air changes /hour |
| | sterilizing room | 10 | Air changes /hour |
| | electric room | 4 | Air changes /hour |
| | machinery room | 5 | Air changes /hour |
| • Ventilation type 3 : | storage | 5 | Air changes /hour |
| | changing room | 5 | Air changes /hour |
| | lavatory | 10 | Air changes /hour |
| | filth treatment room | 15 | Air changes /hour |
| | processing laboratory | 10 | Air changes /hour |

note) ventiation type 1: Supply fan and exhaust fan system
ventiation type 3: Exhaust fan system

(3) Electrical system

1) Design standard

Electrical system design will be performed based on the following codes and standards.

GBJ52-83 Code for industrial and civil electrical supply system design
JGJ/T 16-92 Code for electrical design of civil buildings
GBJ16-87 Fire defence code for architectural design
GBJ116-88 Code for automatic fire alarm system design
IEC, JIS, standards etc.

2) Classes of systems

• Power source system

According to 3.1 of " Code for electrical design of civil buildings (JGJ/T 16-92)", this emergency and first-aid centre corresponds to the first level load as that of the international airport of Shanghai City. Therefore the power service system will consist of two lines from two systems.

3) Power sources

・Power service system

Power is received by a $3\phi 4W0.4kV$ system from the airport substation. The service system will have two separate lines connected to the two transformers of the substation, to ensure reliability of power source. Each line will have a full load capacity, assuming the case when one line is cut off.

According to the result of discussion with the Chinese side, no power generator system will be installed because the power source is already backed up by the two-line service system.

・Power receiving and distribution system

Both of the above-mentioned two lines are to be main lines to receive power through a power receiving board to be installed in the electric room on the first floor. When either of the lines is cut off, switching to the other will be done by a breaker set on the low voltage bus. The power supply to each installed load will be taken from a voltage distribution board. For effective use of space, the power receiving/distribution board will be of metal clad type.

Estimated loads: about $150VA/m^2 \times 3{,}000m^2 = 450kVA$

Breaker: low voltage ACB

・DC battery and charger system

This will be installed in the electric room on the first floor for control and indications of the power receiving/distribution board. The battery will be of lead-acid type (HS).

・Uninterruptible power supply (UPS) / Constant voltage and constant frequency system.

Uninterruptible power supply system to such facilities as artificial respiratory machines, resuscitators and electric-shock system will be installed in each room. Installation of UPS will not be included in the scope of work under this project. Constant voltage and constant frequency system (CVCF) (for X-ray photographing apparatus, supersonic photographing apparatus, etc.) will be installed in each room. Installation of the CVCF system will not be included in the scope of work under this project.

・Supply voltage

| | | |
|---|---|---|
| lights, socket outlets | $1\phi 2W$ | 220 V + grounding line |
| power | $3\phi 3W$ | 380 V + grounding line |

・Power mains

Power mains will be installed by kind as indicated below.

air-conditioning power power mains: 3 $\phi$ 4W 380/220

power mains for sockets for lighting: 3 $\phi$ 4W 380/220

power mains for medical system: 3 $\phi$ 4W 380/220

4) Earthing system

Method of earthing for general equipment

Earthing system will be arranged based on "14. Grounding and safety" of "Code for electrical design of civil buildings (JGJ/T 16-92)". For earthing of general equipment, reinforcing bars of buildings and piles will be utilized and lines will be connected synthetically.

・Method of earthing for medical equipment

Earthing system will be arranged based on "14.7.6 Earthing of medical electric equipment" of "Code for electrical design of civil buildings (JGJ/T 16-92)". This will consists of protection earthing to prevent micro shock. The earthing method of each medical room is indicated in TableII4-3.2.1.

**TableII4-3.2.1. Earthing Method for Medical Rooms**

| Room | Earthing Method for Medical Rooms | | Non-earthing System |
|---|---|---|---|
| | Protection Earthing | Equipotential Earthing | |
| Emergency room for internal treatment | ○ | — | — |
| Emergency room for surgery | ○ | — | — |
| Emergency hall | ○ | — | — |
| X-ray room | ○ | — | — |
| Medical office | ○ | — | — |

5) Load system

・General lighting system

Lighting will be planned to conform to Chinese codes, JIS and the purpose of the use, dividing the rooms into areas such as medical, business, etc. In the areas for first-aid, quarantine, etc., fluorescent lamps with cover will be used, taking into consideration the presentation and reduction of glare. The lightings of main rooms is shown in TableII4-3.2.2.

• Emergency light, guidance light systems

These systems will be arranged in conformity with Attachment C of "Code for electrical design of civil buildings (JGJ/T 16-92)". The emergency lights will be built-in nickel-cadmium battery type and will be off at normal time and on at power-off time. The guidance light system will also be of built-in nickel-cadmium battery type and will be on at both normal/power-off times.

• Socket outlet system

Sockets will be installed as necessity demands. For medical treatment use, socket panels will be set in the rooms such as first-aid room, quarantine room, medical office, and examination room. Socket outlets for medical use will also be installed.

• Motor control system

Motor control panel will be installed for air-conditioning, hygiene and general power load in machine rooms, etc., so that power can be distributed to each power load.

**TableII4-3.2.2 List of Lightings for Emergency and first-Aid Centre**

| Room | Luminance (JGJ/T16-92) | Lighting Fixture | Note |
|---|---|---|---|
| Emergency hall | 500 | Recessed-mounted-type fluorescent lamp with cover | |
| Emergency room internal treatment | 500 | Recessed-mounted-type fluore-scent lamp with glass cover | |
| Emergency room surgery | 500 | Recessed-mounted-type fluore-scent lamp with glass cover | |
| Emergency hall | 100 | Recessed-mounted-type fluorescent lamp with cover | |
| Medical treatment room | 500 | Recessed-mounted-type fluorescent lamp with cover | |
| Quarantine room | 500 | Recessed-mounted-type fluorescent lamp open at bottom | |

* Refer to JIS, IEC, etc.

6) Communication and information systems

• Telephone and information pipe systems

a) Conduiting for general telephones

Conduits will be laid in the building to accommodate 20 lines. They shall be so arranged that telephones can be installed where necessary. Installation of telephones and wiring will not be included in the scope of work under this project.

b) Conduiting for telephones of exclusive use

Conduits will not laid in order to install the telephones for the exclusive calls to emergency hospitals in the city in the office room on the first floor. Installation of telephones for exclusive use and wiring will not be includedin the scope of work under this project.

c) Space to install radio-communication system for fire engines

Appropriate space shall be provided for installation of the radio-communication system for fire engines and power sources in the office room on the first floor. Installation of the radio communication system will not be included in the scope of work under this project.

d) Conduiting for airport information

Conduits in the building so that the information such as monitor pictures of runways, apron information, flight information, guidance to runways, etc. can be received in the office room on the first floor. Installation of equipments and wiring will not be included in the scope of work under this project.

・Public address system

As to emergency public address system (also used for general broadcasting), the system for exclusive use within the first aid centre will be installed, based on "24.4 Fire and accident broadcast" of "Code for electrical design of civil buildings (JGJ/T 16-92)". Amplifier and channel selector will be installed in the office room on the first floor.

・Master antenna television system

Mount TV antenna on the rooftop, and connecting TV terminals in office, conference and night duty rooms.

・Intercom system

An intercom system for emergency and first-aid will be installed. Conduits for intercom for elevator will also be installeds. TableII4-3.2.3 shows the use and classification.

**TableII4-3.2.3 Interphone System**

| | Master Station | Terminal Set | Indicating Lamps at Passageways | Note |
|---|---|---|---|---|
| Intercom for emergency | First-aid rooms for surgery & internal treatment | Inspector room | ○ | |
| Intercom for elevator | Office room | Elevator, elevator machine room | -- | Install conduits between elevator machines and office room |

7) Indicator system

・Emergency indicator system

As a system to indicate the start of rescue and first-aid, emergency buzzers and emergency lamps will be installed in the emergency hall, passageways, etc. The main station will be installed in the office room on the first floor.

8) Fire prevention system

Fire alarm system will be installed in conformity with " 24 Fire alarm and fire fighting interlocking device" of "Code for electrical design of civil buildings (JGJ/T 16-92)". This will be a concentrated system. The control panel is to be of P-type and installed in the office room on the first floor. A signal contact is to be installed in the control panel so as to transfer important signals to the airport fire command room.

### 3.3 Fire Extinguishing System

Although the fireplug system is employed for fire extinguishing systems in China, it different from the Japanese system in which water is discharged directly from the fireplug. Instead, a fire truck is connected to the fireplug and water is discharged from the fire truck. The fire extinguishing system will be designed in accordance with the Chinese Standards for Safety Facilities (MH 7003-95).

#### 3.3.1 Design Conditions for Basic Facilities

(1) Fire fighting for the main facilities of the airport has special conditions different from normal urban fire fighting. Therefore, an independent water supply piping system for fire fighting will b e provided. Fire fighting pipelines and underground fireplugs will be installed on both sides of the runway, and the water supply pipeline for fire fighting will be designed as a loop.

(2) An independent water supply system for fire fighting with fire fighting pumps and reservoir will be provided.

(3) Between the airport fire fighting center, fire stations and the Airport Emergency Administration Center (or Control Tower), a private communication line will be provided.

#### 3.3.2 Pipes for Fire Hydrants

(1) Materials

The main water supply pipes for the fire hydrants will be globular black-lead cast iron pipes.

(2) Piping Method

1) There will be two pipelines form the fire fighting pump station to the area around the runway, one of which will be a spare.

2) The pipeline around the runway will be a loop. The pipes will cross under the runway at several places to allow establishment of a network with shortest possible length even when a section is damaged.

3) At the branching pint or the pipeline to the apron area, a parting valve and a check valve will be provided.

4) At T-shaped parts of pipes in the block pipe network in the runway area, two parting valves will be provided.

5) Under the runway pavement area, pipelines will be provided with protection pipes.

- Material of protection pipes : cement mortar lining steel pipe
- Water main in protection pipes : Seamless steel pipe (corrosion-proof)

### 3.3.3 Capacity of Fire Fighting Pump

(1) Design Conditions Based on the Standards

1) Capacity if fire trucks should be the maximum discharge specified for Airport Category 9 by ICAO, i.e. 4,500 ℓ/min. Tank capacity of a fire truck will be 6,000 ℓ.

2) The minimum discharge pressure of a fire hydrant should be more the 0.1 Mpa (1.02 kgf/cm$^3$).

3) The number of fire fighting pumps should be three (one of which is a spare).

4) The capacity of the fire fighting pumps should satisfy the following criteria :

a) The discharge capacity should be sufficient to allow fire trucks to discharge simultaneously while connected to two different fire hydrants.

4,500 ℓ/min × 2 = 9,000 ℓ/min = 160 ℓ/s.

b) It should be possible to fill up the tanks of two fire turcks withi two minutes.

6,000 ℓ/min × 2 ÷ 2 = 6,000 ℓ/min = 100 ℓ/s.

(2) Capacity of Fire Fighting Pumps

1) Discharge volume

From conditions a) and b) above, total discharge will be 150 ℓ/s.

150 ℓ/s ÷ 2 = 75 ℓ/s / pump

2) Pump lift

The Hezen William's Formula will be used for the flow rate calculation of the water pipeline.

$$I = \frac{10.666 \times Q^{1.85}}{C^{1.85} \times D^{4.87}} \times L$$

where C = 110

Q = 0.15 m$^3$/s

a) Orifice diameter and distance to the farthest fire hydrant

The orifice diameter and the distance to the farthest fire hydrant for each section are as follows:

$\phi$400 : 660m

$\phi$350 : 2,910m

$\phi$250 : 143m

b) Calculation of pump lift

• Loss of head in pipes (Hfa)

$$I_1 = \frac{10.666 \times 0.15^{1.85}}{110^{1.85} \times 0.4^{4.87}} \times 660\text{m} = 3.053 \text{ m}$$

$$I_2 = \frac{10.666 \times 0.15^{1.85}}{110^{1.85} \times 0.35^{4.87}} \times 2{,}910 \text{ m} = 25.791\text{m}$$

$$I_3 = \frac{10.666 \times 0.15^{1.85}}{110^{1.85} \times 0.25^{4.87}} \times 143 \text{ m} = 6.525 \text{ m}$$

$$\text{Hfa} = I_1 + I_2 + I_3 = 35.369 \text{ m}$$

• Actual head (Ha)

Actual head = Fire hydrant elevation - LWL of fire fighting water tank

Ha = + 4.0 + (- 2.05) = 6.05 m

• Head loss of fire hydrant ($Hf_1$)

$Hf_1 \fallingdotseq 5$ m

• Minimum discharge pressure of fire hydrant ($Hf_2$)

$Hf_2 = 10.2$ m (0.1 Mpa)

Therefore, the total lift is:

$H = Hfa + Ha + Hf_1 + Hf_2 = 56.619$ m

The total lift will be given an allowance of 5 %, therefore:

56.619 × 1.05 = 59.450 → 60 m

C) Output of electric motors

$$\text{Mkw} = \frac{0.163 \times r \times Q \times H}{\eta p} \times (1 + \alpha)$$

$$= \frac{0.163 \times 1 \times 4.5 \times 60}{0.7 \sim 0.74} \times (1 + 0.15)$$

$$= 67.48 \sim 72.30 \text{ kW} \rightarrow 75\text{kW}$$

(3) Specifications of Fire Fighting Pumps

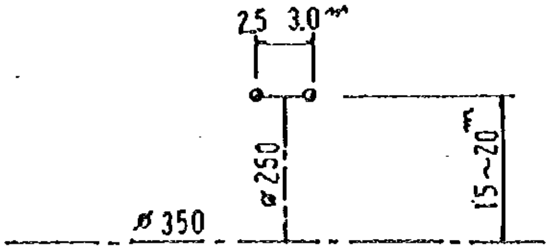
| | | |
|---|---|---|
| Type | : | multistage centrifugal pump |
| Orifice diameter | : | Suction ϕ 200 mm ; discharge ϕ 125 mm |
| Discharge volume | : | 60 ~ 97.5 ℓ/s (75 ℓ/s) |
| Lift | : | 50 ~ 69m (60 m) |
| Electric motor | : | 75 kW |
| Number of pumps | : | 3 (one spare) |

(4) Power Supply System

Japanese Fire Laws stipulate that the pumps should be driven by diesel motors or an emergency power generator should be provided when commercial power supply is sued. However, in China, power is received from tow independent power lines and direct connection to commercial power lines is permitted. Following discussions with the Chinese side, it was decided to follow Chinese practice Power will be supplied directly from commercial power lines with no emergency generators.

### 3.3.4 Fire Hydrant

(1) The orifice diameter of the fire hydrants will be ϕ 100. The set-up is as follow:




(2) The layout of the fire hydrants will divide the runway into three sections. In the central section, the hydrants will be laid at 200 m pitch or less. In the sections at both ends, the hydrants will be laid at 120 m pitch or less.

(3) The hydrants will be laid at 120 m pitch ore less in the apron area.

(4) Fire hydrants will be of the underground type. The covers will withstand aircraft load.

(5) The minimum discharge pressure of the fire hydrants will be more than 0.1 Mpa.

(6) The Practice Fire Fighting Facilities to be provided at the Min Fire Station will be fire hydrants.

### 3.3.4 Water tank for Fire Fighting

(1) The tank structure will be of steel reinforced concrete, semi-underground type.

(2) The capacity of the tank will be for Category 9 (500 m3) or more and be sufficient for more than one hour discharge at 159 ℓ/s (540 m3). Accordingly, the capacity of the tank has been set at 600 m3.

# CHAPTER 4 ROUGH ESTIMATE OF CONSTRUCTION COST

## 4.1 Method of Estimate

### 4.1.1 The way of Estimate in China

In China, there is a material for estimate called "預算定額" which indicates the percentages and unit prices corresponding to each detailed construction work item. In principle, rough and detailed estimations are performed according to this. (Private projects are not always so.) This "預算定額" is revised only about every ten years, therefore in practice, the revised unit prices regarding construction work items, materials, man-day rate, machines, etc. are announced by districts every year, and direct construction cost is estimated adding these revised prices, and then total construction cost is estimated adding indirect costs to it, which is found by the fixed rate and others including tax. Probably due to the high rising ratio of prices, the data on a recent example of an airport, which the Chinese side has provided to us for reference, show that the total construction cost is 2.4 - 2.95 times as much as the lump-sum direct construction cost in the building work cost. Also in another example of a building which was roughly estimated last November (estimated by a certain Shanghai QS) shows that it is 2.35 times as much. There is a case of a private building project (estimated by a Hong Kong QS) where estimate was not done according to "預算定額". In the comparison of concrete work costs, this case costs 50% higher than the case where estimate was done by adding to the lump-sum cost.

### 4.1.2 Method of Estimate for this project

The construction cost of this project is to be estimated by the values obtained by multiplying the roughly estimated quantity by the reference unit price of each construction work item, referring to the estimates for similar airport facilities. (For many items, the unit prices of 福州長楽 Airport facilities are to be referred to [(Total construction cost/lump-sum direct cost) ×lump-sum unit price]). As to the cost for electrical/mechanical works, it will be estimated by the ratio of construction cost of similar works in China. The accuracy of the rough estimate is supposed to range from ±10 % to 20 % with the process mentioned above.

### 4.1.3 Supply of Machinery

For the building works and mechanical/electrical works, no machinery will be imported but only domestic machinery will be used. Among the fire engines, a high-speed fire engine, main chemical fire engines, a chemical foam sprinkler and a disaster rescue car will be imported, and others will be purchased from the domestic market. The prices of imported fire engines differ largely depending on the specifications even if the capacities are the same. Also, if a fire engine is imported and purchased in Japan, the price is almost twice as much as the same engine in China. In this report, the rough estimate is performed based on the assumed prices determined from the values given in past records in China and price information from the makers. As to emergency vehicles, two ambulances and an emergency control car will be imported, and others will be procured locally. The conversion rate will be 1$=8.3 元.

## 4.2 Rough Estimate of Construction Cost

### 4.2.1 Building Construction Cost

**TableII4-4.2.1 Building Construction Cost**

| Name of Building | Construction Work Item | Construction Cost(元) | Unit Price (元/$m^2$) |
|---|---|---|---|
| Main fire station<br>RC+2<br>Total 3750 $m^2$ | Building<br>Mechanical/electrical<br>Total | 5,776,371<br>1,925,460<br>7,701,831 | 2,054 |
| Sub fire station<br>RC+2<br>Total 1072 $m^2$ | Building<br>Mechanical/electrical<br>Total | 1,731,564<br>516,704<br>2,248,268 | 2,097 |
| Training tower<br>RC+4<br>H=15m | Building<br>Mechanical/electrical<br>Total | 100,180<br>11,131<br>111,311 | 1,545 |
| Total of<br>Fire station | | 10,061,410 | |
| Emergency centre<br>RC+2<br>Total 2729$m^2$ | Building<br>Mechanical/electrical<br>Total | 5,149,270<br>2,772,683<br>7,921,953 | 2,902 |
| Garage<br>RC+2<br>Total 228 $m^2$ | Building<br>Mechanical/electrical<br>Total | 406,728<br>45,192<br>451,920 | 1,982 |
| Total of<br>Emergency ---- | | 8,373,873 | 2,832 |
| Fire Hydrant System | | 16,157,774 | |
| Total of Buildings | | 34,593,057 | |

### 4.2.2 Price of Vehicles

(1) Fire engines

**TableII4-4.2.2 Prices of Fire engines**

| No | Kinds of Vehicles | Assumed Model | Number of cars | Assumed Unit Price | Assumed Total Price |
|---|---|---|---|---|---|
| 1 | High-speed fire engine (import) | RIV5000/600 | 1 | $580,000～650,000 | $580,000～650,000 |
| 2 | Main chemical fire engine (import) | RIV10000/1200 | 4 | $700,000～800,000 | $2,800,000～3,200,000 |
| 3 | Fire engine for powder extinguisher | CF20 | 1 | (1,000,000～1,200,000元) | (1,000,000～1,200,000元) |
| 4 | Large chemical fire engine | CPP15(1) | 1 | 1,200,000～1,500,000元 | 1,200,000～1,500,000元 |
| 5 | Large water supply car | CG70/60 | 2 | 1,000,000～1,100,000元 | 2,000,000～2,200,000元 |
| 6 | Chemical foam sprinkler (import) | CPP45 | 1 | ($260,000～300,000) | ($260,000～300,000) |
| 7 | Lighting car | CZ4 | 1 | (500,000～800,000元) | (500,000～800,000元) |
| 8 | Communication/ Control car | CX75 | 1 | (500,000～800,000元) | (500,000～800,000元) |
| 9 | Disaster rescue car (import) | R2A | 1 | $260,000～350,000 | $260,000～350,000 |
| 10 | Rear support car | | 1 | (500,000～800,000元) | (500,000～800,000元) |
| 11 | Foam undiluted solution transport car | | 1 | (1,000,000～1,200,000元) | (1,000,000～1,200,000元) |
| TOTAL | | | 15 | about 39,000,000～46,000,000 元<br>including US$ 3,900,000～4,500,000 | |

(2) Emergency vehicles

**TableII4-4.2.3 Prices of Emergency Vehicles**

| No | Kind of Vehicles | Number of cars | Assumed Unit Price | Assumed Total Price |
|---|---|---|---|---|
| 1 | Ambulance (import) | 2 | (10～12万＄) | (20～24万＄) |
| 2 | Ambulance (domestic) | 3 | (45～60万元) | (135～180万元) |
| 3 | Emergency control car (import) | 1 | (10～12万＄) | (10～12万＄) |
| 4 | Middle sized bus | 2 | (50～60万元) | (100～120万元) |
| 5 | Small bus | 10 | (35～40万元) | (350～400万元) |
| TOTAL | | 18 | about 8,400,000～ 10,000,000 元<br><br>including US$ 300,000～ 360,000 | |

Total cost of vehicles : about 47,400,000～56,000,000 元 including US$ 4,200,000 ～,860,000

**＊The necessary data for vehicle procurement was not provided by the Chinese side. The amount in () indicate estimates made from other studies.**

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

SCIENCE AND TECHNOLOGY COMMISSION OF
SHANGHAI MUNICIPAL PEOPLE'S GOVERNMENT,
PEOPLE'S REPUBLIC OF CHINA

# DETAILED DESIGN
# OF
# SHANGHAI PUDONG INTERNATIONAL
# AIRPORT
# FINAL REPORT

## VOLUME I
## MAIN REPORT

### PART III
### DETAILED DESIGN

SEPTEMBER 1997

**NIPPON KOEI CO., LTD.**
**NIKKEN SEKKEI LTD.**

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

SCIENCE AND TECHNOLOGY COMMISSION OF
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# DETAILED DESIGN OF SHANGHAI PUDONG INTERNATIONAL AIRPORT FINAL REPORT

## VOLUME I
## MAIN REPORT

### PART III-1
### DETAILED DESIGN OF AIRSIDE CIVIL WORKS

SEPTEMBER 1997

NIPPON KOEI CO., LTD.
NIKKEN SEKKEI LTD.

# CHAPTER 1 PRINCIPLES OF DESIGN

Upon designing in detail, changes in the Basic Design and their reasons are described below.

(1) Width of runway shoulders were changed from 7.5m to 1.5m.

According to provisions of width of runways of Airport Class 4E based on ICAO, that of runways should be 45m or wider and the total width including a runway shoulder should be 60m or wider. Construction was originally planned with 60m width of the runway of this airport in consideration of future aircraft. Therefore, this reduction has no matters regarding the above-mentioned provisions. Width of 7.5m was originally suggested in the Basic Design in consideration of use by future aircraft, i.e. Type F. However, Chinese policies for preparation work include reduction in early-stage investment and employment of Type E (current aircraft) in the Phase I Work. Accordingly, it was determined to construct shoulders with necessary width for a while. It is considered that, even if Type F becomes main and wider width of shoulders is required, sufficient measures will be able be taken with night work etc. Chinese Technical Standards prescribes that, if width of a runway is planned to be 60m, width of a shoulder should be 1.5m in consideration of installation of lighting equipment(runway lighting equipment should be located at 1.0m from a runway edge). For this reason, according to Chinese Technical Standards, width of shoulders were changed from 7.5m to 1.5m.

(2) Aircraft on the open spot were determined to be limited to Type E. Depth was changed from 75m to 71m. Width of the GSE passage in the eastern side of the Open Spot was changed from 8m to 4m. This results in 8m reduction of depth of the whole Passenger Apron.

On the Open Spot, aircraft of Type E or lower such as B-747-400 should be parked. It is possible to reduce early-stage investment by reducing the area of pavement by using the fixed spot in front of the Terminal Building for a part of large aircraft corresponding to or larger than B-777-300. Even if Type F becomes main, it will be possible to cope with such aircraft only by widening width of pavement. It is because planning is made to secure clearance between the Open Spot and parallel taxiways. For this reason, width of the Open Spot in the Phase I work was determined to be changed from 75m to 71m. On the other hand, the GSE passage was determined to be one-way traffic and width was changed to 4m. It is because it was determined to obtain a circumferential route for GSE transit by dividing the Open Spot.

(3) The following pavement work areas will be excluded from the Phase I Work.

1) Two entrance and exit taxiways at 3,200m from the runway end and between the runway and a parallel taxiway.

2) 5 spots among 8 spots in the Cargo Apron.

3) Maintenance Apron and a taxiway linking to the Maintenance Apron.

The purpose of installation of two entrance and exit taxiways is as follows:

* Increase of capacity of the runway by rapidly removing an airplane which couldn't exit from the final rapid exit taxiway

* Easing by not moving middle- and smaller- sized aircraft to the end part which is crowded during taking off.

*As the number of landings and taking-offs will be small for a while, pavement work will be excluded from Phase I Work to reduce early-stage investment. However, work for, for example, underground structures in the runway area and ground improvement should be carried out this time. The purpose is to enable execution of pavement work when the number of landings and taking-offs will increase in the future. For the Cargo Apron, only three spots which will be necessary for a while should be constructed. Similarly, underground structures, ground improvement in the Cargo Apron should be executed this time. For the Maintenance Apron and connection taxiways, coordination is delayed among parties concerned such as the airport side, aviation companies for which this airport will be a base and maintenance companies. As a result, conditions of the plan cannot be determined now. Accordingly, execution of them should be excluded from the Phase I work because temporary measures will be adopted including maintenance of aircraft to be carried in the present airport (Hongqiao)for a while.

(4) Changes will be made so as to realize such alignment and such a structure where B-777-300 will be able to run similarly on other rapid exit taxiways, while use of the rapid exit taxiway which is the nearest from the grounding point will not limited to middle- sized aircraft (B-767-300)or smaller aircraft.

In the plan, this rapid exit taxiway will be used by the middle- and smaller- sized aircraft. However, it is considered proper that all rapid exit taxiways should be standardized, from the viewpoints of skill of controlling people who will give instructions regarding exit taxiways and from the viewpoint of simplification of conditions of the plan.

(5) The type of pavement in the Over Run area was changed from asphalt pavement to concrete pavement.

In China, concrete pavement is superior in durability, ahievements of maintenance and repair, economy etc. to asphalt pavement. There fore, the type of pavement of the Basic Facilities was determined to be concrete pavement. In the Basic Design, asphalt pavement had been employed to the Over-Run area in the Basic Design according to examples of airports in China. However, it was also determined to be changed to concrete pavement because it was considered appropriate to make a structure same as the Basic Facilities.

(6) Accompanying determination of alignment of the place- surrounding water ways (the Irrigation Bureau), coordinates of the boundaries of the airport premise and locations of regulating reservoirs were changed a little.

The boundaries of the airport premise have been determined from the viewpoint of acquisition of the site necessary for airport functions and use of the land. Therefore, according to establishment of alignment of place-surrounding waterways which had been planned together with the Basic Plan, changes was made a little after adjustment with the coordinates of the boundaries. It was determined that locations of regulating reservoirs should be changed to be near the place-surrounding waterways. It is because turbulent flows, maelstroms etc. would not occur for the hydraulic reason even if they are linked to any places.

(7) Cover of drainageways in aprons were changed from grating structure to concrete structure.

A hydraulic section of drainageways in the aprons will be large to collect water from the vast apron. Covers are also necessary to be strongly-built in order to bear aircraft load. In China, grating structure is inferior in economy because material of steel is expensive. Therefore, structure of covers were changed to be that of concrete.

Necessary notch area should be provided so that water will not stay in aprons due to water-collecting capacity lowered as a result of change to concrete covers.

(8) The safety road parallel with and between the runway and parallel taxiways was determined to be deleted.

The safety road had been planed in consideration of:

*passing of vehicles which will check the airport basic facilities daily and

*passing of urgent vehicles, such as fire trucks, which will use a water tank for fire extinguishment installed along the safety road.

However, the safety road was determined to be deleted according to the following Chinese examples and real situation:

*Usually, a safety road is not constructed between a runway and a parallel taxiway.

*The method of installing fireplugs along a runway, as water facilities for fire extinguishment, is employed.

(9) Control of rainwater drainage pumps should be systematized by linking them with the comprehensive control center for the whole airport.

A comprehensive operation control system regarding pump facilities for the whole airport was suggested in the Basic Design by the Japanese side. The airport side also has a policy of employment of the system. Therefore, for rainwater drainage pumps in this design, such interface that will enable link with the control center should be provided.

(10) Structure of blast fences was changed from that of steel to that of concrete.

There are no examples of blast fences in China. In the Basic Plan, their structure had been determined to be that of steel with reference to Japanese examples. However, it was changed to concrete structure for the reasons including the following ones:

*Material of steel is expensive in China.

*It is difficult to manufacture steel nets to make efficient blast.

# CHAPTER 2 DESIGN OF SITE PREPARATION

## 2.1 Plane Design

The planning of the Flight Area in the Phase I Area was partly changed as a result of the Chinese side's appraisal.

Details of changes are as described in "CHAPTER 1 PRINCIPLES OF DESIGN". Figure III1-2.1.1 shows the planning covered by the detailed design.

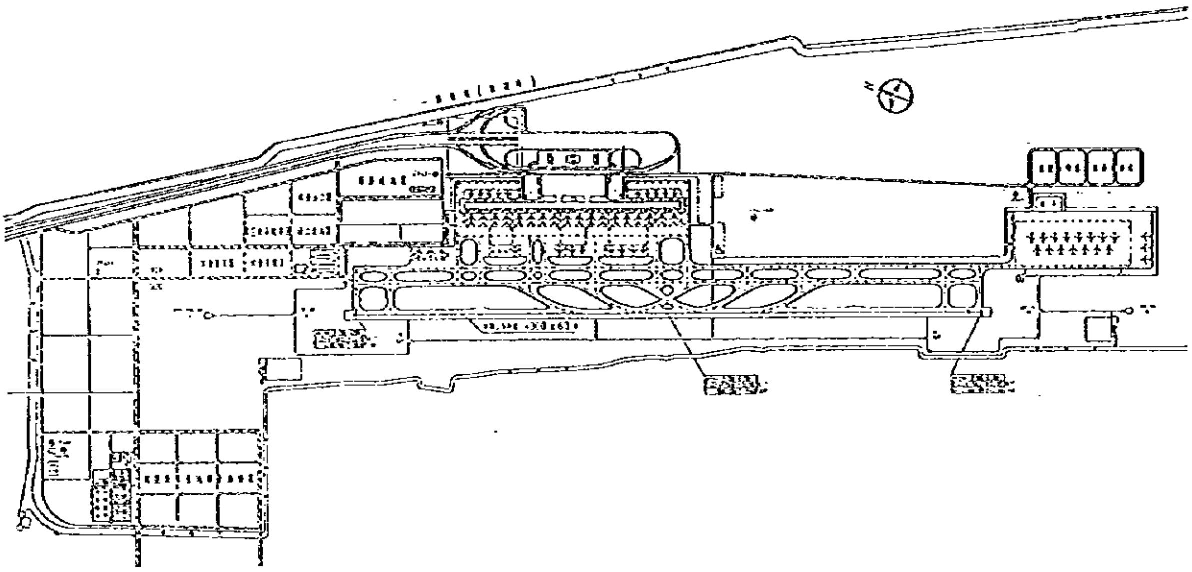

**Figure III1-2.1.1 Planning in Phase I**

## 2.2 Longitudinal and Latitudinal Design

The plan of Basic Facilities and longitudinal and latidutinal shapes should be in accordance with those of the "Basic Design".

(1) Planned Height of Basic Facilities

*As to the center line of the runway and parallel taxiways, the central part should be a 5.3m above the sea level, both ends in the north and the south should be at 5.1m and longitudinal gradient should be 0.01%.

*To the Terminal Apron, concrete pavement should be adopted. The surface of pavement should be at 4.8 - 5.2m above the sea level.

*Height of the the Terminal Building, Fingers and the apron in front of the airplane shed should be 5.2m above the sea. The ground for buildings should be at 5.1m above the sea.

(2) Shape of Longitudinal and Latitudinal Sections

1) Runway and Taxiway Areas

The central part of the runway and taxiways should be at 5.3m above the sea level, and both ends should be at 5.1m.

*Latitudinal gradient of the main bodies of the runway and taxiways : 1.3%

*Latitudinal gradient of shoulders of the runway and taxiways: 1.6%

*Latitudinal gradient of the landing zone: 1.0 - 1.60%

*Latitudinal gradient of the glide slope site: 1.0%

2) Apron Area

Gradient of the area in the direction parallel with the runway should be 0.01% in accordance with longitudinal gradient of the runway. Gradient in the area in the direction vertical to the runway should be changed at every 120m (about)and 0.5% should be adapted.

## 2.3 Design with Ram Drop Compaction Method

### 2.3.1 Scope of Ground Improvement

The scope of ground improvement considered for the Phase I Work should be the scope of pavement in the Phase I Work, including the runway, parallel taxiways, entrance and exit taxiways, rapid exit taxiways, the roading apron and the maintenance apron. Width of the ground to be improved should be what is expanded from the edge of a shoulder (Appropriate adjustment should be partly made based on points of hitting).

In order that work in and after Phase II will not influence structural safety and use realized in Phase I, ground improvement of the following areas should be also completed in the Phase I Work:

* Taxiway areas in the landing zone which will be paved in and after Phase II

* Areas adjoining (within 30m)the areas of the Phase I Work. The area of ground improvement in the Phase I Work is approximately 1.97 million square meters. Among them, the part of pavement in and after the Phase II Work is about 60 thousand square meters.

### 2.3.2 Indexes of Inspection (Management Standard Values)

The degree of importance is different between the main body of pavement and the shoulder part (including the over-run part). Therefore,the former is named the Area A and the latter is named the Area B

(1) Inspection Indexes of Ram Drop Compaction Method

1) In each area, dry density of the mat layer (slag and mountain topsoil)compacted with ram drop after tamping, roll pressurizing and ground leveling should be 1.9g/cm3 or higher.

2) The average value of the ground bearing capacity in Area A should be 50MN/m3 or less. The minimum value at a hitting point should be 40MN/m3 or more. The minimum value between hitting points should be 30MN/m3.

The average value of the coefficient of the ground bearing capacity in Area B should be 40MN/m3 or more. The minimum value should be 30MN/m3 or more.

(2) Inspection Indexes of Ground

1) Static Cone Penetration Test (within the range of 5m under the bottom of the mat layer :

Area A average value of penetration resistance (converted value)should be 3MPa or higher, and the minimum value is 2MP a or higher : Area B minimum value should be 2MPa or higher.

2) Standard Penetration Test (within the range of 5m under the bottom of the mat layer):

(Area A (converted )average N value) ≧Minimum N value≧6;

Area Bvalue ≧6

### 2.3.3 Material of Mat Layer

(1) Design thickness should be 80 - 90cm.

(2) For the runway, slag of 宝鉄blast furnace should be used. For material of mat in other areas, moutain topsoil or gravel stone should be used.

Conditions of mountain topsoil are as follows:

*Maximum grain diameter <10cm

*Content of mountain topsoil (grain diameter of 2 - 10cm)> 50%

*Content of mud<20%

*Cu≧5

*Cv=1-3

Conditions of gravel stone are as follows:

* Maximum grain diameter <10cm

*Content of mud<5%

*Cu≧5

*Cv=1-3

### 2.3.4 Execution of Ram Drop Compaction Method

(1) Parameters of Ram Drop Compaction Method

| Test Area | Type of Hitting | Hitting Energy (kN.m) | Space of Hitting Points (m) | Layout of Hitting Points | 打撃段階 | 各段階打撃数 |
|---|---|---|---|---|---|---|
| Area A | Normal hitting | 1500～2000 | 3.0～3.5 | Square | 2 | 8～10 |
| | Finish hitting | 500～800 | Overlapping d/4 | Overlapping shape | 1 | 2-4 |
| Area B | Normal hitting | 1000 | 3.0 | Square | 2 | 8～10 |
| | Finish hitting | 500～800 | Overlapping d/4 | Overlapping shape | 1 | 2-4 |

(2) Method of Execution

1) Normal hitting should be divided into two stages; hitting in one stage should be done at every other hitting point (first and second hitting points will appear alternately). As shown in the following figure, hitting points in the first stage should be ①, and those in the second stage should be ②.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ① | ② | ① | ② | ① | ② | ① | ② | ① | ② |
| ② | ① | ② | ① | ② | ① | ② | ① | ② | ① |
| ① | ② | ① | ② | ① | ② | ① | ② | ① | ② |
| ② | ① | ② | ① | ② | ① | ② | ① | ② | ① |
| ① | ② | ① | ② | ① | ② | ① | ② | ① | ② |
| ② | ① | ② | ① | ② | ① | ② | ① | ② | ① |
| ① | ② | ① | ② | ① | ② | ① | ② | ① | ② |

2) Finish hitting should be carried out successively in the first stage.

3) For normal hitting in two stages, the no-work period between normal and finish hitting should be 15 days or more. (The concrete execution period will be determined based on the condition of disappearance of pore water pressure.)

4) The average depth of sinking caused by the last two times of hitting should be 5 - 10cm or less.

## 2.4 Calculation of Volume of Earth Work

Based on the longitudinal and latitudinal design of each establishment, planned height of 40m mesh was determined. The volume of earth work in the Flight Area was calculated with difference between this planned height and the actually measured height of the ground. The results are as shown in Table III1-2.4.1.

For calculation of the volume of earth work, the following conditions were included:

*For above-the-sea height of sitea, values of 40m mesh measured actually (in August, 1996)should be used.

*The volume of soil inside the mesh was calculated by multiplying the average value of calculated height (△h shown below)of earth work volume at four points by area inside the mesh. For back filling of existing waterways, calculation will be done separately.

*The method of calculation of calculated height of earth work volume at a mesh point should be as follows:

Pavement area of the main body :

△h = (planned height - thickness of pavement - thickness of mat layer + volume of compression by compaction ) - (height of site ground - thickness of removed topsoil)

Brushwood area :

△h = planned height - (height of site ground - thickness of removed topsoil )

where: volume of removed topsoil : 30cm

volume of compression by compaction of site ground: 2cm

thickness of mat layer, volume of compression by compaction :

from H206+9.5 to west 0.8m, 0.3m

from H206+9.5 to east 1.0m, 0.35m

* Proportion of excavation and embankment is, area under pavement 1:1.3, area not under pavement 1:1.15

**Table III1 - 2.4.1 Calculation of Volume of Earth Work**

( Unit : 1,000m³)

| Excavated Volume | | Embankment Volume | |
|---|---|---|---|
| Sludge Dredging under Pavement | 121 | Filling of Existing Channels under Pavement | 542 |
| Stripping of topsoil | 437 | Filling of Existing Channels not under Pavement | 303 |
| Mapping Volume under Pavement | 195 | Embankment for Soil Preparation under Pavement | 333 |
| Excavation for Soil Preparation under Pavement | 135 | Embankment for Soil Preparation not under Pavement | 1,242 |
| Excavation for Soil Preparation not under Pavement | 94 | | |
| Surplus Soil from Regulation Pond | 238 | | |
| Surplus Soil from Drainage Channels | 284 | | |
| Excavated materials from river | 120 | | |
| Imported Soil from outside Flight Area | 796 | | |
| Total Excavated Soil | 2,420 | Total Embankment Soil | 2,420 |

The results of the Earth Work volume calculation is more embankment soil reguired than supplied from excavated soil.

The deficit soil volume, approx 796,000m³, will reguire imported soil from outside the airport area.

# CHAPTER 3 DESIGN OF DRAINAGE CHANNEL FACILITIES

Coordinates of the boundaries of the airpport premise and locations of regulating reservoirs were changed. Therefore,amended in calculation for discharge.

## 3.1 Design Parameters

[BASIC DESIGN] were followed in calculating the discharge volume and drainage capacity.

(1) Discharge Volume Calculation

1) Frequency of Occurrence, Rainfall Intensity : I

The frequency of occurrence is set as follows :

- Flight area 5 years
- Other areas 3 years

The rainfall intensity is determined by the following formula :

$$I = \frac{(9.45 + 6.732 \log Te) \times 60}{(t + 5.54)^{0.6514}}$$

where $Te$ : frequency of occurrence (year )

$t$ : duration of rainfall (min )

$I$ : rainfall intensity (mm / hr )

2) Coefficient of Discharge : $C$

| | |
|---|---|
| Asphalt pavement | : 0.95 |
| Concrete pavement | : 0.90 |
| Planting | : 0.30 |
| Buildings | : 0.90 |

3) Discharge Volume (rational method)

$$Q = 1/360 \cdot C \cdot I \cdot A$$

where $C$ : coefficient of discharge

$I$ : rainfall intensity mm/hr )

$A$ : drainage area (ha )

4) Duration of Rainfall : $t$

$$t = t_1 + t_2$$

$$t_1 = \frac{3.261(1.1 - C)\sqrt{D}}{\sqrt[3]{S}}$$

$$t_2 = L / 60V$$

where $t_1$ = inflow time ( min )
$t_2$ = time of flow (min )
D : inflow distance (m)
S : gradient (%)
C : coefficient of discharge
L : horizontal length of channel (m)
V : average velocity (m/ s)

(2) Drainage Capacity Calculation

1) Velocity : $V$ ( Manning formula)

$$V = \frac{1}{n} \cdot R^{\frac{2}{3}} \cdot i^{\frac{1}{3}}$$

where $n$ : coefficient of roughness
$R$ : hydraulic radius (m)
$i$ : gradient

2) Coefficient of Roughness : n

| | |
|---|---|
| Concrete channel | : 0.014 |
| Covered conduits (including precast channels) | : 0.014 |
| Masonry channel | : 0.017 |

3) Drainage Capacity : $Q$

Q = A · V

where A : cross section ($m^2$) ,
V : velocity (m/s)

* open channels and covered conduits are both calculated on a full depth basis; open channels will be provided with a 15 cm freeboard, and masonry channels a 20 cm freeboard.

## 3.2 Calculation of Drainage Sections

The drainage channels in the Flight Area will be U-type open channels, U-type channels with concrete covers trapezoidal section channels (outside the runway strip), covered conduits of box section, etc. The rational method will be used to determine discharge volume for each area and the Manning formula will be used to calculate the drainage sections of the drainage channels for the respective discharge volumes.

The results of calculation of discharge volumes and drainage sections for each area are shown in TablesIII1 3.2.1 ~ 3.2.6.

A区

# TableIII1-3.2.1 Calculation for discharge volumes and drainage sections (1)

| Line | Length of catchment (m) | Drainage area (ha) | Runoff Coefficient | Accumulated drainage area (ha) | Flow length (m) | Runoff time (min) | Time of flow (min) | Rainfall intensity ( l/ha•s) | Runoff Volume (m3/s) | Cross section type | width of ditch bottom (m) | Design water depth (m) | Gradient | Flow velocity (m/s) | Flow capasity ($m^3/s$) | Hydraulic slope (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A1 | 200 | 13.89 | 0.42 | 5.83 | 725 | 31.36 | 10.3 | 192.34 | 1.12 | TM | 1.2 | 1.0 | 0.0009 | 1.18 | 2.59 | 0.65 |
| | | | | 5.83 | 20 | 41.61 | 0.3 | 191.54 | 1.12 | F | 1.6 | 0.7 | 0.0009 | 1.11 | 1.24 | 0.02 |
| | | 10.16 | 0.42 | 10.10 | 525 | 41.91 | 7.4 | 174.24 | 1.76 | TM | 1.2 | 1.0 | 0.0009 | 1.18 | 2.59 | 0.47 |
| | | | | 10.10 | 20 | 49.33 | 0.3 | 173.69 | 1.75 | T-1 | 1.6 | 1.0 | 0.0009 | 1.25 | 2.00 | 0.02 |
| | | 11.93 | 0.42 | 15.11 | 620 | 49.60 | 8.8 | 157.77 | 2.38 | TM | 1.2 | 1.0 | 0.0009 | 1.18 | 2.59 | 0.56 |
| | | | | 15.11 | 20 | 58.37 | 0.2 | 157.38 | 2.38 | F | 1.6 | 1.4 | 0.0009 | 1.37 | 3.06 | 0.02 |
| | | 8.57 | 0.42 | 18.71 | 460 | 58.61 | 5.6 | 149.02 | 2.79 | T-1 | 1.6 | 1.4 | 0.0009 | 1.37 | 3.06 | 0.41 |
| | | 4.88 | 0.42 | 20.76 | 261.85 | 64.22 | 1.9 | 146.39 | 3.04 | TM | 1.6 | 1.0 | 0.003 | 2.26 | 5.87 | 0.79 |
| | | | | *TOTAL LENGTH* | *2651.9* | 66.16 | | | | | | | | | | |
| A2 | 138.35 | 2.23 | 0.81 | 1.81 | 20 | 11.12 | 0.3 | 349.68 | 0.63 | T-1 | 1.2 | 0.55 | 0.0010 | 0.98 | 0.65 | 0.02 |
| | | | | 1.81 | 108 | 11.46 | 1.8 | 324.25 | 0.59 | F | 1.2 | 0.55 | 0.0010 | 0.98 | 0.65 | 0.11 |
| | | 6.21 | 0.60 | 5.53 | 230 | 13.29 | 2.3 | 324.25 | 1.79 | T-1 | 1.4 | 0.80 | 0.0020 | 1.66 | 1.85 | 0.46 |
| | | | | 5.53 | 180 | 15.61 | 2.6 | 300.75 | 1.66 | F | 1.6 | 0.95 | 0.0008 | 1.16 | 1.76 | 0.14 |
| | | 8.03 | 0.60 | 10.35 | 220 | 18.20 | 2.8 | 279.92 | 2.90 | T-1 | 1.8 | 1.3 | 0.0008 | 1.33 | 3.10 | 0.18 |
| | | | | 10.35 | 160 | 20.96 | 2.1 | 266.62 | 2.76 | F | 1.8 | 1.2 | 0.0008 | 1.30 | 2.80 | 0.13 |
| | | 7.82 | 0.57 | 14.81 | 260 | 23.02 | 3.1 | 249.07 | 3.69 | T-1 | 1.8 | 1.5 | 0.0008 | 1.38 | 3.72 | 0.21 |
| | | | | 14.81 | 80 | 26.17 | 1.0 | 244.31 | 3.62 | F | 1.8 | 1.6 | 0.0008 | 1.40 | 4.03 | 0.06 |
| | | 11.21 | 0.53 | 20.75 | 440 | 27.12 | 5.1 | 222.26 | 4.61 | T-1 | 1.8 | 1.8 | 0.0008 | 1.44 | 4.66 | 0.35 |
| | | | | 20.75 | 160 | 32.22 | 1.9 | 215.43 | 4.47 | F | 1.8 | 1.8 | 0.0008 | 1.44 | 4.66 | 0.13 |
| | | 4.41 | 0.81 | 24.32 | 100 | 34.08 | 1.1 | 211.50 | 5.14 | T-1 | 1.8 | 2.0 | 0.0008 | 1.47 | 5.29 | 0.08 |
| | | | | 24.32 | 182.5 | 35.21 | 1.9 | 205.34 | 4.99 | F | 1.8 | 1.8 | 0.0010 | 1.61 | 5.21 | 0.18 |
| | | | | 24.32 | 17 | 37.11 | 0.2 | 204.76 | 4.98 | TM | 2.0 | 1.6 | 0.0008 | 1.53 | 8.82 | 0.01 |
| converged from A3, A7 | | 9.62 | 0.30 | 96.39 | 328.33 | 37.29 | 2.8 | 196.44 | 18.93 | TM | 3.0 | 2.0 | 0.0009 | 1.94 | 19.42 | 0.30 |
| | | | | 96.39 | 120 | 40.11 | 0.8 | 194.16 | 18.71 | F | 5.0 | 2.0 | 0.0010 | 2.42 | 24.23 | 0.12 |
| | | | | 96.39 | 140 | 40.93 | 1.1 | 196.44 | 18.93 | TM | 3.0 | 2.0 | 0.0010 | 2.07 | 24.88 | 0.14 |
| converged from A1 | | 6.78 | 0.30 | 119.18 | 42 | 40.11 | 0.3 | 195.52 | 23.30 | TM | 3.5 | 2.0 | 0.0010 | 2.12 | 27.53 | 0.04 |
| | | | | 119.18 | 20 | 40.44 | 0.1 | 195.14 | 23.26 | F | 5.0 | 2.0 | 0.0010 | 2.42 | 24.23 | 0.02 |
| | | | | 119.18 | 16 | 40.58 | 0.1 | 194.79 | 23.22 | TM | 3.5 | 2.0 | 0.0010 | 2.12 | 27.53 | 0.02 |
| | | | | *TOTAL LENGTH* | *2823.83* | 40.70 | | | | | | | | | | |

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# TableIII1-3.2.2 Calculation for discharge volumes and drainage sections (2)

| Line | Length of catchment (m) | Drainage area (ha) | Runoff Coefficient | Accumulated drainage area (ha) | Flow length (m) | Runoff time (min) | Time of flow (min) | Rainfall intensity ( 1/ha·s) | Runoff Volume (m 3/s) | Cross section type | Width of ditch bottom (m) | Design water depth (m) | Gradient | Flow velocity (m/s) | Flow capasity ($m^3$/s) | Hydraulic slope (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A3 | 74.2 | 0.88 | 0.64 | 0.5[illegible] | 60 | 12.92 | 0.97 | 334.74 | 0.19 | U-1 | 1.0 | 0.8 | 0.001 | 1.03 | 0.82 | 0.06 |
| converged from A5-1 | | 2.98 | 0.64 | 13.3[illegible] | 247 | 14.60 | 2.90 | 306.64 | 4.10 | U-1 | 1.8 | 1.7 | 0.0008 | 1.42 | 4.34 | 0.20 |
| | | | | 13.3[illegible] | 80 | 17.50 | 0.95 | 298.65 | 3.99 | F | 1.8 | 1.6 | 0.0008 | 1.40 | 4.03 | 0.06 |
| | | 0.78 | 0.64 | 13.9[illegible] | 60 | 18.46 | 0.70 | 293.14 | 4.07 | U-1 | 1.8 | 1.8 | 0.0008 | 1.44 | 4.66 | 0.05 |
| converged from A5-2 | | 3.15 | 0.64 | 26.6[illegible] | 178 | 19.15 | 1.55 | 281.76 | 7.50 | U-1 | 3.8 | 1.8 | 0.0008 | 1.92 | 13.11 | 0.14 |
| | | | | 26.6[illegible] | 80 | 20.70 | 0.74 | 276.72 | 7.36 | F | 3.2 | 1.8 | 0.0008 | 1.81 | 10.42 | 0.06 |
| converged from A5-3 | | 0.9 | 0.66 | 35.5[illegible] | 20 | 21.44 | 0.17 | 275.56 | 9.80 | U-1 | 3.3 | 1.8 | 0.0008 | 1.92 | 13.11 | 0.02 |
| | | | | 35.5[illegible] | 80 | 21.61 | 0.74 | 270.79 | 9.63 | F | 3.2 | 1.8 | 0.0008 | 1.81 | 10.42 | 0.06 |
| | | 0.99 | 0.66 | 36.2[illegible] | 115 | 22.35 | 1.00 | 264.65 | 9.58 | U-1 | 3.8 | 1.8 | 0.0008 | 1.92 | 13.11 | 0.09 |
| converged from A5-6 | | 1.04 | 0.66 | 40.9[illegible] | 120 | 23.35 | 1.04 | 264.39 | 10.83 | U-1 | 3.8 | 1.8 | 0.0008 | 1.92 | 13.11 | 0.10 |
| | | | | 40.9[illegible] | 80 | 23.39 | 0.72 | 260.19 | 10.65 | F | 3.4 | 1.8 | 0.0008 | 1.85 | 11.51 | 0.06 |
| | | 0.38 | 0.8 | 41.2[illegible] | 20 | 24.11 | 0.17 | 259.19 | 10.69 | U-1 | 3.8 | 1.8 | 0.0008 | 1.92 | 13.11 | 0.02 |
| converged from A6 | | 0.83 | 0.8 | 55.6[illegible] | 43 | 24.29 | 0.34 | 258.23 | 14.38 | U-1 | 5.0 | 1.8 | 0.0008 | 2.08 | 18.74 | 0.03 |
| | | | | 55.64 | 80 | 24.46 | 0.67 | 254.52 | 14.17 | F | 4.2 | 1.8 | 0.0008 | 1.98 | 14.96 | 0.06 |
| | | 3.49 | 0.79 | 58.4[illegible] | 327 | 25.13 | 2.62 | 241.30 | 14.10 | U-1 | 5.0 | 1.8 | 0.0008 | 2.08 | 18.74 | 0.26 |
| converged from A7-1 | | 0.16 | 0.79 | 63.3[illegible] | 15 | 27.75 | 0.12 | 253.88 | 16.09 | U-1 | 5.0 | 1.8 | 0.0008 | 2.08 | 18.74 | 0.01 |
| | | | | 63.3[illegible] | 80 | 25.25 | 0.66 | 250.37 | 15.87 | F | 4.4 | 1.8 | 0.0008 | 2.01 | 15.89 | 0.06 |
| | | 1.75 | 0.79 | 64.75 | 135 | 25.91 | 1.08 | 244.92 | 15.86 | U-1 | 5.0 | 1.8 | 0.0008 | 2.08 | 18.74 | 0.11 |
| | | | | 64.75 | 90 | 26.99 | 0.75 | 241.33 | 15.63 | F | 4.4 | 1.8 | 0.0008 | 2.01 | 15.89 | 0.07 |
| converged from A7-3 | | | | 67.2[illegible] | 4.5 | 27.74 | 0.03 | 241.16 | 16.21 | F | 6.0 | 1.8 | 0.0008 | 2.19 | 23.60 | 0.00 |
| | | | | 67.2[illegible] | 157.33 | 27.78 | 1.48 | 234.45 | 15.76 | TM | 2.5 | 2.0 | 0.0008 | 1.78 | 15.98 | 0.13 |
| | | | | TOTAL LENGTH | 2071.83 | 29.25 | | | | | | | | | | |
| A6 | 80 | 6.03 | 0.8 | 4.82 | 427 | 8.75 | 5.69 | 336.45 | 1.62 | T-1 | 1.4 | 1.0 | 0.001 | 1.25 | 1.75 | 0.43 |
| | | | | 4.82 | 195 | 14.44 | 2.48 | 301.74 | 1.46 | T-1 | 1.4 | 1.0 | 0.0011 | 1.31 | 1.84 | 0.21 |
| | | | | 4.82 | 20 | 16.92 | 0.21 | 292.91 | 1.41 | F | 1.4 | 1.2 | 0.0015 | 1.61 | 2.70 | 0.03 |
| | | | | 4.82 | 76 | 17.13 | 0.79 | 285.67 | 1.38 | T-1 | 1.4 | 1.2 | 0.0015 | 1.61 | 2.70 | 0.11 |
| | | | | 4.82 | 17 | 17.92 | 0.16 | 276.84 | 1.34 | F | 1.6 | 1.4 | 0.0015 | 1.76 | 3.95 | 0.03 |
| converged from A5-5 | | | | 11.8[illegible] | 91 | 18.08 | 1.10 | 292.91 | 3.48 | T-1 | 1.8 | 1.5 | 0.0008 | 1.38 | 3.72 | 0.07 |
| | | | | 11.8[illegible] | 80 | 19.18 | 0.97 | 292.91 | 3.48 | F | 1.8 | 1.5 | 0.0008 | 1.38 | 3.72 | 0.06 |
| | | 2.36 | 0.79 | 13.7[illegible] | 109.33 | 20.15 | 1.27 | 285.67 | 3.93 | U-1 | 1.8 | 1.8 | 0.0008 | 1.44 | 4.66 | 0.09 |
| | | | | 13.7[illegible] | 90.85 | 21.42 | 1.05 | 276.84 | 3.81 | F | 1.8 | 1.6 | 0.0008 | 1.44 | 4.66 | 0.07 |
| | | | | TOTAL LENGTH | 1106.18 | 22.47 | | | | | | | | | | |
| A7-1 | 90 | 5.34 | 0.9 | 4.8[illegible] | 287 | 6.19 | 3.38 | 387.98 | 1.86 | T-2 | 1.6 | 1.3 | 0.001 | 1.41 | 2.94 | 0.29 |
| | | 0.99 | 0.5 | 5.3[illegible] | 78.35 | 9.57 | 0.95 | 377.52 | 2.00 | TM | 1.0 | 1.3 | 0.001 | 1.38 | 4.13 | 0.08 |
| | | | | 5.3[illegible] | 80.85 | 10.52 | 0.69 | 377.52 | 2.00 | F | 1.6 | 1.2 | 0.002 | 1.96 | 3.76 | 0.16 |
| | | | | TOTAL LENGTH | 446.2 | 11.20 | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| A7-2 | 90 | 4.92 | 0.5 | 2.4[illegible] | 315 | 18.56 | 4.35 | 313.18 | 0.77 | TM | 1.0 | 1.0 | 0.001 | 1.21 | 2.41 | 0.32 |
| | | | | | | 22.91 | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| A7-3 | 51 | 0.16 | 0.38 | 0.0[illegible] | 50 | 16.77 | 1.09 | 267.26 | 0.02 | TM | 1.0 | 0.4 | 0.001 | 0.76 | 0.45 | 0.05 |
| converged from A7-2 | | 0.29 | 0.38 | 2.6[illegible] | 95 | 22.91 | 1.90 | 256.27 | 0.67 | TM | 1.0 | 0.6 | 0.0008 | 0.84 | 0.80 | 0.08 |
| | | | | 2.6[illegible] | 5.5 | 24.81 | 0.05 | 255.97 | 0.67 | U | 6.0 | 1.0 | 0.0008 | 1.67 | 10.01 | 0.004 |
| | | | | TOTAL LENGTH | 150.5 | 24.86 | | | | | | | | | | |

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# TableIII1-3.2.3 Calculation for discharge volumes and drainage sections (3)

| Line | Length of catchment (m) | Drainage area (ha) | Runoff Coefficient | Accumulated drainage area (ha) | Flow length (m) | Runoff time (min) | Time of flow (min) | Rainfall intensity ( l/ha*s) | Runoff Volume (m 3/s) | Cross section type | width of ditch bottom (m) | Design water depth (m) | Gradient | Flow velocity (m/s) | Flow capasity ($m^3$/s) | Hydraulic slope (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ramp | | | | | | | | | | | | | | | | |
| A5-1 | 120 | 6.41 | 0.9 | 5.77 | 270.5 | 7.14 | 3.3 | 388.58 | 2.24 | T-2 | 1.6 | 1.1 | 0.001 | 1.35 | 2.38 | 0.27 |
| | | | | 5.77 | 21 | 10.48 | 0.3 | 384.17 | 2.22 | T-2 | 1.6 | 1.2 | 0.0008 | 1.24 | 2.38 | 0.02 |
| (converged from | | | | 5.77 | 194 | 10.76 | 2.6 | 348.74 | 2.22 | F | 1.6 | 1.2 | 0.0008 | 1.24 | 2.38 | 0.16 |
| A4-1, A4-2) | | | | 10.90 | 95.5 | 13.37 | 1.2 | 335.52 | 3.66 | F | 1.8 | 1.5 | 0.0008 | 1.38 | 3.72 | 0.08 |
| | | | | *TOTAL LENGTH* | *581* | 14.53 | | | | | | | | | | |
| A5-2 | 120 | 7.37 | 0.9 | 6.63 | 390 | 7.14 | 4.7 | 368.49 | 2.44 | T-2 | 1.6 | 1.2 | 0.001 | 1.38 | 2.66 | 0.39 |
| | | | | 6.63 | 21 | 11.84 | 0.3 | 364.72 | 2.42 | T-2 | 1.6 | 1.3 | 0.0008 | 1.26 | 2.63 | 0.02 |
| | | | | 6.63 | 194 | 12.12 | 2.6 | 336.38 | 2.23 | F | 1.6 | 1.2 | 0.0008 | 1.24 | 2.38 | 0.16 |
| (converged from | | | | 10.72 | 95.5 | 14.45 | 1.2 | 324.28 | 3.48 | F | 1.8 | 1.5 | 0.0008 | 1.38 | 3.72 | 0.08 |
| A4-3, A4-4) | | | | *TOTAL LENGTH* | *700.5* | 15.61 | | | | | | | | | | |
| A5-3 | 120 | 5.04 | 0.9 | 4.54 | 255 | 7.14 | 3.2 | 390.22 | 1.77 | T-2 | 1.6 | 1.0 | 0.001 | 1.32 | 2.10 | 0.26 |
| (converged from A5-4) | | 3.19 | 0.9 | 7.41 | 21 | 10.38 | 0.3 | 385.94 | 2.86 | T-2 | 1.6 | 1.4 | 0.0008 | 1.29 | 2.89 | 0.02 |
| | | | | 7.41 | 79 | 10.65 | 1.0 | 370.72 | 2.75 | F | 1.6 | 1.35 | 0.0008 | 1.28 | 2.76 | 0.06 |
| | | 1.58 | 0.6 | 8.36 | 120.25 | 11.68 | 1.5 | 351.31 | 2.94 | U-1 | 1.8 | 1.4 | 0.0008 | 1.35 | 3.41 | 0.10 |
| | | | | 8.36 | 90.25 | 13.16 | 1.1 | 338.34 | 2.83 | F | 1.8 | 1.4 | 0.0008 | 1.35 | 3.41 | 0.10 |
| | | | | *TOTAL LENGTH* | *565.5* | 14.27 | | | | | | | | | | |
| A5-4 | 120 | 2.47 | 0.9 | 2.22 | 125 | 7.14 | 1.5 | 420.52 | 0.93 | T-2 | 1.6 | 1.2 | 0.001 | 1.38 | 2.66 | 0.13 |
| | | | | | | 8.65 | | | | | | | | | | |
| A5-5 | 126.2 | 8.26 | 0.9 | 7.43 | 411 | 7.33 | 4.8 | 363.96 | 2.71 | T-2 | 1.6 | 1.3 | 0.001 | 1.41 | 2.94 | 0.41 |
| | | | | | | 12.17 | | | | | | | | | | |
| A4-1 | 175.6 | 2.01 | 0.85 | 1.71 | 60 | 10.80 | 0.7 | 373.38 | 0.64 | U-1 | 1.0 | 0.8 | 0.002 | 1.46 | 1.16 | 0.12 |
| | | | | | | 11.49 | | | | | | | | | | |
| A4-2 | 176.9 | 4.03 | 0.85 | 3.43 | 210 | 10.84 | 3.2 | 341.39 | 1.17 | U-1 | 1.0 | 1.1 | 0.001 | 1.11 | 1.22 | 0.21 |
| | | | | | | 14.00 | | | | | | | | | | |
| A4-3 | 176.9 | 1.6 | 0.85 | 1.36 | 50 | 10.84 | 0.6 | 374.45 | 0.51 | U-1 | 1.0 | 0.8 | 0.002 | 1.46 | 1.16 | 0.10 |
| | | | | | | 11.42 | | | | | | | | | | |
| A4-4 | 176.4 | 3.21 | 0.85 | 2.73 | 140 | 10.83 | 2.1 | 354.12 | 0.97 | U-1 | 1.0 | 1.1 | 0.001 | 1.11 | 1.22 | 0.14 |
| | | | | | | 12.93 | | | | | | | | | | |
| A4-5 | 177.2 | 1.59 | 0.85 | 1.27 | 95 | 10.85 | 1.1 | 367.10 | 0.47 | U-1 | 1.0 | 0.8 | 0.002 | 1.46 | 1.16 | 0.19 |
| | | | | | | 11.94 | | | | | | | | | | |
| A4-6 | 179.1 | 3.18 | 0.85 | 3.50 | 95 | 10.91 | 1.0 | 367.08 | 1.28 | U-1 | 1.0 | 1.0 | 0.002 | 1.54 | 1.54 | 0.19 |
| | | | | | | 11.94 | | | | | | | | | | |

# TableIII1-3.2.4 Calculation for discharge volumes and drainage sections (4)

| Line | Length of catchment (m) | Drainage area (ha) | Runoff coefficient | Accumulated drainage area (ha) | Flow length (m) | Runoff time (min) | Time of flow (min) | Rainfall intensity (l/ha•s) | Runoff Volume (m 3/s) | Cross section type | width of ditch bottom (m) | Design water depth (m) | Gradient | Flow velocity (m/s) | Flow capasity ($m^3/s$) | Hydraulic slope (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B1 | 200 | 18.15 | 0.38 | 6.90 | 670 | 33.20 | 9.17 | 190.34 | 1.31 | TM | 1.2 | 1.2 | 0.0008 | 1.22 | 3.51 | 0.54 |
| | | | | 6.90 | 20 | 42.37 | 0.30 | 189.56 | 1.31 | T-1 | 1.6 | 0.8 | 0.0008 | 1.10 | 1.40 | 0.02 |
| | | 17.37 | 0.38 | 13.50 | 640 | 42.67 | 8.76 | 170.04 | 2.30 | TM | 1.2 | 1.2 | 0.0008 | 1.22 | 3.51 | 0.51 |
| | | | | 13.50 | 20 | 51.43 | 0.27 | 169.52 | 2.29 | F | 1.6 | 1.2 | 0.0008 | 1.24 | 2.38 | 0.02 |
| | | 11.58 | 0.38 | 17.90 | 440 | 51.70 | 5.52 | 177.29 | 3.17 | T-1 | 1.6 | 1.6 | 0.0008 | 1.33 | 3.40 | 0.55 |
| | | 7.24 | 0.38 | 20.65 | 250 | 47.89 | 3.26 | 170.58 | 3.52 | TM | 1.6 | 1.2 | 0.0008 | 1.28 | 4.29 | 0.20 |
| | | | | 20.65 | 25 | 51.15 | 0.30 | 170.00 | 3.51 | F | 1.8 | 1.6 | 0.0008 | 1.40 | 4.03 | 0.02 |
| | | 4.4 | 0.3 | 21.97 | 309.95 | 51.45 | 3.62 | 163.84 | 3.60 | TM | 1.6 | 1.2 | 0.001 | 1.43 | 4.80 | 0.31 |
| | | | | *TOTAL LENGTH* | *2374.95* | 54.77 | | | | | | | | | | |
| B2 | 148.5 | 1.30 | 0.88 | 1.14 | 107.0 | 8.74 | 1.99 | 384.63 | 0.44 | F | 1.0 | 0.50 | 0.001 | 0.90 | 0.45 | 0.11 |
| | | 6.49 | 0.60 | 5.04 | 242 | 10.73 | 3.23 | 341.88 | 1.72 | T-1 | 1.4 | 1.0 | 0.001 | 1.25 | 1.75 | 0.24 |
| | | | | 5.04 | 180 | 13.96 | 2.63 | 314.80 | 1.59 | F | 1.6 | 0.9 | 0.0008 | 1.14 | 1.64 | 0.14 |
| | | 7.72 | 0.60 | 9.67 | 200 | 16.59 | 2.51 | 293.50 | 2.84 | T-1 | 1.8 | 1.3 | 0.0008 | 1.33 | 3.10 | 0.16 |
| | | | | 9.67 | 200 | 19.10 | 2.57 | 275.13 | 2.66 | F | 1.8 | 1.2 | 0.0008 | 1.30 | 2.80 | 0.16 |
| | | 1.34 | 0.57 | 10.43 | 40 | 21.68 | 0.50 | 271.87 | 2.84 | T-1 | 1.8 | 1.3 | 0.0008 | 1.33 | 3.10 | 0.03 |
| | | 6.70 | 0.57 | 14.25 | 200 | 22.18 | 2.38 | 257.65 | 3.67 | T-1 | 1.8 | 1.6 | 0.0008 | 1.40 | 4.03 | 0.16 |
| | | | | 14.25 | 80 | 24.56 | 0.95 | 265.94 | 3.79 | F | 1.8 | 1.6 | 0.0008 | 1.40 | 4.03 | 0.06 |
| | | 11.27 | 0.53 | 20.23 | 448 | 23.13 | 5.13 | 238.88 | 4.83 | T-1 | 1.8 | 1.9 | 0.0008 | 1.45 | 4.97 | 0.36 |
| | | | | 20.23 | 152 | 28.27 | 1.74 | 231.19 | 4.68 | F | 1.8 | 1.9 | 0.0008 | 1.45 | 4.97 | 0.12 |
| | | 4.19 | 0.59 | 22.70 | 80 | 30.01 | 0.91 | 227.43 | 5.16 | T-1 | 1.8 | 2.0 | 0.0008 | 1.47 | 5.29 | 0.06 |
| | | | | 22.70 | 20 | 30.91 | 0.23 | 226.51 | 5.14 | F | 1.8 | 2.0 | 0.0008 | 1.47 | 5.29 | 0.02 |
| | | | | 22.70 | 220 | 31.14 | 2.23 | 218.80 | 4.97 | F | 1.8 | 2.0 | 0.0010 | 1.64 | 5.92 | 0.22 |
| | | 14.4 | 0.6 | 31.34 | 284.33 | 33.15 | 2.98 | 208.47 | 6.53 | TM | 1.0 | 1.7 | 0.0010 | 1.59 | 7.30 | 0.28 |
| | | | | 31.34 | 28 | 36.13 | 0.16 | 207.96 | 6.52 | F | 1.8 | 1.8 | 0.0034 | 2.96 | 9.60 | 0.10 |
| converged from B3 | | 10.97 | 0.85 | 116.09 | 130 | 36.28 | 1.14 | 204.84 | 23.78 | TM | 3.0 | 2.1 | 0.0008 | 1.90 | 24.57 | 0.10 |
| converged from B6 | | 21.89 | 0.9 | 135.78 | 213 | 37.27 | 1.78 | 199.48 | 27.09 | TM | 3.0 | 2.3 | 0.0008 | 2.00 | 29.63 | 0.17 |
| | | | | 135.78 | 10 | 39.04 | 0.08 | 199.24 | 27.05 | TM | 3.0 | 2.3 | 0.0008 | 2.00 | 29.63 | 0.01 |
| | | | | 135.78 | 20 | 39.13 | 0.12 | 198.89 | 27.01 | F | 5.0 | 2.3 | 0.0012 | 2.79 | 32.10 | 0.02 |
| | | 7.3 | 0.4 | 138.70 | 203.5 | 39.25 | 1.39 | 194.98 | 27.04 | TM | 3.0 | 2.3 | 0.0012 | 2.45 | 36.29 | 0.24 |
| | | | | 138.70 | 20 | 40.63 | 0.12 | 194.65 | 27.00 | F | 5.0 | 2.3 | 0.0012 | 2.79 | 32.10 | 0.02 |
| | | 3.02 | 0.4 | 139.91 | 34 | 40.75 | 0.23 | 198.82 | 27.58 | TM | 3.5 | 2.3 | 0.0012 | 2.50 | 39.92 | 0.04 |
| | | | | *TOTAL LENGTH* | *3111.8* | 39.27 | | | | | | | | | | |

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## TableIII1-3.2.5 Calculation for discharge volumes and drainage sections (5)

| Line | Length of catchment (m) | Drainage area (ha) | Runoff coefficient | Accumulated drainage area (ha) | Flow length (m) | Runoff time (min) | Time of flow (min) | Rainfall intensity ( l/ha·s) | Runoff Volume (m 3/s) | Cross section type | width of ditch bottom (m) | Design water depth (m) | Gradient | Flow velocity (m/s) | Flow capasity ($m^3/s$) | Hydraulic slope (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B3-1 | 110 | 3.17 | 0.52 | 1.65 | 99.65 | 20.37 | 1.83 | 271.69 | 0.45 | U-1 | 1.2 | 0.6 | 0.0008 | 0.91 | 0.65 | 0.08 |
| | | | | 1.65 | 90.85 | 22.21 | 1.53 | 262.36 | 0.43 | F | 1.2 | 0.8 | 0.0008 | 0.99 | 0.95 | 0.07 |
| B3 | | 0.23 | 0.55 | 1.77 | 55 | 23.74 | 1.08 | 256.24 | 0.45 | U-1 | 1.0 | 0.6 | 0.0008 | 0.85 | 0.51 | 0.04 |
| | | 2.11 | 0.58 | 4.87 | 58 | 24.81 | 0.92 | 257.12 | 0.74 | U-1 | 1.2 | 1.0 | 0.0008 | 1.05 | 1.26 | 0.05 |
| | | | | 4.87 | 80 | 24.66 | 1.35 | 249.91 | 0.72 | F | 1.2 | 0.8 | 0.0008 | 0.99 | 0.95 | 0.06 |
| converged from B5 | | 1.48 | 0.66 | 11.57 | 111 | 26.00 | 1.40 | 242.97 | 2.81 | U-1 | 1.8 | 1.3 | 0.0008 | 1.33 | 3.10 | 0.09 |
| | | | | 11.57 | 20 | 27.40 | 0.25 | 241.77 | 2.80 | F | 1.8 | 1.3 | 0.0008 | 1.33 | 3.10 | 0.02 |
| | | 2.32 | 0.66 | 13.10 | 150 | 27.65 | 1.89 | 233.22 | 3.06 | U-1 | 1.8 | 1.3 | 0.0008 | 1.33 | 3.10 | 0.12 |
| converged from B4-1 | | | | 25.14 | 24 | 29.53 | 0.24 | 228.83 | 5.75 | U-1 | 3.8 | 1.3 | 0.0008 | 1.70 | 8.40 | 0.02 |
| | | | | 25.14 | 80 | 29.77 | 0.80 | 219.30 | 5.51 | F | 3.2 | 1.4 | 0.0008 | 1.66 | 7.45 | 0.06 |
| | | 3.55 | 0.63 | 27.38 | 256 | 30.57 | 2.44 | 219.30 | 6.00 | U-1 | 3.8 | 1.4 | 0.0008 | 1.75 | 9.31 | 0.20 |
| converged from B4-2 | | | | 36.20 | 17 | 33.01 | 0.16 | 218.70 | 7.92 | U-1 | 3.8 | 1.4 | 0.0008 | 1.75 | 9.31 | 0.01 |
| | | | | 36.20 | 80 | 33.17 | 0.77 | 215.93 | 7.82 | F | 3.2 | 1.6 | 0.0008 | 1.74 | 8.91 | 0.06 |
| | | 5.31 | 0.68 | 39.81 | 253 | 33.94 | 2.29 | 208.13 | 8.28 | U-1 | 3.8 | 1.6 | 0.0008 | 1.84 | 11.18 | 0.20 |
| | | | | 39.81 | 80 | 36.23 | 0.77 | 205.68 | 8.19 | F | 3.2 | 1.6 | 0.0008 | 1.74 | 8.91 | 0.06 |
| converged from B4-3 | | 5.11 | 0.7 | 43.38 | 420 | 37.00 | 3.81 | 194.52 | 8.44 | U-1 | 3.8 | 1.6 | 0.0009 | 1.84 | 11.18 | 0.34 |
| converged from B4-4 | | 0.8 | 0.7 | 54.90 | 66 | 40.80 | 0.55 | 193.02 | 10.60 | U-1 | 5.0 | 1.6 | 0.0008 | 1.99 | 15.90 | 0.05 |
| | | | | 54.90 | 80 | 41.36 | 0.71 | 191.13 | 10.49 | F | 4.0 | 1.6 | 0.0008 | 1.87 | 11.95 | 0.06 |
| | | 2.18 | 0.72 | 56.47 | 137 | 42.07 | 1.15 | 188.18 | 10.63 | U-1 | 5.0 | 1.6 | 0.0008 | 1.99 | 15.90 | 0.11 |
| | | | | 56.47 | 100 | 43.22 | 0.89 | 185.97 | 10.50 | F | 4.0 | 1.6 | 0.0008 | 1.87 | 11.95 | 0.08 |
| converged from B4-5 | | | | 73.89 | 297 | 44.11 | 2.98 | 179.04 | 13.23 | TM | 2.5 | 1.7 | 0.0008 | 1.66 | 14.24 | 0.24 |
| | | | | TOTAL LENGTH | 2364.0 | 47.09 | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |

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# TableIII1-3.2.6 Calculation for discharge volumes and drainage sections (6)

| Line | Length of catchment (m) | Drainage area (ha) | Runoff Coefficient | Accumulated drainage area (ha) | Flow length (m) | Runoff time (min) | Time of flow (min) | Rainfall intensity ( l/ha-s) | Runoff Volume (m 3/s) | Cross section type | width of ditch bottom (m) | Design water depth (m) | Gradient | Flow velocity (m/s) | Flow capasity ($m^3$/s) | Hydraulic slope (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B4-0 | 20.5 | 2.7 | 0.65 | 1.76 | 351.33 | 6.64 | 4.40 | 379.96 | 0.67 | TM | 0.4 | 0.8 | 0.002 | 1.33 | 1.28 | 0.70 |
| | | | | 1.76 | 24 | 11.04 | 0.23 | 376.56 | 0.66 | F | 1.2 | 1.2 | 0.002 | 1.73 | 2.50 | 0.05 |
| | | | | TOTAL LENGTH | 375.33 | 11.27 | | | | | | | | | | |
| B4-1 | 60 | 13.34 | 0.58 | 7.74 | 200.12 | 13.13 | 2.00 | 329.10 | 2.55 | TM | 0.4 | 1.2 | 0.002 | 1.67 | 3.21 | 0.40 |
| | | | | 7.74 | 20 | 15.13 | 0.19 | 327.16 | 2.53 | F | 1.2 | 1.3 | 0.002 | 1.76 | 2.75 | 0.04 |
| converged from B4-0 | | 8.9 | 0.65 | 15.28 | 168.81 | 15.32 | 1.48 | 312.86 | 4.78 | TM | 0.4 | 1.5 | 0.002 | 1.90 | 5.41 | 0.34 |
| | | | | 15.28 | 82.25 | 16.80 | 0.95 | 304.45 | 4.65 | F | 1.8 | 1.8 | 0.0008 | 1.44 | 4.66 | 0.07 |
| | | | | TOTAL LENGTH | 471.18 | 17.76 | | | | | | | | | | |
| B4-2 | 57 | 10.63 | 0.83 | 8.82 | 355.81 | 6.65 | 3.39 | 395.68 | 3.49 | TM | 0.4 | 1.3 | 0.002 | 1.75 | 3.86 | 0.71 |
| | | | | 8.82 | 82.25 | 10.04 | 0.95 | 380.66 | 3.36 | F | 1.8 | 1.8 | 0.0008 | 1.44 | 4.66 | 0.07 |
| | | | | TOTAL LENGTH | 438.06 | 10.99 | | | | | | | | | | |
| B4-3 | 57 | 13.21 | 0.83 | 10.96 | 455.81 | 6.65 | 4.16 | 383.42 | 4.20 | TM | 0.4 | 1.4 | 0.002 | 1.82 | 4.60 | 0.91 |
| | | | | 10.96 | 82.25 | 10.81 | 0.95 | 369.52 | 4.05 | F | 1.8 | 1.8 | 0.0008 | 1.44 | 4.66 | 0.07 |
| | | | | TOTAL LENGTH | 538.06 | 11.76 | | | | | | | | | | |
| B4-4 | 57 | 13.20 | 0.83 | 10.96 | 405.21 | 6.65 | 3.70 | 390.65 | 4.28 | TM | 0.4 | 1.4 | 0.002 | 1.82 | 4.60 | 0.81 |
| | | | | 10.96 | 82.85 | 10.35 | 0.96 | 375.99 | 4.12 | F | 1.8 | 1.8 | 0.0008 | 1.44 | 4.66 | 0.07 |
| | | | | TOTAL LENGTH | 488.06 | 11.31 | | | | | | | | | | |
| B4-5 | 57 | 26.40 | 0.66 | 17.42 | 474.5 | 10.83 | 3.40 | 338.78 | 5.90 | TM | 0.4 | 1.5 | 0.003 | 2.33 | 6.63 | 1.42 |
| | | | | 17.42 | 60 | 14.23 | 0.44 | 333.96 | 5.82 | F | 1.8 | 1.8 | 0.002 | 2.27 | 7.36 | 0.12 |
| | | | | 17.42 | 20 | 14.67 | 0.17 | 332.15 | 5.79 | TM | 0.4 | 1.6 | 0.002 | 1.97 | 6.31 | 0.04 |
| | | | | TOTAL LENGTH | 554.5 | 14.84 | | | | | | | | | | |
| B5 | 132 | 10.88 | 0.71 | 7.72 | 430 | 14.61 | 6.00 | 282.39 | 2.18 | T-1 | 1.4 | 1.3 | 0.0008 | 1.20 | 2.18 | 0.00 |
| | | | | 7.72 | 301.42 | 20.61 | 4.66 | 253.80 | 1.96 | TM | 1.0 | 1.0 | 0.0008 | 1.08 | 2.16 | 0.24 |
| | | | | 7.72 | 20 | 25.26 | 0.28 | 252.33 | 1.95 | F | 1.6 | 1.1 | 0.0008 | 1.21 | 2.13 | 0.02 |
| | | | | 7.72 | 209.25 | 25.54 | 3.08 | 237.27 | 1.83 | TM | 1.0 | 1.1 | 0.0008 | 1.13 | 2.62 | 0.17 |
| | | | | 7.72 | 101.25 | 28.62 | 1.36 | 231.30 | 1.79 | F | 1.6 | 1.2 | 0.0008 | 1.24 | 2.38 | 0.08 |
| | | | | TOTAL LENGTH | 1061.9 | 29.98 | | | | | | | | | | |