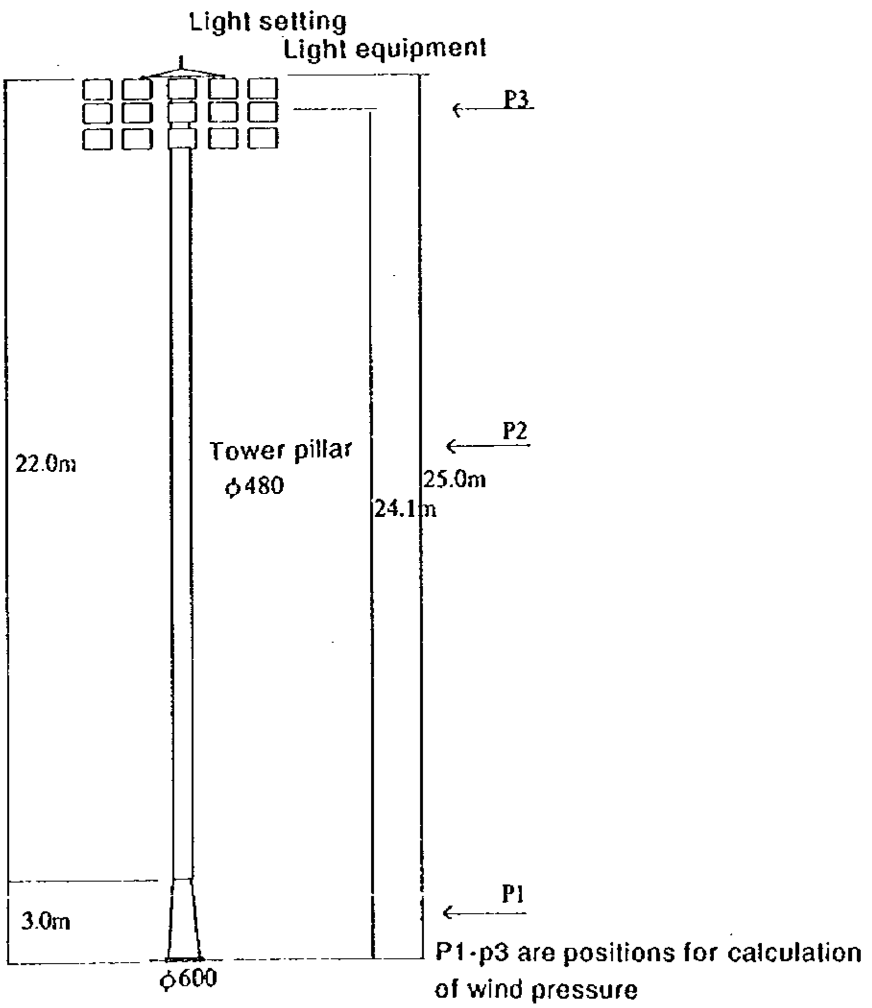
6.3 Foundation of Apron Lightings

6.3.1 Design Tower Pillars

Apron lightings shown in FigureII1-6.3.1 were selected for design. Then, design of their foundation was carried out based on the following features:

• Height of tower pillar	25.0 m	
• Number of lightings	15	
• Tower pillar	From top down to 22 m ···φ480	
	From bottom up to 3 m ···φ600	
• Weight	Lighting equipment	900 kg
	Tower pole	3,400 kg
	Device for prevention of dropping	100 kg
	Elevator	200 kg
	Total	4,600 kg
• Area of wind pressure	Lighting equipment etc.	4.2 m^2
	Tower pillar	12.08 m^2

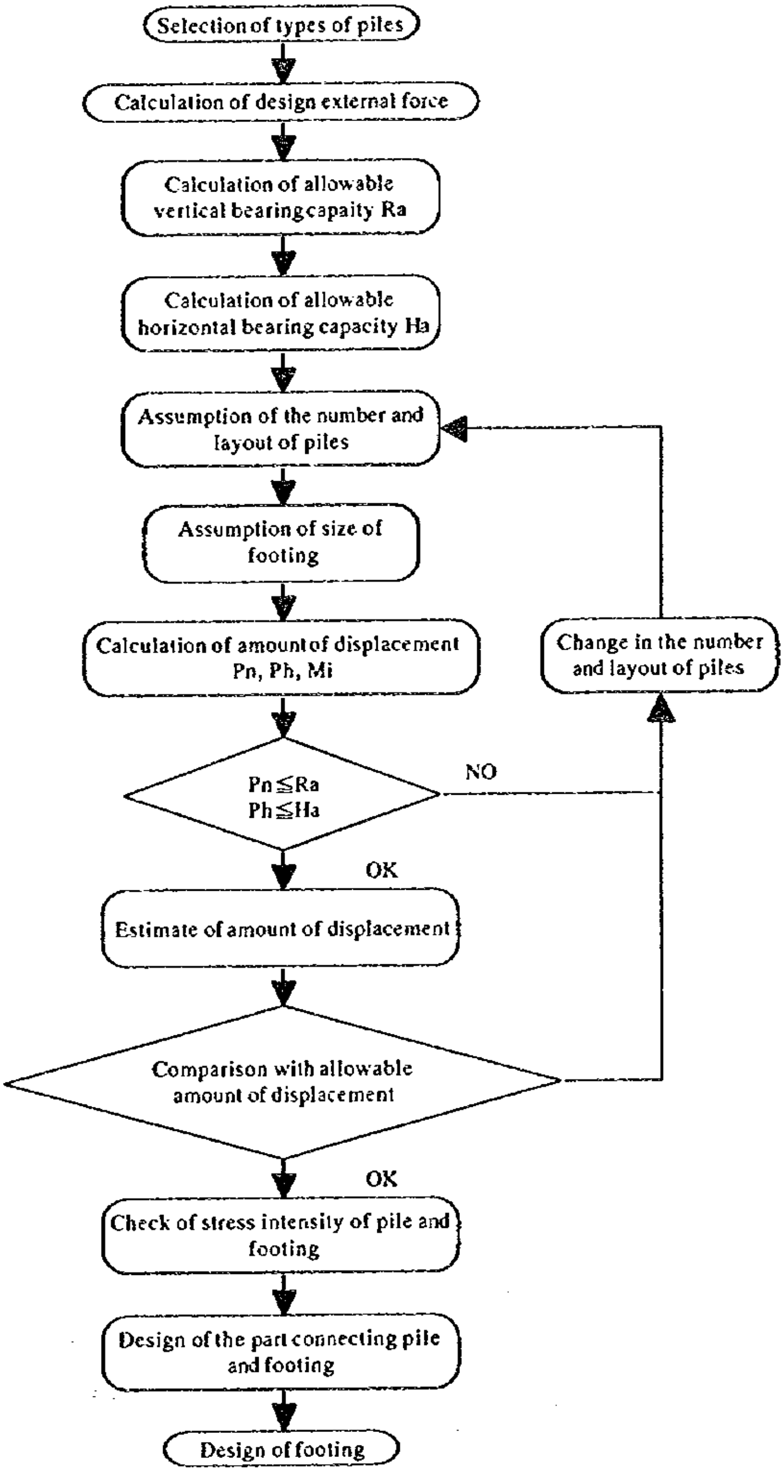


FigureII1-6.3.1 Structure of Upper Part of Apron Lightings

6.3.2 Design Flow

The foundation ground of the proposed airport site is soft. Therefore, foundation for apron lightings was determined to be pile foundation. Design was carried out according to the design flow shown in FigureII-6.3.2.

Existing RC square piles will be used because they are standard piles in China. The bearing stratum of this airport is Stratum ⑦. It has a depth of about 40 m at some points. Therefore, it was determined to use friction piles.



FigureII-6.3.2 Design Flow for Pile Foundation

6.3.3 Design External Force

To calculate the design external force, influence of wind load and earthquake was considered. As to the influence of earthquake, a horizontal seismic intensity of Kh = 0.08 was taken into account, as aforesaid. Wind load was calculated as follows.

Using the following formula, according to the "Criteria of High-Rise Structure Design".

$$\omega = \beta_z \mu_s \mu_z \mu_r \omega_0$$

where,

ω	:	wind load (kgf/m2)
βz	:	coefficient of wind vibration
μs	:	coefficient of wind load system
μz	:	coefficient of Altitude change
μr	:	coefficient of adjustment of frequency
$\omega 0$	:	basic wind pressure (kgf/m2) = 1/2* ρ v2
ρ	:	density of air (0.123 kgfsec2/m4)
v	:	design wind velocity (m/sec)

Design wind load was calculated in the following 2 cases:

- the case with a lighting equipment:
- the case with a lighting pillar only:

The wind velocity in the former case was estimated at 50 m/sec, and in the latter case at 70 m/sec.

The calculation results are given in TableII1-6.3.2 below.

TableII1-6.3.2 List of Calculation of Wind Load

Case 1:With lighting equipment: Design wind velocity 50m/sec

	Position of action m	Design wind velocity m/sec	Basic wind pressure ω0 kgf/m2	μs	μz	μr	ω0T2	ζ	ε1	ε2	βz	Wind load in unit area ω kgf/m2	Area of in unit area A m2	Wind pressure P kgf	ΣP kgf	Action pressure hi m	Moment M kgf・m
3	24.1	50	153.75	1.3	1.32	1.1	0.9	2.49	0.61	0.75	2.14	621	4.20	2,607	2,607	0.90	
2	11.55	50	153.75	0.7	1.04	1.1	0.9	2.49	0.71	0.39	1.69	208	10.56	2,197	3,706	20.20	2,347
1	1.5	50	153.75	0.7	0.8	1.1	0.9	2.49	0.72	0.05	1.09	103	1.62	167	4,888	3.00	77,204
															4,971		**91,867**

(Force in the axis direction) **4,600** kg

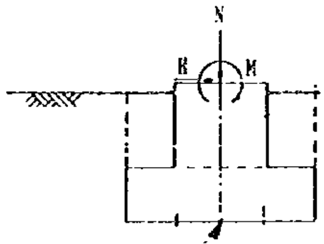
Case 2: With lighting pillar (without lighting equipment) Design wind velocity 70m/sec

	Position of action m	Design wind velocity m/sec	Basic wind pressure ω0 kgf/m2	μs	μz	μr	ω0T2	ζ	ε1	ε2	βz	Wind load in unit area ω kgf/m2	Area of in unit area A m2	Wind pressure P kgf	ΣP kgf	Action pressure hi m	Moment M kgf・m
2	14.0	70	301.35	0.7	1.11	1.1	0.9	2.49	0.68	0.46	1.78	458	10.56	4,838	4,838	11.00	
1	1.5	70	301.35	0.7	0.8	1.1	0.9	2.49	0.72	0.05	1.09	202	1.62	328	5,002	3.00	53,221
															5,166		**68,228**

(Force in the axis direction) **3,400** kg (Lighting pillar only)

From the above, Case 1 (with lighting equipment) was selected for calculating the design external force of wind load.

- N in the axis direction N 4.6 t
- Horizontal force Q 5.0 t
- Moment M 97 t・m



Origin of Calculation

FigureII1-6.3.3 Position of Outer Action

6.3.4 Design of Pile Foundation

(1) Allowable Bearing Capacity of Pile and Allowable Displacement of Pile Head

The Japanese way of calculating the vertical bearing capacity of piles is to employ the estimation formula using N value and cohesion C, according to the "Specifications of Highway Bridge, Infrastructure". However, this was not used in this case. The capacity was calculated in accordance with the "Criteria of Pile Foundation Design" of Shanghai City.

The following calculation formula for vertical bearing capacity was used.

$$R_d = 1 / k\,(Up\ \Sigma\ f_i\, l_i + f_p\, A_p)$$

$$P_a = 1 / N\ Up\ \Sigma\ f_i\, l_i$$

Where,

Nd	: allowable pressing bearing capacity in the (t) axis direction of a pile
Pa	: allowable pull-out force in the axis direction of a pile (6)
K	: safety rate (3)
N	: safety rate (6)
Up	: circumference of a pile (m)
fi	: limit frictional force (t/m2)
li	: thickness of the "i"th layer (m)
fp	: limit bearing capacity of the pile edge (t/m2)
Ap	: sectional area of the pile edge (m2)

As friction piles are the subject, it was assumed that bearing capacity of the pile edge would not be expected. For frictional force, f_i, the lowest value of the standard values of shanghai was used.

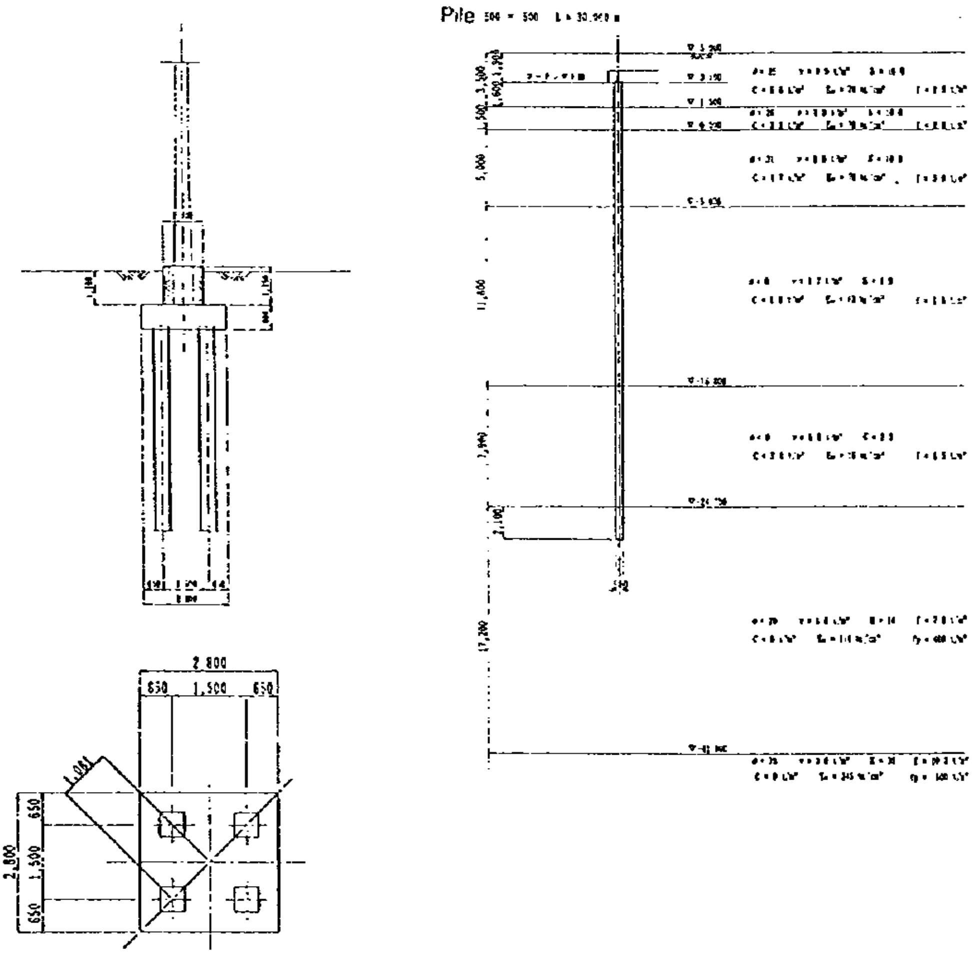
TableII-6.3.3 Surrounding Frictional Force of Existing Piles (Pile Foundation Design Standards, Shanghai City)

Stratum No.	Name of Stratum	Frictional force of existing piles f_i (t/m^2)
②－1	Brownish yellow clay	1.50
②－2, 3	Gray viscous silt	2.00
②－4	Gray viscous silt	3.00
③	Gray sludgy silty clay	1.50
④	Gray silty clay	1.50
⑤－1	Gray viscous soil	4.50
⑤－2	Gray sandy silt	5.00

Allowable amount of displacement of pile foundation was determined to be 1.5 cm according to the "Specifications of Highway Bridge, Infrastructure".

(2) Selection of Pile Layout and Form of Footing

With regard to form of footing, consideration was given to the relation with facilities installed near apron lightings, such as manholes and distributing boards. Accordingly, the form was made as small as possible.



FigureII-6.3.4 Foundation Form

(3) Results of Structure Calculation

For form of foundation shown in FigureII1-6.3.3, calculation of the following items was made:

- Safety (in accordance of "Specifications of Highway Bridge, Infrastructure")
- Structure of concrete pillar and footing
- Main body of a pile
- Part connecting a pile and footing.

The results are as shown in TableII1-6.3.4. Structure Calculation is contained in the statement of design calculation in the Appendix.

TableII1-6.3.4 Calculation Results of Apron Lighting Foundation Design

(1) Calculation Results of Safety

Totalization of degree of safety against load action at an angle of 90°

	Ordinary	Wind	Earthquake
M (tm)	----	102.25	10.77
N (t)	39.08	39.08	39.08
H (t)	----	5.00	2.07
σz (cm)	----	0.17141	0.02082
σy (cm)	0.03304	0.03304	0.03304
θx (rad)	----	0.00121	0.00014
RNmax(t)	9.77	36.63	12.81
Rnmin(t)	9.77	-17.09	6.73
PH (t)	----	1.25	0.52
MT (t)	----	5.42	0.42
Mm (tm)	----	5.70	0.64
Lm (tm)	----	0.500	1.000
Ra (t)	92.00	92.00	92.00
Pa (t)	----	-29.00	-29.00
δa (cm)	1.50	1.50	1.50

Totalization of degree of safety against load action at an angle of 45°

	Ordinary	Wind	Earthquake
M (tm)	----	102.25	10.77
N (t)	39.08	39.08	39.08
H (t)	----	5.00	2.07
σz (cm)	----	0.17134	0.02081
σy (cm)	0.03304	0.03304	0.03304
θx(rad)	----	0.00121	0.00014
RNmax(t)	9.77	47.75	14.06
Rnmin(t)	9.77	-28.21	5.48
PH (t)	----	1.25	0.52
MT (t)	----	5.41	0.42
Mm (tm)	----	5.70	0.64
Lm (tm)	----	0.500	1.000
Ra (t)	92.00	92.00	92.00
Pa (t)	----	-29.00	-29.00
δa (cm)	1.50	1.50	1.50

(2) Calculation Results of Concrete Pillar (the part rising from footing)

		Lower end of pillar	Lower end of pillar	Lower end of pillar
M (tm)		0.00	98.25	9.63
N (t)		9.60	9.60	9.60
S (t)		-0.03	4.24	1.65
Arrangement of	D-n	D25 - 26.0	D25 - 26.0	
reinforcement	As	131.74	131.74	131.74
[c.t.c.]		[150]	[150]	[150]
σc (kg / cm²)		1	59	6
σs (〃)		-1	1,946	118
γm (〃)		0.00	0.42	0.06
σca (〃)		(53)	(669)	(79)
σsa (〃)		(1,600)	(2,000)	(2,700)
γal (〃)		(2.70)	(3.38)	(4.05)
Name of load		Ordinary	Wind	Earthquake

(3) Calculation Results of Footing

		Lower side in the axis direction	Upper side in the axis direction	Lower side in the vertical direction	Upper side in the Vertical direction
M	(tm)	9.80	10.61	Omission	Omission
N	(t)	0.00	0.00	——	——
S	(t)	35.67	0.00	——	——
Arrangement of	D-n	D16 - 8.0	D16 - 4.0	D16 - 8.0	D16 - 4.0
reinforcement	As	15.89	7.94	15.89	7.94
[c.t.c.]		[300]	[300]	[300]	[300]
σc (kg / cm²)		13	25	——	——
σs (〃)		990	1,991	——	——
γm (〃)		4.17	2.66	——	——
σca (〃)		(66)	(66)	——	——
σsa (〃)		(2,000)	(2,000)	——	——
γal (〃)		(6.76)	(6.76)	——	——
Name of load		Wind	Wind	——	——

(4) Stress Intensity of Existing Piles

		Nmax	Nmin
M	(tm)	5.70	5.70
N	(t)	36.63	- 17.09
S	(t)	1.25	1.25
Type of	Diameter of pile	D = 500 mm	D = 500 mm
Piles	Phc Pile		
σc (kg / cm²)		37	24
σs (〃)		142	1,974
γm (〃)		0.56	0.56
σca (〃)		(83)	(83)
σsa (〃)		(2,000)	(2,000)
γal (〃)		(4.00)	(4.00)
Name of load		Wind	Wind

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 as follows:

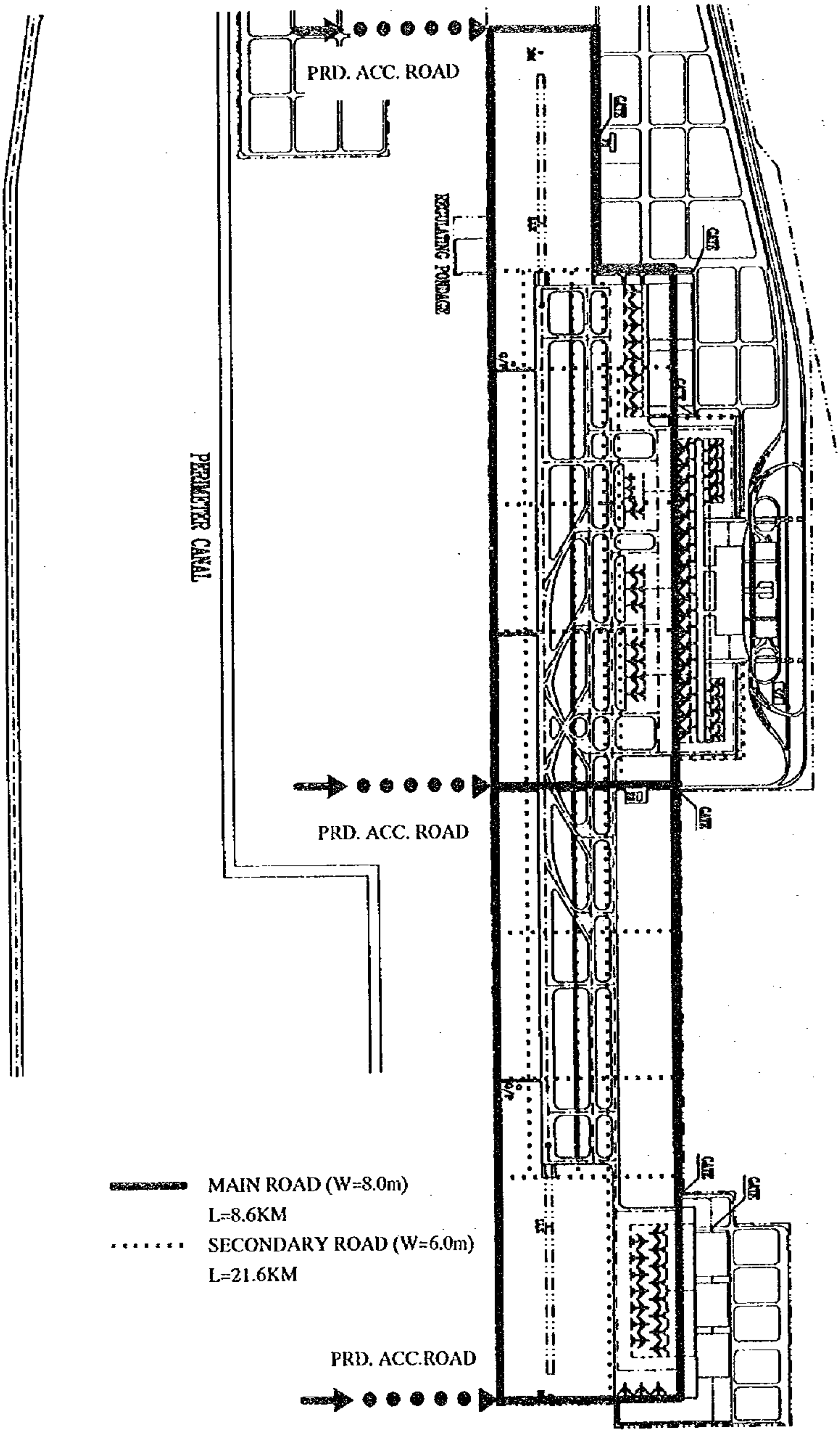
- Embankment material brought from outside : 2.3 million m^3 →3.7 million tons
- Pavement Work

Sub base material	: 1 million m^3 →	2 million tons
Cement		0.3 million tons
Sand and Crushed Stone		1.5 million tons

- Other Materials 1.5 million tons
- Total 9.0 million tons

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 1,900 - 2,500 per day and the number on a peak day would be 2,400 - 3,200 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.



FigureII1-7.1.1 Plan of Main Construction Roads

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
  Total length 8.6 km
- Secondary Road : Pavement width 6.0 m
  Total length 21.6 km

(Refer to FigureII1-7.1.1.)

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 a pavement concrete volume of about 700,000 m^3 is placed during a period of one year,

$$700{,}000 \div (365 \times 0.8) = 2{,}397\ m^3/day \rightarrow 2{,}400\ m^3/day,$$

with a peak rate of 30%, the volume will be 3,000 m^3 on a peak day.

If placement of concrete pavement is carried out on the basis of an 18-hour work day with two shifts and with actual operation of 13 hours, the following equipment capacity will be required ;

$$3{,}000\ m^3/day \div 13\ h/day = 230\ m^3/h$$

The required number of fully automatic concrete mixing plants of 1 m^3 class (nominal capacity 72m^3/h) is calculated as follows.

One plant : $Q = q \times K \times E$

where q = nominal capacity : 72 m^3/h
K = coefficient of mixing for slump of 5 cm or under: 0.75
E = work efficiency : 0.85
$Q = 72\ m3/h \times 0.75 \times 0.85 = 45.9\ m3/h$

The required number of plants is:

$$230\ m^3/h \div 45.9\ m^3/h/\ plant = 5\ plants$$

Total Power requirement per plant is around 50 KW, therefore total power demand is:

5 plants x 50 KW = 250 KW

The necessary amount of materials for cement stabilization treatment for sub base material is estimated to be about 2 million tons. If it is placed during a period of one year :

$$2{,}000{,}000 \div (365 \times 0.8) = 6{,}894\ t/day \rightarrow 6{,}900\ t/day$$

At an assumed peak rate of 30%, the volume on a peak day is 8,900 t. If placement is carried out on the 18-hour work day with two shifts and with actual operation of 13 hours, the following equipment capacity will be required :

8,900 t/day ÷ 13 h/day = 680 t/h

It is assumed that central plants of 120 -150 t/h class will be installed, then the required number of plants is calculated as follows :

One plant : Q = C x E

where Q : volume of mixing per hour (t/h)
C : maximum mixing capacity (150 t/h)
E : work efficiency (0.8)
Q = 150 x 0.8 = 120 t/h

The required number of plants is:

680 t/h ÷ 120 t/h · plant = 6 plants

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

6 plants x 40 kW = 240 kW

Accordingly, an electric power capacity of 750 kVA will be required for plants only will be 750 kVA. 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 900 kVA - 1,000 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 3,000 m^3/day, requiring 500 t/day as mixing water. The volume of discharge from a soil plant is 8,900 t/day, requiring 1,000 t/day as mixing water. Including water requirements for other miscellaneous uses, a volume of 1,800 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 TableII-7.2.1.

TableII-7.2.1 Main Materials to be Carried In

Work Item	Material	Unit	Quantity	Remarks
Site Preparation Works	Sand	m^3	90,000	for sand mats
	Slag	m^3	1,550,000	for ram drop mat
	Earth brought from outside	m^3	660,000	sand of Yangzhou
Pavement Works	Cement	T	315,000	
	Sand for concrete	m^3	380,000	
	Gravel for concrete	m^3	780,000	
	Asphalt mixture	T	13,000	
	Aggregate for sub-base	m^3	1,000,000	
	Slip / Tie bars	T	9,000	
	Steel forms	m	9,600	T = 35 cm
Drainage Works	Cement	T	38,000	
	Sand for concrete	m^3	48,000	
	Gravel for concrete	m^3	89,000	
	Steel reinforcement bars	T	14,000	
	Round stones	m^3	49,000	
	Crushed stones for foundation	m^3	9,000	
	Formwork materials	m^3	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. The leveling capacity of a 21 t class bulldozer is calculated as follows: Q m^3/h

$$Q = \frac{B \times V \times D \times E \times f}{P}$$

where B : effective working width = 3.2 m

V : work speed = 2,000 m/h

D : depth of leveling finish = 0.3 m

E : work efficiency = 0.6

f : volumetric expansion ratio = 0.8

P : number of leveling passes = 6

$$Q = \frac{32 \times 2,000 \times 0.3 \times 0.6 \times 0.8}{6} = 153.6 \text{ m}^3/\text{h}$$

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.

Compaction capacity of a 20-t class tire-roller is: Q m^3/h

$$Q = \frac{W \times V \times D \times E}{P}$$

where W : effective compaction width of one pass = 1.8 m
V : speed of compaction = 4,000 m/h
D : depth of finish = 0.3 m
E : work efficiency = 0.6
P : number of passes over one area = 4

$$Q = \frac{1.8 \times 4,000 \times 0.3 \times 0.6}{4} = 324 \text{ m}^3/\text{h}$$

Compaction capacity of a 8-t class vibration roller is: Q m^3/h

$$Q = \frac{3.0 \times 1,800 \times 0.3 \times 0.6}{3} = 324 \text{ m}^3/\text{h}$$

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).

Working capacity of a 1.2 m^3 backhoe is: Q m^3/h

$$Q = \frac{3,600 \times q \times K1 \times K2 \times f \times E}{Cm}$$

where q : nominal capacity of a bucket = 0.2 m^3
K1 : coefficient of bucket = 0.95
K2 : coefficient of soil type = 0.90
f : = 0.76
E : work efficiency = 0.6
Cm : cycle time (135°) = 4

$$Q = \frac{3,600 \times 1.2 \times 0.95 \times 0.9 \times 0.76 \times 0.6}{22} = 76.6 \text{ m}^3/\text{h}$$

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. Working capacity of mixing machines is as shown in Section 7.1.2. Capacity of conveying and placement machines is calculated in this section.

Working capacity of 11-t dump truck for conveyance of sub-base material, : Q m^3/h

$$Q = C \times N$$

where C : loadage = 5.1 m^3/h

N : number of trips per hour

$$N = \frac{60}{t1 + t2 + 2d/V \times 60}$$

where $t1$: time for loading = 19 minutes

t2 : miscellaneous time = 9 minutes

d : distance of trip = 1.5 km

V : working speed = 30 km/h

$$N = \frac{60}{19 + 9 + (2 \times 1.5 + 30) \times 60} = 1.76 \text{ times}$$

$$Q = 5.1 \times 1.76 = 9.0 \text{ m}^3/\text{h}$$

Leveling capacity of a 3.7 m class motor grader is : Q m^3/h

$$Q = \frac{W \times V \times D \times E}{P}$$

where W : effective working width = 2.9 m

V : working speed = 3,000 m/h

D : depth of finish = 0.18 m

E : work efficiency = 0.6

$$Q = \frac{2.9 \times 3{,}000 \times 0.18 \times 0.6}{8} = 156.6 \text{ m}^3/\text{h}$$

Working capacity of a compaction machine (20-t class tire-roller) : Q m^3/h

$$Q = \frac{1.8 \times 4{,}000 \times 0.18 \times 0.6}{14} = 55.5 \text{ m}^3/\text{h}$$

Working capacity of a 12-t class macadam roller is : Q m^3/h

$$Q = \frac{0.8 \times 2{,}500 \times 0.18 \times 0.6}{4} = 54.0 \text{ m}^3/\text{h}$$

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 (180 m^3/day), even on a 13-hour workday.

Working capacity of a 11 -t class dump truck is :

$Q = 4.5\ m^3/truck \times 1.76\ times = 7.90\ m^3/h$

One concrete placement team will require two trucks.

(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 TableII1-7.2.2.

TableII1-7.2.2 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	5	
	150 t soil plant	6	
	1.4 m^3 tire loader	11	
	3.7 m motor grader	4	
	20 t tire roller	12	
	12 t macadam roller	12	
	simple finisher	14	
	plane vibrator	28	
	cylindrical vibrator	56	
	11 t dump truck	96	

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.

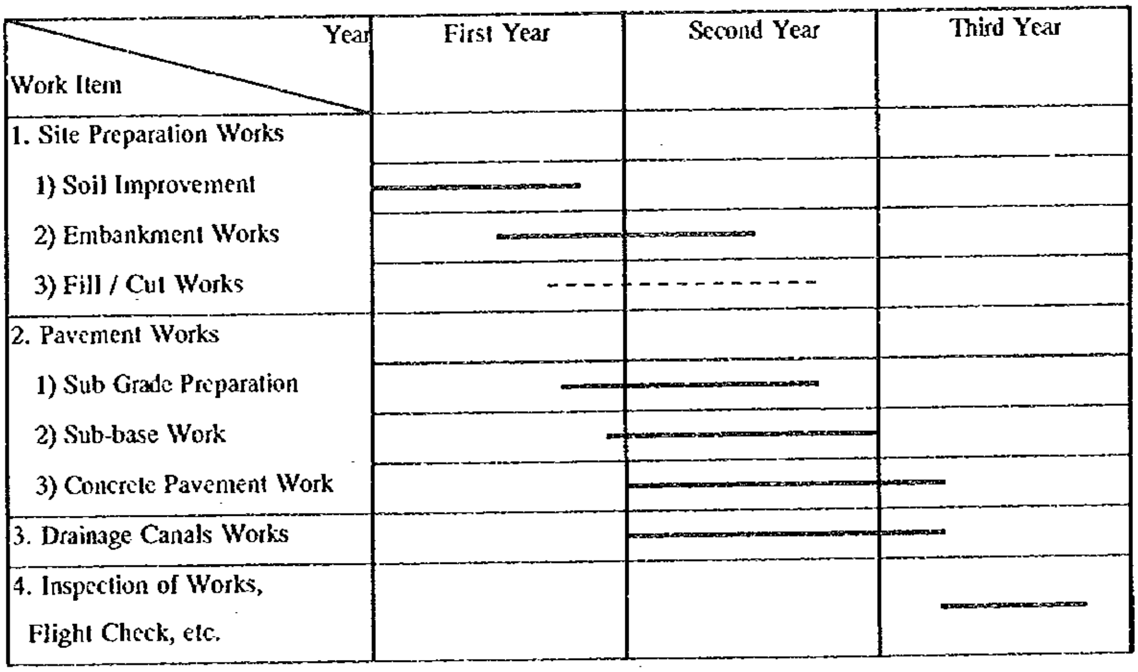
(5) Trial operation, accustomization, flight check and other operations to be conducted after completion of the construction works will be limited to a minimum period of approximately 6 months.

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.

FigureII1-7.3.1 Schedule of Works Related to Earthworks



7.4 Construction Cost Estimate

The construction costs of air-side civil works were estimated using the China Civil Airport Construction Cost Estimate Standards (CAAC Standards) and applicable standards of Shanghai City. First the direct costs were estimated. Minimum required bill-of-quantity items (B/Q Items) were identified referring to work quantity prepared items by the design team and the CAAC Standards pay-items. The direct costs were obtained by multiplying the work quantities by the B/Q Item unit prices that are the sum of the products of resources' requirements and unit prices of each resource (labor, materials, equipment, etc.). Then the indirect costs were estimated as a fraction of the direct costs. The sum of the direct and indirect costs constitutes the construction costs.

The civil works were divided into 5 categories: land formation, pavement works, drainage works, pumping machinery, and appurtenant facilities, for cost estimating purposes. The indirect costs were taken at 75% of direct costs of each facility. The construction costs of the civil works are summarized as follows. Detailed breakdown of direct costs is compiled in Appendices.

Item	Costs(Mil.RMB)
Land formation	427.00
Pavement works	547.00
Drainage works	139.00
Pumping machinery	106.00
Appurtenant facilities	26.00
Total	1,245.00

It should be noted that the cost estimate was done under the following conditions and assumptions.

(1) In China, well established standards namely the CAAC Standards, are available. The current CAAC Standards are based on 1993 price level in Beijing Capital City. First, the Study Team tried to independently estimate the B/Q unit prices using the CAAC Standards resource requirements and update unit prices of resources. Unavailability of unit prices of major resources, however, forced the Study Team to give up this effort. Instead CAAC Design Institute's estimated unit prices of B/Q Items were used as long as applicable.

(2) Regarding the ground improvement works (heavy ram drop method) , the B/Q Items and unit prices shown in "Ground Improvement Test Study Report (September 1996)" were used because of unavailability of more detailed and updated information.

(3) Regarding machinery and equipment (M&E) costs of the pumping facilities, domestic price quotations were not available this time. Instead Japanese manufacturers'

quotations were collected. The Study Team estimated the costs of domestically procured M&E items by adjusting the Japan's price quotations considering the difference of the price levels between Japan and China.

(4) An indirect cost factor of 75% was estimated judging from the actual results of infrastructure projects in Shanghai, the magnitude and quantity of temporary works, current rates of increase in construction materials in Shanghai, etc. More accurate estimate of the indirect cost factor is supposed to be done by the Chinese side. This time the Study Team assumed the factor as an indicative factor for cost estimating purposes.

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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

DETAILED DESIGN OF SHANGHAI PUDONG INTERNATIONAL AIRPORT FINAL REPORT

VOLUME I MAIN REPORT

PART II - 2 BASID DESIGN OF AIRFIELD LIGHTING SYSTEM

SEPTEMBER 1997

NIPPON KOEI CO., LTD.
NIKKEN SEKKEI LTD.

CHAPTER 1 DESIGN CONDITIONS

1.1 General

The design work was carried out according to the "Basic Plan Survey Report for Shanghai Pu Dog International Airport" and the results of the field survey which had been conducted from May 12 through November 10, 1996, as well as the co-ordinated results of discussions with the authorities concerned. The Phase One Work of the project shall cover only the West-side Runway of 4,000 m long, with consideration for its extension in the future.

Airfield lighting systems have been designed on the condition that both approach directions of Runways 17 and 35 shall comply with the requirements for Precision Approach Category-II Runway*.

Standards and recommendations of Annex 14 and Guidances shown in the Aerodrome Design Manual - Part 4 (Visual Aids) and Part 5 (Electrical Systems) by ICAO (International Civil Aviation Organization) as well as ICAO 's Working Agenda by WG (Working Group) of VAP (Visual Aids Panel) have been taken into consideration as reference in the design work. As ICAO standards indicate the minimum requirements, items shown therein as "Recommendations" have been applied to the design concerned as well as the "Standards".

1.2 Aeronautical Lighting System

Aeronautical lighting facilities are visual lighting facilities to aid aircraft operation. Other relating aeronautical facilities to which the China side requested to supply electric power and distributing circuit are shown below.

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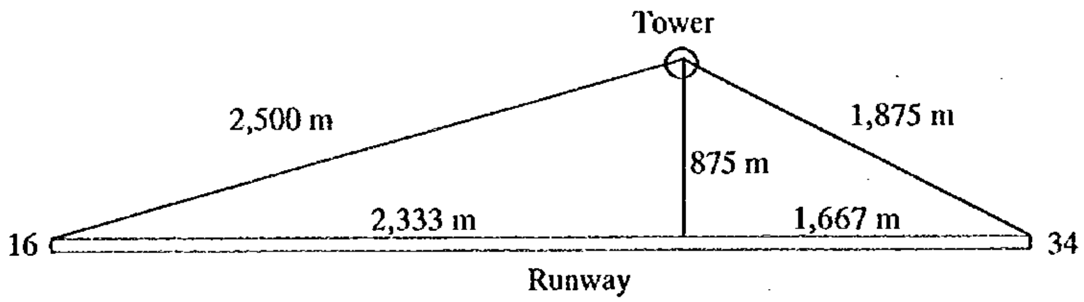
*Precision Approach Category-II-Runway is a runway instrumented with ILS (Instrument Landing System) and/or MLS (Microwave Landing System) and visual aids intended for operations with a decision height lower than 60 m but not lower than 30 m and a runway visual range not less than 350 m.

1.2.1 Aeronautical Lighting Facilities

(1) Control Tower



(2) Radio Facilities

LLZ	295m Note: 295 m is preferable in order to protect the critical area of LLZ.
GP/DME	130 m from the center line of runway, 300m inside from the end of runway (one each).
1M	310m from the end of the runway (one each at both ends).
MM	1,050m from the end of the runway (one each at both ends), DVOR in the north and NDB in the south.
OM	One unit at 9K from South end of runway, DVOR/DME at YOKOSA.

(3) Communication Facilities

Receivers on top of Control Tower, Transmitters in the vicinity of the Airport.

(4) Radars

ATC radars and a weather radar; ASR for Flight Control at 1,500m north of runway, ASDE on roof of Control Tower. Location of weather rader not determined.

(5) Meteorological Facilities

RVR	3 sets
WDIL	2 sets

1.2.2 Electric Power/Lighting System (FigureII2-1.1.1)

(1) The 35 kV transformer substation inside the airport will supply power not only for lightings but also for other facilities according to the Chinese draft. According to the Japanese draft, however, electric power will be supplied exclusively for aeronautical lightings.

(2) The main and sub 10 kV transformer substations will supply power for lightings of the runway and taxiways, as well as for nearby radio and meteorological equipment.

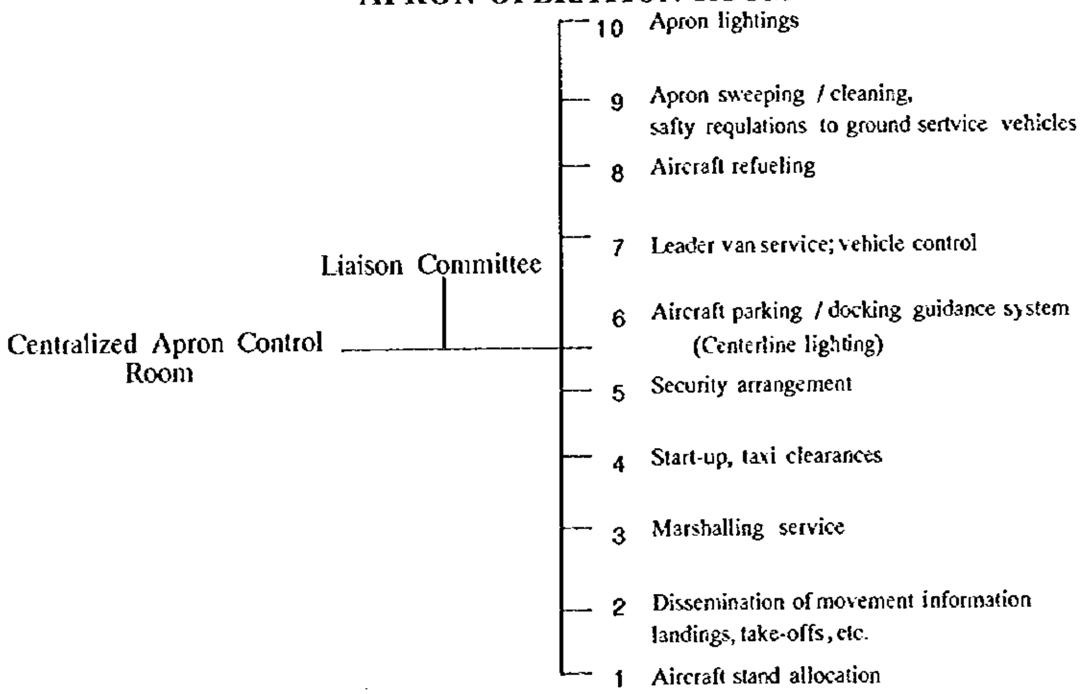
(3) The operation and power supply of apron lightings are controlled from the terminal building.

1.2.3 Apron Management

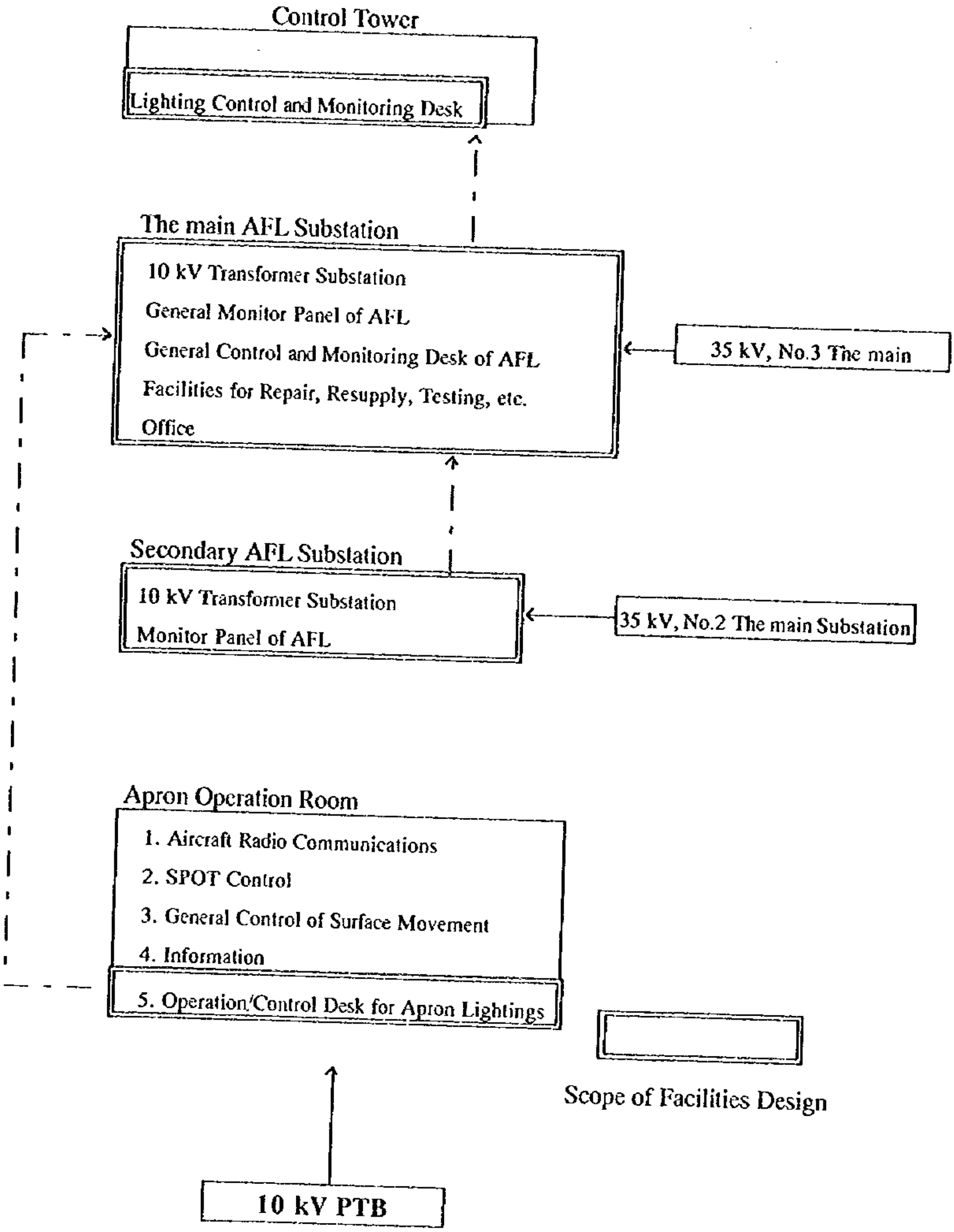
Paragraph 9.6.1 of Annex 14 of ICAO recommends that an appropriate apron management service should be provided on an apron by the aerodrome operating authority when the volume of traffic and operating conditions are warranted.

This project needs to create an apron operation room, as the controll of apron lighting facilities is to be conducted in the apron operation room.

APRON OPERATION ROOM



FigureII2-1.1.1 Power Supply / Lightings Operation System



(Note) Cargo Apron and The maintenance Apron will have a separate Power Supply and Operation System

Existing airport condition (Beijing, Guangzhou, Shanghai) and future plan (Pudong) are as follows.

TableII2-1.1.1 Apron Administration

Service	Beijing	Guangzhou	Shanghai	Pudong
10 Apron floodlight	B	B	B	B
9 Aerodome surface control	B	B	C	C
8 Refueling	D	D	D	D
7 Vehicle control	D	D	B	B
6 Spot guidance	C	C	B	B
5 Security	B	B	B	B
4 START/TAXI instruction	A	A	A	A
3 Marshalling	C	C	C	C
2 Information services	A	A	A	A
1 Spot allocation	B	B	B	B

A: Air Traffic Controler

B: Airport Staff

C: Airline Worker

D: Specified Company Employee

1.2.4 Subjects for Further Discussion

Basic design conditions for the Air Field Lighting (AFL) system to be provided for Shanghai Pu Dong International Airport were determined herein. Following subjects shall be finalized in the detailed design stage in the near future.

(1) Operation ways including positions of stop bars, taxiway intersection lights and runway guard lights shall be finalized in relation to ground movement the main line of aircraft, signs of stop positions, and coordination of ILS.

(2) Since the stop positions and do-not-entry positions as command signs, direction positions as informative signs, position signs and taxing guidance signs for directional positions have been already designed, installation places of lights and contents of signs for taxing instructions shall be fixed through discussions with Chinese experts.

(3) The monitoring control system installed in the General Control Room (a tentative name) shall be designed considering operation of apron spots. Thus, operation way, the maintenance way, and countermeasures for trouble shooting shall be determined through discussions with Chinese experts.

(4) The equipment to be a part of the aeronautical lighting system must be considerably chosen to secure the highest reliability and the maintainability due the reason that the equipment could not be repaired by stopping power supplying. Each equipment should therefore be considered to be standardized by applying the unit component featuring easier the maintenance and repair, and by applying dry-type transformers, switchgears and breakers.

(5) Present planned location for Aerodrome Beacon (ABN) was chosen by considering the least affects of glare to a pilot and a controller. The final location for the ABN shall be decided after the design of the Tower height by Chinese side is completed, though.

(6) Monitoring and control system requires easy obtaining of the operational conditions, functional problems and measured data of supervised equipment. It also requires certain and speedy operative functions over-viewing the total aeronautical lighting facilities. The data processing system supporting the monitoring and control functions shall be applied by concrete specifications introducing dual sub-system having a fail safe function in case of emergency.

(7) The operational console for aeronautical lighting system placed in the VFR room in Control Tower shall be followed by the design of monitoring and control system. The operational console for stop bar lights control can however be designed from three options: i) controlled on the console for aeronautical lighting, ii) controlled on the console for ground control, and iii) controlled on a console exclusively designed for stop bar lights control. The design of the console therefore shall be finalized considering the viewpoint from operational side.

(8) In order to secure the higher reliability of power supply system, double circuit power receiving and distribution was planned. Detailed design should invite deeper considerations for avoiding unnecessary interruptions caused by power failure in case of future's expansion and repairs.

(9) Provision of low voltage connection of stand-by generators and low voltage inter-connecting circuit breakers was designed through discussion between Japanese and Chinese experts. However, this provision shall be subject to re-discussion considering the load and appropriate power supply system for the Phase Two Work.

1.3 Design Standards

International Civil Aviation Organization Annex 14, Volume 1 (November 1995)

International Civil Aviation Organization	Aerodrome Design Manual - Part 4, Part 5
China Civil Aviation Bureau Standards	Technical Standards for Air Navigational Area at Civil Airports

China Civil Building and Electricity Design Standards

1.4 Scope of Design

The scope of design covers the following:

1) Airfield Lighting Systems

- Approach Lighting Systems (Runway 17, Runway 35)
- Sequence Flashing Lights (Runway 17, Runway 35)
- Precision Approach Path Indicator (Runway 17, Runway 35)
- Runway Edge Lights
- Runway Threshold Lights (Runway 17, Runway 35)
- Wing Bar Lights (Runway 17, Runway 35)
- Runway End Lights (Runway 17, Runway 35)
- Runway Touchdown Zone Lights (Runway 17, Runway 35)
- Runway Center line Lights
- Taxiway Edge Lights
- Taxiway Center line Lights
- Stop Bars
- Runway Guard Lights
- Taxiway Intersection Lights
- Taxiway Guidance Signs
- Visual Docking Guidance System
- Apron Floodlighting
- Aircraft Stand Identification Signs
- Aerodrome Beacon
- Wind Direction Lights
- Road-Holding Position Lights
- Road-Holding Position Signs
- Obstruction Lights

An overall configuration plan of airfield lighting (AFL) systems is shown in Figures DWG2-L1(1/4) ~ DWG2-L1(4/4).

2) Power Supply Facilities

- 10 kV power receiving and distribution facilities
- Stand-by power generator
- Uninterrupted power system
- Constant current regulator
- Monitoring control facilities for power facilities
- Airfield lighting monitoring control facilities
- Cable pipes and manholes ducts

3) AFL Substations

- Air-conditioning system
- Electrical system
- Fire extinguishing system
- The maintenance workshop for AFL

1.5 Results of Discussion between Japanese Experts and Chinese Experts

1) Each threshold of the runway shall be provided with one AFL substation adjacent thereto, and each AFL substation shall receive power supply through a double circuit line. The boundary point shall be defined as the power receiving point of the AFL substation, the service cable line to the power receiving point shall not be included in this design.

2) AFL substations shall supply low voltage power to the Radio Navigational Aids. The boundary point shall be on the secondary side of a MCCB (Molded Case Circuit Breaker) for the low voltage distribution board located in the AFL substation. Also, the installation of a power supply cable as well as the design for power supply to the Radio Navigational Aids shall not be included in this design.

3) The design boundary of water supply, rainwater drainage and sewage ejectors for AFL substations shall be 2 m point from the structure's outer wall.

4) An AFL substation located on the Runway 17 side shall be defined as "The main AFL substation", and another AFL substation located on the Runway 35 side shall be defined as "Secondary AFL substation".

5) The telephone system for AFL substations shall be consist of 10 pairs, and the terminal of telephone terminal boards located in both AFL substations shall be defined as the boundary.

6) When an Aerodrome Beacon Aircraft Stand Identification Signs and Visual Docking Guidance System is installed utilizing such structures as terminal building, anchor bolts required for the attachment work and piping work inside the structures for the power supply and monitoring control shall be provided under the building structure package (of the contracts for this project), while the cabling work for monitoring control and power supply shall be included in the scope of this design.

7) Power supply for Apron Floodlights and monitoring control equipment shall be included in this design, while indoor piping required for the work concerned shall be excluded from this design. Instead, it shall belong to the scope of Building Design portion. Hence a 2-m point from the outer surface of a building wall shall be defined as the boundary point.

8) A substation (at one particular location) for the apron floodlighting of the apron in the terminal area and detached apron (apron detached from the terminal building) shall be included in the scope of this design. The substation for apron floodlighting shall receive power supply through a double circuit line cables. The boundary point shall be defined at the power receiving point of the AFL substation. The service cable line to the power receiving point shall not be included in this design.

9) In-door piping work for monitoring control cable wirings to be provided for the Remote Control Desk for Airfield Lightings, Remote Control Desk for Stop Bars and Road Holding Position Signs shall not be included in this design. Instead, it shall be included in the scope of the Building Design portion. Thus the boundary point shall be 2 m from the outer surface of a building wall.

Items regarding installation work:

Cable piping for the runway edge lights and the taxiway lights will be applied with the shallow-type lighting base method, considering easy installation and easy the maintenance.

Items regarding additional equipment:

Easy-wrecking type aircraft stand identification signs for apron floodlightings in the terminal district will be installed in accordance with the request of Chinese experts.

CHAPTER 2 AIRFIELD LIGHTINGS (AFL) DESIGN

2.1 Approach Lighting Systems

According to ICAO standards, a precision approach category II and III lighting system shall be provided to serve a precision approach runway category II or III(5.3.4.1.D).

ILS precision approach category II shall be served from both directions of Runway 17 and Runway 35. Therefore, both directions shall be provided with the precision approach category II and III lighting systems over a length of 900 m. The ALPA SYSTEM and CALVERT SYSTEM are prevalent, but ALPA SYSTEM has been applied in most the main airports in China such as the present Shanghai Hongqiao International Airport as well as most international airports in South-East Asia. Besides, in the light of pilots' familiarity with this system, ALPA SYSTEM shall be introduced.

The approach category II lighting system shall consist of center line barrettes being composed of 5 lights mounted at 1 m lateral spacings between adjacent lights as a unit which shall be placed at longitudinal intervals of 30 m over a distance of 900 m from the runway threshold, 2 cross bars installed symmetrically on an extended center line of the runway at a 150-m point and 300-m point from the runway threshold, and side-row-barrettes placed symmetrically on the extended center line of the runway at longitudinal intervals of 30 m extending 270 m from the runway threshold. Configuration of the lightings is shown in Figures DWG2-L2(1/2) and DWG2-L2(2/2). Longitudinal slope of the site for approach lighting system to be located is 0.01% down to a 310-m point from the runway strip end, 1.0% down to 363.9-m point from the 310-m point, and 0.01% down to a 954-m point from the 363.9-m point. The longitudinal slope of the approach lightings for the approach runway category II shall not have a gradient down to a 450-m point from the runway threshold. Had the most ideal setting of flat slope be provided, the river bank would not shield the beam of approach lightings as the planned height of the runway threshold and the height of embankment will turn out to be at the same level of 5.1 m. Besides, the height of the approach lightings measured from the subgrade level at 900-m point will be no more than 1 m. Thus the lights concerned shall be placed on a leveled arrangement (zero gradient). The longitudinal configuration is shown in Figures DWG2-L3(1/2) and DWG2-L3(2/2).

The system shall comprise 2 circuits by connecting every other light of center line barrettes and 300-m cross bars, and another 2 circuits by connecting every other light of side-row-barrettes and 150-m cross bars in each direction. The circuits shall be 6.6A series-feed circuits and luminous intensity shall be adjustable at 5 stages. The circuit partitions are shown in Figures DWG2-E1(1/2) and DWG2-E1(2/2).

In consideration of presumable undershooting and overshooting by aircraft, support for lighting fixtures shall be of light-weight structure, and breakable couplings shall be used for mounting on the foundations. The foundations shall be made of reinforced concrete and shall not be individually attached to each light, i.e. common foundations shall be used for each row of lights. The bearing strength of the ground at the points of installation shall be taken into account paying attention to eventual uneven subsidence.

Isolating transformers for elevated-type approach lights shall be housed in metal transformer housing boxes annexed to the foundations of the structures supporting the lighting fixtures. Isolating transformers for the surface-type approach lights shall be housed in transformer housing boxes installed off the pavement of the overrun areas. The transformer housing box shall have a size enough to accommodate also a burnt-out lamp detection unit.

Lighting fixtures at the 30-m point shall be of pavement-surface type, same as those located in the overrun area, and shall be of elevated-type in other locations. Luminous intensity distribution characteristics of the center line barrettes and cross bars shall conform to Annex 14, Vol. 1, Appendix 2, Figure 2-1, and that of the side-row-barrettes shall conform to Figure 2-2. And color of the lights shall be variable, white for the center line barrettes and cross bars, and red for the side-row barrettes.

Inspection roads connected to the perimeter road and is made accessible to vehicles for the maintenance and repair services shall be provided.

2.2 Sequence Flashing Lights

It is described in Annex 14 of ICAO standards of that sequence flashing lights should desirably be supplemented, when ALPA system is introduced, as long as such lightings are not considered unnecessary due to meteorological and circumstantial conditions, etc. (5. 3. 4. 30). In this project, sequence flashing lights shall be provided, as they will obviously enhance effective guidance particularly at times of low visibility.

Lighting fixtures for flashing lights shall be supplemented to each center line barrette placed at 30-m point through 900-m point position. Controlling equipment for the flashing lights shall be provided in both the main and secondary ALF substations.

Lighting fixtures at the 30-m point shall be of pavement-surface type are in the overrun area, and shall be of elevated type in other locations. Also, such type of lighting fixture as power cabinet and separate lamp portion shall be applied. The power cabinet shall be installed not less than 30 m from the runway center line.

The luminous intensity shall be adjustable at 3 stages in accordance with the time of day, dusk and night or other visibility conditions.

Each power cabinet shall be supplied with low-voltage power from both the main or secondary AFL substations. The power supply system shall be backed up by stand-by generators. Cables for luminous intensity control and sequential flashing shall be wired from AFL substations to the terminals provided in the power cabinets.

Wiring of cables to deliver power and sequence flashing signals shall be made from the power cabinet to the lamp portion (luminescence section). Standards for the luminous intensity distribution are not specified by ICAO, while the standards prevalent in Japan specify 10,000 ~ 17,000 candelas as the effective luminous intensity for the range of 30 horizontal degrees and 10 vertical degrees, which shall be conformed.

Support for the lighting fixtures and power cabinets shall be light-weight-structured, and breakable couplings shall be used as attachments to the foundations, taking account of presumable undershooting and overshooting by aircraft.

The circuit composition is shown in figure DWG2-E2(2/2).

2.3 Precision Approach Path Indicator (PAPI)

As prescribed in Annex 14 (5.3.5.1) of ICAO standards, provision of the following navigation systems is required under the conditions indicated below.

A visual approach slope indicator system shall be provided to serve the approach to a runway whether or not the runway is provided with other visual approach aids or by non-visual aids, where one or more of the following conditions exist:

a) the runway is used by turbojet or other aeroplanes with similar approach guidance requirements;

b) the pilot of any type of aeroplane may have difficulty in judging the approach due to:

   1) inadequate visual guidance as is experienced during an approach over water or featureless terrain in day time or in the absence of sufficient extraneous lights in the approach area at night; or

   2) misleading information such as that produced by deceptive surrounding terrain or runway slopes;

c) the presence of objects in the approach area may involve serious hazard if an aeroplane descends below the normal approach path, particularly if there are no non-visual or other visual aids to give warning of such objects;

d) physical conditions at either end of the runway present a serious hazard in the event of an aeroplane undershooting or overrunning the runway; and

e) terrain or prevalent meteorological conditions are such that the aeroplane may be subjected to unusual turbulence during approach.

PAPI has good visibility and is significant as a monitor for the ILS, in addition to its effectiveness for an aircraft which is not furnished with ILS devices on board and in such a case that the ILS is out of operation for a certain reason. Thus PAPI shall be provided for both approach directions in the project airport.

The Visual Approach Slope Indicator System (VASIS) which ICAO refers to as the standard method can be classified into two systems: T-VASIS and PAPI. While T-VASIS is composed of 20 lights, PAPI has the economical advantage of being composed of only 4 lights. Although installation location for VASIS shall be designed not to conflict with taxiways in and out of the runway, T-VASIS could induce complication there-with in a large-scale airport. Furthermore, considering the fact that T-VASIS has been introduced only in such limited number of countries as Australia and other countries under its influence (affiliated there-with), in addition to the problem that pilots are not really familiar with the system, it is concluded that PAPI shall be introduced to the project airport.

Setting position of PAPI shall be planned in accordance with the 3° glide slope by ILS. Operational situation in terms of aircraft type at present would refer to large type aircraft. Therefore, the wheel clearance at the runway threshold which is used for determining PAPI's position shall be 9 m as the desirable value and 6 m as the minimum value applied thereto (Annex 14, Table 5-2, Figures 5-12, 5-13).

As the longitudinal slope of the runway is an upslope of 0.01% from the runway threshold, the setting position of PAPI (PL) shall be:

$(14m+9m)\div(\tan\theta+\tan\alpha) = 463.79m$

θ : On-course lower limit angle = 2°50'

α : Runway longitudinal slope angle = $\tan\alpha=0.0001$

The transverse slope is 1.6% on the shoulder, and 1~2% on the runway strip. Since the innermost PAPI is located at 15 m from the runway edge, the subgrade height of the setting position is lower by: 7.5m x 0.016 + 7.5m x 0.01 +3cm= 22.5 cm (provided that the lateral slope of the runway strip is 1%).

It is desirable to set the position of PAPI as low as possible, and the height of PAPI's projection window shall be close to the level of the runway pavement surface. The height of the projection window at its lowest position shall not exceed 50 cm regardless of the variation by manufacturers. The window height in this case shall be not more than 30 cm above the subgrade of runway shoulder and there is a height difference of not more than 30 cm between the window and the lighting fixture installation reference line. It is deemed unnecessary to adjust PAPI for the transverse slope concerned since the height discrepancy between the lighting fixture installation reference line and the lighting fixture reference point does not exceed ±30cm, namely being within the tolerance range.

The configuration is shown in Figure DWG2-L4.

The circuits concerned shall consist of one 6.6A series-feed circuit per approach direction. The circuits shall allow 3-stage adjustment of luminous intensity, and power shall be supplied either from the main or secondary AFL substation.

As uneven subsidences could be expected, an elevation angle inspection device which shall be used for adjustment of elevation angle setting, as well as appropriate facilities for remote surveillance from the AFL monitoring room for irregularity of the elevation angle and detection of the burnt-out lamps, shall be provided. A flexible coupling shall be used for attachment of the lighting fixture and the elevation angle inspection device onto the base and foundation, as a precaution against collision by an aeroplane running off the runway.

The isolating transformer shall be housed in a metal made housing box supplemented in the foundation of PAPI's base. Luminous intensity distribution characteristics of the lighting fixtures shall comply with Annex 14, Volume 1, Appendix 2, Figure 2.20.

2.4 Runway Edge Lights

According to ICAO standards, runway edge lights shall be provided for a precision approach runway (5. 3. 9. 1).

Runway edge lights shall be placed symmetrically in 2 straight lines parallel to the runway center line at a distance of 1.5 m from each runway edge. The installation intervals shall be 60 m for the 31 sections of the center portion, and 59.5 m for the 18 sections of the outer portion. Figure DWG2-L5 shows the configuration.

There will be two 6.6 A series-feed circuits, each connecting every other light. The luminous intensity shall be adjustable at 5 stages (Runway edge lights shall be included in these circuits).

The circuits shall be supplied with power from the main and secondary AFL substations. The circuit composition is shown in Figure DWG2-E3.

The elevated-type lighting fixture to be installed in the paved portion of the runway shoulder shall be attached with a flexible coupling to a concrete-made foundation. The standard installation is shown in Figure DWG2-L6. The surface-type lighting fixture to be installed in the paved portion of a taxiway connecting to the runway shall be placed on a shallow-type lighting base.

There could be a method in which isolating transformers shall be housed in the transformer housing boxes located outside the runway shoulder as piping and wiring for the primary-side cables are laid also outside the runway shoulder, and the other method in which insulating transformers shall be housed in the surface-type lighting bases located under the runway pavement and as primary-side cables are laid in the pipings provided under the runway pavement. The former method has economical disadvantage due to the secondary-side piping and cabling required in comparison with the latter method, however the former method has been determined to be introduced in view of its superior workability and easier the maintenance. The transformer housing box shall be of the size appropriate for the burnt-out lamp detection unit to share the space with the isolating transformer.

Luminous intensity distribution characteristics of the lighting fixtures shall comply with Annex 14, Volume 1, Appendix 2, Figure 2. 11. The lighting fixtures placed between the runway end and 600 m point shall be set up to show yellow, and the other lighting fixtures shall be set up to show variable white to a pilot landing or taking off.

2.5 Runway Threshold Lights

According to ICAO standards, runway threshold lights shall be provided for a runway equipped with runway edge lights (5. 3. 10. 1). Also, wing bar lights are desirable when conspicuous visibility of runway threshold is required (5. 3. 10. 6). In the low visibility operation, the runway threshold is important as conspicuous way, wing bar lights shall be provided.

Runway threshold lights shall be placed on a straight line which is positioned 1 m away from the runway threshold and intersect the extended line of the runway center line at right angles, being disposed symmetrically about the extended center line of the runway at intervals of 2 points 2.85 m between the rows of runway edge lights. Wing bar lights shall be provided on the same straight line of runway threshold lights, with 5 lights at intervals of 3 m extending outward from each end of runway threshold lights. The innermost light fixture shall be located on the extended line of the row of runway edge lights.

The configuration is shown in Figure DWG2-L7.

When 3 m intervals as maximum tolerance is applied, number of the lights installed would be odd and when 6 m intervals is applied, it can not be placed symmetrically to extension line of center line. It is concluded that 2.85 m intervals shall be introduced to make the number of the lights installed even.

There will be two 6.6 A series-feed circuit each connecting every other light. The luminous intensity shall be adjustable at 5 stages. The circuit shall be supplied with power from the main or secondary AFL substations respectively. The circuit composition is shown in Figure DWG2-E4.

Runway threshold lights shall be placed on shallow/surface-type lighting bases which shall be provided in the overrun area pavement. Wing bar lights shall be with breakable couplings attached to the shallow/surface-type lighting bases installed on concrete-made foundations at each installation point.

The standard installation is shown in Figure DWG2-L8.

Isolating transformers for the runway threshold lights and wing bar lights shall be installed in the transformer housing box which shall be provided outside the overrun area pavement. The transformer housing box shall have a size enough to accommodate also a burnt-out lamp detection unit.

Lighting fixtures concerned shall be the surface-type for runway threshold lights and shall be the elevated-type for wing bar lights. The optical characteristics shall respectively comply with Annex 14, Volume 1, Appendix 2, Figure 2. 3 and 2. 4. The light color of the runway threshold lights and wing bar lights shall be green.

2.6 Runway Wing Bar Lights

Refer to Clause 2.5 Runway Threshold Lights

2.7 Runway End Lights

According to ICAO standards, runway end lights shall be provided for a runway equipped with runway edge lights (5. 3. 11. 1).

The lighting fixtures of runway end lights shall be placed on a straight line at right angles to the extended center line of the runway at 1 m approach-ward outside the runway end at intervals of 5.7 m between the rows of runway edge lights symmetrically about the extended center line of the runway.

The configuration concerned here-with is shown in Figure DWG2-L9.

As prescribed in Annex 14, volume 1 of ICAO standards, provision of followings is required. There a method in which the runway end lights shall be arranged to 2 groups providing space in the middle and the other method in which the lights shall be arranged to equally spaced between the rows of the runway edge lights, i.e., more than 6 lights shall be required.

Configuration in the latter method which excels in visibility has been chosen. Since less than 6 m of the spacing between the lighting fixtures is required for the Category III, the spacing of 5.7 m has been applied to this design since minimum condition for the take-off is presumed in the range of take on for category III.

The circuit shall be 2 circuits by connecting every other light being the operative. The luminous intensity shall be adjusted at 5 stages in concert with runway edge lights. The circuit composition is shown in Figure DWG2-E5. The installation of runway end lights shall be in compliance with the runway threshold lights. Configuration is shown in Figure DWG2-L10.

Installation for the isolating transformers used for runway end lights shall conform to the installation manner for runway threshold lights.

Runway end lights shall be of elevated-type for the 2 lights placed on the extended rows of runway edge lights and shall be of surface-type for the others and their optical characteristics shall be in compliance with Annex 14, Volume 1, Appendix 2, Figure 2. 9. As to the lighting fixtures for runway end lights, bi-directional lighting fixtures with 2 lamps shall be used so as to work concurrently as runway threshold lights. The color of runway end lights shall be red.

2.8 Runway Center line Lights

According to ICAO standards, runway center line lights shall be provided to a precision runway category II or III (5. 3. 12. 1).

Runway center line lights shall be located at a spacing of approximately 7.5 m or 15 m on a runway category III, and shall be located at a spacing of seven and 7.5 m, 15 m or 30 m on a runway category II. Since ICAO standards indicate the minimum requirements, 15 m shall be applied to the spacing so as to avoid redesign of the facilities even when converted up to category III in the future. The configuration is shown in Figure DWG2-L11. Cement -concrete pavement being applied to the runway , the runway center line shall be the joint (between the pavement sections). The runway center line lights shall be placed at 60 cm offset to the opposite side to the side where a taxiway is located, being on the line parallel to the runway center line.

The circuit shall be 4 circuits with the interleaved-wiring. And the circuits shall be capable of adjusting luminous intensity at 5 stages and shall be fed by the main AFL substation. The circuit composition is shown in Figure DWG2-E6.

The lighting fixtures shall be placed on shallow/surface-type lighting bases provided in the runway pavement. The standard installation is shown in Figure DWG2-L12.

The installation method for the isolating transformers shall be referred to clause 2.4

Runway Edge Light.

Optical characteristics of the lighting fixtures shall comply with Annex 14, Volume 1, Appendix 2, Figure 2. 8. Lighting fixtures shall be set up so that in the section extending from the runway end to 300 m shall show red color and in the section extending from 300 m to 900 m shall show red and variable white alternately while other shall show variable white to a pilot of an aircraft taking off.

2.9 Runway Touchdown Zone Lights

According to ICAO standards, runway touchdown zone lights shall be provided for the touchdown zone of a precision approach runway category II or III (5. 3. 13. 1). It specifies that from the runway threshold to the point to 900 m, symmetrically located about the center line of runway , pairs of barrettes which shall be not less than 3 m nor more than 4.5 m in length composing at least 3 lights with a spacing between the adjacent lights of not more than 1.5 m, shall be disposed at the longitudinal spacing of 30 m or 60 m. The longitudinal spacing of the runway touchdown zone lights shall be 30 m or 60 m, referring in the "note" of ICAO that it may be desirable to use 30 m longitudinal spacing at lower visibility. Therefore, 3 lights on each side i.e., totaling 6 lights symmetrically placed in the runway center line shall be installed in 30 rows at intervals of 30 m from the runway threshold to 900 m. The spacings between the lights of barrettes shall be one and 1.5 m, and the spacing between the innermost lighting fixtures of the barrettes shall be 18 m in accordance with the spacing between the innermost lighting fixtures of red side row barrettes for precision approach category II lighting systems. (Refer to Figure DWG2-L13)

The circuit shall be two 6.6 A series-feed circuit each connecting every other light. The luminous intensity shall be adjustable at 5 stages. The circuit shall be supplied with power from the main or secondary AFL substation respectively (Refer to Figure DWG2-E7).

Installation method for the runway touchdown zone lights shall conform to the installation method for the runway center line lights.

Optical characteristics of the lighting fixtures shall be in compliance with Annex 14, Volume 1, Appendix 2, Figure 2. 5. The color of light shall be variable white.

2.10 Taxiway Edge Lights

As prescribed in Annex 14 of ICAO standards (5.3.16.1), provision of the taxiway edge lights is required under the conditions indicated below except that adequate guidance can be achieved by surface illumination or other means.

- Night stay and apron district, etc. where are intended to use at night and are not provided with a taxiway center line lights.

In addition, this lights shall be provided to utilize ground movement in case of low visibility promoting flexibility of operation.

Lighting fixtures shall be placed at a distance of one and 1.5 m from taxiway pavement edges to indicate the clear contours of the taxiways.

The circuit shall be of series-feed circuits to fix at a certain assigned current value below 6.6 A. The circuit composition is shown in Figure DWG2-E9 and circuit segments of the taxiway edge lights are shown in Figure DWG2-L17.

The lighting fixtures shall be attached with flexible couplings to the concrete-made foundations in the taxiway shoulder pavement. Isolating transformers shall be housed in the transformer housing box at outside of the taxiway shoulder.

Since Annex 14 specifies that the lights shall show up to 30 degrees above the horizontal plane and at all angles in azimuth, but no specification of luminous intensity distribution characteristics. In Japan, luminous intensity distribution characteristics are required in the specification of equipment that to be not less than 2 candelas from 0 to 5 degrees and not less than 0.2 candelas up to 90 degrees at all angles in azimuth. And in the U.S.A., the luminous intensity distribution characteristics are stipulated in the Advisory Circular AC-5345-46A by FAA (Federal Aviation Administration). Thus, the light color of light shall be blue.

2.11 Taxiway Center line Lights

According to ICAO standards, taxiway center line lights shall be provided in the airport intended for operation in Runway Visual Range conditions of 350 m or greater, from the point on runway to the point on the apron where an aircraft commences for parking guidancing from the runway center line lights (5. 3. 15. 1).

The lowest meteorological conditions for landing on the airport shall be category II (Runway Visual Range conditions: not less than 350m), it is estimated that the lowest meteorological conditions for take-off could be 200 m. (when high luminous intensity runway edge lights and runway center line lights and 3 transmittance-ratio-perimeters are provided).

It is specified in Annex 14 of ICAO that taxiway center line lights should be provided on a taxiway intended for use at night in runway visual range conditions of order of 350 m or greater, they should not exceed a spacing of 15 m on a straight section, and should be at intervals of not greater than 7.5 m on a curving section where a curve is less than 400 m radius.

Commencing points of the taxiway center line lights on a runway in case of the rapid exit taxiway shall be the points at 60 m before the beginning of the taxiway center line curve and shall be located 60 cm offset to and on the side of the runway center line lights.

As the connecting area of a taxiway into the runway shall be provided with cement-concrete pavement to avoid causing the pavement joint in the crown portion and taking account of time allowed for the setting of the maintenance work for the markings, they shall be installed 30 cm offset to the taxiway center line (Refer to Figure DWG2-L14).

The circuits shall be arranged in such composition by taking account of the operational mobile lines as may scarcely affecting aircraft operations even upon the breakdown of one circuit (Refer to Figure DWG2-E7), so the circuits shall be disposed as shown in Figure DWG2-L15. Circuits for the rapid exit taxiway and low visibility taxiway shall be capable of adjusting luminous intensity at 3 stages. The electric power shall be supplied by the main and secondary AFL substations. Also, the rapid exit taxiway center line lights shall have the circuit to interlock the only taxiway of an approach direction required illuminating direction of runway. The circuit composition is shown in Figure DWG2-E8.

Taxiway center line lights shall be placed on the shallow/surface-type lighting base in the taxiway and apron pavement. When the distance between the lighting fixture and transformer housing box located outside the shoulder is too long in the paved portion of the apron, the taxiway center line lights shall be placed on the surface-type lighting bases serving concurrently as transformer housing box provided in the taxiway and apron pavement. The standard installation is shown in Figure DWG2-L16. There is a method in which an insulating transformer shall be housed in a transformer housing box placed outside the shoulder of a taxiway providing the piping and wiring of the primary side cable outside the shoulder of a taxiway as well, and there is another method in which an insulating transformer shall be housed in a surface-type lighting base placed under the pavement of a taxiway providing the piping under the pavement of a taxiway in which the primary side cable shall be laid. Though the former one is economically disadvantageous due to the secondary side piping and cabling are required in comparison with the latter one, the former one shall be chosen due to workability and simplicity in the maintenance. The transformer housing box shall have a size enough to accommodate also a burnt-out lamp detection unit.

Lighting fixtures shall be uni-directional on rapid exit taxiways, besides shall be bi-directional on the other taxiways. Optical characteristics shall be in compliance with Annex 14, Volume 1, Appendix 2, Figure 2. 15, and the color of light shall be green on the exit taxiways, to an aircraft exiting from the runway. On the other taxiways, it shall be green and yellow in mutual to the perimeter of the ILS/MLS critical/sensitive area or the lower edge of the inner transitional surface, whichever is farthest and the beginning and ending points shall be yellow.

Taxiway center line lights located closer to the runway than to the stop bar lights except for rapid exit taxiways shall use bi-directional lighting fixtures. One lamp shall show green to an aircraft approaching into the runway from the taxiway. The circuit shall be operative with the circuit for the stop bar lights(2 circuits by connecting every other light). The other lamp shall show yellow and green in mutual to an aircraft exiting from the runway. The circuit shall be operative with the circuit for the taxiway center line lights located before the stop bar lights.

2.12 Stop Bars

According to ICAO standards, a stop bar shall be provided at every taxiway holding position serving a runway when it is intended that the runway will be used in Runway Visual Range conditions of order 350 m or greater (5. 3. 17. 1).

As referred to in 2.11, the lowest meteorological conditions for take-off is assumed to be 200 m, thus stop bars should be provided. Also, it is referred to that a stop bar should be provided at every taxi-holding position serving a runway when it is intended that the runway will be used in runway visual range conditions of order between 350 and 550 m (5. 3. 17. 2). Since the reference concerned is expected to be revised to standards as of January 1, 2001, the provision shall be concluded as necessary even in this point of view.

Lighting fixtures of stop bars shall be placed across the taxiway at the point where the traffic is desired to stop at intervals of 3 meters. Also, in consideration of such cases as it is desired to stop the aircraft adjacent to the stop bar and the low visibility causing by snow or rain, elevated-type lights shall be additionally installed at the position of 3 m and 6 m at outside from the taxiway edges.

Location of the stop bars is shown in Figure DWG2-L18, and the location of the taxiways is shown in Figure DWG2-L19.

The circuit shall be of two 6.6 A series-feed circuit each connecting every other light. The luminous intensity shall be adjustable at 3 stages. Lighting fixtures shall be placed on the shallow/surface-type lighting bases in the taxiway pavement. The additional elevated-type lighting fixtures shall be attached with flexible couplings to the shallow/surface-type lighting bases installed on concrete foundations. Isolating transformers shall be housed in the transformer housing box provided outside the taxiway shoulder pavement. The transformer box shall have a size enough to accommodate also a burnt-out lamp detection cum switching control unit.

Luminous intensity distribution characteristics of the lighting fixtures shall be in compliance with Annex 14, Volume 1, Appendix 2, Figure 2. 15, and the color of light shall be uni-directional and show red to an aircraft approaching the runway.

2.13 Runway Guard Lights

According to ICAO standards, runway guard lights should be provided at each taxiway/runway intersection associated with a runway intended for use in Runway Visual Range conditions of order of 550 m or less where a stop bar is installed (5. 3. 19. 2). This lights shall be provided due to the category II operation is designed and tensity of air traffic is high.

Runway guard lights shall be placed on each side of the stop bars symmetrically about the taxiway center line. Configuration of the runway guard lights is shown in Figure DWG2-L20, and the installation location is shown in Figure DWG2-L21. The circuit for runway guard lights shall be connected to either one of the two 6.6 A series-feed circuit for the stop bar.

Runway guard lights shall be attached with flexible couplings to the concrete-made lighting bases installed outside the taxiway shoulders.

Isolating transformers shall be housed in the transformer housing boxes provided next to foundations for the lighting fixtures.

The lighting fixtures shall consist of a pair of yellow color with the luminous intensity distribution characteristics complying with Annex 14, Volume 1, Appendix 2, Figure 2. 21, shall flash 60 cycles per minute with the flashing going on and off for equal period of time respectively, and each adjacent light shall be designed to work on flashing alternately.

2.14 Taxiway Intersection Lights

According to ICAO standards, the taxiway intersection lights shall be provided at a taxiway intersection where it is possible to define a specific aeroplane holding limit and there is no need for stop-and- go signals as provided by a stop bar (5. 3. 18. 1).

The point of location which exist between over 30 m and 60 m from the near edge of the intersecting taxiway and where clearance of not less than 15 m between aeroplanes can be secured shall be selectively determined, and the 3 lights at the spacings of 1.5 m shall be installed on a line at right angles to and symmetrically about the taxiway center line. The configuration is shown in Figure DWG2-L22, and the installation location is shown in Figure DWG2-L23.

The circuit shall be connected with 6.6 A series-feed circuits of the taxiway center line lights.

Installation method for the lighting fixtures shall conform to the one for the taxiway center line lights.

Housing of isolating transformers shall conform to the one of the taxiway center line lights.

Luminous intensity distribution characteristics of the lighting fixtures shall be in compliance with Annex 14, Volume 1, Appendix 2, Figure 2. 15, and the color of light shall be yellow.

2.15 Taxiing Guidance Signs

According to ICAO standards, the taxiing guidance signs shall convey a sign, instruction and information in order to provide a specific location or destination on a movement area or an airport meeting the requirements of a surface movement guidance and control system (5. 4. 1).

Taxiing guidance signs shall be classified according to the items indicated below:

1) Mandatory Instruction Signs (it shall be provided to identify a location beyond which an aircraft taxiing or vehicle shall not proceed unless authorized by the aerodrome control tower.)

Runway Designation Sign
Category I, II or III Holding Position Sign
Taxi-Holding Position Sign
Road-Holding Position Sign
No Entry Sign
Information Signs (it shall be provided where there is an operational need to identify by a specific location or routing information)
Direction Sign
Location Sign
Destination Sign
Runway Exit Sign
Runway Vacated Sign

Location of these signs are as below:

1) Runway Destination Sign

The pattern "A" taxi-holding position marking which is shown in Annex 14, Volume 1, Figure 5-20 shall be located on the left side of a taxiway facing the direction of approach to the runway supplementing at a taxiway/runway intersection or a runway/runway intersection on.

At a taxiway/runway intersection, where practicable, a runway designation sign shall be located on each side of the taxiway.

2) Category I, II or III Holding Position Sign

A category I, II or III holding position sign shall be located on the left side facing the direction of approach to the runway supplementing a pattern "B" taxi-holding position marking which is shown in Annex 14, Volume I, Figure 5-20. A category I, II or III holding position sign shall be, where practicable, located on each side of the taxiway.

3) Taxi-Holding Position Sign

A taxi-holding position sign shall be located on each side of the taxiway at the taxi- holding position marking point facing the direction of approach to the obstacle limitation surface or ILS/MLS critical/sensitive area as appropriate.

4) No Entry Sign

A no entry sign shall be located at the beginning of the area to which entrance is prohibited on the left-hand side of the taxiway as viewed by the pilot, where practicable, a no entry sign shall be located on each side of the taxiway.

5) Direction Sign

A no direction sign shall be located on the left side of a taxiway intersection marking at the taxiway intersection. A direction sign shall be provided on the left side of a taxiway at 60 m before the center line of an intersecting taxiway when there is no marking.

6) Location Sign

A location sign shall be provided, solely or in conjunction with a direction sign and runway designation sign at an apron exit, taxiway/taxiway, taxiway/runway, runway/ runway intersection.

7) Destination Sign

A destination sign shall be provided on the left side of a taxiway where the direction to a specific destination such as ((CARGO)), ((GENERAL AVIATION)), ((THE MAINTENANCE)) should be indicated.

8) Runway Exit Sign

A runway exit sign shall be located over 60 m prior to the point of tangency of the exit taxiway and runway on the side of the exit taxiway into which the runway proceeds.

9) Runway Vacated Sign

A runway vacated sign shall be provided, when taxiway center line lights are not provided in the taxiway used for exiting showing the pilot of an aircraft vacating the runway, the perimeter of the ILS/MLS critical/sensitive area or the lower edge of the inner transitional surface whichever is more distant from the runway center line. The runway vacated signs shall not be installed in the airport, since all the runways shall be furnished with taxiway center line lights.

Disposition of the taxiing guidance signs are shown in Figure DWG2-L24. The location shall be, where practicable, at 21 m to the nearest end of the taxiing guidance signs from the taxiway pavement shoulder and 15 m from the runway pavement shoulder.

The circuit shall be of 6.6 A series-feed circuits and shall be connected to the nearest circuit for taxiway edge lights.

A runway vacated sign shall be located sufficiently low to preserve clearance for propellers or the engine pods of jet aircraft using a breakable coupling on the concrete-made base. The installed height of the sign shall not exceed 1.1 m. A transformer housing box shall be provided in a united body with the base for a lighting fixture and the isolating transformer.

Lighting fixtures shall be frangible, and the inscription height shall be 40 cm, the sign face height shall be minimum 80 cm. A mandatory instruction sign shall consist of an inscription in white on a red back-ground, an information sign except a location sign shall be in black on a yellow back-ground, a location sign shall be in yellow on a black background and where it is a stand-alone sign shall have a yellow border. Also, when indicating plural directions, the next neighboring border shall be delineated in black.

Such other requirement for the design as luminous intensity distribution characteristics shall be in compliance with Annex 14, Volume 1, Appendix 4.

2.16 Road-Holding Position Light

According to ICAO standards, road-holding position light shall be provided at each road-holding position serving a runway when it is intended that the runway will be used in runway visual range conditions of order of 350 m of less (5.3.23.1).

The road-holding position lights shall be elevated-type and installed on the concrete base. The standard circuit connection is shown in Figure DWG2-L24.

Each circuit shall be supplied with power from the main or secondary AFL substation.

The road-holding position light shall be operative by ON-OFF switching control at the control tower, the monitoring room of the main and AFL substation.

2.17 Visual Docking Guidance System

According to ICAO standards, a visual docking guidance system is desirable to be provided when the precision required in connection with ground operative facilities and a boarding bridge, etc. Although a visual docking guidance system may not be necessarily when the guidance by marshallers is available, such situation by which the marshallers' guidance become difficult will occur as weather conditions, the number and type/s of aircraft, dead angles due to limited space available in front of an aircraft on the apron (5.3.21.1).

The visual docking guidance system shall be usable to both pilots, i.e., the captain and assistant pilot, and all types of aircraft using the spots. As the means to satisfy the above condition, there is a system in which the pattern-discrimination is carried out using CCD (Charge Coupled Devices) cameras and another system in which the pattern-discrimination or nose-detection of the aircraft is carried out using a laser radar. Since either system has not been practically introduced on a large scale yet, most appropriate one shall be decided later.

A visual docking guidance system shall be placed on the spots in which the boarding bridge is installed or in which every future spots referring to Figure DWG2-L1.

A visual docking guidance system shall be supplied with power by low-voltage /single-phase/2 wire from the power source which is backed up by the stand-by generators and has been stepped down in the power room (cubicle) in the passenger terminal building which is shall be provided with the power supply by high-voltage from the substation. Monitoring control shall be operative from General Control Center.

A visual docking guidance system shall be installed on the outer wall surface of the passenger terminal building with anchor bolts.

Characteristics of the visual docking guidance system shall be in compliance with Annex 14, Volume 1, 5. 3. 21. 3~5. 3. 21. 8, 5. 3. 21. 11~5. 3. 21. 13. and 5. 3. 21. 16.~5. 3. 21. 20.

2.18 Apron Floodlighting

According to ICAO standards, apron floodlighting should be provided on an apron and on a designated isolated aircraft parking position intended to be used at night.

Apron floodlights shall be located between aircraft stands emitting illumination from 2 directions to minimize shadows on the aircraft stands. Configuration of the apron floodlights is shown in Figures DWG2-L25(1/3)~DWG2-L25(3/3). Foundation of this is shown in Figure DWG2-L28.

B-power supply (power supply backed-up by stand-by generators) which is provided by the substation in the passenger terminal building and C-power supply (power supply only from the commercial provider) shall be stepped down from 10 kV through the power room in the passenger terminal building and the transformer cubicle, and shall be supplied to the lights respectively. The piping plan is shown in Figures DWG2-E10(1/3) ~ DWG2-E10(3/3).

A control unit shall be provided at substation for the terminal area, cargo area and the maintenance area, and remote monitoring control for all the apron floodlightings shall be designed to be handled indoors in the general control center. On the other hand, the main AFL substation shall be provided with a monitoring device for the apron.

Besides, a switch box shall be installed adjacent to each lighting pole to control ON-OFF with a molded case circuit breaker.

Lighting fixtures and stabilizers shall be attached to a 25 m height with simultaneous-elevation steel pipe pole providing in the middle of neighboring spots, beside the support pier for a boarding bridge. The spot which is not equipped with the boarding bridge shall be provided with the lighting pole in likewise location. Whereas, detached spot section in the terminal area shall be provided with a 20 m height with simultaneous-elevation steel pipe pole to make space for an obstructing object.

Protective fences shall be provided around the lighting poles and circuit breaker panels so that they will not be damaged by the service vehicle's collision.

Lighting fixtures shall be of cut-off-type with wide beam, and high pressure sodium lamps and metal halide lamps in such manner as the luminous flux ratio may be approximately 2 : 1 in consideration of efficiency and color rendering as the light source. Number of the lighting fixture shall be selectively determined so that horizontal illuminance in the spots shall be not less than 30 lux (luminance in the maintenance area and cargo area shall be not less than 25 lux) with an uniformity ratio of lower than 4 : 1 for average to minimum, and vertical luminance shall be 30 lux at a height of 2 meters above the apron in relevant directions (luminance in the maintenance area and cargo area shall be not less than

25 lux.), and horizontal luminance in the other area shall be not less than 10 lux.

2.19 Aircraft Stand Identification Signs

According to ICAO standards, an aircraft stand identification sign is to indicate code number, etc. of the spot to a pilot of an aircraft to discern the spot for the aircraft stand. There is no stipulation for the aircraft stand identification signs in ICAO standards, but they are always provided in large scale airports equipped with many number of spots. Therefore the aircraft stand identification signs shall be introduced.

Lighting fixtures shall be installed using wall faces on the passenger terminal building.

The lighting fixture shall have a sign and inscription in white on a black background, and in the night or under poor visibility the aircraft stand identification sign shall be illuminated by the reflective lamp or LED (Light Emitting Diode) being inlaid along the sign and inscription or optical fibers, etc. The indication items shall comprise of spot names and latitude and longitude of the spot.

The power supply shall be received at low-voltage from the power room/power supply cubicle from which the visual docking guidance system on the spot receives the power supply pertaining.

The monitoring control shall be operative from the General Control Center.

2.20 Aerodrome Beacon

According to ICAO standards, aerodrome beacon shall be provided with an aerodrome intended for use at night when necessary for the operation there-in (5. 3. 3. 1). Practically it is specified if one or more of the following conditions exist (5. 3. 3. 3).

a) aircraft navigate predominantly by visual means;
b) low visibility occur frequently; or
c) it is difficult to locate the aerodrome from the air due to surrounding lights

The aerodrome beacon shall be introduced since an operation will be expected under low visibility condition.

Aerodrome beacon shall be located in the area where ambient luminance is low and does not cause glaring hazard to the air traffic controller of a control tower and the pilot of an approaching aircraft, and the beam is not shielded in significant directions. As the location to satisfy these conditions, the exact spot is shown in Figure DWG2-L26.

In order to prevent glaring to the air traffic controller, an extended line of 1 vertical degree below the main beam of the lighting at least not to hit on VFR (Visual Flight Rules) room of the control tower for that purpose. The lighting fixture shall be installed on a high level point with a structure considering height of building. The height required shall be calculated as below:

$h = H - L \tan 1°$

Height of the head frame of the control tower's VFR room window(sea level)--- H

Horizontal distance between the control tower and aerodrome beacon------------ -- L

Minimum height of an aerodrome beacon-- -- h

If height of the structure is more than 25 m, the structure shall be of a simultaneous-elevation type or shall be equipped with an elevator.

Power for the aerodrome beacon shall be supplied with the power which shall be transformed into low-voltage through the transformer cubicle installed adjacent to the aerodrome beacon, to which the power shall be distributed at high-voltage from the main AFL substation.

Signal cables shall be laid between the main substation, the above-mentioned cubicle. ON-OFF control by a remote control from the secondary AFL substation as well as the control tower shall be designed to be operative and besides so the direct control on a high-voltage distribution board of the main AFL substation shall be. Also, status of the aerodrome beacon shall be indicated to the control tower and the main and secondary AFL substations.

Luminous intensity distribution characteristics shall comply with ICAO Annex 14 5. 3. 3. 6~5. 3. 3. 7. Also, the lighting fixture shall be equipped with a stand-by lamp to which the connection can be automatically switched over when the lamp burnt-out, and shall have a point of contact with which the signal indicating the burn-out of a primary lamp is to be conveyed to the monitoring room. Rotating device section shall be furnished with an anti-freeze heater in winter.

2.21 Wind Direction Lights

According to ICAO standards, an aerodrome shall be equipped with at least one wind direction indicator, and at least one of the wind indicators should be equipped with illuminating facilities when the aerodrome is intended for use at night (5. 1. 1. 1, 5. 1. 1. 5).

As meteorological information such as wind direction and wind speed at an aerodrome can be obtained from ATIS(Automatic Terminal Information Service), the wind direction indicator shall be located on the side of touch-down zones for both approach directions of a runway to be utilize the existence of local bias current.

The lighting fixture shall be composed of a lighting pole, a streamer rotative around the lighting pole freely according to the wind direction and a light illuminating the streamer. The streamer shall be cone shaped and shall have a length of 3.6 m or more and a diameter at the larger end of 0.9 m or more. The colors of a streamer shall be in alternate bands of orange and white, having the first and last to be orange. Luminous intensity distribution characteristics of the light illuminating the streamer is not specified in Annex 14, and it only refers "clearly visible and understandable from a height of at least 300 m". So, the streamer shall be illuminated with the lighting of 4 lamps which derive the light source from incandescent lamps of approximately 100 watts.

A wind direction indicator shall be installed with a lighting pole being inset into the foundation made of concrete. The installation example is shown in Figure DWG2-L27. Setting out a white colored circular band of 15 m in the internal diameter around the lighting fixture's pole centered and 1.2 m in the width, having the whole inside area and 3 m outer area of the band paved with asphalt, this way the color contrast with a streamer can be emphasized and the visibility can be improved.

Power supply to the wind direction indicator shall be supplied from the main or secondary AFL substations by low-voltage.

The wind direction indicator shall be controlled by ON-OFF switching control at the control tower, the monitoring room of the main AFL and secondary AFL substations.

2.22 Obstruction Lights

An obstruction light with low intensity shall be provided for obstacle limitation surfaces (such as apron flood lighting).

CHAPTER 3 BASIC DESIGN FOR POWER FACILITIES

Operation of AFL systems requires must high reliability and easy of preventive the maintenance having secondary power sources such as a stand-by generator and uniterruptible power supply system, etc. in accordance with ICAO standards and recommendations. Thus, Double-End System* with independent 2 lines power supply shall be applied to the AFL system to achieve high reliability because the AFL system is required to operate as uninterruptible loads, which shall not be governed by the maintenance work. Duplicate system of stand-by generators shall be provided considering 1 set of the generator being in regular repair and the maintenance for long period.

3.1 Power Receiving and Distribution Facilities

The design for power receiving and distribution facilities are achieved by as follows;

(1) The AFL substation shall be provided adjacent respectively to each runway threshold, a substation for the apron floodlighting shall be provided adjacent to detached spot in the terminal area. Each substation shall receive power supply respectively by 2 line cables. The boundary point shall be defined at the power receiving point for each substation, thus the power cables up to the power receiving point shall not be included in the scope of design.

(2) Power supply to the radio navigational aids shall be provided from the AFL substation. The power supply to the radio navigational aids shall be served at low-voltage, and the boundary point shall be defined at the secondary side of the circuit breaker for a low-voltage switchboard of the AFL substation. Also, design of the installation of the power supply cable to the radio navigational aids shall not be included in the scope of design.

(3) Power receiving cables for AFL substations provided by China are not finalized yet but to be deemed that the ones have enough capacity of maximum power demand upon completion of Phase Two Work in the future.

(4) Three (3) phase, 10 kV/380 V/240 V transformers shall be provided, which provide the 380 V for the constant current regulators and provide 240 V for other facilities.

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* Double-end system: Duplex sets of the facilities provided from the power receiving point through the power receiving facilities end.

(5) Bus-bars on the low-voltage side of the AFL substations shall constitute 3 kinds of circuits comprising the circuit feeding from the uninterruptible power supply system (UPS), circuit back-up by the stand-by generator and the circuit feeding from the commercial power supply.

(6) Power supply system of the AFL substation shall be of the Double-End System as shown in Figures DWG2-E11(1/4) ~ DWG2-E11(4/4). Also, the primary side single line connection diagram of the main and secondary AFL substation are shown in Figures DWG2-E12 and DWG2-E13 accordingly, and the secondary side single line connection diagram is shown in Figures DWG2-E14 and DWG2-E15.

(7) Capacity calculation of transformer and generator are based on as below;

Runway 17 Transformer capacity

Description	Quantity	Load capacity (kVA)
CCR 30 kVA	11 sets	330.065
CCR 25 kVA	6 sets	154.315
CCR 20 kVA	6 sets	92.298
CCR 10 kVA	4 sets	42.043
CCR 7.5 kVA	5 sets	35.916
CCR 4 kVA	1 set	4.147
Load subtotal		658.8
Monitoring/Control facilities	1 lot	50
Radio facilities	1 lot	75
AFL substations	1 lot	158.6
Load total		942.4

Transformer capacity becomes 1,000 kVA from the above table.

Generator capacity is added 10% to the transformer capacity.

1,000 x 1.1 = 1,100 kVA

Runway 35 Transformer capacity

Description	Quantity	Load capacity (kVA)
CCR 30 kVA	9 sets	258.375
CCR 25 kVA	2 sets	55.822
CCR 20 kVA	6 sets	98.762
CCR 10 kVA	4 sets	42.675
CCR 7.5 kVA	5 sets	37.271
CCR 4 kVA	1 set	4.274
Load subtotal		497.2
Monitoring/Control facilities	1 lot	20
Radio facilities	1 lot	75
AFL substations	1 lot	66.8
Load total		659.0

Transformer capacity becomes 800 kVA from the above table. Generator capacity is added 10% to the transformer capacity.

800 x 1.1 = 880 kVA

A diagram of power receiving including Phase Two Work is shown in Figure DWG2-E17.

3.2 Stand-by Generators

The design of stand-by generator are based on as follows;

(1) The stand-by generator shall be an AC generator direct-coupled to an internal combustion engine using light oil as the fuel.

(2) The stand-by generator shall supply power to the load substituting the commercial power supply to start by sensing the failure of the commercial power supply (or reduction of the voltage). Time required by the stand-by generator shall not be more than 15 seconds. However, in case of the AFL systems, the time spent since the luminous intensity lowered below 80% until restores up to 80% is defined as switch-over time to the secondary power source, thus the duration time shall be taken into account as much enough as required.

(3) When the commercial power supply is restored, assuring the continuous run for 2 minutes, the switch-over to the commercial power supply shall be done instantaneously. Subsequently, the stand-by generator's run shall be turned off after the spare run for 2 more minutes. These motions from the start-up to turn-off shall be automated. Manual operation shall be workable as well.

(4) Performance of the generator is requested to assure the rated capacity of the time of switch-over, it shall requires more severe conditions than the generator for other

general sorts in such respects as rotary variation ratio, voltage variation ratio, counter-high-frequency-wave characteristics and efficiency, etc.

(5) The main and secondary AFL substations shall be furnished with 2 generators respectively in line with the double-end system.

3.3 Uninterruptible Power Supply (UPS) System

The design of UPS system are achieved by as follows;

(1) Provision of an uninterruptible power supply system shall be planned to the airfield lighting and monitoring control for which Annex 14 stipulates the time required for the switch-over to the secondary power source shall be within 1 second.

(2) Although the terms of "within one(1) second" is not required for the approach lightings, PAPI and runway edge lights other than the supplementary approach lighting barrettes by the stipulation in Annex 14, approach lighting system as well as runway lighting systems could all turn out to be uninterruptible in the power supply if they are added, therefore they shall be counted as objects of the load.

(3) Capacity of the system shall have the redundancy of 50%. And 2 sets of the system composing of 3 units shall be provided in line with the Double-End System for each the main and secondary substation, and shall be of the static-type.

3.4 Constant Current Regulator (CCR)

The design of CCR are carried out as follows;

(1) The constant current regulators shall be used for the series-feed circuits required for luminous intensity adjustment.

(2) The constant current regulator composing of 2 circuits shall sort out into separate groups configurating into groups by the capacity level. It shall be planned to be backed up by the spare one for each group.

(3) Conversion into the spare regulators shall be made by a remote control by which power control and monitoring control are coincidentally operated. Mode of the constant current regulator shall be of thyristor-type.

3.5 Monitoring Control System for the Power Facilities

The design of monitoring control system are based on as follows;

(1) Monitoring control for the AFL power facilities shall be served in the monitoring

control room in the main and secondary AFL substation. Each 1 set of computer indicating the status indication on its display shall be installed at the main and secondary AFL substations. Manual control shall be operative in addition to the remote control.

(2) Function of the monitoring control shall be of a monitoring cum daily-report, the control and status/breakdown of the high-voltage breaker and the switch.

(3) The status indication at the main AFL substation shall be concurrent operation by the graphic system and the computer display defining the status of power supply distribution. The status indication at the secondary AFL substation shall be made only by the computer display.

(4) The breakdown indication shall be classified into Serious Breakdown and Slight Breakdown, Serious Breakdown shall be indicated by red color with the bell alarm. Slight breakdown shall be indicated by orange color with the buzzer alarm.

(5) The serious breakdown shall be indicated classifying by the type of breakdown such as over-current, over-voltage and grounding respectively in the power receiving, power distribution, power generator, transformer, uninterruptible power supply system, etc. The equipment shall be shut off in the incident of breakdown while ((OFF)) indicator flashing for the status indication. The slight breakdown shall be also indicated classifying by the type of breakdown. However, the uninterruptible power supply equipment and stand-by generator shall have the collective indication of the serious breakdown and slight breakdown.

(6) The voltage, current, power, frequency, power factor, etc. shall be provided as measured value and the measurement of voltage and current shall distinguish phase.

(7) Provision of the data logger shall be planned to carry out the recording of status, handling, breakdown which shall be aggregated to be processed into the statistical application.

3.6 Monitoring Control System for Airfield Lightings

The design of monitoring control system are achieved as follows;

(1) Monitoring control system equipment for the AFL shall be provided at the monitoring room of the main and secondary AFL substations, and at the VFR room of the control tower. However, monitoring control equipment for apron floodlights, visual docking guidance system and aircraft stand identification signs shall be served by General Control Center as the main function, and the sub-monitoring shall be operative at the monitoring room of the main AFL substation as well.

(2) Computer control system shall be introduced to the monitoring control system.

(3) Control for the AFL shall be designed to control automatically for flashing and luminous intensity by way of inputting ((APPROACH DIRECTION)), ((DAY/NIGHT/DUSK)), ((VISIBILITY)) and ((CEILING)) on the remote control desk for the AFL in the VFR room.

Also, the monitoring control system shall be furnished with the function to control manually the luminous intensity of certain barrettes high and low upon request by a pilot of an aircraft and to be reset after the landing. Results of these operations as for the significant lightings shall be verified on the actual lighting locations and the consequent result shall be indicated. Alarm indication shall be furnished to the monitoring room of the main AFL substation when working ratio falls below the ICAO standard, Annex 14 (70 ~ 95% depending on lights type) and adjacent 2 lights become unservice. It is also required that the alarm indication shall be carried out to the main AFL substation and the VFR room, when the working ration is altered by the aviation authority.

(4) Control for the AFL shall be designed to monitor both on a monitoring board and the display by change-over switch in the main AFL substation. The monitoring board shall be designed to be capable of serving more detailed monitoring control than the remote control desk located in the VFR room.

Recording of the operational status of lightings and statistical the break-down record, etc. shall be designed to serve by the data logger which is to be co-used by the power facilities.

Over all block disgram of the monitoring control system is shown in Figure DWG2-L29.

3.7 Monitoring for Burnt-out Lamp Detection and Preparation for the Development to A-SMGCS(Advanced Surface Movement Guidance and Control Systems) for Airfield Lightings

For the approach lighting systems, the PAPI, the runway edge lights, the runway threshold lights, the runway end lights, the runway center line lights, the touchdown zone lights, the stop bar lights and the primary taxiway center line lights intended use of runway visual range condition of order of 500 m or less when the working level of any one of them falls below the level specified in Annex 14 as the minimum standard for the preventive the maintenance, it is required to provide such a monitoring system as might serve an immediate indication and relay the information to the maintenance crew (Annex 14, Volume 1, 8. 3. 3). It is also required that the lighting systems should be monitored automatically providing an immediate indication when the working level of any element falls below the minimum level specified by the appropriate authority below which operations should not continue, this information shall be relayed even to the VFR room (Annex 14, Volume 1, 8. 3. 4).

Since the continuous visual monitoring under low visibility is impossible, provision of the burnt-out lamp detection system shall be necessary. Though the burnt-out lamp detection system varies in transmission mode for the burnt-out signal and setting mode for the address depending on the manufacturer, every one of them detect current flow into the lamp as zero, which must have been caused by the burnt-out lamp.

The burnt-out lamp detection system consists of a terminal controller unit (slave stations) normally between isolating transformers and lighting fixtures, and a master station installed in the substations interfacing the slave stations. Host station which integrates the plural number of the master stations through processing by the computer is also included in the system. The master stations shall use the series-feed circuits as transmission lines by way of modems to communicate with the slave stations. The slave station shall fill the role as a burn-out preventive for an isolating transformer as well by short-cutting the secondary side of the isolating transformer upon the burn-out of a lamp.

Some kind of terminal controller unit has a function for switching in addition to the function for burnt-out lamp detection, or even another function for luminous intensity adjustment.

In consideration of the future development into system control of the stop bars, A-SMGCS, terminal controller units for the taxiway center line lights are required to be equipped at least with make and break function. Furthermore, although it could be a desirable choice to use the terminal controller unit with the function of luminous intensity adjustment for taxiing guidance signs, by which they shall be enabled to be coupled with the circuit for taxiway center line lights. As the result of discussion with Chinese experts, the design of taxiway center line light is not equipped with function of ON/OFF but is considered to have an enough space in a terminal control unit for future provision.

3.8 Monitoring Control for Stop Bars

A stop bar shall be provided at every taxi-holding position serving a runway when it is intended that the runway will be used in runway visual range conditions of order 350 m or more in accordance with ICAO (Annex 14, Volume 1, 5. 3. 17. 1). Also, a stop bar should be provided at every taxi-holding position serving a runway when it is intended that the runway will be used in the order of 350 m and 550 m (Annex 14, Volume 1, 5. 3. 17. 2). The provision of 5. 3. 17. 2 shall apply as a standard as of 1 January, 2001, the provision shall be enforced and mandated. Thus, the stop bar lights shall be provided under this design, and the main functions are as below:

(1) Control of the stop bars shall be carried out by an air traffic controller in the control tower.

(2) Stop bars shall be illuminated while any taxiway center line lights installed on the runway-ward side beyond the stop bars shall be extinguished under poor visibility operational conditions.

(3) An air traffic controller shall press an appropriate switch on the control board for stop bars as permitting an approach to the runway for take-off for the aircraft holding at a taxi-holding position. Stop bars shall be extinguished and taxiway center line lights installed beyond the stop bars shall be illuminated automatically, which shall be all indicated on a mimic indicator section of the control panel (or the display).

(4) As an aircraft maneuvers passing a stop bar, the passing of the aircraft shall be detected by an aircraft position sensor, the stop bar shall be automatically re-illuminated, the taxiway center line lights in the first section extending approximately 90 m shall be extinguished, and the status shall be indicated to the control tower. As the aircraft moves on further ahead to reach a take-off start point, the rethe mained taxiway center line lights shall be all extinguished by the sensor (or a pre-set timer), and the status shall be indicated to the control tower. If an aircraft goes across a stop bar when the stop bar is still illuminating, alarm shall be sent to the control tower according to the detection by a sensor. While the taxiway center line lights installed beyond a stop bar are illuminated, even if an air traffic controller might handle the switches, the warning alarm shall be raised, not any one of stop bars can be extinguished.

(5) A signal output terminal shall be provided so that the status indication of illumination/extinguishment of the stop bars shall be shown on the ASDE.

(6) Stop bars and taxiway center line lights installed beyond the stop bars shall be provided with the terminal controller units. The terminal controller unit shall be furnished with functions to receive and discern the signals transmitted through the series-feed circuit cable used as the transmission network, to make and break the current providing to the lightings on the secondary side of isolation transformers and to return the status as the responding signal. Also, the terminal controller unit shall have the function for detecting the burnt-out lamp/s.

(7) The terminal controller unit shall have functions as a controller for a burn-out detection sensor (transmission of detected signals)and a runway alarm light (blinking function).

(8) Status indication of stop bars shall be extended even to the monitoring room of the main AFL substation as well.

3.9 Monitoring Control for Apron Floodlighting, Visual Docking Guidance System, Aircraft Stand Identification Signs

Following functions for monitoring control for apron flood lighting, visual docking guidance system and aircraft stand identification signs are required.

(1) Result of the discussion with Chinese experts, monitoring control for apron floodlighting, visual docking guidance system and aircraft stand identification signs shall be served by the department in charge of spot management in the apron, which shall apply to General Control Center for the airport.

(2) As for apron floodlighting, on-off switching on each spot and for overall lighting on each circuit shall be operative, and the status indication shall be provided on the monitoring control unit.

(3) As for the visual docking guidance system, on-off switching, luminous intensity control and input of the type of an aircraft using a spot shall be operative , and the status indication shall be provided on the monitoring control unit.

(4) As for the aircraft stand identification signs, on-off switching shall be operative for each spot, and the status indication shall be provided on the monitoring control unit.

(5) Operation of the apron floodlighting shall be carried out by General Control Center, whereas it is necessary to indicate the status even to the party that is responsible to the maintain the apron floodlights in workable condition. Hence, while status indication of the lights shall be designed to be provided at the monitoring room in the main AFL substation, control and on-off switching shall be operative in the substation located nearest to the cargo area and the maintenance area as well.

3.10 Cable Duct Line and Man-Hole

a) Duct Line

(1) Material of the Duct

Flexible pipe shall be used for the portion of the duct line laid under unpaved ground, and galvanized steel pipe shall be used for the portion laid under paved ground.

(2) Duct Size

Minimum diameter value of 80 mm shall be applied to the main duct line.

(3) Location of the Duct Line Laid Underground

The main duct line shall be provided at the distance of 75 m parallel to the runway center line. Refer to Figures DWG2-E16(1/4) ~ DWG2-E16(4/4), Duct Line Plan.

(4) Depth of the Duct Line Laid Underground

The main duct line shall be laid underground in such manner as the top point of the duct shall be more 60 cm more below under the ground surface.

(5) Numbers of Cable Installed

Series-feed cable shall be installed for every circuit using one duct line. Also, high-voltage, low-voltage and weak power cables shall not be laid together in a same duct line. The main cable duct for future Phase Two Work which are buried under the concreate pavement shall be included in this design.

(6) Buried Earth Wire

Earth wire shall be placed on the top portion of the duct line for the purpose of lightning discharge. Bare copper wire of not less than 14 mm2 shall be used, which shall be laid underground at 20 cm above the duct line. Plural number of earth wires shall be provided for the duct lines installed within the protection angle of 120 degrees.

(7) Grounding Electrode

Earth wire shall be provided with a grounding electrode at intervals of 200 m. The grounding electrode shall be made of copper clad steel bar or copper plate, and the overall resistance value shall be designed to stay below 10 ohms.

b) Man-hole

(1) Location of the Man Hole

Man holes shall be located before and behind the pavement on intersecting lines of the duct and on every 150 m section in series section and curving points of the duct lines.

(2) Structure of the Man Hole

The man hole shall be made of rein-forced concrete and the entrance cum exit shall be covered with the water-proof cast-iron lid.

CHAPTER 4 BASIC DESIGN OF AFL SUBSTATION

4.1 Basic Policy

The AFL Substations are building facilities for the supply of electricity and remote control of the runway lighting, taxiway lighting and apron lighting equipment in the Phase One . The buildings are the main AFL substation, which will be placed in the Cargo Area at the 17 end of the runway along side the main Fire Station. The unmanned secondary AFL substation will located behind the hangers at the 35 end of the runway. The main components of the facilities are the Power Room Facilities, Remote Control Facilities, Constant Currency Regulator Facilities, Uninterruptible Power Supply Facilities, Diesel Generator Facilities and other Support Facilities.

The main AFL substation includes the facilities for the maintenance and repair of the Lighting Facilities such as the maintenance facilities, testing facilities and the storage facilities. Also, the main AFL substation has support facilities for the personnel engaged in the maintenance and repair of the Lighting Facilities such as offices, locker rooms and shower rooms.

The above facilities will meet the requirements of the Phase One Work Plan. Requirements for the Phase Two Work Plan are also considered. They will be met by expansion of the buildings which will be considered as an integral part of the Phase One Work Plan.

4.2 Design Conditions

4.2.1 Design Standards

The standards and criteria to be used in the design of the AFL substations are the following:

- National Standard of the People's Republic of China

  Fire Code for Architectural Design (GBJ 16-87)

- National Standard of the People's Republic of China
  Standard for Architectural Water Supply and Drainage Design(GBJ 15-88)

- National Standard of the People's Republic of China
  Standards for Industrial and Civil Power Supply Networks Design

- Standards of Shanghai City

Guidelines for Foundation Design (DBJ 08-11-89)

- Standards of Shanghai City
  Requirements for Architectural Aseismic Design
- Japan Ministry of Transportation Civil Aviation Bureau
  Standards for Aeronautical Lighting Design Power Station
- National Standard of the People's Republic of China
  Standards for Civil Architectural Electricity Design(JGJ T16-92)
- National Standard of the People's Republic of China
  Standards for Automatic Fire Alarm Equipment (GBJ 116-88)

4.2.2 Natural Conditions

Climatic Conditions will use the data for Shensha in the Feasibility Study Report. The main numerical values are as follows;

Mean Annual Temperature : 15.5°C	Lowest Temperature:	-9.6°C (January)
	Highest Temperature:	38.8°C (August)

The average annual rainfall is 1,109mm and the monthly rainfall is 30-150mm with heaviest rainfall in June and September. There are few earthquakes and the design seismic coefficient is 0.08.

4.2.3 Social Conditions

The Socio- economic conditions which should be considered in the design of the AFL Substations are the lack of heavy lifting equipment available in the course of normal the maintenance and repair. This will require that heavy equipment should be located on the first floor as far as possible.

Aesthetic consideration to blend with the strong Modern design of the Passenger Terminal building is required. Construction materials will utilize economical materials available in China.

4.3 Basic Design

4.3.1 Site Plan and Plot Plan

Selection of the site for the AFL substations follow the area demarcations under the Airport Master Plan with futher considerations for suitability for the maintenance and operation of Aeronautical Lighting Facilities. The main requirement for the AFL Substations is the accessability to the airside area for lighting the maintenance and repair. Discussions with the Chinese experts were held. The site selected for the main AFL substation is situated adjacent to the airport fire station facing the runway area. The site selected for the secondary AFL substation is situated behind the Hangers in the maintenance Area.

The Plot Plan will take into consideration the maintaining normal operations and providing safe movement corridors during the expansion construction scheduled under the Phase Two Work Plan. Furthermore, the main functional requirement is to be a reliable power supply facility for the Aeronautical Lighting. As such, due consideration for the power cables routes in the site, inlet and outlet to the buildings and cable routing within the buildings is required.

In-site roads and garage will be designed to allow the maintenance vehicles to park and deliver lighting equipment directly to the maintenance room.

Plot plan of the main and secondary AFL substation is shown in Figure DWG2-A1 and DWG2-A4 respectively.

4.3.2 Facility Plan

In determining the dimensions of the principle rooms for the main AFL and secondary AFL substation, the guidelines for power station design set out by the Ministry of Transportation of Japan will be referred to. The principle rooms will be determined by setting out required equipment and allowing for recommended service spaces. The results of the study for the main and secondary AFL substation are shown in the appendix.

The space requirements for the office room, locker rooms and rest rooms, etc will follow the Guidelines for Safety Testing Stations Office Space (MH 7003-95). The results of the space requirements for the proposed facilities are shown in TablesII2-4.3.1 and 4.3.2.

Facility plan and sectional plan of the main and secondary AFL substation are shown in Figure DWG2-A2, A3, and DWG2-A5 and A6.

TableII2-4.3.1 Floor Area of The Main AFL Substation

(unit=m^3)

Room Name	Calculations Basis	Phase 1 Requirement	Phase 1 Proposed	Phase 2
1st Floor				
Power Room	25 panels Phase 1, equivalent expansion Phase 2	200	205.55	200
Generator Room	750KVAx 2, replace with larger unit Phase 2, ceiling height 5m min.	110	110.07	---
CCR Room		170	167.61	200
UPS Room	Phase 1 110kVAx 3	80	84.00	80
Battery Room		80	84.00	---
The maintenance Room	Direct vehicle access,	150	169.38	---
Testing Room	6m x 20m min.	120	130.83	---
Storage Room		90	88.42	---
Special Fire-Fighting Equipment Room	CO_2 extinguisher system	40	32.27	---
The maintenance Personnel Rest Room	3-4persons x 5 m^2/person	20	38.22	---
The maint. Pers. Locker Room	12 persons x 1.5 m^2/person	18	15.00	---
Guard room	1-3 pers. at all times, 3shifts	15	15.00	---
Toilet	mens 2WC, 2urinals, 2basins	15	27.58	---
Shower Room	2 shower booths w/ changing space	9	8.00	---
Hot Water Room	sink, hot water bottle, refrigerator space	5	6.00	---
Miscellaneous Storage	(space under staircase)	5	10.00	---
Corridor, Staircase	(above total x0.15%)	170	164.95	
1st Floor Total		1,297	1356.88	480
2nd Floor				
Control Room		120	127.38	---
CPU Room		90	87.22	---
Data Room		30	24.00	---
Record Storage		25	26.71	---
Manager Room	1 person x $14m^2$+reception $6m^2$	20	26.71	---
Office	2persons x $10m^2$/pers.	20	48.63	---
Conference Room	25pers. x$1.5m^2$/pers.	38	38.90	---
Control Pers. Rest Room	3-4 pers. (total Control pers. 12)	15	10.85	---
Locker Room	men 15 persons x $1.5m^2$/pers.	22	26.71	---
Bedroom	3 beds x $6m^2$/bed	18	28.89	---
Shower Room	2 shower booths w/ changing space	9	8.00	---
Toilet	mens 2WC, 2urinals, 2basins	15	27.58	---
Hot Water Room	sink, hot water bottle, refrigerator space	5	6.00	---
Mechanical Equipment Room	includes Ventilation Room	45	84.80	---
Corridor, Staircase	(above total x 0.15%)	80	108.11	
Total 2nd Floor		594	680.49	
Total Floor Area		1891	2,037.37	
Exterior Ancillary Structures				
Garage (w/ Roof)		180	180	---
Bicycle Parking	20 slots x $1.0m^2$/slot	20	20	---

TableII2-4.3.2 Floor Area of The Secondary AFL Substation

(unit= m^3)

Room Name	Calculations Basis	Phase 1 Requirement	Phase 1 Proposed	Phase 2
Power Room		130	130.28	130
Generator Room		130	129.68	---
CCR Room		130	130.28	130
UPS Room		80	64.40	65
Battery Room		80	59.79	---
Special Fire Fighting Equipment Room		40	32.03	---
Control Ropom		50	34.81	---
The maintenance Pers. Rest Room		20	25.49	---
Toilet		6	5.76	---
Corridors, etc		100	94.33	---
Total Floor Area		766	706.85	325

4.3.3 Summary of Finish

(1) Exterior Finish Plan

Exterior Walls : Ceramic Tile and Concrete w/ Paint Finish

Exterior Joinery : Secondary Eletrolytic Coated Aluminium Sashes, Steel Flush Doors w/ Paint Finish
Glass SSG Curtain Wall
Motor-driven Steel Rolling Doors w/ Paint Finish

Roof : Built-up Asphalt Roofing w/ Concrete cover

(2) Interior Finish Schedule

Floor : CPU Room, Control Room and Data Room/Free-Access Floor with Anti-static floor panels
Office Room,Manager Room and Conference Room/ Marble
Power Room, Generator Room and CCR Room/ Mortar w/ floor coating

Wall : Mortar with Emulsion Paint finish

Ceiling : Control Room, CPU Room, Office, Manager Room and Conference Room / Rockwool Acoustic Panel
The maintenance Rm, Testing Rm, Rest Rms, Locker Rms,etc./
Gypsum Board with paint finish

Power Rm, Generator Rm, UPS and CCR Room / Mortar finish

4.3.4 Structural Design

(1) Main AFL Substation:

Steel reinforced Concrete Moment Resisting Frame construction,2 story building partially single story. Walls are brick with mortar cover. (however, Steel reinforced concrete structural walls may be provided if calculations require.)

(2) Secondary AFL Substation:

Steel reinforced Concrete Moment Resisting Frame construction, Single story building. Walls are brick with mortar cover.(however, Steel reinforced concrete structural walls may be provided if calculations require.)

(3) Foundation Design:

Drilling test surveys will be conducted on the proposed sites to reconfirm soil strata distribution. 4 Drilling tests will be done. One will be driven to 40m below ground level, while the other three will driven to 15m below ground level. The Foundation design will basically be of the Raft type and will be reviewed after the above drilling tests. The bearing stratum is considered to be stratum②-1based on the drilling records in the F/S survey. Differential settlement analysis following Shaghai City Guidelines for Foundation Design is required. If required Piles will be adopted, to make Pile-raft type Foundations. Piles will be ready made concrete piles 25cm square, driven to a depth of about 17m (⑤-1 stratum) based on the F/S survey. These piles will require settlement calculations following the Shanghai City Guidelines for Foundation Design article 6.3.1.

4.3.5 Building Facilities Design

(1) Mechanical Systems Design

1) Plumbing Facilities

Each piece of equipment will follow deisgn standards based on Chinese bylaws.

A. Water Supply System

There are plans for a water supply the main under the proposed area road facing the site. A branch will be taken from this the main , passing through a water meter within the site and then connected directly to each point of supply throughout the building. The daily water supply volume will be 5,700l per day for the main AFL substation.

B. Hot Water Supply System

Potable hot and chilled water will be supplied from dispenser machine using bottled purfied water in the Hot Water Room on each floor.

Electric hot water machines connected to the water supply pipes will be provided for the Shower Rooms on each floor.

Machine data should be referred to the Equipment list in the Appendix.

C. Sewage System

The Sewage System will be separate for ordinary waste water and soil water within the building . They will be combined at catch basin outside of the building and then discharged into the sewer the mains. Ventilation pipes will combine stack vent and loop vent types. They will be taken to the exterior walls for release.

Rain water will be drained through down pipes and catch basins and will be separately connected to storm drains under the roads facing each site.

D. Sanitary Equipment

Sanitory equipment will be provided for the Toilets and Shower Rooms on each floor. Hand basins will be in the maintenance Room and spigots will be provided on exterior walls on the roof and at ground level. Refer to Equipment List in Appendix.

2) Fire Extinguishing System

The following systems will be provided according to respective Chinese laws and standards.

A. Powder type fire extinguishers will be provided with signs throughout the building.

B. Fire Hose Reels

A pump will be installed in the Special Fire-fighting Equipment Room and will be connected to fire hose reels on each floor. A test valve and reserve tank will be provided on the roof. The main resrve will be an underground tank beneath the pump.

A provisional equipment list is shown in the Appendix.

C. Special Fire Fighting Equipment

The Power Room, CCR Room, UPS Room, Generator Room and CPU Room will be provided with CO_2 gas fire extinguishing system. The gas cylinders and header will be placed in the Special Fire-fighting Equipment Room. A control panel and selection valves for each room will also be provided in this room. Each room will have separate piping and control wiring and plugged branches and sleeves will be provided for rooms in the Phase Two expansion scheme which require CO_2 gas fire extinguishing system.

3) Air Conditioning and Ventilation Systems

Each system will be provided in accordance with respective Chinese standards.

A. Air Conditioning System

The requirements and operating conditions of the rooms requiring air conditioning differ. An air-cooled heat pump type separate air conditioner units with humidifier for winter operation will be provided to allow independent operation for the various demands. The interior units will be basically ceiling mounted units.

The CCR and CPU Rooms have large continous heat discharge due to the equipment installed in the rooms. These rooms will be provided with air-cooled heat pump type cooling systems. The heat exchange units will be placed in the Mechanical Equipment room from where cooled air will be delivered by ducts to provide even distribution throughout each room. A provisional Equipment list is shown in the Appendix.

B. Attached Piping and Wiring

Refrigerant piping and control wiring connecting internal units with external equipment will be provided. Water supply for humidifier and drains for condensation discharge are also required.

C. Ventilation System

All rooms other than corridors, staircase and storage space under the staircase will be mechanically ventilated. The respective equipment list is shown in the Appendix. The unit for the Battery Room should be corrosion resistant type.

D.Ventilation Duct System

The supply and exhaust ducts for the ventilation system will be provided as required. Where ducts penetrate fire walls, fire dampers will be provided at each point of penetration. Ducts penetrating fire walls of CO_2 gas fire extinguishing system zones will be piston releaser type.

(2) Electrical Systems Design

Each system will be designed according to respective Chinese standards and laws.

1) Low Tension Electricity Supply

General Power Supply for building facilities will be taken from the Low Tension Panel in the Power Room and distributed to respective zone distribution panels.

Lighting and outlets will be supplied with single phase 3 line 220V 50Hz with earthing line. Power for mechanical equipment will be 3 phase 3 line 380V 50Hz with earthing line. Both will be divided into 3 groups according to reliability requirements.

2) Electrical Mains

Group 1 : General lighting the mains, General air conditioning power the mains (Single cable the main)

Group 2 : Security lighting the mains, security power the mains (CCR, CPU, UPS room)

Group 3 : Emergency lighting and power the mains (redundant the main cable ;2 separate cable system)

3) Earthing System

The Earthing System will be integral with the Power Receiving facilities which are included in the AFL Facilities Package. No separate earthing for computer use will be provided.

4) General Lighting System, Emergency Lighting System

The required lighting facilities will be provided according to Chinese law and JIS standards.

Emegency Lighting will be connected to the generator and will turn on within 15 seconds of commercial power failure. The lighting intensity will be based on JIS standards .

The lighting distribution board will have two separate the mains for General Lighting and Emergency Lighting (with back-up generator).

5) Exit Lighting System

Exit lighting fixtures will be provided according to Chinese law.

Exit lighting fixtures will be of integral battery package type, each capable of turning on independently by battery power in case of power failure.

6) Outlet System

General outlet will be twin outlet type. They will be distributed in each room as required. The outlets will be supplied by General power the mains or Security Power the mains according to reliability requirement of each room.

7) Power the mains for building mechanical equipment will be either from general power the mains or from security power the mains (with Generator backup). Control panels will be connected by cables in electrical piping to each power use.

Ventilation control panels will be electric works portion and fire pump control panel will be included in mechanical works portion. Breakdown and accident alarm signals will be relayed to panels in Control Room.

8) Automatic Fire Alarm System

The main fire indicator panel (FIP) will be installed in the Control Room of the main AFL Substation. Individual FIP will be integral with Fire hose reels Cabinets. Signals from the Secondary AFL Substation will be relayed to the main FIP in the main AFL Substation.

9) Telephone System

External lines in the approach roads will be taken into site by underground conduits and connected to the main Distribution Frame (MDF). The MDF will be installed in the Control Room. The Intermediate Distribution Frame (IDF) will be placed in the CCR room and from there the piping will be taken to each telephone outlet.

Wiring and installation of individual telephone receivers will not be part of this project.

10) Radio Transmission System (Main AFL Substation Only)

Space for Radio Transmission equipment for communication with airport operation center and airport fire station will be reserved in the Control Room. Sleeves for antenna wiring will be provided.

11) Television Reception System (Main AFL Substation Only)

A VHF/ UHF television reception antenna will be provided on the 2nd floor roof. Outlet s will be provided in the maintenance Personnel Restroom, Office Room, Conference Room, Control Room, Data Room and Bedroom.

4.4 Construction Plan

4.4.1 Procurement Plan

Procurement Plan of construction materials and equipment for this project will take into consideration ease and reliability of the maintenance and the speed of replacement or repair of damaged parts.

This project will utilize construction materials and equipment available on the local market as much as possible.

4.5 Estimation of Construction Cost

Estimated Construction cost of Architectural Facilities

Item	Unit	Chinese Yuan (RMB)	Yen Equivalent
The main AFL Substation			
Building Works	Lump Sum	6,819,000	88,647,000
Mechanical Systems	Lump Sum	2,481,000	32,253,000
Electrical Systems	Lump Sum	2,065,000	26,845,000
Temporary Works	Lump Sum	349,000	
Expenses	Lump Sum	2,841,000	
Design and Supervision fee	Lump Sum	1,455,000	
Total Cost of The main AFL Substation		16,010,000	208,130,000
Secondary AFL Substation			
Building Works	Lump Sum	2,705,000	35,165,000
Mechanical Systems	Lump Sum	950,000	12,350,000
Electrical Systems	Lump Sum	854,000	11,102,000
Temporary Works	Lump Sum	138,000	
Expenses	Lump Sum	1,127,000	
Design and Supervision fee	Lump Sum	577,000	
		6,351,000	82,563,000

Estimation Conditions

Date of Estimation : December,1996

Foreign Exchange Rate : 1.00Chinese Yuan (RMB) = 13.00Japanese Yen

1.0 US$ =112.00 Japanese Yen

Yen Equivalent portion of each system in the above is adjusted by Chinese market cost using Japanese market cost.

4.6 The maintenance Workshop for Airfield Lightings

(1) Installation Location

The maintenance workshop for airfield lightings shall be annexed to the main AFL substation.

(2) Function

The maintenance workshop shall be provided with the functions for cleaning, repair, preparation, co-ordination, inspection and storage.

(3) Equipments

The maintenance workshop shall be furnished with the equipments as below:

- Light cleaning device
- Dry-type parts washing device
- Warm water-type parts washing device
- Supersonic wave cleaning device
- Light distribution intensity measuring device
- Air compressor
- Air gun