CHAPTER4 REGULATING RESERVOIRS AND PUMP FACILITIES

4.1 Summary of Design

(1) Purpose

The basic principles of capacity and size of facilities should be in accordance of those of the Basic Design. Facilities should be comprised of a regulating reservoir, drainage pump facilities and electromotive gate facilities. The purpose is no hindrance of safe operation as a result of water standing.

(2) Changes in the Basic Design

Based on the plan of the object control level (the level of surrounding waterways)outside Pudong International Airport, it was determined that changes should be made regarding division of drainage pumps, locations and methods of installation of electromotive gates to be used to switch between natural down- streaming and forced drainage.

1) Details of Changes

Table III1-4.1.1 Details of Changes

Item of Change	Basic Design	Detail Design
1.Electromotive gate (1)Location of installation (2)Number of gates	Front stage of the regulating reservoir 2	Rear stage of the regulating reservoir 1
(3)Reason of change)	Change of the control method of regulating reservoirs One of two methods should be employed to control of regulating reservoirs according to the rainy season (May - October)or the dry season. In the rainy season, if a heavy rain is forecasted, the water level will be lowered as precaution against the rain, and pump drainage will be carried out. In the dry season, natural drainage will be carried out because the outside water level will be low and there will be a small number of heavy rains. Therefore, the number of gates was determined to be one and pump stations and gate rooms were determined to be unified.	
2.Breakdowny of drainage pumps (1)Draining capacity (2)Breakdown of pumps	* 10m3/s=600m3/min (both in the south and the north) In consideration of small volume of rain, two kinds of pumps, big and small, was determined to be used. * 2.87m3/s x 3 pumps (one for a spare among them) * 1.43m3/s x 3 pumps (2.87 x 2 + 1.43 x 3 = 10.0) (2.87×2+1.43×3=10.0)	Same as those in the left column. As a result of change of the control method of regulating reservoir, it was determined to install a pump station to cope with heavy rains. One type of pumps to cope with heavy rains should be used. * 2.0m3/s x 6 pumps (one for a warehouse spare among them)

4.2 Regulating Reservoir

(1) Location of Installation

For the drainage system, the whole airport should be divided into four areas based on the Basic Design . As drainage channels in Phase I will be divided into two systems, A and B, in parallel with the runway and parallel taxiways and in the north and the south. Therefore, reservoirs should be installed at the ends of the both drainage channels in the north and the south.

(2) Form and Size of Facilities

1) South Area (Area A)

a) Size and form of facilities : 130m x 215m x 5.0mH (trapezoid)

b) Effective capacity : 57,570 m3

2) North Area (Area B)

a) Size and form of facilities : 150m x 165m x 5.0mH (trapezoid)

b) Effective capacity : 47,470 m3

(3) Design Conditions

1) Regulating ReservoirRecquired

*capacity : South area (Area A)36.500m3 or more

: North Area (Area B) 37,500m3 or more

*Bottom of inflow tube : Both north and south ±0.00m

*Water level for pump start

: Both north and south +2.350m or more

*Water level for pump stop

: Both north and south ±0.00m

*Height of floor

: Both north and south -- 1.000m (considering sand stop)

2) Drainage Pump Station

*Draining capacity : Both north and south 10m3/s

*Pump capacity : Both north and south 2m3/s x 5 pumps

*Spare pump : Both north and south 1 pump of 2m3/s as warehouse spare

(4) Summary of Facilities

For drainage from the Flight Area, the Two-Step Pump Statiion Plan should be employed according to the geographical features in the airport. The first-step drainage system consists of drainageways and culvers in the Flight Area of the airport. The second-step drainage system consists of natural rivers such as surrounding waterways and artificial rivers. As the geographical position of the airport is low, the first-step drainage system cannot discharge all rainwater in the airport completely to the second-step drainage system. Therefore, it is necessary to install, by the side of each of two regulating reservoirs, one pump station to pump up rainwater. Drainage systems with large volume of water storage in the Flight Area will perform a role as peak cut. This will enable capacity of facilities for rainwater pumps to be reduced. Based on the planned manimum volume of water drained from the Flight Area and the capacity of regulating reservoirs, and in consideration of the way of raining in Shanghai, the planned draining capacity of rainwater pump stations in the Flight Area was determined to be 10m3/s.

4.3 Pump Facilities

(1) Machinery facilities

1) Surrounding Waterways

a) Details

Conditions of surrounding waterways in the north and the south are as follows:

Table III-4.3.1 Details of Surrounding Waterways

Item	South Area	North Area
Height of riverbank	+4.000m	+4.000m
Height of river floor	+0.500m	−0.500m
Height of protection wall on the bank	+4.500m	+4.500m
Regular water level	+2.350m	+2.350m
Water level for flood with 20-year probability	+3.200m	+3.200m
Water level for flood with 50-year probability	+3.800m	+3.800m

b) Draining System

Rainwater from the Flight Area will enter regulating reservoirs first, and then enter rainwater pump stations. If the water level of the first-step drainage system is lower than the level at the drainage exit in the airport, rainwater in the Flight Area will be able to be discharged naturally. Therefore, a draining gate should be constructed in a pump station. Water in Flight Area should be discharged naturally by opening the gate if:

*the water level of the second-step drainage system is +2.35 or lower , and

*difference between first- and second- step drainage systems is +0.5m or more.

If the water level of the first-step drainage system is 2.35m or higher, the gate will be closed. According to climate information, in the cases of a certain volume of rains, and big/heavy rains, gates will be closed in advance first. Then, the water level of regulating reservoirs will be lowered by starting pumps in order to empty water storage. Opening and closing of gates will be carried out by remote control. If it is impossible, gates should be opened or closed manually. Pumps should have the dual control system, automatic and manual. If the water level of a regulating reservoir reaches +2.35m (the water level for alarm), 5 pumps will start operation automatically. If the level of a regulating reservoir reaches ±0.00m, all pumps will stop operation automatically. Operation with the reservoir water level of ±0.00m or higher is as follows:

* One pump will work with level of +0.500m

* One pump will be added each time the level will raise by 0.5m
* Five pumps will work with the level of +2.350m.

In consideration of necessity of cleaning out the bottom of a regulating reservoir, the water level of regulating reservoirs should be made to be lowered to −1.0m at the minimum. This level is the minimum operation water level of pumps. If the water level drops to this minimum level, the control system for pumps will stop pumps compulsorily.

As regulation volume of regulating reservoirs in the Flight Area is large, it will be possible to stabilize stream inflowing to a water absorbing reservoir in the balanced way. Therefore, frequent operation for stop of start will not occur. For rainwater pump stations in the Flight Area, 5 diving axial flow pumps should be used. The flow rate of one pump is 2.0m3/s, planned height of pumping-up is 2.9m, and designed height of pumping-up is 3.7m. Height of the exit of a pump is 2.8m. Water at the exit of the reservoir will be discharged to a river through a drainageway. Screening facilities will be installed in front of an absorbing reservoir for a pump. The facilities will remove large refuse in the inflowing water. They will also perform a role of keeping the pump to work with the normal condition. Space of screens should be 50mm, current velocity of passing a screen should be 0.6m/s, and angle of installation of a screen should 75° . The electromotive drive system should be employed. Large refuse removed with a screen should be stored in a sludge hopper through a conveyor, carried out as the occasion may demand and delivered to the central disposal facilities.

4.4 Proposal of Comprehensive Rainwater-Drainage Control System

In the Flight Area, there are two rainwater-drainage pump stations with regulating reservoirs, Terminal Area rainwater-drainage pump stations and many planned rainwater-drainage pump stations in the related facilities area and future sites planned. In addition, there are two pump stations established by Shanghai Irrigation Department outside the airport. Comprehensive and concentrated control of these rainwater drainage facilities will enable grasp of the situation of respective facilities at one site and realization of proper operation with accurate and quick processing of large volume of information. Therefore, introduction of a comprehensive rainwater-drainage control system is proposed.

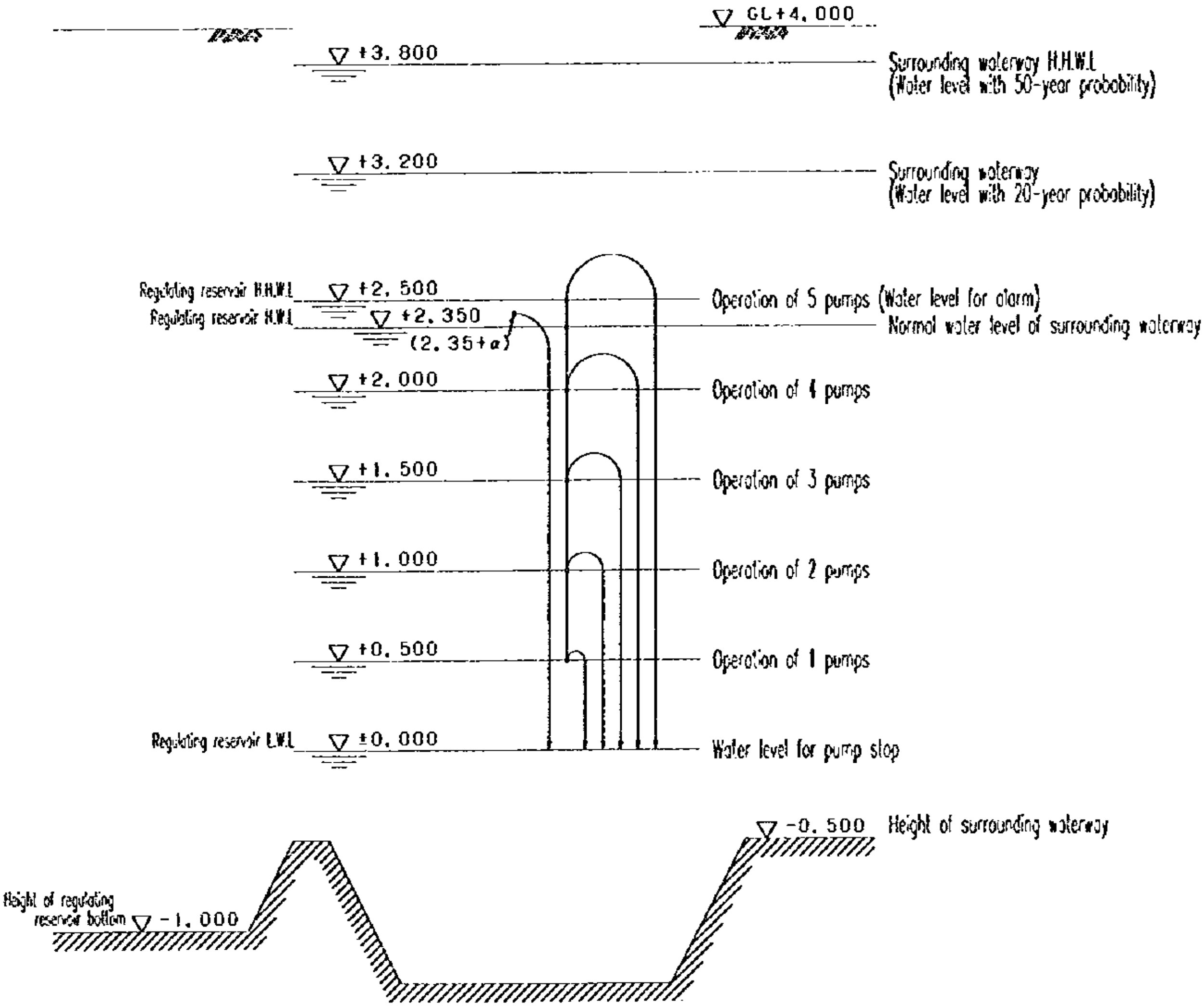
Comprehensive control systems are roughly divided into input/output devices, monitoring and control devices, and data processing devices. The systems are also comprised of transmission channels connecting input/output devices and monitoring and control devices. As materials for final determination, each device necessary for Pudong International Airport is disccussed below.

(1) Input/Output Device

Input/output devices are to be installed in pump stations. They are used to input/output necessary monitoring and control items. The monitoring and control items are as follows:

* Water level	:	Regulating reservoirs, pumping wells in rainwater pump stations, surrounding waterways etc.
* State of Operation	:	Number of pumps, opening/closing of gates, switching of operation/stop/control mode of related equipment, operational index, troubles, abnormality etc.
* Measured values	:	Voltage, current, electric power of destributed electric power, and so on

For control of the number of pumps, possible methods are those using the water level shown in FigureIII1-4.4.1.



Remarks

1. Regulating reservoir volume
   H.W.L ~ L.W.L : 57,540m³ (A)
   H.W.L ~ L.W.L : 47,470m³ (B)
2. Time of pump drainage while the gate is closed (Time of drainage of H.W.L ~ L.W.L)
   During operation of 4 pumps : Approx. 2hours
   $47{,}470m^3 \div (2m^3/sec \times 4 \times 3600) = 1.65hours \doteq 2hours$
3. Specifications of pumps
   Number of pumps : 5
   Capacity : (2m³/sec)

FigureIII-4.4.1 Plan of Control of Operating Pump Number

(2) Monitoring and Control Device

A monitoring and control device is installed in a central monitoring room. It grasps the states of equipment and facilities, which are transmitted from input/output devices, by means of measurement / indication, and operates or controls them to direct the desirable state.

1) Selection of Methods

In consideration of forms of operation control and of monitoring and control systems, monitoring and control methods are divided to the following systems. (See FigureIII1-4.4.2.)

a) Individual Monitoring Operation System

Generally, it is a system to carry out operation on site or in the equipment side while directly monitoring main devices and processes.

b) Central Monitoring Individual Operation System

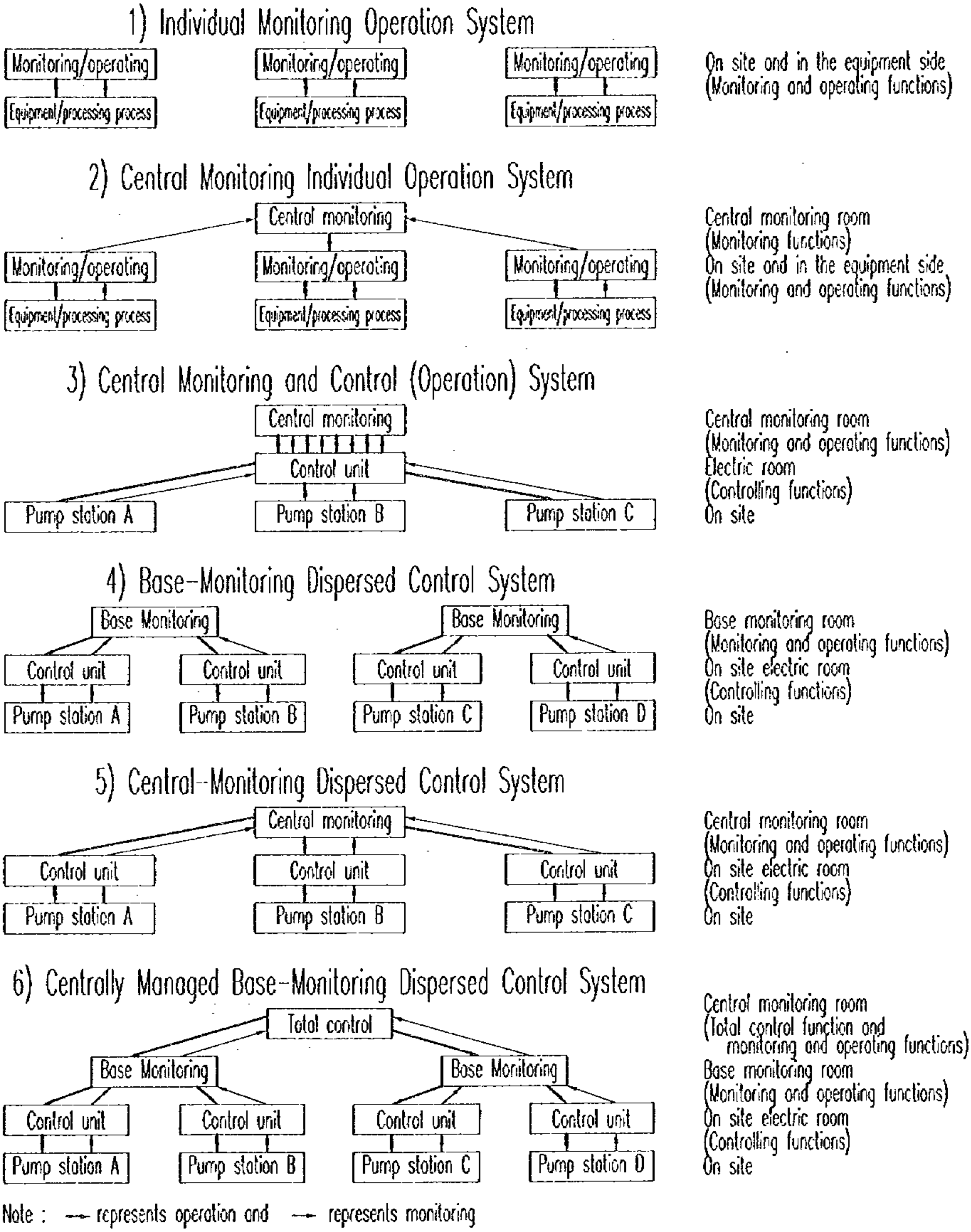
It is a system of individual monitoring operation which gives a central monitoring room a function to monitor conditions of operation of the whole facilities. Rational total control can be carried out by means of feedback of monitored information.

c) Central Monitoring and Control (Operation)System

It is a system for concentrated monitoring and control with installation of a central monitoring room where monitoring and operation of the whole facilities are carried out. Concentrated control means that hardware of control mechanism is installed at one site in the concentrated manner both functionally and locationnaly.

d) Base-Monitoring Dispersed Control System

It is a system to conduct concentrated monitoring and operation by dividing base facilities to several lines (the xxx line, the +++line etc.)or sub-systems (pumping stations, regulating reservoirs, gate facilities etc.) and by installing bases (base monitoring rooms)for monitoring and control in each line/sub-systtem. Dispersed control means that hardware of controlling mechanism is dispersed functionally. This dispersed installation enables to prevent risks that one trouble will influence the whole system and to increase reliability of the whole system.



FigureIII-4.4.2 Classification of Monitoring and Control Systems

e) Central-Monitoring Dispersed Control System

It is a system to carry out monitoring operation at one site, i.e. in a central monitoring room, similarly to the central monitoring and control system, with dispersice installation of controlling functions similarly to the base-monitoring dispersed control system.

f) Centrally Managed Base-Monitoring Dispersed Control System

It is a base-monitoring dispersed control system with a function (central control room)to totally control operation of the whole facilities. The concentrated control function in a base monitoring room (a local monitoring room)in this method is considered a back-up monitoring and control system for central total control functions. Therefore, it doesn't monitor operation regularly.

Upon selection of monitoring and control systems, it is necessary to select a system whicht fits characteristics of each pump, in consideration of arrangement of facilities,movement and development of future measuring technology,equipment forming a system,expansibility in consideration of life time etc. of devices, maintenance and management systems, and so on.

As a result of examination, the central-monitoring dispersed control system is considered suitable for this airport from the following viewpoints:

* Arrangement of Facilities : Pumps are located dispersively and the central monitoring room is at a long distance. However, the sizedoesn't require installation of monitoring bases.

* Expansibility: Pumps will not be completed at one time but constructed step by step. In this case, this system can prevent suspension of facilities and makes change of controlling methods easy aswell as employment of an information processing system.

* Maintenance and Management System: In the management system of this establishment, facilities inside the airport and those outside the airport are different. No-man operation during night can be monitored at a distance. Regular no-man operation is also possible.

(3) Control Unit

Proper control units should be selected in consideration of the degree, kinds etc. of control. Basically, there are three methods of control as follows:

1) Sequence Control

Each stage of control is carried out one by one according to the order fixed in advance.

2) Feedback Control

Volume of control is compared with aimed values by means of feedback, and corrective actions are taken to make the actual volume fall in line with the aimed one.

3) Feedforward Control

Necessary corrective actions are taken by controlling outside disorder before the influence will appear on the control system.

This establishment will have to control pump stations inside the airport and two pump stations outside the airport. In addition, with control of pump stations inside the airport, corrective actions will have to be carried out by controlling pumps outside the airport. However, control volume of pump stations outside the airport is relatively small. Therefore, feedback control is considered the most suitable.

(4) Data Processing Unit

A data processing unit is a device to deal with various kinds of data and information by using excellent functions of computers. In the context of this document, it represents a general term of devices which conduct information processing such as recording, monitoring, controlling etc. of information in the processing process.

Generally, the device is comprised of hardware such as a central processing unit (CPU), a main storage, an arithmetic unit, a control unit and peripheral equipment (input devices, output devices, auxiliary storages and terminals).

Upon introduction of a data processing unit, it is necessary to judge the following items:

* the degree of increase of the role of the unit as support of operators

* value in the aspects of facilities, size of facilities, the management system, technical level of operators, economy etc.

There are the small number of kinds of equipment for pump facilities in this establishment. However, the number of pump facilities is large, and the premise is dotted with them. In addition, pump facilities are relatively important as an airport function. Therefore, introduction of a data-processing unit is considered effective. Cost of facilities assumed from the size is around 25 - 35 million yen.

(5) Signal Transmission System

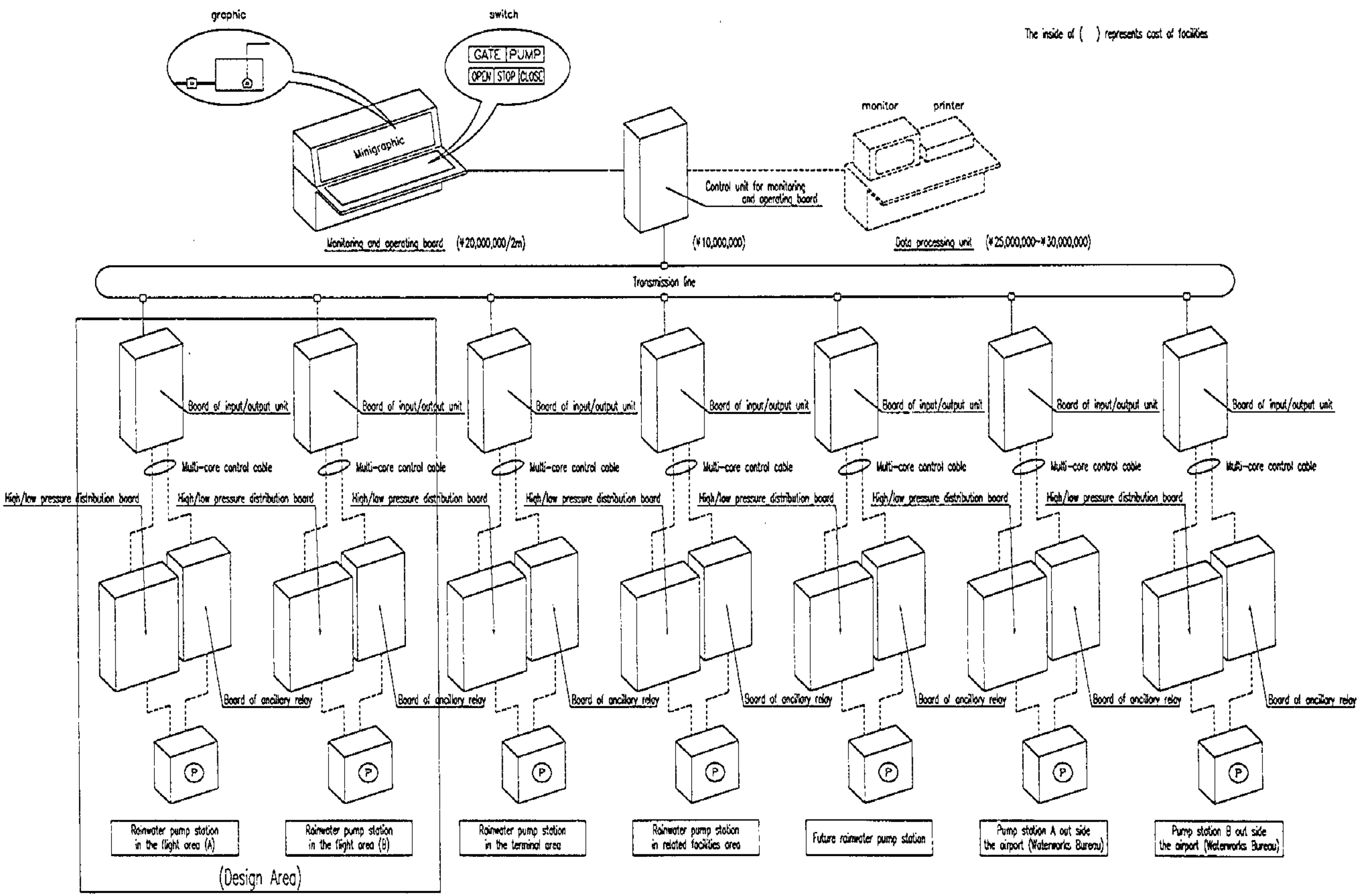
Transmission systems are roughly classified to the radio system and the wire system. The wire system is considered more advantageous from the viewpoint of economy etc. for the following reasons:

* The radio system may influence on the airport facilities.
* The radio system may function in the wrong way due to wether etc.
* Facilities are located within 10km.

Methods of wire signal transmission systems are those of electricity, air pressure, oil pressure and optics. In these years, an electric or optical method is general. It is because they are superior in transmission performance and advantageous for connection with instrumentation controllers.

This establishment is highly electric-noise-proofing because of special characteristics as an airport, and a transmission distance is around 5 - 10km. Therefore, it is recommendable to employ the optical signal system of the data-highway method (of the dual-ring type)and to use fiber cables for information transmission lines.

The system diagram as basic concept of the comprehensive rainwater-drainage management system for this airport is as shown in FigureIII1-4.4.3.



FigureIII1-4.4.3 System Diagram of Comprehensive Rainwater-Drainage Management

CHAPTER5 PAVEMENT DESIGN

5.1 Geometric Design

5.1.1 Design Criteria

(1) Design configuration

For the basic geometric design of the basic facilities, the plan at the time of the Basic Design was changed as shown in Tables III1-5.1.1 and Figure III1-5.1.1. The changes are detailed in "Chapter 1 Principles of Design".

Table III1-5.1.1 Changes in Design Configuration

Name of Facilities	Description of Changes
Runway	· Shoulder width was reduced from 7.5m to 1.5m.
Vertical taxiway	· For two vertical taxiways (between the runway and parallel taxiways) located 3,200m from the end of the runway, the area up to 40m from the center of the runway should be the scope of Phase I execution (Part A)*.
	· Vertical taxiways mainly with "P=230+14.5" should be increased among paralleltaxiways (Part B)*.
Loading apron	· Depth of the open spot was reduced from 75m to 71m.
Cargo apron	· For the plan of 8 spots for large-sized aircraft, only 3 spots should be executed in Phase I (Part C)*.
Maintenance apron	· To be excluded from this design (Part D)*. (Execution Design is planned to be carried out after completion of coordination with aviation companies.)

Note) The location of the area with mark," *", is shown in Figure III1-5.1.1.

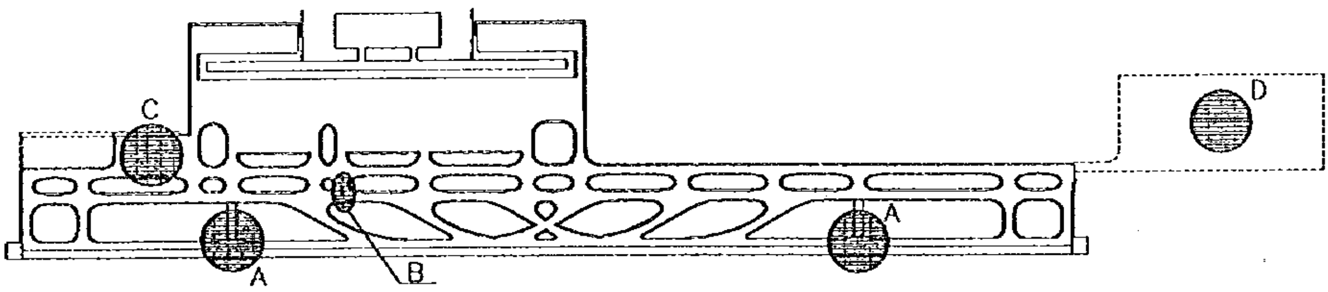


Figure III1-5.1.1 Locations Changed in Basic Configuration

(2) Design Aircraft

According to the Basic Plan, aircraft to enter into service were assumed and classified as shown in Table III1-5.1.2. As the aircraft to be considered for determination of the geometry, B-777-300 was selected as representative large-sized aircraft for the reason detailed in "Section 5.1.3 Fillets in the Crossing Part", and B-767-300 with the longest wheel base was selected as a middle- and smaller-sized aircraft.

TableIII1-5.1.2 Assumed Commissioned Aircraft

ICAO	Grouping	Type	Aircraft
A	I	Middle size, short range	MD-82、B-737
B,C,D	II	Middle size, long range	B-757、B-767-300、A310、A300-600
E	III	Large size	B-747、B-777-200、MD-11
F	IV	Jumbo size	B-747-400、A340、B-777-300
	V	Future type	NLA (Advanced version of B-747)

5.1.2 Width of Pavement

(1) Pavement Width of the Runway

According to "ICAO Annex 14", for airports where E-code aircraft shown in Table III1-5.1.2 are put in commission, required pavement width of the runway is 45m or wider. It is also necessary to pave the area with width of 60m or more including shoulders. In consideration of these conditions and future aircraft, the plan was made as follows:

* Runway width should be 60m in the Basic Design

* 7.5m should be secured as shoulder width.

In the case of runway width of 60m, referring to the provisions mentioned above, shoulders are not required for service of aircraft corresponding to B-747-400 (with total width of 64.94m). Therefore, for shoulders, it was determined to pave the area with width of 1.5m based on actual results in China . This width is necessary for installation of runway lighting facilities .

(2) Pavement Width of Taxiways

According to the supposed main gear spacing of the envisaged future type of aircraft and according to necessary clearance from the outer margin of main leg wheel to the margin of pavement, the width of the main body of parallel taxiways was determined as follows:

* W = T + 2C = 20 + 2 x 4.5 = 29.0 m

where, T: space of main leg wheel margins (20 m according to the ICAO Recommendation)

C: necessary clearance from the main leg wheel margin to a margin of pavement (4.5m according to the ICAO Recommendation)

In addition, it was determined that shoulder width should satisfy pavement width of a taxiway including a shoulder required for an airport where E-code aircraft shown in Table III1-5.1.2. Then, 7.5m was obtained from the following formula.

*Ws=(44-29)/2=7.5m

where, Ws : Width of shoulder

According to the Basic Design, width of other each taxiway was determined as shown in Table III1-5.1.3.

Table III1-5.1.3 Width of Taxiways

Name of Taxiway	Width of Taxiway (m)	Width of Shoulder (m)
Parallel taxiway	29.0 (14.5+14.5)	7.5
Exit taxiway in the middle part	34.0 (17.0+17.0)	7.5
Exit taxiway in the end part	31.5 (17.0+14.5)	7.5
Rapid exit taxiway	29.0 (14.5+14.5)	7.5

On taxiways connecting to the apron for middle-sized aircraft installed in the both sides of the terminal finger, aircraft to be used are limited to those of D code or lower shown in Table III1-5.1.2. Therefore, width was determined as follows:

Width of the main body	:	23m
Width of the shoulder	:	7.5mx2=15m
Total	:	38m

5.1.3 Fillets in the Crossing Part

Fillets in the part crossing a runway and a taxiway or two taxiways were determined with the diagram method after drawing a vehicular swept path (maneuvering), in the similar way to the Basic Design. However, the Basic Design was partly revised based on discussion with the Chinese side (A radius of an inside fillet in the parallel taxiway side of the rapid exit taxiway were changed from 32m to 30m.)

Figure III1-5.1.2 shows places to be discussed for fillets. Figures III1-5.1.3 - 5.1.4 show a vehicular swept path and shape of fillets determined based on the swept path. Table III1-5.1.6 shows details of width of fillets and taxiways.

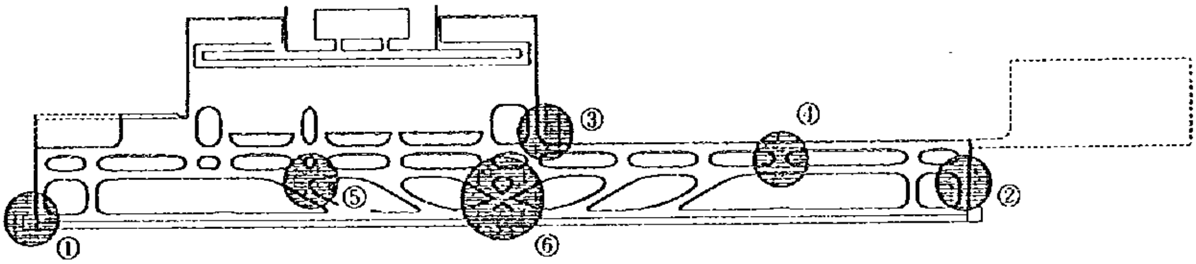


Figure III1-5.1.2 Places to be Discussed for Fillets

The swept path was drawn on the following conditions:

(1) Object Aircraft

Comparison was made between B-777-300 and B-747-400; B-777-300 is planned to enter into service a few years later, and B-747-400 is the largest of all airplanes put in service at present. As a result, a vechecle swept path was determined to be designed based on the swept path of B-777-300. It is because this airplane has the largest wheel base and the widest space between outer wheel of the main gear. (See Table III1-5.1.4.)

For object aircraft, it was assumed that two rapid exit taxiways near the central part of the runway would be used by middle- or smaller-sized jet airplanes. As a result, B-767-300 was selected for the Basic Design. However, there is possibility that large-sized airplanes of the B-777-300 class will also use these rapid exit taxiways. Therefore, fillets were designed based on the vehicular swept path of B-777-300.

TableIII1- 5.1.4 Gear Configuration of Objective Aircraft

Aircraft	Wheel Base (m)	Outer Main Gear Wheel Span (m)	Remarks
B-747-400	25.62 (Nose gear~center of the main gear)	12.46 (wing gear)	
B-777-300	31.22 (Nose gear~the main gear)	12.96 (main gear)	adopted
MD-11	24.60 (Nose gear~the main gear)	12.40 (main gear)	

(2) Clearance

According to the ICAO Recommendation, clearance between the outer wheel of a main gear and the pavement edge of the taxiway was determined to be 4.5 m.

(3) Curve Radius of the Centerline

According to the Basic Design, curve radius was determined as shown in Table III1-5.1.5.

TableIII1-5.1.5 Curve Radium of Centerline of Taxiways

Section			Curve radius (m)
General part			60.0
Between parallel taxiways			49.5
Rapid exit taxiways	Runway side		550.0
	Taxiway side	150° turning part	47.5
		30° turning part	250.0

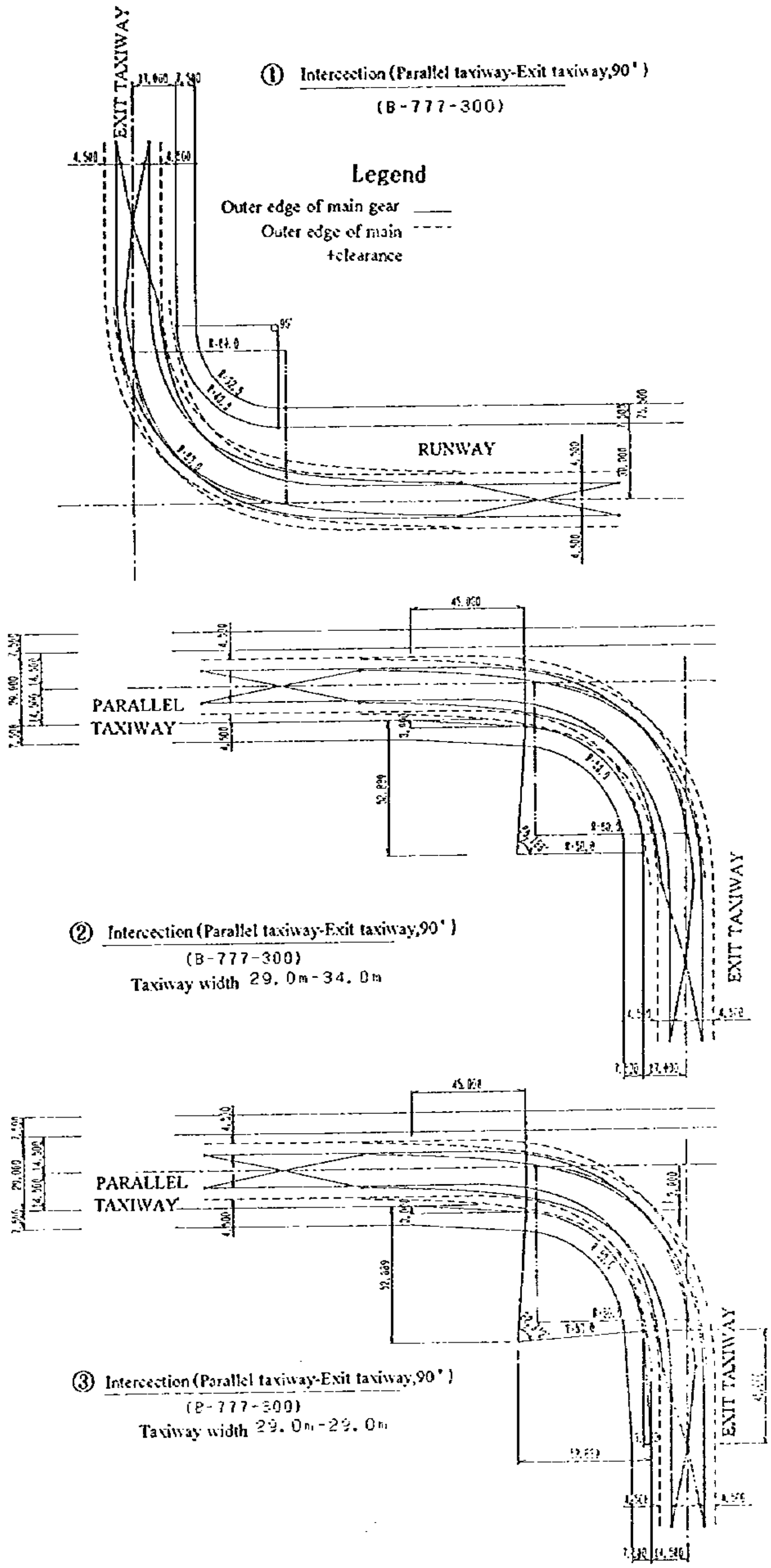
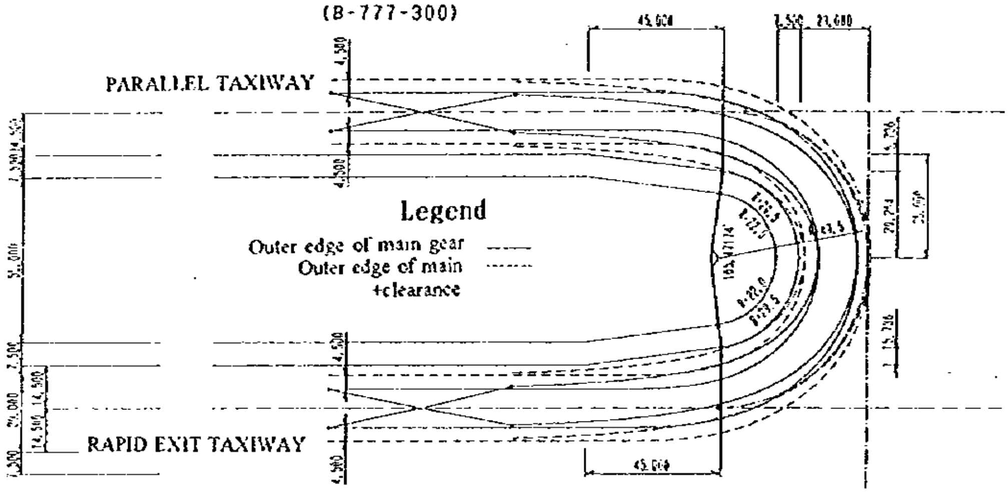
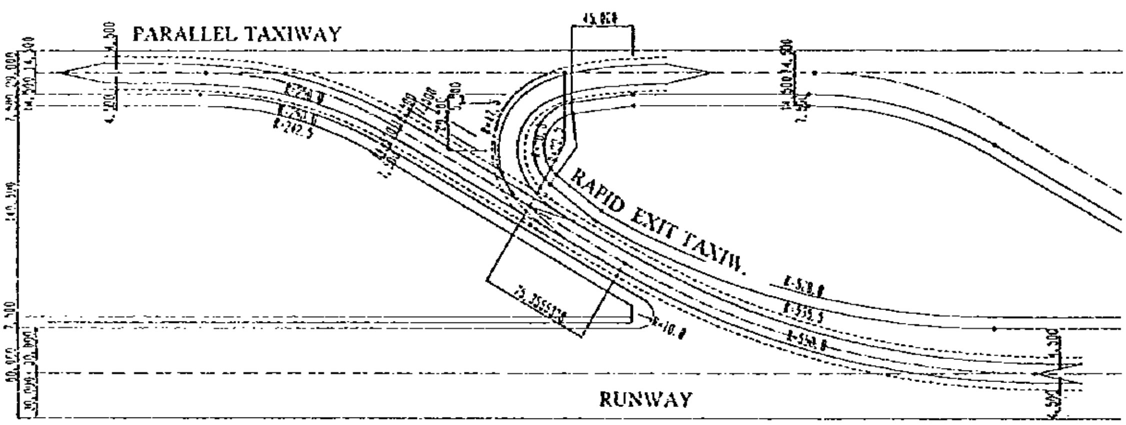


Figure III1-5.1.3 Fillet Form in the Crossing Part (1)

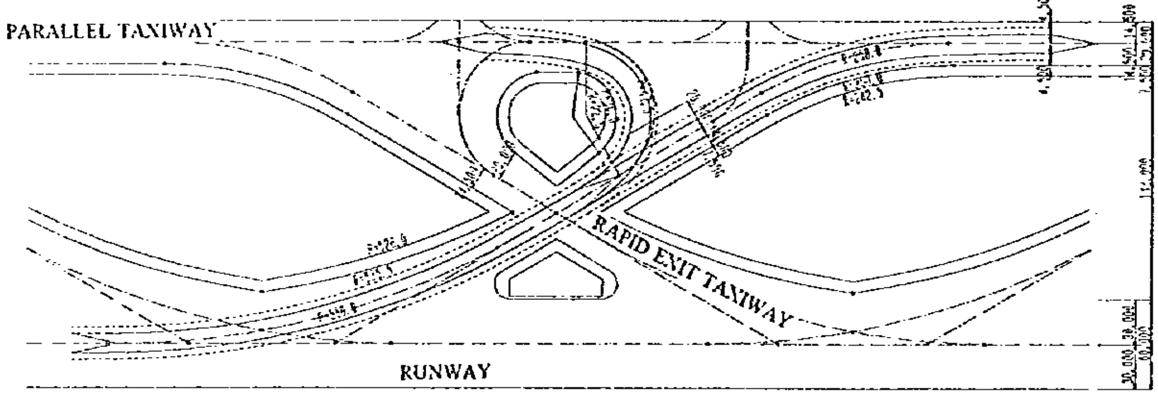
④ Intercection (Parallel taxiway-Exit taxiway,90°)
(B-777-300)



⑤ Intercection (Rapid exit taxiway-Parallel taxiway,30° 150°)
(B-777-300)



⑥ Intercection (Runway-Rapid exit taxiway-Parallel taxiway,30° 150°)
(B-777-300)



FigureIII1-5.1.4 Fillet Form in the Crossing Part (2)

TableIII-5.1.6 Form of Fillets in the Crossing Part and Details of Width Expansion

Position (crossing angle)	Width of one side (m)	Expansion Amont of Width~ Fillet Radius~Expansion L:W(m) R(m) L:W(m)	Aircraft Model Analysis
① R/W~Approach T/W (90)	30.0~17.0	0 :0 ~ 40.0~0 :0	B-777-300
② Approach T/W~Parallel T/W (90)	17.0~14.5	0 :0 ~ 50.0~45.0:3.0	B-777-300
③ Approach T/W~Parallel (90)	14.5~14.5	45.0:3.0 ~ 50.0~45.0:3.0	B-777-300
④ Parallel T/W~Parallel T/W (180)	14.5~14.5	45.0:5.736 ~ 29.5~45.0:5.736	B-777-300
⑤ R/W~ Rapid exit T/W (30)	30.0~14.5	0 :0 ~535.5~0 :0	B-777-300
Rapid exit T/W~ Parallel T/W (150)	14.5~14.5	39.5 :5.5 ~ 30.0~45.0:5.5	B-777-300
Rapid exit T/W~ Parallel T/W (30)	14.5~14.5	0 :0 ~250.0~0 :0	B-777-300
⑥ R/W~ Rapid exit T/W (30)	30.0~14.5	0 :0 ~535.5~0 :0	B-777-300
Rapid exit T/W~ Parallel T/W (150)	1.5~20.0	39.5 :5.5 ~ 30.0~0 :0	B-777-300
Rapid exit T/W~ Parallel T/W (30)	14.5~14.5	0 :0 ~250.0~0 :0	B-777-300

5.2 Design of Pavement Structure

5.2.1 Types of Pavement

As detailed in the Basic Design, for runways and rapid exit taxiways where airplanes run at high speed, asphalt concrete pavement is generally superior to cement concrete pavement in the aspect of maintenance of flatness and large-scaled repair. However, there are problems regarding quality of asphalt and economy (more expensive than cement concrete pavement) in China. In addition, there is possibility that concrete pavement will interfere future maintenance and repair becuase the number of asphalt plants is small. For reasons including the above-mentioned ones, cement concrete pavement was selected for all of the runway, taxiways, aprons and GSE passages.

It had been determined in the Basic Design that asphalt concrete pavement would be employed to stopways (overrun) only. However, it was judged proper that this part should also have the same structure as the Basic Facilities. Therefore, the type of pavement for stop ways was changed to cement concrete pavement.

5.2.2 Design Criteria

Pavement structure was designed on the conditions as follows:

(1) Design Standards to be Adopted

1) Chinese standards : Specifications of Civil Airport Concrete Pavement (Civil Aviation Agency of China, 1995)

2) Japanese standards : Design Criteria of Airport Concrete Pavement Structure (Aviation Promotion Foundation, 1995)

(2) Pavement Areas and Situation of Use

For pavement areas, the form of operation of Basic Facilities as shown in Figure III1-5.2.2 was assumed.

(3) Design Aircraft

TableIII1-5.2.1 shows details of representative aircraft of each grade to be used for designing pavement structure. TableIII1-5.2.2 shows details of design vehicles(towing tractors) on GSE passages.

The number of annual services was converted to A300-600 or B747-400, depending on pavement areas.

TableIII-5.2.1 Details of the Target Aircraft

Section		I	II	III	IV	V
Aircraft Model		MD-82	A300-600	MD-11	B-747-400	New of B747
Gross Wieght (kN)	(1) At full load	670	1630	2790	3880	5960
	(2) Upon landing	580	1350	1910	2800	4150
Gear Load (kN)	(1) At full load	310	760	W1080/C470	910	930
	(2) Upon landing	270	630	W740/C320	660	650
Wheel rrangement form		Dual wheels	Dual tandem wheels	W Dual tandem/C dual wheels	Dual tandem wheels	Special dual tandem
Wheel track of dual wheels S(mm)		7144	927	W1370/C950	1118	1118
Wheel base center of dual tandem ST(mm)		-	1397	1630	1473	1473
Internal type pressure Pi (kPa)		1080	1410	W1410/C1250	1380	1380
Grounding type pressure p(kPa)		1180	1410	W1410/C1250	1380	1380
Contact area of wheel A(m2)	(1) At full load	0.134	0.150	w0.191/C0.187	0.165	0.165
	(2) Upon landing	0.115	0.124	W0.131/C0.128	0.119	0.119
Width of contact area of wheel d(mm)		28	290	-	340	340
Gear configuration		2-leg and tricycle type	2-leg and tricycle type	CD-10 type	B-747 type	Special
Spece of gear center	S1 (mm)	5090	9600	10670	3840	-
	S2 (mm)	-	-	-	358	-
	S3 (mm)	-	-	-	3070	-

TableIII-5.2.2 Details of Towing Tractor (TT-35)

Body	TT-35
Aircraft to be considered	B-747
Gross weight (kN)	49
Wheel load (kN)	12.3
Vehicle form	Single
Type pressure (kPa)	6.8
Contact area of wheel (cm2)	1,810
Wheel base (mm)	4,540
Wheel tread (mm)	2,385

(4) Lifetime of Pavement

30 years (cement concrete pavement)

(5) Number of Annual Services

The number of annual services in 30 years was calculated with "the number of services in 2015 x 30", on the following conditions:

- It was assumed that the airport would open in 2000.
- 2015 should be a reference year of calculation of the number of annual services.

The rate of use of the runway was determined, from window coverage, to be 7:3.

(6) Sub-Grade Bearing Capacity

Based on the results of bearing capacity inspection after creation of the sub-grade for the runway, the sub-grade bearing capacity was determined as follows:

K75 = 40 MN/m3

CBR = 12%

The plan was made with capacity of K15=60MN/m3 for the Basic Design.

(7) Materials

1) Concrete

Design flexural strength (28 days) $\sigma 28 = 5.0$MPa

fem = $\sigma 28 \times 1.1 = 5.5$MPa

Elastic modulus E = 36700Mpa

Poisson ratio $\upsilon = 0.15$

Coefficient of linear expansion $\alpha = 9 \times 10\text{-}6$/℃

2) Reinforcing Bar

Round bar (ϕ) Class I σ sa = 135Mpa

Deformed bar (Φ) Class II σ sa = 185Mpa

(8) Calculation and Verification of Stress

For concrete pavement, calculation and verification were carried out according to Chinese "Specifications of civil Airport Concrete Pavement" (Civil Aviation Agency of China, 1995) under the following conditions:

1) Calculation of Stress

Stress by aircraft : 0.75 σj

75% of load stress in the Westergaard's edge loading (consideration should be given to conveyance).

Stress by Differential Settlement: σ Δ

Differential settlement values and shape of settlement are assumed for differential settlement of the ground, and then stress which will occur in the concrete slab is determined as follows.

Differential settlement value: 5 cm (Δ) in 100 m(L)

Shape of differential settlement

$$y = \frac{1}{2} D \cos \frac{2p}{L} X$$

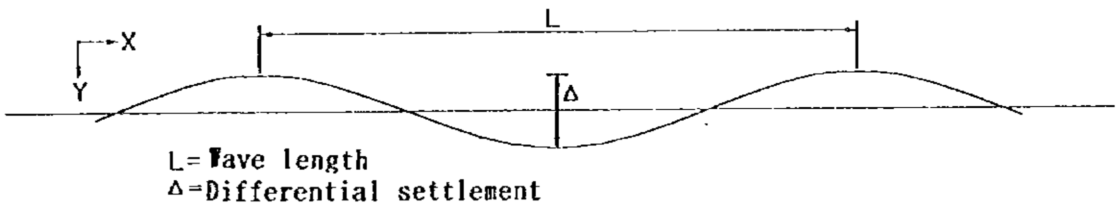
Calculation formula: :

$$\sigma\Delta = \frac{2}{3} \pi 2 E' \frac{\Delta}{L2}$$

where, E = creep (coefficient of creep 1.5) with consideration of elastic modulus

E' = E/1.5 (kg/cm2)

h : thickness of concrete slab (cm)



FigureIII1-5.2.1 Outlined Figure of Differential Settlement

2) Verification of Stress

$\sigma P = 0.75 j + \sigma \Delta$

$\sigma p < frm$ and

$| \sigma p - frm | < 0.025\ frm$

frm: allowable stress intensity in consideration of fatigue(MPa) = fcm (0.885-0.063 log Ne)

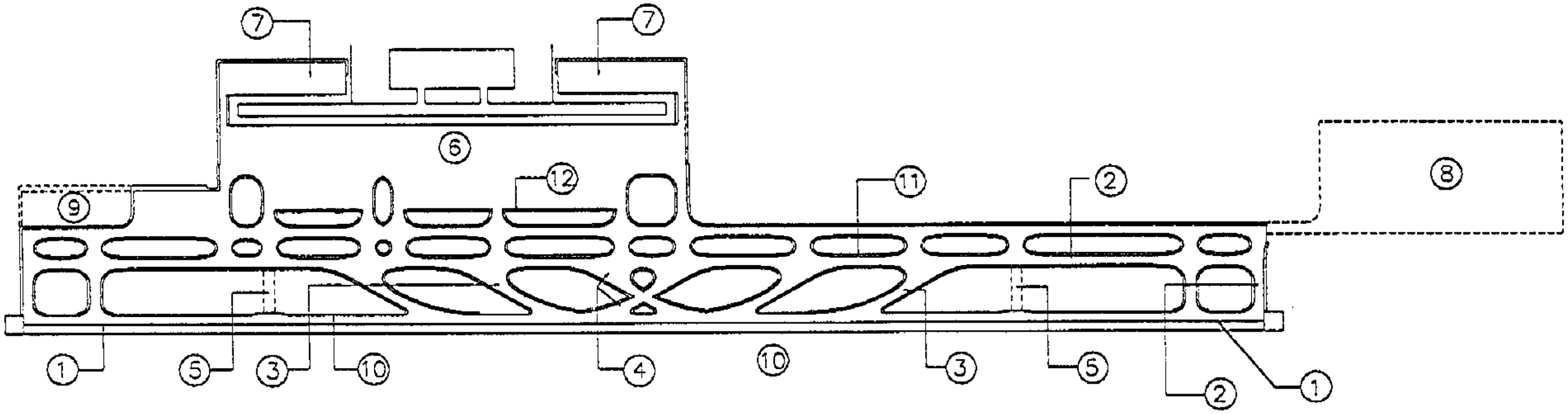
$$Ne = \frac{0.75 \times Nw \times Wt \times Ns \times t}{100T}$$

$Wt = 0.6Lt$

$$Lt = \sqrt{\frac{Ps}{0.05227 \times q}}$$

where,

q	:	external type pressure (MPa)
Ps	:	load per wheel (KN)
Ns	:	number of annual services
t	:	lifetime
Nw	:	number of wheels per gear
T	:	width of passage
		Runway = 11.4 m
		Taxiway & apron = 2.3 m



Pavement sections	Situation of Use		Pavement sections	Situation of Use	
	Aircraft Type	Ratio of USe		Aircraft Type	Raito of USe
(1)	All aircraft	70% of the number of taking-offs and landings	(7)	Aircraft of I & II	50% of the number of taking-offs and landings
(2)	All aircraft	50% of the number of taking-offs and landings	(8)	B-747-400(body) + Maximum fuel	50% of the number of taking-offs and landings
(3)	Landing of II, III, IV & V	70% of landings	(9)	All aircraft	50% of the number of taking-offs and landings
(4)	Landign of I & II	70% of landings	(10)	Runway, shoulder of apron	
(5)	Taking-off of I & II, Landing of III, Iv & V	30% of taking-offs of I & II, 30% of landing of III, IV & V	(11)	Shoulder of taxiways	
(6)	All aircraft	50% of number of taking-offs and landings	(12)	GSE Passage	

Figure IIII-5.2.2 Pavement Sections and Situation of Use

5.2.3 Calculation of Number of Annual Services

(1) Number of Services in the Reference Year

According to the Master Plan, the number of annual services should be calculated based on the number of services in 2005 and 2020 (the number of taking-offs and landings is 126,000 in 2005 and 320,000 in 2020).

The number of runways in 2015 was assumed to be two. Then conversion in this year was made to get the number of services in one runway.

In 2005: 126,000 services

In 2015: 150,000 services.

(2) Composition Ratio and Number of Annual Services Classified by Aircraft

The composition ratio of aircraft and the number of annual services in this airport are shown in the following table.

TableIII1-5.2.3 Composition Ratio of Aircraft and Number of Annual ServicesClassified by Aircraft

Classific	Aircraft	2005			2015		
		Compositi on Ratio	Take-off	Landing	Composition Ratio	Take-off	Landing
I	MD-82	40%	25,200	25,200	20%	15,000	15,000
II	A300-600	30%	18,900	18,900	30%	22,500	22,500
III	MD-11	20%	12,600	12,600	27%	20,250	20,250
IV	B-747-400	10%	6,300	6,300	17%	12,750	12,750
V	Advanced model ofB747	--	—	—	6%	4,500	4,500
Total		100%	126,000		100%	150,000	

(3) Number of Annual Services

The following is the number of annual services converted to that of object aircraft, classified by pavement section.

TableIII1-5.2.4 Number of Annual Services Converted to That of Object Aircraft, Classified by Pavement Section.

Section of Pavement	Design Aircraft	Number of Annual Services	State of Load
①	B-747-400	59,199	Maximum weight
②、⑥、⑨	B-747-400	41,867	Maximum weight
③	B-747-400	51,558	Maximum landing wight
④	A300-600	19,087	Maximum landing wight
⑤	A300-600	16,871	Maximum weight
⑦	A300-600	18,285	Maximum weight
⑧	B-747-400	41,867	Body weight + fuel
⑩	50t towing tractor	7,500	

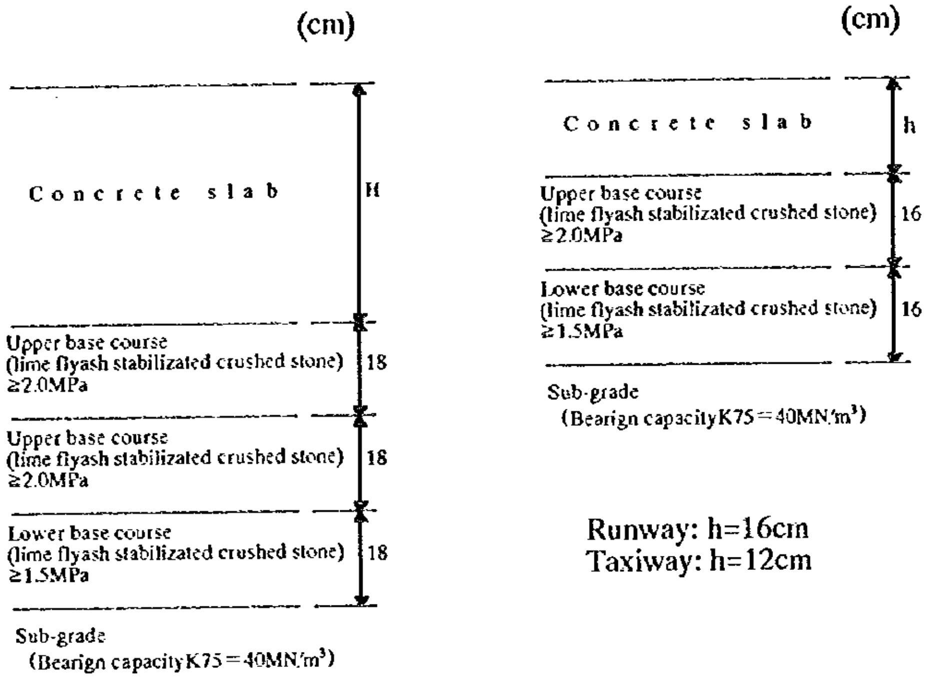
5.2.4 Design of Sub-Base

(1) Material of Sub-Base

In the Basic Design, cement treated aggregate had been planned for the upper base course, and lime, flyash and slug for the lower base course. However, it was determined that lime, flyash stabilizated crushed stone (with equivalency factor of 1.33) should be used as sub-base material for both upper and lower base courses to reinforce sub-grade. It is because these materials have the best load dispersion effect of all road bed materials used in China.

(2) Coefficient of Sub-base Bearing Capacity

The formation of pavement structure is assumed as shown in the following figure. Then, the coefficient of sub-base bearing capacity of (k75) is to be obtained.

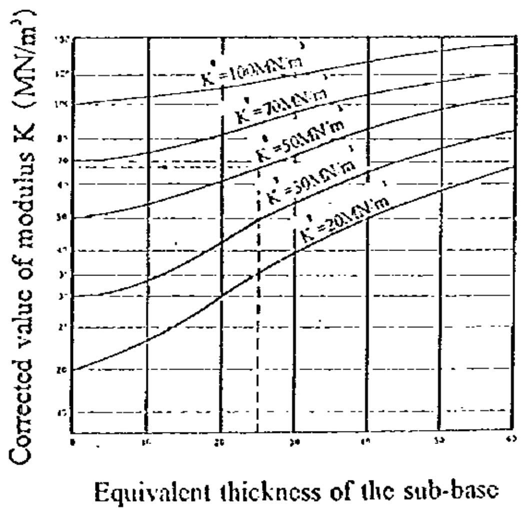


(1)Main Body (2)Shoulder

FigureIII1-5.2.3 Pavement Structure

The coefficient of sub-base bearing capacity should be "k75 =100MN/m3". It is obtained from the graph of the coefficient of upper sub-base bearing capacity and from sub-grade bearing capacity of "k75=100MN/m3".

*Lower sub-base
$h=18\times1.33=23.94$cm
$k75=40 \rightarrow k75=56$MN/m3
*Upper sub-base
$h=18\times2\times1.33=47.88$cm
$k75=56 \rightarrow k75=100$MN/m3



FigureIII1-5.2.4 Graph of Coefficient of Bearing Capacity

5.2.5 Verification of Thickness of Concrete Pavement

(1) Verification of Concrete Pavement Slab

Stress by aircraft included in design conditions, and stress by differential settlement, to thickness of slab, was calculated for each pavement area. As a result of verification, the assumed thickness of slab was judged reasonable. Therefore, it was determined to be thickness of concrete slab. For the runway (width of 40m in the central part) to be grooved and rapid exit taxiways (total width), thickness of concrete slab was determined to be (the assumed thickness + 1 cm).

TableIII1-5.2.5 Verification of Concrete Pavement Slab

(Unit : MPa)

Pavement	Slab Thickeness H (cm)	frm	$0.75\sigma j$	$\sigma\Delta$	σp	σp-frm	0.025frm
①	45	3.07	2.55	0.35	2.90	0.17	0.08
②,⑥,⑨	45	2.88	2.55	0.35	2.90	0.02	0.07
③	36	2.87	2.64	0.28	2.92	0.05	0.07
④	34	3.02	2.62	0.26	2.88	0.14	0.08
⑤	39	3.03	2.82	0.30	3.10	0.07	0.08
⑦	39	3.02	2.82	0.30	3.10	0.08	0.08
⑧	36	2.91	2.64	0.28	2.92	0.01	0.07
⑫	26	3.23	2.63	0.21	2.84	0.39	0.08

(2) Thickness of Runway

According to the Chinese Recommendation, thickness was reduced asfollows:

From 1.0 h to 0.9h at the edge of the middle part of the runway

* To 0.8h at the edge and to 0.7h in the central part, in the end zone of the runway
  Central zone in the runway end part : H=45cm
* Edge zone in the runway end part : H=45×0.8=36cm
* Central part in the runway middle part : H=45×0.9=41cm

* Edge zone in the runway middle part : H=45×0.7=32cn

For the 40m area in the central part to be grooved, thickness of slab was increased by 1cm.

(3) Thickness of Shoulder

According to the Chinese Recommendation, thickness was determined as follows:

* Shoulder of runway and apron : H=16 cm

* Taxiway shoulder : H=12 cm

5.2.6 Design of Joint Structure

(1) Spaces of Joints on Concrete Pavement

Joint spaces on pavement of the runway, taxiways, apron, GSE passage and shoulders were determined considering the width of facilities and ratio of length to breadth of concrete slabs. As a result, the following spaces have been determined to be standards.

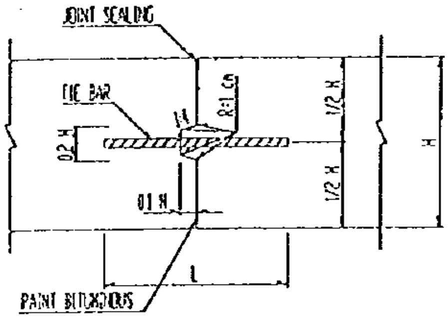
TableIII1-5.2.6 Spaces of Joints on Concrete Pavement

Classification		Determined Width	Arrangement interval	Ratio of Length to Breadth
Joints in the Longitudinal Section	Central zone of the runeay	Center 30.0m	5.0m×6spans	1.00
	Edge zone of the runway	One side 15.0m	5.0m×3 spans	1.00
	Taxiway	One side 17.0m	4.5m×2 spans +4.0m×2 spans	1.11～1.25
		One side 14.5m	5.0m×2 spans +4.0m×1 span	1.00～1.25
	Apron	–	5.0m	1.00
	GSE Passage	8.0m (10.0m)	4.0m×2 spans (4.0m+6.0m)	1.20～1.25
	Shoulder	7.5m	2.5m×3 spans	1.00
Joints in the Transversal section	All pavement of the main bodies	–	5.0m	1.00～1.25
	Shoulder	–	2.5m	1.00

(2) Joint Structure

1) Longitudinal Construction Joint

Longitudinalconstruction joints should be key joints in accordance with the Chinese Standards. In the places shown below, tie bars should be fixed.



FigureIII-5.2.6 Structure of Longitudinal Construction Joint (with tie bar)

* Runway : 3 construction joints in the center and 2 counted from the end. All in the longitudinal direction

* Taxiways : All longitudinal construction joints

Deformed bar steel should be used for tie bars. For size, consideration was given to the results of calculation shown in the "Chinese Criteria" and complicatedness during construction. As a result, the following three kinds of bar-arrangement were employed.

TableIII1-5.2.7 Size of Tie Bars

Space of Longitudinal Construction Joint	Diameter (mm)	Length(cm)	Number of Joints per Slab
5.0	18	140	8
4.5	18	140	7
4.0	18	140	7

2) Transversal Joints

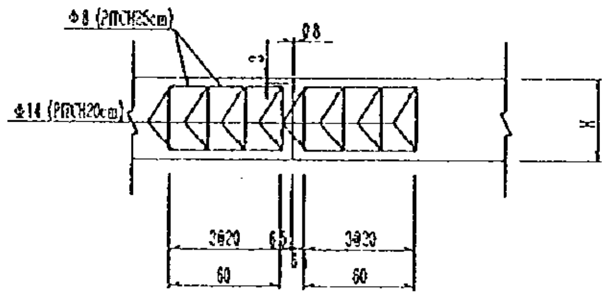
The standard joint should be a dummy joint. The following parts should be reinforced with slip bars .(φ35,l=50cm)

* Runway : Width of 40m in the central part.

*Taxiways : 4 dummy joints in the central part.

3) Butt Joints

Butt joints was determined to be used in the crossing part of the runway, taxiways etc. The end should be strengthened with a reinforcing bar as shown in FigureIII1-5.2.7.



FigureIII1-5.2.7 Structure of Butt Joints

4) Expansion Joints

In China, expansion joints are avoided as many as possible because they may cause structural weakness. In addition, in the area where extension is longer, such as runways and parallel taxiways, underground beams shown in Figure III1-5.2.8 are installed to prevent movement of concrete slab. Based on such examples in China, the following conditions were determined:

* Expansion joints should be installed only in the part connecting shoulders (10m spacing) and the structures.

* The above-mentioned underground beams should be installed at the both ends of the runway and parallel taxiways.

5.2.7 Reinforcement of Concrete Slabs

Reinforcement of concrete slabs will be carried out with reference to the record in China as well as the Chinese Standards .

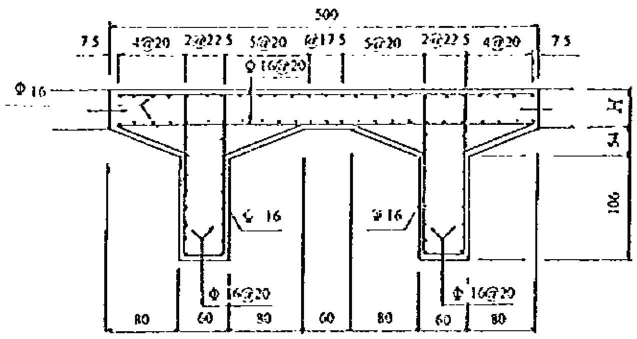
(1) Places to be Reinforced

Places to be reinforced on concrete slabs were determined as follows:

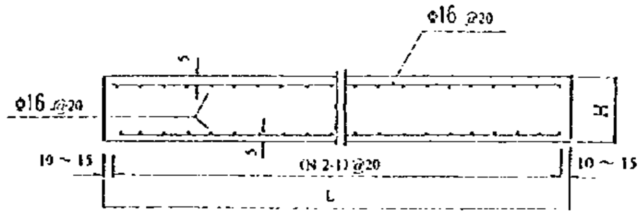
* Place where a large underground equipment such as a drainage structure is located under the concrete pavement.
* Around a lamp socket and various kinds of pit facilities
* The end of a concrete slab with a butt joint

(2) Size and Arrangement of Reinforcing Steel

For reinforcing steel, deformed steel bar with a diameter of 16 mm should be used. Arrangement should be as shown in FigureIII1-5.2.9.



FigureIII1-5.2.8 Structure of Underground Beam



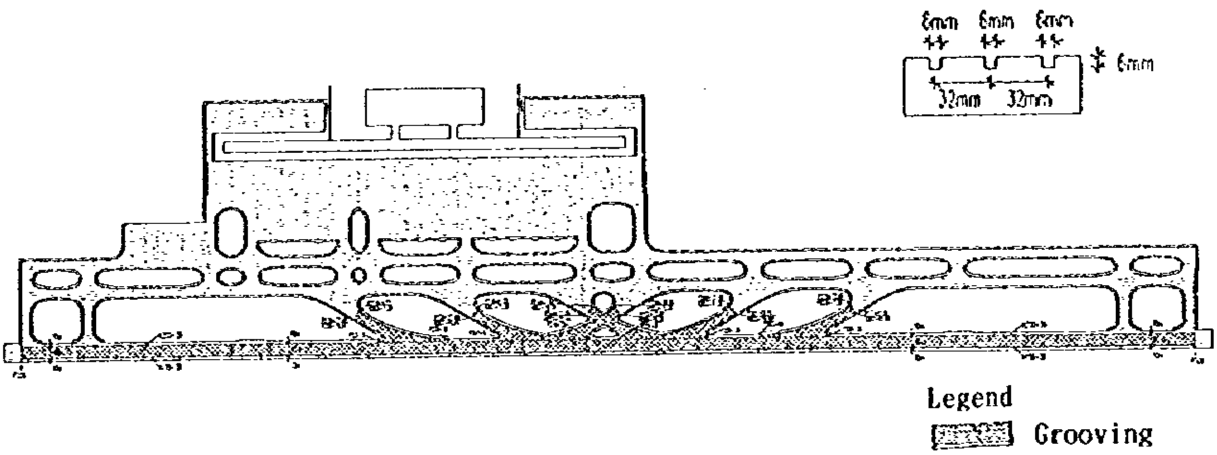
FigureIII1-5.2.9 Reinforcement of Concrete Slab

5.3 Design of Other Facilities

5.3.1 Grooving

Grooving should be carried out on the runway and rapid exit taxiways in order to solve the hydroplaning phenomenon.

The range and the shape of grooving are shown in FigureIII1-5.3.1.



FigureIII-5.3.1 Plane Figure of Grooving

5.3.2 Marking

The following markings should be installed in the runway, taxiways and apron:

* Runway designation marking (17, 35)
* Runway center line marking
* Threshold marking
* Runway center (circle) marking
* Touchdown point marking
* Touchdown zone marking
* Runway - side stripe marking (considering safety, those indicated in the Japanese Standards should be employed).
* Over - run zone marking
* Taxiway centerline marking
* Taxi holding position marking
* Taxiway - side stripe marking
* Apron marking (guideline / bar / spot No., etc.)

CHAPTER 6 DESIGN OF ANCILLARY FACILITIES

6.1 Enclosing Road and Safety Road

For design load of inside roads in the Flight Area, those of a refueler, a large fire truck, a heavy towing tractor and small cars for daily management work, lighting and airport security facilities are 100t, 45t, 100 - 160t and 0.5 - 4t respectively. Therefore, design of inside roads was classified as follows:

(1) Inside roads in adjoining aprons should be the GSE road.They should be design based on load of a refueler. To the part overlapping a shoulder, cement concrete pavement should be applied. To the outer part of a shoulder, asphalte concrete pavement to applied in order to accommodate settlement which will occur because ground work will not have been carried out.

(2) Enclosing roads and road toward the fire substation should be designed based on load of a large fire truck, 45t. Design of pavement structure should be same as (1)written above.

(3) Roads toward each airport security establishment, approach lights site, the transformer substation for light and the vehicle turning part should be designed based on load of a tractor, 4t. Generally, structure of pavement should be that of asphalt concrete pavement. In the case of cement concrete pavement, f28≧4.5Mpa. (Asphalt concrete Marshal Stability)≧ 5000N.

6.2 Enclosing Fence and Gate Door

According to provisions of Security Regulations for Civil-Service Airports in China, enclosing fences for airports should be seen through, strongly-built and preventive against climbing, and should have resistance to shearing. For fences for the airport security facilities, non-metal structure will be required invariably and should be design with brick walls.

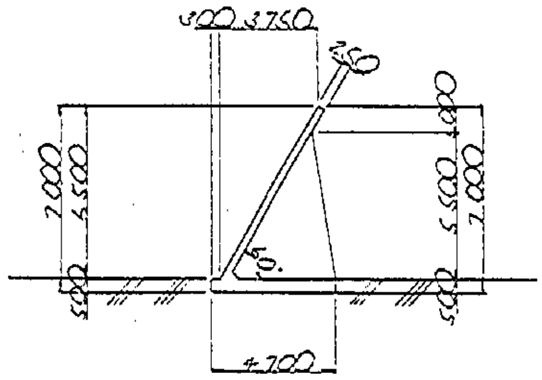
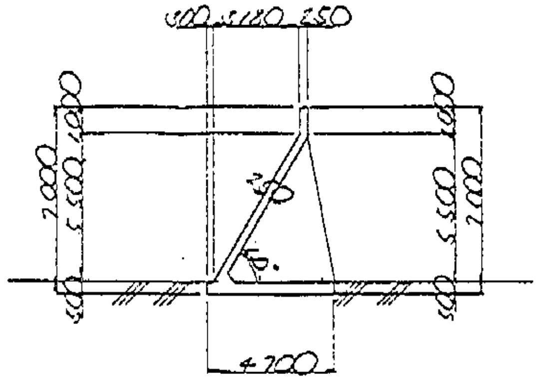
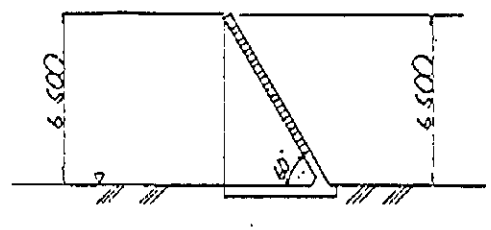
Gate doors of enclosing fences in the Flight Area should be able to be openend and closed in the both directions. Gate doors must be installed at both ends of the Flight Area.

Other fences in the Flight Area around aprons should be equipped with gate doors in consideration of entrance into the Flight Area from adjoining work areas (the airport refueling facilities, the fire station and the airport management facilities).

6.3 Blast Fence

Blast fences should be installed around the Terminal Building. They will protect cars, people etc. passing the land side from blast caused by airplanes. As structure of blast fences, that of the steel-modeling type had been employed. However, at the request of the Chinese side, it was changed to concrete structure from the viewoint of construction and economy. Upon selecting a form of concrete of structure, forms in the three cases as shown in Table III 6.3.1 were selected, and wind directions and wind velocities were simulated. As a result, Case 2 was employed.

Table III1-6.3.1 Comparison of Blast Fence

CASE	CASE-1	CASE-2	CASE-3
Standard cross section			
Characteristics of execution of work	1. Simple structure 2. Simple reinforcing-rod processing and simple assembly of a molding box	1. Same as the left 2. Same as the left	1. Structure is complicated because of a slit on a wall 2. High-grade skill is required for processing of reinforcing rods and assembling molding boxes. 3. The period of construction is longer than Cases 1 and 2.
Specific features	Appropriate structure in the aspects of execution of work and economy. However, due to characteristics of a blast fence, there is a risk that a part of blast emitted to the sky will go to the back of the fence.	Both execution of work and economy are similar to those of Case 1. To realize a better function as a blast fence, the shape is designed to make most of blast go to the sky. Therefore, it is considered the most effective.	Shape doesn't give an oppressing impression. However, considering a function as a blast fence, the most part of blast goes to the back of the fence and the fence cannot reduce the velocity of wind to the fixed allowable one.
Evaluation	○	◎	×

CHAPTER 7 CONSTRUCTION PLAN

7.1 Construction Plan for Temporary Works

7.1.1 Plan of Construction Roads

Construction works for the airport facilities will be carried out over a vast area. Construction vehicles carrying materials, heavy machinery and other contractors' vehicles will create heavy traffic throughout the work area. In order to prevent problems caused by this traffic and for efficient execution of the construction works, it is important to arrange an efficient network of main construction roads and branch roads. These roads should be planned to become perimeter roads and security roads after completion of the works.

Shanghai City is presently planning the Shanghai Outer Loop Road. On the assumption that the Loop will be able to be used by the start of the main construction works at the airport, the construction planning of routes for the transportation of materials determined that three access roads with two lanes each are required.

Critical works for construction in the Flight Area are those for site preparation and pavement works. At present, Shanghai City plans to open the airport by October 1999. In order to meet this target date, the above-mentioned works must be completed before the end of 1998 or the beginning of 1999. Therefore, the actual construction period will be approximately 1.5 years. Materials to be carried into the site for execution of these works are necessity to about 8.4 million tons in the mainly for borrow soil materials and pavement materials.

If it is assumed that these materials will be carried in by 11-t on class trucks during a period of 1~1.5 years, the average numbers of trucks would be 2,100 per day and the number on a peak day would be 2,800 trucks.

Consideration was also given to oil supply vehicles, materials for electrical and telecommunication work and other contractor vehicles, etc. As a result, it was concluded that it will be necessary to secure about three access roads from outside areas.

On the assumption that 11-t on class dump trucks would carry large-sized earth moving machinery and run at 40 km/h on the main construction roads, the temporary construction roads on site were planned as follows.

- Main Construction Road : Pavement width 8.0 m, length 8.6 km
- Secondary Road : Pavement width 6.0 m, length 21.6 km

7.1.2 Temporary Power Facilities

Concrete plants for pavement works and soil plants necessary for mixing the cement for stabilization treatment of base course will require a large amount of electric power.

If pavement concrete of about 550,000 m^3 is placed during period of one year. The product volume on a peek day will be 2,500 m^3. If placement is caried out on the 18 hours work day with two shifts and with actual operction of 13 hours. It is assumed that fully autmatic concrete mixing plants of 1 m^3 class to be required is calculated to 4 set plants.

Power requirment per plant is 50Kw;

4plants x 50 kW = 200 (Cu)

The necessary product amount of cement atabilization treatment material is about 1.5 million tons.The product volume on a peak day will be 6,800 t. If placement is carried out on the 18-hour work day with two shifts and with actual operation of 13 hours.It is assumed that central plants of 120 -150 t/h class will be installed, then the required number of plants is calculated to 5 set plants.

Power requirement per plant is 40 kW, therefore total power demand is:

5 plants x 40 kW = 200 kW

According to as result of study, an electric power capacity of 600 kVA will be required. Considering the requirement of other facilities such as maintenance facilities for heavy machinery, offices, lodging houses and site lighting, a huge electric power capacity of 800 kVA will be required.

7.1.3 Water Supply Facilities

Water will be supplied mainly for concrete and soil plants and for domestic use of offices and lodging houses. The volume of discharge from a concrete plant is 2,500 m^3/day, requiring 400 t/day as mixing water. The volume of discharge from a soil plant is 6,800 t/day, requiring 800 t/day as mixing water. Including water requirements for other miscellaneous uses, a volume of 1,500 t/day will be required for the plants only. In addition, another 350 t/day will be required for lodging houses accommodating 2,000 workers, and 50 t/day for other offices. Therefore, water supply facilities with a capacity of 2,200 t/day - 2,500 t/day will be required.

7.2 Procurement Plan of Materials

7.2.1 Logistical Planning of Construction Materials

The construction of an airport requires a great amount of earthworks. The basic principle is to reduce, as much as possible, embankment material needed to be brought in from outside areas, by balancing cut and fill-in soil volumes. However, the proposed construction site for this airport is located on the extremely flat delta of the Yangzhou River. In addition, the level of groundwater is high. Therefore, the site preparation will be mainly embankment. About 2.3 million m^3 of embankment materials will have to be carried in. Other main materials required for pavement works, etc. are shown in TableIII-7.2.1.

TableIII1-7.2.1 Main Materials to be Carried In

Work Item	Material	Unit	Quantity	Remarks
Site Preparation Works	Sand	m³	90,000	for sand mats
	Slag	m³	1,550,000	for ram drop mat
	Earth brought from outside	m³	660,000	sand of Yangzhou
Pavement Works	Cement	T	200,000	
	Sand for concrete	m³	270,000	
	Gravel for concrete	m³	550,000	
	Asphalt mixture	T	13,000	
	Aggregate for sub-base	m³	750,000	
	Slip / Tie bars	T	4,000	
	Steel forms	m	9,600	T = 35 cm
Drainage Works	Cement	T	25,000	
	Sand for concrete	m³	40,000	
	Gravel for concrete	m³	89,000	
	Steel reinforcement bars	T	4,100	
	Round stones	m³	45,000	
	Crushed stones for foundation	m³	8,300	
	Formwork materials	m³	3,500	three time use

7.2.2 Machinery Capacity Planning

(1) Working Capacity of Heavy Earthwork Machinery

According to Section 1.4 Earthwork Design, the soil cutting volume within the Flight Area will be 1.53 million m^3. On the other hand, the fill volume within the Flight Area will be 3.38 million m^3. The deficit will be made up with material brought from outside areas. The main earthwork for site preparation will be leveling work by bulldozer.

As it is assumed that sandy soil or sandy soil mixed with gravel will be brought from outside, the efficient combination for compaction machinery will be four passes by a 20 t class tire-roller and three passes by a self-propelled vibration roller.

Therefore, site preparation work for embankment will require a combination of two 21 t class bulldozers, one 20-t class tire-roller, and one 8-t class vibration roller to secure a working capacity of 300 m^3/h, i.e. 4,000 m^3/day.

Among earthworks, the second important work to be considered is the excavation of drainage canals, etc. According to Section 6.2 Drainage Structures, excavation of 550,000 m^3 will be required. This excavation will be of the channel type. Typical excavators to be used are backhoes (drag shovels).

Therefore, excavation at a rate of 1,000 m^3/day will be possible.

(2) Work Capacity of Pavement Machines

Main pavement works involving machinery are the placement of sub-base material and pavement concrete of 1 million m^3.

Therefore, a sub-base work volume of 2,000 m^3/day can be achieved by a combination of one 3.7 t-class motor grader, three 20-t class tire rollers, three 12-t class macadam rollers and seventeen 11-t class dump trucks.

In Japan, concrete finishers are usually used for concrete pavement. However, in China, placement is carried out by human power with simple finishers. Working capacity of a simple finisher is only 400 m^3/day, even on a 13-hour workday.

(3) Required Number of Main Heavy Machinery

According to calculated working capacity, the required number of main heavy machinery classified according main work categories is shown in TableIII1-7.2.2.

TableIII1-7.2.2 Required Numbers of Main Heavy Machinery

Work Item	Name of Heavy Machinery	Number	Remarks
Site Preparation Works	60 t crawler crane	16	for ram drop
	21 t bulldozer	10	
	20 t tire roller	5	
	8 t vibration roller	5	
	1.2 m backhoe	5	excavation of canals
Pavement Works	1 m^3 concrete plant	4	
	150 t soil plant	5	
	1.4 m^3 tire loader	9	
	3.7 m motor grader	3	
	20 t tire roller	9	
	12 t macadam roller	9	
	simple finisher	11	
	plane vibrator	21	
	cylindrical vibrator	42	
	11 t dump truck	72	

7.3 Schedule Planning

7.3.1 Prerequisite Conditions

(1) At present, the soil improvement work under the runway pavement is under execution by a contractor. The work is planned to be finished by the end of February 1997. It is expected that the work in the apron area will be started subsequently. Therefore, the schedule planning for full-scale site preparation works was planned on the assumption that the works would be started within the first half of 1997.

(2) The Chinese Government desires to open the airport on October 1, 1999 (National Foundation Day). This was taken as the target date in schedule planning.

(3) Large-scale construction works are typically planned on the assumption of an 8-hour work day and a actual operation time of 6.5 hours per day. Considering the above

conditions, it was assumed that a two-shift system will be employed with a 16-hour workday and 13- hour actual operation time per day.

(4) Aggregate for concrete, sub-base material, etc. will be carried to the construction site from outside areas. Vehicles will pass partly through some urbanized districts. Therefore, the use of 11-t class trucks were assumed in the schedule planning.

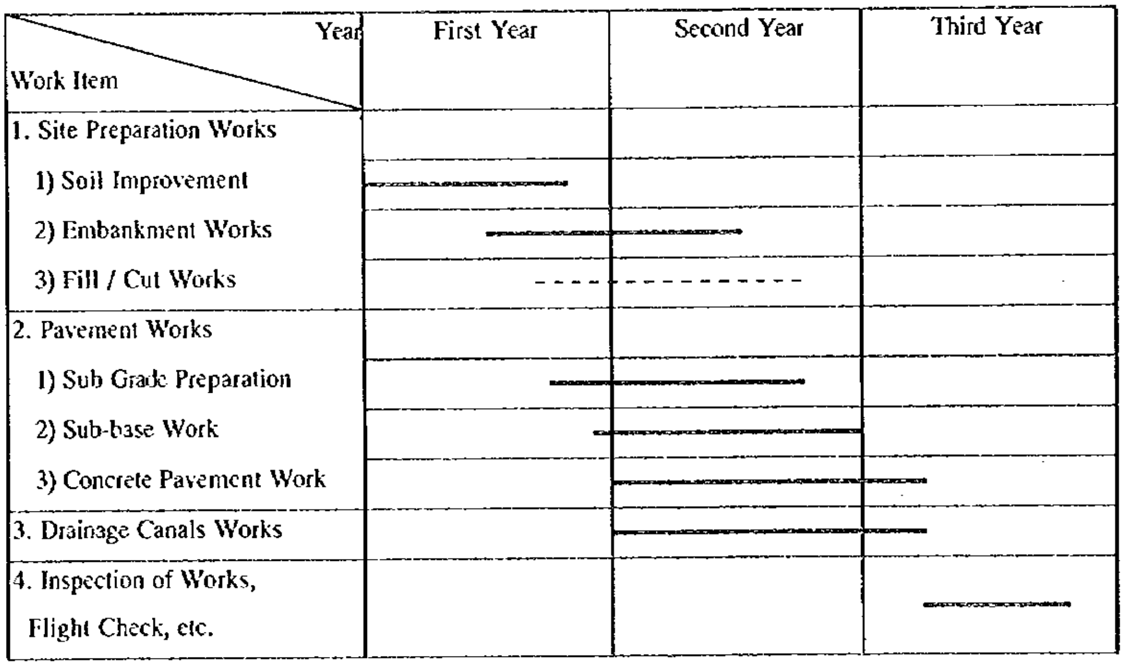
(5) Trial operation, accustomization, flight check and other operations to be conducted after completion of the construction works will be limited to a minimum period of approximately 6 months.

7.3.2 Schedule Planning for Works Related to Earthworks

On the assumption that ongoing soil improvement work under the runway, rerouting of existing channels and roads, and the construction of the three access roads are completed, the schedule planning was conducted on the basis of utilization of the equipment and machinery with the capacity calculated in the previous section.

Assuming that the earthworks will take 6 - 8 months and pavement work will be started successively from each area where the base surface of earthworks has been completed, beginning with the sub-base work, it will take 12 - 15 months for pavement work.

FigureIII1-7.3.1 Schedule of Works Related to Earthworks



7.4 Construction Cost Estimates

Calculation of construction cost estimates for the first stage construction of the Airside Civil Works has been made pursuant to the Civil Aviation Administration of China Airport Construction Cost Estimates Guideline (hereinafter referred to as "CAAC Guideline") and the Shanghai Infrastructure Construction Cost Estimates Guideline (hereinafter referred to as "Shanghai Guideline"). The procedures followed for calculation of the cost estimate are as discussed below. First the quantity of work was taken off for each relevant work item covered under the CAAC Guideline, and a work quantity table was compiled. Applicable Shanghai cost estimates manuals were used for work that was not covered by the CAAC Guideline, including such items as ground improvement work, and planting work (sodding and seeding). For direct work costs, the unit price for each item of work was calculated based on the unit resource requirement involved for each payment item, including labor, materials and equipment. The unit price was then multiplied by the quantity of each work item to obtain direct cost of the item. Based on the direct costs obtained, total construction costs were calculated by adding in various indirect expenses, in accordance with the Shanghai Guideline. The details of these calculations are attached in Part I of Volume IV (Appendices).

The cost estimates for the civil work have been divided into five categories: (1) Land Grading, (2) Pavement Work, (3) Drainage System, (4) Regulating pond and Pump Station, and (5) Appurtenant Works. The total costs for each category in accordance with the above procedure are as follows:

No.	Category	Construction Cost (Mill. RMB)
1	Land Grading	248 (28%)
2	Pavement Work	490 (55%)
3	Drainage System	89 (10%)
4	Regulating Pond and Pump Station	25 (3%)
5	Appurtenant Works	45 (5%)
	Total	897 (100%)

The total costs are estimated at 897 million RMB. This represents a reduction of 363 million RMB, or 29%, off of the initial estimate at the basic design of 1,260 million RMB. As stated in PART III-1 of this report, the main reason for this cost reduction is that a part of the access taxiway, the maintenance apron and the cargo apron have been removed from the first stage construction. In addition, a variety of modifications have been made in the detailed design to reduce the quantity of the work through final adjustment to the work volume, and to cut the costs.

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-2
DETAILED DESIGN OF AIRFIELD LIGHTING SYSTEM

SEPTEMBER 1997

NIPPON KOEI CO., LTD.
NIKKEN SEKKEI LTD.

CHAPTER 1 MODIFICATION ON BASIC DESIGN

1.1 Comments by Chinese Side

Followings are comments on basic design from Chinese side.

(1) Category
Surface type lighting equipment installed on pavement shall be designed based on the requirement of category III. Control system and other equipment shall be designed based on the requirement of category II.

(2) Uninterrupted Power Supply (UPS)
UPS shall be deleted in first development phase. In detail design, however, space and interfaces for UPS shall be included in the design.

(3) Aerodrome Beacon/Wind Direction Lights
Both shall be deleted in the design.

(4) Taxiway lights for straight sections
This shall be based on the basic design.

(5) Diesel Generators
Initial installation shall be only 1 unit for each sub-station, with the condition of re-calculation for the generator's capacity. Space for 2 units however shall be provided.

1.2 Direction of Detail Design

As the comments of the above five items, the defection of the detail design by JICA Study Team shall be as follows.

(1) Category
In case that the category is shifted from II to III, the design of airfield lighting does not change. The Study Team recommended that the design for radio navigational facilities and the conditions of operational management in Pudong airport should be considered. Regarding airfield lighting system designed, since the basic design for aeronautical lighting facilities was done considering the shifting category from II to III, this comment is in line with the idea of basic design. The detailed design shall be done followed by the basic design.

(2) Uninterrupted Power Supply (UPS)

The Study Team insisted that the UPS shall be installed from the beginning due to the reason which the switching time of one second regulated by ICAO could not be secured without introduction of UPS. From a viewpoint of the design for airfield lighting, since UPS will be installed in the future, this comment is in line with the idea of basic design. Followed by the basic design, thus UPS shall be included in the detailed design.

(3) Aerodrome Beacon/Wind Direction Lights

Taking into consideration that no other airport in China is equipped with aerodrome beacon, and also that no direct minor effects to aircraft ground movement which premises the concept of SMGC unless the beacon was installed, the Study Team desired that the aerodrome beacon could be deleted from the detailed design. Wind direction lights, however, shall be considered to be installed for night operation, and included in the detail design.

(4) Taxiway lights for straight sections

Against the opinion of Chinese side that the taxiway edge lights should not be initially installed in the straight sections, the Study Team insisted the necessity for the straight sections. Consequently since this comment is followed by the basic design, no modification from the original basic design is taken place.

(5) Diesel Generators

The initial design by the Study Team was to install one sub-station for airfield lighting system. This design was changed to two sub-stations followed by the Chinese requirement. Accordingly two sets of diesel generators were designed to install in each sub-station, and those sets shall be installed at the same time. From the design point of view, since the number of diesel generator is not changed for the design, this comment is in line with the idea of basic design. The number of diesel generator in each AFL sub-station shall therefore be two sets.

CHAPTER 2 CONDITIONS FOR DETAIL DESIGN

2.1 Design Concept

Higher category of ILS has brought a possibility of aircraft's departing and arriving in condition with poorer visibility, and has contributed to continuity of air traffic. This however conversely makes long stay of the aircraft at a ground. In case of Pudong International Airport characterized a large scale airport, this long staying becomes more remarkable. As a mean in order to reduce this long staying, introduction of surface movement guidance and control (SMGC) system is essential.

The design of this airfield lighting system aims at the initial provision of SMGC system which will be proceeded to standard surface movement guidance and control for the aircraft. Its design concepts are as follows;

- since the SMGC system is in a stage of preparation for its standards, the detail design shall not be at the mercy of the final standards,
- since the air field lighting system is directly concerned in human life, system reliability shall be concerned in the highest priority for the design, and the design standards shall be in equivalent or more with international ones.
- since the airport operation will be made by only one runway for several years, the damages by the designed air field lighting system shall not absolutely occur the serious disorders for the airport operation.

Concretely double end power supply, burnt-out lamp detection, stop bar, visual docking guidance and control are the important functional essence, and those design are well considered.

2.2 Conditions for Detail Design

The Detail Design was based on the following standards.

International Standards

ISO : (International Organization for Standardization)

ICAO : Annex 14 Aerodromes, Volume 1 Aerodrome Design and Operations, Second Edition, July 1995

ICAO : Aerodrome Design Manual, Part 4, Visual Aids, third Edition, 1983

: Aerodrome Design Manual, Part 5, Electrical Systems, First Edition, 1983

IEC : (International Electrotechnical Commission) Publication on Standard and

Recommendation

CIE : (International Commission on Illumination) Regulations

Chinese National Standards

- Fire Code for Architectural Design (GBJ 16-87)
- Standard for Architectural Water Supply and Drainage Design (GBJ 15-88)
- Standards for Industrial and Civil Power Supply Networks Design
- Code for Electrical Design of Civil Buildings (Standard for Civil Architectural Electricity Design) JGJ T16-92)
- Standards for Automatic Fire Alarm and Equipment (GBJ 116-88)
- Construction Standards for Security & Protection Installation of Civil Aviation Transportation Airport, CAAC (MH/T 7003-95)
- Technical Standard for Flight Area of Civil Aviation Transportation Airport, CAAC No. 155-76 (MH 1-85, August 1985)
- Shanghai City Standards
- Guidelines for Foundation Design (DBJ 08-11-89)
- Requirements for Architectural Seismic Design

Equivalent Japanese Standards

JIS : Japanese Industrial Standards

JEC : Standards of Japanese Electromechanical Committee

JEM : Japan Electrical Manufacturers' Association, Standards

JCAB : Japan Civil Aviation Bureau; Standard Specification of Airport Lighting, Technical Standards for electrical Facilities (Public Utilities Department, Agency of Natural Resources and Energy of Japan)

Equivalent American Standards

FAA : US Federal Aviation Administration, Advisory Circulars

NEMA : US National Electrical Manufacturers' Association, Standards

2.3 Design Coverage

Detail design includes all equipment designed for basic design, with one exception of aerodrome beacon. Uninterrupted power supply equipment, therefore, second diesel generator which will be installed in future's development stage are included in the detail design. This is because based on the consideration that designed air field lightning system is a integrated system and that those system shall be developed at one time. The actual implementation schedule may however be changed to staged development, and the design contents may also be modified due to the circumstances and the constraints of the project budget by Chinese side.

CHAPTER 3 CONTENTS OF CONSULTATION

3.1 Results of Consultations between China and Japan

The results of the consultations between China and Japan on the Detail Design are described below.

(1) Dual Circuit Power Supply System

The Study Team proposed a circuit system which would enable power to be supplied for all loads from the healthy circuit even in the event of power failure in either circuit under normal 2 circuit operations. This reflected the Study Teams' opinion that it was essential to secure higher reliability of power supply during maintenance and for future category III operations.

On the other hand, the Chinese side proposed a circuit design that isolate circuits by a master connection circuit breaker when attempting reconnection after stoppages and short circuits in circuits after the main line.

It is the opinion of the Study Team that it is inappropriate to adopt the Chinese proposal as the power supply circuit for supplying power to airfield lighting systems as it lacks sufficient reliability. The airfield lighting will be shut down in case a power outage occurs when one circuit is undergoing normal maintenance and repair. This is not acceptable in World Standard Hub Airports. It was therefore decided that power supply systems for airfield lighting will be complete dual circuited double-end systems including the peripherals, as was originally designed in the Basic Design.

The Study Team commend the proposal designed by the Study Team.

(2) Stop Bar Lights

It is the opinion of the Study Team that Stop Bars for Exit Taxiways and High Speed Exit Taxiways are indispensable in preventing accidental entry into runway.

The Chinese side was of the opinion that Stop Bars were not needed for High Speed Exit Taxiways, since there would be no-entry signs, making reverse entry from the taxiway into the runway impossible.

The Proposal of the Study Team is based on actual accidents occurring world-wide and on the consideration that ICAO is preparing to make Stop Bars mandatory by 2001. The Study Team insisted that Stop Bars for all connecting taxiways was necessary.

After discussions, Japanese and Chinese sides agreed that all taxiways connecting to the runway will be provided with Stop Bar Lights.

(3) Taxiway Center Line Lights

According to ICAO, Center Line Lights on taxiways with runway visibility conditions lower that 350 m is mandatory. The Study Team noted that the interval for placing the Taxiway Center Line Lights should be 15 m, based on other international airports and the preparation for future upgrading to category III.

The Chinese side proposed that the interval could be extended to 30 m and infilling to 15 m could be carried out when the Airport was upgraded to category III in the future.

The Study Team is of the opinion that the future upgrading to category III is obvious. In order to reduce unnecessary revisions, it is more appropriate to design for 15 m intervals at the present time.

After discussions, both Japanese and Chinese sides agreed to designing to 15 m intervals.

(4) Burnt-out Lamp Detection 78695

The Study Team considers in the light of the necessity for prevention and preservation measures to accommodate future upgrading to higher categories and installation of SMGC systems, it is necessary to provide burnt-out detection devices for Approach Lights, PAPI, Runway Edge Lights, Runway Center Line Lights, Runway Threshold and End Lights, Runway Touchdown Zone Lights, Stop Bars and Taxiway Center Line Lights interconnected with Stop Bars, Runway Guard Lights, and Road-holding Position Lights.

The Chinese side considered that burnt-out detection devices had not reached sufficient levels of development, at present. The Chinese side suggested that burnt-out lamp detection devices shall be installed for lighting which would be difficult to visibly confirm line severance, including Runway Center Line Lights, Runway Threshold and End Lights, Runway Touchdown Zone Lights, Stop Bars and Taxiway Center Line Lights, which were interconnected to Stop Bars.

The Study Team adopted some Chinese proposals and concluded that the following lights would be provided with burnt-out detection devices. This proposal was agreed to by the Chinese Side.

Runway Center Line Lights, Runway Touchdown Zone Lights, Runway Threshold and End Lights, Precision Approach Path Indicator, Stop Bars and Taxiway Center Line Lights interconnected to Stop Bars , Runway Guard Lights and Road-Holding Position Lights.

(5) Monitoring and Control

The Study Team believes that the central monitoring and control of Airfield Lighting as designed in the Basic Design to be an essential part of the Project. The Monitoring and Control Equipment for the Airfield Lighting were installed in the Control Room of the Main and Secondary AFL Sub-station and in the VFR Room of the Control Tower.

Monitoring and control equipment for the Apron Flood Lights, Visual Docking Guidance System and Aircraft Stand Identification Sign will be placed mainly in the Control Center in terminal building with supplementary monitoring at the Main AFL Sub-station.
The Chinese Side stated the need to accommodate monitoring and control system to the Airport Management System which is divided into independent management areas for the Terminal Area, Cargo Area and Maintenance Area.
The Study Team decided that accommodating the monitoring and control system to the airport management system would not be hopelessly detrimental to the functioning of the Airfield Lighting System as a whole. Apron Flood Lights, Visual Docking Guidance System and Aircraft Stand Identification Signs will be independent from other lighting systems. They will be monitored and controlled individually at each management Area with separate monitoring at the Control Center in the terminal building. The Chinese Side agreed to this proposal.

(6) Wind Direction Lights
The Chinese side proposed to eliminate Wind Direction Lights from the Design.
The Study Team considers that the provision of Wind Directions Lights is essential at aerodrome intended for use at night. ICAO stipulates that at least one wind direction indicator must be provided. Night time operations require this to be illuminated.
The Chinese side accepted the Study Team's argument and agreed to provide Wind Direction Lights.

(7) Aerodrome Beacon
The Chinese side proposed to eliminate Aerodrome Beacon as no other airport in China was equipped with the facility.
The ICAO provisions for mandatory installation of Aerodrome Beacons are;

- aircraft operations are principally by visual flight rules (VFR).
- frequent low visibility conditions
- difficulty in recognizing airport due to close lying city lights or topography.

When one or more of the above conditions are present and night operations are intended, provision of Aerodrome Beacon is mandatory. The weather conditions at Pudong Airport are not good and frequent low visibility conditions are expected. However, taking into consideration that no other airport in China is equipped with Aerodrome Beacon and that Aerodrome Beacons themselves cannot be seen under low visibility conditions, Aerodrome Beacons by themselves will not improve operation efficiency in low visibility conditions. Therefore, the Study Team considers that there are no strong reasons requiring immediate provision of Aerodrome Beacons. The Chinese proposal was accepted and the Design will be modified to delete it.

(8) Taxiway Lights

The Chinese side proposed to eliminate Taxiway Lights from straight sections of the Taxiway. However, the Study Team was of the opinion that Taxiway Lights are required even for straight sections. The Chinese side agreed.

(9) Taxiway Guidance Signs

Chinese side proposal was that the power supply circuit of Taxiway Guidance Signs should be independent separately form taxiway lights. The Study Team agreed this proposal.

(10) Capacitor Discharge Lights

Chinese side proposed that a Capacitor Discharge light can not be installed on the over run. The Study Team agreed.

The above discussions are summarized in the following table III2-3.3.1;

Table III 2-3.3.1 Discussion Result

Discussion Item	Chinese Opinion	Japanese Opinion	Results of Discussion
1. Dual Power Supply Circuit	A system using mainline breaker to isolate circuits when rebooting after interruption during normal dual circuit operations.	It is necessary that one circuit can supply all necessary power for total needs even when the other circuit is out. High reliability of power supply is essential for regular maintenance and future upgrading to Category-Ⅲ.	The Study Team commend the proposal designed by the Study Team.
2. Stop Bar Lights	Stop Bar lights for the high speed exit taxiway are not necessary as aircraft do not stop on this taxi way.	Stop Bar lights for all exit taxiways and high speed taxiways are necessary to prevent accidental entry into runway from taxiway.	It was agreed to provide Stop Bar Lights for high speed exit taxiways.
3. Taxiway Center Line Lights	Initially will be installed at 30 m intervals and filled in to 15 m intervals when future upgrading to Category-Ⅲ is realized.	ICAO requires runway center line lights where runway visibility is below 350 m. Considering future upgrading to Category-Ⅲ and installation at other international airports, the	It was agreed to install the lights at 15 m intervals.

Discussion Item	Chinese Opinion	Japanese Opinion	Results of Discussion
		center line lights should be installed at 15 m intervals.	
4. Burnt-out Lamp	Present systems are not mature. Only lights difficult to confirm visibly, including Runway Center Line Lights, Runway Threshold and End Lights, Touchdown Zone Lights, Stop Bars and Taxiway Center Line Lights interconnected with Stop bars will have Burnt-out Lamp Detection.	Considering the preventive maintenance and instantaneous repair required when upgrading to higher Category and installation of SMGC, it is desirable to provide Burnt-out Lamp Detection for PALS, PAPI, REDL, RCLL, RTHL, RENL, RTZL, Stop Bars, Taxiway Center Line Lights interconnected to Stop Bars, Runway Guard Lights, Runway Holding Position Lights.	Burnt-out Lamp Detection devices will not be provided for PALS, REDL and Taxiway Center Line Lights not interconnected to Stop Bars. However, space will be reserved for future installation of Burnt-out Lamp Detection devices for PALS, Taxiway Center Line lights not interconnected to Stop Bars.
5. Monitoring & Control	Management organization are separate for Terminal Area, Cargo Area and maintenance Area.. Separate control should be provided for each area.	Integrated monitoring and control provided for Aeronautical lighting in the Control Room of Main and Secondary AFL Sub-station.	Apron Flood Lights, Visual Docking System and Aircraft stand Identification Signs will be independent of the other lighting and have separate controls for each airport Area.
6. Wind Direction Lights	Not needed	Required for Pudong Airport for Night Operations.	Will be Installed
7. Aerodrome Beacon	No other Chinese airport has Aerodrome Beacon	Desirable in view of weather conditions at Pudong Airport.	Will not be designed, on condition of future installation.
8. Taxiway Lights	No Taxiway Lights needed for straight sections.	Required in straight section.	Will be installed in straight sections.
9. Taxiway Guidance Sign	Individual power line should be required considering operational dotage.	Common use of power line with TEDL will be favorable in view of economy.	Will be followed by Chinese proposal.
10. Capacitor Discharge Lights	Should be eliminated a surface type light on over-run.	Can be eliminated.	Will be eliminated.

3.2 Differences between Basic/Detail Design

As a result of the discussions summarized above, the following revisions to the Basic Design have been born.

(1) Burnt-out Detection

Burnt-out Detection Devices will not be provided for Approach Lights, Runway Edge Lights and Taxiway Center Line Lights not interconnected to Stop Bars.

(2) Monitoring and Control

Apron Flood Lights and Aircraft Stand Identification Signs will be independent from other lighting and will have separate monitoring and control for each airport management area.

(3) Aerodrome Beacon

On the condition that it will be installed in the future, Aerodrome Beacon will not be designed initially.

(4) Taxiway Guidance Signs

Power circuits shall be separated from other air field lighting.

(5) Capacitor Discharge Lights

A surface type light installed on over-run shall be eliminated from the design.

Following items are concerned with installation.

(1) The installation of pipes for runway center line lights and son on was adopted with burring the pipes under the pavement by using shallow type base. This method brought the elimination of flexible pipes designed for the basic design.

(2) Due to the width deduction of runway shoulder, isolation transformer shall be designed to be installed under the lamp base.

CHAPTER 4 CONTENTS OF DETAIL DESIGN

4.1 Airfield Lighting

Category II operations are possible with future upgrading to Category III as a pre-condition. Lighting Facilities to be installed are as follows;

(1) Approach Lights
(2) Capacitor Discharge Lights
(3) Precision Approach Path Indicator
(4) Runway Edge Lights
(5) Runway Threshold lights and Wing Bars
(6) Runway End Lights
(7) Runway Center Line Lights
(8) Touch Down Zone Lights
(9) Taxiway Center Line Lights
(10) Taxiway Edge Lights
(11) Stop Bar Lights
(12) Runway Guard Lights
(13) Taxiway Intersection Lights
(14) Taxiway Guidance Signs
(15) Wind Direction Lights
(16) Apron Flood Lights
(17) Visual Docking Guidance System
(18) Aircraft Stand Identification Signs
(19) Road-Holding Position Lights
(20) Maintenance Equipment

Detail of the maintenance equipment (20) are as below ;

- Light cleaning device
- Dry type cleaning device
- Hot water type parts cleaning device
- Simplified air leakage testing device
- Super sonic wave cleaning device
- Spare parts

In addition, the following technical analysis was conducted for the air field lighting on ① Burnt-out Lamp Detection, ② Stop Bars and ③ Visual Docking Guidance System.

(1) Burnt-out Lamp Detection

Preventive maintenance and immediate emergency response are required for the Aeronautical Lighting for Pudong International Airport. Monitoring of burnt-out lamp detection is an important element in this capability. Comparative analysis of burnt-out lamp detection methods was conducted for evaluation.

Address to identify individual lights are necessary to locate wire severance points. Addressing methods differ for each manufacturer. Two methods of detecting wire severance itself are, one, detecting signal interruption from individual units to master unit due to wire severance and two, detecting the output voltage/current fluctuation of the secondary side of constant current transformer due to wire severance. Methods of identifying individual lights are one, sending signals to the master unit at different given time intervals for each light, two, identifying from differing time required for wave change and three, identifying units by polling and detecting no-response units. It is extremely difficult to construct a wire severance detection system mixing several different manufacturers. The present Project utilizes power line carrier signals identifying the affected unit to the monitors due to economical superiority. The signal transmission time chart for each manufacturer also differs. In conclusion, burnt-out lamp detection device, isolation transformer and CCR Equipment must all be composed with components from the same manufacturer, including the power cables.

(2) Stop Bars

Stop bar is one of the sub-system composing SMGC system. Since ICAO regulates that stop-bar shall be installed for category II operation from January 1 in 2001, the stop bars were included for the design. Airport operational category differs from arrival and departure. In case of Pudong Airport, even if the arriving minimum classify category II (RVR 350m), departing minimum can indicate category IIIA (RVR200m). At present conditions, therefore, stop bar must be installed considering to be higher operational rate.

This air field lighting system drawn the detail design can be extended to automated surface movement guidance and control linking with airport surface detection radar in the future by expanding the aircraft guidance method which can be integrated the stop bar with taxiway center line lights to all areas in taxiway and the apron.

Aircraft detection method and monitoring and control method were analyzed below.

1) Analysis of Aircraft Detection Method

Radio wave sensors, pressure and magnetic sensors were compared.

a) Micro-Wave Type, Laser Barrier Type

This type detects aircraft when they interrupt photon or electromagnetic beams between two sensors on each side of taxiway. The sensors may emit radio interference or become obstructions. However, as far as sensors on the commercial market are considered, the weak micro-wave transmissions in the 10 Giga Hertz band are difficult to conceive as a radio obstruction in the immediate vicinity of the sensors. The sensors are placed above ground. However, the height is low so they will not constitute an obstruction for aircraft and vehicular movement.

b) Pressure Sensors Type

This type detects aircraft by means of pressure sensors embedded in the pavement surface. However, they liable to mechanical failure when subjected to high-density traffic.

c) Loop Magnetic Sensors Type

Embedded coils emitting alternating magnetic fields detect fluctuations in the characteristic value of the coils when aircraft approaches. Long-term, continuous-use reliability is low due to failure of the sensors from mechanical stress induced by movement in the pavement and wiring under temperature changes.

The requirements for sensors at Pudong international airport are as follows;

- Ability to operate under category III weather conditions.
- Ability to detect all aircraft landing/taking-off at Pudong International Airport.
- Does not obstruct or interfere with aircraft operations and is not hazardous to humans.
- Easily maintained and capable of being repaired within China in case of breakdown.
- Functionally capable of withstanding heavy aircraft traffic.
- Easily constructed within the short proposed construction schedule.

At present commercially developed sensors are micro-wave sensors and loop magnetic sensors. Laser light sensors have only recently been put into actual use. Pressure sensors have only been used for Visual Docking Guidance systems and no examples of use in Stop Bar sensors are known. Embedded loop magnetic sensors require cutting into the pavement surface following the loop coil shape and are problematic in construction. Therefore, it is concluded that micro-wave type sensors are appropriate for Pudong International Airport.

2) Analysis of Monitoring and Control Systems

Two systems were compared for monitoring and control of the airfield lighting facilities. Direct Control System , where individual lighting circuits are connected by separate cables to the aeronautical lighting sub-station and Monitoring & Control Transmission System, where individual lamp units have terminal control devices. Monitoring & Control systems can be further divided into Power Line Carrier type, where the control signals are carried on the power lines and Signal Cable Type, where a separate cable for signals is laid. Direct Control Systems require numerous cables and Signal Cable Type Transmission Systems are not economical. The Power Line Carrier Type Transmission System is superior in both regards and is considered appropriate for Pudong International Airport. However, Impedance of serial transformers differ widely among manufacturers. All equipment for the Monitoring & Control System must follow the specifications of a single manufacturer.

(3) Visual Docking Guidance

Four Systems were compared. Combination of Photonic Sensors and Guidance Loops, Photonic Sensors only, Arm Joint Sensors and Micro Wave or Laser Light Sensors. The description of each system is given below;

1) Photonic· Guidance Loop System

System using photonic guidance for direction and guidance loop coils for position.

2) Photonic Sensor System

System where only direction guidance by photonic sensors is given and position is confirmed by the pilot himself using stop lines markings.

3) Arm Joint Sensors

The pilot visually directly and continuously recognizes indicators embedded on the parking spot entry line at the parking position.

4) Micro Wave Sensors, Laser Light Sensors

A system which measures direction, position and aircraft type simultaneously by analyzing echo of micro wave or laser light emission.

The requirements of Pudong International Airport are, one; can be installed in a short time, two; can adopt to various aircraft types, three; minimum of equipment on the pavement surface. The Photonic· Guidance Loop System requires cutting of the pavement and is not desirable. Photonic Sensor System cannot adopt to various aircraft. Arm Joint System are not desirable, requiring structures on the pavement in the parking area and can become obstructions. The Micro Wave Sensor System or Laser Light Sensor System require only sensor and indicator to be installed on anchor at the front of the Terminal building and can measure both direction and distance to parking position of the aircraft. This System can also be easily interfaced with Spot Management System and SMGC. This type is recommended for Pudong International Airport.

4.2 Power Supply Facilities

The power supply facilities were analyzed below.

In the detailed design, the double power circuits so called double-end method which were doubled from power receiving points to constant current regulators (CCRs) were introduced. It was designed that CCRs had their stand-by equipment enabled to convert from main to stand-by and its reverse without interruption. In case that the airport with the plural runways which is observed in America and Europe can be fed the power from each air field sub-station located each runway by formulating loop circuits. One-runway airport like Pudong airport, however, can not be fed power form another alternative sub-station in case of emergency power failure. This one-runway condition in Pudong airport will continue for around ten years by the year of about 2010 with heavy traffic.

The power failure caused by the damages on the power facilities for air field lighting, which will be anticipated that the double-end circuit had not been adopted in Pudong airport, may bring serious problem of airport operation in addition with difficulty of keeping the regular air traffic operation. Double-end circuits and stand-by CCRs are the design which prevent the worst conditions.

The circuit connection of double-end system enable to maintain on emergency engine generator without any power cut, and to be continuous operation by switching in case of any damages on any points. And the switching from main to stand-by CCRs does not involve the power failure.

According to the ICAO standard, the switching time for approach landing lights regulates to be within one second in category II operation. This is the time between less than 50% deduction point and 50% recovered point of light intensity of each light. The mechanical switching method like pre-started engine generator operation can not keep within one second transfer due to the relay's detection, transmission, switching movement and starting up the CCRs. By those reason UPS is essential.

Above discussion could lead to the necessity the double-end circuits for air field lighting facilities in Pudong airport.

4.3 AFL Sub-Stations

(1) Siting and Site Plan

Site selection and Site Plan are designed to be suitable for management and operation of Aeronautical Lighting Facilities, based on the Master Plan, Basic Design and discussions between the Study Team and Chinese side. The Site Plan for the Main AFL Sub-Station took into account space requirements for expansion during second phase and placed the building to the west of the site.

(2) Planning

1) Main and Secondary AFL Sub-Stations

The Planning of the Main and Secondary AFL Sub-Station are based on the Basic Design and discussions with the Chinese side. The changes between the Basic Design and Detail Design are shown in Table III 2-4.3.1 and Table III 2-4.3.2.

2) Ancillary Facilities

A Garage with roof capable of parking 4 cars will be provided near the main entrance to the Main AFL Sub-Station. There will be a maintenance pit for repair and maintenance. The structure and floor area of the garage will be a single story reinforced concrete structure, 126.36 m^2 in floor area. The building will have normal building electrical facilities, including lighting, power outlets, and power mains.

TableIII 2-4.3.1 Floor Area of Main AFL Sub-Station

Unit : m²

Floor	Room Name	Floor Area		Notes
		D/D	B/D	
First Floor	Entrance / Lobby	56.7	174.95	
	Corridor	129.6		
	Guard Room	9.0	15.0	
	Rest Room	25.92	15.0	
	High-Tension Distribution Rm.	68.4	205.55	Power Room Divided by Walls
	Low-Tension Distribution Rm.	143.82		
	Transformer Room	57.6		
	CCR Room	153.18	167.61	
	UPS Room	43.2	84.0	
	Hot Water Room	12.6	6.0	
	Miscellaneous Storage	21.6	10.0	
	Testing Room	122.4	130.83	
	Locker Room	12.6	8.0	
	Storage Room	72.0	88.42	
	Generator Room	93.6	110.07	
	Maintenance Room	109.44	169.38	
	Toilet	11.52	27.58	
	Maintenance. Personnel Rest Room	28.08	38.22	
	Special Fire Fighting Equip. Rm.	--	32.27	Moved to Second Floor
sub total		1,214.46 m²	1,366.88 m²	
Second Floor	Office Room (1), (2), (3), (4),	119.16	25.41	
	CPU Room	86.4	87.22	
	Manager Room	21.42	25.41	
	Conference Room	48.96	49.43	
	Data Room	36.0	24.0	
	Special Fire Fighting Equip, Rm.	36.0	--	
	Corridor	1323.92	108.11	
	Hot water Room	12.6	6.0	
	Control Room	136.8	127.38	
	Storage	21.6	--	
	Control Personnel Rest Room	21.6	67.64	
	Locker Room	12.6	26.71	
	Record Storage	12.96	26.71	
	Women's Toilet/Shower room	11.52	35.58	Women's Toilet added
	Men's Toilet/Shower Room	18.0		
	Bed Room	25.92	28.89	
	Mechanical Equipment Room	--	42.0	eliminated by change in air conditioning machinery
sub total		755.46 m²	680.49 m²	
Total		1,969.92 m²	2,047.37 m²	

Table III 2-4.3.2 Floor Area of Secondary AFL Sub-Station

Unit : m^2

Floor	Room Name	Floor Area		Notes
		D/D	B/D	
First Floor	Battery Room	36.0	59.79	
	UPS Room	36.0	64.4	
	Transformer Room	57.6	130.28	Power Room divided by walls
	High-Tension Distribution Room	75.6		
	Low-Tension Distribution Room	134.64		
	Generator Room	81.9	129.68	
	OCR Room	115.2	130.28	
	Special Fire Fighting Equipment Room	7.2	32.03	
	Toilet	7.2	5.76	
	CPU Room	14.4	--	CPU functions Added
	Maintenance Personnel Rest Room	35.1	25.49	
	Corridor	77.76	94.33	
	Control Room	--	34.81	Room eliminated
Total		678.6	706.85	

(3) Summary of Finish

1) Exterior Finish Schedule

The Main Exterior Finish schedule for the Main and Secondary AFL Sub-Station are shown in Table III 2-4.3.3.

Table III 2-4.3.3 Exterior Finish Schedule

Area	Finish	Notes
Exterior Walls	Exterior Tiles, t= 10mm on concrete wall J-302 treatment	
Exterior Joinery		
Window		
Door	Aluminum Air-tight sashes w/ double glazing	
	Steel flush door w/ paint finish	
Roof Waterproofing	Built-up Asphalt waterproofing w/3-6 small gravel protection	non- walking

2) Interior Finish Schedule

The Interior Finish of the Main AFL Sub-Station was selected for the following 6 groups based on function and usage.

Type-I-	Rooms	:	(1st Floor) Entrance /lobby, Corridor, Guard Room, Rest Room, Testing Room, Locker room, Storage Room, Guard Room (2nd Floor) Office (1), (2), (3), (4), Manager Room, Conference Room, Locker Room, Control Personnel Rest Room
	Floor	:	Terrazzo Block Tiles 450×450×25 mm (light green)
	Skirting	:	Terrazzo Block 15 mm thick, height, 120 mm (black)
	Wall	:	Paint Finish on Cement Mortar
	Ceiling	:	Paint Finish on Gypsum Board 900×3000×9 mm
Type-II-	Rooms	:	(1st Floor) High-tension Distribution Room, CCR Room, UPS Room, Low-tension Distribution Room, transformer Room, Battery Room, Maintenance Personnel Rest Room, Storage, Generator Room (2nd Floor) Special Fire Fighting Equipment Room, Storage
	Floor	:	Terrazzo Block Tiles 450×450×25 mm (light green)
	Skirting	:	Terrazzo Block 15 mm thick, height, 120 mm (black)
	Wall	:	Paint Finish on Cement Mortar
	Ceiling	:	White Anti-abrasive Paint Finish on Cement Mortar
Type-III-	Rooms	:	(1st Floor) Men's Toilet (2nd Floor) Women's Toilet/Shower, Men's Toilet/ Shower
	Floor	:	Ceramic Floor Tiles 10 mm thick
	Walls	:	Semi-Ceramic Tiles 5 mm thick (white), height 3,300 mm
	Ceiling	:	Paint Finish on Gypsum Board 900×3000×9 mm
Type-IV-	Rooms	:	(1st Floor) – (2nd Floor) CPU Room, Data Room, Control Room, Record Storage, Control Personnel Rest Room
	Floor	:	Anti-static Vinyl Floor Tiles on Free Access Floor, height 300 mm
	Skirting	:	Soft Vinyl Skirting, height 78 mm
	Wall	:	Paint Finish on Cement Mortar
	Ceiling	:	Paint Finish on Gypsum Board 900×3000×9 mm
Type-V& VI	Rooms	:	(1st Floor) Hot Water Room (2nd Floor) Hot Water Room
	Floor	:	Ceramic Floor Tiles 10 mm thick

Skirting	:	Soft Vinyl Skirting, height 78 mm
Wall	:	Paint Finish on Cement Mortar
Ceiling	:	White Anti-abrasive Paint Finish on Cement Mortar

The Interior Finish schedule for the Secondary AFL Sub-Station was selected for the following two groups based on function and usage.

Type-I- Rooms	:	Control Personnel Rest Room, Corridor
Type-II- Rooms	:	Battery Room, UPS Room, Transformer Room, Generator Room, High-tension Distribution Room, Low-tension Distribution Room, CCR Room, Special Fire Fighting Equipment Room, Toilet, CPU Room

(4) Elevation Design

The design for the Elevations was based on the Basic Design Concept and discussions between the Study Team and the Chinese Side. Harmony with the Terminal Building and related other structures and ease of maintenance and repair were important criteria. Exterior ceramic wall tiles were chosen for local availability, strength and durability.

(5) Structural Design

1) Main AFL Sub-Station

Two story Reinforced Concrete Moment Resisting Frame Structure, (Partially Single story).

Walls are brick masonry construction with mortar coating. The Foundations were designed as Raft-Type Construction based on Soil Investigation Report.

2) Secondary AFL Sub-Station

Single story Reinforced Concrete Moment Resisting Frame Structure,

Walls are brick masonry construction with mortar coating. Foundations are Raft-Type Construction.

(6) Building Mechanical Equipment Design

Each facility is designed in accordance with relevant Chinese laws and regulations.

1) Main AFL Sub-Station

a) Plumbing Facilities

- Water Supply Facilities

  The water will be taken by branching from the water mains beneath the airport internal road fronting the site on the east. A control valve will be installed in the site distributed to each usage by direct pressure piping.

- Hot Water Supply

  Water for the Hot Water Room on both 1st and 2nd floor will use distilled bottled water, fitted to a Cold/ Hot Water Dispenser.

  Water for the Shower Rooms on 1st and 2nd floors will be supplied by Electric Instantaneous hot Water Heaters connected to the normal water supply pipes.

- Waste Water Drainage

  Internal drainage for the waste water will be divided into soil water and general waste water. They will be joined at the external receiving basin and conducted to the sewage mains beneath the road fronting site on the north via connection basin.

- Sanitary Fittings

  Sanitary fittings will be provided for the Toilets, Showers and Hot Water Room on both floors.Hand Washing Basin will be provided in the Maintenance Room on the 1st floor.

b) Fire Fighting Equipment

- Fire Extinguisher

  Powder Fire Extinguishers will be deployed at the completion of Building construction.

- Internal Fire Hydrant System

  Two Fire Hydrant Boxes will be provided on each floor. The Fire Hydrant will be connected to the water supply piping.

- Special Fire Fighting Equipment

  CCR (Constant Current Regulator)Room, UPS (Un-interruptable Power Supply) Room, on the 1st floor and CPU (Central Processor Unit) Room on the 2nd floor are the designated rooms to be provided with CO_2 fire fighting system. The CO_2 canisters and header equipment will be placed in the Special Fire Fighting Room on the 2nd floor. Valves to select activated room and control; panel will also be placed here.

c) Air-Conditioning and Ventilation Equipment

- Air-Conditioning Equipment

  Individual Air-Conditioning systems will be provided to handle differing air-conditioning needs of the various rooms. Ease of operation and maintenance considerations are also considered. Air-Cooled Heat Pump Type Separate units with Ceiling Mounted Cassette internal units (with Humidifier for winter use) are selected for all rooms.

  1St Floor : CCR Room, Testing Room, Maintenance Room, Guard Room, Locker Room, Maintenance Personnel Rest Room, Rest Room

  2nd Floor : office (1), (2), (3), (4), CPU Room, Manager Room, Control Room, Control Personnel Rest Room, Locker Room, Data Room, Bed Room

- Ventilation Equipment

  Transformer Room and Battery Room on 1st floor will have external wall mounted exhaust fans and Low-tension Distribution Room and Testing Room will have internal wall mounted exhaust fans facing corridor for ventilation.

2) Secondary AFL Sub-Station

a) Plumbing Facilities

- Water Supply Facilities

  The water will be taken by branching from the water mains beneath the airport internal road fronting the site on the south. A control valve will be installed in the site distributed to each usage by direct pressure piping.

- Waste Water Drainage

  Internal drainage for the waste water will be divided into soil water and general waste water. They will be joined at the external receiving basin and conducted to the sewage mains beneath the road fronting site on the north via connection basin. Ventilating pipes will be a combination of extension pipe type and loop type releasing gas through external walls.

  Rain water from standpipes will be received in catch basins and conducted to the storm drain mains underneath the road facing on the east and north of the site.

- Sanitary Fittings

  Sanitary fittings will be provided for the Toilet.

b) Fire Fighting Equipment

- Fire Extinguisher
  Powder Fire Extinguishers will be deployed at the completion of building construction.

- Special Fire Fighting Equipment
  CCR (Constant Current Regulator)Room, UPS (Un-interruptable Power Supply) Room and CPU (Central Processor Unit) Room are the designated rooms to be provided with CO_2 fire fighting system. The CO_2 canisters and header equipment will be placed in the Special Fire Fighting Room. Valves to select activated room and control panel will also be placed here.

  As this building is normally uninhabited, the release mechanism will automatically activate after receiving fire alarm from automatic fire detectors.

c) Air-Conditioning and Ventilation Equipment

- Air-Conditioning Equipment
  CCR Room, UPS Room, CPU Room and Control Personnel Rest room will be provided with remote controlled separate type floor cooler units.

- Ventilation Equipment
  Transformer Room, Battery Room and Low-tension distribution Room will have external wall mounted exhaust and intake fan units for ventilation.

(7) Building Electrical Equipment Design

Each Equipment will be designed to Chinese laws and standards(JGJT16-92).

1) Low-tension Distribution System

General Power for building equipment will be distributed from the low-tension distribution panel to each distribution panel in respective rooms and areas.
Lighting and Outlet will be supplied with single phase 3 line 200 V 50 Hz electricity with grounding line. Power supply will be 3 phase 3 line 380 V 50 Hz with grounding line. Both single phase and 3 phase supply will be Grouped into 3 categories according to importance.

2) Power Mains

Category -1 : general lighting main (single line main), general power for air-conditioning (single line main)

Category -2 : Security Lighting· Security Power mains (CCR, UPS and CPU rooms)

Category -3 : Emergency Lighting (dual line), Emergency Power (dual line)

3) Grounding Equipment

Grounding will be incorporated into comprehensive electrical receiving equipment works. No independent grounding for computers will be provided.

4) General Lighting· Emergency Lighting Equipment

Lighting Equipment will be designed for function based on Chinese laws and standards(JGJT16-92) and JIS standards. Emergency lights will turn on within 15 seconds of power failure.

Light Distribution Panel (X1, X2, X3) will have General Lighting Circuit and Emergency Lighting Circuit (dual line back-up by Diesel generator).

5) Exit Signs Lighting

Exit Sign Lighting will be provided based on Chinese laws and standards.

Exit Sign Lighting will be equipped with batteries and be turned on constantly (normal/ power failure modes).

6) Outlet

General Outlets will be two connector type and be placed as needed on walls in each room. The mains will be selected according to the importance of the room into general power circuit and emergency power circuits.

7) Power Supply

Each Building Mechanical Equipment Power Distribution Panel will have General Security Power (diesel generator back-up) dual line connection. Equipment control panels will be connected to individual units by piping and cables. (Control Line , Water Level Detector for Fire fighting Tank included).

Control panels for ventilation equipment will be part of Building Electrical Works. Control; Panel for Fire Hydrant Pump will be part of Building mechanical Works.

Failure and abnormal operation signals monitoring line will be connected to panel in Control Room.

8) Automatic Fire Alarm System

The receiving panel will be installed the Control Room and master panel will be placed in each fire hydrant box.

The signals from the alarm system in the Secondary AFL Sub-Station will be relayed to the master panel in the Main AFL Sub-Station.

9) Telephone Equipment

An external receiving pit will placed outside the building and underground ducts will be connected. The incoming lines will be connected to the Main Distribution Frame(MDF) Unity. The MDF will be placed in the Control Room and a Intermediate Distribution

Frame (IDF) will be placed in the CCR Room. Extension piping will be taken from these to telephone jacks on the walls in each room.
Actual wiring and connection of individual telephone handsets will be done by the telephone company.

10) Radio Communication Equipment (for Main AFL Sub-Station Only)
Space will be Reserved in the Control Room for radio communication equipment to contact Airport Operations Center and Airport Fire Station.(Sleeve for Antenna connection included)

11) Television Reception Facilities
VHF / UHF antenna will be placed on the second floor roof. Television reception jacks will be provided in the following rooms;
1st Floor: Maintenance Personnel Rest Room
2nd Floor: Office, Manager Room, Conference Room, Control Room, Control Personal Rest Room

CHAPTER 5. CONSTRUCTION PLAN / COST ESTIMATE

5.1 Construction Plan

Construction plan of AFL system, which is essential for taking off and landing of airplanes, is planned on assumption that this work shall be by a lump-sum and a Turn-key contract through international competitive bid. It was also planed the construction schedule to meet demand by Chinese government that opening date of airport should be by October 1st, 1999 (Independence Day of China) and construction schedule is attached herewith.

Total period is estimated as 24 months to carried out the opening date, but it shorten sharply a usual period required construction of airport, and construction works will be accomplished by 2 or 3 shifts system. Thus, supervisory work for the construction work is very important.

In addition to the above, following conditions shall be observed to meet the construction schedule.

(1) Completion of 35 kV high voltage substation by Chinese side: By 8 months to meet the construction schedule.

(2) Completion of passenger terminal building and control tower: By 12 months to meet the construction schedule.
Meanwhile, materials such as AFL pipes and so on shall be provided by AFL system side to meet progress of the Airside Civil Work.

5.2 Remarks of Lighting Facilities

Ground movement has important function in the design of the airfield lighting. So, the Study Team requires the Chinese side submitting data of the ground movement from the beginning of design stage, but the Chinese side could not submit it to the Study Team. Thus, the ground movement is not considered in this detailed design. In the case that number of character signed and location of the taxiway guidance signs and the taxiway intersection lights differ from the ones of this detailed design, which result to affect at the capacity of the taxiway guidance signs and the taxiway intersection lights, and remember to which the capacity of the CCR. Therefore, Chinese side shall review the design of the taxiway guidance signs and the taxiway intersection lights, and remember to check the capacity of the CCR at the construction stage.

In addition to the above, followings shall be given to attention also at the construction stage.

The following pavement work areas, which are excluded from the phase I work are not described in the drawings of the airfield lighting for convenience,

- Spot numbers in the Cargo Apron
- Two entrance and exit taxiways at 3,200 m from the runway end between the runway and a parallel taxiway.

In this detailed design, however, quantities and cost estimate of the airfield lighting include the above areas considering concept of the basic design. Thus, Chinese side is required to adjust the quantities of the airfield lighting considering above areas when actual order is made.

(1) Light distribution intensity characteristics are very important. Since each light has mutual directional characteristics, slight error will have an effect on function of lights. Therefore, following items shall be taken care under the construction stage.

- Location of lights are measured by a special surveyor.
- A common difference shall be observed within the specification.
- Coordination work with the Airside Civil Work

Installation of surfaced lights placed on concrete pavement of runway and taxiway shall be coordinated with the Airside Civil Work. Coordination meeting will be necessary to understand procedure and progress of the installation work with each other. After the mutual understanding, installation work shall be started.

(2) Taxiway Intersection Lights
As taxiway intersection lights installed on entrance between the taxiway intersection and apron area to keep security of airplane movement on the runway and the taxiway, it may be obstacle if volume of the air plane movement is increased. Thus, exact location place shall be determined to discuss with airplane companies and administrative departments considering airplane movement.

(3) Taxing Guidance Signs
Exact location place for theses sings are also decided by the discussion with the airplane companies and the administrative departments considering the airplane movement.

(4) Location Place of Stop Bar Lights
Location place of stop bar lights is planned to install at 90.5 m (90+0.5 m) from center of runway avoiding sensitive area and inner surface transposition of Radio Navigational

Aids (GP and LLZ). Exact location place shall be determined through discussion with relevant departments.

(5) Remote Control Panel at VFR room of Control Tower
Remote control panel shall be installed at suitable place for operator considering easy operation and coordination with the Radio Navigational Aids. Space for future extension of four runways shall be designed.

(6) Visual Docking Guidance (VDG) Lights and Apron Stand Identification Signs (ASIS)
Resume of operation and management of VDG lights and ASIS shall be necessary to make smooth operation. The points of resume shall be discussed with the relevant departments.

(7) Location place of the Precision Approach Path Indicator (PAPI)
Exact location place of the PAPI is decided by considering cooperation of the ILS, and location of the G/P is also re-considered.

5.3 Estimation of Construction Cost

Total estimation of construction cost is about 6.7 billion Japanese Yen (J¥) and items of the cost consists of as below

Item	Cost (Million J¥)	
1.Airfield Lighting	4,190	
2.Power Distribution	1,123	
3.Transportation and Packing fee	319	
4.Direct cost(Dispatching of engineers)	213	
Total of Direct Construction Cost	5,845	(1)
5.Temporary Work Cost	176	
6.Work at Site Cost	293	
7.General Management Cost	293	
Total of Indirect Construction Cost	762	(2)
Total of Construction Cost (1)+(2)	6,607	(3)
8.AFL Sub-Stations	93	(4)
Grand Total of Construction Cost (3)+(4)	6,700	

The above construction cost is estimated by following conditions.

(1) There is formulated "Estimation of Construction Cost Standards" in China, and it is a complex construction cost covering man-power, material fee and machine-use fee that is similar to Japanese one. Nevertheless, the Chinese standards are not applied to this construction work. Therefore, Japanese Constriction standards of Ministry of Transpiration and Construction are applied instead because there are some problems in the Chinese standards, which were mentioned in the Progress Report (2) and summarized as below,

- Common labour cost is only applied and required man-power such as electrician and surveyor are not adopted.
- Estimated working day is short.
- Specifications of equipment in the material fee are old.

(2) Design and Supervision fee, and the contingency are not included.

(3) Planing of Procurement attached in Volume IV "Appendices" denotes equipment and material procured from abroad and within China.
Imported equipment and materials deem as duty free. Details are refereed to as followings that are also annexed in the Volume IV.

- Design calculation.
- Estimate of Works.
  - Table of Direct Construction Cost
  - Table of Complex Construction Cost- Unit Rate Estimate.
  - Annex

(4) The total construction cost of 6.7 billion J¥ as mentioned above is made by as below, and conversion rate is 1J¥ is 12.66 Chinese RMB.

Items (Equipment and materials only)	J¥	Chines RMB	Total (RMB conversion)	Total (J¥ conversion)
• Airfield lights	2,148,616,746	161,258,174.86	330,974,663	4,190 million J¥
• Power	1,086,942,508	2,885,433.78	88,741,872.02	1,123 million J¥
• AFL Sub-Station	0	7,359,364	7,359,364	93 million J¥

Total amount of direct and indirect cost for airfield lighting facilities in the basic design was around 10.8 billion yen without buildings. This cost was reduced to 6.6 billion yen with the deference of 4.2 billion yen. The main reasons of reduction are as follows;

- Some cables, pipes and so on were deducted due to the reason that monitor and control system were divided into three areas.

- The number of burnt-out lamp detection devices were reduces due the changes of the kind of lights to be detected.

- The country of manufacturer of lights and materials was changed for reduction.

- The kinds of maintenance machine parts were reconsidered for reduction.

- An aerodrome beacon was deleted from the design.

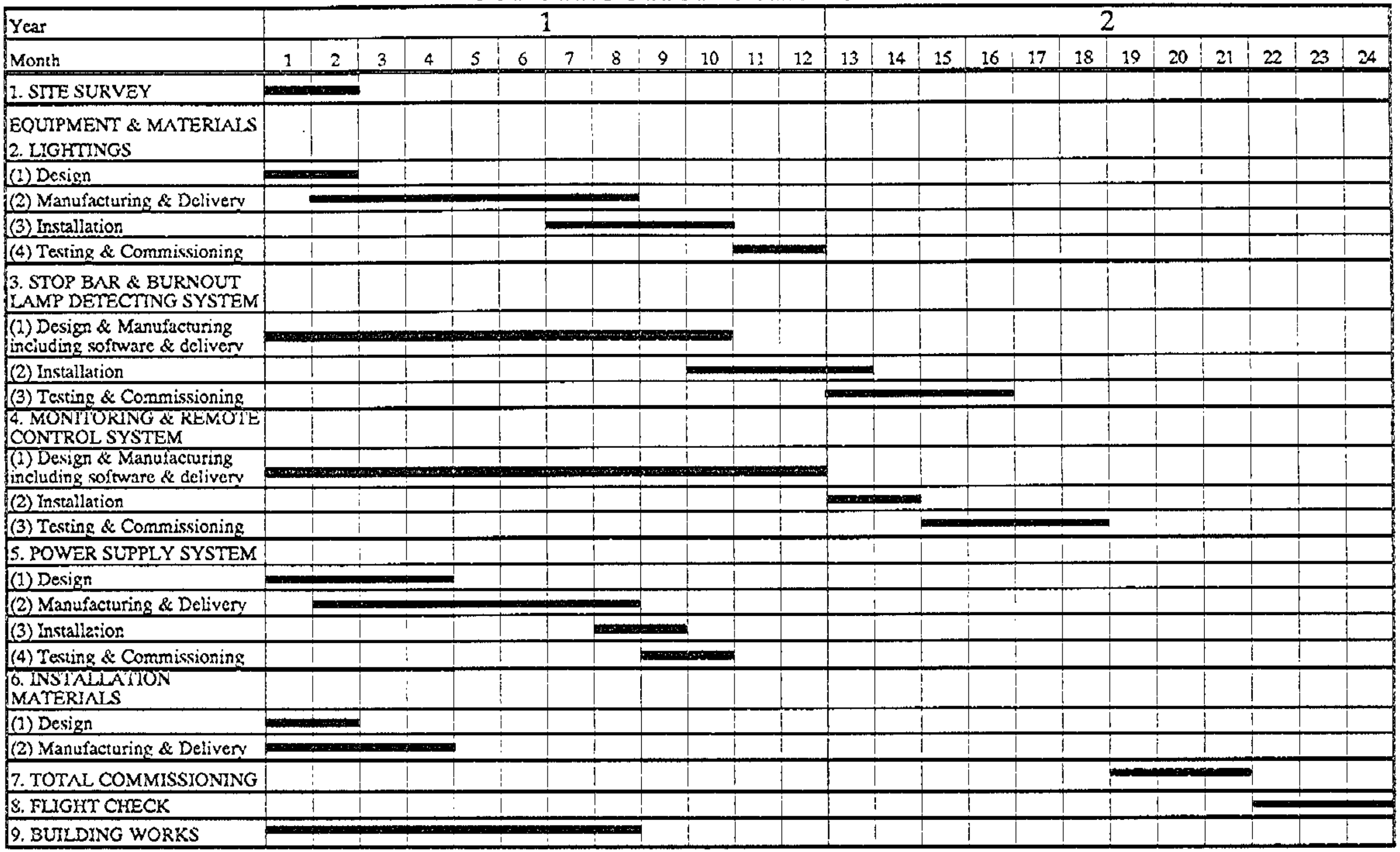
- The number of flexible pipes were reduced depending on type of lighting due the type change of lighting base and the change of installation method to burring under the pavement.

- Lamp and the transformer were installed in one box due the narrowing of runway shoulder.

- The costs for maintenance and training shall be a matter of preparation by Chinese side, and these were deleted from the estimate.

- The percentages of indirect cost were reconsidered.

SHANGHAI PUDONG INTERNATIONAL AIRPORT
AIRFIELD LIGHTING SYSTEM
CONSTRUCTION SCHEDULE



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-3
DETAILED DESIGN OF FUEL SUPPLY SYSTEM

SEPTEMBER 1997

NIPPON KOEI CO., LTD.
NIKKEN SEKKEI LTD.

CHAPTER 1 DESIGN SCOPE AND DESIGN SUMMARY

1.1 General

This Report covers the detailed design of Fuel Hydrant System among Shanghai Pudong International Airport Designs carried out by the Shanghai Pudong International Airport Detailed Design Study Team of JICA (Japan International Cooperation Agency, hereinafter referred as "Study Team").

The referred Report consists of (1) Design Scope, (2) Design Conditions, (3) Explanations of contents of Detailed Design, (4) Construction Plan and (5) Estimated Construction Cost.

The contents of detailed designs per (3) provide a description of changes from the basic design to the detailed design, and also of the design details added during detailed design. Most reasons for the changes from the basic design stem from the Chinese Side formal design apprisal. The construction plan per Item (4) describes the construction execution method and flushing plans.

1.2 Design Scope and Detailed Design Summary

1.2.1 Design Scope

Within the design scope of aircraft fueling facilities are the fuel storage facility to be installed within the site of Shanghai Pudong International Airport in the Phase-1 Project, hydrant facility and ancillary facilities required for the above. The receiving pipeline system, etc. of aircraft fuel to the aircraft fuel storage facility shall be outside the referred design scope.

The details of the basic design are identified as follows:

Feasibility Studies

Studies on the scale of the entire airport facilities in consideration of future expansion

↓

Overall Design

Studies on entire facility layout. — Interim Report (1)

↓

Basic Design
(in the Phase-I Project)

Studies on basic configuration of facilities.
Studies on basic specifications of facilities.
Calculation of approximate construction cost. — Interim Report (2)

↓

Detailed Design
(in the phase-I Project)

Detailed design for bidding
Cost calculation for bidding — Final Report

1.2.2 Design summary

Detailed design of the following aircraft fueling facilities was conducted.

- Fuel receiving facilities:
  The fuel receiving facilities will receive fuel to be sent from a transfer system outside the airport, via 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 covers foam and water fighting systems.

- Electrical system:
  The electrical system for the aforementioned facilities.

- Instrumentation/control system
  The instrumentation/control system for 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

The phase-1 project (2005)

2.2 Applicable laws/regulation and standards

- 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
- Chinese national code
- Chinese industrial standard

2.3 Fuel conditions

(1) Standard : According to the Chinese standard GB 6537-86

(2) Fuel name : RP3

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

(4) Flash point : 38°C or higher

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

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

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

(8) Vapor pressure : 0.0007MPa

2.4 Climatic conditions

(The values shown in the final report on basic design of Shanghai Pudong International Airport were used.)

Place: Observatory records of the Shanghai Chuan Sha Observatory

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

(2) Atmospheric temperature : Average temperature; 15.5°C

- Highest temperature; 38.0°C
- Lowest temperature ; -9.6°C

(3) Rainfall

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

(4) Snowfall

- Max. snow depth : 15cm
- 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 conformed to the "Soil Data of Airside Civil Works" .

2.6 Fuel receiving flow rate

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

2.7 Fuel storage capacity

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

2.8 Hydrant discharge flow rate

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

2.9 Refueler loading rate

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

2.10 Power receiving conditions

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

2.11 Water receiving conditions

The line was branched from the main city water line buried under the trunk road north of the fuel farm.

2.12 Oily water discharge criteria

The Chinese discharge criteria for fuel oil in water is 10ppm or under.