CHAPTER 4 PAVEMENT DESIGN

4.1 Geometric Design

4.1.1 Design Criteria

(1) Design configuration

The basic geometric design of the runway, taxiways and apron should be in accordance with the Master Plan.

(2) Design Aircraft

According to the Master Plan, aircraft supposed to enter into service in this airport are classified as follows. The aircraft to be considered for determination of the geometry is B-777-300 as explained in Section 4.1.3(1).

TableII1-4.1.1 Assumed Commissioned Aircraft

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

4.1.2 Width of Pavement

(1) Pavement Width of the Runway

According to the Master Plan, pavement width of the runway is as follows:

• the main body of the runway: 60 m

• runway shoulder: 7.5 m

(2) Pavement Width of Taxiways

1) Parallel Taxiway

According to the supposed main gear spacing of the envisaged future type of aircraft the width of the main body of parallel taxiways is as follows:

• Width of parallel taxiways $W = T + 2C = 20 + 2 \times 4.5 = 29.0$ m

where, T: main gear space (20 m according to the ICAO recommendation)

C: mecessary clearance to a margin of the main body of a taxiway

2) Exit Taxiways in the Middle Part

With reference analysis of fillet design mentioned later and from examples of the other airports in China; the width of exit taxiways is as follows:

- Width of exit taxiway in the middle part W = 17.0 + 17.0 = 34.0 m

3) Entrance Taxiway at the end of the Runway

Necessary expansion of width of the crossing part to connect to the end of the runway will be made on only one side. Therefore:

- Width of the entrance taxiway in the end part W = 17.0 + 14.5 = 31.5 m

4) Rapid Exit Taxiway

In the connection part with the runway, the radius of the centerline curve is extremely large, (according to the ICAO recommendation, 50 cm). Movement of the gear to the inside is small, in addition, the width is expanded enough to transition of the width difference, therefore, like parallel taxiways, the width of the rapid exit taxiway is; W = 14.5 + 14.5 = 29.0 m

5) Shoulders

Taxiway shoulders should have a pavement width required by the ICAO recommendation (44 m).

Therefore:

- Width of shoulders ws = (44 - 29)/2 = 7.5 m.

In the case of the width of a taxiway is 31.5 m / 34.0 m, the shoulder width should be also 7.5 m.

TableII-4.1.2 Width of Taxiways

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

4.1.3 Fillets in the Crossing Part

Fillets at the part crossing a runway and a taxiway or two taxiways will be determined with the diagram method after reproducing a vehicular swept path (maneuvering).

(1) Selection of object aircraft

One of elements necessary for analysis of fillets in the crossing part of taxiways is gear configuration of the aircraft.

It is supposed that new large aircraft (NLA) will appear in the future. However, their gear configurations and timing of service are not clear. Therefore, comparison was made between B-747-400 and B-777-300. It is because the former is the largest one at present, and the latter is planned to enter into service a few years later. As a result of the comparison, B-777-300 was selected, because it has a large wheel base as well as wide spacing of outer rims of the main legs.

As for a rapid exit taxiway to be located in the nearest to the Touch Down Point, middle-sized aircraft and smaller ones were examined, and as a result, B-767-300 with a long wheel base was chosen.

TableII-4.1.3 Gear Configuration of Objective Aircraft

	Aircraft	Wheel Base (m)	Space of Outer Wheel Rims of the Main Legs (m)	Remarks
Large size	B-747-400	25.62 (Nose gear~center of the main gear)	12.46 (wing gear)	
	B-777-300	31.22 (Nose gear~the main gear)	12.90 (main gear)	To be adopted
	MD-11	24.60 (Nose gear~the main gear)	12.40 (main gear)	
Middle size	B-767-300	22.76 (Nose gear~the main gear)	10.74 (main gear)	To be adopted
	A-300-600	18.60 (Nose gear~the main gear)	10.85 (main gear)	

(2) Clearance

According to the ICAO recommendation, clearance between the outer wheel rims of the main legs of aircraft and the pavement edge of the main body of taxiways should be 4.5 m.

(3) Curve Radius of the Centerline

Taxing speed of an aircraft on a taxiway other than the rapid exit taxiway is usually 30 km/h.

Therefore, in order to run smoothly on a taxiway, the radius of the curve part should allow this speed to be kept.

1) In the ICAO recommendation, the relation between running speeds of aircraft and curve radiuses is as shown in TableII-4.1.4, therefore, the curve radius in the standard part should be 60 cm.

In Japanese standards, the centerline radius of the curving part is also prescribed to be 60 m for large-sized airplanes.

TableII-4.1.4 Relation between RunningSpeeds of Aircraft and Curve Radiuses (ICAO Recommendation)

Running Speed (km/h)	Curve Radius (m)
16	15
32	60
48	135
64	240
80	375
96	540

Running speed of aircraft V = (127.133×(f)×R)1/2

= (127.133×0.133×R)1/2

= 4.1120×(R1/2)

where, (f): load rate in the horizontal direction.

Then, width V = 30 km/h, R = (V/4.1120)2

= 53.3 m→60 m.

2) Curve Radius between Parallel Taxiways

A space between parallel taxiways is 99 m. On the assumption that the curve radius is the half of it, the radius should be:

• 99/2 = 49.5 m.

3) Curve Radius of rapid exit taxiway

Based on the ICAO recommendation, the radius of the curve between the runway and the rapid exit taxiway should be 550 m, considering that the drive - in speed is 96 km / h.

As to the curve from the rapid exit taxiway to parallel taxiways, a straight line section of 75 m is to be secured, considering the distance needed for stopping within the rapid exit taxiway. Then the radiuses should be as follows:

• In the part of 150° turning: 47.5 m

• In the part of 30° turning: 250 m (based on experience of other airports in China).

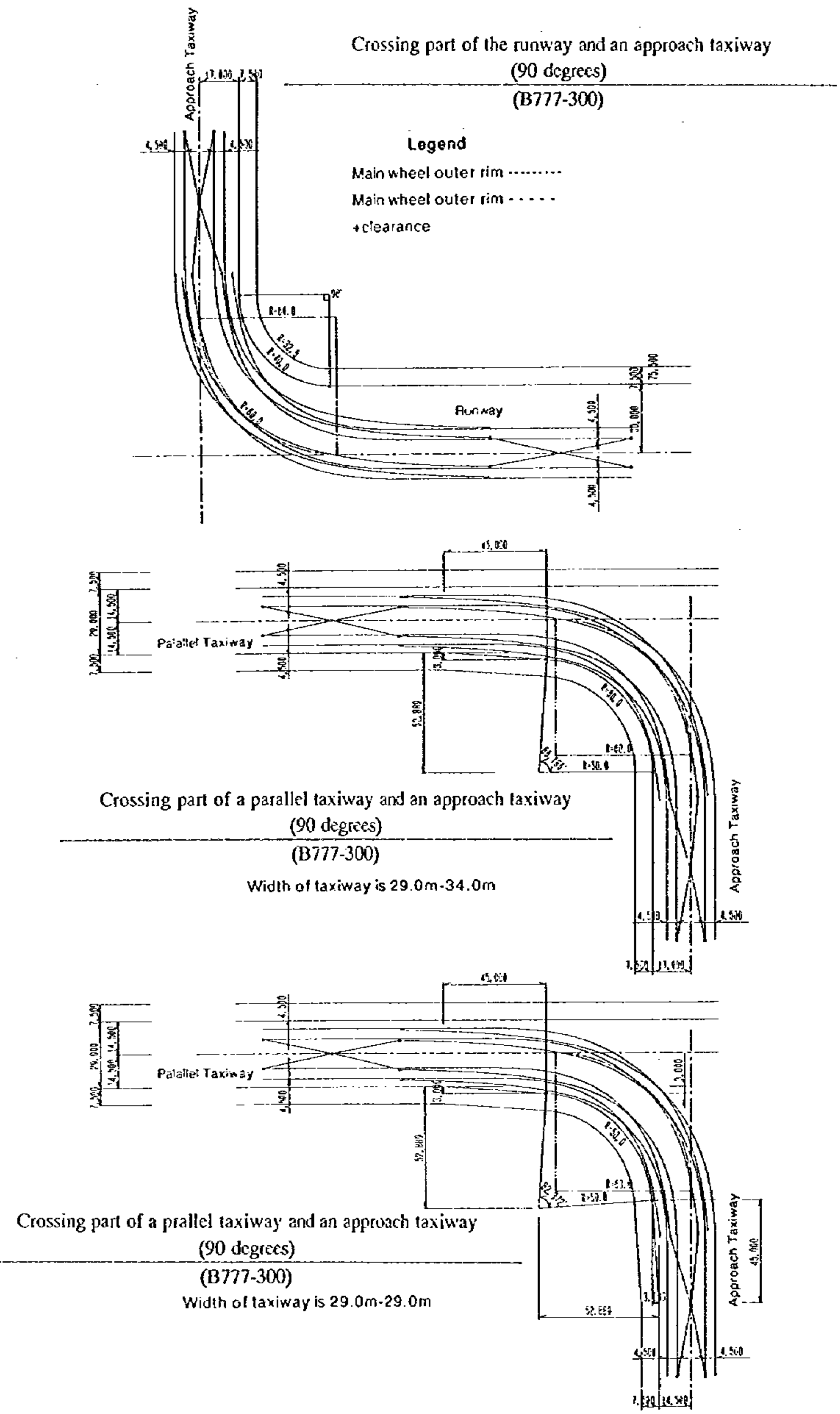
4) Determination of Form of Fillets

Maneuvering of B - 777 - 300 and B - 767 - 300 aircraft will be reproduced. The fillet form must be capable to secure required clearance of 4.5 mm from outer wheel rims of the main legs. Therefore, the form should be a combination of a single curve and a line as shown below, considering constructability.

TableII1-4.1.5 Form of Fillets in the Crossing Part

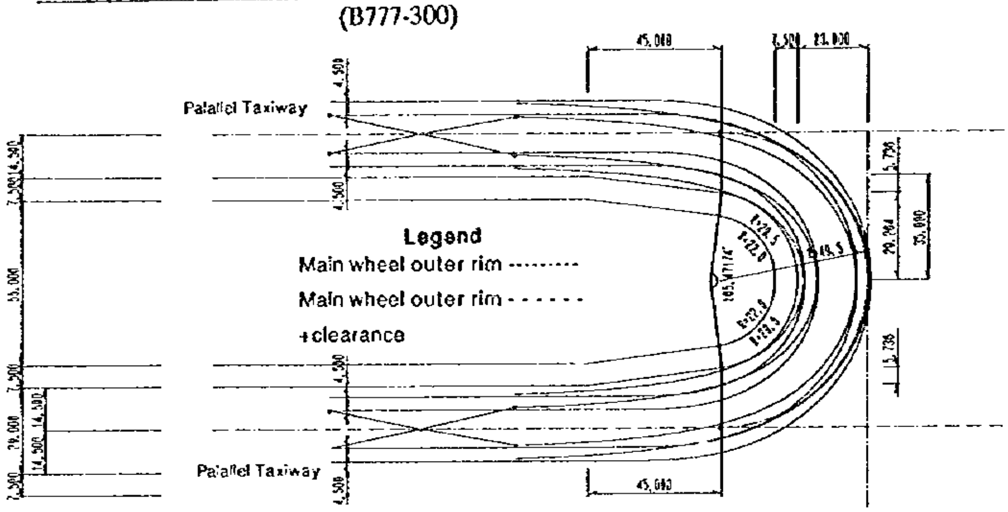
Position (crossing angle)	Width of one Size (m)	Expansion Amount of Width～ Fillet Radius～Expansion L:W(m)	R(m)	L:W(m)	Aircraft Model Analysis
① R/W～Approach T/W (90)	30.0～17.0	0 :0	～40.0	～0 :0	B-777-300
② Approach T/W～Parallel T/W (90)	17.0～14.5	0 :0	～50.0	～45.0:3.0	B-777-300
③ Approach T/W～Parallel T/W (90)	14.5～14.5	45.0:3.0	～50.0	～45.0:3.0	B-777-300
④ Parallel T/W～Parallel T/W (180)	14.5～14.5	45.0:5.736	～29.5	～45.0:5.736	B-777-300
⑤ R/W～Rapid exit T/W (30)	30.0～14.5	0 :0	～535.5	～0 :0	B-777-300
Rapid exit T/W～Parallel T/W (150)	14.5～14.5	0 :0	～32.0	～45.0:5.759	B-777-300
Rapid exit T/W～Parallel T/W (30)	14.5～14.5	0 :0	～250.0	～0 :0	B-777-300
⑥ R/W～ Rapid exit T/W (30)	30.0～14.5	0 :0	～535.5	～0 :0	B-767-300
Rapid exit T/W～Parallel T/W (150)	14.5～14.5	0 :0	～34.0	～0 :0	B-767-300
Rapid exit T/W～Parallel T/W (30)	14.5～14.5	0 :0	～250.0	～0 :0	B-767-300

The details of analysis are shown in FiguresII1-4.1.1 and 4.1.2.

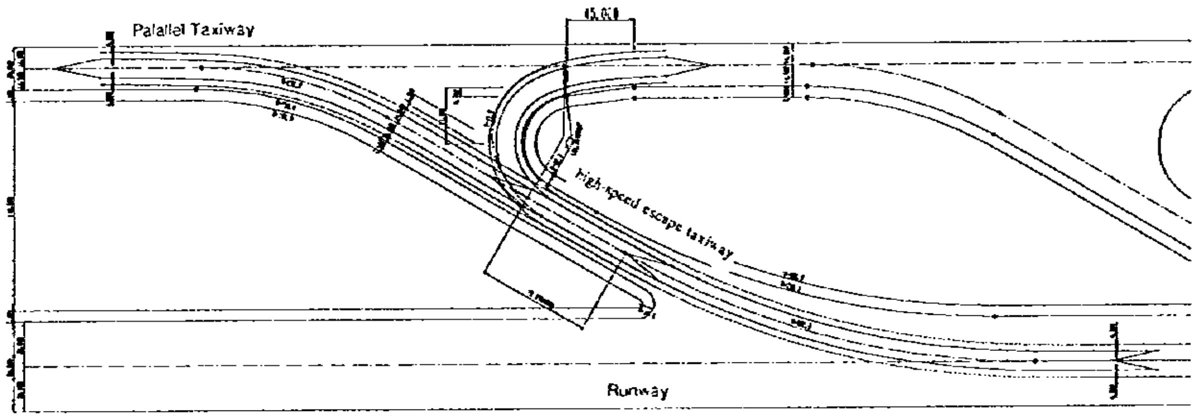


FigureII1-4.1.1 Fillet Form in the Crossing Part (1)

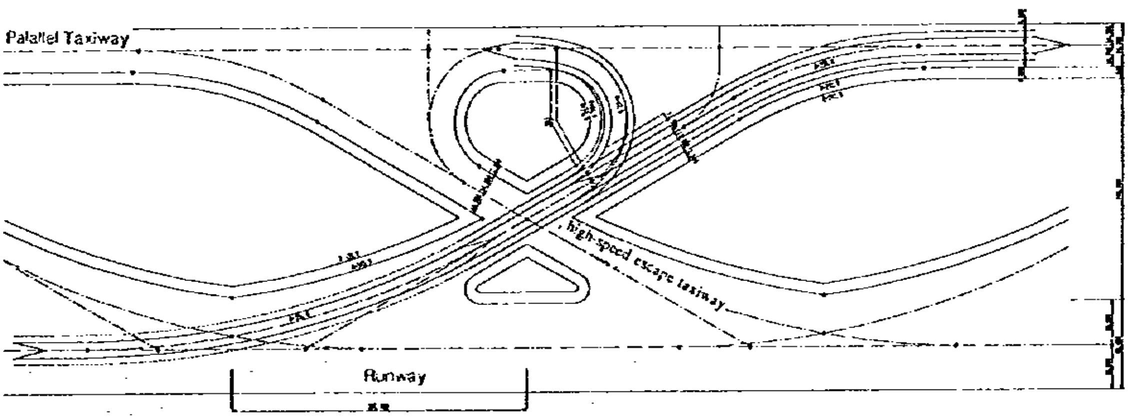
Crossing part of a prallel taxiway and an approach taxiway
(180 degrees)
(B777-300)



Crossing part of a high-speed escape taxiway and a parallel taxiway
(30 or 150 degrees)
(B777-300)



Crossing part of the runway, the high-speed escape taxiway
amd a parallel taxiway (30 or 150 degrees)
(B767-300)



FigureII1-4.1.2 Fillet Form in the Crossing Part (2)

4.2 Types of Pavement

4.2.1 General Matters Regarding Types of Airport Pavement

(1) Types of Airport Pavement

Pavement of basic airport facilities (runway, taxiways, apron, etc.) IS either flexible or rigid. The former is asphaltic concrete pavement and the latter is cement concrete pavement. Types of cement concrete pavement include non-reinforced concrete pavement, prestressed-concrete (PC) pavement, and continuous reinforced-concrete pavement. Except for special cases such as those with large differential settlement expected, non-reinforced concrete pavement is generally used due to cheaper construction cost.

(2) Record of Each type of Pavement of Airports in Various countries

The tendency of adoption of the types of pavement in civil international airports in various countries in the world indicates that asphaltic concrete pavement is adopted at a higher rate for runways and taxiways, while cement concrete pavement is adopted for aprons. This is also true in Japan, not only for international airports but also for local airports with service of middle and larger aircraft (MD-81, A300, etc.). In international airports with a large traffic, cement concrete pavement is provided at the end part of the runway. It is because this pavement is superior in durability. The main reasons for selection of these pavement types are as follows:

- For runway and taxiway pavement, superior evenness of surface, comfortable running, and easy maintenance and repair are required.
- For apron pavement, high durability and oil resistance are required.
- Construction cost of asphaltic concrete pavement is generally lower than that of cement concrete pavement.

(3) Record of Types of Pavement Adopted in China

On the other hand, almost all civil airports in China were constructed with cement concrete pavement in the past. Asphaltic concrete was introduced recently. It is mainly used for overlay for the purpose of repair of cement concrete. Only one example of use of asphaltic concrete for newly constructed runway and taxiway is observed in Xi Ning Airport. It is partly because the quality of asphalt produced in China and the construction technique do not reach a certain level under the present situation.

4.2.2 Conference between China and Japan Regarding Types of Pavement

Selection of types of pavement for the basic facilities of this airport is one of important subjects. The Shanghai Pudong International Airport Construction Headquarters held a conference before final decision of the pavement type for the runway and taxiways. The purpose was to collect opinions of the Chinese and Japanese sides. Opinions of each side are as follows.

(1) Japanese Investigation Committee:

As mentioned in the "Interim Report (1) of Detailed Design for Shanghai Pudong International Airport", asphaltic concrete pavement is recommended for the following main reasons:

• superior in evenness and good running conditions

• easy repair in the case of deformation / damage on the surface

• possible repair on a large scale without closing the airport.

A prerequisite for application of this powerment type is to satisfy the following to a certain level:

- quality and standards of asphalt,

- construction technique of asphaltic pavement

- maintenance system.

(2) Hougqiao International Airport:

From the viewpoint of construction, maintenance, management and operation, it can be said that Chinese technique regarding cement concrete pavement is mature. However, that of asphaltic concrete pavement is still under development. Therefore, it is appropriate to adopt cement concrete pavement for Phase I Work of Shanghai Pudong International Airport.

(3) China Airport Construction Corporation of CAAC (Consultant of Department of the Headquarters)

There are many canals in the area to be paved. If differential settlement occurs there, asphaltic concrete pavement is more flexible than cement concrete pavement.

In the case of cement concrete pavement, as shown in the example of Peking Airport, the more the traffic volume increases, the more easily destruction gets worse. If large-scale repair is required, it will be necessary to close the runway. Countermeasures against this are now a big problem for airports in China.

Even under the present condition, there is enough technical ability to construct asphalt concrete pavement.

4.2.3 Comparison and Examination of Types of Pavement

(1) Types of Pavement to be Examined

Apron pavement should be rigid because durability is especially required .

Types of rigid pavement include non-reinforced concrete (NC) pavement, prestressed concrete (PC), and continuous reinforced concrete (CRC). NC pavement is the most popular type. It is used in all civil airports in China. As for PC, deformation of pavement surface caused by settlement, etc. can be restored/repaired by lifting with a jack. It has superiority as pavement on the soft ground. CRC pavement largely reduces joints in the horizontal direction. It can also the minimize width of cracks and defects. It is superior in terms of evenness and smoothness of pavement.

Among these types of concrete pavement, non-reinforced concrete (NC) pavement was chosen for rigid pavement for the following reasons.

• Ground improvement will be carried out aiming at:

- residual settlement value : 10 cm/10 years

- differential settlement value : 5 cm/50 m

• Economical efficiency of NC pavement is the highest.

• NC pavement has been used in most airports in China.

Therefore, the types of runway/taxiways pavement to be examined are flexible, asphaltic concrete pavement and rigid, non-reinforced concrete pavement.

(2) Structure of Pavement

Based on the following design conditions, analysis was made of representative structure of pavement for the runway and taxiways. The results are as shown in TableII1-4.2.1.

• Load	B-747-400
• Design lifetime	Asphalt concrete pavement: 10 years
	Cement concrete pavement: 30 years
• Subgrade bearing capacity	CBR=12%, K75 = 6 kgf / cm^3
• Standards to be conformed to	Asphaltic concrete pavement: Japanese standards
	Cement concrete pavement: Chinese standards

(3) Comparison of Types of Pavement

On the assumption that flexible pavement (asphalt concrete pavement) and rigid pavement (non-reinforced concrete pavement) will be adopted for this airport, a comparison of pavement structure, technique, cost etc. is shown in TableII1-4.2.1.

TableII-4.2.1 Table of Comparison of Types of Pavement

	Flexible : Asphalt Concrete Pavement	Rigid : Non-Reinforced Concrete Pavement
Section of Pavement Structure	(cm) Surface layer (fine-grain AsCo) 4 Binder layer (coarse-grain AsCo) 6 Binder layer (coarse-grain 6 Upper basecourse (cement stabilization) 17 Lower basecourse (Unscreened crushed stone) ModifiedCBR≧30% 24 Lower sub-base (Unscreened crashed stone) ModifiedCBR≧20% 24 Lower sub-base (Unscreened crushed stone) ModifiedCBR≧10% 24 Total 105 Subgrade Design CBR=12%	(cm) concrete slab 45 Middle layer (chip screed) 2 Upper basecourse (cement stabilization) 18 Lower (cement stabilization) 18 Sub-base (lime, fly ash, slug) 18 Total 101 Subgrade Design bearing capacity k75=6kg/cm³
Evenness/Running Condition	In comparison with concrete pavement, the surface is smoother. Required conditions are high quality of asphalt and high technique.	Joints are not avoidable. They may influence on evenness and running condition.
Maintenance/Repair	Generally repair is easy. But repair will be required at an early time (usually after 5-10 years). In addition, frequency of repair is high. Problems include supply of small amount of asphalt material meeting quality standards, repair technique and a management system.	Durability is long. Damage requiring repair occurs generally after 10-20 years. In addition, frequency of repair is low. Experience of repair, technique and management systems have been obtained from performance so far.
Large-Scale Repair/Increase in Load	Large-scale repair is possible without closing the airport. (Necessity of large-scale repair will occur generally after 10 years).	Repair with cement concrete requires closing of the airport. Repair without closing the airport is limited to overlay with asphalt. (Large-scale repair will occur generally after 20-30 years).
Flexibility to Uneven Settlement	High flexibility to differential settlement exceeding the allowable value. Easy repair.	If differential settlement with a value over the allowable one occurs, there is more or less concern about deformation / cracks of concrete slab. Repair of these is difficult.
Cost	254 RMB/m²	202 RMB/m²

4.2.4 Selection of Types of Pavement

Asphaltic concrete pavement and non-reinforced concrete pavement were compared and examined. For the runway and a part of taxiways, asphaltic pavement is superior in terms of evenness and large-scale repair in the future. However, under the present situation, there are problems regarding technique and the system of maintenance and repair. On the other hand, rigid pavement is superior in respect of economical efficiency and durability. Consideration was given to these points and to policies regarding pavement types of the Shanghai Pudong International Airport Construction Headquarters. As a result, in all areas of the runway, taxiways, apron, GSE passage and shoulders, rigid and non-reinforced concrete pavement has been decided to be adopted. Steel fiber concrete (SFRC) is concrete mixed with steel fiber chip in order to increase strength. There are examples of its use in general structures and road pavement. Its efficiency is now being confirmed. However, steel fiber concrete pavement (SFRC) and aforementioned CRC pavement have no example of adoption to airport pavement.

Details such as places of adoption and the size are subject to implementation design. Probably, it is necessary that SFRC and CRC pavement will be partly adopted within the scope of Phase 1 area, on a test basis. The purpose is to investigate their adaptability as types of airport pavement and their characteristics, and to confirm whether or not they should be adopted for Phase 2 construction of Pudong International Airport.

Pavement of stop ways (overrun) should be asphaltic concrete pavement based on Chinese examples.

4.3 Design of Pavement Structure

4.3.1 Design Criteria

Conditions necessary for the design of pavement structure were determined as follows:

(1) Design Standards to be Adopted

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

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

(2) Pavement Areas and Situation of Use

Pavement areas have been determined with due consideration of the situation of use, as shown in FigureII1-4.3.1.

(3) Design Aircraft

Representative aircraft to be used for designing pavement structure should be as follows.

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

TableII1-4.3.1 Details of the Target Aircraft

Section		I	II	III	IV	V
Aircraft Model		MD-82	A300-600	MD-11	B-747-400	New of B747
Gross weight (ton)	(1) At full load	68.3	165.9	284.9	396.0	607.4
	(2) Upon landing	59.0	138.0	195.0	285.8	423.2
Gear Load (ton)	(1) At full load	32.1	77.2	W109.8/C47.6	92.8	94.9
	(2) Upon landing	27.7	64.2	W 75.2/C32.6	67.0	66.1
Wheel arrangement form		Dual wheels	Dual tandem wheels	W Dual tandem /C dual wheels	Dual tandem wheels	Special dual tandem
Wheel track of dual wheels S(cm)		71.4	92.7	W137/C95	111.8	111.8
Wheel base center of dual tandem ST (cm)		–	139.7	163.0	147.3	147.3
Internal Type pressure pi (kg/cm2)		11.0	12.9	W14.4/C12.7	14.1	14.1
Grounding Type pressure p (kg/cm2)		12.0	12.9	W14.4/C12.7	14.1	14.1
Contact area of wheel A (cm2)	(1) At full load	1337	1496	W1906/C1874	1645	1645
	(2) Upon landing	1154	1244	W1306/C1284	1187	1187
Width of contact area of wheel, d (cm)		28	29	--	34	34
Gear configuration		2-leg and tricycle type	2-leg and tricycle type	CD-10 type	B-747 type	Special
Space of gear center	S1 (cm)	509	960	1067	384	–
	S2 (cm)	–	–	–	358	–
	S3 (cm)	–	–	–	307	–

TableII1-4.3.2 Details of Towing Tractor

Item / Body	TT-35	TT-26
Aircraft to be considered	B-747	B-767
Gross weight (ton)	49	35
Wheel load (ton)	12.3	8.8
Vehicle form	Single	Single
Wheel track of double wheels (mm)		
Type pressure (kgf/cm^2)	6.8	6.8
Contact area of wheel (cm^2)	1,810	1,290
Wheel base (mm)	4,540	2,895
Wheel tread (mm)	2,385	2,240

(4) Lifetime of Pavement

Concrete pavement : 30 years

Asphaltic pavement : 10 years

(5) Number of Annual Services

It is assumed that the airport will open in 2000. In the case of 30-year life time, 2015 should be a reference year of calculation of the number of annual services.

(6) Subgrade Bearing Capacity

Based on the design of soft ground improvement described in Chapter 2, the subgrade bearing capacity was determined as follows:

K75 = 6 kgf/cm^3

CBR = 12%

(7) Materials

1) Concrete

Design flexural strength (28 days)	σ 28 (fem) = 51 kg/cm^2
Allowable bond strength	τ oa = 18 kg/cm^2
Allowable bearing pressure strength	σ ca = 120 kg/cm^2
Elastic modulus	E = 36700 kg/cm^2
Poisson ratio	υ = 0.15
Coefficient of linear expansion	$\alpha = 9 \times 10^{-6}/^\circ C$

2) Reinforcing Bar

Round bar (ø) Class I	σ sa = 1370 kg/cm2 (135 Mpa)
Reformed bar (Φ) Class II	σ sa = 1880 kg/cm2 (185Mpa)

(8) Calculation and Verification of Stress

For concrete pavement, calculation and verification are carried out under the following conditions:

1) Calculation of Stress

• Stress by aircraft : 0.75 σ j

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

• Temperature Stress: σ t

Difference in temperature between the upper and lower sides of pavement should be 10℃. Warp-constrain stress.

The standard joint space should be 5 m.

Warp-constrain stress t = $\sigma t = 0.35 \times Cw \times E \times \alpha \times \Delta t$

where,
CW : coefficient of warp constrain
E : elastic modulus (g/cm2)
α : coefficient of linear expansion
Δt : difference in temperature

- Stress by Differential Settlement: $\sigma \Delta$

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

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

Shape of differential settlement

$$y = \frac{1}{2} \Delta \cos \frac{2\pi}{L} X$$

Calculation formula: : $\sigma \Delta = \frac{2}{3} \pi \, 2E' \frac{\Delta}{L2}$

where, E' = creep (coefficient of creep 1.5) with consideration of elastic modulus
E' = E/1.5 (kg/cm^2)
h : thickness of concrete slab (cm)

2) Verification of Stress

Stress should satisfy both Formulas A and B below.

- Formula A:

$$\Sigma \sigma = 0.75 \sigma j + \sigma t + \sigma \Delta \leqq \frac{1.1fem}{F}$$

where,
σj : stress by aircraft (kgf / cm2)
αt : temperature stress (kgf / cm^2)
$\alpha \Delta$: stress by differential settlement (kgf / cm^2)
fem : design flexural strength (kgf / cm^2)
F : safety ratio (F = 1.4)

• Formula B:

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

$\alpha p \leq$ frm and

$| \alpha p\text{-frm} | \leq 0.025$

fem: allowable stress intensity (kgf/cm^2) = frm (0.885-0.063 log Ne)

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

$$Wt = 0.6Lt$$

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

where, q : external type pressure (kgf / cm2)

Ps : load per wheel (kgf)

Ns : number of annual services

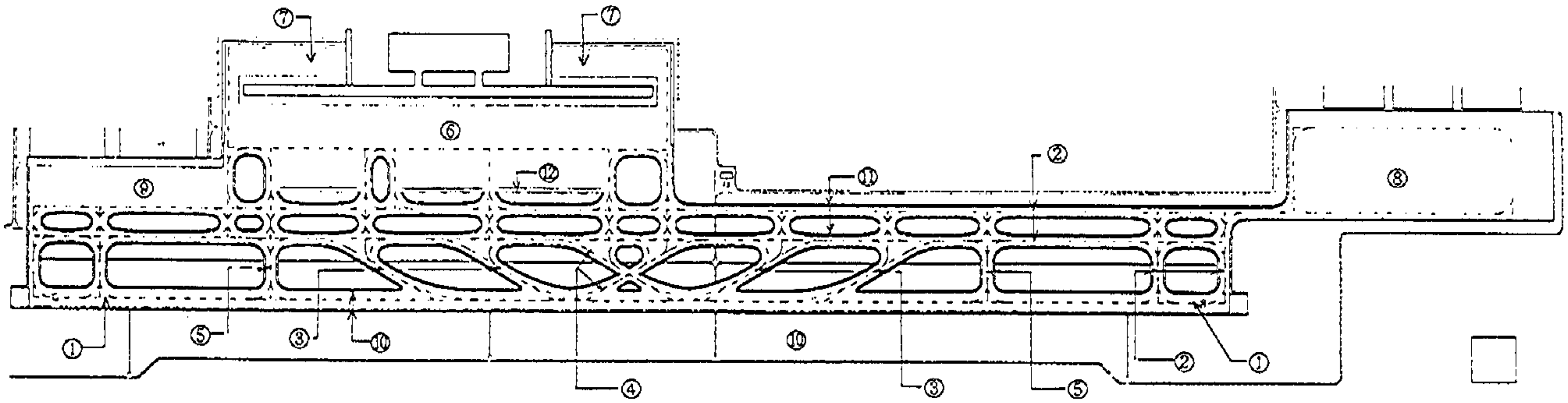
t : lifetime

Nw : number of wheels per gear

T : width of passage

Runway = 11.4 m

Taxiway & apron = 2.3 m



Pavement Sections	Situation of Use		Pavement Sections	Situation of Use	
	Aircraft Type	Ratio of Use		Aircraft Type	Ratio of Use
①	All aircraft	70% of the number of taking-offs and landings	⑦	Aircraft of Ⅰ・Ⅱ	50% of taking-offs and landings
②	All aircraft	50% of the number of taking-offs and landings	⑧	B-747-400 (body) +Maximm fuel	50% of taking-offs and landings
③	Landing of Ⅱ,Ⅲ,Ⅳ&Ⅴ	70% of landings	⑨	All aircraft	50% of taking-offs and landings
④	Landing of Ⅰ&Ⅱ	70% of landings	⑩	Runway, shoulders of apron	
⑤	Taking-off of Ⅰ&Ⅱ ,Landing of Ⅲ,Ⅳ&Ⅴ	50% of taking-offs of Ⅰ&Ⅱ, 30% of landings of Ⅲ,Ⅳ&Ⅴ	⑪	Shoulders of taxiways	
⑥	All aircraft	50% of the number of taking-offs and landings	⑫	GSE Passage	

FigureII1-4.3.1 Pavement Sections and Situation of Use

4.3.2 Calculation of Number of Annual Services

(1) Number of Services in the Reference Year

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

In the case of 2015, the number of runways was assumed to be two. Then conversion was made to get the number of services in one runway.

- In 2005: 126,000 services
- In 2015: 150,000 services.

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

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

TableII-4.3.3 Composition Ratio of Aircraft and Number of Annual Services Classified by Aircraft

Classification	Aircraft	2005			2015		
		Composition Ratio	Take-off	Landing	Composition Ratio	Take-off	Landing
I	MD-82	40%	25,200	25,200	20%	15,000	15,000
II	A300-600	30%	18,900	18,900	30%	22,500	22,500
III	MD-11	20%	12,600	12,600	27%	20,250	20,250
IV	B-747-400	10%	6,300	6,300	17%	12,750	12,750
V	Advanced model of B747	—	—	—	6%	4,500	4,500
Total		100%	126,000		100%	150,000	

(3) Number of Annual Services

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

TableII-4.3.4 Number of Annual Services Converted to That of Design Aircraft, Classified by Pavement Section.

Section of Pavement	Design Aircraft	Number of Annual Services	State of Load
①	B-747-400	59,199	Maximum weight
②、⑥、⑨	B-747-400	41,867	Maximum weight
③	B-747-400	51,558	Maximum landing weight
④	A300-600	19,087	Maximum landing weight
⑤	A300-600	22,163	Maximum weight
⑦	A300-600	18,285	Maximum weight
⑧	B-747-400	41,867	Body weight +fuel
⑩	50t towing tractor	7,500	

4.3.3 Design of Sub-base

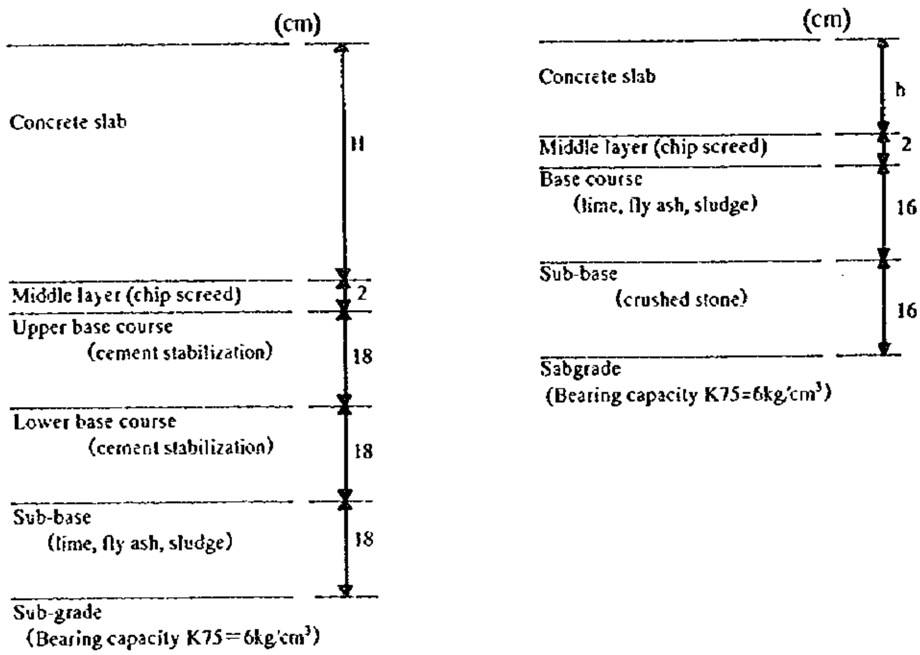
(1) Material of Sub-base

The following material should be used for sub-base generally used in civil airports in China.

- Base courese: Cement treated aggregate Equivalency factor 1.25
- Sub-base: Lime, fly ash, slug Equivalency factor 1.20

(2) Coefficient of Sub-base Bearing Capacity

The formation of pavement structure was assumed as shown in the following figure. The coefficient of sub-base bearing capacity of (k75) was obtained.



(1) Main body (2) Shoulder

FigureII-4.3.2 Pavement Structure

- Sub-base

  h=18×1.2=21.6cm

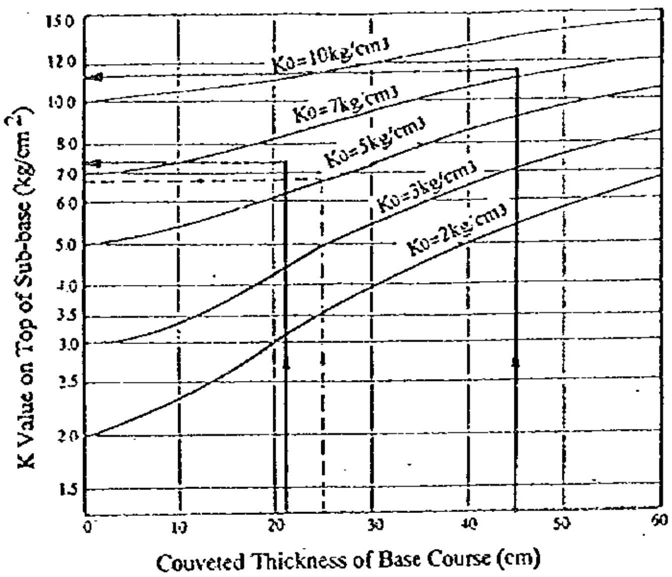
  k75=6 → k75=7.4kg/cm^3

- Base course

  h=18×2×1.25=45.0cm

  k75=7.4→ k75=11.4kg/cm^3

  → k75=11.0kg/cm^3



FigureII1-4.3.3 Effect of Stabilized Base on the Subgrade Modules

4.3.4 Verification of Thickness of Concrete Pavement

For slab thickness classified by pavement section, stress calculation and verification are carried out. As a result, thickness of concrete slab was determined as shown in the following table.

TableII1-4.3.5 Verification of Concrete Pavement Slab

Pavement	Slab Thickness H (cm)	Formula A					Formula B					
		0.75σj	σt	σΔ	Σσ	σa	frm	0.75σj	σΔ	σp	σp-frm	0.025frm
①※	45	26.0	9.8	3.6	39.4	40.1	31.3	26.0	3.6	29.6	1.7	0.8
②,⑥,⑨	45	25.4	9.8	3.6	38.8	40.1	29.4	25.4	3.6	29.0	0.4	
③	36	26.3	9.8	2.9	39.0	40.1	39.3	26.3	2.9	29.2	0.1	0.8
④	34	26.8	9.8	2.7	39.3	40.1	30.8	26.8	2.7	29.5	1.3	0.8
⑤	39	27.2	9.8	3.1	40.1	40.1	30.4	27.2	3.1	30.3	0.1	0.8
⑦	39	27.2	9.8	3.1	40.1	40.1	30.7	27.2	3.1	30.3	0.4	0.8
⑧	36	26.3	9.8	2.9	39.0	40.1	29.4	26.3	2.9	29.2	0.2	0.8
⑫	26	26.4	9.8	2.1	38.3	40.1	29.7	26.4	2.1	28.5	1.2	0.8

Mark "※" means inclusion of grooving of 1 cm.

According to the standards, slab thickness of the middle part of the runway and shoulders is as follows:

- Middle part of the runway : H=41 cm (0.9×①)
- Shoulder of runway and apron : H=16 cm
- Taxiway shoulder : H=12 cm

4.3.5 Pavement Structure of Over-run

Referring to the structure employed in other international airports in China, the pavement structure of the over-run was compared with the structure specified by Japanese standards. As a result, it was found that the Chinese plan can secure almost all necessary thickness. Therefore, the Chinese plan is to be adopted.

(1) Structure of Over-Run Pavement according to Japanese Standards

- The results of examination of the structure of over-run pavement is shown in FigureII-4.3.4. The following conditions were used for examination.
- Design standards to be applied: Japanese standards: "Design criteria of Airport Asphaltic Pavement Structure"
- Classification of design load: LA - 1 (B - 747 - 400)
- Number of design coverage: 80,000 (calculated according to Japanese standards)
- Thickness of standard pavement: Pavement Area A (113 cm)
- Thickness of the over-run: Pavement Area D (56.5 cm, 50 % of Pavement Area A)

(2) Verification of the Chinese Plan

For the structure of over-run pavement presented by the Chinese side, asphaltic pavement is used, as shown in FigureII-4.3.4.

This structure was examined by reference to the following conditions.

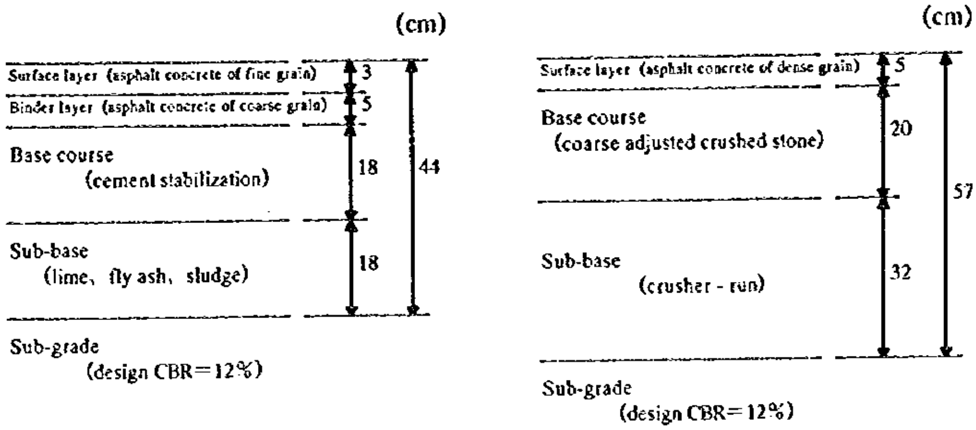
- Characteristics of material (equivalency factor)

Surface layer	:	asphaltic concrete of fine grain	:	2.0
Basic layer	:	asphaltic concrete of coarse grain	:	2.0
Base course	:	cement treated aggregate	:	1.25
Sub-base	:	lime, fly ash, sludge	:	1.20

- Verification of Structure

Thickness of over-run reference pavement $= 5 + (3x2.0) + 18x1.25 + 18 \times 1.20$
$= 5 + 6 + 22.5 + 21.6$
$= 55.1$ cm

This figure is almost the same as 56.5 cm in the Japanese standards. Therefore, it is judged that there will be no problem.



(1) Chinese Plan (2) Structure According to Japanese Standards

(based on examples inside China)

FigureII1-4.3.4 Structure of Over-Run Pavement

4.3.6 Design of Joint Structure

(1) Spaces of Joints on Concrete Pavement

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

TableII1-4.3.6 Spaces of Joints on Concrete Pavement

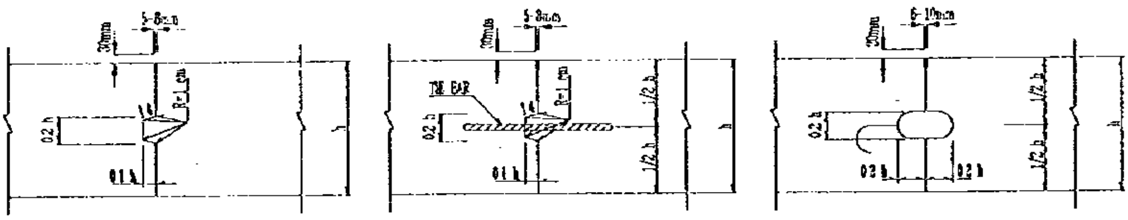
Classification		Determined Width	Arrangement interval	Ratio of Length Breadth
Joints in the Longitutdinal Section	Central zone of the runway	Center 30.0 m	5.0 m×6 spans	1.00
	Edge zone of the runway	One side15.0 m	5.0m×3 spans	1.00
	Taxiway	One side17.0 m	4.5 m×2 spans+4.0 m×2spans	1.11~1.25
		One side14.5 m	5.0 m×2 spans+4.0 m×1 spans	1.00~1.25
	Apron	–	5.0 m	1.00
	G S E passage	8.0 m(10.0 m)	4.0m×2 spans (4.0 m+6.0 m)	1.20~1.25
	Shoulder	7.5 m	2.5 m×3 spans	1.00
Joints in the Transverse section	All pavement of the main bodies	–	5.0 m	1.00~1.25
	Shoulder	–	2.5 m	1.00

(2) Joint Structure

1) Longitudinal Construction Joint

Longitudinal construction joints were determined to be "key joints" in accordance with the "Chinese standards".

There are examples where the projecting part of "key joints" is damaged, the causes of which include differential settlement and repetition of load for a long time. Therefore, in the current Japanese standards, butt joints with a bar" or "improved key joints" (defect of "key joints" is improved) are employed. However, they will not be employed here, because they cost more than ordinary "key joints" as a result of processing of molding boxes, preparation of joint material, etc.



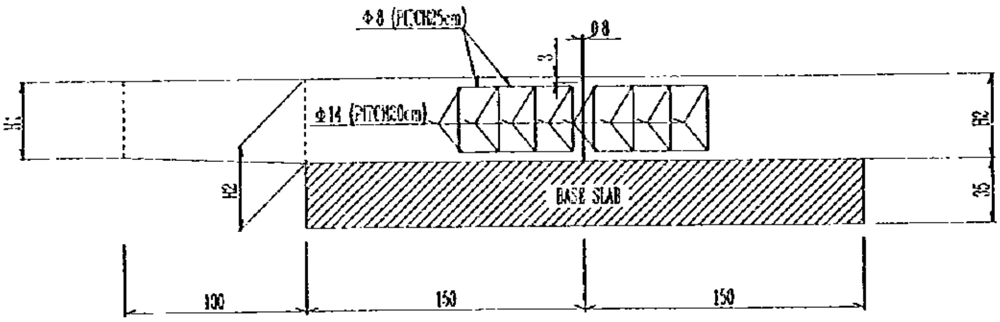
FigureII1-4.3.5 Structure of Longitudinal Construction Joint

2) Transverse Joints

The standard joint was determined to be a dummy joint reinforced with a bar if neccessary.

3) Butt Joints

Butt joints will be used in the crossing part of the runway, taxiways etc. The end should be strengthened with a reinforcing bar. In addition, a sleeper slab will be installed in order to prevent difference in level in the part of the joint.



FigureII1-4.3.6 Structure of Butt Joints

4) Expansion Joints

Expansion joints will not be used for pavement of the runway, taxiways, apron, and GSE passage.

However, for shoulders, expansion joints will be used in the connection parts with other structures. A space should be 10 cm.

5) Tie Bar

a) Type of Tie Bars

For tie bars, deformed steel bar will be used.

Regarding the size, consideration was given to the results of calculation with formulas shown in the "Chinese standards" and to complexity during execution. As a result, the following three types of tie bars will be used, depending on the number of joints counted from the free end.

Installation position should be the center of thickness of a concrete slab.

TableII-4.3.7 Size of Tie Bars

Number of Joints from the Free End	Diameter (mm)	Length (mm)	Number of Joints per Slab
One	18	100	8
Two	26	140	8
Three or more	35	190	8

b) Installation Position of Tie Bars

Installation position of a tie bar was determined as follows:

- Runway : 3 construction joints in the center and 2 counted from the end. All in the longitudinal direction
- Taxiways : All longitudinal construction joints
- Apron : All longitudinal construction joints (because examples in China show that tie bars are used at the apron part on the soft ground).
- GES passage : All longitudinal construction joints

6) Slip Bar

a) Types of Slip Bars

For slip bars, round steel bar should be used.

Regarding the size, consideration was given to the results of calculation with formulas shown in the "Chinese Standards" and to complexity during execution. As a result, the following three types of slip bars will be used, depending on the thickness of concrete slabs.

Installation position should be the center of thickness of a concrete slab.

TableII1-4.3.8 Size of Slip Bars

Thickness of Concrete Slab (cm)	Diameter (mm)	Length (mm)	Setting Space (cm)
41～45	38	55	40
32～40	35	50	35
26	30	50	30

b) Installation Position of Slip Bars

Installation position of a slip bar was determined as follows:

- Runway : dummy joints in each 100 sections at the both ends.
- Taxiways : 3 dummy joints counted from the free end of pavement
- Apron : All dummy joints (because examples in China show that slip bars are used in transverse direction at the apron area on the soft ground.)
- GES passage : 3 dummy joints counted from the free end
- Others : Dummy joints of reinforced concrete slabs.
  : Transverse construction joints

4.3.7 Reinforcement of Concrete Slabs

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

(1) Places to be Reinforced

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

- Place where a large underground facility such as a drainage structure is located under the concrete pavement.
- Stepping part in a place, which had a drainage, etc. before execution of earthworks.
- Around a lamp socket and various kinds of pit facilities
- the end of a concrete slab with a butt joint

(2) Size and arrangement

For reinforcing steel, deformed steel bar with a diameter of 12 mm will be used.

An installation position should be at 2/5 of thickness of a concrete slab, from the upper surface.

Regarding layout interval, consideration was given to the results of calculation with formulas shown in the "Chinese Standards" and to complexity during execution. As a result, intervals will be as shown in TableII1-4.3.9, depending on the thickness of concrete slabs and distance from the free end.

TableII1-4.3.9 Size of Reinforcing Steel and Arrangement

Position		Slab Thickness (cm)	Interval (cm)	
			Longitudinal Direction	Transverse Direction
End of runway	Center	45	14	30
	Margin	36	25	50
Middle of runway	Center	41	30	50
	Margin	32	20	50
Approach taxiway	Center	45	14	30
	Margin	45	30	30
Rapid exit taxiway	Center	36	20	50
	Margin	36	30	50
Rapid exit taxiway	Center	34	20	50
	Margin	34	30	50
Parallel taxiway	Center	45	14	30
	Margin	45	30	30
Apron		45	14	30
		39	15	50
		36	20	50

4.4 Design of Other Facilities

4.4.1 Grooving

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

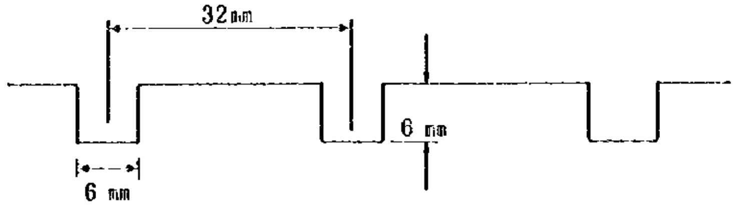
The range and the shape of grooving are shown below.

(1) Range of Grooving

- 2/3 of the central part throughout the runway: 40 m
- All pavement of the main body of the rapid exit taxiway

(2) Shape of Grooving

The following shape should be a standard.



FigureII-4.4.1 Standard Shape of Grooving

4.4.2 Marking

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

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

CHAPTER 5 DESIGN OF ANCILLARY FACILITIES

5.1 Summary

The ancillary facilities include:

• Enclosing fences ("keep-out" fences) / gate doors

• Safety roads / Enclosing roads

• Blast fences

Enclosing fences/gate doors are installed in order to prevent people, vehicles, etc. from entering the Flight Area without permission. Safety roads and place-enclosing roads are installed to maintain, manage and check the airport facilities. Blast fences are installed to protect people and vehicles inside and outside the airport from blast of aircraft.

5.2 Safety Roads / Enclosing Roads

5.2.1 Design Conditions

Design of safety roads and enclosing roads was carried out on the following conditions.

(1) Design Standards to be Applied

• "Construction Standards for Civil Transportation -
Airport Safety and Sanitary Facilities" (MHT003-95) (Chinese Standards)

• "Design Standards for Airport Civil Engineering Facilities" (Japanese Standards)

• "General Principles of Asphaltic Pavement" (Japanese Standards)

• "Design Criteria of Airport Asphaltic Pavement Structure" (Japanese Standards)

(2) Types of Pavement

Safety roads and place-enclosing roads will be installed in places without soil improvement. (This is different from the runway etc.) Accordingly, repair of defects of pavement caused by settlement, etc. cannot be avoided. Therefore, asphaltic concrete pavement has been chosen because it allows relatively easy repair.

(3) Design CBR

It was determined that the design of asphaltic pavement for safety roads and enclosing roads will be designed in using the CBR method, according to the Japanese Standards.

TableII-5.2.1 shows the results of CBR tests of the original ground. From these results, design CBR for the existing ground is calculated at 2.5 % (the ground will be a roadbed of a safety road / enclosing road). However, according to the "General Principles of Asphaltic Pavement", the minimum CBR value is 3% for the newly constructed pavement. It is also stated that improvement should be made for roadbeds on the ground with a design CBR of 3%

or less. Therefore, it was determined that the pavement will be designed with a minimum CBR value of 3 %.

TableII1-5.2.1 Results of CBR Tests of the Original Ground

Measuring point No.	1	2	3	4	5	6	6A	7	8
Average CBR value of each test (%)	3.6	4	2.4	5.1	5.4	1.5	5	3.7	3.8
Average (%)	3.8								
Standard deviation (%)	1.3								
Design CBR (%)	2.5								

Detailed Geological Observation Report(Glide Path), August 1996

(4) Design Traffic Volume

Enclosing / safety roads are used for daily administration etc. It is judged that the daily traffic volume of large-sized vehicles will not exceed 100 vehicles / day. Therefore, the design traffic volume was determined to be Traffic L as shown in TableII1-5.2.2.

TableII1-5.2.2 Classification of Design Traffic Volume

Classification of Design Traffic Volume	Traffic Volume of Large-Sized Vehicles (Range of Number / Day and Direction)
Traffic L	Under 1 0 0
Traffic A	1 0 0 or more, under 2 5 0
Traffic B	2 5 0 or more, under 1, 0 0 0
Traffic C	1, 0 0 0 or more, under 3, 0 0 0
Traffic D	3, 0 0 0 or more

(5) Design Coverage

Among enclosing roads, the section from the passenger terminal area to the servicing area in the east side of Phase 1 Flight Area will be the common-use area. Therefore, it was determined to apply pavement design of the GSE passage stated in the "Design Criteria of Airport Asphaltic Pavement Structure".

For standard pavement thickness of LT-1 stated in the above-mentioned "Criteria", a coverage of 10,000 times is maximum (by separately preparing the design curve for standard pavement thickness, a coverage of 10,000 times or more can be obtained). In the case of Japanese airports, in Tokyo International Airport (Haneda Airport) even if the design coverage of the apron is 20,000 times, that of the GSE passageway is set up to be 10,000 times.

The GSE passage is within the scope of this design. It is a passage to connect the passenger terminal area and the servicing area. It is considered that frequency of use is low. Probably, a design coverage of 10,000 times is enough. Therefore, the design coverage of the GSE passage in the section mentioned above has been determined to be 10,000 times.

5.2.2 Alignment

(1) Layout

In the layout, safety / enclosing roads are placed within the site to be created as the minimum area necessary for operation of Phase 1 Flight Area.

FigureII-5.2.1 shows the layout of safety / enclosing roads. It was determined that the enclosing roads on the west side of Phase 1 Flight Area will be put in the road area for work. FigureII-5.2.2 shows radio facilities (a glide path and a localizer). In the area around them, the roads were aligned outside the critical/protection areas.

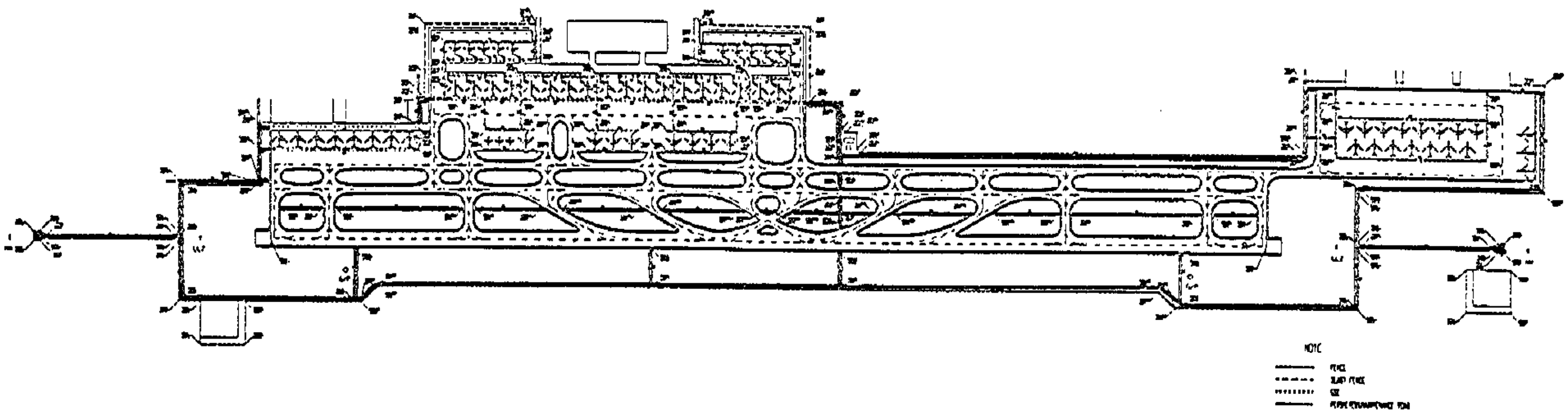
(2) Width of Pavement

- GSE passage from the passenger terminal area to the servicing area (following the concept of pavement width of other sections of the GSE passage)
  : Pavement width 8 m, Shoulder 0.5 m
- Enclosing roads other than the above passage
  : Pavement width 5.5 m, Shoulder 0.5 m
- Safety road : Pavement width 4 m, Shoulder 0.5 m

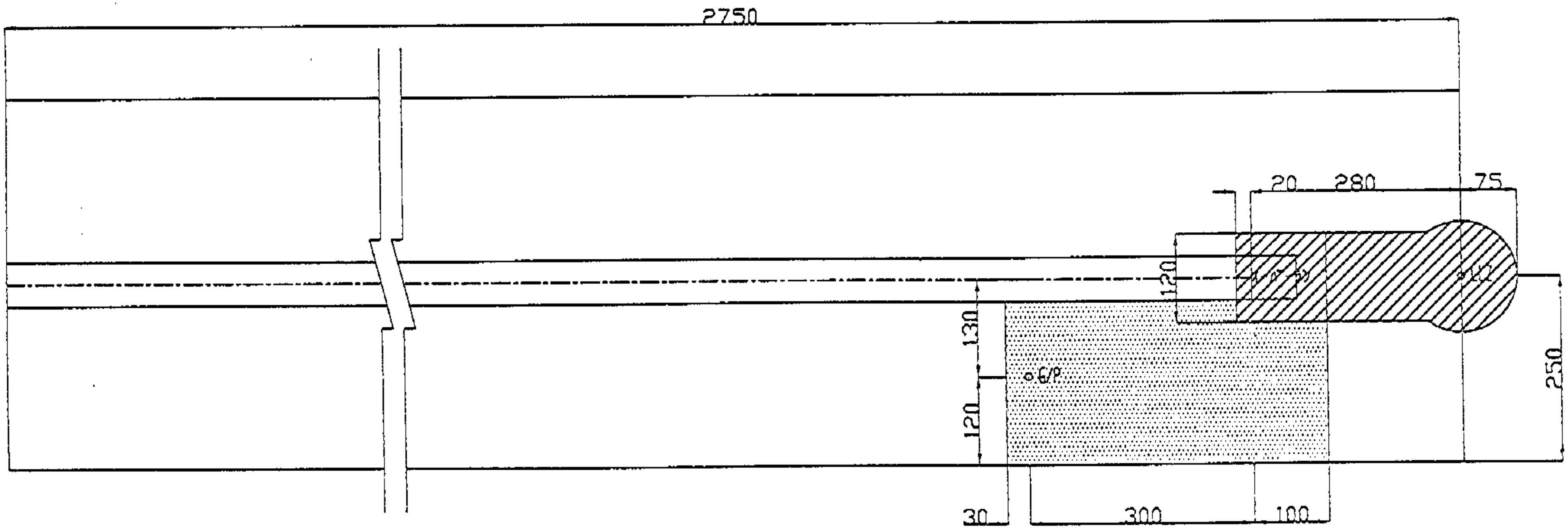
Pavement width and shoulders of enclosing / safety roads are standard values stated in the "Design Standards for Airport Civil Engineering Facilities".

(3) Curve Radius

The minimum curve radius of safety / enclosing roads was determined to be 20 cm, based on design examples of airport designs in China.



FigureII1-5.2.1 Layout Plan of Safety / Enclosing Roads



FigureIII-5.2.2 Range of Critical / Protection Area around Radio Facilities

5.2.3 Design of Pavement

Pavement of safety / enclosing roads was designed based on the design conditions shown in 5.2.1.

(1) Safety / Enclosing Roads Except for the Section from the Passenger Terminal Area to the Servicing Area

1) Design Criteria

- Type of pavement : Asphalt concrete pavement
- Design standards : "General Principles of Asphalt Pavement" (Japanese Standards)
- Design CBR : 3%
- Design traffic volume : Traffic L (traffic volume of large-sized vehicles is 100 or less per day and per direction.)

2) Thickness of Pavement

From the design criteria and TableII1-5.2.3, a converted equivalent - conversion thickness of 15 cm is obtained (T_A: necessary thickness when the surface layer and the binder layer of pavement are designed to be of heated asphalt mixture).

TableII1-5.2.3 Target T_A (cm)

Design CBR	Traffic L	Traffic A	Traffic B	Traffic C	Traffic D
(2)	(17)	(21)	(29)	(39)	(51)
3	15	19	26	35	45
4	14	18	24	32	41
6	12	16	21	28	37
8	11	14	19	26	34
12	11	13	17	23	30
20	11	13	17	20	26

3) Structure of Pavement

When

- the surface and binder layer are of asphalt mixture,
- the upper sub-base consists of crushed stone with adjusted grading (coefficient of equivalency factor 0.35), and
- the sub-base consists of crusher-run (coefficient of equivalency factor 0.25, modified CBR 30 or more),

T_A' = 5+0.35×10 cm + 0.25×30 cm = 16 cm > 15 cm, which is satisfactory.

From the result of the above calculation, the structure of pavement is set up as follows:

TableII-5.2.4 Structure of Pavement of Enclosing/Safety Roads

Layer Classification	Thickness of Layer(cm)	Pavement Material
Surface and binder layer	5	Asphalt mixture
Base course	10	Crushed stone with grading adjusted, CBR80 or more
Sub-base	30	Crusher run, Modified CBR30 or more

TableII-5.2.5 Minimum Thickness of Each Base Course Layer

Method/Material	Minimum Thickness of One Layer
Bituminous treated layer	Twice the maximum grain size and 5cm
Other base course material	Three times the maximum grain size and 10cm

If cement treated aggregate is used, a thickness of 15 cm is secured for Traffic L.

If cement treated aggregate is used for the upper sub-base, layer composition will be as follows:

T_A '= 5+0.5×15 cm + 0.25×10 cm = 15 cm ≥ 15 cm, which is satisfactory.

• *1: If cement treated aggregate is used for the sub-base, it is desirable that the minimum thickness is 15 cm.

• *2: Standard quality and coefficient of equivalency factor of for cement treated aggregate are:

- strength of unconfined compression: 30 kg/cm^2, and

- coefficient of equivalency factor: 0.55.

However, when it is used for sub-bases, both of them are lowered in some cases, in order to prevent reflection cracks. If unconfined compression is 25 kgf/cm, equivalency factor is 0.5. If unconfined compression is 20 kgf/cm, equivalency factor is 0.45 (age of unconfined compression strength: 7 days).

(2) GSE Passage from Terminal Area to Servicing Area

1) Design Criteria

- type of pavement: Asphalt concrete pavement
- Classification of pavement area: Pavement Area E
- Design CBR: 3%
- Design load: LT-1 (50t towing tractor)
- Design coverage: 10,000 times

2) Standard Thickness of Pavement

According to the design criteria, standard thickness of pavement for the GSE passage was determined to be 87 cm as shown in TableII-5.2.6.

TableII1-5.2.6 Standard Thickness of Pavement of LT-1

Design CBR of Subgrade	Classification of Design Number of coverage		
	a	b	c
2	95	100	108
2.5	85	89	95
3	77	80	87
3.5	71	74	80
4	66	69	74
4.5	61	64	69
5	57	60	65
6	51	54	58
7	47	49	53
8	43	45	49
9	40	41	45
10	40	40	41
12 or more	40	40	40

3) Structure of Pavement

Thickness of the surface and base layers of the GSE passage is 4 cm and 6 cm respectively. These are derived from standard thickness of pavement (TableII1-5.2.7) described in the "General Criteria of Airport Asphaltic Pavement Structure".

TableII1-5.2.7 Standard Thickness of Surface and Base Layers

Classification of Design Load	Classification of Design Number of Coverage	Standard of Surface	Standard Thickness of Base Course	
			Upper Layer	Lower Layer
LT - 1	a	4	6	-
	b	4	6	-
	c	4	6	-
LT - 2	a	4	5	-
	b	4	5	-
	c	4	5	-
LT - 2	a	4	4	-
	b	4	4	-
	c	4	4	-

If material of the upper sub-base is crushed stone with adjusted grading, its thickness is 25 cm.

TableII1-5.2.8 Standard Thickness of the Upper Sub-Base

<table>
<tr><th>Design CBR
Design Load</th><th>2</th><th>2.5</th><th>3</th><th>3.5</th><th>4</th><th>4.5</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th><th>12</th><th>14</th><th>16</th><th>18</th><th>20 more</th></tr>
<tr><td>LA-1</td><td colspan="7">40(35)</td><td colspan="2">35(30)</td><td colspan="3">30(25)</td><td colspan="5">25(20)</td></tr>
<tr><td>LA-12</td><td colspan="6">40(35)</td><td colspan="2">35(30)</td><td colspan="3">30(25)</td><td colspan="6">25(20)</td></tr>
<tr><td>LA-2</td><td colspan="6">35(30)</td><td colspan="3">30(25)</td><td colspan="4">25(20)</td><td colspan="4">20(15)</td></tr>
<tr><td>LA-3</td><td colspan="8">30(25)</td><td colspan="4">25(20)</td><td colspan="5">20(15)</td></tr>
<tr><td>LA-4</td><td colspan="17">20(15)</td></tr>
<tr><td>LSA-1</td><td colspan="4">15(10)</td><td colspan="13">10(10)</td></tr>
<tr><td>LSA-2</td><td colspan="17">10(10)</td></tr>
<tr><td>LT-1</td><td colspan="12">25</td><td colspan="5">20</td></tr>
<tr><td>LT-12</td><td colspan="9">20</td><td colspan="8">15</td></tr>
<tr><td>LT-2</td><td colspan="17">15</td></tr>
</table>

If material of the lower sub-base is crusher run, its thickness of 52 cm is obtained from the following expression.

Thickness of sub-base = Standard thickness of pavement (87) - Surface layer (4) - binder layer (6) - Base course (25) = 52 cm

As a result of the above-mentioned calculation, the structure of pavement for the GSE passage (from the terminal area to the servicing area) is decided as shown in TableII1-5.2.9.

TableII1-5.2.9 Structure of Pavement for GSE Passage (from the Terminal Area to the Servicing Area)

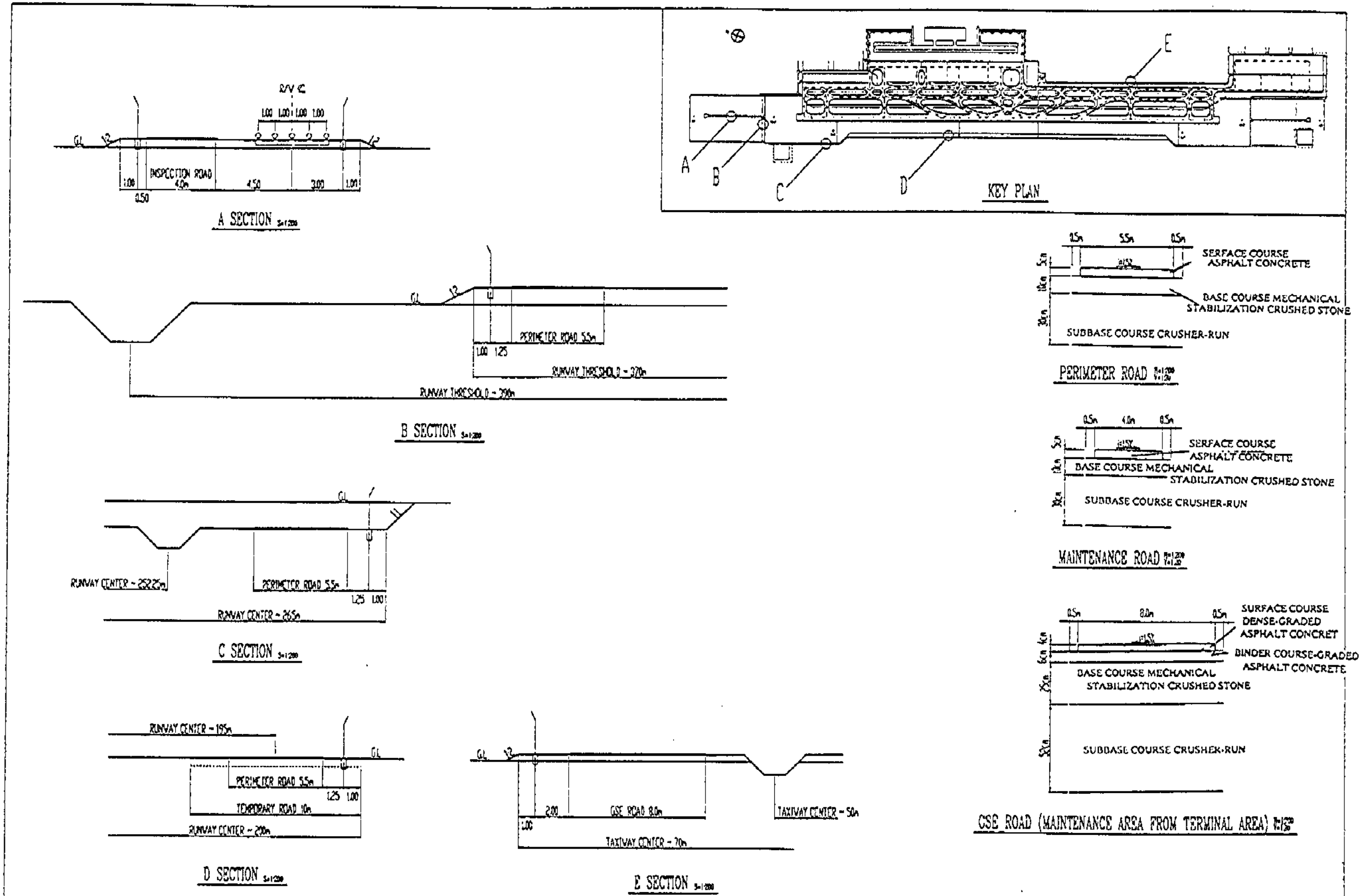
Classification of Layer	Thickness of Layer(cm)	Material
Surface course	4	Dense grading asphalt concrete
Binder course	6	Coarse grading asphalt concrete
Base course	25	Crushed stone with adjusted grading
Sub-base	52	Granular material(crusher run)
Total thickness of pavement	87	

According to TableII1-5.2.10, the thickness of a sub-grade should be 100 cm.

TableII1-5.2.10 Thickness of Sub-grade

Classification of Design Load	Thickness of Sub-grade(cm)
LA-1,LA-12	200
LA-2	150
Except LA-1,LA-12&LA-2	100

FigureII1-5.2.3 shows the established structure of pavement for safety / enclosingroads.



FigureII1-5.2.3 Figure of Pavement for Safety/Place-Enclosing Roads

5.3 Enclosing Fences and Gates

5.3.1 Plan

It was determined that, like the safety / enclosing roads, enclosing fences will be basically built along the delineated borders of the Phase 1 Flight Area. Their layout was set up considering the following items:

- Runway strip
- Construction road
- Enclosing roads and sites for drainage ways
- Glide path, and critical / protection areas of the localizer (see FigureII1-5.2.2)
- Site for approach light
- Space between taxiways and fixed obstacles

It was decided to install gate, at place where entrance to and exit from the airport area enclosed by fences are necessary for people and vehicles concerned. The people concerned are those who maintain, manage, and check the airport facilities.

5.3.2 Shape and Size

(1) Size

According to Japanese standards, the height of enclosing fences is 1.8 m above the ground plus 0.45 m for spikes. It is higher in some important airports (In Tokyo International Airport, 3 m high fences are used in same parts.)

In this design, the height of fence above the ground was determined to be 2.5 m, referring to Chinese design examples.

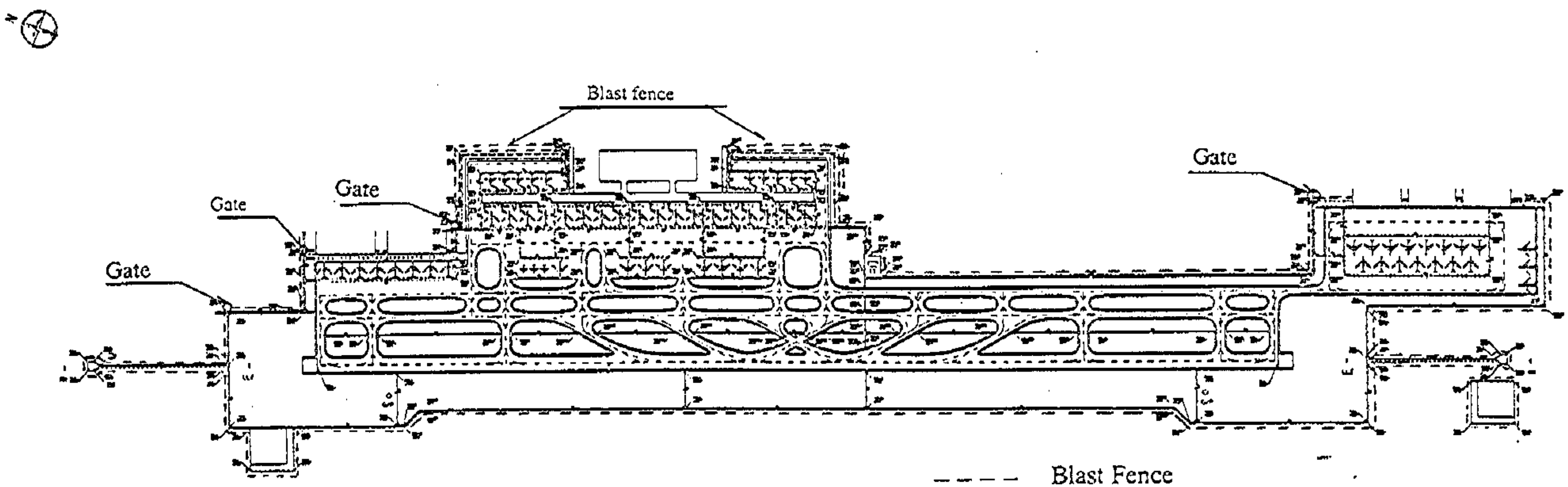
Enclosing fences and gate were designed not to touch the restricted surface.

(2) Shape

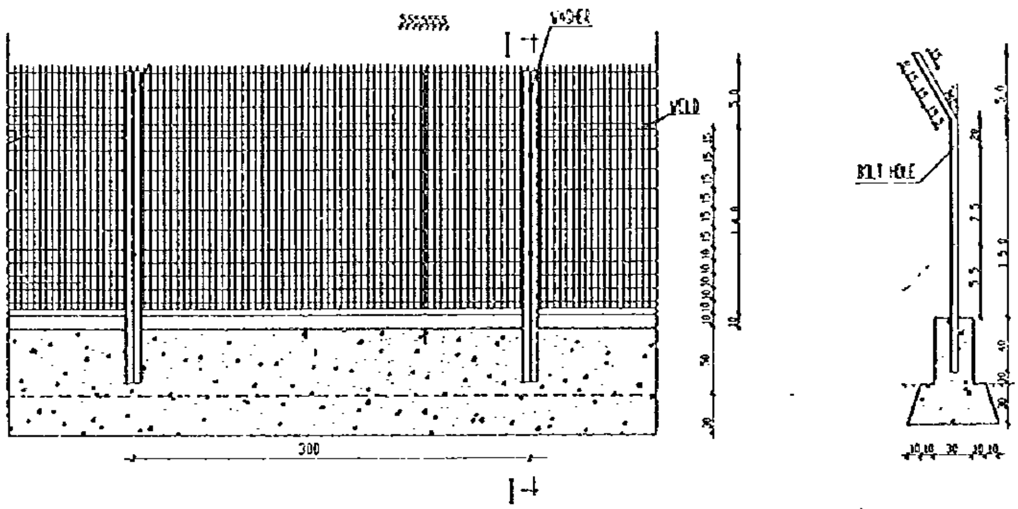
As for the shape of enclosing fences, Chinese design were also referred to. The decisions are as follows:

- For enclosing fences and gates, iron-rod nets will be basically used.
- There are places where installation of an iron-rod fence will cause hindrances to operation of facilities such as radio facilities (radio-wave obstacles). In these places, brick walls will be used.

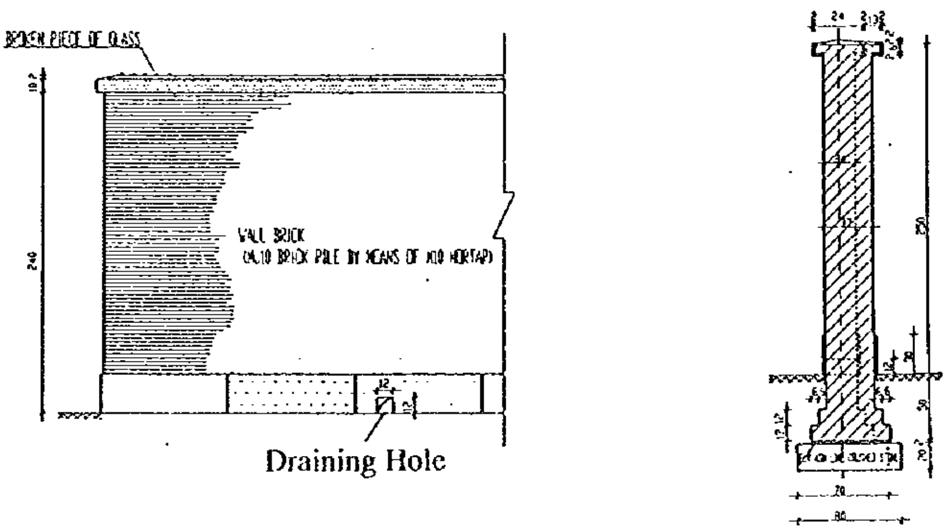
FiguresII1-5.3.1 ~ 5.3.4 show the installation positions and structure of enclosing fences and gates.



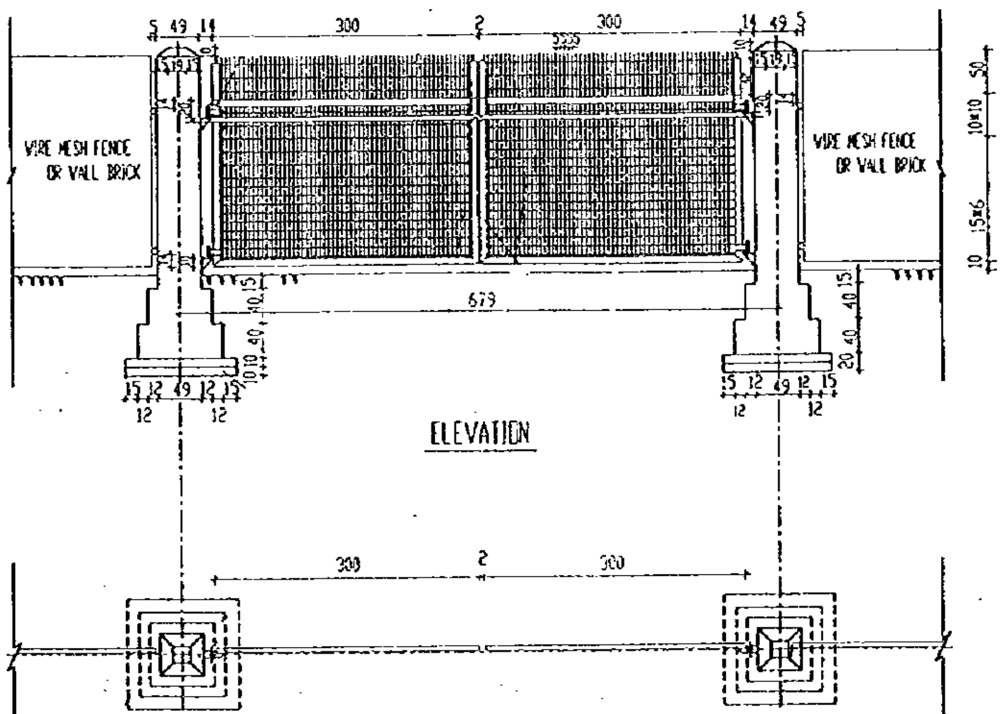
FigureII1-5.3.1 Positions of Encloseing Gences and Gates



FigureII1-5.3.2 Enclosing Fence (Iron-rod type)



FigureII1-5.3.3 Enclosing Fence (Brick-wall type)



FigureII1-5.3.4 Gate

5.4 Blast Fence

5.4.1 Design Conditions

(1) Aircraft to be Considered

The types of aircraft to be considered for design were determined to be B-767-300 and A-300-600. These are considered to park in the parking apron to be examined.

(2) Blast to be Considered

Blast to be considered for design was determined to be in the state of break away power.

(3) Wind Velocity

Allowable design wind velocity was determined to be 15 km / hr according to "ICAO Aerodrome Design Manual".

(4) Wind Pressure Load

It was decided that wind load would be employed as wind pressure load to be used for calculation of structure of blast fences. It is because wind velocity is faster than blast speed of the aircraft to be considered. The blast speed is shown in TableII1-5.4.1. (For relation between the subject aircraft on the ground and blast, see FiguresII1-5.4.5 and 5.4.6.)

Velocity pressure (1/2) ρ V2 = 300KG/m2 (wind velocity V = 70 m/sec.)

TableII1-5.4.1 Distribution of Blast Speed to Input to Fence

Unit : m/sec

Aircraft	Horizontal Distance from the End	Height(m)							
		0	1	2	3	4	5	6	6.5
B-767-300	9m	44	40	32	28	22	15	0	0
	15m	42	37	31	25	22	15	0	0
	50m	28	26	23	20	18	16	0	0
A-300-600	9m	30	36	41	30	25	20	0	0
	15m	28	30	36	28	23	20	15	0
	50m	22	23	24	23	21	20	18	15

(5) Earthquake Load

Earthquake load during earthquake is used for analysis. For the load, intensity recorded in Shanghai District was used. It is employed in "Figure of Intensity Divisions" of China.

For conversion to horizontal seismic intensity, relation between intensity and horizontal seismic intensity (described in Shanghai "Official Regulations for Architectural Earthquake-Resistant Design") was used.

Horizontal seismic intensity: Intensity 7 (kh conversion, kh = 0.08)

(6) Structural Form

Types of blast fences can be largely divided into steel structure and concrete structure. Steel structure form was selected, as it is recommended in ICAO Manual, and is a general type.

(7) Constants of Members

For blast fence members to be used for structure calculation, constants shown in TableII1-5.4.2 were used.

TableII1-5.4.2 List of Constants of Blast Fence Members

Type	Allowable Tensile strength ft(kgf/m²)	Allowable Shearing Strength fs	Part for Use
SS400	1600	900 (kgf / m²)	Framework
SR235	1600	900 (kgf / m²)	Anchor bolt
SD295	2000		Foundation
M16		1.81ton / 1 side	Connection part of framework

*ss400 and M16 are subject to standards for steel structure design.

SR235 and SD295 are subject to Structural Calculation Standards for reinforced concrete structures.

5.4.2 Layout

In Phase 1 Flight Area, there is an area where blast fences is necessary to be installed; it is around the apron behind of the terminal (on the access road side). This apron is to be parked by middle-sized aircraft.

Layout of blast fences was decided based on running trace of B-767-300. It is because this layout has the largest range of blast influence among all aircraft to be considered. For running trace, see FigureII1-5.4.1. The layout is shown in FigureII1-5.4.2.

The blast area of each aircraft to be considered is shown in FiguresII1-5.4.3 ~ 5.4.4.

5.4.3 Shape and Size

(1) Sites of Blast Fences

With regard to sites for installation of blast fences, adjustment was made with the terminal area. Then, the sites were determined as follows:

• Blast fence along the apron taxilane:

A taxiway clearance of 34 m should be secured. The site has a width of 5 m from the end of this clearance (34 m clearance is stated in ICAO as clearance for middle-sized aircraft).

• Blast fence on the side of building:

Clearance of 0.5 m should be secured between the site and the building. The site has a width of 5 m from the end of this clearance.

(2) Height of Blast Fence

The ICAO Manual stipulates that blast fences should have a height which reaches the center of the blast (engine) at least. In this design, taking safety into account, the height of fence capable receiving the blast area was decided to be 15 km/h.

Distribution of blast of each aircraft to be considered is as shown in FiguresII1-5.4.5 and 5.4.6.

When blast speed is 15 km/h, height of the blast area is:

- 6 m above the ground in the case of B-767-300, and

- 6.5 m in the case of A300-600.

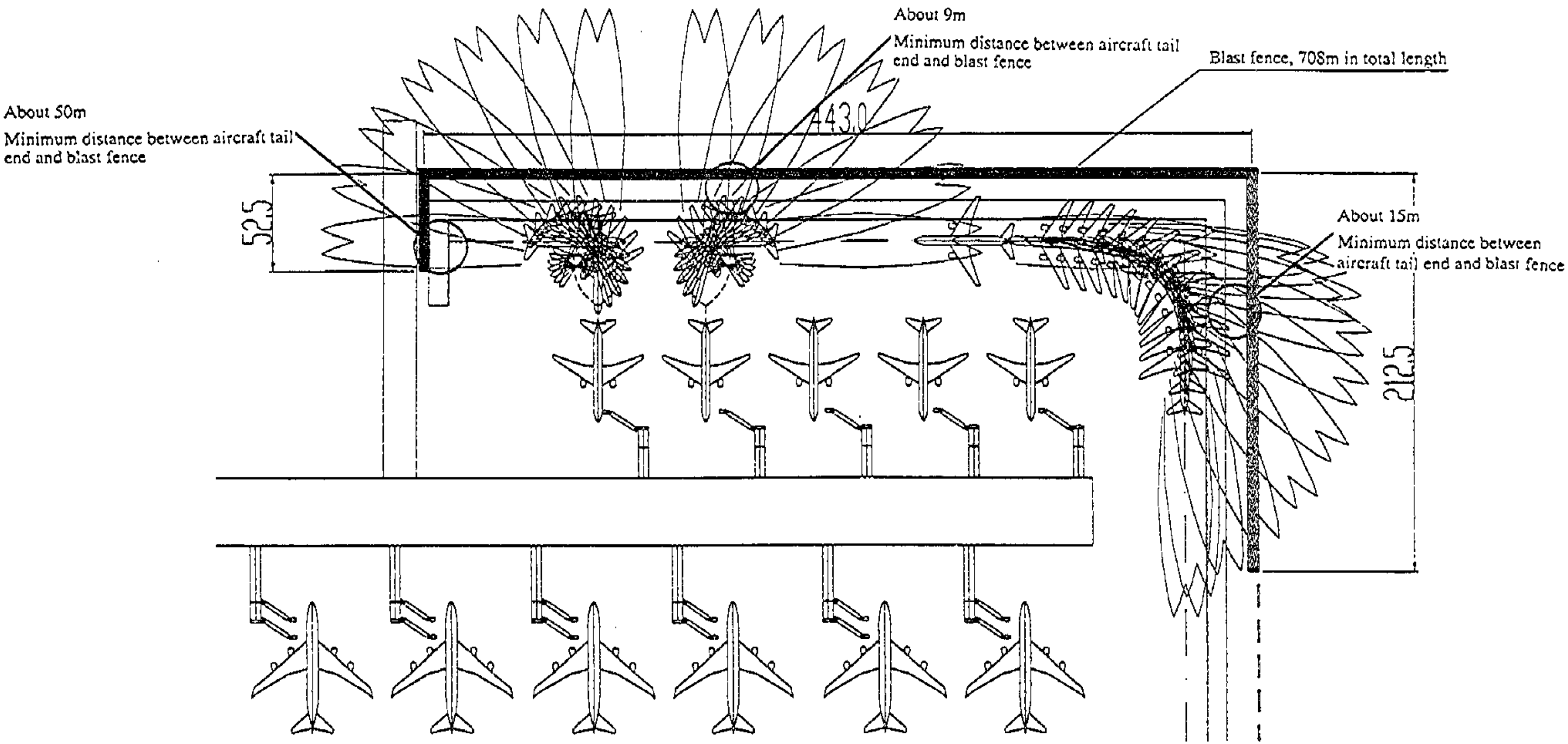
Therefore, the height of blast fences was determined to be 6.5 m.

5.4.4 Design of Structure

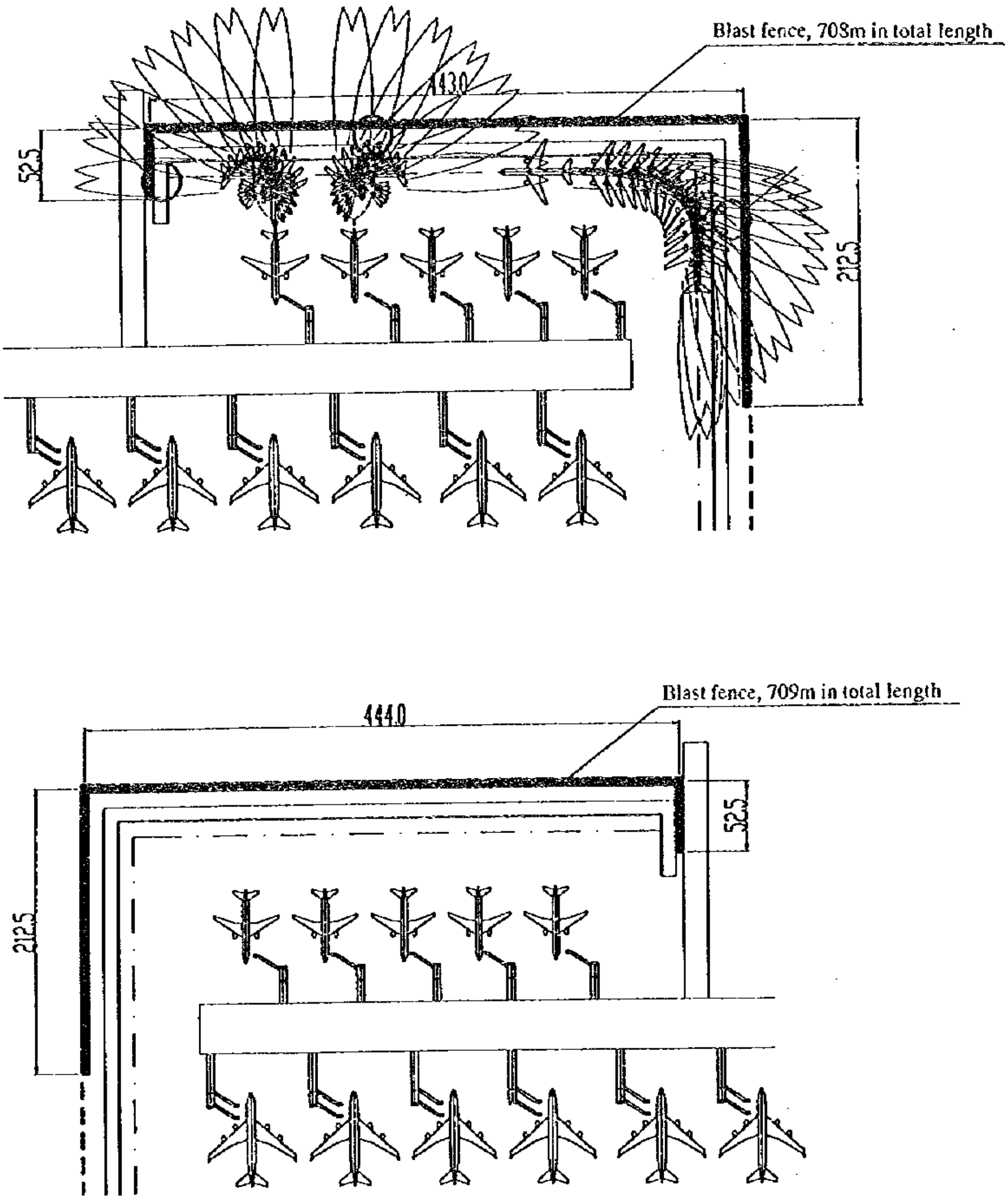
(1) Design Standards to be Applied

Following standards related to construction were applied to calculation of structure of blast fences.

- Standards for Steel Structure Design
- Criteria of Calculation of Reinforced Concrete Structure
- Guides for Design of Architectural Foundations Structure
- Order of execution of the Building Standard Act
- Standards for Design of Airport Civil Engineering Facilities



FigureII1-5.4.1 Trace of Blast (B-767-300)



FigureII1-5.4.2 Figure of Installation Positions of Blast Fences

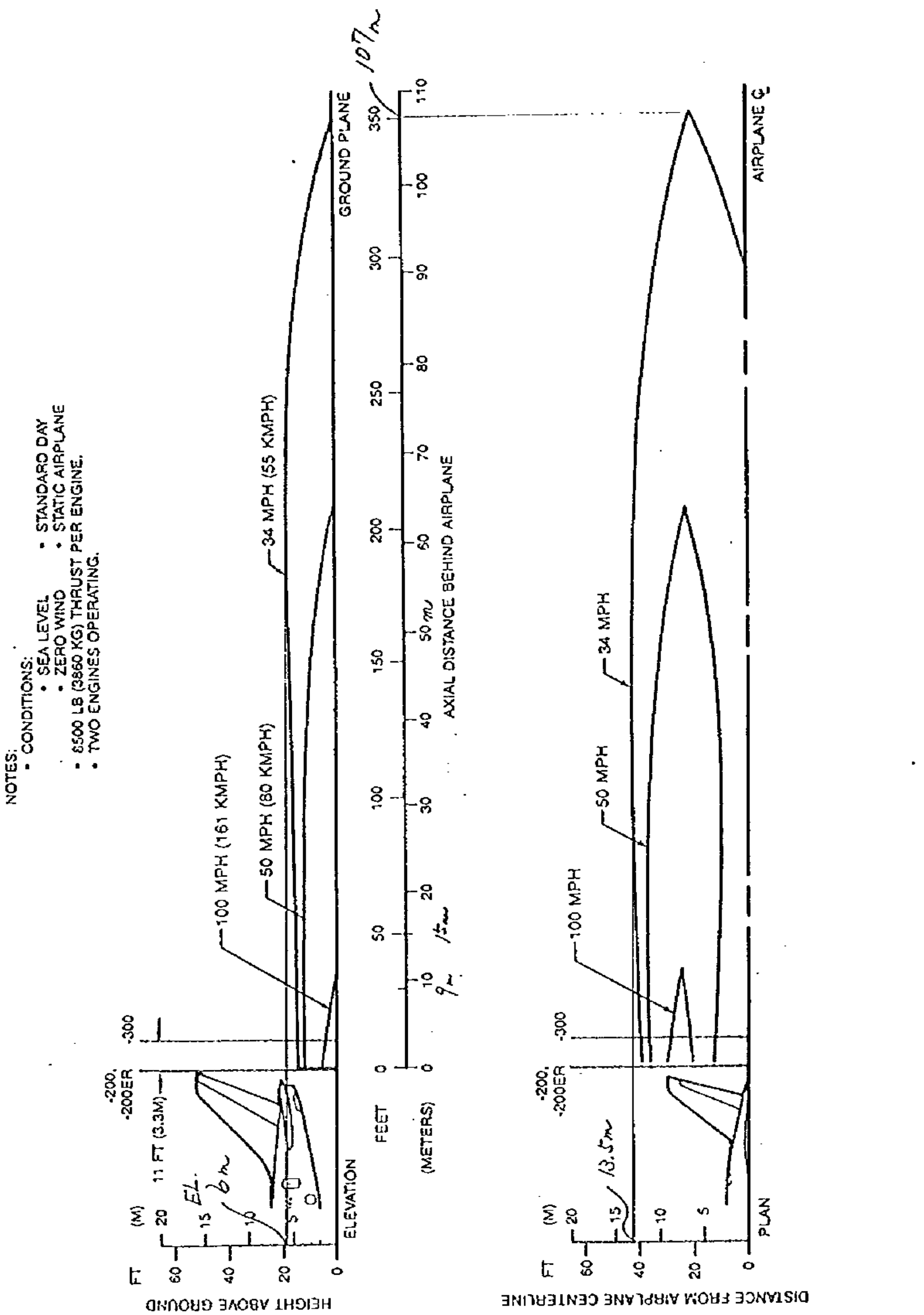
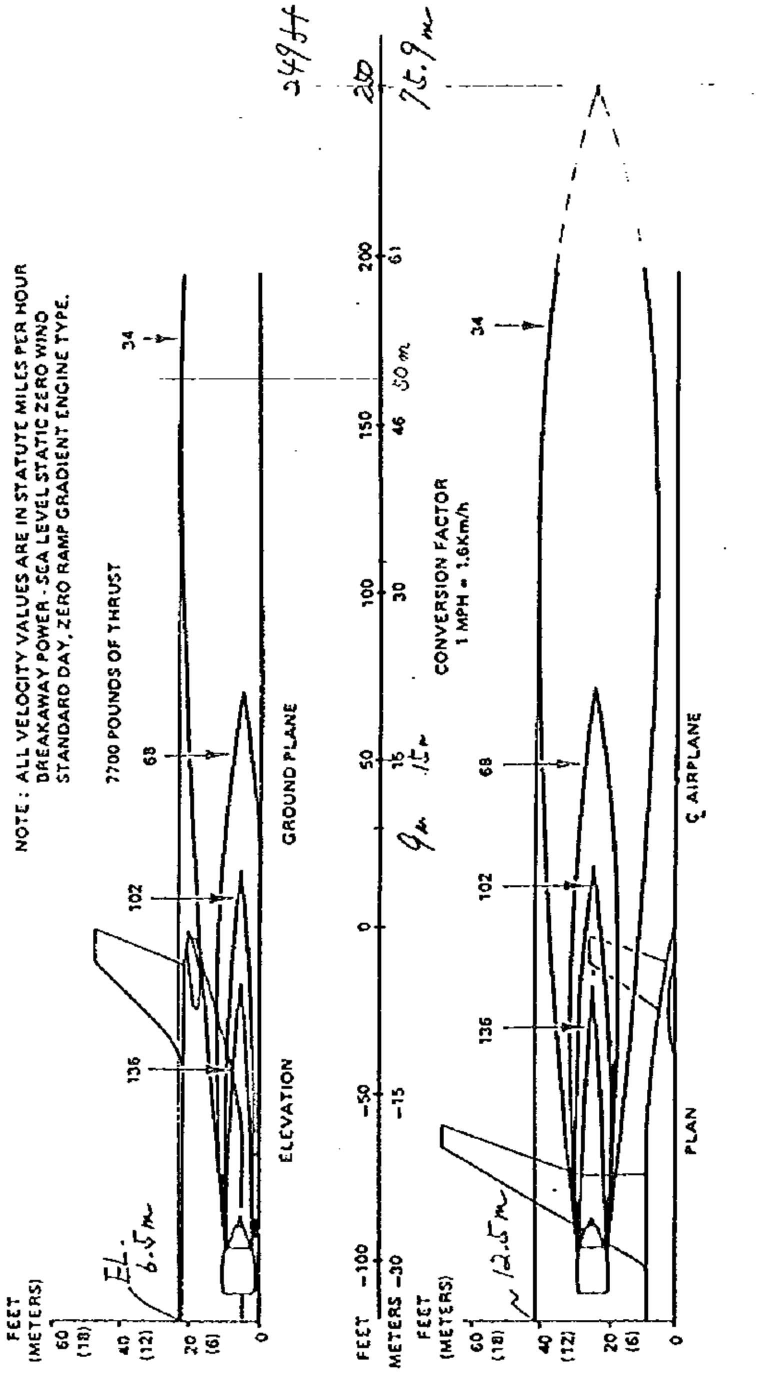


Figure II1-5.4.3 Blast Area of B-767-300

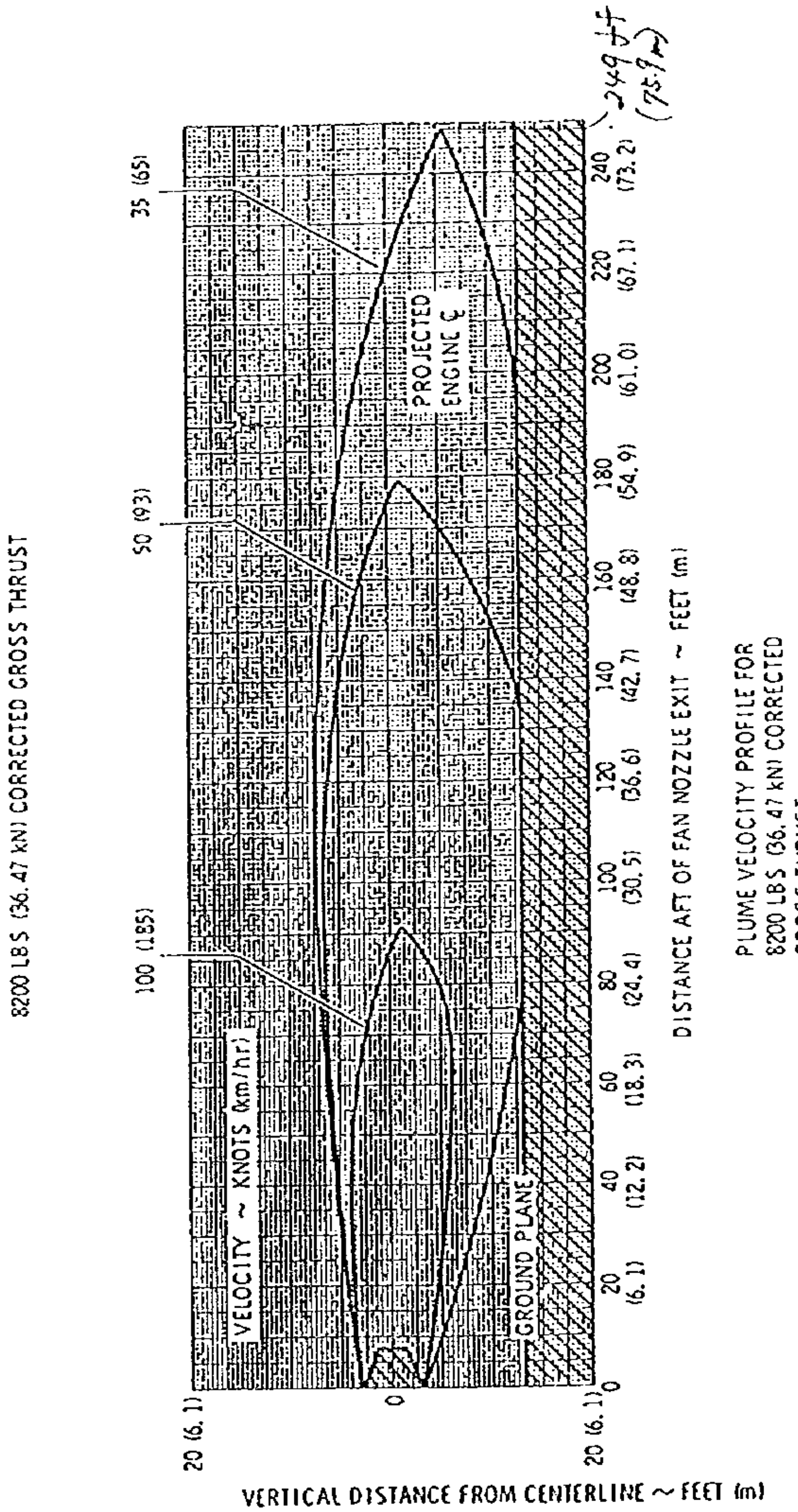
6.1.4 PREDICTED JET ENGINE EXHAUST VELOCITY CONTOURS—LOW BREAKAWAY THRUST

MODEL 767-200, -200ER, -300 (JT9D-7R4D, -7R4E ENGINES)



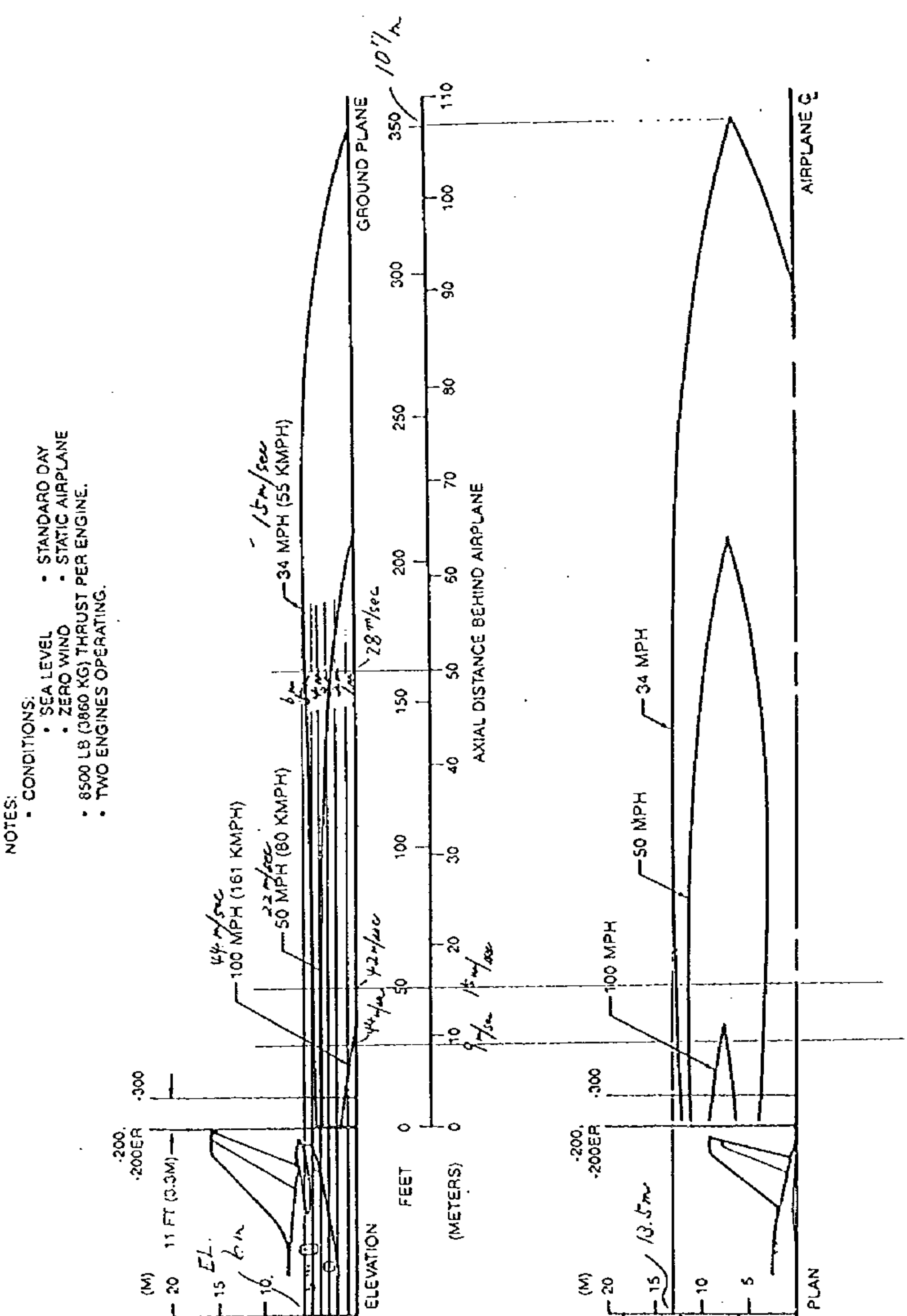
FigureII-5.4.4(1) Blast Area of A300-600

JET ENGINE EXHAUST VELOCITIES AND TEMPERATURES
EXHAUST VELOCITY CONTOURS - BREAK AWAY POWER
(PW JT9D-7R4H1 ENGINE)
MODEL A300-600



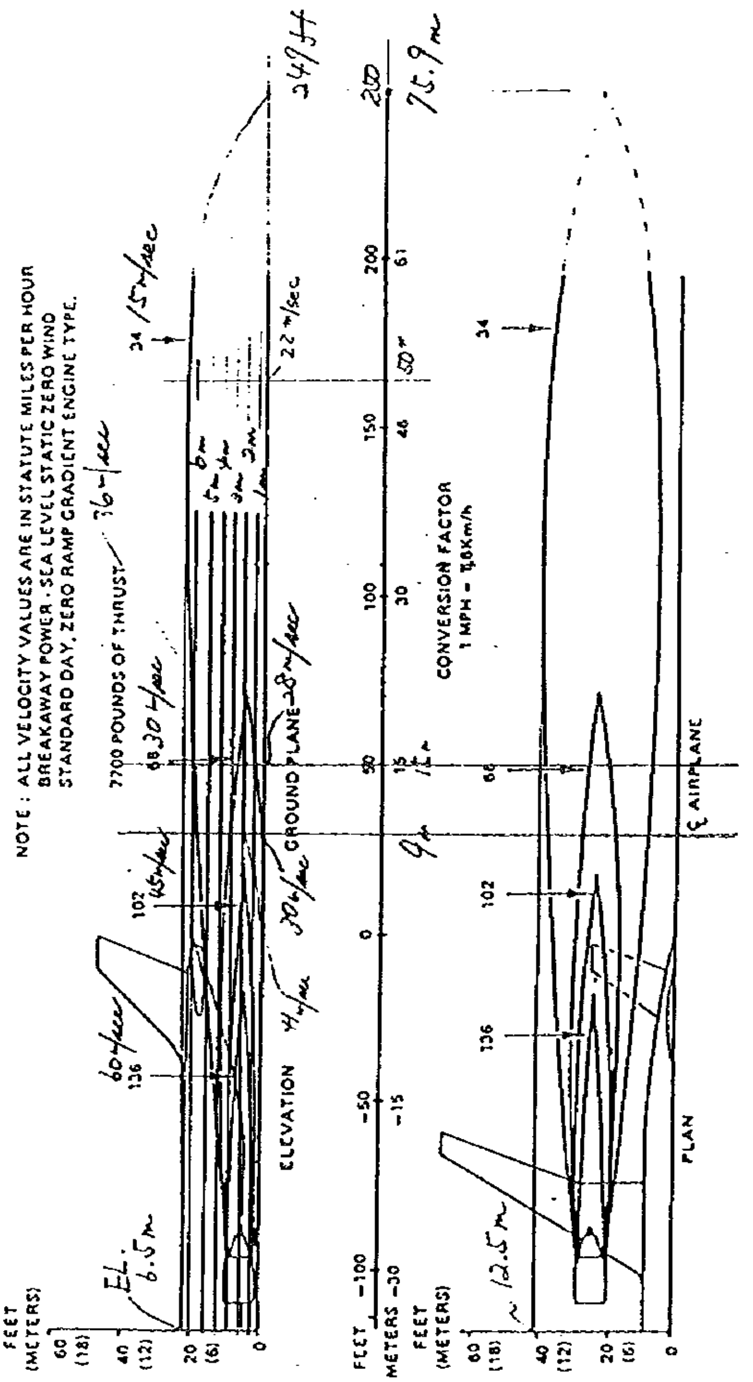
FigureII1-5.4.4(2) Blast Area of A300-600

JET ENGINE EXHAUST VELOCITIES AND TEMPERATURES
EXHAUST VELOCITY CONTOURS - BREAK AWAY POWER
(GE CF6-80C2 ENGINE)
MODEL A300-600
(SHEET 1 OF 3)



FigureIII-5.4.5 Blast Distribution of B767-300

6.1.4 PREDICTED JET ENGINE EXHAUST VELOCITY CONTOURS—LOW BREAKAWAY THRUST
MODEL 767-200, -200ER, -300 (JT9D-7R4D, -7R4E ENGINES)

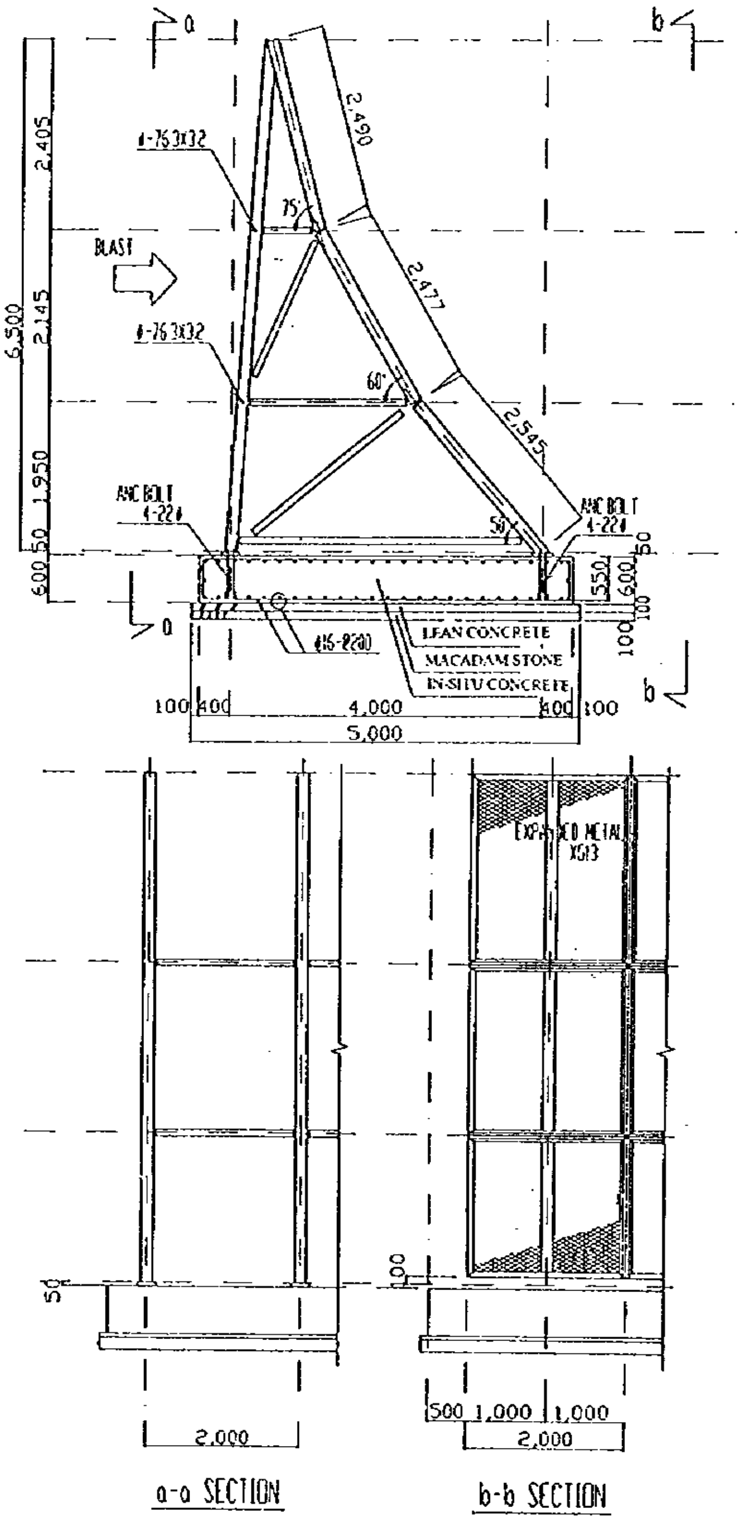


FigureII1-5.4.6 Blast Distribution of A300-600

6.1 JET ENGINE EXHAUST VELOCITIES AND TEMPERATURES
6.1.1 EXHAUST VELOCITY CONTOURS - BREAK AWAY POWER
(PW JT9D-7R4H1 ENGINE)
MODEL A300-600

(2) Setting-Up of Structure

As a result of calculation of structure (for statement of calculation, see attached data), structure of blast fences was determined as shown in FigureII-5.4.7. These fences will be installed around the apron behind the terminal building on the access road side.



FigureII-5.4.7 Structure of Blast Fence

CHAPTER 6 DESIGN OF STRUCTURES

6.1 General

6.1.1 Structures to be Designed

Structures to be designed of are the following:

• Drainage structures (box culverts, U-shaped side ditches)

• Foundation of apron lightings

6.1.2 Basic Design Policies

Discussion was made on Chinese design criteria, design methods, load conditions and materials used, and examples of design of other airports in China. As a result, the following basic policies were determined:

• For load conditions and provisions about materials to be used, Chinese standards values will be employed as much as possible.

• Basic design of structures will be carried out using to Japanese design methods.

6.1.3 Design Standards and Methods to be applied

Main design standards to be applied to structure design are as follows:

• "Criteria of Concrete Structure Design"	GBJ 10-89 (Peking 1989)
• "Criteria of Ground Foundation Design"	DBJ 08-11-89(Shanghai 1989)
• "Criteria of High-Rise Structure Design"	GBJ 135-90 (Chinese Construction Department 1991)
• "Criteria of Steel Structure Design"	GBK 17-88 (Chinese Construction Department 1989)
• "Standards for Air Civil Engineering Facilities"	(Supervised by Civil Aviation Bureau, Japan)
• "General Principles of Design of Airport Drainage Facilities, Underground Passages and Common Ditches"	(Supervised by Civil Aviation Bureau, Japan)
• "Specifications of Concrete Standards"	(Civil Engineering Society, Japan)
• "Specifications of Highway Bridge, Explanation of the Same, Infrastructure"	(Ministry of Construction, Japan)

The design methods are summarily described below.

(1) Concrete Structure

As design methods of concrete structures, the "Allowable Stress Intensity Method" is employed in Japan, and the "Critical State Method" in China. This brings about a large difference. A summary of these design methods is given below.

1) Allowable Stress Intensity Method (Basic concept of the Ministry of Transport and the Ministry of Construction, Japan)

• According to load conditions to be covered, allowable stress intensity is set up for each material. Safety of structures is confirmed by comparing allowable stress intensity with section verification with action load.

• In this method, coefficients of material, load, member, etc. are collectively estimated with a concept of "an extra allowable stress intensity". The analysis method is standardized. Therefore, there is no complexity.

• On the other hand, it slightly lacks rationality in terms of designing a little. For example, even evaluation of the width of a crack must be made with stress intensity.

• There are enough examples of use of this method for structures of airports, harbors, roads, etc. Safe and economical structure design is possible.

• The unit system is that of engineering.

2) Critical State Method (Concept of the Japanese Civil Engineering Academic Society)

• This method was introduced for the first time in 1986.

• As coefficients of safety, the following items are considered, and rational design is sought for: - Coefficients of material, load, structural analysis, members, and structure.

• This is rational as a concept of design. However, evaluation of an appropriate safety coefficients is very important to realize safe and economical design.

• There is only a limited number of examples. It is difficult to evaluate the results of design.

• SI Unit system is used.

3) Critical State Method (Chinese basic concept)

• The critical state method has been employed since 1989.

• The design standard (allowable) values are determined from members, material strength, dimensions of a section, etc.

• In the ultimate state, the product of internal strength and the coefficient of importance are compared with the values mentioned above. The purpose is to confirm safety.

• In the usage state, stress, width of cracks and amount of deformation are compared with allowable values to confirm safety.

As mentioned above, in Japan, the "Critical State Method" is included in the "Specifications of Concrete Standards" of the Civil Engineering Society. But, it has been adopted actually in few airports. Therefore, design according to Allowable Stress Intensity Method and design according to the Critical State Design of the Japanese Engineering Academic Society were compared and analyzed. The subject is box culverts because they have a representative drainage structure. As a result, it was determined that the design of concrete structures should be carried out using the Allowable Stress Intensity Method. The reason is that a design section according to the Allowable Stress Intensity Method is safe also in the ultimate state design.

(2) Pile Foundation Structure

The foundation for apron lighting will be a pile foundation structure. Its design was carried out according to Japanese "Specifications of Highway Bridge".

6.1.4 Ground and Soil Conditions

Conditions of the ground and soil taken into consideration in designing drainage structures are as follows. The constant of strength of the present ground and fill-back material were set up based on the lowest value (N value: 10) among the target values. Soil conditions of pile foundation are as described later

• Ground conditions	See Chapter 2	
• Unit volume weight of soil	At ore above water level	$\gamma t = 1.90\ tf/m^3$
	Underwater level	$\gamma t = 1.00 tf/m^3$
• Constant of strength	Adhesion	$C = 3.2 tf/m^3$
	Angle of internal fiction	$\phi = 26°$
• N value	N = 10	
• Underground water level	Planned height of pavement - 1.0 m	

6.1.5 Load Conditions

(1) Dead Load

- Reinforced concrete — $2.6\ tf/m^3$
- Non-reinforced concrete — $2.4\ tf/m^3$
- Steel material — $7.85\ tf/m^3$
- Asphaltic pavement — $2.0\ tf/m^3$ (to the entire thickness of pavement)
- Concrete pavement — $2.1\ tf/m^3$ (to the entire thickness of pavement)

(2) Live Load

1) Aircraft Load Type F) was considered for aircraft load. For ground structures, B-777c (Type E) load was employed, since wheel load is the largest. Underground structures were designed with either load of B-777 plane (Type E) or B-747 advanced plane (Type F) which is disadvantageous for structures.

Details of B-777C (Type E)

• Gross weight at full load	327 tf
• Main gear configuration	2 gears & 6 wheels
• Gear load at full load	156 tf
• Wheel load	25.9 tf
• Contact area of wheel	length 46.5 cm × width 32.0 cm
• Tyre pressure	17.4 kgf/cm^3

Details of B-747 Advance Plane (Type F)

• Gross weight at full load	607 tf
• Main gear configuration	6 gears & 4 wheels
• Gear load at full load	96.2 tf
• Wheel load	24.0 tf
• Contact area of tyre	length 48.4 cm × width 34.0 cm
• Tyre pressure	14.6 kgf/cm3

2) Load of Large-Sized Fire Fighting Truck

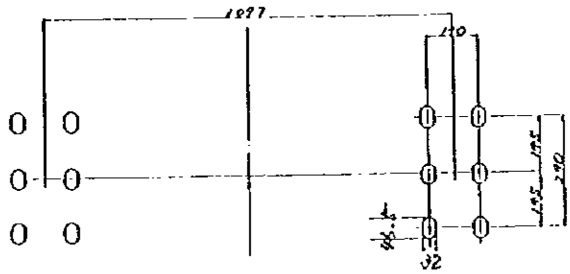
For load of large-sized fire fighting trucks, details in Japanese "General Principles of Design of Airport Drainage Facilities, Underground Passageways and Common Dritchess" were used.

• Full length	11.985 m
• Full width	3.100 m
• Gross weight of vehicle	44.56 tf
• Gear configuration	4-gear type
• Wheel load	4.800 tf (front wheel)
	4.802 tf (rear part of front wheel)
	6.345 tf (rear wheel)
	6.332 tf (rear part of rear wheel)
• Contact area of tyre	length 41.8 cm × width 31.8 cm

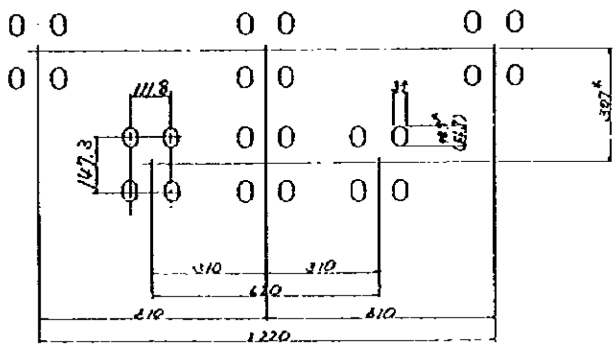
3) Car Load

For car load, the 15th class load in China was employed.

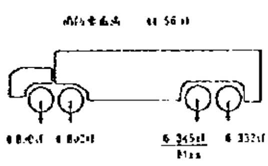
- Wheel base 4.0 m
- Full width 2.5 m (width occupied by vehicle)
- Gross weight 20 tf
- Axis weight 7.0 tf (front axis), 13.0 tf (rear axis)
- Contact width of tyre 20 cm



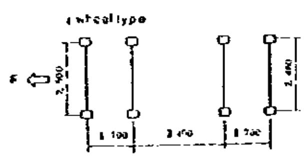
Main Gear Configuration of B777c (Type E)

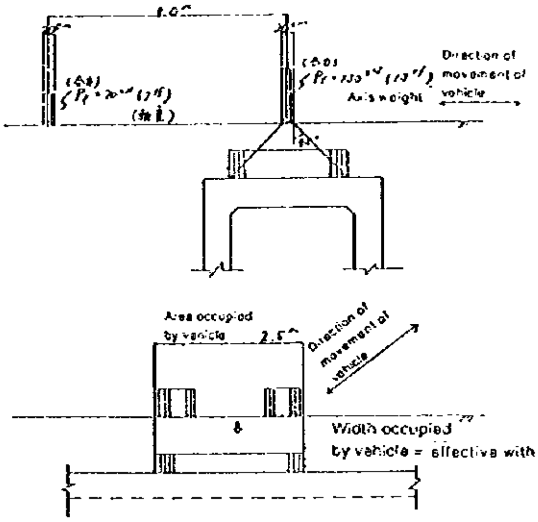


Main Gear Configuration of B747 advanced plane (Type F)



Contact length of tyre 0.418m
Contact width of tyre 0.318m
Widthe occupied by vehicle 3.1m





Details of Large-Sized Fire Fighting Truck

Details of Car (Class 15)

FigureII-6.1.1 Details of Live Load

4) Underground Vertical Stress Direction Acting on Underground Structures

There are two kinds of live load acting on underground structures, i.e., box culverts. They are aircraft load and load of a large-sized fire fighting truck.

Both China and Japan have a similar way of thinking about calculation of vertical stress acting on an underground structure by a live load. Namely, the stress disperses 45° in the direction of movement (axis) and in the vertical direction. Then, the value is calculated by "influencing load/distribution area of stress". However, there is a large difference between Chinese and Japanese standards. It is the number of influencing wheels and distribution area of stress in the calculation formula of live load. On assumption that live load is equally distributed and loaded, Japanese design principles take the largest value. However, in China, the average value of equally distributed load is taken. This results in a large difference in the form of a section of a structure.

As an example, underground stress, in the vertical direction and 1 m under the ground, of B-777C (Type E) is calculated by Japanese and Chinese formulas as follows:

(Japanese Formula)

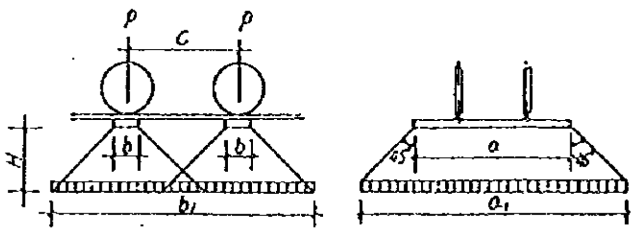
$$q = N*W / \{(l + 2h)(w + 2h)\}$$
$$= 4*25.9 / \{(0.465 + 2*1)(0.320 + 2*1)\}$$
$$= 18.11 \text{ tf/m}^2$$

(Chinese Formula)

$$q = N*W / \{(2d + l + 2h)(c + w + 2h)\}$$
$$= 6*25.9 / \{(2*1.45 + 0.465 + 2*1)(0.40 + 0.320 + 2*1)\}$$
$$= 7.79 \text{ tf/m2}$$

where,

- q : underground stress in the vertical direction (tf/m2)
- N : number of influencing wheels
- W: wheel load (tf)
- l : contact length of tyre (cm)
- w : contact width of tyre (cm)
- h : depth (m)
- c : wheel track of dual tandem wheels (cm)
- d : wheel base of dual tandem wheels (cm)



FigureII-6.1.2 Example of Distribution of Live Load According to Chinese Standards

The value calculated according to Japanese standards is 18.11 tf / m^2, while that calculated according to Chinese standards is 7.79 tf / m^2. The letter is about 1 / 2.3 of Japanese value.

However, in Japanese standards ("General Principles of Design of Airport Drain Facilities, Underground Passage Ways and Common Ditches"), the following is stated: "It can be said that, if a structure comes under pavement, it is rational to fully estimate the load dispersion effect."

Then, underground stress was obtained with multilayer elastic theory, and compared between Japanese and Chinese standards. The value obtained by elastic theory was smaller than the value determined by Chinese standards. Therefore, it was judged that use of live load calculation expression of Chinese standards would not bring about any problem in fact. Concrete comparison is described in the Appendix.

TablesII-6.1.2 and 6.1.3 show the results of calculation of underground stress in the vertical direction, regarding load of aircraft and load of large-sized fire fighting truck. For this calculation, Chinese calculating expression for live load was used. The number of influencing wheels was also taken into account.

5) Live Load Acting on Ground Structures

It was assumed that load directly acting on a U-ditch, a ground structure, would disperse only in the vertical direction.

Pi = (2* rear wheel load) / width occupied by vehicle
Pvl = Pi / (2*h + 0.2)

where,

Pi : load per unit length (tf/m)
Pvl : underground stress in the vertical direction (tf/m2)
h : depth (m)

(3) Impact Coefficient

For impact coefficient, the following Chinese standard values were used.

TableII-6.1.1 Impact Coefficient

Depth h	h≦30 cm	40 cm	50 cm	60 cm	h≧70 cm
Impact coefficient	1.25	1.20	1.15	1.05	1.00

(4) Soil Pressure

1) Underground Structures

For underground structures, static soil pressure (coefficient of static soil pressure 0.6) was used.

TableII1-6.1.2 Underground Stress in the Vertical Direction Caused by Aircraft load

B－777C

Depth(m)	Number of influencing wheels	Influenced area (m2)	Stress (tf/m2)
0.2000	1	0.6228	41.59
0.3000	1	0.9798	26.43
0.4000	1	1.4168	18.28
0.4925	1	1.8923	13.69
0.4925	3	5.6768	13.69
0.5000	3	5.7618	13.49
0.5400	3	6.2230	12.49
0.5400	6	12.4460	12.49
0.6000	6	13.3298	11.66
0.7000	6	14.8668	10.45
1.0000	6	19.9578	7.79
1.5000	6	30.0428	5.17
2.0000	6	42.1278	3.69
2.5000	6	56.2128	2.76
3.0000	6	72.2978	2.15
3.5000	6	90.3828	1.72
4.0000	6	110.4678	1.41
4.5000	6	132.5528	1.17
4.6250	6	138.3866	1.12
4.6250	12	276.7731	1.12
5.0000	12	303.2519	1.02
6.0000	12	379.3619	0.82

B747 advanced type

Depth(m)	Number of influencing wheels	Influenced area (m2)	Stress (tf/m2)
0.2000	1	0.6542	36.69
0.3000	1	1.0190	23.55
0.3890	1	1.4109	17.01
0.3890	2	2.8218	17.01
0.4000	2	2.8993	16.56
0.4945	2	3.6044	13.32
0.4945	4	7.2089	13.32
0.5000	4	7.2683	13.21
0.5565	4	7.8930	12.16
0.5565	8	15.7859	12.16
0.6000	8	16.5514	11.60
0.7000	8	18.3684	10.45
0.8000	8	20.2654	9.47
0.8210	8	20.6739	9.29
0.8210	24	65.1957	8.83
1.0000	24	75.3869	7.64
1.5000	24	105.2119	5.47
2.0000	24	137.0369	4.20
2.3210	24	158.5227	3.63
2.3210	24	158.5227	3.63
2.5000	24	168.6638	3.42
3.0000	24	198.3488	2.90
3.5000	24	230.0338	2.50
4.0000	24	263.7188	2.18
4.5000	24	299.4038	1.92
5.0000	24	337.0888	1.71
6.0000	24	418.4588	1.38

TableII1-6.1.3 Underground Vertical Stress Caused by Load of Large-Sized Fire Fighting

Depth(m)	Number of influencing wheels	Influenced area (m2)	Stress (tf/m2)
0.2000	1	0.5873	10.80
0.3000	1	0.9345	6.79
0.4000	1	1.3617	4.66
0.5000	1	1.8689	3.40
0.6000	1	2.4561	2.58
0.6410	1	2.7200	2.33
0.6410	2	5.4400	2.33
0.7000	2	6.0439	2.10
0.8000	2	7.1311	1.78
1.0000	2	9.5455	1.33
1.0710	2	10.4796	1.21
1.0710	4	20.9592	1.21
1.2000	4	23.3942	1.08
1.4910	4	29.3760	0.86
1.4910	8	58.9560	0.76
1.5000	8	59.2443	0.75
2.0000	8	76.2803	0.58
2.5000	8	95.3163	0.47
3.0000	8	116.3523	0.38
3.5000	8	139.3883	0.32
4.0000	8	164.4243	0.27
4.5000	8	191.4603	0.23
5.0000	8	220.4963	0.20
5.5000	8	251.5323	0.18
6.0000	8	284.5683	0.16

2) Ground Structures

For ground structures, active soil pressure (coefficient of active soil pressure $\tan^2(45° - \phi/2)$) was used.

(5) Water Pressure

1) Underground Structures

Water pressure was evaluated with water level difference between inside and outside water. The sum of empty weight and weight of soil placed on, and up-lift were compared. Then rising was examined.

2) Ground Structures

Water pressure was not considered basically. For up-lift, the water level was determined according to the load condition to be considered.

(6) Wind Load (Apron Lighting Pole)

- Design wind velocity : 50m / sec. (with lighting equipment installed)
  70m / sec. (without lighting equipment, only a lighting pole)
- Shape factor : Plane · Square pillarl 1.3, Round shape 0.7

(7) Influence by Earthquake

- Intensity : 7
- Horizontal seismic intensity : Kh = 0.08

6.1.6 Materials to be Used

(1) Concrete

Concrete to be used for drainage structures was determined as follows.

TableII-6.1.4 Norms of Concrete (Allowable Stress Intensity Method)

Unit : kgf / cm^2

Norm	Part for use	Axis Pressure	Bending Compression	Bending Tensile	Shearing	Bearing Pressure	Bond (Round Bar)	Bond (Deformed Bar)
C30/C25	Precast of cover	68	83	-	4.0	7.5	8.1	16.3
C20/C16	Construction of RC for site	41	53	-	2.7	48	5.3	10.6
C15/C12	Drainage foundation	30	30	1.5	2.0	36	-	-

(2) Reinforcing Bar

Reinforcing bars to be used for structures were determined as follows. The minimum space for reinforcement arrangement was discussed and determined to be 125 mm.

TableII1-6.1.5 Norms of Reinforcing Rods (Allowable Stress Intensity Method)

Unit : kgf / cm2

Norm	Yield Point Strength	Tensile (general)	Tensile (at or under the water level)	Compression	Standard value	Diameter to be Used
Round bar, class I	2,350	1,400	1,400	1,400	1,400	φ8,10
Deformed bar, class I	3,350	1,800	1,600	1,600	1,800	φ12,14,16,18, 20, 22, 25, 28, 32

(3) Pile

Piles to be used for foundation of apron lightings were determined to be existing RC square piles prescribed in the Chinese National Standards 87SG361.

6.2 Drainage Structures

6.2.1 Box Culvert

(1) Sections to be Examined

A structural section of a box culvert based on "3. Design of Drainage Facilities" is as shown in FigureII1-6.2.1.

For the sections, consideration was given to conditions of live load, examples of execution in China and so on. Then, they were set up according to the following basic policies:

- Influence of live load stress and influence on the road surface were considered. As a result, the minimum depth on box culverts was determined to be 60 cm.
- Width of channels should be 20 cm pitch.
- If width of inside space of a channel is:

  - 1.8 m or less, a culvert with a cover,
  - 2.0 m - 3.2 m, a single-box culvert, and
  - over 2.1, double-box culvert

  should be set up.
- Length (coupling space of one block of a box culvert should be 20 m.
- Joints with a width of 20 mm should be placed among blocks and should be included in the length of a block.
- Foundation is as follows:

  - leveling concrete (C15) 15 cm.
  - crushed stone 15 cm.
  - Width of the part projecting from a box culvert bottom slab should be 30 cm.

• Excavation width for the purpose of construction of a box culvert should be 50 cm above the end of crushed stone foundation. Excavation gradient should be:

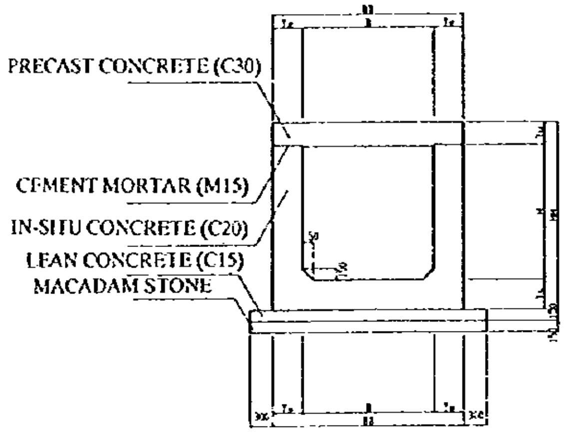
- 1:0.3, if depth of excavation is under 3 m,
- 1:0.5, if the depth if 3 m or more.

In the basic design, calculation of structure was made for box culverts with the following live load, size of inside space, and conditions of soil to be covered.

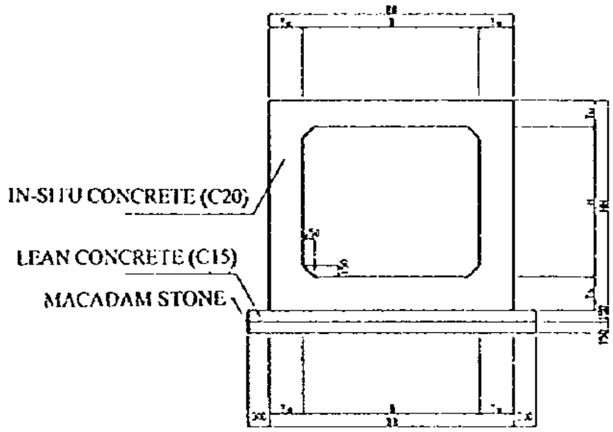
TableII-6.2.1 Size of Section for Structure Calculation of Box Culvert

Load Conditions	Size of Inside Space Width(m)	Height(m)	Covered Soil depth (m)	Structure	Symbol
Aircraft	1.40	1.40	1.00	Culvert with a cover	B-TYPE1(A)
	1.80	1.80	1.00		
	2.40	2.00	1.00	Single box	B-TYPE2(A)
	1.80*1.80	1.80	1.00	Double box	B-TYPE3(A)
	2.40*2.40	2.00	1.00		
Large Fire Fighting Truck	1.80	1.80	2.00	Culvert with a cover	B-TYPE1(F)
	2.40	2.00	2.00	Single box	B-TYPE2(F)
	2.40*2.40	2.00	2.00	Double box	B-TYPE3(F)

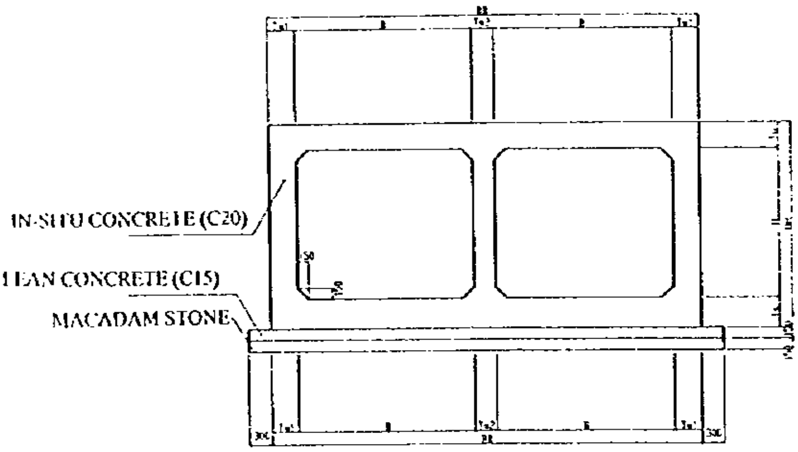
B-TYPE1



B-TYPE2



B-TYPE3



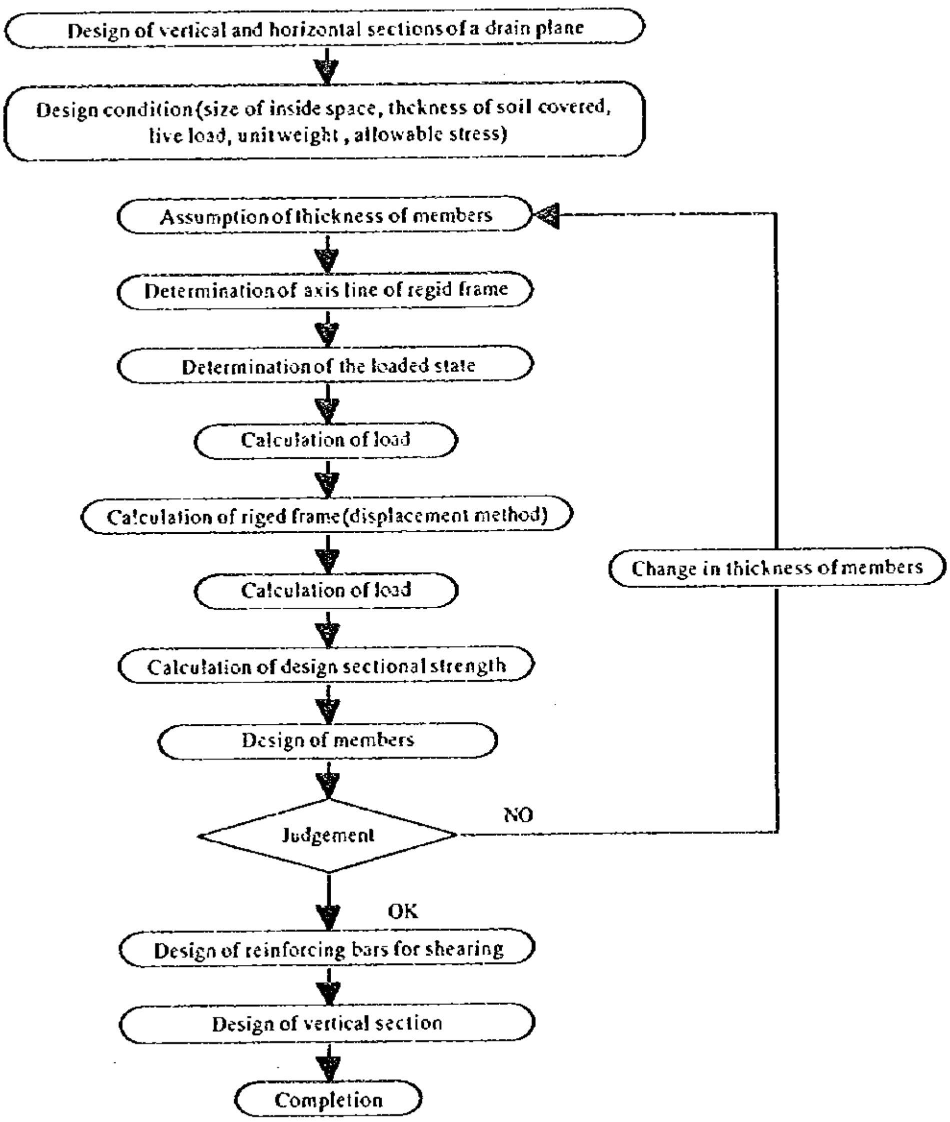
FigureII1-6.2.1 Box Culvert Structure

(2) Design Flow

Design of box culverts was carried out according to the procedures shown in FigureII1-6.2.2.

First, a section of member of a box culvert was set up by calculation of the transverse direction (in the direction of a short hand of the box culvert). As load acting on the box culvert, inside load was taken. Calculated sectional strength is shaft strength, bending moment and shearing strength. Therefore, a plane frame model was used for analysis of structure.

Next, design of the Longitudinal direction was carried out for box culverts capable to accommodate aircraft load. Then, distributing bars determined by calculation of the horizontal direction were re-examined. For this examination, it was assumed that the foundation would be elastic material (Displacement of the ground proportionate to load.). And, considering box culverts as beams, beams on the elastic floor were analyzed.



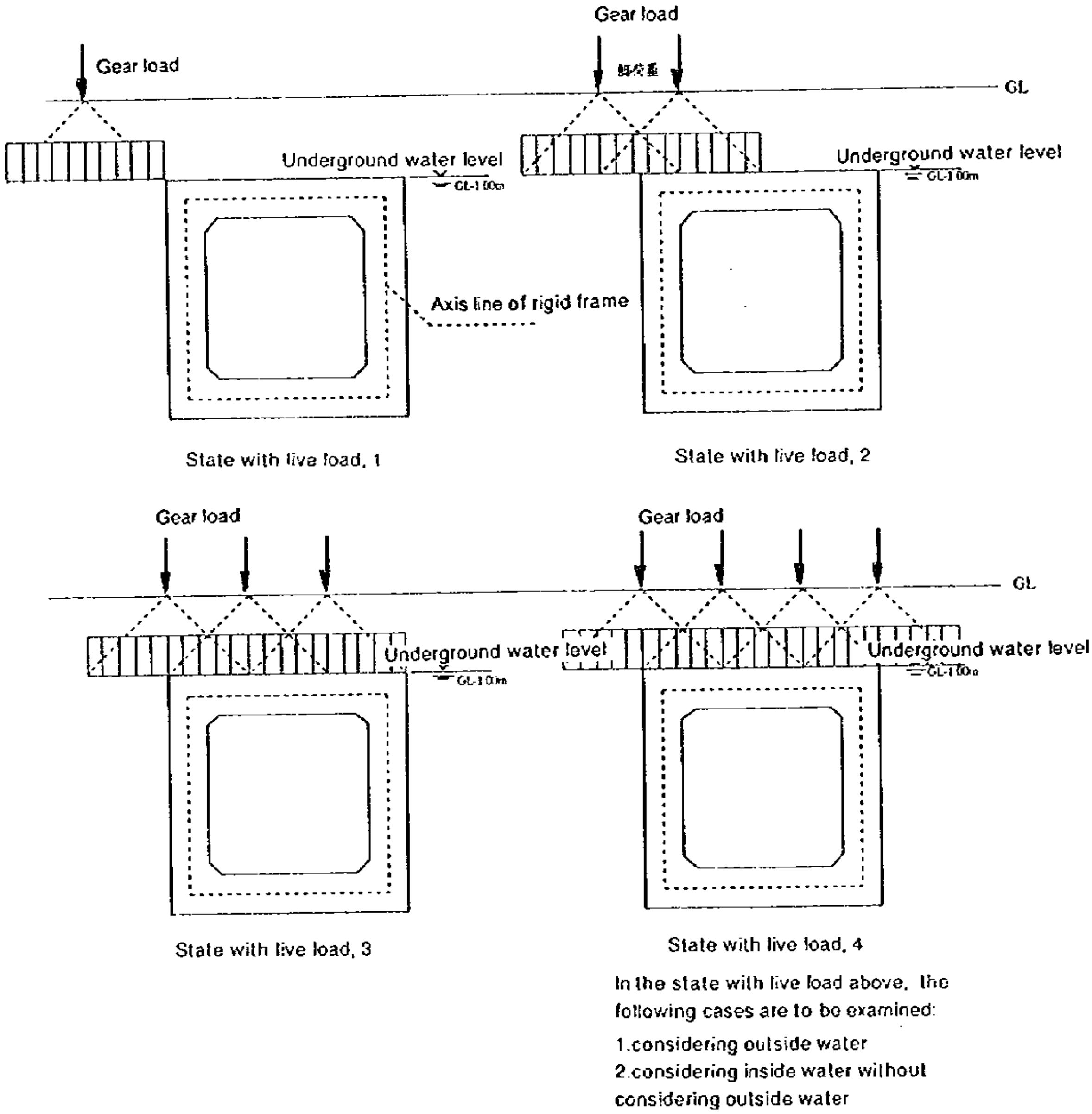
FigureII1-6.2.2 Design Flow of Box Culverts

Calculation of structure based on the design flow is described in the statement of design calculation in the Appendix.

In this Chapter, determination of the loaded state in analysis of structure and the results of calculation only are mentioned below.

(3) Determination of the Loaded State

As to live load acting on box culverts, the following four states were considered. Further, two cases were considered regarding each live load; the case of considering outer water and that of considering inside water without considering outside water. The loaded state was examined for a total of eight cases. Then, members were designed in the most disadvantageous state to structures.



FigureII-6.2.3 Loaded State in Examination of Box Culvert Structure

(4) Results of Examination

1) Box Culverts capable to accommodate Aircraft Load:

TableII1-6.2.2 shows the results of structure calculation of box culverts capable to accommodate aircraft load.

TableII1-6.2.2(1) Results of Structure Calculation of Box Culverts Capable of Accommodating Aircraft Load(1)

Inside Space: 1.40 m × 1.40 m

Item			Sectional intensity			Reinforcement	Stress intensity						Calculation of stability	
							Actual stress intensity			Allowable stress intensity				
			M	N	S	As	σc	σs	τ	σca	σsa	τa	Calculated value	Allowable value
			tfm	tf	tf	cm²	kgf/cm²	kgf/cm²	kgf/cm²	kgf/cm²	kgf/cm²	kgf/cm²		
Transverse section	Top slab	End part			8.41	φ18-150			4.67	83	1600	8.0		
		2d			4.65	〃			2.69	〃	〃	4.0		
		Middle part	3.57			〃	63	1355		〃	〃			
	Bottom slab	End part	4.65	7.78	8.41	φ14-150	41	1203	3.36	53	〃	5.4		
		Haunch(2d)	3.21	7.78	4.65	〃	36	942	1.94	〃	〃	2.7		
		Middle part	2.97	6.55		〃	33	1054		〃	〃			
	Side slab	Middle part	1.47	3.00		φ12-300	29	1326		〃	〃			
		Haunch(2d)	3.55	9.62	5.02	φ14-150	45	1170	2.18	〃	〃	2.7		
		End part	4.65	9.73	7.75	〃	47	1272	3.35	〃	〃	5.4		
Longitudinal section	Head part of side wall		180.99			φ32-100	51	1309		〃	〃			
	Bottom slab		-88.48			φ22-150	14	503		〃	〃			
	Rising												4.00 tf/m²	8.32 tf/m²
	Ground bearing capacity												14.77 tf/m²	38.37 tf/m²

Inside Space: 1.80 m × 1.80 m

Item			Sectional intensity			Reinforcement	Sucss intensity						Calculation of stability	
							Actual stress intensity			Allowable stress intensity				
			M	N	S	As	σc	σs	τ	σca	σsa	τa	Calculated value	Allowable value
			tfm	tf	tf	cm²	kgf/cm²	kgf/cm²	kgf/cm²	kgf/cm²	kgf/cm²	kgf/cm²		
Transverse section	Top slab	End part			10.87	φ20-150			4.73	83	1600	8.0		
		2d			6.32	〃			2.75	〃	〃	4.0		
		Middle part	5.98			〃	64	1437		〃	〃			
	Bottom slab	End part	7.82	10.37		φ16-150	43	1418	4.77	53	〃	5.4		
		Haunch(2d)	5.88	10.37		〃	44	1194	3.35	〃	〃	2.7		
		Middle part	3.59	8.41		φ14-300	35	1393		〃	〃			
	Side slab	Middle part	2.40	4.29		φ12-300	27	1430		〃	〃			
		Haunch(2d)	6.34	12.95	6.13	φ16-150	45	1417	1.85	〃	〃	2.7		
		End part	7.82	13.14	10.37	〃	49	1548	3.14	〃	〃	5.4		
Longitudinal section	Head part of side wall		315.04			φ22-100	51	1029		〃	〃			
	Bottom slab		-143.29			φ25-150	14	626		〃	〃			
	Rising												6.50 tf/m²	11.96 tf/m²
	Ground bearing capacity												11.32 tf/m²	38.58 tf/m²

Inside Space: 2.40 m × 2.00 m

Item			Sectional intensity			Reinforcement	Sucss intensity						Calculation of stability	
							Actual stress intensity			Allowable stress intensity				
			M	N	S	As	σc	σs	τ	σca	σsa	τa	Calculated value	Allowable value
			tfm	tf	tf	cm²	kgf/cm²	kgf/cm²	kgf/cm²	kgf/cm²	kgf/cm²	kgf/cm²		
Transverse section	Top slab	End part	6.76	5.19	15.16	φ16-150	48	1477	5.41	53	1600	5.4		
		2d	4.59	5.19	9.63	〃	40	1178	3.44	〃	〃	2.7		
		Middle part	5.03	3.97		〃	43	1349		〃	〃			
	Bottom slab	End part	8.06	9.83	17.69	〃	41	1267	5.05	〃	〃	5.4		
		Haunch(2d)	5.87	9.83	10.60	〃	35	991	3.03	〃	〃	2.7		
		Middle part	6.60	7.53		φ14-150	40	1478		〃	〃			
	Side slab	Middle part	6.76	3.89	9.96	φ16-150	34	1314	3.02	〃	〃			
		Haunch(2d)	6.00	15.32	5.54	〃	41	945	1.68	〃	〃	2.7		
		End part	2.94	16.41		φ12-300	21	315		〃	〃	5.4		
Longitudinal section	Head part of side wall		470.91			φ16-150	24	1464		〃	〃			
	Bottom slab		-213.72			φ22-150	14	1248		〃	〃			
	Rising												8.96 tf/m²	17.59 tf/m²
	Ground bearing capacity												14.41 tf/m²	41.41 tf/m²

TableII1-6.2.2(2) Results of Structure Calculation of Box Culverts Capable of Accommodating Aircraft Load(2)

Inside Space: 1.80 m (2) × 1.80 m

Item			Sectional intensity			Reinforcement	Stress intensity						Calculation of stability	
							Actual stress intensity			Allowable stress intensity				
			M	N	S	As	σc	σs	τ	σca	σsa	τa	Calculated value	Allowable value
			tfm	tf	tf	cm²	kgf/cm²	kgf/cm²	kgf/cm²	kgf/cm²	kgf/cm²	kgf/cm²		
Transverse section	Top slab	End part	3.62	4.16	11.65	φ12-150	42	1455	5.17	55	1600	5.4		
		Haunch	2.13	4.16	7.34	〃	32	1041	3.19	〃	〃	2.7		
		Middle part	2.56	5.01		φ16-300	41	1392		〃	〃			
		Haunch	3.17	4.77		φ14-300 φ12-300	43	1223		〃	〃			
		End part	4.84	4.79		〃 〃	47	1533		〃	〃			
	Bottom slab	End part	3.72	7.47	15.67	φ14-300	33	1341	5.22	〃	〃	5.4		
		Haunch	2.45	7.25	9.27	〃	25	891	3.09	〃	〃	2.7		
		Middle part	3.79	7.08		φ16-300	31	1290		〃	〃			
		Haunch	4.14	7.08		φ14-150	35	1091		〃	〃			
		End part	6.37	7.08		〃	44	1540		〃	〃			
	Side slab	End part	3.62	10.65	7.45	φ12-150	34	856	2.65	〃	〃	5.4		
		Haunch	3.02	10.8	6.16	〃	32	816	2.2	〃	〃	2.7		
		Middle part	1.55	4.45		φ12-300	22	916		〃	〃			
		Haunch	2.67	11.1		φ14-300	31	672		〃	〃			
		End part	3.72	11.24		〃	35	1197		〃	〃			
	Partition wall	End part	2.80	13.83	2.47	φ12-300	34	889	1.07	〃	〃	5.4		
		Haunch	2.43	13.94	2.47	〃	49	1000	1.07	〃	〃	2.7		
		Haunch	2.13	15.39		〃	31	537		〃	〃			
		End part	2.50	15.5		〃	27	492		〃	〃			
Longitudinal section	M-MAX		592.80			φ25-150	8	926		〃	〃			
	M-MIN		-255.52			φ14-150				〃	〃			
	Rising												11.50 tf/m²	22.81 tf/m²
	Ground bearing capacity												13.02 tf/m²	40.79 tf/m²

Inside Space: 2.40 m (2) × 2.00 m

Item			Sectional intensity			Reinforcement	Stress intensity						Calculation of stability	
							Actual stress intensity			Allowable stress intensity				
			M	N	S	As	σc	σs	τ	σca	σsa	τa	Calculated value	Allowable value
			tfm	tf	tf	cm²	kgf/cm²	kgf/cm²	kgf/cm²	kgf/cm²	kgf/cm²	kgf/cm²		
Transverse section	Top slab	End part	4.96	4.96	15.4	φ12-300	42	1513	5.5	55	1600	5.4		
		Haunch	3.13	4.99	9.86	〃	32	1093	3.52	〃	〃	2.7		
		Middle part	4.51	5.76		φ14-150	45	1437		〃	〃			
		Haunch	5.60	5.42		φ12-300	49	1174		〃	〃			
		End part	8.09	5.42		〃	51	1377		〃	〃			
	Bottom slab	End part	4.86	8.47	19.45	φ16-300	31	1234	5.56	〃	〃	5.4		
		Haunch	3.23	8.1	11.55	〃	24	822	3.3	〃	〃	2.7		
		Middle part	5.98	7.68		φ14-150	37	1292		〃	〃			
		Haunch	7.35	7.68		φ16-300	40	1133		〃	〃			
		End part	10.45	7.68		〃	45	1462		〃	〃			
	Side slab	End part	4.98	13.09	8.47	φ12-300	40	1104	3.03	〃	〃	5.4		
		Haunch	4.26	13.21	6.94	〃	43	1113	2.45	〃	〃	2.7		
		Middle part	1.75	5.5		〃	24	951		〃	〃			
		Haunch	3.67	13.81		φ16-300	41	1055		〃	〃			
		End part	4.89	13.95		〃	42	1297		〃	〃			
	Partition wall	End part	3.73	18.45	2.92	φ14-300	42	941	1.04	〃	〃	5.4		
		Haunch	3.28	18.6	2.92	〃	50	1066	1.04	〃	〃	2.7		
		Haunch	2.65	20.24		〃	40	619		〃	〃			
		End part	3.26	20.35		〃	34	545		〃	〃			
Longitudinal section	M-MAX		763.52			φ25-150	8	926		〃	〃			
	M-MIN		-370.93			φ14-150				〃	〃			
	Rising												16.24 tf/m²	29.54 tf/m²
	Ground bearing capacity												13.36 tf/m²	46.17 tf/m²

2) Box Culverts Capable of Accommodating Load of Large-Sized Fire Fighting Truck

TableII1-6.2.3 shows the results of structure calculation of box culverts capable to accommodating load of large-sized fire fighting truck.

TableII1-6.2.3 Result of Structure Calculation of Box Culverts Capable of Accommodating Load of Large - Sized Fire Fighting Truck

Inside Space: 1.80 m × 1.80 m

Item			Sectional intensity			Reinforcement	Stress intensity						Calculation of stability	
							Actual stress intensity			Allowable stress intensity				
			M	N	S	As	σc	σs	τ	σca	σsa	τa	Calculated value	Allowable value
			tfm	tf	tf	cm²	kgf/cm²	kgf/cm²	kgf/cm²	kgf/cm²	kgf/cm²	kgf/cm²		
Transverse section	Top slab	End part	0.01	0	5.13	φ14-150			2.55	83	1600	8		
		2d	0.00	0	3.33	″			1.85	″	″	4		
		Middle part	2.63	0	0	″	55	1592		″	″			
	Bottom slab	End part	2.71	6.85	6.62	φ4-300	40	1355	3.31	53	″	5.4		
		Haunch(2d)	1.80	6.85	4.22	″	35	1017	2.11	″	″	2.7		
		Middle part	1.47	4.37		φ12-300	28	1053		″	″			
	Side slab	Middle part	1.44	5.38		φ12-300	41	1354		″	″			
		Haunch(2d)	1.75	6.38	4.67	φ14-300	44	1298	2.59	″	″	2.7		
		End part	2.71	6.47	6.85	″	47	1571	3.62	″	″	5.4		
Longitudinal section	Head part of side wall		37.39			φ12-100	15	858		″	″			
	Bottom slab		-46.05			φ12-300	11	1370		″	″			
	Rising												5.41 tf/m²	12.93 tf/m²
	Ground bearing capacity												9.16 tf/m²	10.20 tf/m²

Inside Space: 2.40 m × 2.00 m

Item			Sectional intensity			Reinforcement	Stress intensity						Calculation of stability	
							Actual stress intensity			Allowable stress intensity				
			M	N	S	As	σc	σs	τ	σca	σsa	τa	Calculated value	Allowable value
			tfm	tf	tf	cm²	kgf/cm²	kgf/cm²	kgf/cm²	kgf/cm²	kgf/cm²	kgf/cm²		
Transverse section	Top slab	End part	2.61	4.75	6.72	φ14-300	49	1541	3.73	53	1600	5.4		
		2d	1.65	4.75	4.92	″	43	1333	2.73	″	″	2.7		
		Middle part	2.26	3.15		φ18-300	50	1415		″	″			
	Bottom slab	End part	3.01	6.63	8.2	φ16-300	41	1226	4.1	″	″	5.4		
		Haunch(2d)	1.87	6.63	5.77	″	34	888	2.69	″	″	2.7		
		Middle part	3.18	3.85		φ18-300	48	1455		″	″			
	Side slab	Middle part	3.01	8.01	6.64	φ16-300	48	1350	3.69	″	″	5.4		
		Haunch(2d)	2.08	7.91	4.32	″	45	1197	2.4	″	″	2.7		
		End part	0.71	6.66		φ12-300	15	157		″	″			
Longitudinal section	M-MAX		69.28			φ12-300	8	926		″	″			
	M-MIN		-81.74			″	9	1071		″	″			
	Rising												7.4 tf/m²	17.88 tf/m²
	Ground bearing capacity												10.58 tf/m²	10.77 tf/m²

Inside Space: 2.40 m(2) × 2.00 m

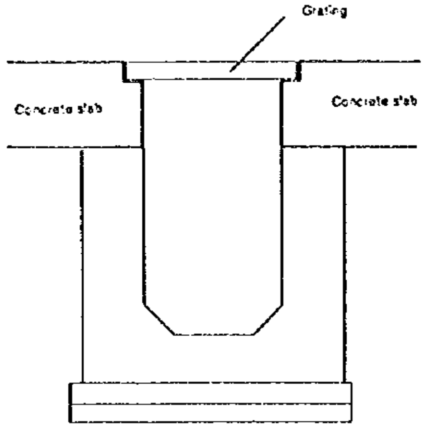
Item			Sectional intensity			Reinforcement	Stress intensity						Calculate of stability	
							Actual stress intensity			Allowable stress intensity				
			M	N	S	As	σc	σs	τ	σca	σsa	τa	Calculated value	Allowable value
			tfm	tf	tf	cm²	kgf/cm²	kgf/cm²	kgf/cm²	kgf/cm²	kgf/cm²	kgf/cm²		
Transverse section	Top slab	End part	2.41	4.76	7.23	φ14-300	43	1461	4.02	53	1600	5.4		
		Haunch	1.54	4.76	5.43	″	40	1219	3.02	″	″	2.7		
		Middle part	1.77	3.37		φ16-300	42	1292		″	″			
		Haunch	2.43	3.32		φ14-150	59	1282		″	″			
		End part	3.46	3.32		″	49	1356		″	″			
	Bottom slab	End part	2.62	6.47	6.83	φ14-300	37	1303	4.42	″	″	5.4		
		Haunch	1.61	6.47	6.49	″	31	873	3.25	″	″	2.7		
		Middle part	2.20	3.82		″	49	1458		″	″			
		Haunch	3.07	3.82		φ14-150	43	1224		″	″			
		End part	4.35	3.82		″	53	1587		″	″			
	Side slab	End part	2.49	6.38	6.47	φ14-300	42	1403	3.59	″	″	5.4		
		Haunch	1.87	7.73	4.47	″	44	1291	2.48	″	″	2.7		
		Middle part	0.85	6.49		φ12-300	29	393		″	″			
		Haunch	1.72	7.66		φ14-300	43	1136		″	″			
		End part	2.61	7.76		″	45	1414		″	″			
	Partition wall	End part	0.33	13.08	0.27	φ12-300	7	-39	0.15	″	″	5.4		
		Haunch	0.29	13.11	0.27	″	8	-51	0.15	″	″	2.7		
		Haunch	0.25	14.49		″	9	-57		″	″			
		End part	0.29	14.19		″	7	-48		″	″			
Longitudinal section	M-MAX		130.03			φ12-300	8	926		″	″			
	M-MIN		-148.23	-		″		-		″	″			
	Rising												14.15 tf/m²	33.04 tf/m²
	Ground bearing capacity												9.15 tf/m²	10.77 tf/m²

6.2.2 U-Shaped Ditches

(1) U-shaped Ditch of Capable of Accommodating Aircraft Load

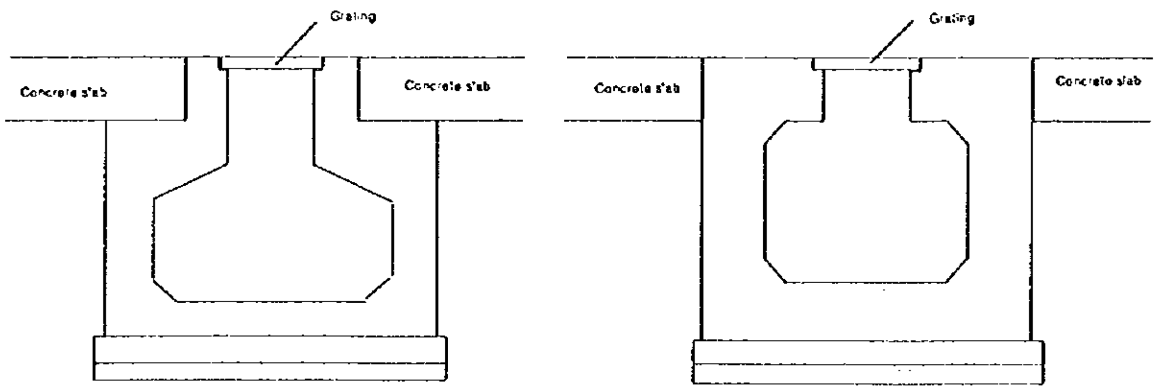
1) Determination of Standard Structure

Surface drain ditches to be installed on the ground of the apron are structures directly receiving aircraft load. In existing Chinese airports, there are examples of employing structures where concrete pavement slabs are placed directly on ordinary U-shaped ditches. What can be pointed out is a matter of safety when action such as expansion / contraction of concrete pavement occurs.



FigureII1-6.2.4 Example of U-Shaped Ditch in China

Therefore, for surface drain ditches in the apron of this airport, the following two plans were compared and examined. Type 1 is designed to realize uniformity of concrete pavement and surface drain ditches. Dog is placed on a surface drain ditch, and concrete pavement is placed on it. This allows to avoid difference in level between them.



Type－1 Type－2

FigureII1-6.2.5 Plans to Basic Form of U-shaped Ditch Capable of Accommodating Aircraft Load

Calculation of structure was carried out for both types. Water-running section was set up almost in the same way.

Type 1:

Volume of concrete $V = 1.98\ m^3$

Type 2:

Volume of concrete V = 2.84 m3

For the following reasons, Type 1 was retained as the basic form of U-shaped ditches:.

- Volume of concrete of Type 2 is 1.4 times as large as that of Type 1;
- Type 1 is advantageous in terms of prevention of difference in level (caused by settlement) in the part connecting pavement and a drain ditch.
- Structure similar to Type 1 have been employed in New Tokyo International Airport, Tokyo International Airport ,etc. in Japan.

2) Examined Section

The section of a U-shaped ditch was determined as follows:

- For width of channel, even numbers should be used.
- Length of one block of ditch should be 20 m.
- Foundation should be as follows:

  - leveling concrete (C15): 15 cm.
  - foundation crushed stone: 15 cm.

  Width of the part projecting from the bottom slab should be 30 cm.

- Width of excavation of foundation for constructing box culverts should be 50 cm from the end of foundation crushed stone. Excavation gradient should be:
  - 1:0.3, if depth of excavation is 3 m or less
  - 1:0.5, if the depth is over 3 m.

For basic design, the following sections of U-shaped ditches examined.

TableII-6.2.4 Sections Examined in Structured Calculation of U-Shaped Ditches Capable of Accommodating Aircraft Load

Load	Inside space		Structure	Symbol
	Width (m)	Height (m)		
Aircraft load	1.40 1.40	0.55 1.20	Grating	U-TYPE(A)

3) Design Concept

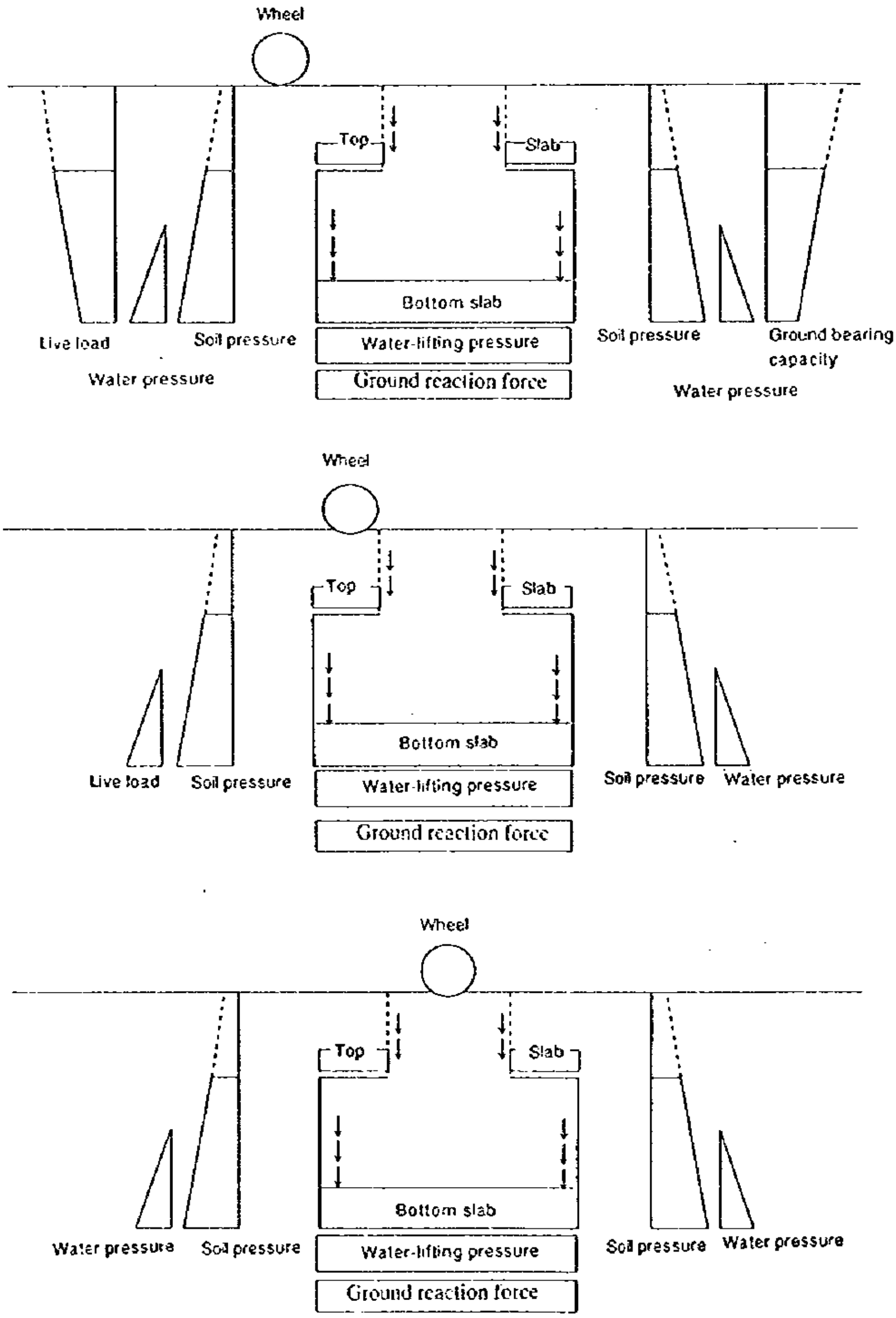
The design concept was basically the same as that adopted for structure of box culverts as follows:

• As a model for structure analysis, the plane frame model should be used.
• First, thickness of members was assumed.
• Members were designed under the severest load condition to structures.

Structural calculation is included in the statement of design calculation in the Appendix.

4) Determination of Loaded State

The following 3 states were considered as the state with live load acting on U-shaped ditches:



FigureII-6.2.4 Loaded State for Examination of Structure of U-Shaped Ditches

5) Results of Examination

TableII1-6.2.5 shows the calculation results of structure of U-shaped ditches capable of accommodating aircraft load.

6) Design of Grating

Structure of grading covers which are capable of accommodating aircraft load was examined. Consideration was given to existing grating examples in China. Structure calculation is included in the statement of design calculation in the Appendix.

TableII1-6.2.5 Results of Structure Calculation of U-Shaped Ditches Capable of Accommodating Aircraft load

Inside Space: 1.40 m × 0.55 m

Item			Sectional intensity			Reinforcement	Stress intensity						Calculate of stability	
							Actual stress intensity			Allowable stress intensity				
			M	N	S	As	σc	σs	τ	σca	σsa	τa	Calculated value	Allowable value
			tfm	tf	tf	cm²	kgf/cm²	kgf/cm²	kgf/cm²	kgf/cm²	kgf/cm²	kgf/cm²		
Transverse section	Top slab	End part	3.65	0.00	10.75	φ16-300	23	1357	2.50	53	1600	5.4		
	Bottom slab	End part	4.18	1.21	11.69	φ20-300	38	1376	4.68	〃	1600	〃		
		Haunch	3.97	6.78	6.19	〃	46	1297	2.45	〃	〃			
	Side slab	Haunch	4.01	11.57	2.97	〃	42	984	1.29	〃	〃			
		Lower end	4.18	11.69	4.85	〃	53	1274	2.10	〃	〃	7.0		
Longitudinal section	Top slab		275.21			φ32-150	53	1461		〃	〃			
	Bottom slab		-166.36			φ32-150	21	697		〃	〃			
	Rising												3.43 tf/m²	6.05 tf/m²
	Ground bearing capacity												15.09 tf/m²	34.45 tf/m²

Inside Space: 1.40 m × 1.20 m

Item			Sectional intensity			Reinforcement	Stress intensity						Calculate of stability	
							Actual stress intensity			Allowable stress intensity				
			M	N	S	As	σc	σs	τ	σca	σsa	τa	Calculated value	Allowable value
			tfm	tf	tf	cm²	kgf/cm²	kgf/cm²	kgf/cm²	kgf/cm²	kgf/cm²	kgf/cm²		
Transverse section	Top slab	End part	3.92	0.00	10.60	φ16-300	23	1455	2.51	53	1600	5.4		
	Bottom slab	End part	7.59	7.78	12.49	φ18-150	44	1181	4.16	〃	1600	〃		
		Haunch	7.18	7.78	3.92	〃	52	1337	1.33	〃	〃			
	Side slab	Haunch	6.47	2.87	7.78	〃	53	1457	2.04	〃	〃			
		Lower end	7.59	3.01	5.60	〃	47	1425	2.78	〃	〃	7.0		
Longitudinal section	Top slab		403.64			φ32-150	49	1567		〃	〃			
	Bottom slab		-237.68			φ -150	23	1523		〃	〃			
	Rising												5.04 tf/m²	7.78 tf/m²
	Ground bearing capacity												15.15 tf/m²	37.15 tf/m²

(2) U-Shaped Ditches Capable of Accommodating Car Load

1) Examined Section

There are following two kinds of U-shaped ditches are capable of accommodating car load (T-15):

- those which have a cover and are installed between the runway and the parallel taxiways, and
- those which have no cover and are installed in other places.

The form of structural section was determined as follows:

- Length of one block of ditch should be 20 m.
- 20 mm joints will be placed between blocks, and are included in the length of a block.
- The foundation was determined as follows:

- leveling concrete (C15) 15 cm
- foundation crushed stone 15 cm

The part projecting from the bottom slab should be 10 cm.

- Width of excavation for foundation should b3 50 cm above the end of crushed stone. Excavation gradient should be:

- 1:0.3, if depth of excavation is under 3 m,
- 1:0.5, if the depth is 3 m or more.

For basic design, the following sections of U-shaped ditches were examined.

TableII1-6.2.6 Sections Examined in Structure Calculation of U-Shaped Ditches Capable of Accommodating Car Load

Load	Inside space (m)		Structure	Symbol
Car load	1.80	3.00	Without a cover	U-TYPE1(T15)
	4.25	4.20		
	1.80	3.00	With a cover	U-TYPE2(T15)

2) Design concept

The design concept is basically the same as that of U-shaped ditches which are capable of accommodating aircraft load.

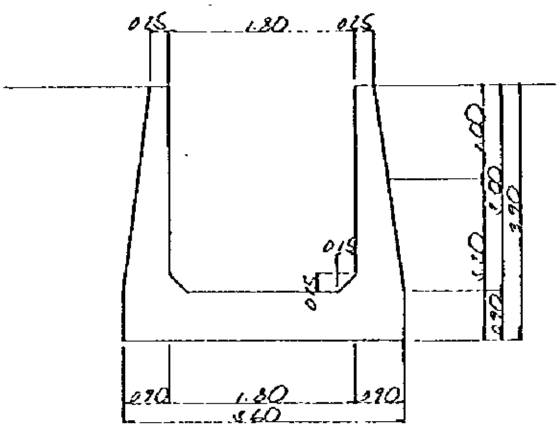
Structural calculation is described in the statement of design calculation in the Appendix.

3) Result of Examination

TableII1-6.2.7 shows the result of structural calculation of U-shaped ditches which are capable of accommodating car load. The ditch structure includes a concrete cover.

TableII1-6.2.7(1) Calculation Results of U-Shaped Ditches Capable of Accommodating Car Load (1)

Inside Space: 1.80 m × 3.00 m (without a cover)



Calculation of bending stress intensity (sidewall)

	Lower end	Starting point haunch	Middle	
M (tm)	60.78	56.26	17.18	
N (t)	2.35	2.19	0.85	
S (t)	0.00	0.00	0.00	
b (cm)	100.00	100.00	100.00	
h (cm)	95.00	90.00	62.00	
f (cm)	12.00	7.00	7.00	
f' (cm)	7.00	7.00	7.00	
d (cm)	88.00	83.00	55.00	
As (cm²)	D25-10.0 49.09	D25-10.0 49.09	D25-5.0 24.55	
As' (cm²)	D25-5.0 24.55	D25-5.0 24.55	D25-5.0 24.55	
k	0.3195	0.3210	0.2799	
x (cm)	28.11	26.64	15.40	
{C}	6.1186	5.7716	6.2988	
{S}	13.0335	12.2095	16.2028	
{Z}	1.1226	1.1136	1.1106	
σc	49	48	36	
σs	1,558	1,518	1,397	
τm	0.00	0.00	0.00	
σck	160	160	160	
σca	53	53	53	
σsa	1,600	1,600	1,600	
τal	0.00	0.00	0.00	
Mc	40.27	36.14	17.08	
4/3・M	81.04	75.01	22.91	
As min	17.60	16.60	11.00	

Calculation of bending stress intensity (lower slab)

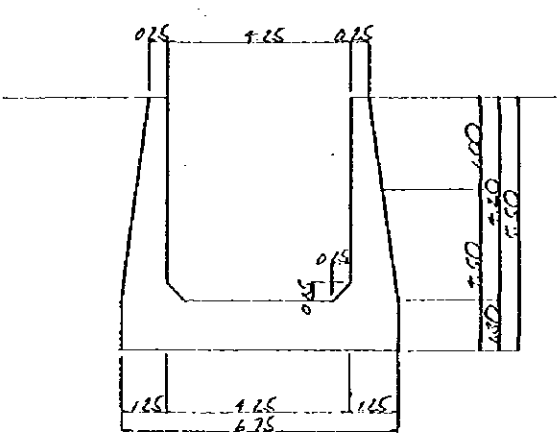
	End part	Starting point of haunch		
M (tm)	60.78	60.05		
N (t)	30.13	30.13		
S (t)	0.00	0.00		
b (cm)	100.00	100.00		
h (cm)	95.00	90.00		
f (cm)	12.00	7.00		
f' (cm)	10.00	10.00		
d (cm)	85.00	80.00		
As (cm2)	D25-10.0 49.09	D25-10.0 49.09		
As' (cm2)	D32-5.0 40.21	D32-5.0 40.21		
k	0.3603	0.3586		
x (cm)	30.63	28.69		
{C}	5.1132	4.7647		
{S}	9.0785	8.5225		
{Z}	1.1196	1.1045		
σc	51	53		
σs	1,359	1,410		
τm	0.00	0.00		
σck	160	160		
σca	53	53		
σsa	1,600	1,600		
τal	0.00	0.00		
Mc	44.67	40.33		
4/3・M	81.04	80.07		
As min	17.00	16.00		

Calculation of bending stress intensity

	End part of side wall	End part of bottom slab		
M (tm)	0.00	0.00		
N (t)	0.00	0.00		
S (t)	30.49	5.17		
b (cm)	100.00	100.00		
h (cm)	90.00	90.00		
f (cm)	7.00	7.00		
f' (cm)	7.00	10.00		
d (cm)	83.00	80.00		
As (cm2)	D25-10.0 49.09	D25-10.0 49.09		
As' (cm2)	D25-5.0 24.55	D32-5.0 40.21		
k	0.3171	0.3072		
x (cm)	26.32	24.58		
{C}	5.8278	5.3450		
{S}	12.5528	12.0519		
{Z}	1.1137	1.1093		
σc	0	0		
σs	0	0		
τm	3.67	0.65		
σck	160	160		
σca	0	0		
σsa	0	0		
τal	5.40	5.40		
Mc	35.81	35.81		
4/3・M	0.00	0.00		
As min	16.60	16.00		

TableII1-6.2.7(2) Calculation Results of U-Shaped Ditches Capable of Accommodating Car Load (2)

Inside Space: 4.25 m × 4.20 m (without a cover)



Calculation of bending stress intensity (sidewall)

	Lower part	Starting point of haunch	Middle	
M (tm)	128.02	120.97	35.05	
N (t)	4.66	4.47	1.94	
S (t)	0.00	0.00	0.00	
b (cm)	100.00	100.00	100.00	
h (cm)	130.00	125.00	83.00	
f (cm)	12.00	7.00	7.00	
f' (cm)	7.00	7.00	7.00	
d (cm)	123.00	118.00	76.00	
As (cm²)	D32-10.0 80.42	D32-10.0 80.42	D32-5.0 40.21	
As' (cm²)	D25-5.0 24.55	D25-5.0 24.55	D25-5.0 24.55	
k	0.3448	0.3475	0.3061	
x (cm)	42.41	41.00	23.26	
{C}	5.8151	5.6197	5.9467	
{S}	11.0486	10.5545	13.4839	
{Z}	1.1253	1.1195	1.1097	
σc	50	50	37	
σs	1,432	1,404	1,251	
τm	0.00	0.00	0.00	
σck	160	160	160	
σca	53	53	53	
σsa	1,600	1,600	1,600	
τal	0.00	0.00	0.00	
Mc	75.72	70.01	30.72	
4/3 · M	170.69	161.29	46.73	
As min	24.60	23.60	15.20	

Calculation of bending stress intensity (lower slab)

	End part	Staring point of haunch		
M (tm)	128.02	126.64		
N (t)	46.78	46.78		
S (t)	0.00	0.00		
b (cm)	100.00	100.00		
h (cm)	135.00	130.00		
f (cm)	12.00	7.00		
f' (cm)	10.00	10.00		
d (cm)	125.00	120.00		
As (cm²)	D32-10.0 80.42	D32-10.0 80.42		
As' (cm²)	D22-10.0 38.01	D22-10.0 38.01		
k	0.3874	0.3884		
x (cm)	48.42	46.61		
{C}	5.0077	4.8290		
{S}	7.9197	7.6038		
{Z}	1.1138	1.1048		
σc	50	51		
σs	1,178	1,207		
τm	0.00	0.00		
σck	160	160		
σca	53	53		
σsa	1,600	1,600		
τal	0.00	0.00		
Mc	91.10	81.85		
4/3 · M	170.69	168.85		
As min	25.00	24.00		

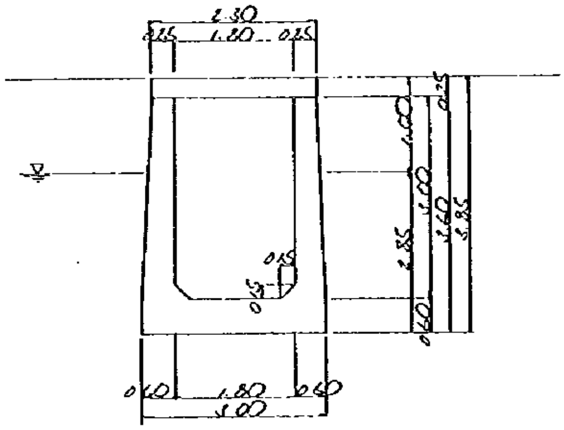
Calculation of bending stress intensity

	End part of side wall	End part of bottom slab		
M (tm)	0.00	0.00		
N (t)	0.00	0.00		
S (t)	47.51	9.46		
b (cm)	100.00	100.00		
h (cm)	125.00	130.00		
f (cm)	7.00	7.00		
f' (cm)	7.00	10.00		
d (cm)	118.00	120.00		
As (cm²)	D32-10.0 80.82	D32-10.0 80.82		
As' (cm²)	D25-5.0 24.55	D20-10.0 31.42		
k	0.3419	0.3347		
x (cm)	40.35	40.17		
{C}	5.6904	5.5795		
{S}	10.9517	11.0892		
{Z}	1.1196	1.1147		
σc	0	0		
σs	0	0		
τm	4.03	0.79		
σck	160	160		
σca	0	0		
σsa	0	0		
τal	5.40	5.40		
Mc	69.08	74.71		
4/3 · M	0.00	0.00		
As min	23.60	24.00		

TableII1-6.2.7(3)-1 Calculation Results of U-Shaped Ditches Capable of Accommodating Car Load (1)

Inside Space: 1.80 m × 3.00 m (without a cover):

Result of calculation with a cover



Calculation of bending stress intensity (upper slab)

	Lower part of slab	End part		
M (tm)	3.50	0.00		
N (t)	0.00	0.00		
S (t)	0.00	6.85		
b (cm)	100.00	100.00		
h (cm)	25.00	25.00		
f (cm)	7.00	7.00		
f' (cm)	7.00	7.00		
d (cm)	18.00	18.00		
As (cm^2)	D14-10.0 15.39	D14-10.0 15.39		
As' (cm^2)	D14-5.0 7.70	D14-5 7.70		
k	0.3936	0.3936		
x (cm)	7.09	7.09		
{C}	5.8324	5.8324		
{S}	8.9852	8.9852		
{Z}	1.1524	1.1524		
σc	63	0		
σs	1,456	0		
τm	0.00	3.81		
σck	160	160		
σca	83	83		
σsa	1,800	1,800		
τa1	0.00	8.00		
Mc	2.76	2.76		
4/3 · M	4.67	0.00		
As min	3.60	3.60		

Calculation of bending stress intensity (sidewall)

	Lower end	Starting point of haunch	Middle	
M (tm)	5.76	4.26	4.47	
N (t)	3.79	3.66	2.40	
S (t)	0.00	0.00	0.00	
b (cm)	100.00	100.00	100.00	
h (cm)	65.00	60.00	60.00	
f (cm)	12.00	7.00	7.00	
f' (cm)	7.00	7.00	7.00	
d (cm)	58.00	53.00	53.00	
As (cm^2)	D25-10.0 49.09	D25-10.0 49.09	D22-5.0 19.01	
As' (cm^2)	D22-5.0 19.01	D22-5.0 19.01	D25-5.0 24.55	
k	0.4252	0.4427	0.2816	
x (cm)	24.66	23.46	14.92	
{C}	4.9391	4.5158	6.2665	
{S}	6.6778	5.6847	15.9895	
{Z}	1.1505	1.1399	1.1021	
σc	10	8	11	
σs	200	155	429	
τm	0.00	0.00	0.00	
σck	160	160	160	
σca	53	53	53	
σsa	1,600	1,600	1,600	
τa1	0.00	0.00	0.00	
Mc	19.09	16.28	16.16	
4/3 · M	7.68	5.68	5.96	
As min	11.60	10.60	10.60	

Calculation of bending stress intensity (lower slab)

	End part	Starting point of haunch		
M (tm)	5.76	5.15		
N (t)	10.14	10.14		
S (t)	0.00	0.00		
b (cm)	100.00	100.00		
h (cm)	65.00	60.00		
f (cm)	12.00	7.00		
f' (cm)	7.00	7.00		
d (cm)	58.00	53.00		
As (cm^2)	D25-10.0 49.09	D25-10.0 49.09		
As' (cm^2)	D25-10.0 49.09	D25-10.0 49.09		
k	0.4891	0.5001		
x (cm)	28.37	26.50		
{C}	3.8056	3.3659		
{S}	3.9753	3.3648		
{Z}	1.1282	1.0984		
σc	9	9		
σs	148	134		
τm	0.00	0.00		
σck	160	160		
σca	53	53		
σsa	1,600	1,600		
τa1	0.00	0.00		
Mc	19.78	16.93		
4/3 · M	7.68	6.87		
As min	11.60	10.60		

TableII-6.2.7(3)-2 Calculation Results of U-Shaped Ditches Capable of Accommodating Car Load (1)

Inside Space: 1.80 m × 3.00 m (without a cover): Result of calculation with a cover

Calculation of bending stress intensity (sidewall)

	Lower end	Starting point of haunch	Middle	
M (tm)	30.41	27.79	7.82	
N (t)	3.40	3.27	2.01	
S (t)	0.00	0.00	0.00	
b (cm)	100.00	100.00	100.00	
h (cm)	65.00	60.00	44.00	
f (cm)	12.00	7.00	7.00	
f' (cm)	7.00	7.00	7.00	
d (cm)	58.00	53.00	37.00	
	D25-10.0	D25-10.0	D25-5.0	
As (cm2)	49.09	49.09	24.55	
	D22-5.0	D22-5.0	D22-5.0	
As' (cm2)	19.01	19.01	19.01	
k	0.3845	0.3892	0.3437	
x (cm)	22.30	20.63	12.72	
{C}	5.3877	4.9947	5.5477	
{S}	8.6250	7.8371	10.5925	
{Z}	1.1547	1.1464	1.1413	
σc	50	51	33	
σs	1,203	1,194	943	
τm	0.00	0.00	0.00	
σck	160	160	160	
σca	53	53	53	
σsa	1,600	1,600	1,600	
τal	0.00	0.00	0.00	
Mc	19.05	16.24	8.71	
4/3・M	40.55	37.05	10.43	
As min	11.60	10.60	7.40	

Calculation of bending stress intensity (lower side)

	End part	Starting point of haunch		
M (tm)	30.41	29.80		
N (t)	17.61	17.61		
S (t)	0.00	0.00		
b (cm)	100.00	100.00		
h (cm)	65.00	60.00		
f (cm)	12.00	7.00		
f' (cm)	10.00	10.00		
d (cm)	55.00	50.00		
	D25-10.0	D25-10.0		
As (cm2)	49.09	49.09		
	D25-10.0	D25-10.0		
As' (cm2)	49.09	49.09		
k	0.4016	0.3949		
x (cm)	22.09	19.75		
{C}	4.5099	3.9490		
{S}	6.7196	6.0500		
{Z}	1.1647	1.1415		
σc	51	53		
σs	1,145	1,210		
τm	0.00	0.00		
σck	160	160		
σca	53	53		
σsa	1,600	1,600		
τal	0.00	0.00		
Mc	20.59	17.68		
4/3・M	40.55	39.73		
As min	11.00	10.00		

Calculation of bending stress intensity

	Lower end of sidewall	Side wall 2d	End part of bottom slab	Bottom slab 2d
M (tm)	0.00	0.00	0.00	0.00
N (t)	0.00	0.00	0.00	0.00
S (t)	17.82	12.47	7.58	1.98
b (cm)	100.00	100.00	100.00	100.00
h (cm)	60.00	60.00	60.00	60.00
f (cm)	7.00	7.00	7.00	7.00
f' (cm)	7.00	7.00	10.00	10.00
d (cm)	53.00	53.00	50.00	50.00
	D25-10.0	D25-10.0	D25-10.0	D25-10.0
As (cm2)	49.09	49.09	49.09	49.09
	D22-5.0	D22-5.0	D25-10.0	D25-10.0
As' (cm2)	19.01	19.01	49.09	49.09
k	0.3811	0.3811	0.3555	0.3555
x (cm)	20.20	20.20	17.77	17.77
{C}	5.0805	5.0805	4.2835	4.2835
{S}	8.2523	8.2523	7.7664	7.7664
{Z}	1.1465	1.1465	1.1438	1.1438
σc	0	0	0	0
σs	0	0	0	0
τm	3.36	2.35	1.52	0.4
σck	160	160	160	160
σca	0	0	0	0
σsa	0	0	0	0
τal	5.40	2.70	5.40	2.70
Mc	15.92	15.92	15.92	15.92
4/3・M	0.00	0.00	0.00	0.00
As min	10.60	10.60	10.00	10.00

6.2.3 Estimated Quantity of Drainage Facilities

TableII1-6.2.8 shows the estimated quantity of drainage facilities.

The bases of calculation are shown in the Appendix.

(Ab6C)

FigureII-6.2.8 (1) Estimated Quantity of Drainage Facilities

Type	Route No	B	H	Overburden	Length	Concrete C30/C25	Concrete C20/C16	Concrete C15/C12	Form	Macadam Stone	Excavation	Backfill	Masonry Volume	Masonry Joint Sealing	Masonry Joint Filler	Joint (U-branch Box) Joint Sealing	Joint (U-branch Box) Joint Filler	Dowel Bar	Grating	Deformed Bar 12	14	16	18	20	22	25	32	Total
		(m)	(m)	(m)	(m)	(m3)	(m3)	(m3)	(m2)	(m3)	(m3)	(m3)	(m3)	(m2)	(m)	(m)	(m2)	(kg)	(unit)	(t)	(t)	(t)	(t)	(t)	(t)	(t)	(t)	(t)
Masonry	A1	2.00	1.87		4,151.39	0.00	0.00	0.00	0.00	0.00	39,767.71	0.00	3,304.04	17,488.12	51.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	A2	3.00	4.00		1,092.50	0.00	0.00	0.00	0.00	0.00	35,415.30	0.00	3,014.93	16,729.45	30.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	A8	1.00	1.40		910.00	0.00	0.00	0.00	0.00	0.00	4,676.38	0.00	1,677.09	5,423.60	16.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	A9	1.00	1.30		910.00	0.00	0.00	0.00	0.00	0.00	5,118.71	0.00	1,704.43	3,681.15	17.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL					[illegible]	0.00	0.00	0.00	0.00	0.00	[illegible]	0.00	13,834.50	43,314.70	136.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B-Type1	A2	1.00	1.00	0.45	534.74	17.94	119.60	32.36	941.02	32.36	1,276.51	802.61	0.00	0.00	0.00	21.90	7.10	387.31	0.00	4.09	4.13	0.80	3.02	2.29	3.79	0.40	20.86	39.49
	A2	1.20	1.20	0.50	203.00	94.31	394.47	47.15	1,436.72	47.15	2,370.03	1,407.17	0.00	0.00	0.00	40.60	19.36	95.09	0.00	4.22	7.36	0.60	2.29	4.02	6.48	0.00	36.37	61.92
	A2	1.60	1.60	0.70	203.00	157.46	463.97	93.25	3,138.72	93.25	3,782.23	2,508.13	0.00	0.00	0.00	36.00	22.63	404.86	0.00	6.77	12.19	12.38	0.00	13.59	13.33	10.76	0.00	68.96
	A2	1.80	1.80	1.33	487.61	[illegible]	1,220.34	234.06	5,733.19	234.06	12,498.37	9,060.43	0.00	0.00	0.00	116.00	40.07	2,197.27	0.00	14.60	32.92	32.43	0.00	33.60	34.11	20.19	0.00	180.63
	A3	1.80	1.80	0.50	81.80	39.90	212.76	40.80	797.64	40.80	1,660.83	1,070.87	0.00	0.00	0.00	20.40	10.61	351.21	0.00	2.91	3.72	3.61	0.00	6.21	6.09	4.91	0.00	31.49
	A5	1.40	1.40	0.35	438.00	251.08	672.09	167.70	3,863.12	167.70	5,088.11	3,992.81	0.00	0.00	0.00	101.86	32.02	1,336.35	0.00	19.52	17.20	0.00	13.36	9.55	15.39	0.00	86.46	161.08
	A5	1.60	1.60	1.50	301.30	363.13	1,136.89	225.60	1,207.20	225.60	16,654.82	13,633.19	0.00	0.00	0.00	140.00	36.58	2,612.13	0.00	13.54	30.46	30.79	0.00	31.21	32.61	26.33	0.00	168.72
	A5	1.20	1.20	0.43	91.50	[illegible]	131.12	34.36	762.17	34.36	1,006.61	406.61	0.00	0.00	0.00	17.00	5.49	363.41	0.00	3.63	3.71	0.00	2.46	1.87	3.02	1.18	17.04	31.99
	A6	1.60	1.60	0.80	113.00	97.31	257.28	31.16	1,380.34	31.16	2,307.31	1,475.43	0.00	0.00	0.00	28.00	11.32	493.43	0.00	5.33	6.93	4.87	0.00	7.58	7.39	5.97	0.00	38.27
	A6	1.80	1.80	0.75	170.90	142.71	476.96	81.64	1,960.77	81.64	3,646.44	2,344.33	0.00	0.00	0.00	49.60	20.07	703.47	0.00	5.69	11.47	11.36	0.00	12.45	12.21	9.45	0.00	63.13
	A7	1.40	1.40	0.20	99.50	55.91	151.32	38.01	893.91	38.01	1,082.06	406.43	0.00	0.00	0.00	19.60	6.23	292.60	0.00	4.32	3.90	0.00	2.91	2.21	3.56	0.00	20.10	37.28
SUB TOTAL					[illegible]	1,715.12	1,270.71	1,046.17	34,403.89	1,046.17	31,597.80	36,222.47	0.00	0.00	0.00	633.99	23.45	8,819.30	0.00	91.60	136.07	48.96	24.34	129.38	130.60	86.01	191.43	867.46
B-Type1(F)	A1	1.60	1.60	0.35	20.00	11.96	31.18	8.10	197.00	8.10	238.61	111.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.03	0.38	0.00	0.00	0.00	0.00	0.00	0.00	2.40
	A6	1.20	1.20	0.30	10.00	4.41	12.18	3.45	78.84	3.45	63.94	36.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.31	0.00	0.00	0.00	0.00	0.00	0.00	1.11
	A7	1.20	1.20	0.30	10.00	4.41	12.18	3.45	78.84	3.45	63.94	36.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.31	0.00	0.00	0.00	0.00	0.00	0.00	1.11
SUB TOTAL					40.00	20.49	55.33	15.00	335.56	15.00	367.57	203.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.63	1.00	0.00	0.00	0.00	0.00	0.00	0.00	5.05
B-Type1 Total					2,308.00	1,736.30	5,466.21	1,061.17	23,239.20	1,061.17	31,603.32	36,426.29	0.00	0.00	0.00	653.99	291.43	8,875.30	0.00	91.30	137.47	48.96	24.34	128.54	130.89	86.01	187.43	892.48
B-Type3	A3	3.60	1.80	0.66	170.00	0.00	864.70	172.80	2,664.49	132.40	3,079.79	2,809.59	0.00	0.00	0.00	102.40	40.68	2,107.26	0.00	27.77	19.92	9.81	0.00	0.00	0.00	18.13	0.00	75.69
	A3	4.80	2.00	1.40	263.11	0.00	1,787.13	234.93	4,859.77	254.93	11,571.31	6,709.12	0.00	0.00	0.00	204.10	87.49	3,806.79	0.00	41.40	44.77	11.79	29.90	6.21	16.09	36.81	0.00	186.97
TOTAL					433.11	0.00	2,633.63	387.31	7,527.36	387.51	14,561.30	9,514.71	0.00	0.00	0.00	306.50	128.37	5,913.05	0.00	69.13	64.69	21.70	29.90	6.21	16.09	33.14	0.00	262.66
U-Type1 (T15)	A3	1.80	2.72		305.00	0.00	1,826.55	112.85	3,914.31	112.85	7,371.61	4,032.71	0.00	0.00	0.00	134.10	69.61	1,073.36	0.00	0.00	4.94	2.93	0.00	44.34	0.00	167.51	39.74	251.06
	A3	1.00	1.75		85.10	0.00	349.91	20.15	441.38	20.13	899.80	467.34	0.00	0.00	0.00	25.20	12.37	351.24	0.00	0.00	0.79	0.33	0.00	6.04	0.00	22.02	4.05	34.21
	A3	3.80	3.15		510.10	0.00	5,172.84	330.10	8,203.43	330.30	21,971.01	9,340.70	0.00	0.00	0.00	326.70	263.57	4,741.30	0.00	0.00	20.41	1.44	0.00	130.30	0.00	473.23	89.40	727.78
	A3	4.25	3.99		472.50	0.00	6,314.81	314.21	8,839.53	314.21	28,633.96	11,092.01	0.00	0.00	0.00	336.49	317.12	4,480.37	0.00	0.00	24.73	9.02	0.00	157.90	0.00	396.84	101.98	696.30
	A4	1.00	1.80		430.00	0.00	2,039.79	182.50	5,442.90	182.50	7,398.30	3,978.55	0.00	0.00	0.00	168.80	100.42	2,809.70	0.00	0.00	7.75	2.83	0.00	99.47	0.00	186.86	33.18	380.09
	A7	1.40	2.00		129.00	0.00	500.91	38.70	1,341.90	38.70	2,078.69	1,182.11	0.00	0.00	0.00	40.80	33.30	61.17	0.00	0.00	1.90	0.00	0.00	15.15	0.00	43.89	8.15	68.79
TOTAL					3,187.30	0.00	16,304.20	978.60	28,346.03	978.60	66,751.33	30,633.85	0.00	0.00	0.00	1,030.09	696.50	14,825.31	0.00	0.00	62.70	22.46	0.00	400.29	0.00	1,313.13	268.30	2,166.30
U-Type1 (A)	A5	1.40	2.12		1,111.00	0.00	2,700.86	449.96	9,219.06	449.96	6,610.41	3,147.46	0.00	0.00	0.00	266.70	177.71	16,921.40	1,111.00	59.81	11.27	33.14	64.36	0.00	26.00	0.00	141.36	332.27
	A5	1.40	2.42		363.00	0.00	1,044.13	155.91	3,726.13	155.91	3,030.72	1,463.70	0.00	0.00	0.00	136.04	51.44	4,063.17	363.00	23.11	5.00	8.73	25.01	0.00	10.30	0.00	57.62	128.77
	A7	1.40	2.10		441.00	0.00	1,650.81	776.82	1,612.80	776.87	6,001.70	1,842.05	0.00	0.00	0.00	314.30	65.16	6,751.38	487.00	36.95	9.30	17.74	39.44	0.00	16.36	0.00	69.74	203.09
TOTAL					2,179.00	0.00	5,395.09	892.51	19,658.10	892.11	17,642.85	6,473.21	0.00	0.00	0.00	[illegible]	267.33	31,736.43	2,179.00	119.13	30.42	43.03	129.05	0.00	53.16	0.00	286.98	664.09
U-Type2(T15)	A2	1.20	1.63		193.00	94.77	267.76	70.20	1,722.24	70.20	2,119.26	1,347.06	0.00	0.00	0.00	38.23	13.36	997.67	0.00	6.73	4.03	0.47	0.00	0.00	13.74	43.89	0.00	74.36
	A2	1.80	1.89		195.00	122.66	482.87	36.11	2,041.26	36.11	2,306.02	1,016.62	0.00	0.00	0.00	37.02	32.38	46.11	0.00	16.71	1.06	1.06	0.00	0.00	17.24	59.09	0.00	97.19
	A2	1.80	2.76		467.00	411.25	2,302.20	203.67	9,305.12	203.67	13,302.01	7,332.12	0.00	0.00	0.00	353.44	116.07	609.18	0.00	31.09	24.14	9.30	0.00	0.00	83.27	281.90	0.00	444.39
	A6	1.20	2.05		717.00	330.36	1,773.16	172.08	7,613.11	172.08	8,330.82	4,372.11	0.00	0.00	0.00	313.00	86.34	335.45	0.00	20.44	16.13	3.91	0.00	0.00	61.93	232.15	0.00	334.36
	A6	1.60	2.96		85.00	48.71	317.08	25.30	1,263.91	25.30	1,479.27	1,049.01	0.00	0.00	0.00	72.00	14.94	51.15	0.00	6.09	3.16	0.00	0.00	0.00	10.78	36.95	0.00	58.24
TOTAL					1,649.00	1,006.93	5,223.00	528.00	21,941.60	524.00	28,179.38	15,116.96	0.00	0.00	0.00	181.39	232.17	1,474.96	0.00	115.43	14.50	11.73	0.00	0.00	185.90	617.14	0.00	1,008.94
TOTAL					14,368.09	3,766.13	35,087.93	3,877.90	101,896.33	3,877.90	242,848.90	98,271.09	13,834.50	43,514.30	136.41	3,292.07	1,706.38	52,824.15	2,179.00	389.41	349.84	200.32	183.17	535.08	385.88	2,298.64	736.83	5,080.97

(HIGH[illegible])

Figure II-1 – 6.2.8 (2) Estimated Quantity of Drainage Facilities

Type	River No.	B (m)	H (m)	Overburden (m)	Length (m)	Concrete C30/C25 (m3)	Concrete C20/C14 (m3)	Concrete C15/C12 (m3)	Form (m2)	Masonry Stone (m3)	Excavation (m3)	Backfill (m3)
Masonry	B1	2.00	2.15		[illegible]	0.00	0.00	0.00	0.00	0.00	[illegible]	0.00
	B2	3.00	3.30		20.00	0.00	0.00	0.00	0.00	0.00	[illegible]	0.00
	B2	3.50	3.80		[illegible]	0.00	0.00	0.00	0.00	0.00	[illegible]	0.00
	B2	4.00	4.76		[illegible]	0.00	0.00	0.00	0.00	0.00	[illegible]	0.00
	B2	4.50	5.08		[illegible]	0.00	0.00	0.00	0.00	0.00	[illegible]	0.00
	B4	1.00	2.55		[illegible]	0.00	0.00	0.00	0.00	0.00	[illegible]	0.00
	B4	1.00	2.80		[illegible]	0.00	0.00	0.00	0.00	0.00	[illegible]	0.00
	B4	1.00	3.10		[illegible]	0.00	0.00	0.00	0.00	0.00	[illegible]	0.00
	B4	1.00	3.40		[illegible]	0.00	0.00	0.00	0.00	0.00	[illegible]	0.00
	B4	1.00	3.60		[illegible]	0.00	0.00	0.00	0.00	0.00	[illegible]	0.00
	B7	2.00	2.75		[illegible]	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL					[illegible]	0.00	0.00	0.00	0.00	0.00	[illegible]	0.00
B-Type1	B2	1.00	1.00	0.40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B2	1.20	1.20	0.55	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B2	1.60	1.60	0.90	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B2	1.80	1.80	1.15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B2	1.80	1.80	1.54	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B3	1.00	1.00	0.70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B4	1.80	1.80	1.54	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B5	1.40	1.40	0.70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B6	1.60	1.60	0.40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SUB TOTAL					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
B-Type1(P)	B1	1.80	1.80	0.55	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B2	1.20	1.20	2.50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B3	1.60	1.60	0.95	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B5	1.40	1.40	0.30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SUB TOTAL					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
B-Type1 Total					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
B-Type2(A)	B6	2.40	2.00	2.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
B-Type3	B3	3.60	1.80	1.10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B3	4.80	2.00	1.83	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
U-Type1 (T15)	B2	1.60	1.90		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B3	1.80	2.16		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B3	1.60	2.69		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B3	3.80	3.67		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B3	1.00	1.00		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B3	4.25	4.39		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B6	1.00	2.10		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
U-Type1 (A)	B6	1.40	2.53		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
U-Type2	B2	1.20	1.63		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B2	1.80	2.92		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B3	3.40	1.35		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Type	River No.	Masonry Volume (m3)	Masonry Joint Sealing (m2)	Masonry Weep Pipe (m)	Joint (U-shaped Pier) Joint Sealing (m)	Joint Form Filler (m2)	Dowel Bar (No.)	Grating (unit)	Reinforced Bar 12 (t)	14 (t)	16 (t)	18 (t)	20 (t)	22 (t)	25 (t)	32 (t)	Total (t)
Masonry	B1	[illegible]	[illegible]	[illegible]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B2	[illegible]	[illegible]	[illegible]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B2	[illegible]	[illegible]	[illegible]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B2	[illegible]	[illegible]	[illegible]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B2	[illegible]	[illegible]	[illegible]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
B-Type1	B2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SUB TOTAL		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
B-Type1(P)	B1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SUB TOTAL		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
B-Type1 Total		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
B-Type2(A)	B6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
B-Type3	B3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
U-Type1 (T15)	B2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
U-Type1 (A)	B6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
U-Type2	B2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]