ROYAL GOVERNMENT OF LAOS

DESIGN REPORT
ON
VIENTIANE AIRPORT EXTENSION PROJECT-II

June 197[illegible]

Nippon Koei Co., Ltd.
Consulting Engineers
Tokyo

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LETTER OF SUBMITTAL

June 20, 1971

The honorable Kiichi Aichi
Minister of Foreign Affairs
Government of Japan

Excellency:

I have the honor of submitting herewith to Your Excellency the Detailed Design Report on the Vientiane Airport Extension Project - II together with relative papers in accordance with the request of the Royal Government of Laos.

This report is an outcome of the survey and study carried out both on the spot and at home by experts mainly of Nippon Koei Co., Ltd. and Japan Airport Consultants, Inc. since January, 1971.

The present Vientiane Airport with a runway of 3,000 m will be assured of its role as international airport upon completion of the project by introducing two runway exit taxiways, one parallel taxiway and incidental facilities accommodating large size jet plane.

It is really a matter of congratulation that the Government of Japan has recently decided to provide part of the construction cost of the project in form of grant to the Government of Laos in addition to the previous technical and financial cooperation extended to the identical project - I.

At any rate, there is no doubt that the airport extension project mentioned above shall contribute not only to the promotion of aerial transportation means in Laos but also to the encouragement of economic and social development in the country.

In conclusion, it gives me a happy duty to inform Your Excellency that we are pleased to acknowledge the Government Authority of Laos as well as that of Japan, especially, the Aviation Bureau of Ministry of Transport, and also all the persons concerned in both two countries for their considerable assistance offered to us.

Very truly yours,

K. Tatsuke

Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency
Japan

June 13, 1971

LETTER OF TRANSMITTAL

Mr. Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency
Tokyo, Japan

Dear Sir,

In fulfilment of contract No.   awarded to this firm on 1st April, 1971, we have the pleasure to submit herewith the design works for the extension phase II of Vientiane Airport in three volumes which comprise;

(i) Design report on Vientiane Airport Extension - II
(ii) Tender documents for - ditto -
(iii) Drawings for - ditto -

The field investigation required for the above work was carried out during the period from 26th January to 6th April, 1971 by a team composed of staffs from Nippon Koei Co., Ltd. and Japan Airport Consultants, Inc. and administrative staffs despatched from the Civil Aviation Bureau. Ministry of Transportation.

In respective stages of the planning and design we have also received a support from Japan Airport Consultants, Inc. as well as the guidance of the technical control committee headed by Mr. Akira Takeda, Chief of construction Section, Airport Division, Civil Aviation Bureau, Ministry of Transportation.

Taking this opportunity, we wish to express our sincere gratitude for the encouragement and support received from you and your officials concerned throughout the period of our services. We must also mention the helpful assistance and friendly co-operation to the field investigation team rendered by the officials of the Civil Aviation Bureau, Covernment of Laos, and, last but not the least, of the Japanese Embassy in Laos.

Very truly yours,

Y. Kubota
Yutaka Kubota
President
Nippon Koei Co., Ltd.

Design Report

Vientiane Airport Extension Project-II

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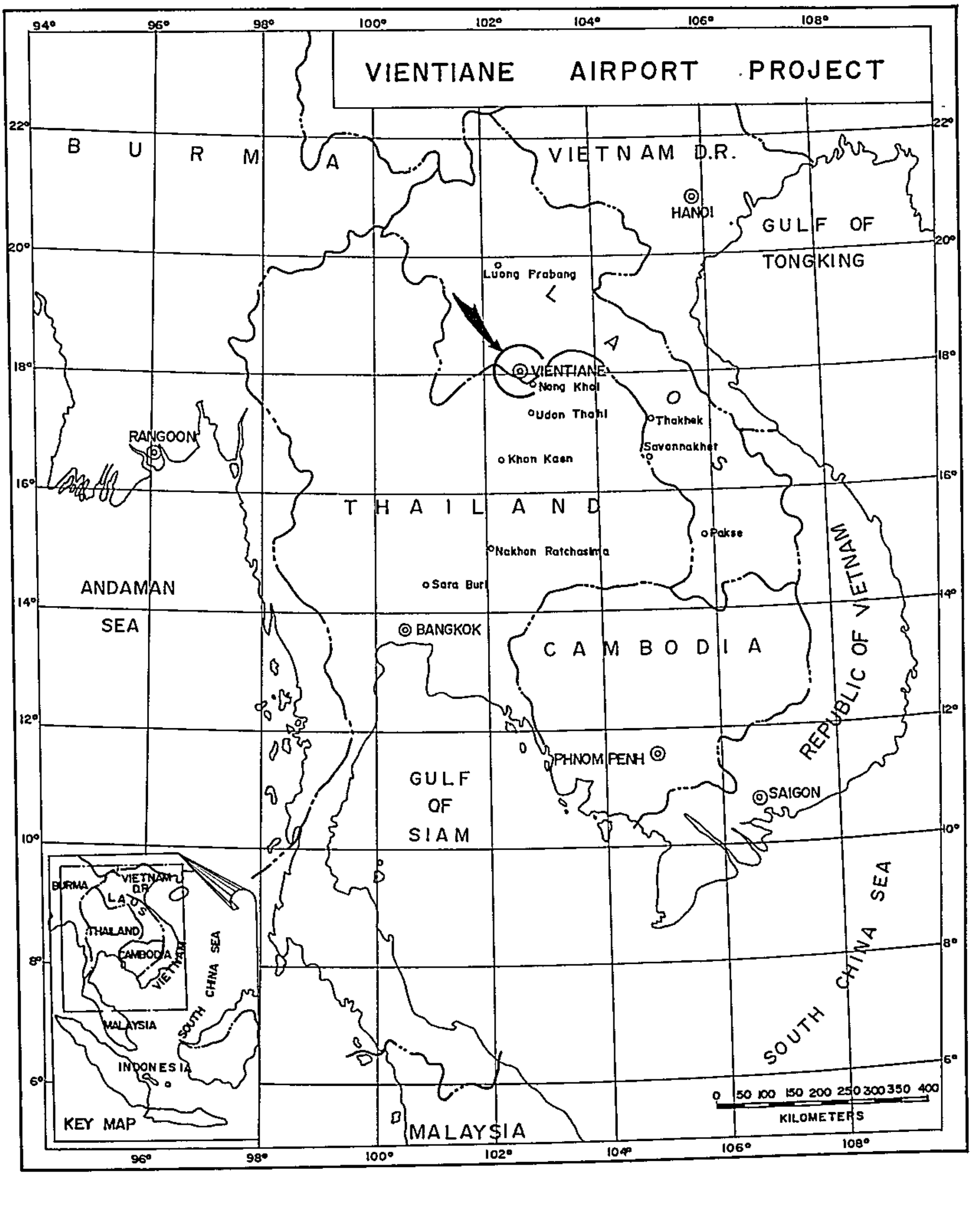
VIENTIANE AIRPORT PROJECT
BURMA
VIETNAM D.R.
HANOI
GULF OF TONGKING
Luong Prabang
LAOS
VIENTIANE
Nong Khai
Udon Thani
Thakhek
Savannakhet
Khon Kaen
RANGOON
THAILAND
Pakse
Nakhon Ratchasima
Sara Buri
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CAMBODIA
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SOUTH CHINA SEA
MALAYSIA
INDONESIA
0 50 100 150 200 250 300 350 400
KILOMETERS
94° 96° 98° 100° 102° 104° 106° 108°
22° 20° 18° 16° 14° 12° 10° 8° 6°

Foreword

In February, 1967, a five men investigation team, headed by Mr. Kotaro Hayashi, the then Chief of the Construction Section, Civil Aviation Bureau, Ministry of Transportation, Japanese Government, carried out, at the request of the Royal Laotian Government an investigation of Vientiane Airport concerning its expansion to permit the landing and take-off of large jet aircrafts such as DC-8 or B-707 etc. In a report submitted, entitled as "Investigation Report on Vientiane Airport Runway Extension Project", the team had suggested that the extension might be implemented in three stages, observing the growth of the need of such expansion.

The first stage of the expansion, which included the extension of the runway from the existing 2,000 meters to 3,000 meters and the widening of the width of the holding way, was undertaken under the economic co-operation programme and grant of the Japanese Government. The study and the detailed design of the above work were carried out by the Nippon Koei Co., Ltd., and the construction thereof was executed and completed by August, 1970 by Tomen K.K. under the supervision of Nippon Koei Co., Ltd.

With a view to complete the expansion to a fuller extent, the Royal Laotian Government requested the Japanese Government to extend further economic co-operation. Complying the request, the Japanese Governmemt had decided to render the technical co-operation for the investigation and design of the second extension work through the office of the Overseas Technical Co-operation Agency (referred to hereinafter OTCA), and the work was awarded to Nippon Koei Co., Ltd.

The field investigation for the second extension, referred to as the Vientiane Airport Extension Project-II, was carried out during the period from January 26 to April 6 of 1971: The investigation team as organized by the Nippon Koei included administrative officers from the Civil Aviation Bureau, Ministry of Transportation, Japanese Government, and planning experts from the Japan Airport Consultant K.K. as well.

The members of the field investigation team are listed below:

Project Manager	H. Ito	Nippon Koei Co., Ltd.
Airport planning expert	H. Hiraide	Japan Airport Consultant K.K.
" "	S. Sakai	" " "
" "	A. Yoshioka	" " "
Civil engineer, Airport	H. Hata	Nippon Koei Co., Ltd.
" "	K. Fukurono	"
Electrical engineer	H. Kitaichi	"
Soil and foundation expert	T. Terai	"
Civil engineer	K. Suzuki	"
" "	H. Tazoe	"
" "	Y. Watanabe	"

Administrative Officer	S. Yoshioka	Civil Aviation Bureau, Ministry of Transportation
" "	T. Kuri	"

The planning and design of the extension project-II were carried out in Tokyo under the guidance of the technical control committee headed by Mr. Akira Takeda, Chief of Construction Section, Airport Division, Civil Aviation Bureau, Ministry of Transportation.

The grant from the Japanese Government for the extension project - II was already fixed and the construction is expected to be started in September 1971. The work prepared by the Nippon Koei includes the specifications and other necessary tender documents and drawings for the construction of the extension project-II as well as this design report.

1. Summary

1-1 Outline of the project.

Laos is landlocked bordering on six countries as Burma, Thailand, Cambodia, South Vietnam, North Vietnam and China, and except for the air transportation, accessible only through the railway and highway in Thailand coming up from Bangkok. The domestic road system is meager except for a few national highway systems, even which are often rendered out of use due to rains. Under the circumstances, the transportation means by air plays a greater roles in the communication within and without Laos, and in which the role of Vientiane airport is the greatest, the entrance to the country as well as the hub of the domestic air services.

To keep pace with the trend of ever expanding size of aircrafts and use of jet-engine planes for commercial services, the first stage extension of Vientiane Airport was undertaken and completed in August 1970.

The demand for the air transportation is increasing rapidly in recent years. For 1966 - 1969 period, the increase rates were 1.55 times for passengers and about 2.55 times for air cargo. The rapid increase of the air transportation volume is a worldwide trend, as ICAO estimates the number of passengers and the tonnage of the air cargo as five folds of the present. We assume that the air transportation volume would increase quite rapidly, if not the same as the world trend.

Upon these background, the following expansion works were proposed to follow the first stage expansion.

a) Construction of a new runway exit taxiway and expansion of loading and parking aprons

b) Consolidation of navigation aids such as lighting system etc.

c) Improvement of drainage system and others.

The principal features of these works will be given in the following section.

1-2 Scope of major works

a) Runway exit taxiway

New extension	600 m x 2 = 1,200 m
Width	23.00 m
Thickness	28 cm (concrete pavement)

b) Parallel taxiway

Extended length	440 m
Width	22.825 m
Thickness	28 cm (concrete pavement)

c) Extension of apron

Extended area	21,310 m^2
Thickness	28 cm (concrete pavement)

d) Drainage work

Concrete box culvert work	(1) 1.2 m x 0.8 m x 90 m
"	(2) 1.6 m x 0.6 m x 2 series x 55 m
Concrete channel work	(3) 0.9 m -- 1.3 m x 0.6 m x 210 m
Open channel work	2,200 m

e) Lighting facilities

Runway lights	9 (Realignment of the existing lights)
Taxiway lights	207 (To remove the existing lights and install new lights)
Main cable duct and hand holes	500 m
Underground cable	Approx. 8,000 m

f) Felling and soil preparation 163,000 m^2 (Area with obstacles)

1-3 Construction time schedule

The works of the expansion project-II include, among others, approximately 104,000 m^3 of earthwork, 18,000 m^3 of base course and 68,400 m^3 of concrete pavement. Due to the climatic conditions, these works, in particular the earthwork and base course laying, can be executed only in the dry season which usually starts in October and ends in May next, and for the work of magnitude as in the present case, it is advisable to complete the whole works in a stretch of one dry season.

To attain the above schedule, the working with equipment capable of handling 900 - 1,400 m^3 of earth work per day, 200 m^3 of base course material per day and 180 - 200 m^3 of concrete placing per day will be required.

1-4 Construction cost

The total construction cost is estimated at US$1,800,000 including the foreign currency and local currency portions.

The estimate of cost in local currency is based on the labour wages and material prices as of December, 1971 and this amount was converted to U.S. dollar figures at the rate of 500 kips per U.S. dollar.

2. The aeronautical position of the Vientiane Airport and the present condition of its facilities

2-1 Aeronautical circumstance in Laos

There are 19 military and civil airports in Laos. Six of them as Vientiane, Luang Prabang, Sayaboury, Pakse, Savanakhet and longcheng have regular air service. Table 2-1 gives the general features of these airports.

The type of aircrafts currently used and those used in 1967 are listed in Table 2-2. Table 2-3 shows number of flights, passengers and freight tonnage in 1965 and 1969.

Table 2.1 List of Airports in Laos

	Name of Airport	Runway direction	Runway length & width	Pavement	SIW bearing capacity
Civil of military (common use)	1 BAN HOUEISAI	16/34	1414 x 23M	Asphalt	14T
	2 LUANG PRABANG	6/24	1600 x 25M	Asphalt	25T
	3 SAYABOURY	16/34	810 x 40M		11T 500
	4 VIENTIANE	13/31	3000 x 45M		
	5 SAVANNAKHET	4/22	1753 x 38M		
	6 SARAVANE	6/24	1598 x 20M	Laterite	13T
	7 PAKSE	14/32	1775 x 43M	Asphalt	30T
	8 ATTOPEU	13/31	1466 x 12M	Laterite	13T
Military	9 HONGSA	2/20	700 x 30M	Asphalt	5T
	10 XIENG LOM	8/20	1200 x 50M		8T
	11 VANGVIENG	18/36	1640 x 30M		14T
	12 PAKSAM	18/36	1000 x 14M	Laterite	14T
	13 PAK LAY	2/20	608 x 36M	Laterite	6T
	14 PKONE	14/32	350 x 30M		3T
	15 KENE THAO	9/27	906 x 44M	Asphalt	14T
	16 THAI HEK	10/28	1006 x 30M	Laterite	14T
	17 PAKSONG	5/18	500 x 60M		3T
	18 WATPHOU	12/30	800 x 30M		6T
	19 KHONG	3/21	1036 x 20M	Asphalt	13T

Table 2-2 Types of Civilian Aircrafts Used

Year	Types of Civilian Aircrafts Used							
1967	DC-3	DC-4	DC-6	AVRO	C-47	CESSNA		
1971	DC-3	DC-4	DC-6	AVRO	CESSNA	B-307	VISCOUNT	IL-18

Table 2-3 Comparison of Number of Flights & Passengers

	1965	1969
Number of Flights	3,441	8,907
Number of Passengers (Persons)	47,081	136,842
Freight (ton)	1,331	6,562

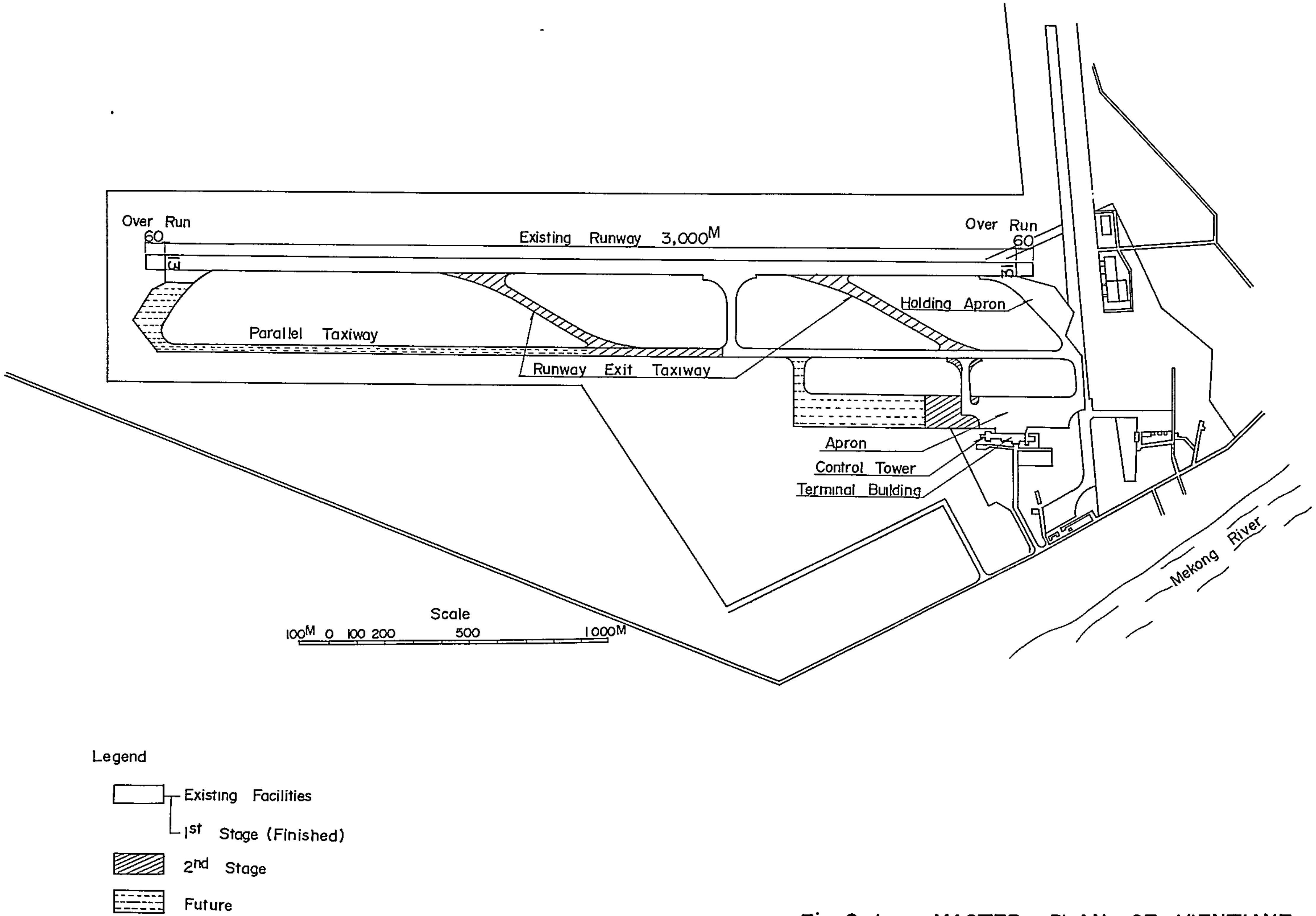

Fig 2-1 MASTER PLAN OF VIENTIANE AIRPORT

2-2 Present condition of the Vientiane Airport

2-2-1 Topography around the airport

The Vientiane Airport is located at about 2 kilometers north of the Mekong River in the suburbs of the Vientiane City in the center of the alluvial plain along the Makong River. The airport is surrounded by level farmland. The elevation of the surface of the runway of the Vientiane Airport is 170 meters above mean sea level, which is almost the same as that of the embankment of the Mekong River. The elevation of the surrounding farmland is 168 - 169 m, and the difference in elevation is very small. Therefore, drainage is very poor in the area around the Vientiane City, and water stays in the rainy season on the lowland in the compound of the airport, as shown in attached DWG [1] No. 1. As stated in the 1st Report, the improvement of the drainage plan is not merely the problem of the airport, and it should be improved as a part of city planning.

2-2-2 Basic facilities

Such basic facilities of an airport as the runway, taxiways, and apron were partly constructed by France, and were used by the Japanese forces during World War II. Most of the facilities now being installed were constructed by the US Forces during the period of 1958 - 1963.

Attached DWG. No. 2 is the ground plan of the Vientiane Airport. On the northern side of the east end of the airport are the taxiways and the facilities of the Laotian Air Force, and the civil aviation area and the facilities of Air America etc. are on the southern side with the runway in between. These facilities were submerged for about 20 days due to the flooding of the Mekong River in August 1966. In spite of the heavy damage done to the navigation aides, the damage to these facilities was slight, and it was reported that their functions were almost perfect when the US made investigations after the occurrence of the flood.

At the time when investigations were made, it was found out that damages done to the pavement were as follows:-

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1 Attached DWG. No.1 Drainage

1) Runway Construction joint, contraction joint, and expansion joint were damaged. The damage to expansion joint was most conspicuous.

2) Taxiways Same as in the case of the runway, more damages were done to the expansion joint.

3) Apron Many expansion joints had the joint filler torn off. Cracks running through the center toward the shorter side of 4.57 m x 3.81 m slabs were found, and more cracks were found particularly on the portion (in front of the terminal building) used as the loading apron. Though these cracks do not seem to interfere with the passage of the aircrafts at present, it would be advisable to repair such cracks in the early stage to prevent shortening of the useful life of the pavement.

2-2-3 Navigation Aids

(1) Radio navigation aids

There was an NDB (non-directional radio beacon) installed by France on the left hand side of the access road running toward the terminal building from the entrance of the airport. This radio beacon was submerged in the flood of 1966, and all machinery and tools became unusable, and they were left unused eversince. Later, Air America established a new N.D.B. at the point about 500 meters east of the runway threshold, and this is still being used. This is operated on a frequency of 400KHZ and 400 w output, and has a spare power source for joint use with other facilities of Air America.

(2) Lighting Aids

The Vientiane Airport had been equipped with aerodrome identification signs, wind cone (wind direction indicator), runway lights, runway threshold lights, taxiway lights, and identification beacons but the taxiway lights and the wind direction indicator became unusable due to the 1966 flood.

(a) Aerodrome beacon

Placed on top of the Control Tower, throwing alternately green and white flashes, and satisfies the international standard. This seems still usable.

(b) Wind cone (wind direction indicator)

Damaged by the 1966 flood, but repaired under the first stage extension work completed recently.

(c) Runway lights

C-1 type lights had been installed on the 2000 meter runway. The runway was extended to 3000 meters under the first stage extension work. H-C type lights (same as C-1 type) were installed on the extended portion of the runway. The cable on the old portion of the runway is superannuated.

(d) Runway threshold lights

Moved during the first stage extension work and the number of lights was increased. The lights use the same circuit for the runway lights.

(e) Taxiway lights

Lighting apparatus had not been removed. Most of the transformers had been cut off and lost. The cable seems unusable due to penetration of moisture from the exposed sections of the cable. Air America formulated the plan of rehabilitation three years ago, but the lights are still unusable.

(f) Identification beacon

Identification beacon throwing red lights and sending out Morse signalling codes from top of the elevated water tank in red color had been installed. As the switch is now out of order, this light is not functioning as a flashing light, and is being used now only as the obstruction light with fixed light.

2-2-4 Control facilities

The control tower is on the fourth floor of the terminal building. VHF (ultra short wave) radiophone operating on a frequency of 118.1 MHZ and 20 w output and a spare of the same are the only means of communications between the controller and the pilot. There is one portable radio of 2 w output operating at the same frequency. Also a radiophone operating on a frequency of 236.6 MHZ and 2 w output is being installed for communication between the control tower and the military planes. A control panel for the illuminating facilities and a light gun are installed at the corner of the control tower.

2-2-5 Communications facilities

There is a communication room on the eastern side of Floor 1 of the airport office building. This room is equipped with two sets of LLT (Land Line Teletype), one connecting Vientiane with Bangkok, and and other connecting Vientiane with Saigon Via Bangkok. These are being used for transmitting and receiving flight plans of the international air routes, and information on meteorological conditions. In case of the failure of the teletypes, two sets of HF (high frequency) 400 w wireless telegraphs are used to connect Vientiane with Saigon.

Again, HF 100 w wireless telegraph is normally used to contact airports on domestic air routes such as Pakse, Savannakhet, Luang Prabang, Sayaboury, B. Houei Sai. Radiophone (VOICE) is being used in case of emergency.

2-2-6 Terminal building

The terminal building is a two-story reinforced concrete building having a total floor space of approximately 3,700 square meters. The building which was constructed in 1962 was donated by the French Government. There is a lobby next to the front entrance on the first floor. shops and ticket counters of the aviation companies are on the left side. Toilet and the telegram office are on the right side. In front are the baggage claim and the entrance for departure. More ticket counters of the aviation counters are found after turning to the left from the lobby.

The VIP room is on the second floor by the side of the stairs on the right side of the lobby. There is a tea room on the left. Passengers ready for departure can move from the waiting room to this tea room through a separate staircase. However, this tea room is not being operated at present. The terrace on the second floor is being used for welcoming and sending off passengers.

Passengers departing and arriving are not separated at all for either the domestic air routes or the international air routes, and they all move in the same direction. It is said that the current capacity of the airport terminal building of handling passengers is 300 passengers per hour.

In front of the terminal building is a small parking area for automobiles. As the number of automobiles is increasing rapidly, this parking area will soon become insufficient. Again, the location of the parking area does not seem proper in view of the right-hand traffic practised in this country.

2-2-7 Fuelling facilities

Fuelling facilities are located at about 100 meters west of the airport office building where SHELL and ESSO have their fuel tanks.

SHELL is supplying fuel to all civilian airplanes both on domestic and international air routes. It has four ground tanks each having the capacity of storing 25,000-liters of JP-1 (kerosene type jet fuel), one tank capable of storing 170,000-liters of 100/120 (gasoline for aircrafts), and another tank for storing 170,000-liters of 115/145 (gasoline for aircrafts). At present, fuelling is being carried out with using four refuelling stands, namely, one 120,000-liter tank, one 10,000-liter tank, and two 7,000-liter tanks.

This airport had the hydrant equipment possible of refuelling at 3 places of the apron, but was damaged in the 1966 flood. The repair of this equipment is not being planned at present.

ESSO is supplying fuel to the aircrafts of the Laotian Air Force and of Air America. It has one 12,000-liter ground tank for storing JP-1 (kerosene type jet fuel) and one 258,000-liter semi underground tank for storing 115/145 (gasoline for aircrafts). It has a total of nine refullers, namely, one 3,000-liter refueller, one 7,000-liter refueller, one 8,000-liter refueller, one 9,000-liter refueller, three 10,000-liter refuellers, one 12,000-liter refueller, and one 16,000-liter refueller.

2-2-8 Fire facilities

The Laotian Government does not have any fire facilities at the airport, and at present, it is solely dependent on fire apparatus possessed by Air America. Air America possesses the followings:-

P-10 Type Fire Engine (for oil fire)	2
R-2 Type Fire Engine (for demolition)	1
O-10 Type Fire Engine (for oil fire)	1
Fire engine	1
Water wagon (5,000 gallons)	1
Supervisor's car	1
Ambulance car	1

According to Annex 14 of ICAO titled "Rescue and fire fighting activities at an airport, and the machinery", the scale of fire apparatus of an airport is determined as follows. The number of movements of all types of aircrafts during a consecutive busiest period of 3 months of a year is added up in the order beginning with that showing the highest rate of risk, and the movement which corresponds to the 700th movement is made the "critical aircraft". Table C-1 gives the classification of the airports calculated from the fuel load and the maximum design passenger capacity planned for accommodation. The category is then applied to Table C-2 to determine quantities of extinguishing agents required.

Since the data available are not sufficient, it is difficult to find out the "critical aircraft" for the Vientiane Airport.

The types of aircrafts now being used at this airport are the VISCOUNT, C-123, AVRO, DC-4, etc. The quantities of extinguishing agents required was calculated as follows on the basis of the VISCOUNT as the "critical aircraft" for this airport.

Fuel load	8,640 liters ...	4 points
Maximum design passenger capacity	68 persons ..	4 points
	Total	8 point

Classification of Airport
VI

Classification of the airport comes to VI, and the followings are required under this classification.

Water for foam production	2,200 gallons
Discharge rate water	480 gallons/min.
Complementary agents (dry chemicals)	300 lbs (or 600 lbs of CO_2)

Fire apparatus now being possessed by Air America well satisfy ICAO requirements with the followings:-

Water for foam production	5,900 gallons
Complementary agents (dry chemicals)	710 lbs.

2-2-9 Power facilities

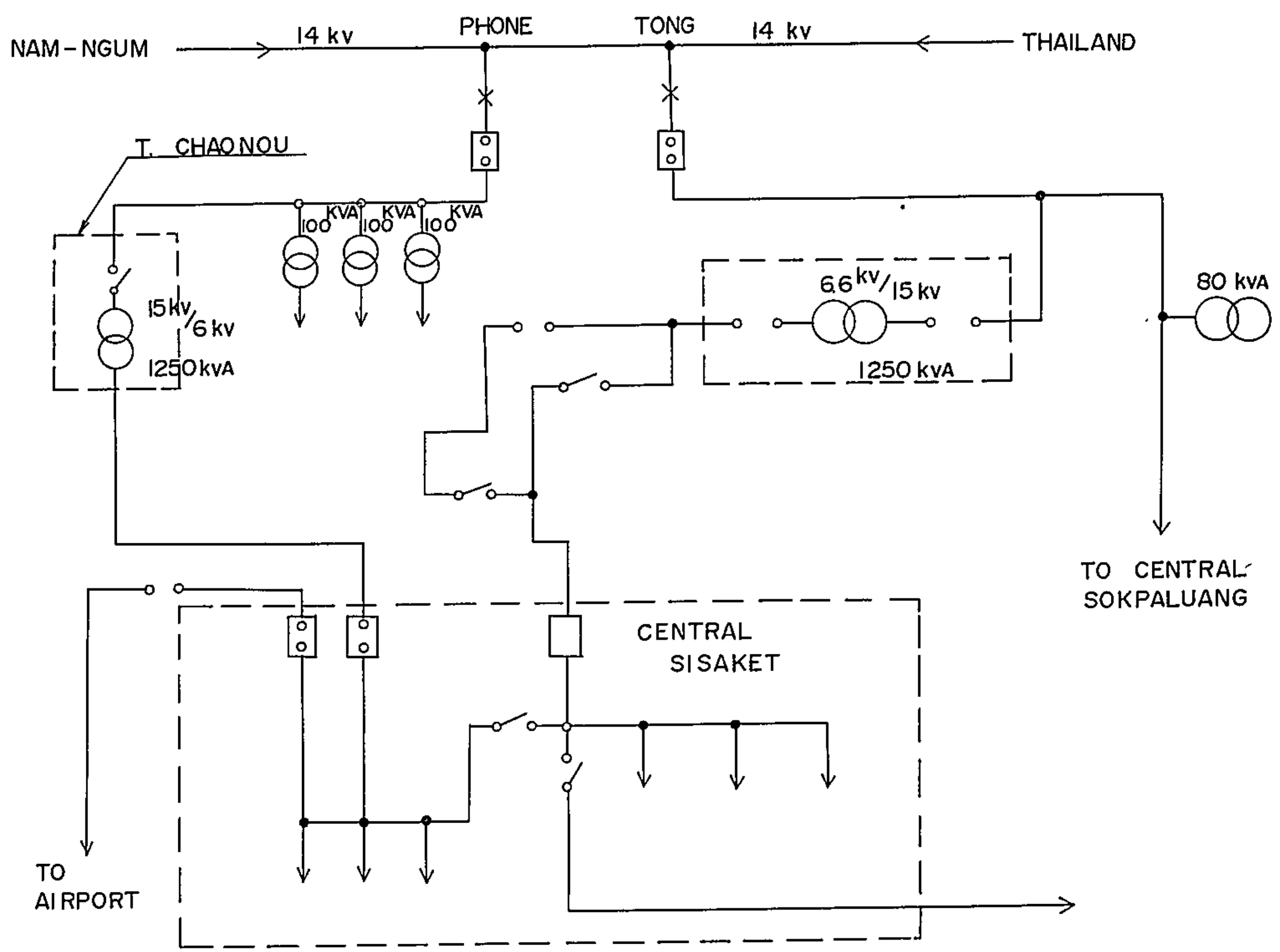
Power supply in Laos (Vientiane City) is being managed by E.D.L. (Electricite du Laos), which is a semi-governmental organization similar to a public corporation in Japan.

Laos presently is purchasing power from Thailand transmitted by means of 140 kV overhead wire crossing the Mekong River. It will become self-sufficient in the near future upon completion of the Nam Ngum Power Station.

15,000 V and 6,000 V high tension distribution lines are now being used in the Vientiane City, but they seem to be unified in the near future with the German aid. The distribution line to the airport is of 6,000 V as shown in Fig. 2-2, but the Ministry of Planning is now planning to step-up in to 22,000 V within the year of 1971.

Power used at the airport is lowered to 389 V/220 V by means of a pole transformer, and is distributed by 3-phase 4-wire distribution line. Three 75-VA Diesel generating equipments are being installed at the vault room as stand-by facilities for use in case of interruption of the city power service. These generating were out of order at the last investigation, but they were repaired later by Air America, and are now functioning well. At present, power is supplied from this vault room to the airport terminal building, offices, and navigation aids, etc. with the exception of the facilities of the Laotian Air Force and Air America.

Fig 2-2 POWER DISTRIBUTION SYSTEM



2-2-10 Present operating conditions of airport

One runway is being used jointly by the civilian aircrafts and the military aircrafts. According to the 1970 monthly flight records, the number of flights was 5,473 (lowest) and 7,089 (highest), and the average was 6,228. [1]

The airport is being operated from 6 a.m. to 6 p.m., but the aircrafts of the Laotian Air Force land and take-off even outside these hours.

Classified the airplanes into the following categories, the results of the investigation carried out for a period of two weeks (Jan. 18, 1971 - Jan. 30, 1971) are shown as follows.

Cat. I	DC-6	DC-4	DVC-123	CH-6
Cat. II	DC-3	DH-2		
Cat. III	Small AIRPLANE		HELICOPTER	

			Average numbers of landing and take-off a day
Civilian Aircrafts	Domestic	Cat. I	3
		Cat. II	10
		Cat. III	2
	Foreign (Including those of Air America)	Cat. I	57
		Cat. II	11
		Cat. III	58
Military aircrafts	Domestic	Cat. I	0
		Cat. II	13
		Cat. III	20
	Foreign	Cat. I	0
		Cat. II	2
		Cat. III	1

1 According to the 1967 report, the number of flights in 1966 per month comprised 450 of the civilian airplanes and 1,200 flights of the aircrafts of the Laotian Air Forces and other aircrafts.

Additionally the rate of use of civil and military aircrafts is 79.9% for civil aircrafts and 20.1 % for military aircrafts as the result of that investigation. According to the results of the investigation of landing and take-off observed during the peak hours, 32 aircrafts have landed and taken-off during the highest peak hour.

What should be mentioned here specially is that the airplanes land the airport from the western side and take-off toward the western side of the airport. This has been reported in the first Investigation Report. The reason being that landing from the eastern side and taking-off toward the eastern side are prohibited for the purpose of preventing noises caused by airplanes because Vientiane City is located at about 3 kilo-meters east of the runway, except in such emergency cases when landing is absolutely necessary for the safe navigation of the airplanes. (A.I.P. (aeronautical information publication) prohibits flight at less than 3,000 ft. over Vientiane City). Again, the meteorological conditions of this area (much breeze) justify such regulation. (See Fig. 2-4)

At the investigation conducted this time, the investigation team has noticed that the civil aviation apron and the facilities of Air America and the Laotian Air Force are all located at the east threshold of the runway. Such an arrangement of the facilities make possible the landing and take-off mentioned before, and thus shorter and more efficient landing run and take-off run can be obtained. As the runway is sufficiently long, it seems that tail wind landing and take-off does not seem to pose any problem on the phase of safety operation.

The total performed of passengers and air cargo were 136,822 persons and 6,571 tons respectively in total of domestic and international airline.

The aviation companies using this airport are the Royal Air Lao, Lao Air Lines, Thai Air Ways, Air Vietnam and Aero Float servicint the international air routes. Royal Air Lao, Lao Air Lines, Lao Air Charter, and Xiengkhouang Air Transport are the four aviation companies servicing the domestic air routes.

International air routes are:-

- Vientiane - Bangkok
- Vientiane - Saigon
- Vientiane - Hanoi
- Vientiane - Moscow

Domestic air routes are:-

Vientiane	- Lonchen (irregular)	Savannakhet	- Pakse
Vientiane	- Luang Prabang	Luang Prabang	- Houei Sai
Vientiane	- Sayaboury	Savannakhet	- Pakse
Vientiane	- Pakse	Sayaboury	- Luang Prabang
Vientiane	- Savannakhet		

Fig. 2-3 gives the air routes in 1969 and 1971. The domestic and international flight schedules are not so much different from that of the preceding design report.

Major aircrafts landing and taking off at this airport are DC-3, DC-4, C-47, AVRO-748, B-307. ILIOUCHINE - 18, and CESSNA. The approach way to this airport is in conformity with A.I.P. (Airport Information Publication) as shown in Fig. 2-4.

Table 2-4 Aircrafts in Laos - 1

Data: Data presented by CAB of Laos (dated January 29, 1971)

Civilian Aircrafts in Laos (Registered in Laos)

Note 1: Of those registered aircrafts,

(a) aircrafts which are not being used due to shortage of pilots or are now under repair have been included as aircrafts which can be used.

(b) those aircrafts, which cannot be repaired in Laos due to damaged body, or requiring replacement of the engine, or are chartered by foreign countries have been excluded from (a) above and are marked with x.

Air Lines	A/C Type	No. of A/C	Remarks
LOYAL AIR LAO	DC-3	2	
	DC-4	1 x 1	x 1 on ground at Saigon
	B-307	1	
	DHC2	1	Not operated due to shortage of Pilots
LAO AIR LINES	DC-3	2 x 2	x 2 Unrepairable
	Viscount	1	
LAO AIR CHARTER	DC-3	2 x 3	x 2 Unrepairable x 1 In Cambodia
XIENG KHUOANG AIR TRANSPORT	DC-3	1 x 1	x 1 Damaged
AIR UNION	C-46	x 1	Damaged
LAO UNITED AIR LINES	DC-6	x 1	In Indonesia
LAO AIR COMMERCIAL	Beechcraft	x 3	Damaged
LAO AIR DEVELOPMENT	Cessna 150	3	
OTHERS	Cessna 180	1	
	DHC 2	1	
	Rally Club	1	
LAOS CIVILIAN AIRPLANES TOTAL	C-46	x 1	
	DC-3	7 x 6	
	DC-4	1 x 1	
	B-307	1	
	DC-6	x1	
	Viscount	1	
	Light-plane	7 x 3	

Table 2-4 Aircrafts in Laos - 2

Semi-civilian aircrafts (Operated under Government contract, temporary registration)

Air Lines	A/C Type	No. of A/C	Remarks
AIR AMERUCA INC.	C-46 Helio Helicopter DHC-2	5 12 x 3 3 x 1	1. Those marked with x are not operated. 2. A.A. terminal area is being used as the base 3. Though DHC2 is a private aircraft, A.A. is being used.
CONTINENTAL AIR SERVICES INC.	Porter Cessna 180 Piper Skyvan DC-3 DHC-6	17 2 2 1 2 1	Though C.A.S. terminal area of the Vientiane Airport is the base, not all aircrafts are parked here always.

Foreign civilian aircrafts (On regular air service)

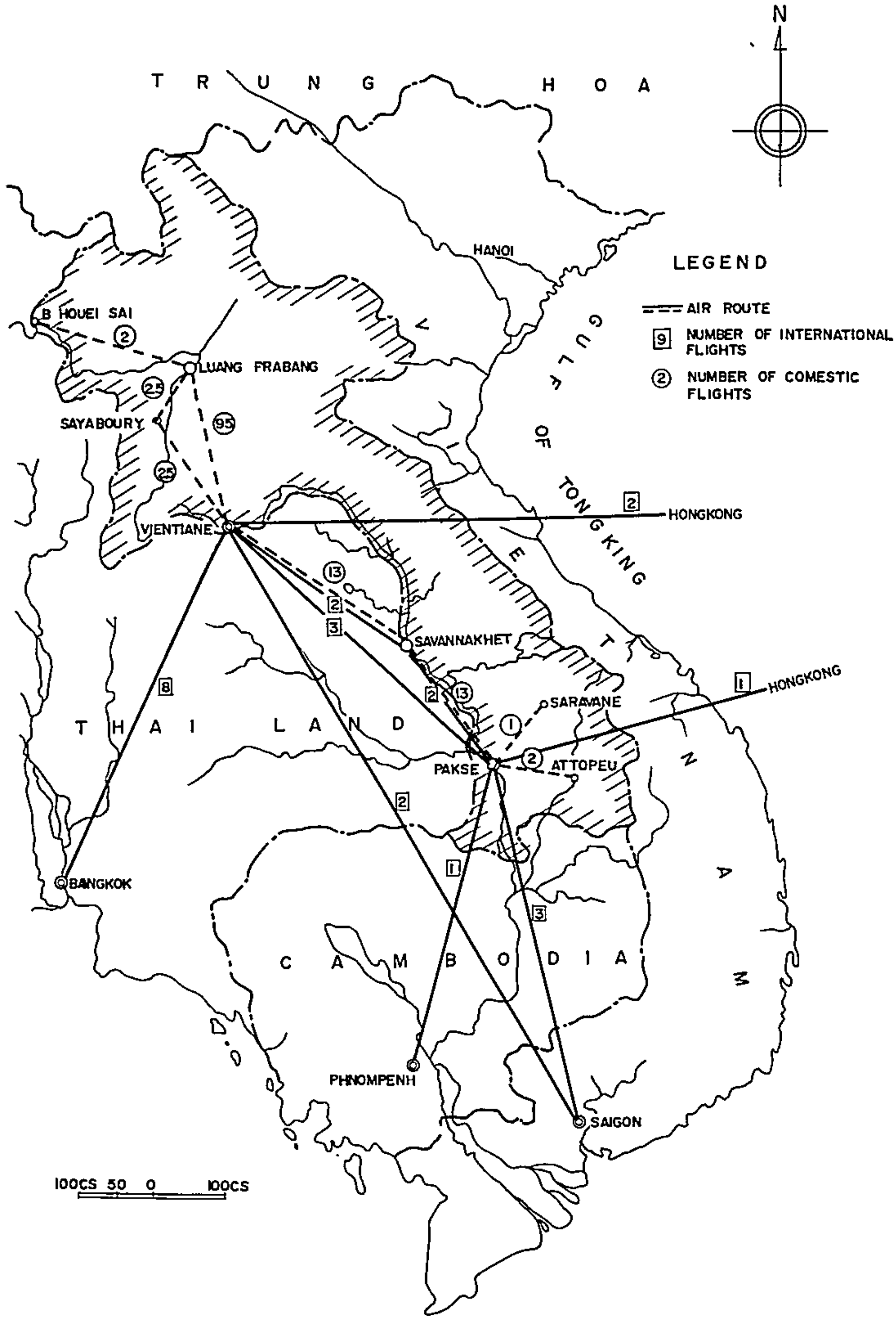
Air Lines	A/C Type	No. of A/C	Remarks
THAI AIRWAYS	ABRO	4 FLS/week	BKK/VTE/BKK
AIR VIET-NAM	DC-4/DC-6	2 FLS/week	SGN/VTE/SGN
AEROFLOT	IL-18	2 FLS/week	Moscow/VTE/HNOI
AIGLE AZUR	B307	1 FLT/week	SGN/PNP/VTE/HNOI

Note: Terminal area for civilian aircrafts at Vientiane Airport is used.

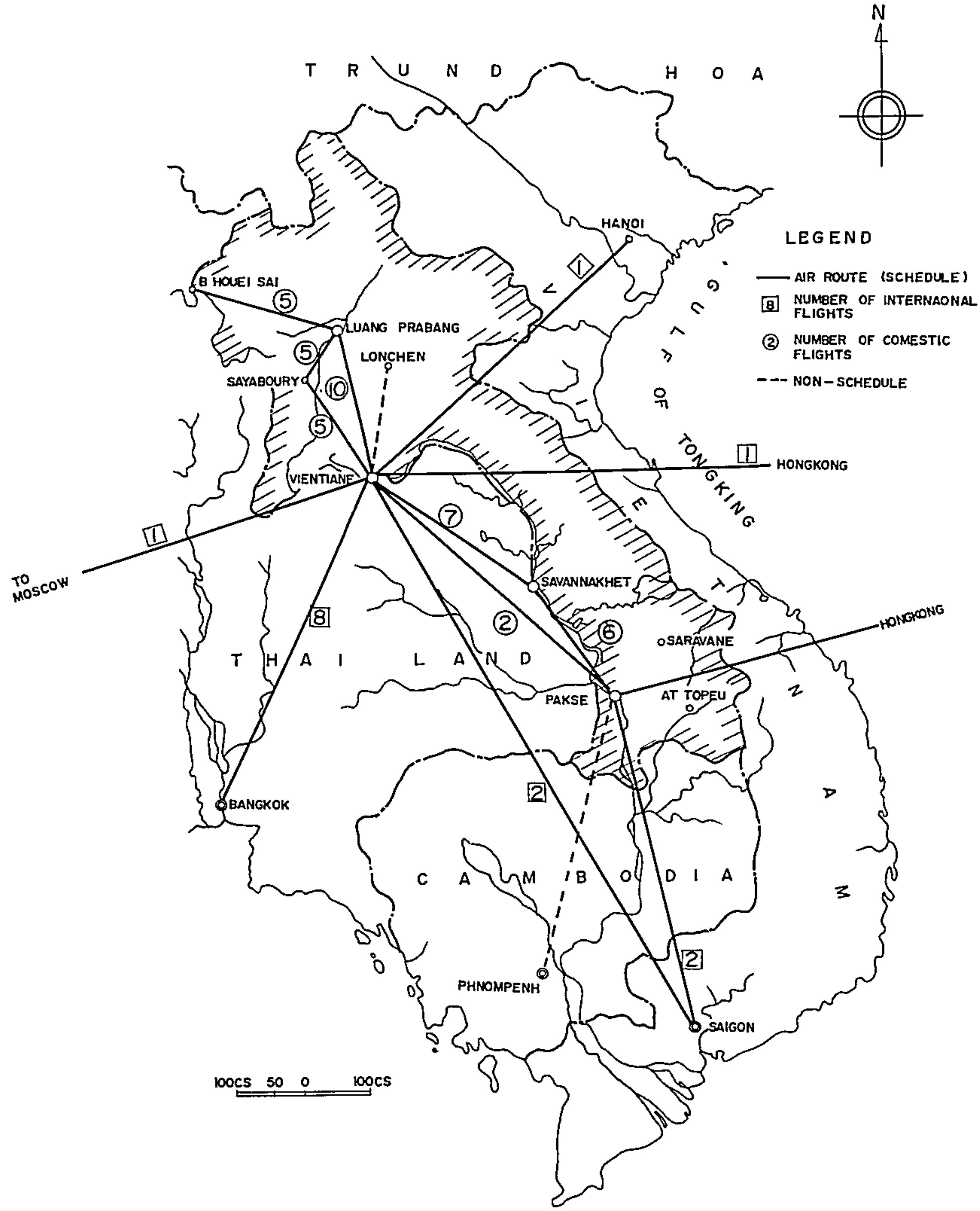
Table 2-4 Aircrafts in Laos - 3

Military Aircrafts (Including aircrafts of U.S. registration operated in Laos)

Nationality	Type of A/C	No. of A/C	Remarks
LAOS	C-47	10	Terminal area for exclusive use is being used.
	T-28	20	
	Cessna	5	
	CHC-2	2	
	Helicopter	8	
AIR AMERICA Inc.	C-120	7	
	C-123	7	
	Porter	4	
	Helicopter	3	
CONTINENTAL AIR SERVICES Inc.	C-46	2	
	DC-3	2	
LAO AIR Development	Cessna	1	
	Helicopter	2	



NUMBER OF SCHEDULED FLIGHTS FROM OR TO VIENTIANE, 1969

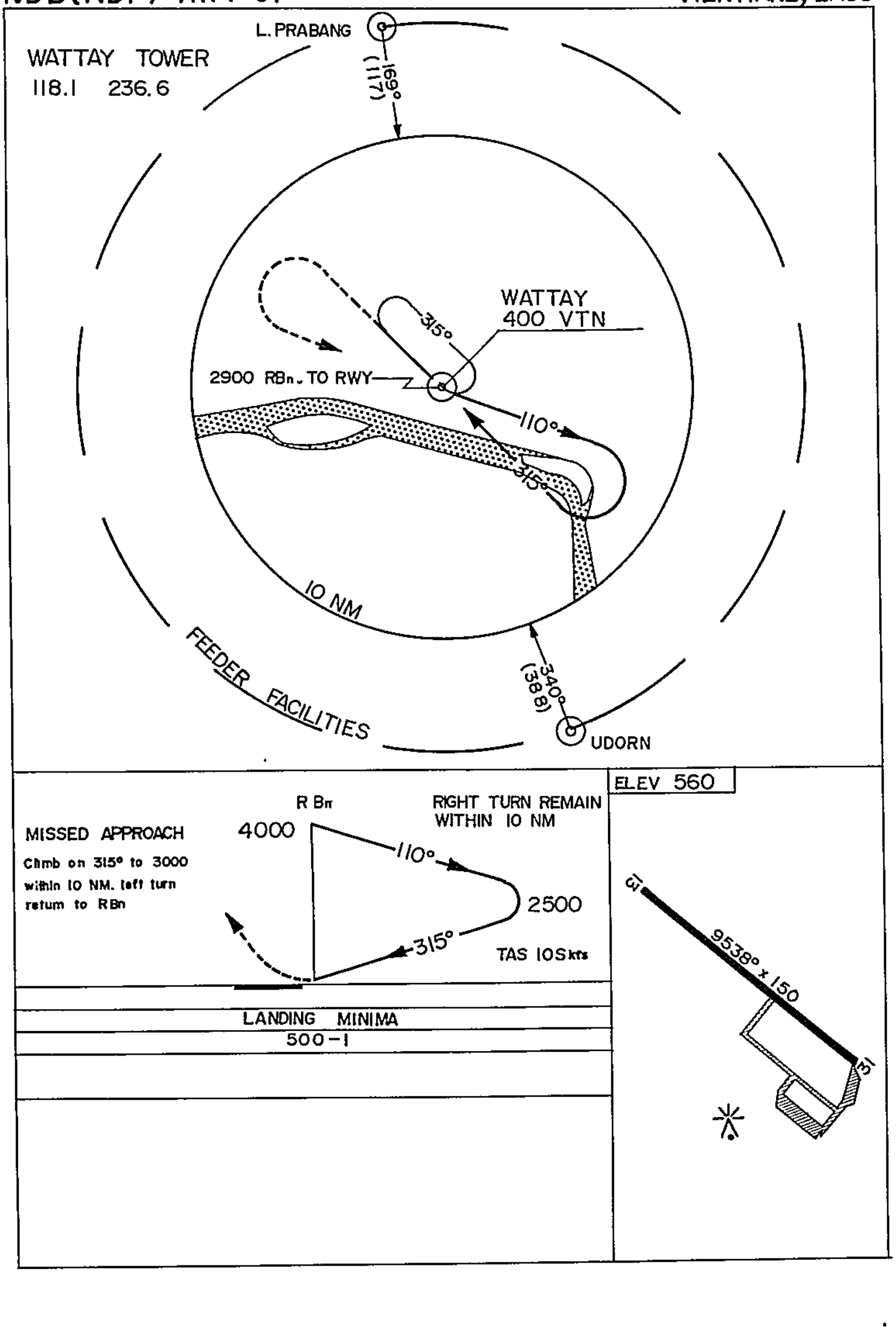


NUMBER OF SCHEDULED FLIGHTS FROM OR TO VIENTIANE, 1971

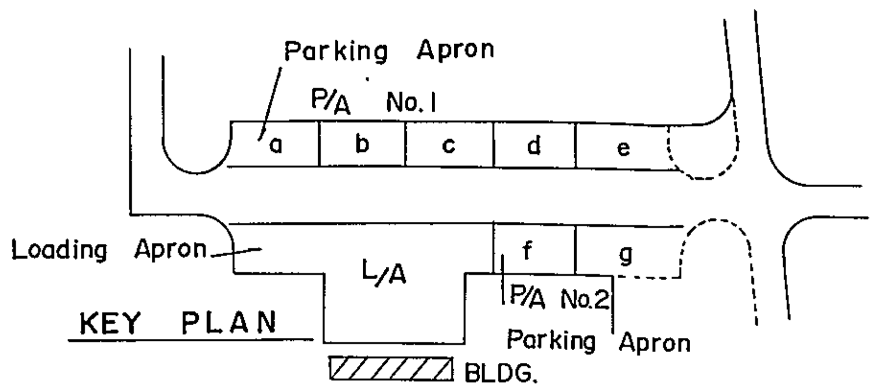
Fig 2-3 AIR ROUT CENTERED AROUND VIENTIANE

Fig 2-4 WATTAY A/D

NDB(ADF)-RWY 31 VIENTIANE, LAOS



30 JAN'71 TO 2 FEB'71



Legend

Ⓢ		CLASS "CESSNA"
RY	:	ROYAL AIR LAO
WL	:	LA AIR LINES
XK	:	XIENGKHOUANG AIR TRANSPORT
TH	:	THAI AIR WAYS
VN	:	AIR VIETNAM
UR	:	U.S.S.R
A.A	:	AIR AMERICA Inc.

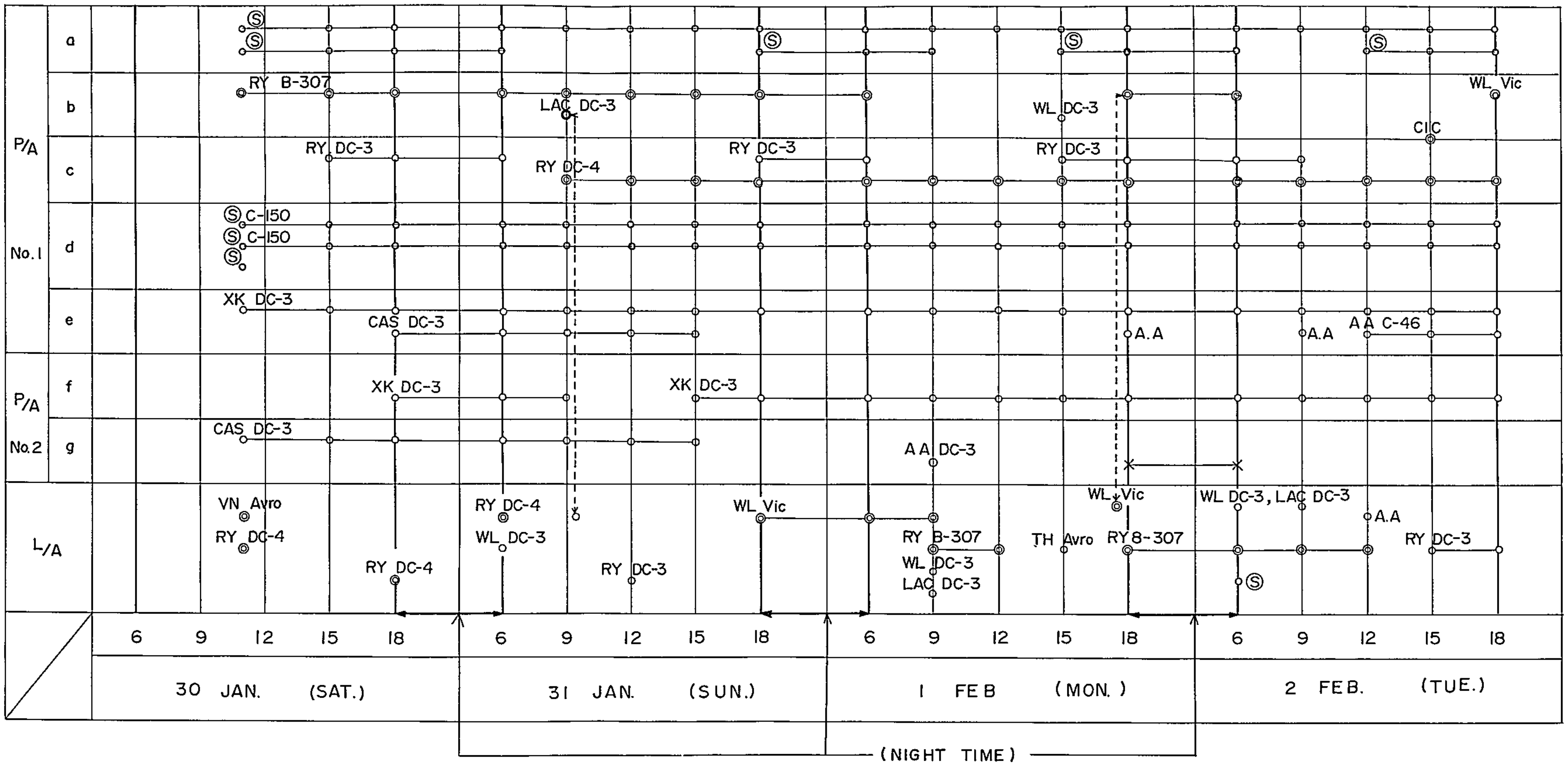
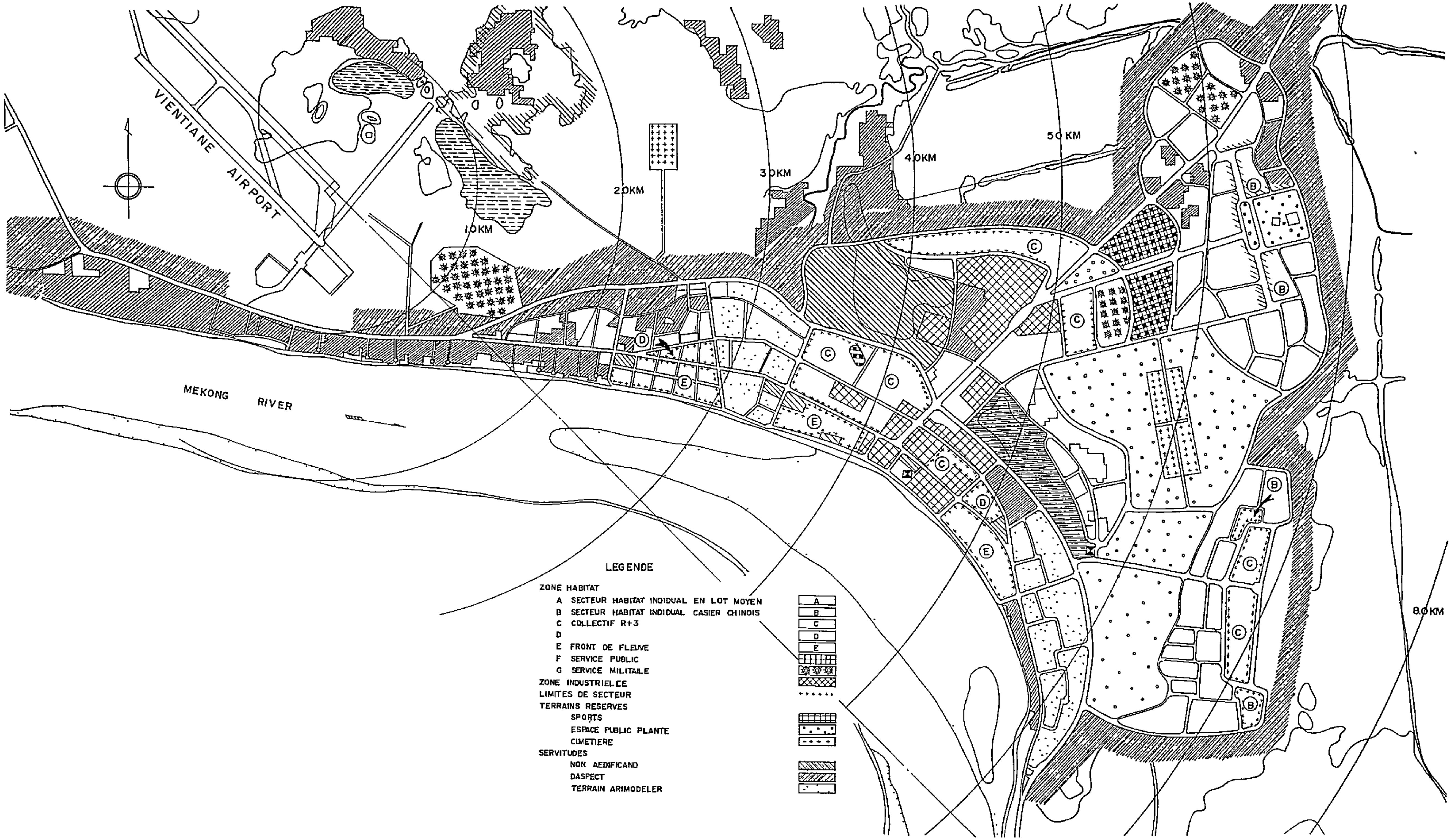


Fig 2-5 CONDITION OF AIRCRAFT PARKING



SCALE
0 500 1000m

Fig 2-6 CITY PLAN OF VIENTIANE

2-2-11 Weather conditions

The meteorological service for aircrafts at present is being provided by the Vientiane Weather Station of the Meteorological and Hydrological Bureau of the Laotian Government. One specialist is dispatched to the airport who prepares a meteorological map using information received from the weather station and through teletype via Bangkok.

The weather conditions which are closely related to landing and take-off of aircrafts at the airport are the wind, height of cloud, and visibility. It will be necessary to know the temperature for the study of runway length, and the rainfall for planning drainage.

The climate of the Vientiane area is roughly divided into the rainy season which begins in May or June, and the dry season which sets in around October. The climatic conditions are very mild and quiet with the exception of heavy rainfall in the rainy season.

(1) Wind

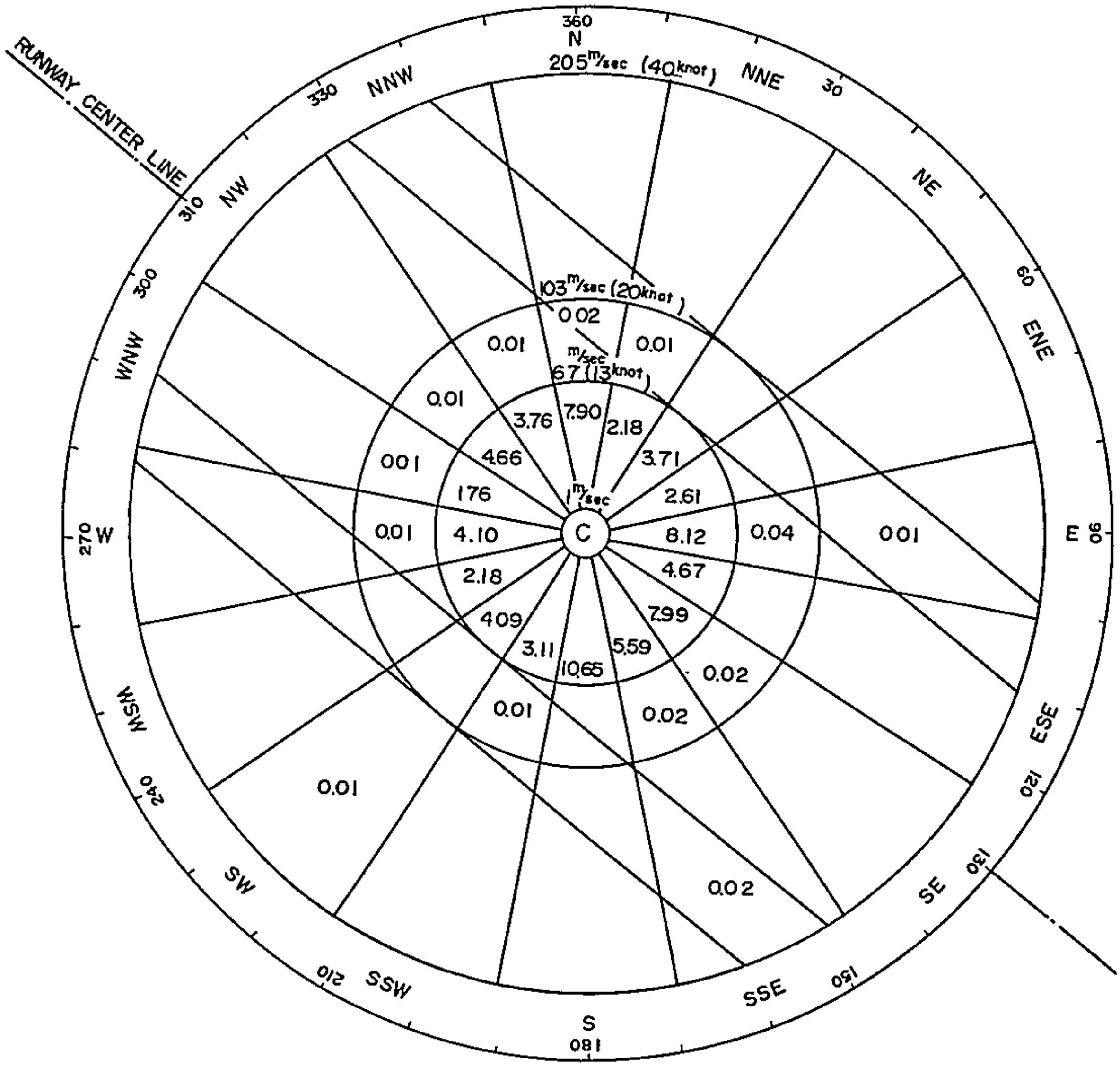
According to the Design Report prepared last time, the wind velocity recorded less than 3 meters/sec. at 97 % of the observations made during the period of 1966 to 1968, and it was windless at 23 % of the observations at which the wind velocity was less than 3 m/sec. Fig. 2-7 shows the wind rose of this area. According to the wind rose, for the cross-wind components of 13 knots, the existing runway shows 99 percent wind coverage. Additionally in case that the fair wind limit is 10 knots, 95 percent wind coverage is shown when landing from the western side or taking-off toward the western side, and this makes such operation of aircrafts possible.

(2) Height of cloud and the visibility

Table 2-5 and 2-6 give the data on clouds of below 500 ft. high and visibility below 10 km observed at a number of observations made during 1966-1970. Height of clouds and visibility were favorable.

(3) Temperature

No new data were obtained at the investigation made this time.



C = Calm 22.72 %

Fig 2-7 WIND ROSE

The standard temperature at the airport is obtained from the data (1956 - 1966).

$$T = T_1 + \frac{T_2 - T_1}{3}$$

T : Standard temperature

T_1 : Monthly mean value of mean daily temperature of the hottest month of the year

T_2 : Monthly mean value of the highest temperature during the hottest month

$$T = 28.4 + \left(\frac{34.3 - 28.4}{3}\right) \doteqdot 30.4\ ^{\circ}C$$

(4) Rainfall

Efforts were made to obtain the maximum values in a short period (mm/15 min. mm/30 min. mm/hour), but not successful. Table 2-7 gives the statistics of monthly rainfall for the period of 1959 - 1969. According to the data, the lowest rainfall was 1,200 mm, the highest 2,106 mm, and the mean 1,684 mm. Rainy months in the order of the amount of rainfall are September, August, June, May and July, and the rainfall during the rainy season reaches almost 87 % of the annual rainfall.

Table 2-5 Low Clouds (500 ft.)

Vientiane Meteorological Station

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1966	0	0	6	0	0	0	0	6	0	6	0	0
1967	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	4	6	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0	0

: The figures in the columns for each month show the average of low clouds (500 ft.) for the period of 5 years (1966 - 1970)

Table 2-6 Minimum Value of Visibility

Vientiane Meteorological Station

	50 m	50-200m	200-500m	500-1000m	1000- 2km	2km-4km	4km-10km
Jan.	0	0	0	1	2	10	177
Feb.	0	0	0	0	0	39	216
Mar.	0	0	0	0	3	41	169
Apr.	0	0	0	1	1	30	252
May	0	0	0	0	0	9	180
June	0	0	0	0	0	12	159
July	0	0	0	0	0	6	135
Aug.	0	0	0	0	0	10	143
Sep.	0	0	0	0	0	14	155
Oct.	0	0	0	0	0	5	115
Nov.	0	0	0	0	0	1	118
Dec.	0	0	0	0	0	5	151

Note: The figures in the table show the minimum values of visibility observed during the past ten years.

Table 2-7 Rainfall (unit : mm)

Year \ Month	1	2	3	4	5	6	7	8	9	10	11	12	Year
1950			25.8	12.4	406.9	354.6	184.7	382.4	166.3	108.1	43.7		1684.9
1951	27.4	0.0	25.5	133.9	245.9	275.0	350.3	242.0	333.8	165.6	7.6	0.1	1807.1
1952		1.0	48.0	49.0	193.0	263.0	252.0	578.0	462.0	69.0	8.0	0.0	1923.0
1953	50.4	65.1	7.5	24.4	219.9	365.8	196.7	291.4	390.6	31.3	108.6		1751.7
1954	22.9	3.3		35.5	389.3	139.2	122.1	445.4	237.0	65.0	0.0	4.7	1464.4
1955		0.6	24.1	153.6	189.6	272.1	273.5	300.2	357.2	15.2	3.0		1589.1
1956		45.8	46.1	134.3	388.3	354.2	212.2	428.1	384.9	9.0	1.2	0.0	2004.1
1957		1.3	12.1	56.7	172.7	355.7	292.2	274.3	200.1	83.7	10.0		1458.8
1958	35.2	6.6	2.7	25.3	97.4	260.0	186.3	344.0	233.7	7.9	0.9		1200.0
1959		16.2	78.9	125.6	228.7	210.8	437.1	219.0	638.3		1.5	0.0	1956.1
1960	10.3	0.0	6.7	41.3	134.9	116.4	274.5	420.2	609.8	48.4	16.9		1679.4
1961		29.9	43.7	59.6	377.7	428.0	137.2	372.7	518.5	138.8			2106.1
1962	0.0		10.6	118.3	253.1	196.4	207.4	429.1	356.0	111.7	0.0	2.7	1685.3
1963		0.0	17.4	56.5	156.0	309.5	279.2	188.7	182.3	106.1	30.3	6.3	1332.3
1964		11.6	28.5	100.1	407.3	213.1	306.0	238.5	400.1	152.1	0.5		1857.8
1965		8.4		241.5	309.8	298.5	265.8	391.8	327.7	64.6	12.5		1920.6
1966	2.4	18.7	78.4	109.5	349.3	232.7	174.3	646.7	119.5	33.5	6.0		1771.0
1967	2.3	12.6	6.0	94.2	159.9	221.8	327.3	209.8	488.9		21.2		1544.0
1968	0.9		100.6	88.8	301.8	243.5	258.2	206.8	272.0	27.7	0.0		1500.3
1969	19.6		42.4	40.9	204.3	295.9	402.1	128.9	247.9	49.9	14.3		1446.2
Total	171.4	221.1	605.0	1701.4	5185.8	5406.2	5139.1	6738.0	6926.6	1287.6	286.2	13.8	33682.2
Total period (years)	20	20	20	20	20	20	20	20	20	20	20	20	20
Mean	8.6	11.1	30.2	85.1	259.3	370.3	257.0	336.9	346.3	64.4	14.3	0.7	1684.1
%	0.6	0.7	2	5	15.5	16	15	20	21	4	1	0	100%

3. Projects Constructed under French Aid

The following projects are being planned under French Aid, the completion of which is expected in 1973.

(1) Adjustment of the terminal area

Extension of the terminal building
Construction of a freight hangar

(2) Navigation aids, etc.

Radio navigation aids
Airport lighting facilities
Control facilities, communication facilities
Meteorological facilities

3-1 Terminal building

The French Plan includes remodelling of the existing terminal building to solve the following problems.

The area of the existing terminal building is too small for an airport equipped with a 3,000-meter runway, and no sufficient floor space can be secured for the anticipated new aviation companies to provide their services. Arrival and departure facilities for the passengers on international routes, and customs accommodation in transit are insufficient. Operation of the terminal building under the present condition is not perfect, particularly about flow planning. In order to solve the problem of confusion of baggage handling and flow of the international terminal and the domestic terminal, it has been planned to expand the terminal building by 900 m^2 and to construct a cargo handling hangar of 800 m^2. The officials concerned to the Aviation Bureau of the Laotian Government are thinking that it would be possible to increase the passenger handling capacity from 300 persons/hour to 500 persons/hour upon completion of this extension work. The figures show the number of persons a peak hour.

3-2 Navigation aids, etc.

The survey team investigated all facilities at the Vientiane Airport. The basic facilities are designed and built to accommodate

DC-8, which is the long distance turbo jet passenger airplane now being used on the international air routes. However, the navigation aids and other facilities at the airport have not been improved much.

It is expected that the Vientiane Airport will be improved and become a well balanced international airport upon implementation of the French aid plan, the details of which are given below.

3-2-1 Radio navigation aids

N.D.B., V.O.R., I.L.S. (localizer, glide path, middle marker, outer marker) are being scheduled for installations by 1973.

The N.D.B. now being used at the airport belongs to Air America, and it is necessary to repair the N.D.B. which has become unusable in the 1966 flood. V.O.R. is installed at the point about 2 km west of the runway, and is functioning as V.O.R. approach and the compass locator for holding pattern. According to the officials of the Aviation Bureau, this V.O.R. was first planned to be installed west of the outer marker, but was later changed to the present position in consideration of the navigation conditions.

As regards I.L.S., the localizer is not on the axis of the runway and is planned to be installed on the northern side of the runway. According to the French Aid Plan, the regular position for installation is the point about 250 m from the east edge of the runway. As there are still other facilities on this position, the location has been changed to the northern side of the runway. Although installation of I.L.S. is physically possible, it would be better to install it on the northern side of the runway as formulated in the French Plan. This is due to the possibility that the radio wave of the localizer may be disturbed in case there are aircrafts awaiting take-off at the holding bay of the taxiway on the taxiway on the east edge of the runway.

It has been planned to establish a glide path at the point on the inside about 400 meters from the runway threshold. This, compared with the standard position of 270 - 300 m toward the inside, is about 100 meters more toward the inside. This is probably for the purpose of reducing the influence of the aircrafts awaiting at the holding bay of the installed taxiway, which might interfere with the radio wave of the glide path in case the parallel taxiway is extended in the future and the installed taxiway is joined to the west edge of the runway.

If it should be necessary to avoid the abovementioned influence, an alternative plan is to move the glide path to the northern side of the runway.

3-2-2 Airport lighting facilities

Along with the improvement of the radio navigation aids, installation of the simple approach lighting on the west side of the runway and the VASIS on the east side of the runway is being planned.

According to Annex 14 of ICAO, ALPA system or Culvert system is the standard approach in case I.L.S. is operated under Cat. I, but the installation of simple approach lighting of lower cost has been planned because the weather conditions at the Vientiane Airport are very favorable and there practically are no cases of poor visibility.

VASIS has been installed only on the eastern side, because I.L.S. has been considered more than sufficient for the approach from the west site. As 99 % of the approaches to this airport is made from the western site, the visual aids facilities function as the monitor to determine whether the radio navigation aids are working perfectly. It would be advisable to establish a similar facility on the western side to reduce the stresses on the pilots.

3-2-3 Control facilities and communications equipment

It is being planned to complete by 1973 the following transmitting equipment.

(1) One unit of ISB 5 kW (CSF) Vientiane - Bangkok, RITY ATS VOICE

(2) One unit of ISB 2.5 kW (CSF) Vientiane - Phnom Penh, RTTY ATS VOICE

(3) One unit of ISB 2.5 kW (CSF) Vientiane - Saigon, RTTY ATS VOICE

(4) One unit of ISB 2.5 kW (CSF) (stand-by)

(5) Seven units of 1 kW A3 antiaircraft communication equipment

Same as in the case of transmitting equipment, the following receiving equipment are being planned for installation by 1973.

(1) Three units of ISB receiver

The following communication equipment are being planned for installation by 1971.

(1) Two units of LTTY, RTTY Teletype (Vientiane - Bangkok) (Vientiane - Saigon)

(2) More than two units of HF SSB 150 W (CW RTTY) (Vientiane - Pakse - Savannakhet - Luang Prabang - Sayaboury - Houei Sai). As the antenna for transmitting and the antenna for receiving are too close to each other causing much inductive interference, it is being planned to move the antenna for transmitting area to the west of the runway for improvement.

(Notes) ISB = Independent Side-band
SSB = Single Side-band
RTTY= Radio teletype
LTTY= Land line teletype
CW = Continuous Wave (A2)
AM = Amplitude Modulation
HF = High Frequency
CSF = Common Signal Frequency
ATS = Airport Terminal Service

3-2-4 Meteorological facilities

Meteorological service will be improved since it will become possible to obtain promptly the newest meteorological information upon completion of the communications network. As a facility, a ceiling meter is being planned for installation by 1973.

Fig. 3-1 TERMINAL

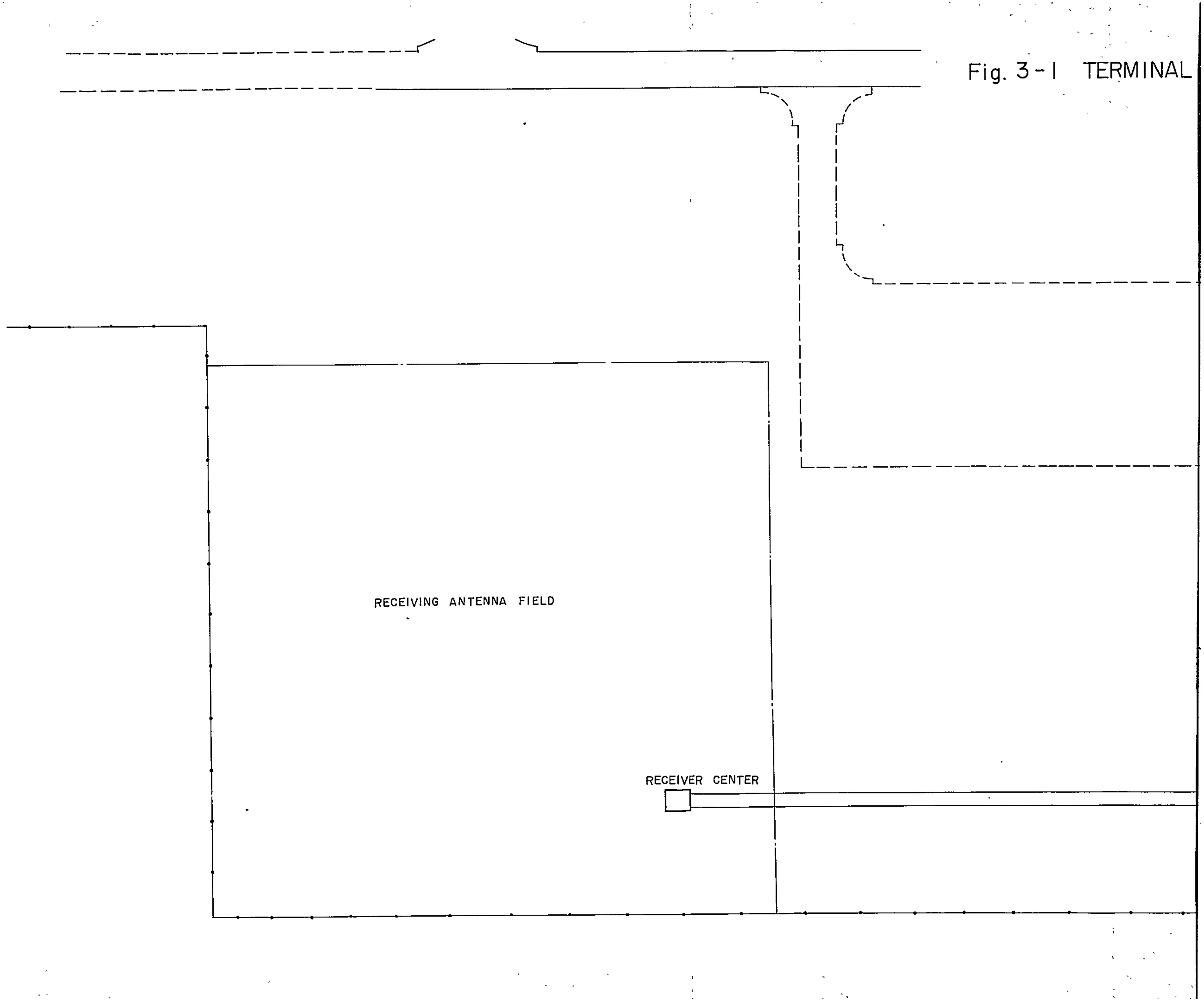
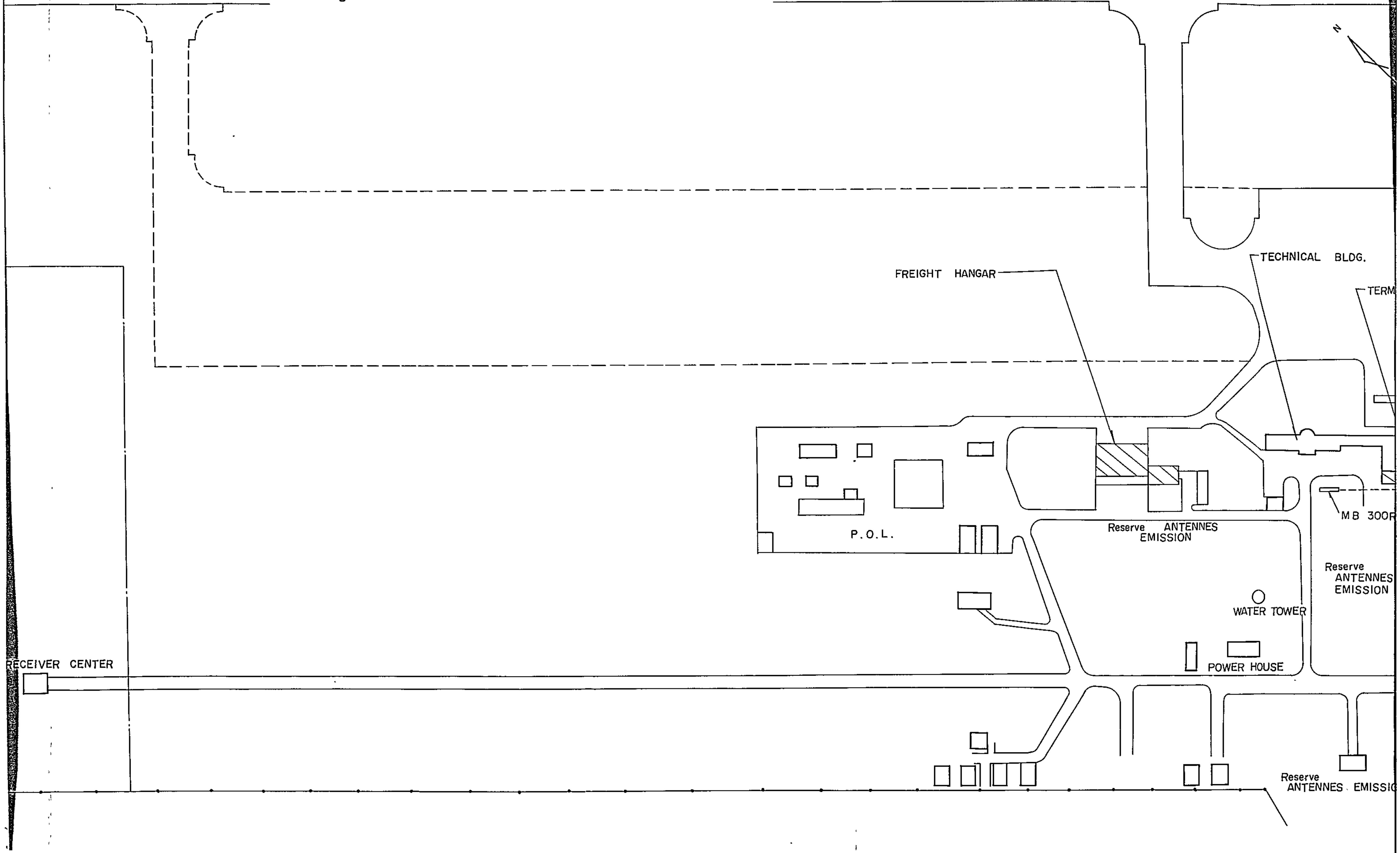
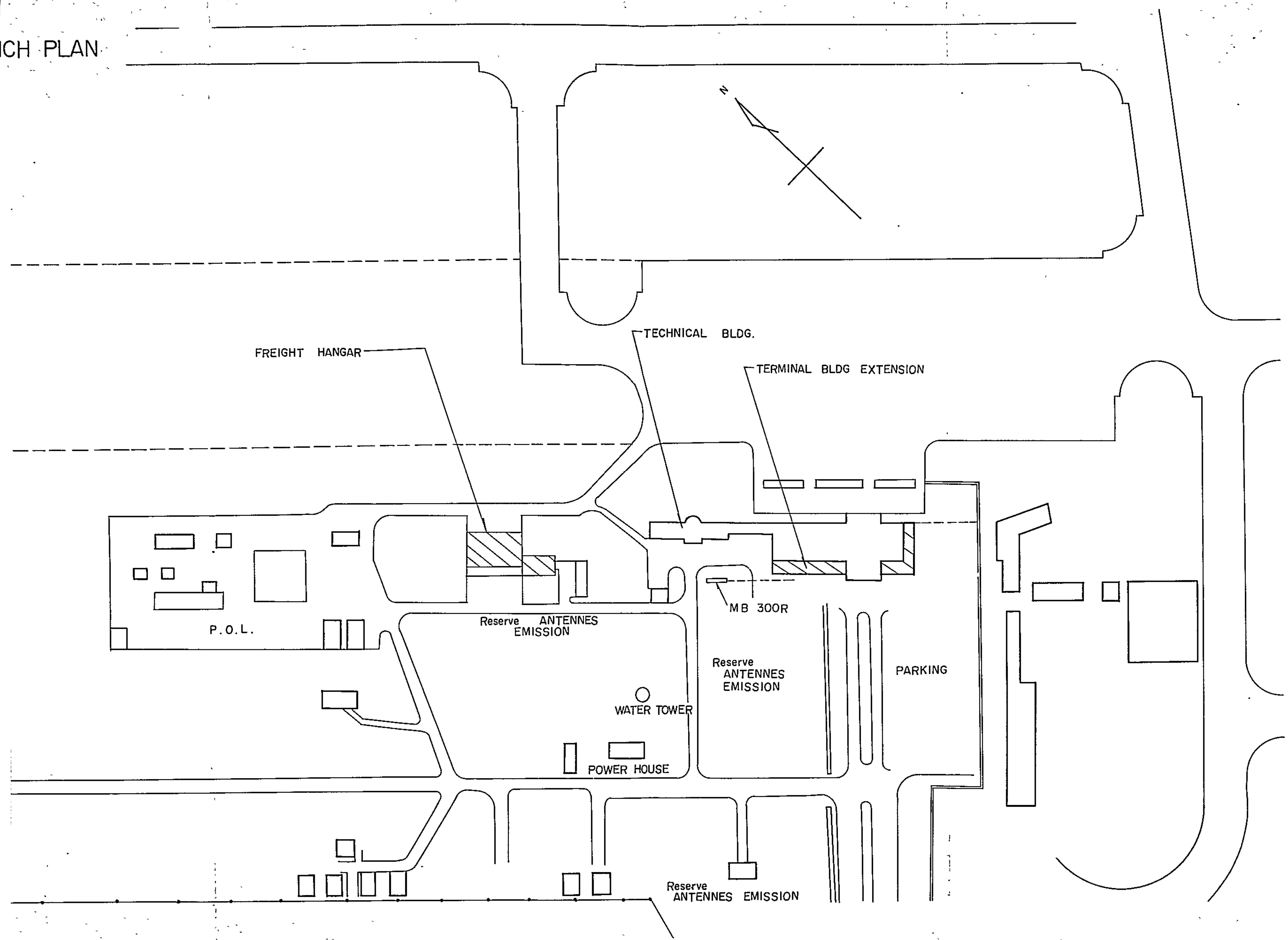


Fig. 3-1 TERMINAL AREA FRENCH PLAN



ICH PLAN


N
TECHNICAL BLDG.
FREIGHT HANGAR
TERMINAL BLDG EXTENSION
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MB 300R
Reserve ANTENNES EMISSION
PARKING
WATER TOWER
POWER HOUSE
Reserve ANTENNES EMISSION

4. Master Plan

4-1 A study of principal facilities

4-1-1 Demand forecast

In case of formulating an improvement plant of an airport, the scale is considered first of all, and then the details of arrangements and structure, etc. are decided. To fix tentatively the scale of such improvement plan, a demand forecast for air transportation in the expected year (1979) of completion of such improvement works is made. Then the number of annual flights is obtained from the calculated demand and the anticipated types of aircrafts and materials and the rate of utilization of seats. Then, the number of flights at peak hour is obtained from the operating hours of the airport and in consideration of the rate of concentration on peak hour based on past records. An improvement plan has been formulated by comparing the number of flights with the capacity of the airport having the existing facilities.

There are many ways of forecasting the future demand for air transportation such as the method based on the least squares method to forecast the future demand directly from the past results, the method based on correlation functions obtained from the relation between the economic growth and the increase in the demand for air transportation, and a highly advanced method in which various economic indices, flow of passengers in the area, time value, etc. are combined. In Laos, it is extremely difficult to forecast the future demand for air transportation because statistical data necessary for the forecast are almost nil, and also because the domestic situation is unstable.

The forecast of demand for air transportation made in the First Design Report has been made on the assumption that the growth rate would be the rate between the growth rates of gross national product and population, and that the demand for air transportation would increase. The forecast made when formulating the French Aid Plan was based on the correlation of population and passengers. The results are as shown in Fig. 4-1.

Table 4-1 French Forecast

	Passengers per year (Persons)
1974	237,000
1979	391,000

Relations between the population and the demand for air transportation based on the data obtained last time and this time are as shown in Table 4-2.

Table 4-2 Relations between the population and the demand for air transportation in Laos

	Population in Laos (10^3 persons)	Air Passengers (persons)	Air Cargo (tons)
1964	2,569	45,568	1,055
1965	2,635	47,081	1,399
1966	2,698	88,497	3,041
1967	2,765	105,363	3,869
1968	2,825	132,571	7,101
1969	2,893	136,824	6,562

Based on the actual number of passengers during the period of 1964 to 1969, the demands in 1974 and 1979 have been estimated as follows by least square method.

$$Y = 192\ x^2 + 10{,}423\ x + 94.897$$

where y: number of passengers

x: 2n - 1

n: Number of years based on 1966

Year	Number of Passengers (Persons)
1974	208,000
1979	237,000

The coefficient of correlation of the population of Laos and the passengers is y = 0.94. This shows that there is correlation between two.

The average population growth rate in Laos for the period of 1964 1969 is 2.5%. Assuming that the population will increase hereafter at rate, the population in 1974 and 1979 will be $3{,}273 \times 10^3$ persons and 10^3 persons respectively.

The correlative formula of population and air passengers is

$$y = -789 + 0.323\ x$$

where y = number of air passengers

x = population

The estimated number of air passengers is shown in the following table.

Table 4-3

Year	Number of air passengers (persons)
1974	268,000
1979	409,000

Table 4-4 and Fig. 4-1 show the comparison of the forecast of air pass in the First Design Report, the French forecast, and the forecast made time.

Table 4-4 Comparison of Forecasts Number of Air Passengers

Year	1st Design Report	French	Forecast this time	
			Least square method	Correlation method
1974	112,800 - 132,000	237,000	208,000	268,000
1979	127,200 - 166,800	391,000	237,000	407,000

4-1-2 Control capacity and handling capacity

The demand forecast for air transportation has been made in the foregoing paragraph, but this is not a satisfactory forecast as data necessary were not sufficiently available. In opposition this time, the control capacity at peak hour in case of scheduled equipment installed is calculated to study the number of passengers that can be handled at an airport.

It is considered that Instrument Approach System will be as shown in Fig. 4-2 upon completion of V.O.R., I.L.S., etc. under the French Aid Plan. Assuming that the rule of landing from the western side and taking-off toward the western side is still enforced and also that landing and take-off are carried out alternately, the control capacity will be about 20 aircrafts an hour. Landing and take-off of 5 to 6 small military airplanes by V.F.R. will also be possible in the same hour.

Fig. 4-1 COMPARISION OF THE FORECAST OF AIR PASSENGERS.

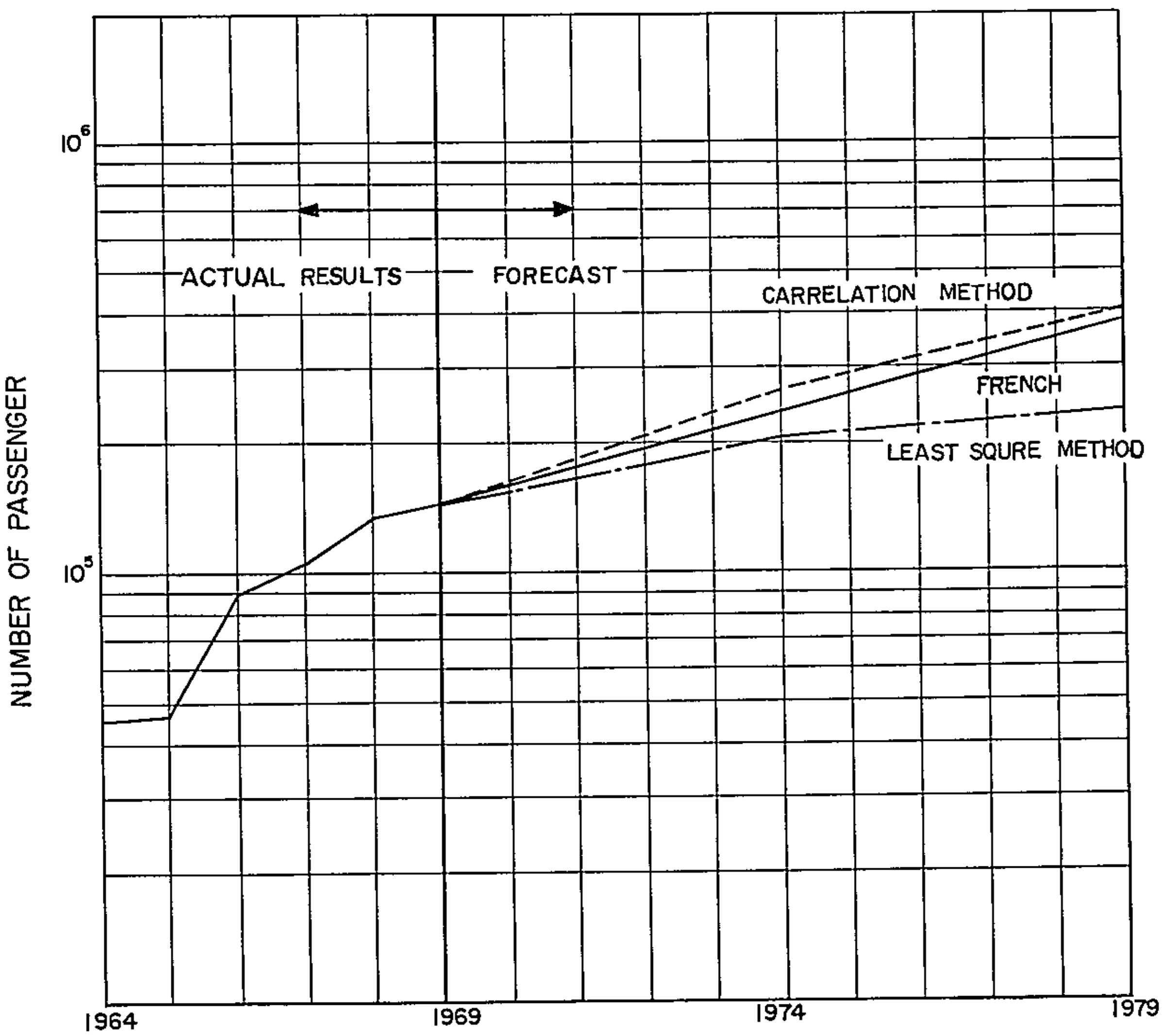
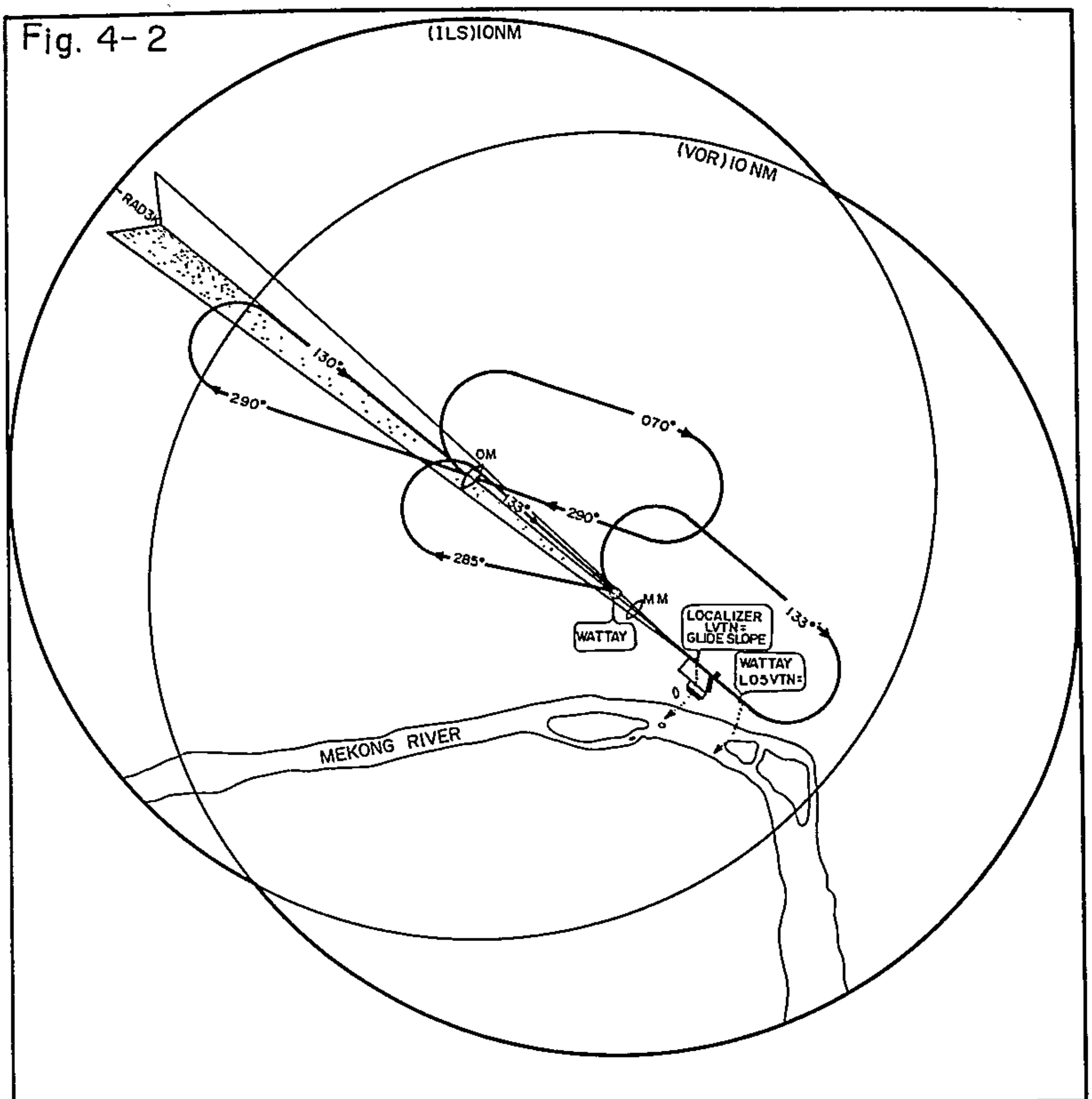
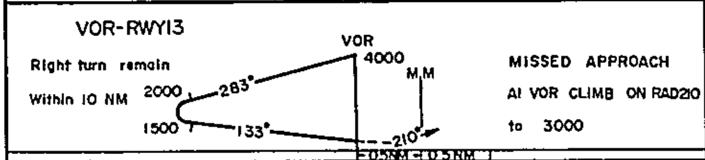


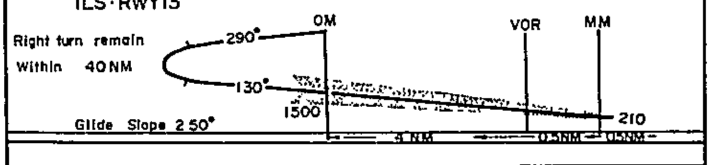
Fig. 4-2

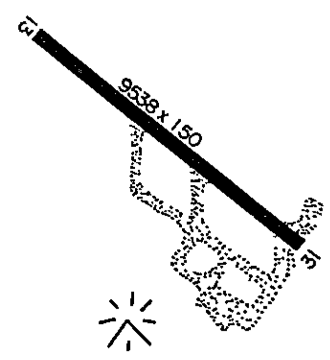




ELEV 561

LANDING MINIMA	
Straight in	NOT AUTHORIZED
Circling	1061(MSL) : 1061-1





Straight in	761 ft — 800 rn.
Circling	1061(MSL) : 1061-1

4-1-3 Calculation of basic numerical values

The basic numerical values calculated for 1979 on the basis of maximum estimated value of 407,000 persons under Para. 4-1-1 are as follows. The annual passengers for the period from 1966 to 1969 is divided according to the mean ratio of international air passengers to domestic air passengers.

International air routes	407,000 x 0.335 ≒ 136,000
Domestic air routes	407,000 x 0.665 ≒ 271,000

As regards the type of aircraft, B-727 (129 passengers) has been contemplated for short-distance air routes such as Vientiane - Bangkok and Saigon - Vientiane routes. DC-8 will be used upon resumption of long distance air routes after the international situation in Indochina has stabilized. Here, the long distance air routes have not been taken into consideration. In view of the present condition of all domestic air routes, the load factor of 50% has been taken, assuming that YS-11 (60 passengers) class of aircraft would be used coupled with the improvement of the airports on domestic air routes.

The annual number of flights calculated on the above assumptions is as follows:-

International air routes	136,000 ÷ (129 persons x 0.5) ≒ 2,109 flights
Domestic air routes	271,000 ÷ (60 persons x 0.5) ≒ 9,033 flights

The average number of flights per day is 1/365 respectively, which is multiplied by the assumed concentration rate of 1.2. The results are:-

International air routes	2,109 ÷ 365 x 1.2 ≒ 6.9 flights
Domestic air routes	9,033 ÷ 365 x 1.2 ≒ 29.7 flights

Assuming that the concentration rate is 0.1 at peak hour, the number of flights at peak hour is obtained as follows:-

International air routes	6.9 x 0.1 ≒ 0.7 flights
Domestic air routes	29.7 x 0.1 ≒ 3.0 flights

Therefore, the total number of flights at peak hour is 3.7. Besides this, there are landing and take-offs of the aircrafts of Air American on irregular service and of the aircrafts of the Laotian Air Force. According to the data obtained at the investigation made recently, the number of flights per day at present is as follows:-

Military aircrafts	46 flights/day	(Average during the period of Jan. 18- Jan. 24, '71)
Air America's aircrafts	132 flights/day	"
Total	178 flights/day	

Assuming the same concentration rate as that of aircrafts on regular service, the number of landings and take-offs at peak hour is 178 x 0.1 - 17.8. Together with the abovementioned 3.7, the total number of landings and take-offs at peak hour is 21.5.

As mentioned under Para. 4-1-2, the control capacity when all aircraft take I.L.S. approach is 20 aircrafts/hour, and is 25 - 26 aircraftss of the air force taking V.F.R. approach. Therefore, the total number of flights in 1979 will increase to the full control capacity.

4-1-4 Runway

The construction work for the extension of the runway by 1000 m was completed in July 1970. Its dimension is as follows.

Runway length	3000 meters
Width	45 meters
Over-run	45 m x 60 m x 2
Landing strip	150 m x 3120 m

The above was based on the recommendation of the 1st Survey Team, and the future air routes and the flying distance envisaged at that time were as follows.

Vientiane - Bangkok	500 km
Vientiane - Hong Kong (via Bangkok & Danan)	2,500 km
Vientiane - Karachi (via Bangkok)	4,400 km
Vientiane - Djakarta	3,000 km
Vientiane - Calcutta	1,500 km

Types of aircrafts used

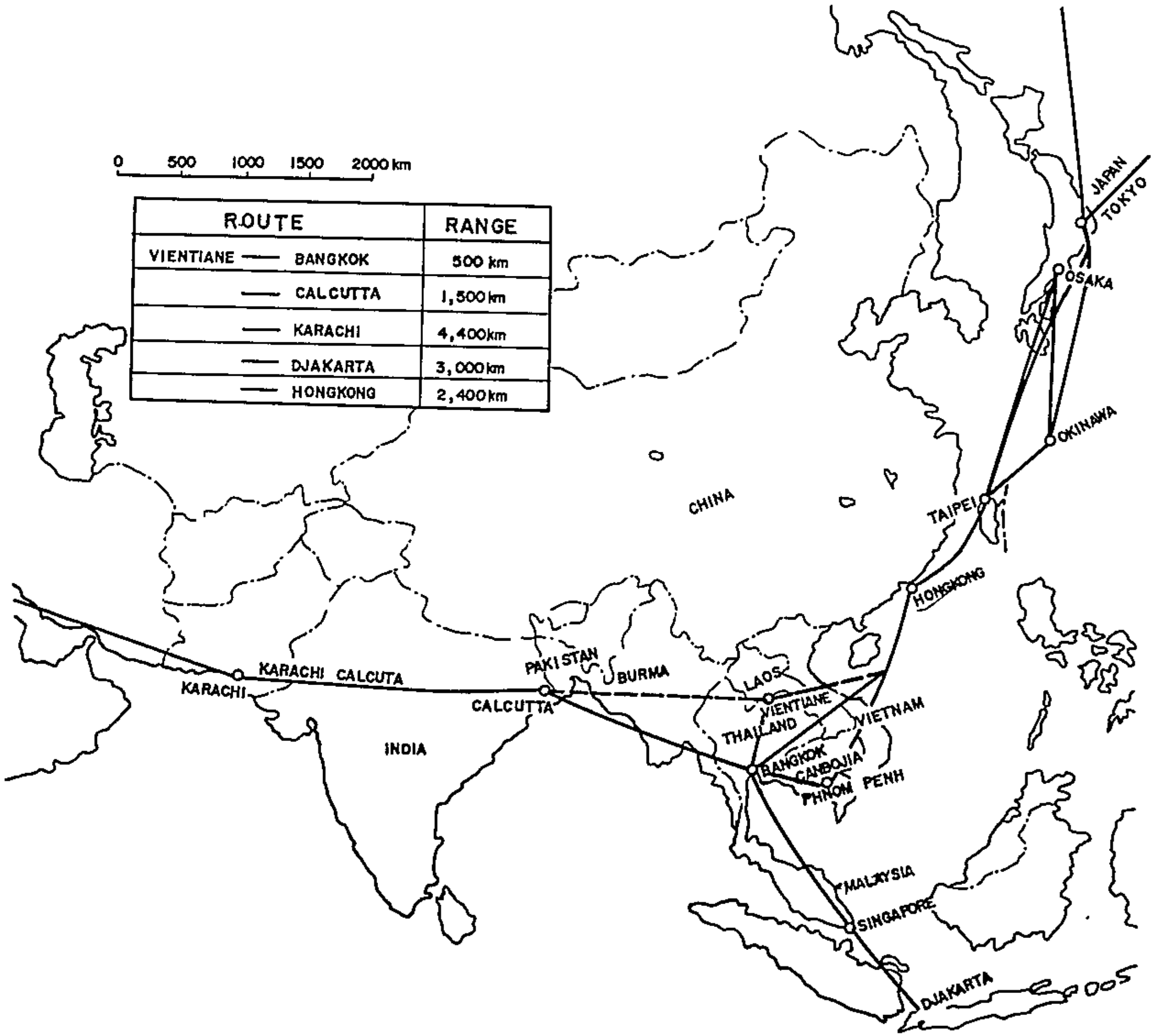
B - 707   DC - 8

At present there is no aviation company using B-707 and DC-8 on regular service after the runway was extended. The largest aircraft now being used is IL - 18.

So far, Japan Air Lines operated DC-8 on charter service on August 10 and 16, 1970.

The use of DC-8 on Vientiane - Karachi air route recommended by the 1st Survey Team is considered appropriate.

Information has been received that a certain aviation company is planning to operate an air route using DC-8 class aircrafts by 1975, and this master plan is also based on the same type of aircraft and the same air route. (See Fig. 4-3)



ROUTE	RANGE
VIENTIANE —— BANGKOK	500 km
—— CALCUTTA	1,500 km
—— KARACHI	4,400 km
—— DJAKARTA	3,000 km
—— HONGKONG	2,400 km

Fig. 4-3. ROUGH PLAN OF AIRROUTES IN SOUTHEAST ASIA

4-1-5 Taxiway

In this airport, where the military and civil terminal facilities are maldistributed on the eastern edge of the runway, it is desirable that the aircraft which has landed on the runway is extricated promptly from the runway to clear the runway for the next aircraft for landing of for take-off.

This is directly connected with the safety of the aircrafts, increased efficiency of the runway and increased capacity of the airport. It will further increase the efficiency of the 3,000-meter runway completed under the 1st Stage Extension Work, coupled with the improvement of the facilities for landing and take-off.

As to the construction of the taxiway, it was recommended in the First Report to carry it out in the 2nd Stage.

(1) Selection of the type of taxiway

One way of increasing effectively the capacity of the runway is to shorten as much as possible the time the landing aircraft occupies the runway. For this purpose, a runway exit taxiway would be most appropriate, because it allows the aircraft to extricate from the runway while running smoothly and safely at high speed. The taxiway for the Vientiane airport is planned as a runway exit taxiway.

(2) Exit speed at runway exit taxiway

It is desirable that an aircraft which has landed on the runway to pass through the runway exit taxiway between the runway and the taxiway as fast as possible, but there certainly is a limit to the speed for safe running.

According to the Aerodrome Manual (ICAO Doc, 7920 Part 2), 60 m.p.h. (97 km/hour) is the speed for both the military and the civil aircrafts to turn off at the runway exit taxiway regardless of the condition of the surface of the exit taxiway, and it has been reported that the passengers do not feel unconfortable at that speed. This speed has been used when designing this airport, since it has been recommended that the exit taxiway planned for the said speed would allow the pilots to operate the aircrafts safely.

(3) Determination of position (See Figs. 4-4, 4-5 & 4-6)

(i) Basic conditions will conform to ICAO.

(ii) Various indices of the Vientiane Airport and the revised gliding distance coefficient

Elevation	170.0 meters
Temperature	28.8°C
Atmospheric pressure	74.47 cm
Revised coefficient	1.07

(iii) A study

		GROUP I	GROUP II	GROUP III
ICAO	Type of aircraft	CV-440 CV-340 M -440 F - 27 DC-3, DC-4	Electra Viscount 810-745 Lockheed 1649-1049 DC-6, DC-7	Boeing 707 DC-8 CV-880 Caravelle
	M S	200 m 760 m	200 m 1,220 m	150 m 1,830 m
VIENTIANE AIRPORT	Type of aircraft	DC-3, DC-4 C-46, AVRO B-307	YS-11 class B-727-100 class IL-18 class	DC-8 class
	SC	827 M	1,320 m	1,970 m
	Plan	900 m		2,100 m
PLAN. I		Landing from west side ④ Insufficient Landing from east side ②	② is used ④ is used	③ is used Will be End-turn
PLAN. II		Landing from west side ① OK Landing from east side ②	② OK ①	③ OK End-turn

(iv) Conclusion

Plan II is appropriate as the result of a study of plan I and plan II.

(a) Existing taxiway ② can be used effectively.

(b) When landing from the west side, taxiing to Taxiways ① , ② and ③ respectively is possible for each group of air-crafts, and this minimizes the time of occupation of the runway by the aircrafts.

(c) When landing from the east side, the wind is a head wind at this airport. It is possible to turn the aircrafts of Group 3 to Taxiway ① . In this case, it is advisable to make larger the radius of the fillet on the east side of ① .

(d) The new parallel taxiway for connecting with the runway exit taxiway ① is the portion which had been used as pierced steel prank runway before the present runway was constructed.

(4) Design for runway exit taxiway

About the configuration of runway exit taxiways, as the result of a study based on the recommendation of ICAO and that of Horonjeff and etc., the configuration of combination of simple curve shown in Fig. 4-7 shall be recommended.

Fig. 4-4 ORIGINAL PLAN

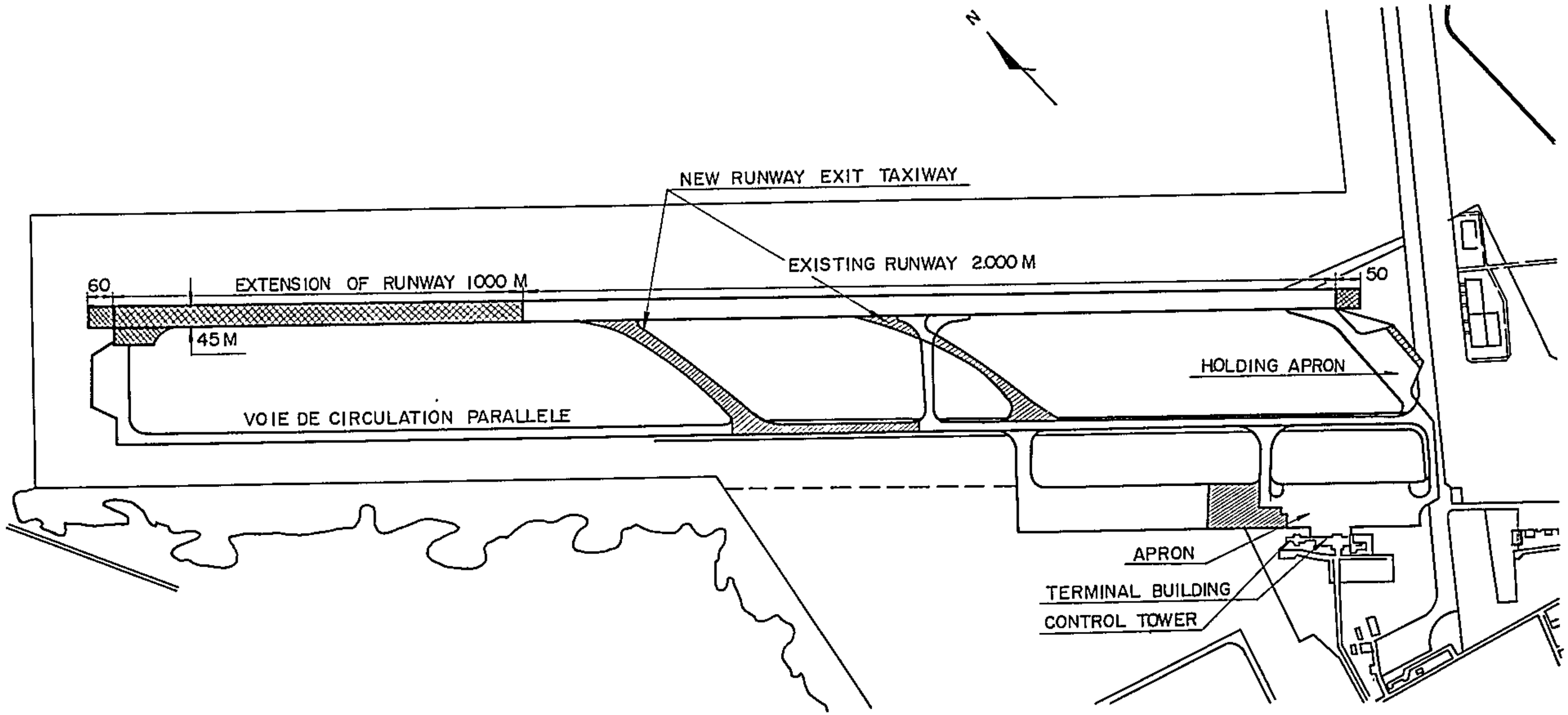
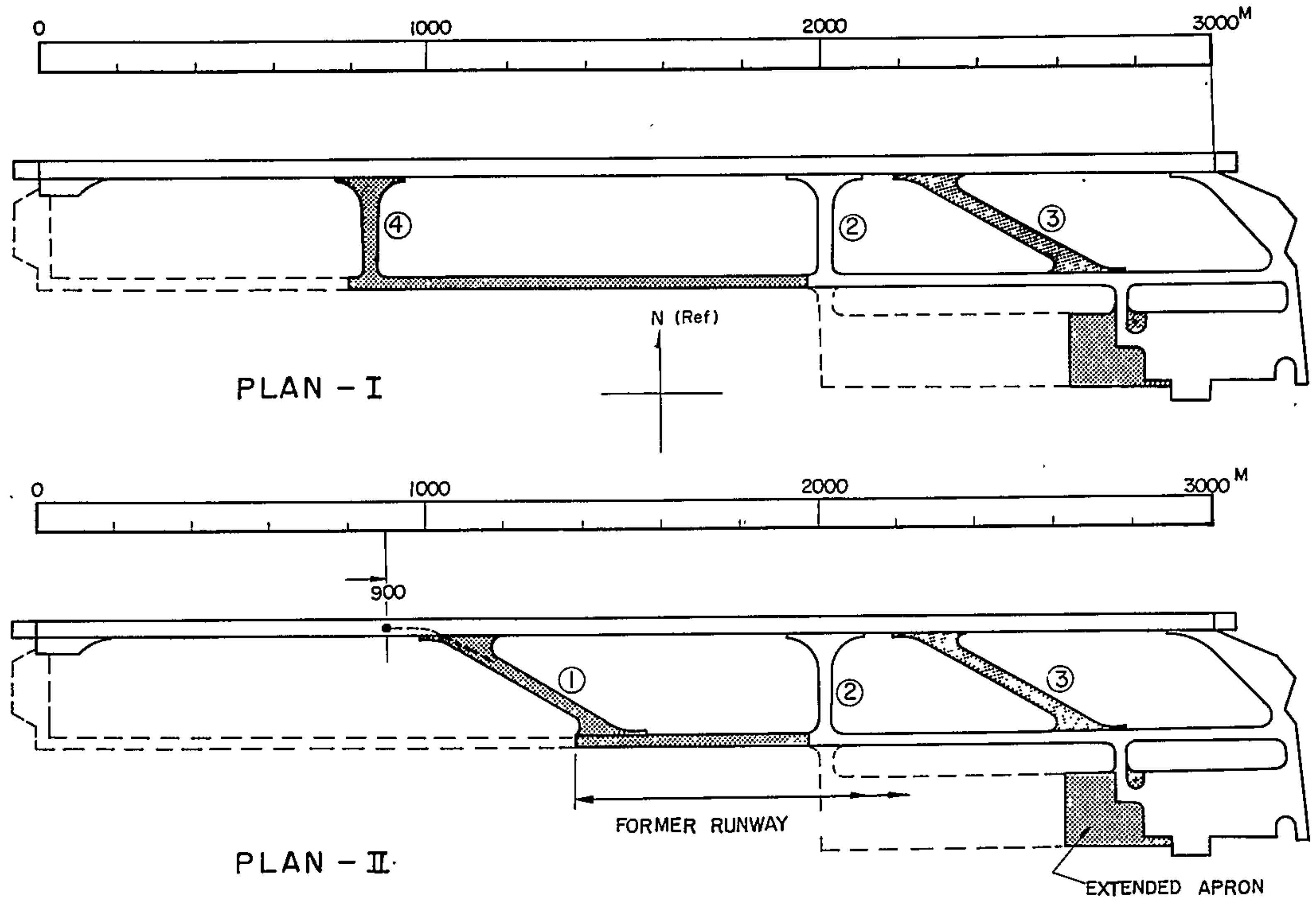


Fig. 4-5



0
1000
2000
3000M
④
②
③
N (Ref)
PLAN - I
0
1000
2000
3000M
900
①
②
③
FORMER RUNWAY
PLAN - II
EXTENDED APRON

Fig. 4-6 DISTANCE REQUIRED TO REDUCE SPEED FROM 60 M.P.H TO OPTIONAL SPEED.

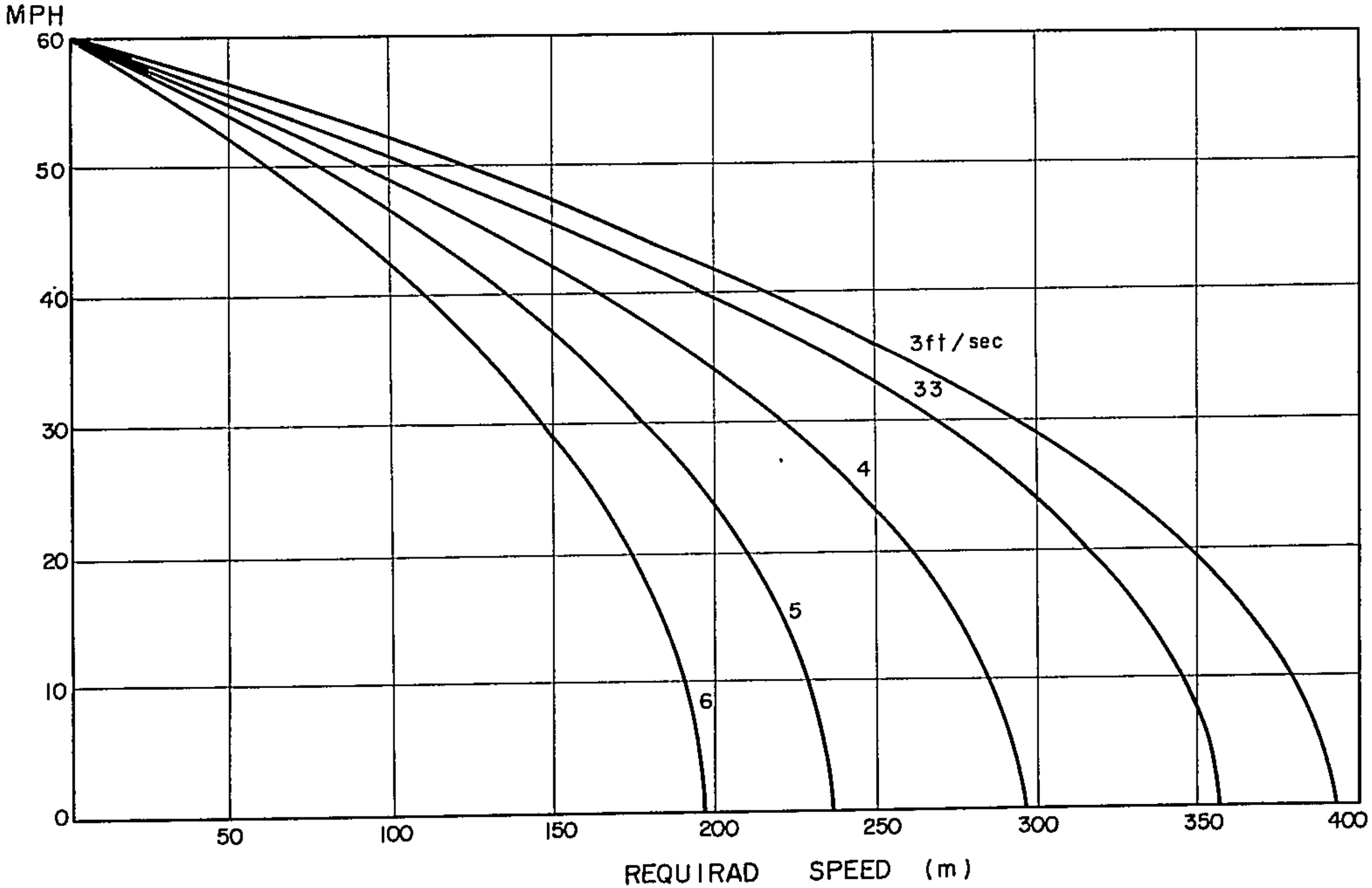
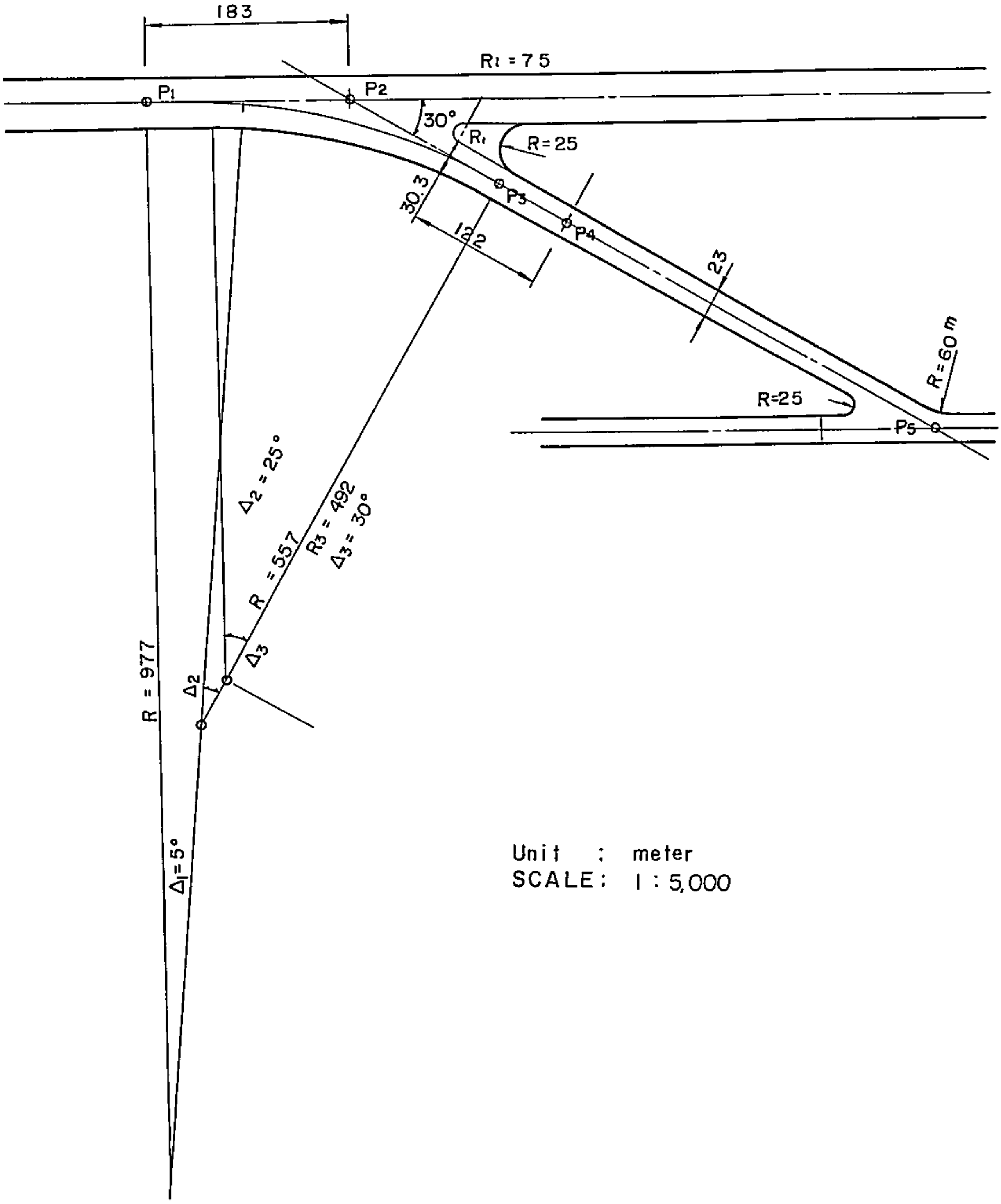


Fig. 4-7 DESIGN FOR RUNWAY EXIT TAXIWAY



Unit : meter
SCALE: 1 : 5,000

4-1-6 Apron

As explained in Para. 4-1-3 on Calculation of Basic numerical values, the number of flights at peak hour is estimated at 0.7 flight on the international air routes using short range turbo jet B-727-100 class aircraft, and 3.0 flights on domestic air routes using short range turbo-propor piston-engine aircraft of YS-11 class. The number of berths required will be studied on the basis of the number of flights, but the relations between the types and the number of aircrafts now in service, together with the remodelling and expansion of the terminal building now being planned by the French Government should be taken into consideration.

When the design for the 1st Stage Extension Work (1969) was prepared, 7 or 8 berths were taken into consideration. They were 2 berths for DC-8 (turbojet), 3 to 4 berths for DC-7C class aircrafts, and 2 berths for DC-3 or DC-4 class aircrafts. Judging from the capacity of the ground force, self-manoeurring system was suggested. For taxiing DC-8, it was considered necessary to widen the neck of the entrance to the taxiway on the eastern end of the apron. The extension work on this portion had already been completed when the runway was extended and widening of the holding apron was carried out.

Remodelling and expansion of the terminal building planned under the French aid (called French Plan) was studied at the survey conducted this time, and it was decided to design the 2nd Stage Extension Work following this French Plan. Under the French Plan, the entrance and exit for international air routes is arranged on the left side of the apronlooking from the terminal building, while the entrance and exit for the domestic air routes is on the right side. Because of this, the design of aprons, particularly that of Loading Apron, differs largely from the proposed plan submitted at the time of implementation of the 1st Stage Extension Work.

Although most of the aircrafts presently owned by the Laotian aviation companies are of the piston-engine DC-3 class developed in the latter half of 1930 (See Table 2-4), the types and the scale of aircrafts for the domestic air routes will have to be the same for some time hereafter, because of the present condition of local airports in Laos (See Tabl 2-) and other circumstances.

However, the Laotian aviation companies, sooner or later, will have to face such difficulties as the superannuation of the aircrafts and reduced rate of operation due to unavailability of parts, and must work out countermeasures to keep pace with the rapid changes in the types of and sizes of the aircrafts. (See Fig. 4-8)

(1) Planning of aprons

Diversity and adaptability of the plan are required when planning the aprons of this airport since it is difficult to forecast the future demand for air transportation in Laos, and the types of aircrafts put on service on international air routes are getting more and more diverse.

(i) Loading spot

Special attention has been paid to the following points.

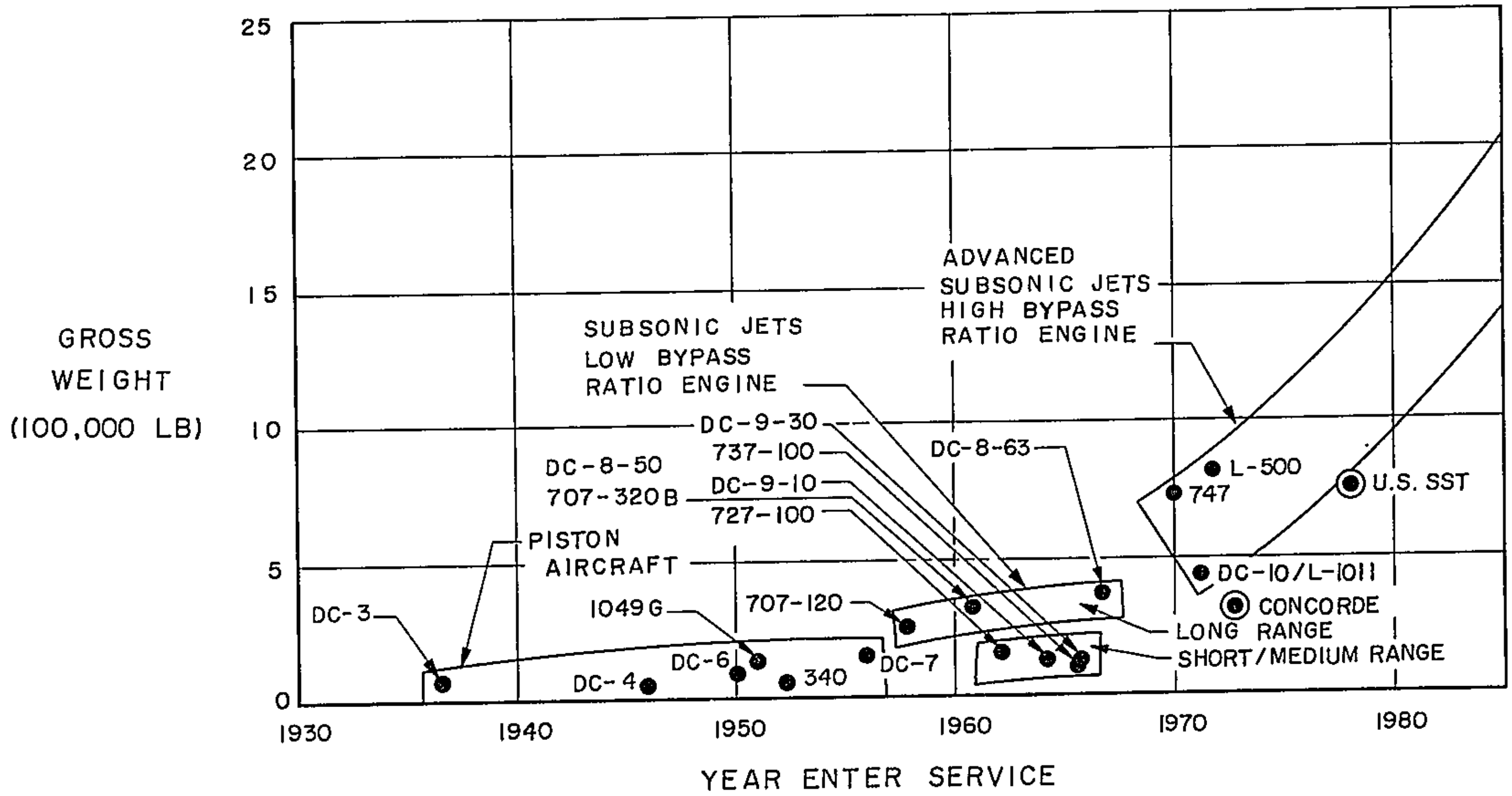
a. The open apron system has been avoided and the spots on the sides of the terminal building have been secured to provided efficient operation of aircrafts and better services to the passengers, and to alleviate traffic congestion at the airport. The spot on the left side of the terminal building will be used for international air routes, and the right side for the domestic air routes to conform to the French Plan.

b. As far as the space in the apron area permits, aircrafts, from the viewpoint of operating efficiency, as a rule are to taxi in and taxi out under their own powers. Regularization of ground service has been taken into consideration in such a way that the short range turbojet plane on international air routes can nose-in at the self-manoeuvring spot for the short range piston-engine plane in case the short range turbojet plane on international air routes cannot get a spot.

(ii) Parking spot (Night stay spot)

All Laotian aviation companies are using the Vientiane Airport as the base. Therefore, the necessity of the spot for night stay should naturally be taken into consideration. Fig. 2-5 shows

Fig. 4-8 GROSS WEIGHT GROWTH



that there are about 8 aircrafts staying at the airport at night, and the number of such aircrafts is expected to increase further in the future. Self-manoeuvring parking system will be employed in the first stage, and spots will be arranged with employing the nose-in system, keeping pace with the increase in number of aircrafts. Machinery and equipment such as the towing tractor, etc. for ground service will become necessary at such a time.

(iii) Spot for light aircrafts (including helicopters)

As shown in Fig. 2-5, there are many light aircrafts and their time of stay at the airport is longer. This is not peculiar to this airport, and is common to all airports. Light aircrafts including helicopters will be accommodated at the end of the left side of the apron.

It is generally said that the demand for light aircrafts grows fast keeping pace with the progress of regional development, economic growth and elevation of the living standard. The expected increase in the number of aircrafts is mainly due to the increase in the number of aircrafts owned by the educational institutions for the training of pilots, private aircrafts, aircrafts for government and public offices, and aircrafts for labor saving and land development cooperation. Again, more aircrafts are expected to be used in the fields of survey, inspection, relief activities, patrolling for disaster prevention on rivers, roads, and forests and such public services.

(iv) Spot for retired aircrafts

Though gradually, the number of aircrafts which will be put out of service will increase along with the changes in the types of aircrafts mentioned in the foregoing paragraph. Again, by moving the damaged aircrafts now staying at the maintenance factory apron to the spot for retired aircrafts, it will be possible to increase the efficiency of the maintenance apron. No particular Spot has been planned this time, but it will become necessary that the airport authorities work out some countermeasures in the near future for the effective management of the airport.

(2) Study of plans

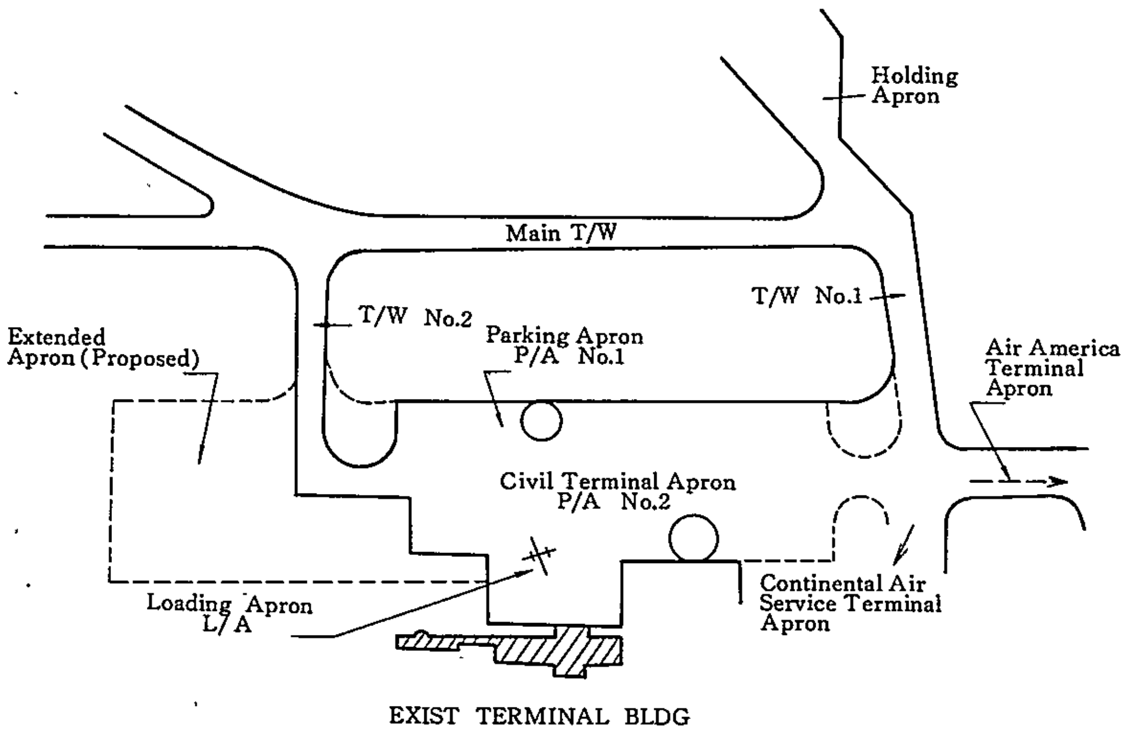
The types and the number of aircrafts are expected to change gradually. Various plans to cope with the situation have been formulated and studied especially about the following items. (See Fig. 4-8 and Fig. 4-9)

(i) A tendency of an increase in air transportation demand forecast

(ii) Development and transition of the types of aircrafts

(iii) Development of the Southeast Asian air lines

(iv) Actual investigative results of parking situation at Vientiane Airport



TERMINAL APRON PLAN

Fig. 4-9 TYPICAL PASSENGER/CARGO GROWTH FORECAST

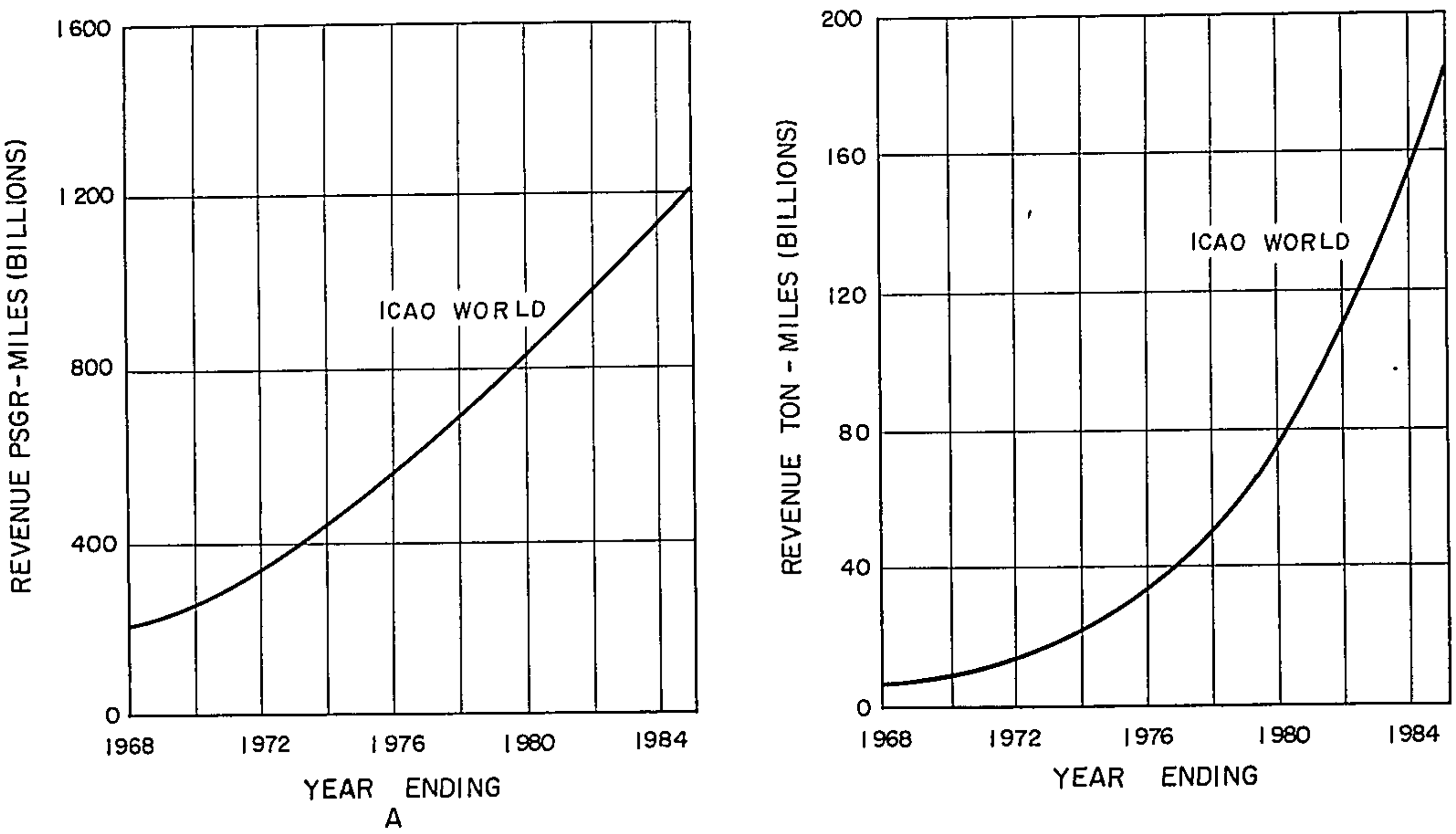
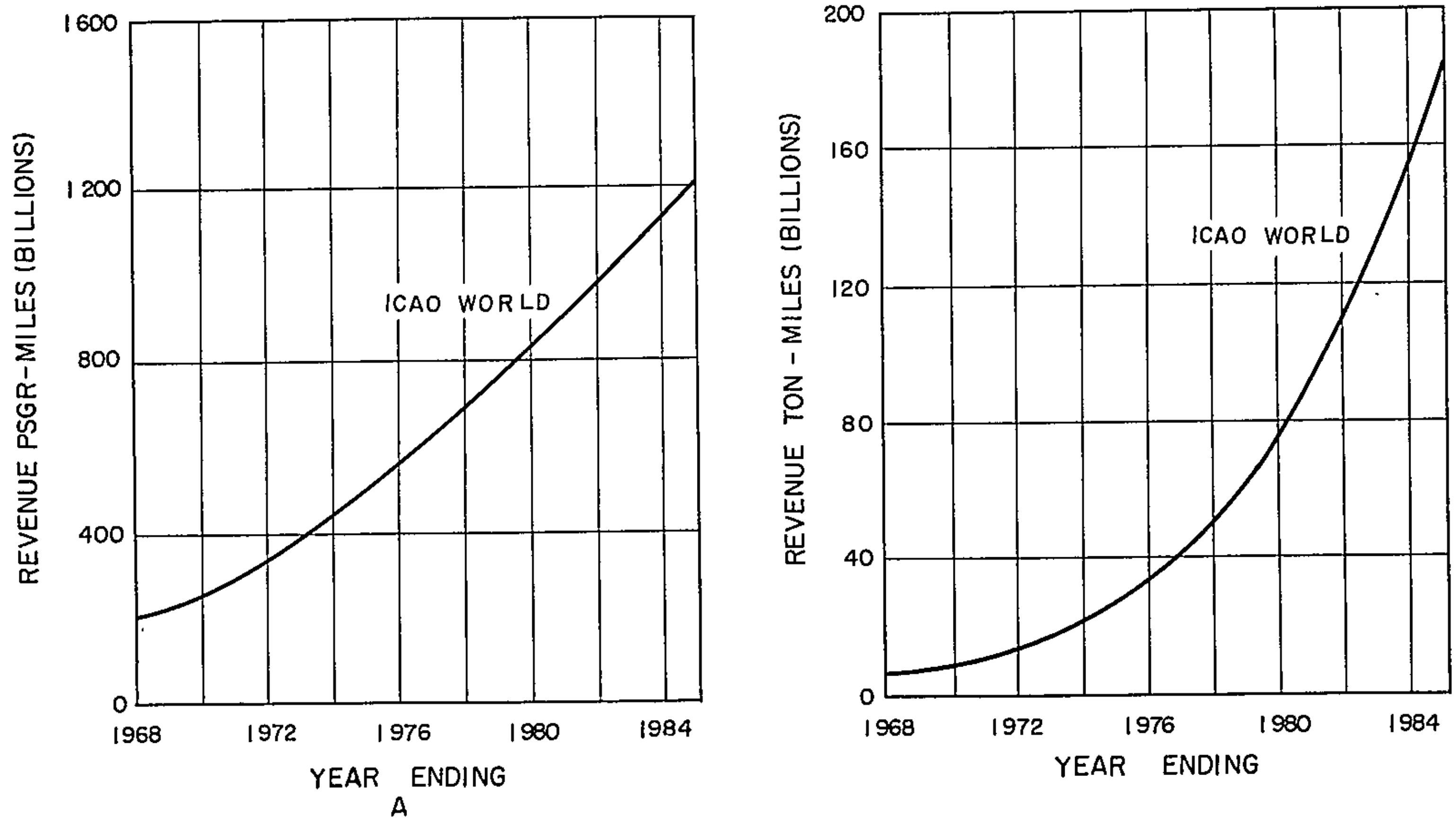


Fig. 4-9 TYPICAL PASSENGER / CARGO GROWTH FORECAST



The civilian aircrafts presently owned by Laos are as follows:-

DC-3 ..... VISCOUNT class	10
Light aircrafts	7

The Laotian Civil Aviation Bureau has the intention of planning the construction of aprons based on the following factors.

Anticipated number of flights at peak hour in 1979

Domestic air routes	3 flights	YS-11 class
International air routes	0.7 flight	B-727-100 class

Parking time on Loading Apron

Domestic air routes	60 minutes
International air routes	120 minutes

The above parking time is considered appropriate. The number of loading spots which should be secured by 1979 has been calculated as follows on the above assumptions.

Domestic air routes	3 aircrafts + 1 stand-by = 4 spots YS-11 class
International air routes	0.7 x 2 + 1 stand-by = 2 or 3 spots B-727-100 class
Required number of spots =	6 or 7 spots

(1) PLAN I (See DWG No.3-1 Scheme 1)

Type of aircraft:	YS-11 or equivalent B-727-100 or equivalent	
Conditions for parking:	Taxi-in and taxi-out both for loading and parking	
Loading spots:	Domestic air routes	4
	International air routes	3

Parking spots:	6 By removing the illuminating light which is an obstacle on the side of No.1 P/A, it is possible to park 8 or 9 aircrafts.

A part of the extended apron will be used for parking of light aircrafts. It will be necessary to provide a side-walk connected with the loading apron for the passengers to pass through.

(2) PLAN II (See DWG No.3-2 Scheme 2)

Type of aircraft:	YS-11 or equivalent	
	B-727-100 or equivalent	
Conditions for parking:		
Loading:	Taxi-in, taxi-out	
Parking:	Taxi-in, taxi-out	
	Tow-in, tow-out	
Loading spots:	Domestic air routes	4
	International air routes	3
Parking spots:	YS-11 or equivalent	9*
	B-727 or equivalent	2

Note: * If No.1 P/A is limited to taxi-in and taxi-out, the number of parking spots on the side of No.1 P/A comes to 6, and the total number of parking spots comes to 7.

The parking area for light aircrafts will be the same as mentioned in PLAN I.

Same as in PLAN I, a side-walk connected with the loading apron for the passengers is necessary.

(3) PLAN III (See Fig. 4-10)

Type of aircraft:	YS-11 or equivalent
	B-737-100 or equivalent
	B-727-100 or equivalent
	DC-8-60 series or equivalent

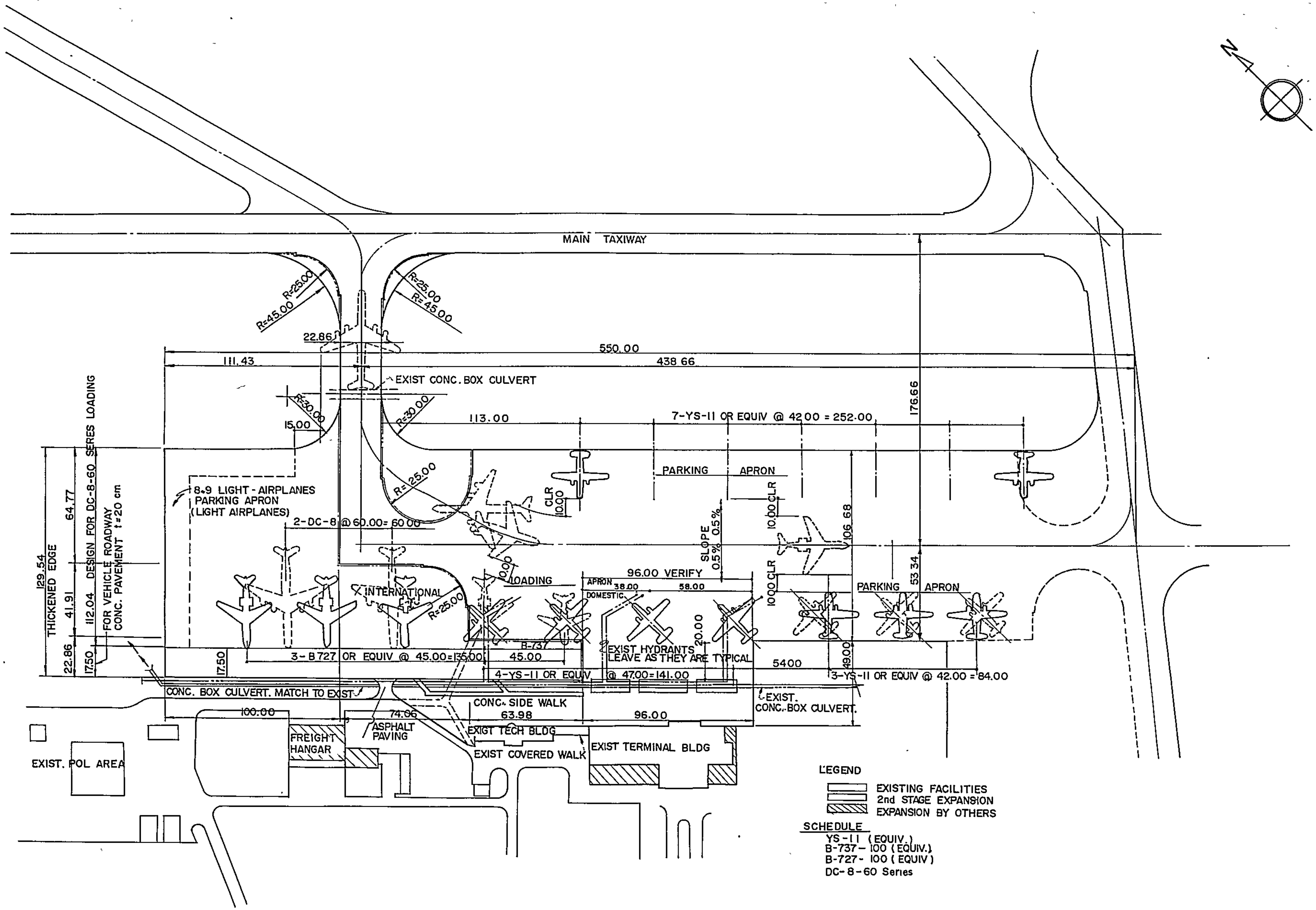


Fig. 4-10 APRON PARKING CONFIGURATION SCHEME III (FINAL)

In this case, DC-8 is considered to substitute a part of B-727.

Conditions for parking:

Loading:	YS-11	taxi-in, taxi-out
	B-727	taxi-in, taxi-out
	DC-8	taxi-in, taxi-out
Parking:	YS-11 or equivalent	
		taxi-in, taxi-out
		tow-in, taxi-out

Loading spots:

Domestic air routes:	4 (2 of these are for common use with B-737 or B-727)
International air routes:	B-737 or equivalent 1 (common use with YS-11 class) B-727 or equivalent 3 (one of these is for common use with YS-11 class) DC-8 or equivalent 2 (common use with 3 B-727's)

A part of the extended apron will be used as the parking apron for light aircrafts same as in PLAN I and PLAN II.

Conditions for allowing DC-8 to park under PLAN III are the followings:-

(a) The entrance to the apron is limited to No.2 T/W

(b) The width of the apron necessary is 100 m on the west side and about 130 m on the south side.

(c) The extension of the connective fillet of the runway exit taxiway No.2 with the runway for tow-out

(4) Result of the study of each plan (See Table 4-5)

It is considered that consolidation of the airport of its capital accomplish an important part for an inland country like Laos in promoting her economic growth in view of the present circumstances in which land transportation network is poor.

Under these circumstances, PLAN III is recommended for the extension of the terminal apron of the airport at present. Therefore, the master plan will be based on PLAN III.

(i) Extend the area between the box culvert and the existing apron running through the green belt in front of the existing terminal building and the area surrounded by the 100-meter line on the west of No.2 T/W.

(ii) Widen the fillet joining New Apron and No.2 T/W by increasing the radius to 30 m, and about the joining fillet between main T/W and holding apron, parallel T/W crosses the joining T/W to the east end of R/W at an angle of 47°, and the radius of the fillet is 27 m. In case DC-8 class aircrafts aproach from parallel taxiway to joining taxiway, regulating taxing speed and steering, the fillet is not improved as it is sufficiently available under present conditions.

(iii) Construct a concrete pavement passage-way (T = 20 cm) for automobile's passage 17.5 m in width parallel to the terminal building.

(iv) The drainage is planned to stream to the existing drainage ditches on the south side of apron crown and to the extended new ones, and the covers are structures bearable with T-20 class load.

(v) Construct the side-walk about 2.0 m in width at the situation shown in Fig. 4-10 in the passenger's passage

(vi) Construct the facilities of tie-down for safety of parking of light airplanes as mooring facilities

Table 4-5 Apron Plans

Notes: L/A: Loading apron
P/A: Parking apron

Plan	Aircraft		Type of aircraft L/A	Type of aircraft P/A	Accommodation L/A	Accommodation P/A	Study
PLAN I	General	YS - 11 class	Taxi-in Taxi-out	Taxi-in Taxi-out	4	6[*2]	*1 It is conditional to use side-walk. *2 Possible to increase by one aircraft if the illuminating light is moved.
	Max	B-727-100 class	Taxi-in Taxi-out	Taxi-in Taxi-out	3[*1]	-	
			Total 13				
PLAN II	General	YS - 11 class	Taxi-in Taxi-out	Taxi-in Taxi-out Tow-in Taxi-out	4	9[*1]	*1 Towing tractor becomes necessary
	Max	B-727-100 class	Taxi-in Tow-out	Taxi-in Tow-out	3	2[*1]	
			Total 18				
PLAN III	General	YS - 11 class	Taxi-in Taxi-out	Tow-in Taxi-out	4[*2]	10[*1]	*1 Taxi-in Taxi-out parking is possible if used jointly with other small aircrafts. *2 Possible for joint use with B737, B727 *3 2, if 12 of loading apron are available for night stay. *4 Joint use with 3 B727's.
	General	B-727-100 class	Taxi-in Tow-out	Taxi-in Tow-out	3	-[*3]	
	Max	DC-8 class	Taxi-in Tow-out	-	2[*4]	-	
			Total 17				

Note: L/A Parking hours

Domestic air routes	60 min.
International air routes	120 min.

4-1-7 Markings and facilities

There are many among the existing markings which have either worn out due to the passage of aircrafts or have become indistinct due to weathering. Facilities for incidating the distance to go information facilities for the 2,000-meter runway are being left as they are even after the runway was extended to 3,000 meters.

It is necessary that markings and facilities are perfect to allow the pilots to get information on correct position and distance, etc. to operate the aircraft safely on the runway and the apron. In order that markings and facilities are in common internationally, those on the runway and the taxiway should satisfy the regulations indicated in Annex 14 of ICAO.

1. Runway

   Runway Designation Markings
   Runway Centre Line Markings
   Threshold Markings
   Fixed Distance Markings
   Touchdown Zone Markings
   Side Strip Markings
   Distance to go Information

2. Taxiway

   Taxiway Centre Line Markings
   Taxi-holding Position Markings

3. Apron

   It is necessary to provide markings to indicate the maneuvering paths and the parking positions of the aircrafts in conformity with Part 2 of Doc. 7920 of ICAO. Depending on the aviation bureau, the centre line marking of the gate position is provided, and the aviation companies usually draw the guidelines to satisfy the requirements of their own companies.

4-2 Study of navigation aids, etc.

4-2-1 Radio navigation aids

Radio navigation aids will be sufficient upon completion of the French aid plan. At present, it is being planned to use V.O.R. located at about 2 km west of the runway for V.O.R. approach, and also as compass and locater of the holding pattern. When the problems of public peace and power supply are settled in the future, it would be advisable to change the holding pattern by attaching compass and locater to I.L.S. outer marker.

The installation of DME in addition to VOR will solve the problems of maintenance and power supply. Moreover, establishment of the holding pattern can be done with this. However, this cannot be used when there are many aircrafts not equipped with DME.

4-2-2 Airport lighting (See attached Fig. 4-3)

(1) Approach light

The airport is going to be equipped with simple approach light under the French Aid Plan. It seems that the simple approach light will be more than sufficient because the meteorological conditions are particularly at the Vientiane Airport. However, it is stipulated in ANNEX 14 of ICAO that a standard approach light (ALPA type or Culvert type) has to be installed if the airport is to be operated under Cat. 1 with the installation of I.L.S.. It would be necessary to change the type of approach light depending on how the airport is going to be operated.

(2) VASIS

This is going to be installed on the eastern side of the runway under the French Aid Plan, but there is no plan of installing the same on the Western side. As more than 99 % of the aircrafts approach the airport from the western side, it would be advisable to install the same also on the western side so that this VASIS (visual approach slope indicator system) will play the role of a monitor even in case of ILS approach to set the pilots at ease.

(3) Runway edge light

The runway edge light presently installed is all right, but the cable on the 2,000-m portion on the eastern side installed by US Forces has poor insulation, it will be necessary to replace this cable. Again, there is only one circuit at present. This circuit should be separated into 2 or 3 circuits for better reliability of the facility.

(4) Runway threshold light

As the present arrangement of the runway threshold light does not satisfy the standards of the precision approach system, it would be advisable to arrange the rows of runway edge lights at an equal interval of less than 3 meters, and change the type of lights in the pavement to the flush type.

(5) Runway centre line light

According to Annex 14 of ICAO, it is advisable to install the runway center line light on the runway on which high speed aircrafts (jet planes) land and take off. As guidance for distance to go information based on color coding of the runway centre line light will be standardized in the near future, it would be advisable to install the runway center line light at the time the jet planes are put on service.

(6) Taxiway light

Concerning the parallel taxiway and the exit taxiway to be increased, the taxiway light may be planned in the same way as for the existing facility. However, it would be necessary to change the light to inset light to protect the projectors on both runway thresholds from jet blasts when jet planes are put on service.

(7) Taxiway centre line light

As for the runway exit taxiway and the exit taxiway on the east end of the runway, it is advisable to install the taxiway centre line light for safe and prompt clearance of the runway at nighttime.

(8) Wind direction indicator

There are cases in which local atmospheric disturbance occurs at an airport having a long runway, depending on the geographical position. Usually, wind direction indicator is installed near both ends of the runway at an airport where the occurrence of such atmospheric disturbance could be anticipated.

As the Vientiane Airport topographically is level and no local changes in the wind direction are anticipated, the existing facility is considered sufficient.

(9) Aerodrome beacon

The existing aerodrome beacon is sufficient as the surrounding area is dark. As the useful life of this aerodrome beacon expires 10 years later, it would be advisable to change it to a more powerful one (for example, the Japanese made A-4 type airport beacon) when it has to be changed in the future.

(10) Apron lighting

At present, the airport is being operated from 6:00 a.m. to 6:00 p.m., and so illumination for the apron particularly for loading and unloading of passengers is not required. Again, no ground service had been witnessed at the apron at nighttime during the period of the survey. It seems that this was installed from the viewpoint of maintenance of public peace, and the existing facility is sufficient for the intended purpose. This facility, however, should be improved when the operating hours of the airport should be extended in the future and the number of landings and take-offs at night should increase in the future.

4-2-3 Control facilities and communications facilities

The control facilities and the communications facilities will be sufficient when they are improved under the French Aid Plan.

4-2-4 Meteorological facilities

A ceilometer will be installed under the French Aid P'an, but it would be advisable that the airport itself establish a system of carrying out independently the meteorological observations. Observations include wind direction, wind velocity, temperature (atmospheric condition, runway), cloud base, visibility, rainfall, atmospheric pressure, humidity, etc. It would be advisable to conduct R.V.R. observation and tropospheric observation in the future in addition to the above.

4-2-5 Power facilities

As mentioned before, EDL is going to step-up the voltage of the distribution line from 6 KV to 22KV. It is therefore necessary to install the power receiving equipment for 22 KV quickly at the receiving point. It would be appropriate to install a receiving equipment equipped with metering outfil, transformer (3 ∅, 22KV/6KV 250 KVA), and arrester (see attached Fig. 4-1) adjacent to the existing 6 KV power receiving equipment.

It is advisable to plan the establishment of a new power room equipped with the facilities, because the existing vault room leaves no room for improvement.

4-3 Study of the terminal facilities, etc.

4-3-1 Terminal building

The required floor space in the terminal building at the peak hour mentioned in 4-3-2 has been calculated as follows:-

Table 4-6 Calculation of Required Floor Space at the Terminal Building

	No. of dep. passengers at peak hr.	No. of people at dep. lobby: passengers	No. of people at dep. lobby: Senders-off	No. of people at dep. lobby: Total	No. of arriving passengers at peak hour	No. of people at arr. lobby: Passengers	No. of people at arr. lobby: Greeters	No. of people at arr. lobby: Total	Required floor space: Departure	Required floor space: Arrival	Required floor space: Building
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)
Domestic Air Routes	45	$A \times \frac{30}{60} \times 0.9$ =20	$A \times \frac{35}{60} \times 2 \times 0.9$ = 47	B + C = 67	45	$E \times \frac{4}{60}$ = 3	$E \times \frac{25}{60} \times 2$ = 38	F + G = 41	D x 2 = 134	H x 2 = 82	
International Air Routes	33	$A \times \frac{30}{60} \times 0.9$ = 15	$A \times \frac{35}{60} \times 3 \times 0.9$ = 52	B + C = 67	33	$E \times \frac{4}{60}$ = 2	$E \times \frac{25}{60} \times 3$ = 41	F + G = 43	D x 2 = 134	H x 2 = 86	
									268	168	3,630

Notes: 1. Average time of stay of the departing passengers and their senders-off at the lobby is considered as 30 minutes for the passengers and 35 minutes for the senders-off.

2. Senders-off and receiving people per passenger have been considered as 2 for the domestic air routes and 3 for the international air routes.

3. The average time of stay of the arriving passengers at the lobby has been considered as 4 minutes.

4. The average time of stay at the lobby of the receiving people has been considered as 25 minutes.

5. It has been assumed that 10% of the departing passengers and their senders-off stay at the stores, restaurants, etc., and 90% stay at the lobby.

6. Required floor space per person is assumed at 2.0 m^2.

7. It has been assumed that 12% of the floor space of the terminal building is the floor space of the lobby.

The above required space of the building is studied according to the floor space of the terminal building at the time of completion of the improvement works of the presently used terminal building planned under the French Aid Plan.

Floor space of the terminal building according to the French Plan is as follows:-

1st Floor	2,580 m^2
2nd Floor	1,190 m^2
Total	3,770 m^2
Floor space of lobby	550 m^2

50% of the ticket lobby has been calculated as the waiting lobby.

All values obtained are higher than the required values, and the handling of passengers at peak hour can be managed smoothly if the terminal building is completed according to the French Plan.

4-3-2 Parking area for automobiles

Vehicles using this parking area are the vehicles of the passengers and those who send-off and receive the passengers, employees' vehicles, commercial cars, and visitors' cars. The number of senders-off and persons receiving the arriving passengers is comparatively large, being 3 per passenger on the international air routes and 2 per passenger on the domestic air routes.

Frequency of landings and take-offs at peak hour has been given under 4-1-3 as follows:

International air routes 1 time/hour B-727 (129 persons) rate of boarding 50%

Domestic air routes 3 time/hour YS-11 (60 persons) rate of boarding 50%

Therefore, the total number of passengers, senders-off and persons receiving the arriving passengers at peak hour comes to 530.

a) Passengers

International air routes

129 persons x 1 x 0.5 ÷ 65 persons

Domestic air routes

60 persons x 3 times x 0.5 = 90 persons

b) Senders-off and persons receiving arriving passengers

International air routes

65 persons x 3 = 195 persons

Domestic air routes

90 persons x 2 = 180 persons

In Vientiane City, taxies are operated on "sharing system", and are being used as substitutes for buses.

One-third of the automobiles used by the passengers, senders-off, and persons receiving the arriving passengers are private cars, cars belonging to public offices and companies. Two-thirds are the taxies which make round trips to the airport. 60% of the taxies arriving at the airport are expected to park at the parking area to wait for their customers. The total number of cars parking at the airport has been calculated at the rate of 2 persons to a private car and 4 persons to a taxi.

$$N_1 = \frac{530}{3 \times 2} + \frac{530 \times 2 \times 6}{3 \times 10 \times 2 \times 4} \doteqdot 107 \text{ cars}$$

Assuming that each car requires a parking area of 30 m^2, the required area in the parking area S_1 is as shown below.

$$S_1 = 30 \text{ m}^2 \times 107 = 3,210 \text{ m}^2$$

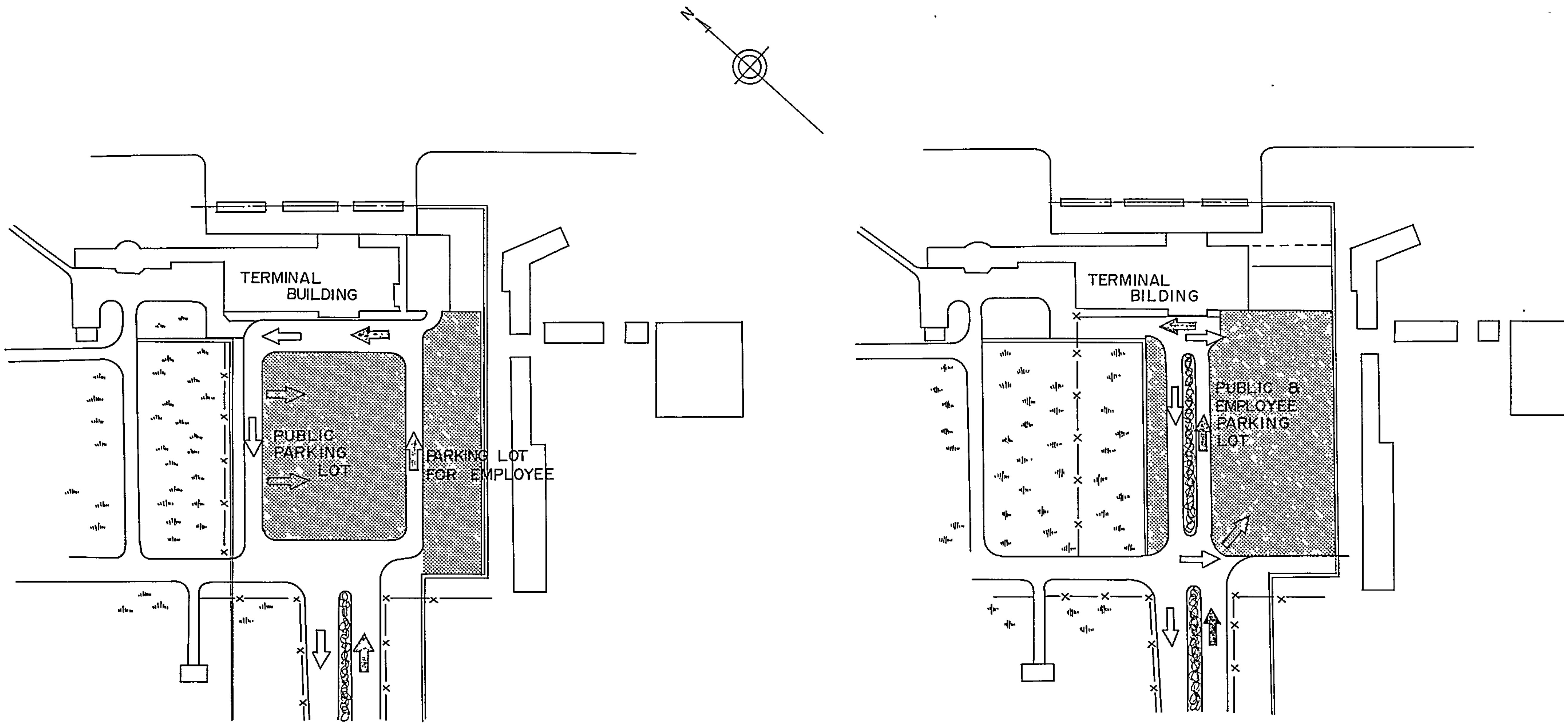
The area necessary for the employees' parking area calculated at the rate of one employee per annual number of passengers of 1,000 working on two shifts and the rate of owning private cars is 30% is shown as S_2.

$$S_2 = 30 \text{ m}^2 \times \frac{409,000}{1,000} \times 1/2 \times \frac{3}{10} \doteqdot 1,860 \text{ m}^2$$

This, compared with the area in front of the existing terminal building, gives the following values.

Area in front of the terminal building	9,000 m^2
Area required for the parking area $S_1 + S_2$	5,070 m^2

Parking area can be planned with leaving sufficient reserve in space. (See Fig. 4-11)



NOT TO SCALE

POSSIBLE LAYOUT PLAN

EXISTING PLAN

Fig 4-11 PARKING AREA

4-3-3 Fueling facilities

Fuel for aircrafts are the kerosene type jet fuel for jet engines and gasoline for piston engines.

As the aircrafts carry a large quantity of fuel and the fuel consumption is large, it is necessary to secure a fixed quantity of fuel at the airport. Generally, the appropriate quantity of fuel stored at the airport is the quantity sufficient to last for 5 to 7 days. As fuel is imported to Laos and transported to Vientiane Airport via Thailand and crossing the Mekong River, it is desirable to secure a sufficient quantity to last for at least 10 days.

It would be advisable to install four fuel tanks, one each for receiving, storage, fueling, and spare.

The quantity of fuel to be supplied has been calculated as follows from the anticipated types of aircrafts on service and the expected number of flights.

International air routes B-727 (30 ℓ/NM) Vientiane - Bangkok (about 300 NM)

Domestic air routes YS-11 (8 ℓ/NM) Vientiane - Domestic Airports (mean 200 NM)

International air routes	30ℓ x 300 NM x 7 flights x 1/2 =	31,500 liters
Domestic air routes	8ℓ x 200 NM x 30 flights x 1/2 =	24,000 liters
	Total	55,500 liters

This means 555,000 liters is required for every 10 days.

At present, Shell Oil Co. has 4 tanks each storing 25,000 liters of kerosene, and 2 tanks each storing 170,000 liters of gasoline. It would be necessary to increase drastically the tanks for storing kerosene. On the contrary, gasoline tanks may be reduced if piston engine aircrafts should have retired in the future. At present, there is no problem in securing land for future extension. As for the fueling system, refuelling system would be appropriate for an airport of the abovementioned fueling frequency.

4-3-4 Fire equipment

According to the forecast of the future demand, the number of flights per day of B-727 on international air routes is 7, or 630 flights per three months. Although "critical aircraft" is the 700th aircraft, fire equipment was studied assuming that B-727 is the "critical aircraft" taking into account the number of irregular flights.

Max. design passenger capacity	131 persons	7 points
Fuel load	26,500 litres	5 points
	Total	12 points

Therefore, aerodrome category is VIII.

Water for foam production	3,600 gallons
Discharge rate water	720 gallons/min.
Dry chemicals	500 lbs. or CO_2 1000 lbs.

Fire engines having the above functions will become necessary. Besides these, there are the commander's car, demolition fire engine and water wagon etc.

Again, as a large river known as the Mekong River flows through the neighboring area, it is desirable to provide rescue boats.

The airport at present is depending on Air America for these fire equipment, but the airport should install such fire equipment as the equipment of the airport itself.

5. Design of principal facilities

5-1 General

As mentioned in the foregoing chapter on master plan, two runway exit taxiways classified by group of aircrafts and the parallel taxiway connected with these exit taxiways will be extended to increase the capacity of the runway. As regards the apron, the loading apron and the parking apron will be expanded and the fillet on the joint of the taxiway will be widened for the smooth operation of the landing and take-off of the aircrafts.

This chapter deals with the study of geometrical designing etc. of these facilities.

5-2 Runway exit taxiway and parallel taxiway

5-2-1 Longitudinal slope, width, etc.

Values which correspond to the ICAO design standards are as follows:-

* Width of taxiway: More than 23 m (However, parallel taxiway will be 22.825 m width, same as the existing parallel taxiway)
* Maximum longitudinal slope: Less than 1.5%
* Rate of longitudinal slope change: 1.0% per 30 m (Minimum radius of curvature 3,000m)
* Maximum transverse slope: Less than 1.5%

The difference of elevation of the existing runway and the parallel taxiway is approximately 20 cm, and so are almost level. Hence, the longitudinal slope of the runway exit taxiway was studied, taking into consideration the volume of earthwork, drainage of the fillet, and submergence in the rainy season, and the value obtained was less than 1.0% in all cases. The slope of the parallel taxiway connected to the runway exit taxiway No. 1 is level.

With the exception of the fillet, transverse slope was fixed uniformly as 1.0%, and the slope of 0.5% has been fixed as the standard slope of the fillet. The shoulder of the taxiway has been fixed as 7.5 m in consideration of the weather condition, and sodding will be provided on the entire surface. Again, no base course will be built in the same way as in the case of the existing taxiway. And that will be of rolling compaction finishing.

5-2-2 Location and alignment of runway exit taxiway

The location and alignment of the runway exit taxiway are decided according to ICAO's Aerodrome Manual, and particularly on the basis of the following conditions which the aircrafts use at the airport.

(1) Approach speed

(2) Deceleration ability

(3) Position of touch down

As studied in the master plan of the foregoing chapter, the locations of Runway Exit Taxiway No.1, Runway Exit Taxiway No.3 were decided as 900 m and 2,100 m from 13 side respectively. These values are reasonable in view of the optimum location of the exit taxiway based on the result of investigation of actual state by Horonjeff, etc.

1) Approach speed and deceleration speed

The approach speed when an aircraft enters the runway exit taxiway from 13 side is fixed at 60 mph for this airport on the following basis. From the viewpoint of shortening the time the runway is occupied by an aircraft and of the relations between the runway and the taxiway, it is stated in ICAO's Aerodrome Manual and Horonjeff's recommendation and investigation that an aircraft can leave the runway safely and comfortably at 60 - 65 mph.

Again, the length of the runway exit taxiway is decided according to the deceleration ability of an aircraft, as shown in Fig. 4-6. Assuming that the optional approach speed is 60 mph and the deceleration speed is 3 ft/s^2, the required length of the runway exit taxiway is 400 m. Adding that it is desirable that the approach angle is smaller than 30^o, the length of the runway exit taxiway has been fixed at more than 600 m.

2) Turning radius and transition curve

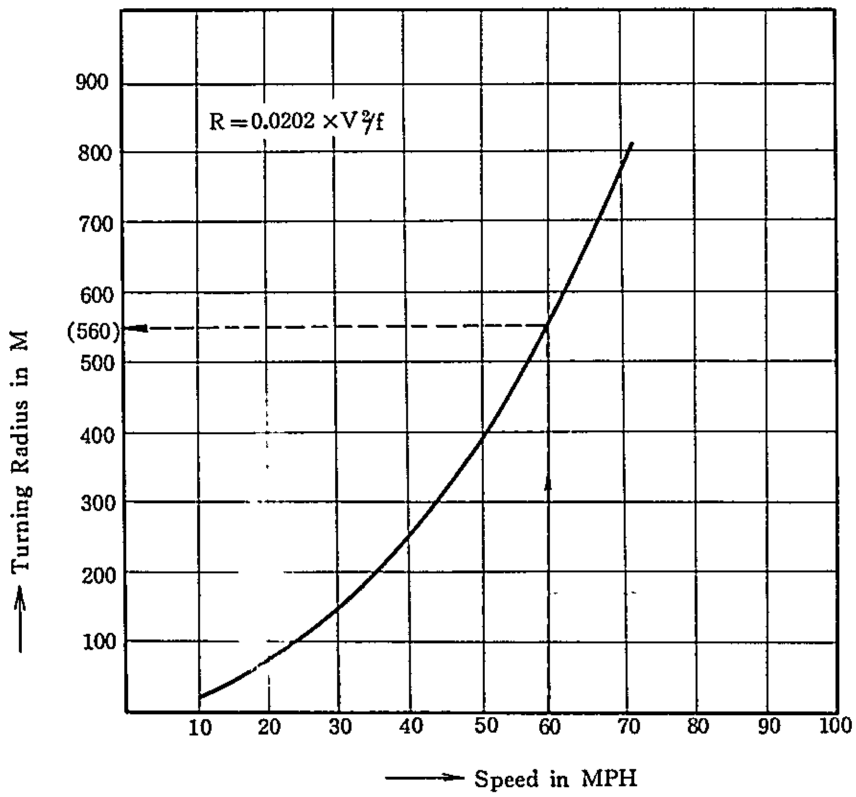
In order to simplify the construction work, the alignment of the runway exit taxiway for this airport is the combination of simple curves to avoid complicated alignment. The relation of turning radius with speed can be expressed by the following formula.

$$R = 0.0202 \times v^2/f$$

According to ASSHO's data and Horonjeff report on the investigation of aircrafts, the lateral skidding resistance coefficient (f) of around 0.13 is considered most appropriate.

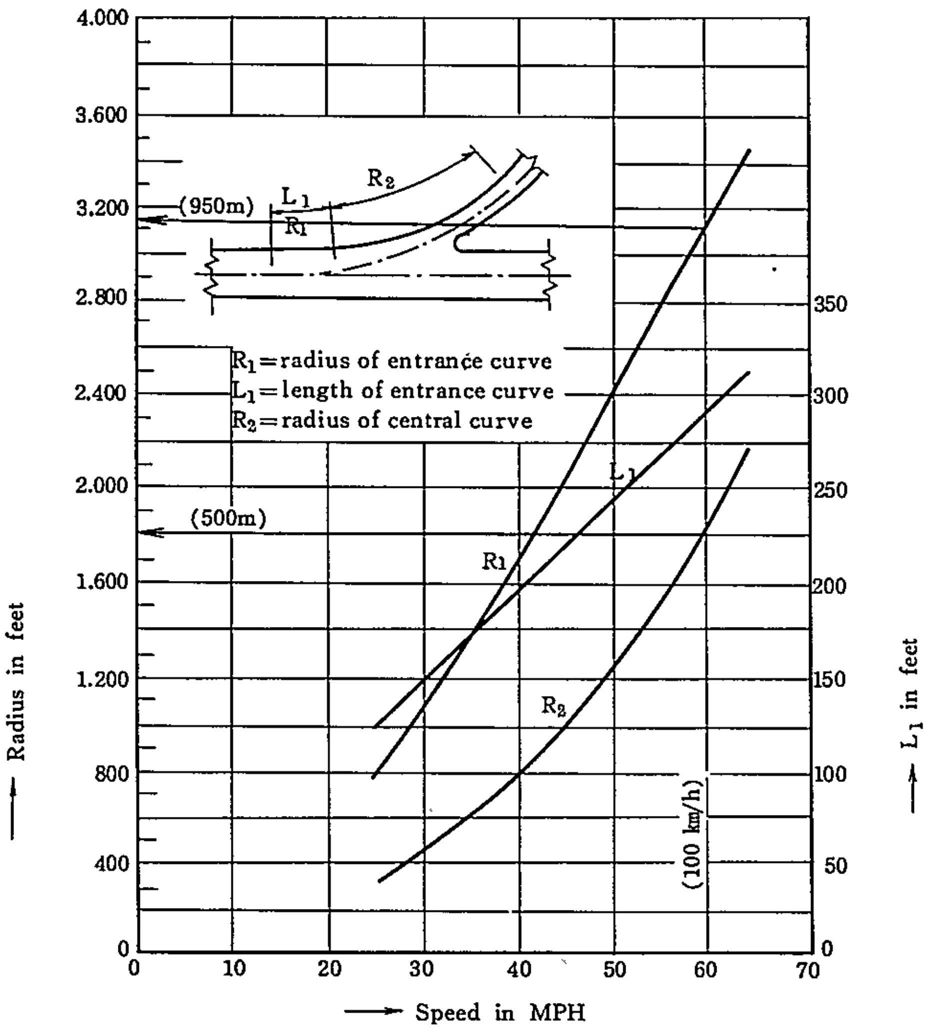
In this study, the above coefficient was used to find out the relation between turning radius and speed from Fig. 5-1. Assuming that V = 60 mph, R ≑ 560 m can be obtained from Fig. 5-1.

Fig. 5—1. THE RELATION OF TURNING RADIUS VERSUS SPEED



Since it is considered desirable from the viewpoint of operation of an aircraft to insert a transition curve between the runway and the runway exit taxiway, a calculation was made from Fig. 5-2. The values obtained are R_1 = 950 m and R_2 = 500 m. As R_1 = 977 m and R_2 = 577 m are considered reasonable, these have been made the design values under this project. (See Fig. 4-7)

Fig. 5 — 2. RADIUS OF CURVATURE FOR TAXIWAYS



3) Radius of fillet

Fillet was provided at the junction or intersection of taxiways with runways and other taxiways in accordance with the standards set by ICAO.

Intersection angle of paved areas	Minimum fillet radius	Design values
Less than 45°	23 m (75 ft)	25 m
45° to 135°	30 m (100 ft)	30 - 40 m
More than 135°	60 m (200 ft)	60 m

The radius of fillet was determined also upon consideration of the approach from the opposite side (31) of 13 side to the runway exit taxiway.

5-3 Design of apron improvement

(1) The necessity of extension of the apron was explained in the foregoing chapter on master plan. In the 3rd plan of apron extension, a space for a total of 17 gate positions has been taken into consideration. The breakdown of the number of gate positions is, 14 gate positions including loading and parking aprons for YS-11 class aircrafts and 3 gate positions for B-727-100 class aircrafts. The space for B-727 is large enough for changing it to 2 gate positions for DC-8-60 class aircrafts.

As the factors which would exert influence on the size and location of the gate positions, IATA is recommending the system under which the aircrafts can depart with their own power within the space allowable. The area for apron extension was determined by employing taxi-in,taxi-out for YS-11 class aircrafts which are expected to be used most frequently at the airport, and taxi-in tow-out system for B-727 or DC-8 class aircrafts, the frequency of use of which is comparatively low.

(2) Size and spacing of gate positions are determined according to the size of aircraft, turning radius, parking angle and clearance, etc.

i) Clearance (Clearance between a manoeuvering aircraft and fixed or moving obstructions) Clearance between a parked aircraft is 10 m in consideration of the manoeuvering of a large-sized jet aircraft.

ii) Spacing of parked aircrafts for each type of aircraft has been calculated from the following formula assuming the parking angle is 90^{o}.

$$D_1 = a \cos A + C + R + K\cos A$$

$$D_2 = K\cos A + R + F + \eta \cos A + P\sin A$$

$$D_3 = (a + F + R) \operatorname{cosec} A$$

Where a: Distance perpendicular to the center line of the aircraft from the pivot point to the wing tip ($\div S/2 - P$)

C.E.F: Clearances

R: turning radius of the aircraft

A: aircraft parking angle

K: forward roll

η: distance along the aircraft center line from nose to the main landing gear

P: perpendicular distance from the center line of the aircraft to the pivot point

D was determined as follows according to the values mentioned above. (See Fig. 4-10)

YS-11 or equivalent	42.0 m - 47.0 m
B-727 or equivalent	45.0 m
DC-8	60.0 m

5-4 Structural design of pavements

5-4-1 General

Concerning the structural design of pavements, concrete pavement was studied from the viewpoint of the rate of utilization of taxiway, apron, etc. and in consideration of the field condition and the difficulty of continued repair, etc. same as those of the design of the 1st Stage Extension Work.

As to the original ground condition, the results of the field exploitation have proved that bearing capacity of subsoil for the taxiway to be extended and built newly is favorable. However, as the result of the Auger boring carried out on the area for extension of apron on the side closer to the terminal building, the presence of soft clay layer (0.5 m - 1.0 m) was detected, and a study was made by carrying out sampling since there was a fear of settlement due to consolidation.

As the result of the soil investigation conducted on filling materials and base course materials to be transported from the borrow-pit, such materials were found usable.

5-4-2 Design of embankment and subgrade

1. General

In order to design embankment and subgrade, it is necessary to know the original ground condition. For this purpose, Auger boring, test pit, field C.B.R. and plate bearing test were conducted at those points shown in Fig. 5-3. Table 8-1 shows the soil of the original ground condition, Table 8-2 gives the results of the field test, and Table 8-4 contains the results of the test of the soil for use as filling materials. As the result of the field investigation, it seemed more than sufficient if the surface soil is stripped to a thickness of 30 cm.

2. Extension of parallel taxiway

(1) Result of investigation

The area investigated was the portion which had been used as runway before the existing runway was constructed. Because of this, the ground was filled with gravel with clay or gravel with loam to a thickness of 0.8 m - 1.10 m. The soil on the old ground contained silty clay or clay, laterite with clay, and clay distributed evenly in the order beginning from the top. Again, a field test was conducted on ST. No. 25C, and the results obtained were Field C.B.R. = 69.0% and K_{75} = 16.8 kg/cm^3, as shown in Table 8-2.

(2) Decision

As shown in the results of the investigation conducted, the original ground condition is very good, and it could be used as subgrade or base course as it is.

3. Portions of Runway Exit Taxiways No. 1 and No.3 to be constructed Newly

(1) Result of investigation

These taxiways are about 1,200 m apart from each other, but their geological features are about the same. The soil on the original ground is roughly classified into silty clay, laterite with clay, clay or gravel with clay, accumulated in the same order. The entire area requires banking. Ground water level is around 2 m below ground surface.

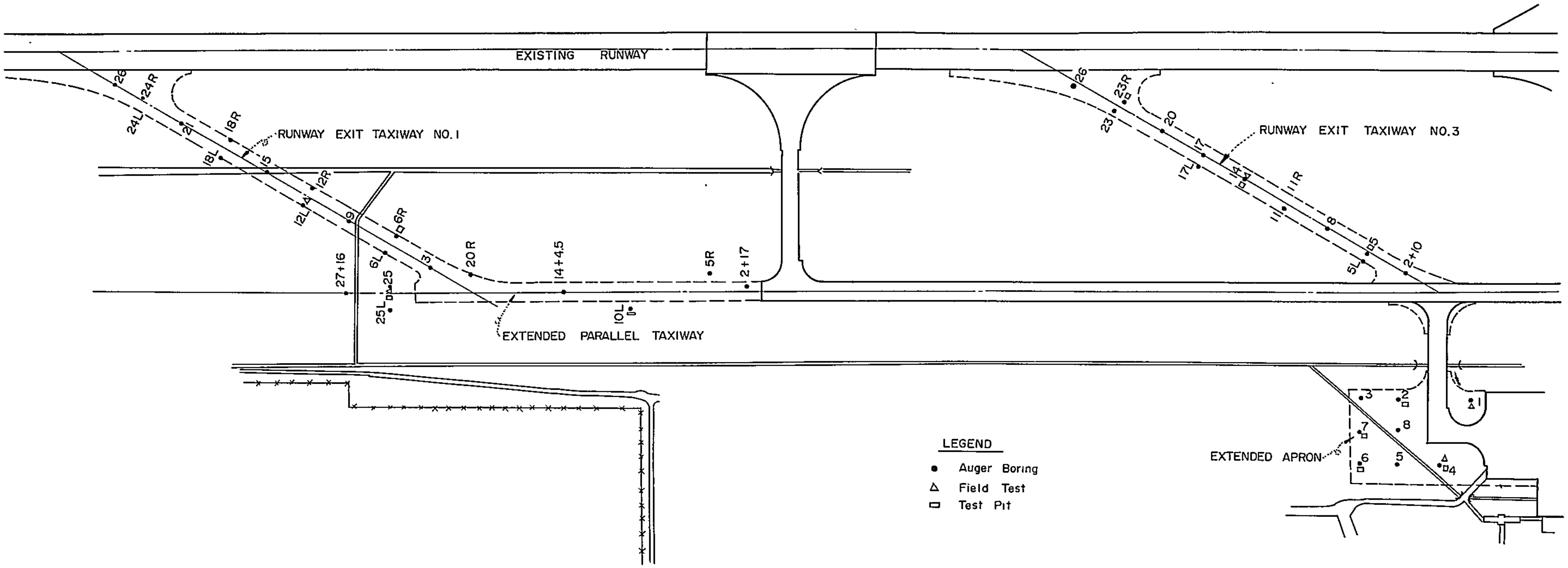


Fig.5-3 PLAN OF SOIL TEST

In order to find out the mechanical characteristics of silty clay and laterite with clay as they are, field test was conducted as St. No. 12 L of Runway Exit Taxiway No. 1 and St. No. 14 C of Runway Exit Taxiway No. 3. The results, as shown in Table 8-2, were as follows:-

Field C.B.R.: 21.2% and 58.0% respectively

K-75: 5.5 kg/cm^3 and 21.2 kg/cm^3 respectively

(2) Decision

As the results of the investigation show, the present ground condition is favorable for use as embankment, and stripping only is required before banking.

4. Extension of apron

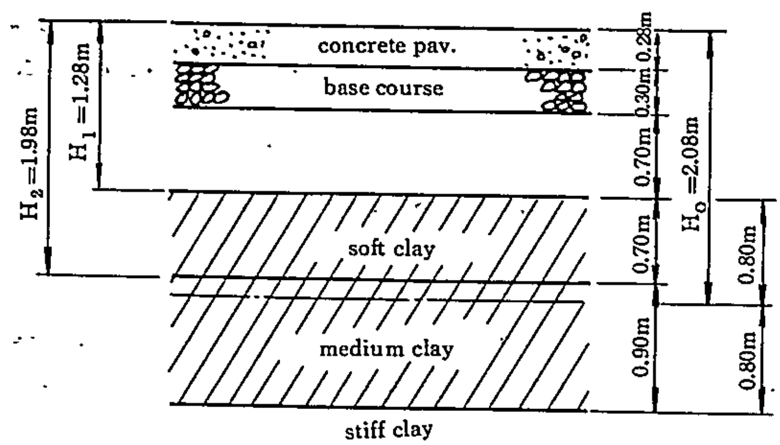
(1) Result of investigation

As the result of Auger boring carried out in this area, it has become clear that this area is divided into two areas, one having the layer same as that of the runway exit taxiway (runway side), and the other a low damp area, which is the remaining portion of the old swamp area.

The soil layer on the runway side is the same as the soil layer mentioned under 3. above, and Field C.B.R. and K-75 obtained at the field test conducted at St. No. 2R were 48% and 6.1 kg/cm^3 respectively. As the area on the terminal building side was low damp ground where the soft clay layer was as thick as one meter, it was considered necessary to study the bearing capacity and the settlement due to consolidation of the soil layer. Three undisturbed samples were collected from each place, on which direct sheering test, triaxial compression test, and consolidation test were conducted. The results of the tests are as given in Table 8-4.

(2) Study of settlement due to consolidation

Typical section of this area is as shown in the following diagram.



a) Surcharge and consolidation settlement

Unit weight of base course material and filling material is the weight of such materials as perfectly saturated with water. The total surcharge is as follows:-

Materials	H (m)	W ton/m^3	P ton/m^2
Concrete	0.28	2.35	0.66
Base course	0.30	2.26	0.68
Embankment	0.70	2.13	1.49
Clay	0.80	2.00	1.60

Total Surcharge P = 4.43

Settlement due to consolidation is as shown in the following formula.

$$S = \frac{e_o - e}{1 + e_o} H_o = 2.70 \text{ cm}$$

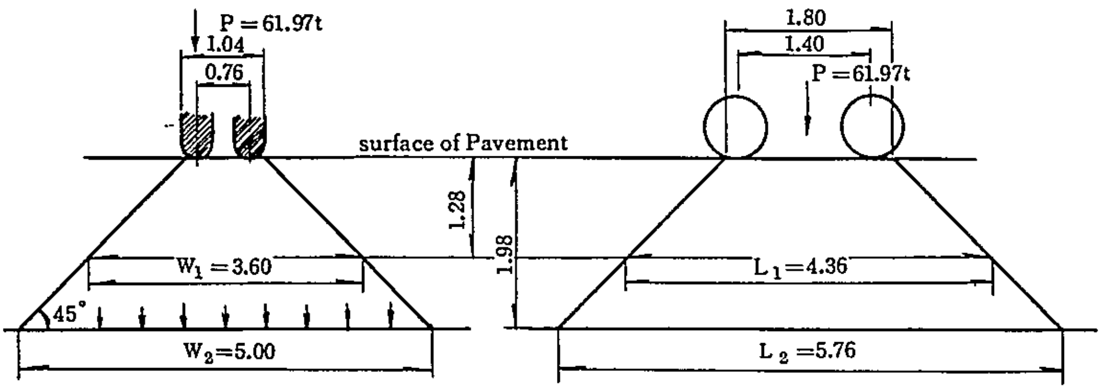
Where e_o = 1.39: Initial void ratio

H_o = 160 cm: thickness of consolidatable soil layer

e = 1.35: final void ratio of soil at pressure P in "e - log p" curve

(3) Study of bearing capacity

It is assumed that the gear load of aircrafts on foundation layer is distributed uniformly.



The gear load (DC-8-55) is

$P = 141{,}000$ lbs $= 64.0$ tons

Therefore, the intensity of load ($Q\ell$) on the clay layer is

$Q\ell_1 = P/(L_1 \times W_1) = 4.08\ t/m^2$

$Q\ell_2 = P/(L_2 \times W_2) = 2.22\ t/m^2$

And, the total surcharge is calculated as follows respectively.

$Qd_1 = 2.83\ ton/m^2$

$Qd_2 = 4.23\ ton/m^2$

Therefore, the intensity of total load on each clay layer is calculated as follows respectively.

$Q_1 = 6.91\ ton/m^2$ (Soft clay on the depth H_1)

$Q_2 = 6.45\ ton/m^2$ (Soft clay on the depth H_2)

On the other hand, as the result of Triaxial Compression Test,

$C_1 = 9.0\ t/m^2$

$C_2 = 11.0\ t/m^2$

are obtained.

Therefore

$Qu_1 = 2C_1 = 18\ t/m^2$

$Qu_2 = 2C_2 = 22\ t/m^2$

are obtained.

Consequently, each Safety Factor is obtained as follows.

	Qu	Q	F.S.
H_1 = 1.28 m	18 t/m^2	6.91 t/m^2	2.60
H_2 = 1.98 m	22 t/m^2	6.45 t/m^2	3.41

Ultimate bearing capacity of clayey soil layer based on Terzaghi formula can be obtained by using the following formula.

For general shear failure

$$Qz = \alpha \cdot C\ Nc + \beta \cdot \gamma_1 \cdot B\ N \quad + \gamma_2 \cdot Df\ Nq$$

Therefore

Qz_1 = 15.18 t/m^2

Qz_2 = 25.54 t/m^2

are obtained.

For local shear failure

$$Qz = \alpha \cdot C\ Nc' \quad + \beta \cdot \gamma_1 \cdot\ B\ N' \quad + \quad \gamma_2 \cdot Df\ Nq'$$

Therefore,

Qd_1 = 10.15 t/m^2

Qd_2 = 16.24 t/m^2

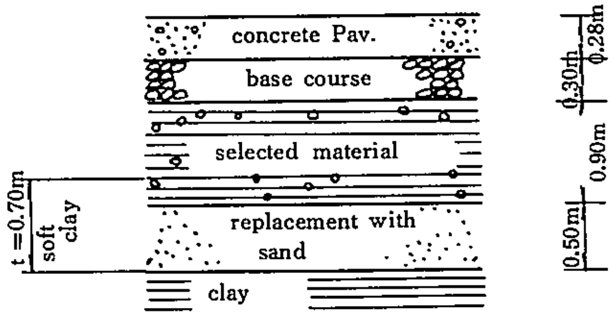
are obtained.

Each Safety Factor is represented as following table.

	Q	General Shear		Local Shear	
		Qz	F.S.	Qd	F.S.
H_1=1.28 m	6.91 t/m^2	15.18 t/m^2	2.19	10.15 t/m^2	1.47
H_2=1.98 m	6.45 t/m^2	25.54 t/m^2	3.95	16.24 t/m^2	2.52

(4) Judgement and the counterplan

In the preceding paragraph, those have been studied, settlement due to consolidation and bearing capacity of the foundation under embankment, consequently, consolidation settlement is equal to 2.7 cm, and that does not cause any problem. On the other hand, as concerns with the Safety Factor for bearing capacity, that of soft clay (t=0.70 m) becomes less than 1.5. Therefore, about this soft clay (t=0.70 m), some disposal is required. Displacement method is adopted, taking economy into consideration, as one of the various counterplan method. In this method of construction, after removed soft clay, natural riverine sand shall be spread and compacted evenly with 50 cm thickness, and the soft clay layer shall be replaced with suitable soil in good condition. Safety Factor of the ground base under the replacement layer is equal to 2.57, so that sufficient bearing capacity shall be expected, and it is considered that any improvement shall not be needed.



5. Embankment and subgrade materials

It is expected that the earthwork will amount to about 86,000 m^3 in this project. It has become clear that sufficient materials shall not be obtained in the work site as the result of investigation. Therefore, a borrow pit shall be provided in the position 3.4 km north west of TOM BOM village, and various tests shall be carried out and some studies added.

(1) Physical tests

The test results of the embankment materials are summarized in the following table.

	Sample Number	Borrow Pit No. 1-1	Borrow Pit No. 1-2	Borrow Pit No. 2-1	Borrow Pit No. 3-1	Borrow Pit No. 3-2	Borrow Pit No. 4-1
	Sampling Depth (m)	0.2-1.0	1.0-2.2	0-0.9	0-1.0	1.0-1.7	0-0.7
	Observation	Brown	Reddish Brown	Reddish Brown	Brown	Gray	Brown
	Natural Water Content (%)	8.4	11.4	13.9	11.3	16.1	9.4
	Specific Gravity Gs	2.62	2.65	2.56	2.59	2.53	2.66
Grain Size Proportion	Gravel Part (%)	0.2	0.4	0.6	1.1	3.9	0.4
	Sand Part (%)	48.8	39.2	39.4	27.4	18.9	47.6
	Silt Part (%)	23.0	22.2	32.1	31.5	50.7	24.6
	Clay Part (%)	28.0	38.0	27.9	40.0	26.5	27.4
	Max. Diameter (mm)	2.0	2.0	2.0	2.0	4.8	2.0
	Classification	Clayey Loam	Clay	Clayey Loam	Clay	Silty Clay Loam	Clayey Loam
Consistency	Liquid Limit (%)	27.1	32.8	36.5	31.3	32.8	31.5
	Plastic Limit (%)	15.8	16.3	18.1	17.8	18.9	20.3
	Plasticity Index	11.3	16.5	18.4	13.5	13.9	11.2

Above mentioned, the materials to be obtained from the borrow pit are mostly clay soils including clayey loam, silty clay loam and loam, the natural water content is of the range from 8.4% to 16.1%, also Plasticity Index from 18.4 to 11.2.

(2) Compaction Test and C.B.R. test

In regard to the preceding samples, compaction test and C.B.R. test are carried out. The results are summarized in the following table.

Sample Number			Borrow Pit No. 1-1	Borrow Pit No. 1-2	Borrow Pit No. 2-1	Borrow Pit No. 3-1	Borrow Pit No. 3-2	Borrow Pit No. 4-1
Sampling Depth(m)			0.2-1.0	1.0-2.2	0-0.9	0-1.0	1.0-1.7	0-0.7
Natural Water Content(%)			8.4	11.4	13.9	11.3	16.1	9.4
Classification			Clayey Loam	Clay	Clayey Loam	Clay	Sitly Clay Loam	Clayey Loam
Comp. Test		O.M.C. (%)	10.5	12.5	13.0	12.0	12.4	11.5
		Max.Dd(kg/cm^3)	1.94	1.95	1.84	1.93	1.90	1.94
Modified C.B.R. Test	No Soaked	Water Content (%)	14.4	12.0	13.8	11.4	15.4	13.1
		Dry Density (kg/cm^3)	1.83	1.92	1.85	1.90	1.82	1.90
		C.B.R. (%)	11.1	15.0	30.3	30.5	26.0	14.3
	4 days Soaked	Water Content (%)	18.2	14.3	16.0	13.5	18.9	16.0
		Dry Density (kg/cm^3)	1.72	1.85	1.83	1.92	1.79	1.86
		C.B.R. (%)	4.2	5.2	8.1	6.4	4.0	4.0

As shown in the upper table, O.M.C. (optimum moisture content) is 10.5% - 13.0%, Modified C.B.R. (4 days soaked) 4.0 - 8.0%.

(3) Study as embankment and sub grade materials

Upper soil layer in the borrow pit is mostly clayey soil including clay and clayey loam, and as shown in the test results, L.L. is less than 50%, P.I. less than 30. If carried out suitable rolling compaction, that is considered usable sufficiently as embankment materials.

Between the optimum moisture content and the natural moisture content, there is little difference between them.

Therefore, the materials can be compacted to specified densities sufficiently almost without adjusting the moisture content during the construction work in the dry season.

6. Design C.B.R. value and K-value of the subgrade

(1) Design C.B.R. and K-value

On the occasion of determination of C.B.R. of the subgrade, field C.B.R. of the original ground condition and modified C.B.R. (4 days soaked) of the embankment materials, are studied. As conserns with field test, those are carried out in the position of runway exit taxiway No.1 ST. No.12L, runway exit taxiway No.3 ST.No.14C, parallel taxiway St. No.25C, and apron ST.No.-2R, plate bearing test and field C.B.R. test. The test results are shown as the following table.

	Tested Depth(m)	Soil Classification	Calculation C.B.R. (%)	Field K-Value(kg/cm^3) K-75
R.E.T. No.1 ST. No. 12L	0.30	Clay	11.1	5.5
R.E.T. No.3 ST. No. 14C	0.10	Laterite with Clay	5.2	21.2
P.T.W. ST. No. 25C	0.10	Gr. + Lat. with Clay	11.0	16.8
Apron ST.No. -2R	0.30	"	4.0	6.1

As shown above the table, C.R.B. is 4.0% - 11.1%, on the other hand, above mentioned, C.B.R. of materials was 4.0% - 8.1%. The design C.B.R. is determined to be equal to 4.0% (minimum C.B.R. value), taken into consideration that the period of rainy season in this Veintiane area is very long, having a high water level, possibility of the embankment be soaked and etc. From Figure 5-4, in which the curve shows the relations between C.B.R. and K-value, design K-value, K75, was decided as 3.5 kg/cm^3.

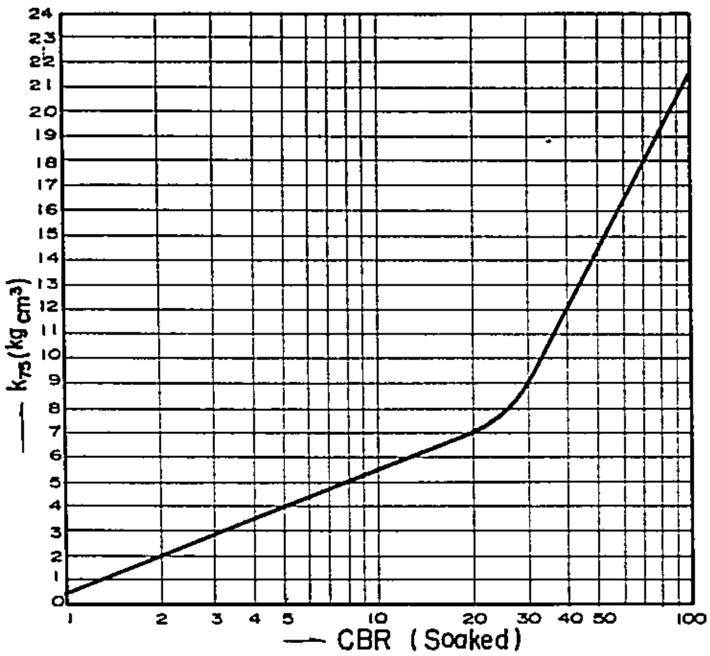


Fig. 5-4 RELATION BETWEEN C.B.R. AND K-VALUE

5-4-3 Design of base course

1. Base course materials

In this project, base course materials amounted to about 22,000 m^3, are required. As this base course materials, as mentioned in the preceding paragraph 5-4-2, gravels and Laterite with clay obtained from the borrow pit, are used, some tests carried out and some studies added.

(1) Physical Test

The test results are shown in the following table.

Sample Number		Borrow Pit No. 2-2	Borrow Pit No. 4-2	Borrow Pit No. 4-3
Sampling Depth(m)		0.90-	0.7-1.0	1.00-
Observation		Reddish Brown	Reddish Brown	Reddish Brown
Natural Water Content (%)		7.7	8.8	7.7
Specific Gravity GS		2.66	2.64	2.62
Grain Size Proportion	Gravel Part (%)	57.1	61.9	63.9
	Sand Part (%)	13.7	13.3	10.8
	Silt Part (%)	13.2	7.8	8.2
	Clay Part (%)	16.0	17.0	17.0
	Max. Diameter (mm)	25.4	19.1	19.1
	Classification	Gr. + Lat. with Clay	Gr. + Lat. with Clay	Gravel with Clay
Consis-tency	Liquid Limit (%)	38.5	36.0	41.1
	Plastic Limit (%)	23.6	20.9	24.3
	Plasticity Index	14.9	15.1	16.8

As shown above the table, the materials were mostly gravels including gravel with clay, gravel and laterite with clay. Natural water content was 7.7% - 8.8% and plasticity index 14.9 - 16.8.

(2) Compaction test and C.B.R. test

Compaction test and C.B.R. test were carried out on the preceding samples. The test results are shown in the following table.

Sample Number			Borrow Pit No. 2-2	Borrow Pit No. 4-2	Borrow Pit No. 4-4
Sampling Depth (m)			0.9-	0.7-1.0	1.00-
Natural Water Content (%)			7.7	8.8	7.7
Classification			Gr. + Lat. with Clay	Gr. + Lat. with Clay	Gravel with Clay
Comp. Test	O.M.C. (%)		7.8	10.0	11.0
	Max. Dry Density (kg/cm^3)		2.06	2.18	2.00
Modified C.B.R. Test	No Soaked	Water Content (%)	7.5	11.5	9.9
		Dry Density (kg/cm3)	2.04	2.01	1.99
		C.B.R. (%)	130.0	45.5	57.0
	4 dyas Soaked	Water Content (%)	14.2	14.2	12.3
		Dry Density (kg/cm3)	2.20	2.15	2.10
		C.B.R. (%)	24.0	17.0	20.5

As shown above the table, O.M.C. was 7.8% - 11.0% and modified C.B.R. (4 days soaked) 17.0% - 24.0%.

(3) Study as base course

Modified C.B.R. of this gravel with clay, as the result of the test, is 17.0% - 24.0%, that is small. By the way, as for the last Construction work, sand in 5% weight was mixed the similar materials with, so that 35.7% - 45.7% for C.B.R. and 5.1 - 5.7 for P.I., are obtained. Therefore, this time, by use of this method, it shall be expected that C.B.R. value shows more than 30% and P.I. less than 6.

(4) Determination of base course composition and its thickness

As same as the last construction work, as the base course materials, stabilized materials in which sand is mixed gravel with clay with, shall be used and design C.B.R. shall show more than 30%. By the determination of the base course thickness, the method that is experimental estimation from subgrade K-value is adopted.

The relation among subgrade K-value, base course K-value and the base course thickness can be represented experimentaly by the following equation.

$$\frac{h}{a} = \alpha \left(\frac{K_1}{K_2}\right)^{\beta}$$

where, h : base course thickness (cm)

a : diameter of the bearing-plate (cm)

β : constant

α : coefficient determined from the base course materials

By substituting the values determined experimentally in this equation, the curve shown in Fig. 5-4 can be obtained. In general, the bearing capacity of the base course is represented by using the K-value obtained from plate-bering tests while it is assumed from past experiences that the K-value of 7.0 kg/cm^3 (250 lb/cubic inch) is sufficient for the base course for concrete pavement. The thickness of the base course with the K-value of 7 kg/cm^3 on the subgrade having a K-value of 3.5 kg/cm^3 can be determined as shown in Fig. 5-5.

Therefore, h is obtained equally to 30 cm. Consequently, as same as the last construction work, it is taken, as the design value for control of construction, that is 30 cm for h, 30% for design C.B.R. and 7.0 kg/cm^3 for K_{75}.

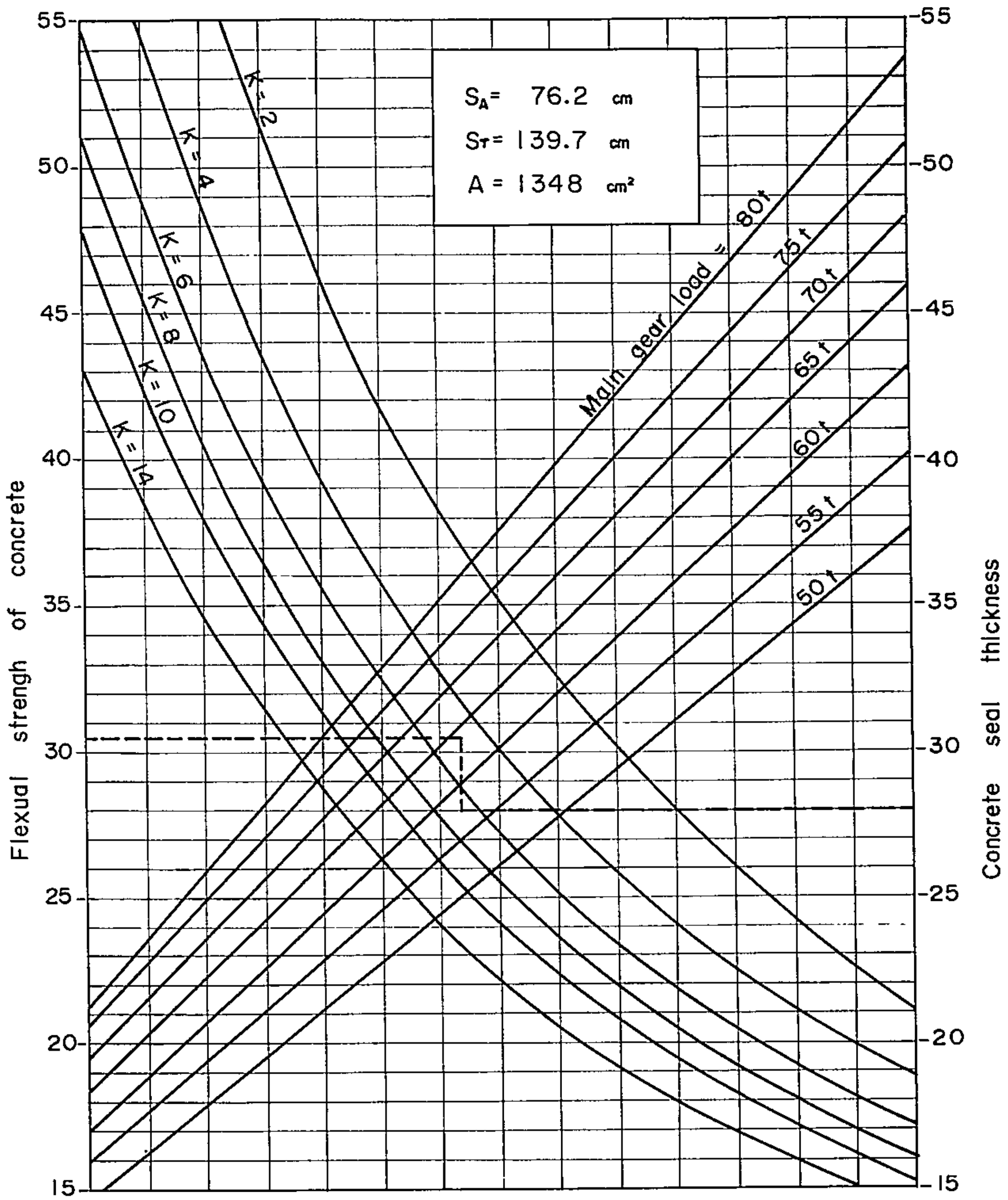


Fig. 5-5 Design Chart for Concrete Airfield Pavements, Dual-in-Tandem Landing Gear Type (DC-8·55, 61, 62)

S_A = Transverse distance between the center of the tires

S_T = Longitudinal distance, between the center of the tires

A = Contact area of each wheel

5-4-4 Design of concrete pavement

As regards the study of pavement thickness and stress intensity DC-8 class aircraft has been made the model aircraft in the desing same as last time. Assuming that the thickness of critical area was 28 cm (11 inches), stress intensity and safety factor were calculated in accordance with Dr. H. M. Westergard's formula and Pickett, G. Ray's influence chart. The following values were obtained. (See Fig.5-4)

Critical aircraft:	DC-8 (297,000 lbs)
Load of a Main Gear:	297,000 x 0.475 = 141,000 lbs (64 t/wheel)
Slab thickness:	28 cm
Tensile stress:	435 PSI (30.6 kg/cm^2)
Tensile strength of concrete at 28 days:	640 PSI (45 kg/cm^2)
Safety factor:	About 1.47

According to F.A.A. and P.C.A. Design standards on safety factor of airport pavements, the appropriate safety factor is 1.7 - 2.0 for the aprons and taxiways, and 1.25 - 1.50 for the central part of the runway. In consideration of the flight frequency of the aircrafts using this airport, it is considered that slab thickness of 28 cm will be sufficiently bearable. On the other hand, the thickend - edge of the pavement edge is thickend to 35 cm (the rate of increase is 25% versus 28 cm) and, tapered off to normal thickness in a distance of a joint spacing.

As the result of field investigation made on the condition of damaged parts of the existing concrete slabs and on the strength, it was found that the slabs were damaged mostly at the joints, and the slabs generally were in favorable condition. As to compressive strength, the average value of approximately 400 kg/cm^2 was obtained when it was measured at about 150 points using concrete test hammer. This converted to tensile strength, was about 400 x 1/7 = 57 kg/cm^2. The safety factor came to about 1.6, and it was considered that the tensile strength was sufficient.

5-4-5 Design of joints

1) In consideration of transmission of load of adjacent slabs, the Keyed type joints will be used for longitudinal construction joints. The spacing between joints is 5.27 m on the taxiway. The spacing between joints on the apron is 4.69 - 4.80 m same as for the existing joints, and the spacing between joints on the extended portions is 5.25 - 5.85 m. The joint will be the deformed tie bar (σsa = 1,800 kg/cm^2, τoa = 18 kg/cm^2) 800 mm long and 16 mm diameter with a standard spacing of 80 cm.

2) Transverse joints

(1) Transverse contraction joints will be dummy joints, the spacing of which is 5.0 m at the taxiway, and 4.5 - 4.7 m at the apron.

As the joint for 3 spans adjacent to the transverse expansion joint, ø 38 mm x 650 mm slip bar will be used. The spacing will be 35 cm.

(2) Transverse expansion joints

The spacing between expansion joints has been fixed as 60 mm, and the width of the joint 20 mm. These figures have been fixed in consideration of the load transmitting effect of the joint, blow-up of the slabs, expansion condition of the joints, and the structure of the existing joints. Again, slip bar will be ø 38 mm x 650 mm, and the spacing 35 cm. On those parts insulating the adjacent slabs, butt joints will be used, the width of which is 20 mm. On the ends, slab thickness will be increased to 35 cm.

(3) Transverse construction joints

Construction joints shall be constructed at places where concrete placing has been completed, or when the concrete pavement work has been discontinued for more than 30 minutes due to rainfall or for other reasons. The joints shall be the butt joints with the insertion of tie bars.

6. Design of drainage

6-1 Plan of drainage

The runway exit taxiway to be constructed this time is required to cross the existing open ditch. Again, the extension and improvement of the existing drainage ditch (reinforced concrete structure) have become necessary accompanying the expansion of the apron.

As mentioned in the design and investigation of the 1st construction work, drainage of this airport involves much difficulty due to the flat topography of the project site and the surrounding areas. (See Fig.2)

At the investigation conducted this time, it was witnessed that rain water in the project area was collected into the two main drainage canals (one old and one new), flowed along the lowland into the swampy area located at about 3.0 km north of the project area with the water level rose, and then was discharged into the Mekong River after threading through the Vientiane City. Difference of elevation is practically close to zero (about 5 cm), and this shows how poor the drainage condition is in this area.

The installation of box culvert is required where the drainage crosser the runway exit taxiway, and if the section of box culvert is to be determined by the drainage area, intensity of rainfall, etc., it will become tremendously large and will lose its balance with the existing culvert. For this reason, the section of the culvert has been determined according to the outflow of the rain water, assuming that rain water, which does not reach the water level required for this overflow, remains as stagnant water in the compound of the airport and the surrounding lowland.

As the existing box culvert which crosses the access taxiway and connected with the apron is not possible to withstand the load of DC-8 class aircrafts, it will be removed and constructed newly on the same place.

6-2 Drainage system and section

Same as before, the box culvert crossing the runway will be used for draining off water of the box culvert to be established as the drainage system on Runway Exit Taxiway No.3.

The existing box culvert beneath the access taxiway on apron side will be removed and reconstructed at the same place. Water in this box culvert will be driven into the existing open ditch, a part of which will be remodelled to allow the water to run into the box culvert constructed under the 1st Stage Airport Extension Project.

As to the section, the section of No. 1 Box Culvert will be 1.2 m x 0.8 m which is the same as the existing adjacent section. The section for No.2 Box Culvert on the Access Taxiway will be 1.6 m x 0.6 m x 2 series. The section of the drainage channel on the apron side will be 1.0 m x 0.9 m -- 1.3 m with cover, same as the section of the existing channel. The height of the box culvert has been fixed at more than 0.6 m in consideration of repair and cleaning. The gradient of the portion of the open ditch crossing Runway Exit Taxiway No.1 will be changed so that it will drain into the box culvert constructed newly under the 1st Stage Extension Project.

6-3 Design of box culvert

In designing the box culvert, DC-8-61 class aircraft has been considered the design load. Single and double series culverts of reinforced concrete structure have been adopted. The drainage channel on the apron side is for design load eqaivalent of T-20, and is of rainforced concrete structure. The safety factor of the structures is required more than 3.0.

Section and quantity of reinforcing steel bars were calculated according to the following load and allowable strength when designing the drainage structures.

Item	No. 1 Box Culvert	No.2 Box Culvert	No.3 U Channel	Remarks
Location	No.3 RE T/W	Access Taxiway	Apron side	
Type of aircraft	DC-8-61	DC-8-61	T-20	
Gross weight	148.78 t (330,000 lbs)		20.0 t	
Gear load	18.226 t		8.0 t (Rear wheel)	
28 days compressive strength of concrete	σ_{28} = 240 kg/cm^2	240	240	Control of construction Safety factor 3.0
Allowable compressive strength	σ_{ca} = 80 kg/cm^2	80	80	
Allowable shearing strength	τ_{ca} = 9 kg/cm^2	9	9	
Allowable adhesive strength	τ_{oa} = 16	16	16	
Allowable tensile strength of reinforcement bar	σ_{sa} = 1,800 kg/cm^2	1,800	1,800	Deformed reinforcing steel bar

7. Design of lighting system

7-1 Present condition of the electrical equipment

7-1-1 Illumination system

The present condition of aviation rotating beacon, wind cone, obstruction light, runway edge lights, runway threshold lights, and taxiway edge lights has already been explained under 2-2-3 on navigational aids.

7-1-2 Electrical power source system

(1) Power receiving and power generating equipment

The present condition of power receiving and power generating equipment has been explained under 2-2-9 on power system.

(2) Power source equipment for the runway edge lights and runway threshold lights

CR-30 type constant current regular (CCR) for the runway edge lights and runway threshold lights, etc. was installed under the 1st stage extension project.

(3) Power source equipment for the taxiway edge lights

Six 4-kW constant current regulators which had been installed here were removed during the 1st stage extension project because they were not usable.

(4) Power source equipment for the wind cone, aviation rotating beacon, and obstruction light, etc.

As a power source control device for CR-30 Type CCR, wind cone, aviation rotating beacon, and obstruction light, etc., a Distribution Panel is being installed next to CR-30 Type CCR.

(5) Electrical power source equipment for the aviation rotating beacon

One single-phase transformer of 220/110 V, 2 kVA is being used.

(6) Electrical power source equipment for electrical apparatus in the terminal building

One 3-phase transformer of 75 kVA (380/220 - 127V) has been installed and is in service.

7-1-3 Control equipment for the airport illumination

In the 1st stage construction work, the control equipment for the airport illumination system was installed at the vault room and the control room of the control tower respectively, and they are now being used.

7-1-4 Power distribution system of the airport

The distribution system is installed as shown in Fig. 7-1 Connection Diagram.

7-1-5 Existing main cable duct and handholes

Main cable duct is being laid underground over a distance of about 700 meters from the vault room to the runway. Handholes are being placed at 13 places on this duct.

At 3 places near the vault room, the handhole is being set in the swampy area about 1.5 meters below the water level. All handholes are submerged during the rainy season.

7-1-6 Apron lights

As the apron lights, illumination lights each having five 1000-Watt lamps are being installed at five places on the terminal building and the control tower. Again, the apron is being equipped with 8 pole-lights each carrying four 160-Watt lamps.

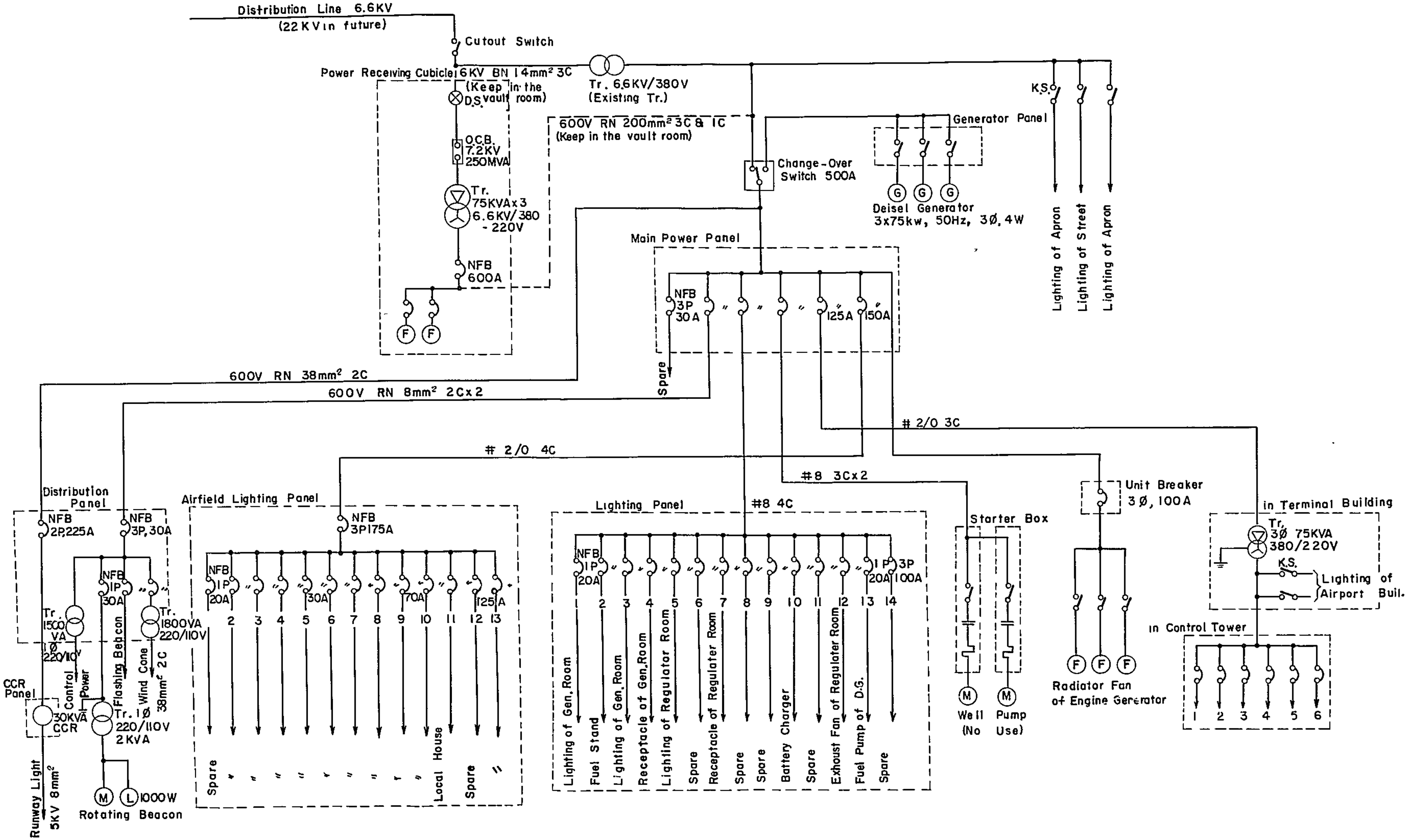


Figure 7-1 CONNECTION DIAGRAM

7-2 Installation of new taxiway edge lights

A total of 207 taxiway edge lights will be installed newly to illuminate the following places.

(1) Existing and extended apron
(2) Existing access taxiway No.4
(3) Some parts of the existing access taxiway No.2
(4) Existing and extended parallel taxiways
(5) New runway exit taxiway No.1
(6) New runway exit taxiway No.2

7-2-1 Selection of the taxiway edge lights

Taxiway edge lights have been designed in the same way as for the existing ones, and M-1 Type Medium Intensity Lights (45 W, Blue) have been chosen. Also, five unserviceability lights will be installed at the end of the parallel taxiway to be constructed newly, and the lighting fixture will be the M-1 Type (45 W) equipped with red lens.

7-2-2 Location of the taxiway edge lights

Taxiway edge lights shall be placed on the outside, one meter away from the concrete edge of the taxiway pavement.

The spacing of the lights on the light line shall be inconformity to the technical standards of TSO-No. 001 of JCAB.

7-2-3 Circuit system of the Taxiway edge lights

Circuit system of all taxiway edge lights shall be of one-circuit series connection, which gets power supply from the constant current regulator through insulating transformers.

7-2-4 Selection of the constant current regulator

There are three types of constant current regulator, namely, the CR type, the SCR type, and the SR type. CR type is selected for this project because the constant current regulator for the runway lights currently installed is the CR type, and also because its electrical system is simple and has less parts to be adjusted, and what is more is that the price is low. Including Air America's scheduled area, the total number of lighting fixtures would come to approx. 300, and the anticipated maximum load is 16 kVA. For these reason, CR-20 Type Constant Current Regulator has been selected.

7-2-5 Control for light intensity of the taxiway lighting

The output current of constant current regulator for light intensity of the taxiway lights shall be of 5-step, but the control equipment for the airport illumination (installed at the vault room and the control room of the control tower) shall be operated with ON-OFF switch alone, and the step button for output current control of the constant current regulator shall be stationary.

Change-over of the intensity shall be conducted by means of the constant current regulator installed at the vault room.

As for the control cable, the existing one will be used.

7-2-6 Laying of the cable

PVC (poly vinyl chloride) pipes shall be for duct line for the cable. Where PVC pipes cannot be used, ducts and handholes shall be used. (For example, portions which cross the taxiway)

8 sq. mm. bare annealed copper wire shall be laid as distributing line, and it should be grounded by the grounding rod.

The cable to be used shall be 3 kV, 8 sq. mm, single core BN cable.

7-3 Improvement of the runway edge lights

At the intersections between the existing runway and runway exit taxiways No.1 and No.3. C-1 type and H-6 type high intensity runway edge lights are presently being installed. As these are the surface types, these will be removed and replaced by the flush type lights. The new type to be installed is the H-8-III Type High Intensity Marker Light(200 W). The number of lights required is 9.

Runway edge light line shall be parallel to the runway on the outside, 1.5 m away from the edge of the runway, same as for the existing runway lights. To conform to ICAO-ANNEX-14, lighting fixture within

600 meters of the runway end shall be equipped with filters of variable yellow color. Cable to be used shall be the 5 kV, 8 sq. mm, single core BN cable. Carbon steel pipe (SGP-50A) shall be used for the duct line below the concrete pavement.

7-4 Replacement of the wind cone

I-type wind cone is currently being installed, but since this will run into runway exit taxiway No.3 in the extension work to be carried out this time, it will be moved to the point 100 m toward northwest and about 50 m northeast from the edge of the parallel taxiway. The upper portion of the I-type wind cone now being installed will be used as it is, and only the lower portions of the lighting fixture will be installed newly. The existing cable now being used is the 38 sq. mm cable, but 8 sq. mm cable will be used and power will be supplied at 220 V because the cost of cable is quite high. A step-down transformer will be installed on the lower portion of the wind cone.

(1) Light base

Light base shall be made of plain concrete, but it shall be in one body with the base for fixing the handhole and the transformer box.

(2) Circular zone

Circular zone shall be of plain concrete, and the white portion of the circular zone shall be finished with white mortar on the upper layer when concrete placing has been completed.

The inside and the outside of the circular zone shall be paved with asphalt.

(3) Laying of cable duct line

PVC (poly vinyl chloride) pipe shall be used for the duct line for the cable.

(4) Cable

The cable to be used shall be the 600 V, 2C-8 sq. mm BN cable.

7-5 Flashing equipment for flashing beacon

The flashing equipment for the existing flashing beacon on the water tank is broken and the beacon is not flashing now.

Therefore, flashing equipment (600 W, for two lights, 220V) will be installed newly. At present, 110 V lamps are being used with the temporary 110 V distribution line because lamps for 220 V are not available. Therefore, 220 V, 600 W lamps will be supplied, so that electric Power can be supplied to the beacon at 220 V.

7-6 Installation of new cable ducts and handholes

7-6-1 The use of existing main cable duct

If the apron where the existing cable duct is being laid should be extended, the distance underneath the concrete pavement will come to about 140 meters, and it becomes difficult to pass a cable underneath it. It is not advisable to lay the cable duct underneath the pavement of the apron from the viewpoints of operation of the airport, execution of the construction work, and economy. Therefore, a new route (about 500 m) which goes round the outer side of the apron will be established. The existing main cable duct and handholes not on this new proposed route will be reused after providing sufficient drainage.

The roundabout main cable duct to be established newly and the handholes shall be made of reinforced concrete, and the inside of the handhole shall have the waterproof mortar cement finish. The inside of the handhole will be provided with a ladder, cable rack, drainage pipe, etc. The cover of the manhole shall be made of cast iron. Same as for the existing cable duct, 100 mm dia. asbestos cement pipe will be used as cable duct.

7-6-2 Cable ducts for crossing the taxiway

The cable ducts to be installed on the parallel taxiway and the runway exit taxiways scheduled for extension have been planned in the same way as for the existing cable duct. In the same manner as on the existing cable ducts, handholes will be build at the points, the minimum distance of which from the edge of the taxiway is 9 m.

7.7 Improvement of the electrical equipment for power source

(1) 22/6.6 kV power receiving equipment

(2) Change-over magnet switch (City power - Diesel generators)

(3) Main power distribution panel

As mentioned under 2-2-9 on "Power Facilities", power receiving equipment for 22 kV will be installed at the receiving end since E.D.L. is going to boost the voltage on the distribution line from 6.6 kV to 22 kV.

Again, in order to keep the balance of load equipment, main power distribution panel will be installed, and the existing main power panel and the unused airfield lighting panel will be removed.

As the change-over switch for the city power and the diesel generating equipment currently installed is the hand-operated type and the same is partially damaged, this will be removed and replaced by a magnet type switch.

As the existing vault room leaves no room for improvement, it would be advisable to abolish the same in the future and plan the establishment of a new substation and a power house equipped with such facilities.

(1) 22/6.6 kV power receiving equipment

6.6 kV/380-220 V power receiving cubicle now being installed has not been used hitherto because an information was received that the voltage would be boosted from 6.6 kV to 15 kV. For this reason, power is being distributed through the pole mounted transformer.

According to the Ministry of Plan and Cooperation, the voltage would be boosted to 22 kV under the extension project to be implemented this time, but E.D.L. was not confident if they could boost the voltage from 6.6 kV to 22 kV all at once during 1971 although they intended to do so. The new 22/6.6 kV power receiving equipment will be installed adjacent to and connected to the existing 6.6 kV/380 - 220 V power receiving cubicle.

Consequently, the pole mounted power receiving equipment (3 transformers, etc.) will be removed. In case the boosting of the voltage to 22 kV will be delayed, the pole mounted power receiving equipment will be removed, and the existing 6.6 kV/ 380 - 220 V power receiving cubicle will be used.

In this case, 22/6.6 kV power receiving equipment will be installed in such a way that it can be used immediately when the voltage is boosted to 22 kV in the near future. 22/6.6 kV power receiving equipment scheduled for installation consist of the arresters, fusible disconnecting switches, outdoor type 3 ϕ, 22/6.6 kV 250 kVA transformer, metering outfit and watthour meter, etc.

(2) Demand factor and load factor of load equipment in the airport

(i) Present demand factor and loal factor

Average load	About 25 kVA (daytime)
Maximum load	About 45 kVA (nighttime)
Demand factor	About 30% (45 kVA + 154 kVA x 100)
Load factor	About 56% (25 kVA + 45 kVA x 100)

(ii) Estimated demand factor and load factor of the 2nd Stage Plan

Average load	About 25 kVA
Maximum load	About 60 kVA
Demand factor	About 30% (55 kVA + 170 kVA x 100)
Load factor	About 42% (25 kVA + 60 kVA x 100)

Tables showing the distribution of load are given below.

Tables showing the distribution of load

(a) Present

Description	Phase A	Phase B	Phase C	Note
1. Lighting of vault room	VA	2,550 VA	VA	1 ø 220 V
		2,690		" "
		2,370		" "
2. Ventilation fan	7,500	7,500	7,500	3 ø 380 V
3. Terminal building (Including control tower)	20,230	20,230	20,230	" "
4. Wind cone		1,500		1 ø 220 V
5. Aviation rotating beacon		1,500		" "
6. Transformer for control of the airport illumination		1,500		" "
7. Obstruction lighting		1,200		" "
8. Runway lighting	14,000		14,000	1 ø 380 V
9. Well pump				Not used (damaged)
10. Taxiway lighting				Use of equip. impossible
11. Apron lighting	10,000	10,000	10,000	1 ø 220 V
Total	51,730	51,040	51,730	154,000 VA

(b) Second Stage Plan

Description	Phase A	Phase B	Phase C	Note
1. Lighting of vault room	VA	2,500 VA	VA	1 ø 220 V
		2,690		" "
		2,370		" "
2. Ventilation fan	7,500	7,500	7,500	3 ø 380 V
3. Terminal building (Including control tower)	20,230	20,230	20,230	" "
4. Wind cone			1,500	1 ø 220 V
5. Aviation rotating beacon			1,500	" "
6. Transformer for control of the airport illumination			1,500	" "
7. Obstruction lighting			1,200	" "
8. Runway lighting	14,000		14,000	1 ø 380 V
9. Well pump				Not used (damaged)
10. Taxiway lighting	8,000	8,000		1 ø 380 V
11. Apron lighting	10,000	10,000	10,000	1 ø 220 V
Total	59,730	53,340	57,430	170,000 VA

(c) Future Plan

The future plan includes the followings:-

* Double circuits of the runway edge lights
* Installation of runway center line lights, and increase of taxiway edge lights following the extension of the parallel taxiway
* Increase the number of apron illumination lights
* Installation of center line lights for runway exit taxiways and holding apron, approach lighting system
* Consolidation of radio equipment
* Increase of load and construction of panels

As the present vault room leaves no room for improvement, it would be advisable to abolish this vault room and establish newly the well equipped substation and a power house.

(3) Change-over magnet switch (City power - Diesel generators)

The switch now being installed is the 3-pole, double-throw, 500-A Knife Switch Type. This is a hand-operated switch which is partially damaged. This will be removed, and a 600-V 600-A magnet type change-over switch will be installed newly.

(4) Main power distribution panel

The distribution systems for power source of load equipment are connected together to give a balanced 3-phase load at the main power panel, lighting panel and change-over switch.

Again, the load capacity of single phase, 16 kVA will be required for the taxiway edge lights to be installed at the 2nd stage extension project.

Since only five local houses are now receiving power supply through airfield panel, the source line will be connected to the spare portion of the existing lighting panel.

For the reasons mentioned above, the existing main power panel will be installed newly to obtain a balanced 3-Phase load.

(5) Renewal of the existing cable inside the vault room

As some cables in the vault room do not have sufficient capacity, partial renewal of the cables will be carried out. Again, since the distribution line of the existing apron lights is getting power supply only from city power, power will be supplied from city power as well as from the diesel generators by installing a change-over magnet switch.

7-8 Others

7-8-1 Tools for maintenance operation

Tools and maintenance equipment will be provided in such quantities as to ensure proper daily maintenance work.

7-8-2 Spare parts

Spare parts such as lamps, lighting fixtures, cables, and insulating transformers, etc. will be provided for maintenance service.

7-8-3 Maintenance lanes

Reliable maintenance work is indispensable to proper maintenance of the airport facilities. For this purpose, maintenance lanes must be provided to secure free access to the handholes of the main cable duct, wind cone, and other facilities.

7-8-4 Weed growth

As the existing taxiway shoulders are unpaved, it is quite possible that the taxiway edge lights may be covered by grass and weeds. The same applies to the taxiways scheduled for extension. Permanent measures must be established in such a way that mowing and other necessary work are included in the daily inspection and maintenance work.

7-8-5 Temporary installations

Necessary temporary facilities should be provided during the period the construction work under the 2nd stage extension project is in progress, since it is impossible to discontinue the operation of the existing runway, taxiways, etc.

7-8-6 Training of maintenance personnel

Training of maintenance personnel is absolutely necessary for the reliable maintenance of all electrical equipment of the airport.

8. Construction

8-1 Construction time schedule

It is the key point of this construction work that the construction period is relatively short, so in the execution of works it is indispensable to complete the whole work during one dry season. Therefore the construction period of this project is estimated at 7 months from September to next March. The plan is scheduled to need 1.0 month for the preparatory work, 5 months for earth works, 5.5 months for base course and concrete pavement works, and 7 months for electrical installation. The tentative construction schedule is as shown in Fig. 8-1.

8-2 The rate of operation

The rate of operation calculated from the weather condition data for the last decade in Vientiane is 76 % on the average in dry season. The total number of workdays does not include such national holidays on which the workers work to cover the work delayed by rainy weather.

8-3 Construction

8-3-1 General

The work site shall consist of four areas (extended apron, runway exit taxiways No.1 and No.3, and extended parallel taxiway). Embankment and base course materials shall be carried by dump trucks from the borrow pit as shown in the drawings to the construction sites. As various works at the construction site are carried out independently, they do not interfere with one another.

8-3-2 Earth work

Prior to excavation and embankment in each site, top soils shall be stripped and deposited in the disposal area as shown in the drawings. Cutting and filling works shall consist of excavation, loading, transportation, gradation and compaction in each site. For embankment and base course works, it is specified to transport the filling materials from the borrow pit, and to carry out grading and compaction at the filling site. Soft clay layer, lying at the embankment foundation site of apron shall be removed and replaced with send to 50 cm thickness, transported from the nearest Mekong river bed. Base course materials

NO.	DESCRIPTION	QUANTITY	UNIT	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	REMARK
	SITE PREPARATION WORKS	1	ls								
A	TAXIWAY										
A - 1	STRIPPING OF TOPSOIL	14,030	M^3								BY DUMP TRUCK
A - 2	STRIPPING OF TOPSOIL	12,550	M^3								BY CARRY-ALL SCRAPER
A - 3	CUTTING AND FILLING	1,610	M^3								
A - 4	EMBANKMENT	54,090	M^3								BORROWING AND SUBGRADING
A - 5	BASE COURSE	36,500	M^2								BORROWING AND GRADING
A - 6	CONCRETE PAVEMENT	12,740	M^3								28^{cm} THICKNESS
A - 7	SHOULDER SODDING	23,540	M^2								
A - 8	GRADED AREA SEEDING	37,800	M^2								
B	APRON AND FILLET IMPROVMENT										
B - 1	STRIPPING OF TOPSOIL	6,150	M^3								BY DUMP TRUCK
B - 2	STRIPPING OF TOPSOIL	800	M^3								BY CARRY-ALL SCRAPER
B - 3	REMOVAL OF SOFT CLAY	13,800	M^3								
B - 4	REPLACEMENT WITH SAND	5,710	M^3								
B - 5	CUTTING AND FILLING	900	M^3								
B - 6	EMBANKMENT	16,800	M^3								BORROWING AND SUBGRADING
B - 7	BASE COURSE	22,900	M^2								BORROWING AND GRADING
B - 8, 9	CONCRETE PAVEMENT	5,800	M^3								20, 28, 35 & 38^{cm} THICKNESS
B - 10	SHOULDER SODDING	5,500	M^2								
B - 11	GRADED AREA SEEDING	2,300	M^2								
C	DRAINAGE										
C - 1	EXCAVATION AND REFILLING	1,700	M^3								
C - 2	MACADAM STONE FOR STRUCTURAL BED	180	M^3								
C - 3	STRUCTUAL CONCRETE	114	M								BOX CULVERT NO 1
C - 4	STRUCTUAL CONCRETE	53	M								BOX CULVERT NO 2
C - 5	STRUCTUAL CONCRETE	175	M								BOX CULVERT NO. 3
C - 6	EXCAVATION EARTH OPEN DITCH	2,600	M^3								
D	MISCELLANEOUS WORKS	1	ls								
E	LIGHTING INSTALLATIONS										
	LIGHTING FACILITIES	207	NOS								TAXIWAY
	LIGHTING FACILITIES	9	NOS								RUNWAY
	LIGHTING FACILITIES	1	ls								WIND CONE
	CABLE DUCTS AND HAND HOLES	500	M								
	POWER RECEIVING EQUIPMENT	1	ls								

Fig 8-1 CONSTRUCTION SCHEDULE

on the prepared sub-grade shall consist of the stabilized materials transported from the borrow pit, which consist of the mixtures of natural materials (gravels) and binder sands. Bulldozers, scraper shovels, dump trucks and rollers will be used in the above operation as planed.

8-3-3 Concrete work

For aggregates to be used in concrete works, the deposits of the Mekong river collected at the point about 43 km downstream from the work site (near the government's gravel plant), will be used. As the equipment for concrete works, batching and mixing plant specified is as 28 cf x 2, which will be installed at the work site, and the products will be transported by agitator or dump tracks and placed where required.

8-4 Construction materials, machinery, and equipment

8-4-1 Construction materials

The quantities of the main materials required for the work are estimated as follows.

	taxiways extension	Apron	Drainage	Lighting	Total
1. Cement (t)	4,030	1,890	180	70	6,170
2. Reinforcement bar (t)	45	6	56	13	120
3. Gravel for concrete (m^3)	10,830	4,920	450	210	16,410
4. Sand for concrete (m^3)	5,230	2,320	260	100	7,910
5. Sand for base coarse (m^3) of mixed materials	640	410			1,050
6. Gravel and sand of bad (m^3)			900		900
7. Electrical installation (ls)				1	1

Cement, reinforcement bars, joint filler and other particular materials will be imported from abroad. Timber, stone, sand, fuel oil and lubricants, etc. and other minor materials will be purchased locally.

8-4-2 Construction machinery and equipment

The principal construction machinery required for this project are estimated as follows:

Item	Description	Nos.	Remarks
Bulldozer	D-50	2	Excavation
Bulldozer	D-80	7	"
Swampdozer	D-50 p	1	"
Power shovel .	0.6 m^3 class	3	"
Scraper	6.0 m^3 class	2	"
Grader	MG-III	3	"
Roller	WMB-10	1	Compaction
Tire roller	WP-15	1	"
Dump truck	6 ton class	32	Earth & concrete transport
Water tanker	5,500 ℓ	2	Earth, concrete works
Batcher plant	28 cf x 2	1	Concrete works
Concrete spreader	CF-S	1	"
Concrete finisher	CS-S	1	"
Concrete cutter	RSC-2	3	"
Concrete vibrator		6	"
Ordinary truck	6 ton class	1	Miscellaneous

9. Cost estimate

9-1 General

Construction cost of the Vientiane airport extension project II is estimated at 1,800,000 US dollars equivalent, including the foreign exchange and the local currency portion.

The estimate of cost inlocal currency is based on the labor wages and material prices as of the December, 1971 and this amount was converted to US dollar at the rate 500 kips to one US dollar.

9-2 Basis for cost estimate

All estimates are exclusive of any import duties or other taxes on equipment, materials and supplies that might be payable in Laos, and of any taxes which might be levied in Laos on the engineers, the contractor, contractor's equipment, or contractor's foreing employees.

The estimates are made on the conditions that the principal labor wages and material prices are as follows.

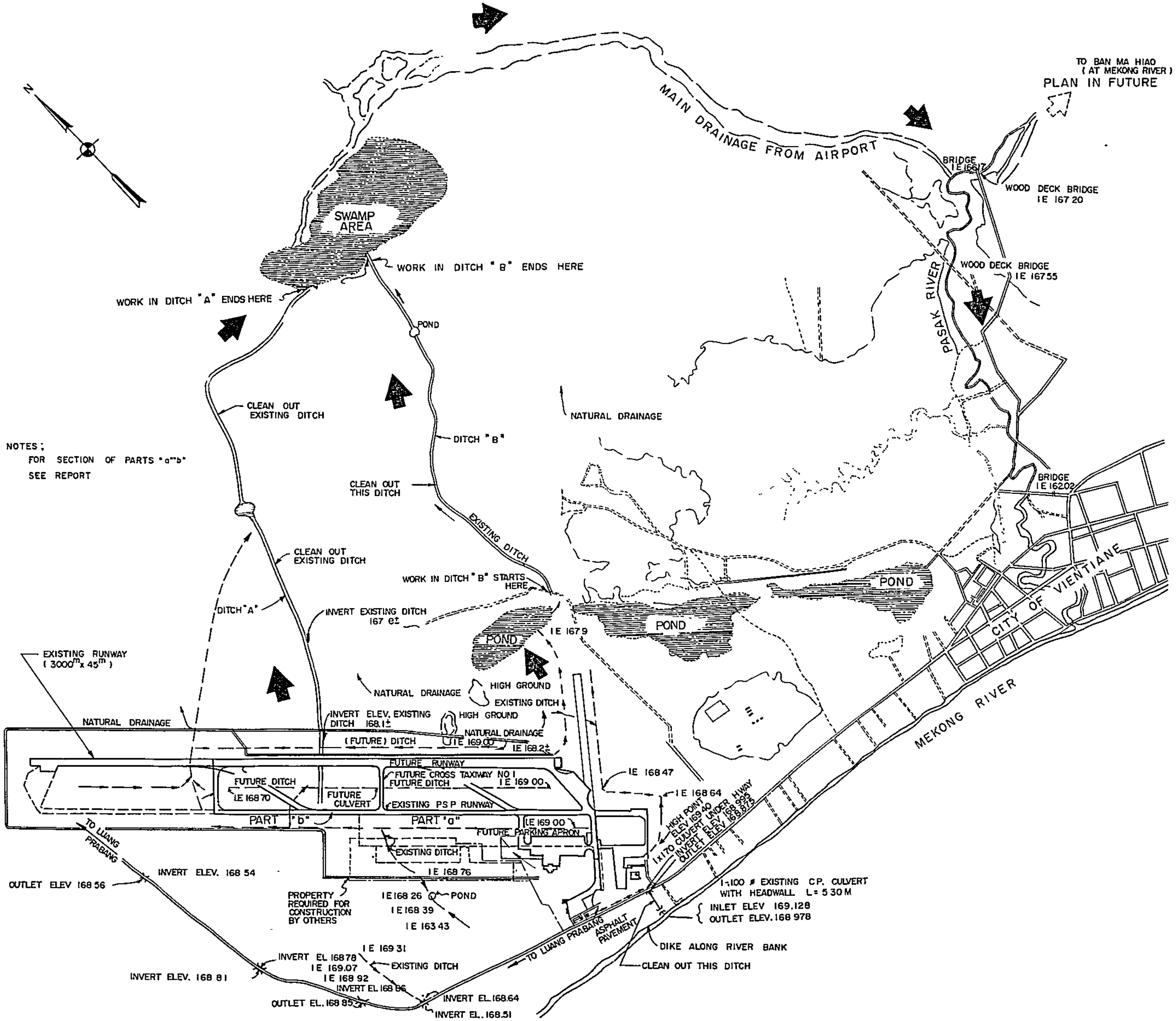
Wages and Material Cost

Item	Local KP/day	Item	Local KP/day
Foreman	2,000	Cement (Portland.c)	16,500
Head man	1,800	Sand (Wet)	900
Skilled labour	1,500	" (Dry)	
Steel man	1,200	Gravel (Wet)	1,500
Carpenter	1,500	" (Dry)	
Driver (Ord.)	800	Crushing stone	3,500
" (Dump)	1,000	Reinf. bar	
Operator (D.E)	1,200	Hard wood (Log)	32,000
Helper	500	" (Sawn)	32,000
Mechanic	1,800	Soft wood (Log)	18,000
Electrician	1,500	" (Sawn)	19,000
Welder	1,500	Nail (Large size)	

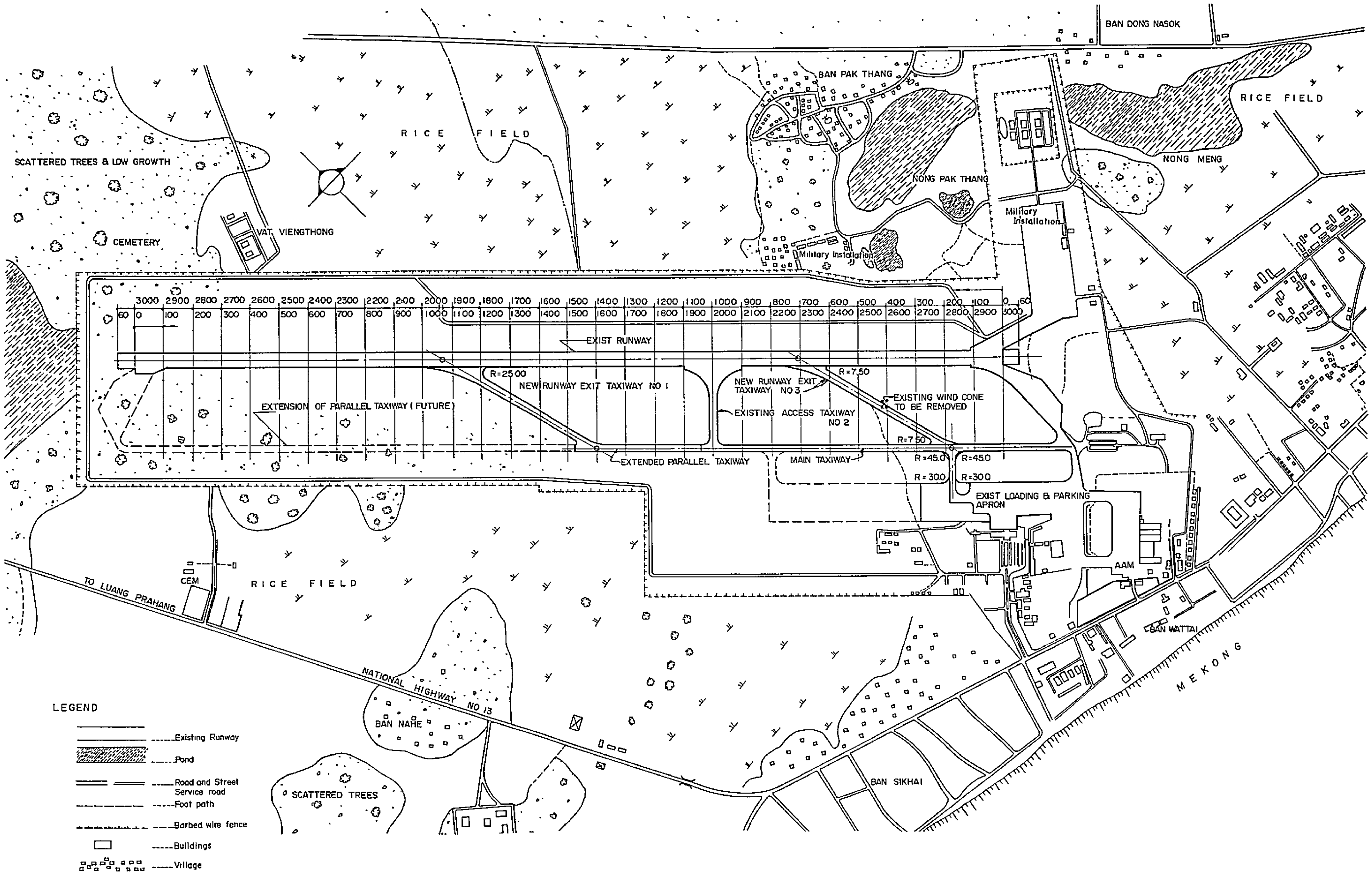
Item	Local KP/day
Nail (Small)	
Sad	1,000
Seed	
Paint (White)	
" (Coloured)	
Steel wire	
Gasoline	33
Diesel oil	16.8
Mobile oil	180
Gear oil	180
Grease	243
Kerosene	23

At the investigation conducted this time, the prices of materials to be procured locally and the wage scale of local workers and other expenses maintained almost the same level as that at the last investigation. The annual rate of price rise is about 0.3% - 0.5%. These factors has been taken into consideration when formulating this cost estimate.

APPENDIX

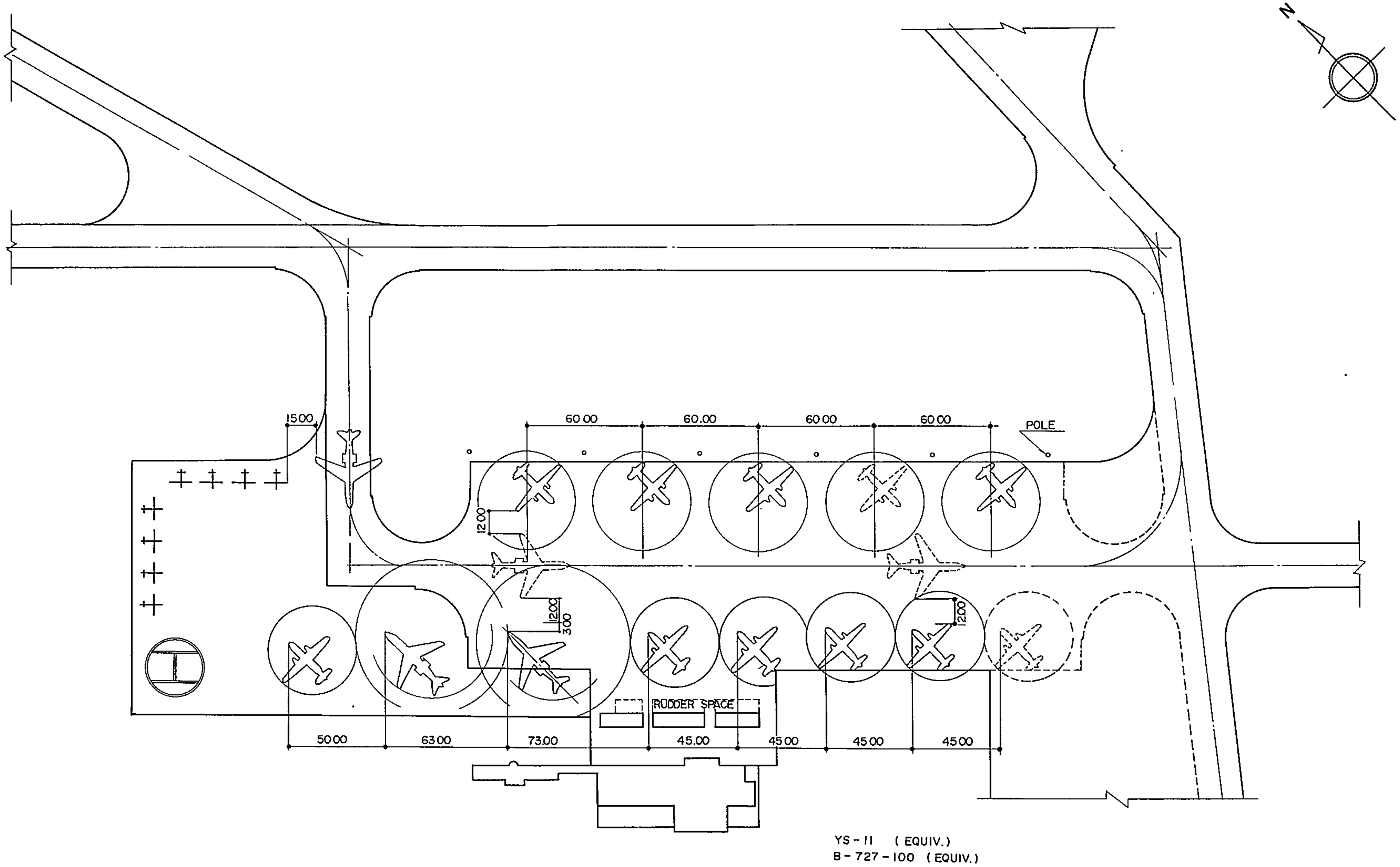


DWG. NO. I . AIRFIELD AND OFF-FIELD DRAINAGE



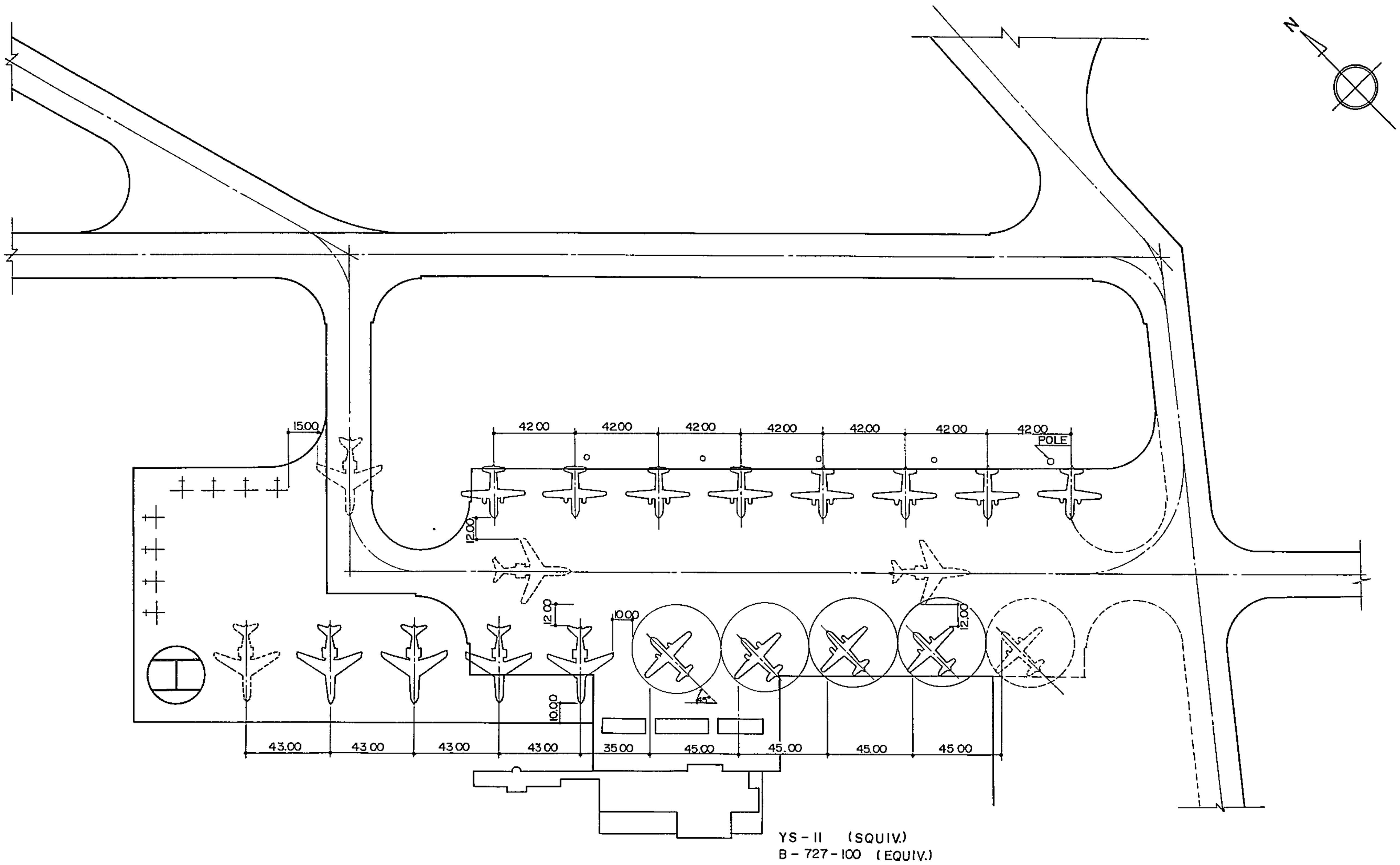
DWG. No. 2 MASTER PLAN

TAXIWAY AND APRON



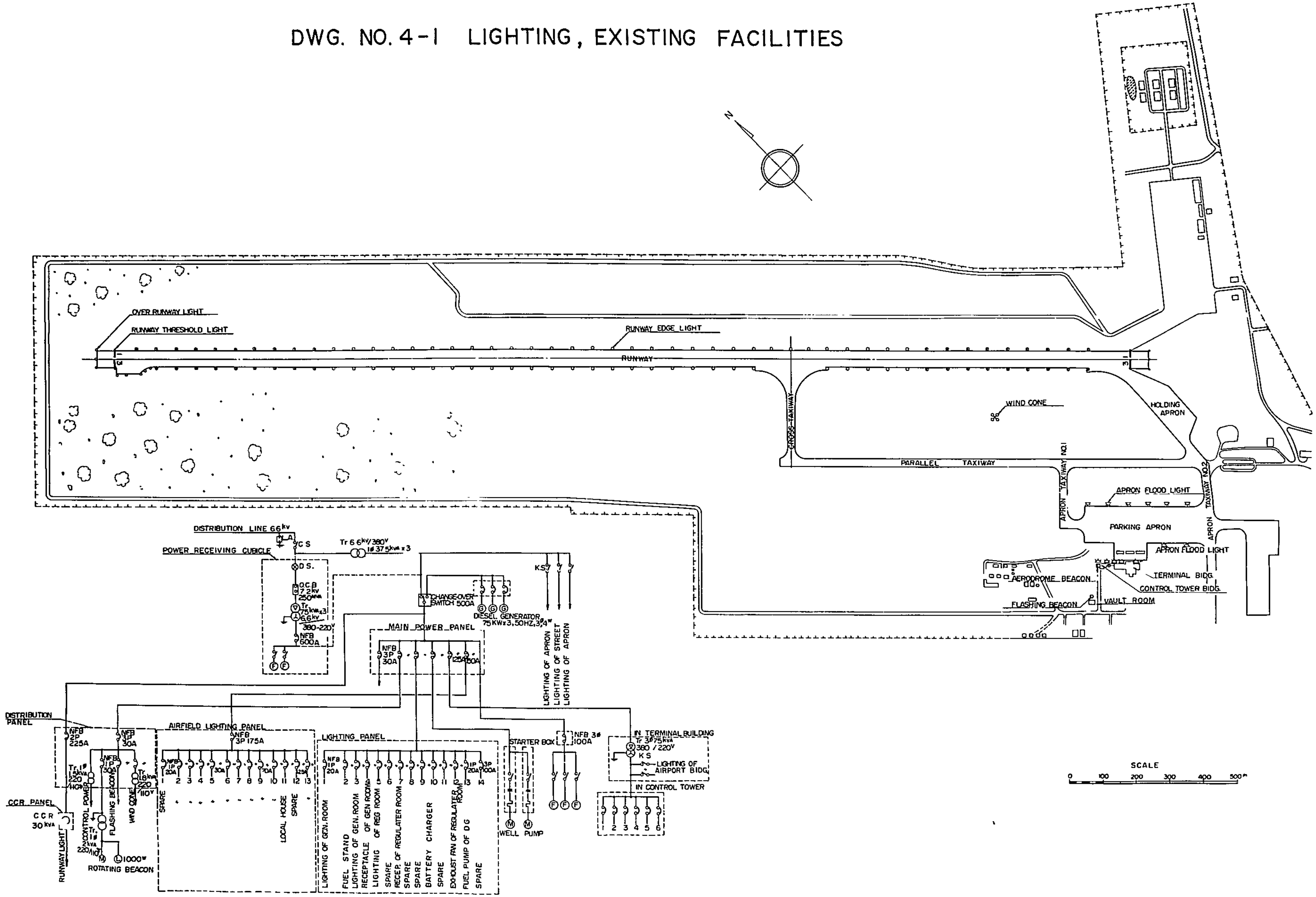
DWG. No. 3 - 1 APRON PARKING CONFIGURATION

SCHEME I

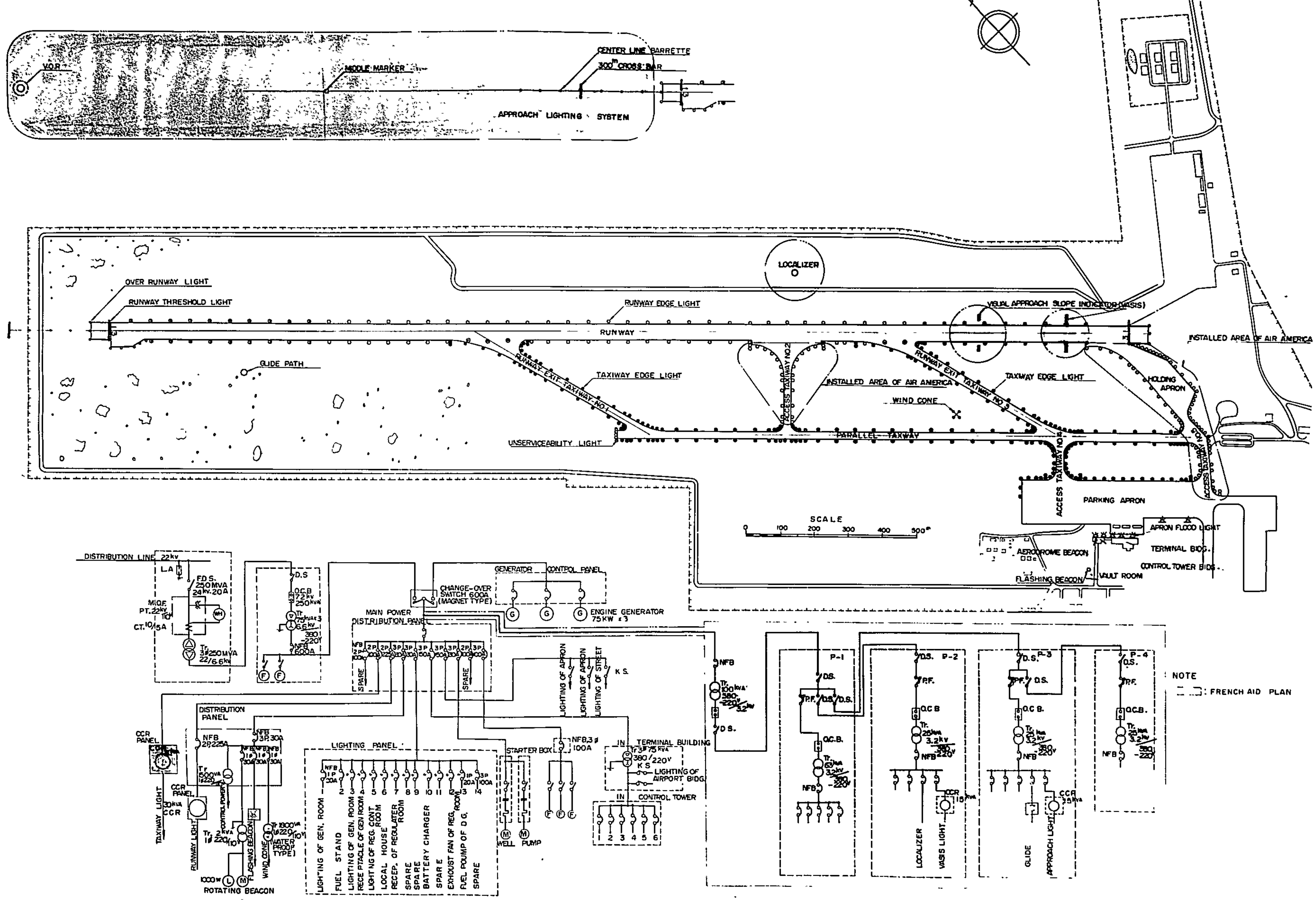


DWG. No. 3-2 APRON PARKING CONFIGURATION
SCHEME II

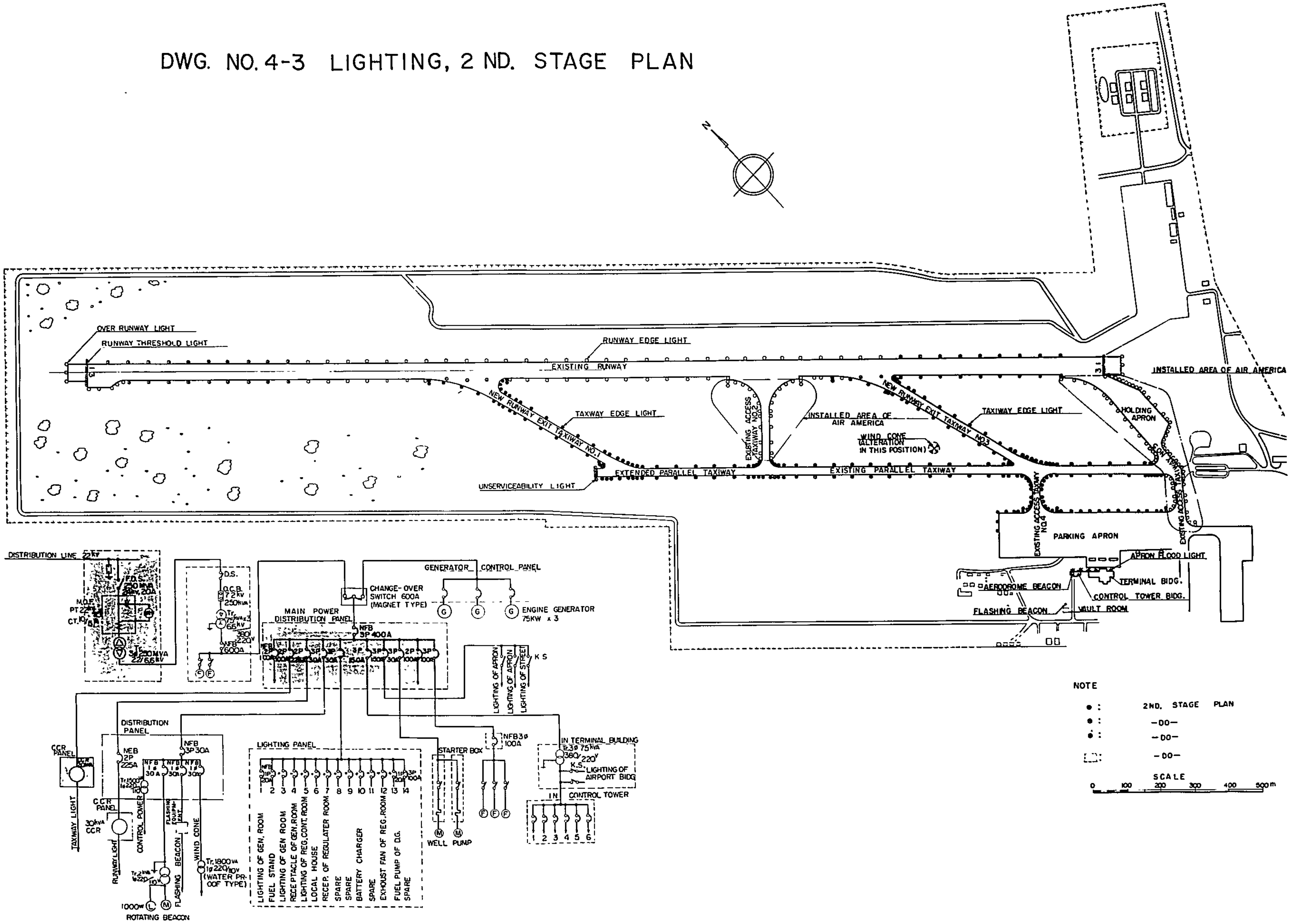
DWG. NO. 4-1 LIGHTING, EXISTING FACILITIES



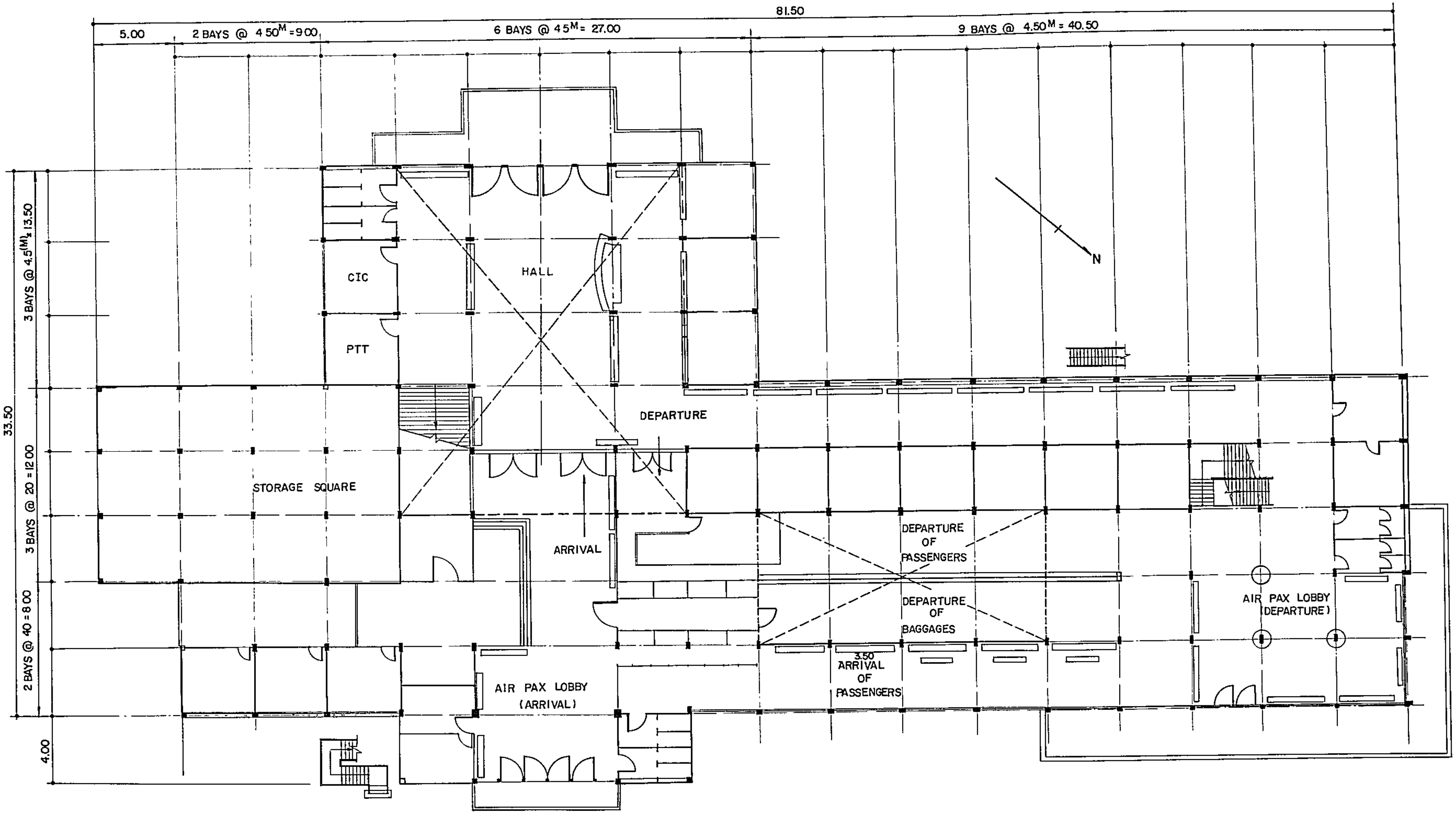
DWG. NO. 4-2 LIGHTING, FRENCH AID PLAN



DWG. NO. 4-3 LIGHTING, 2 ND. STAGE PLAN



DWG. No. 5-1 EXISTING TERMINAL BUILDING IST FLR, PLAN



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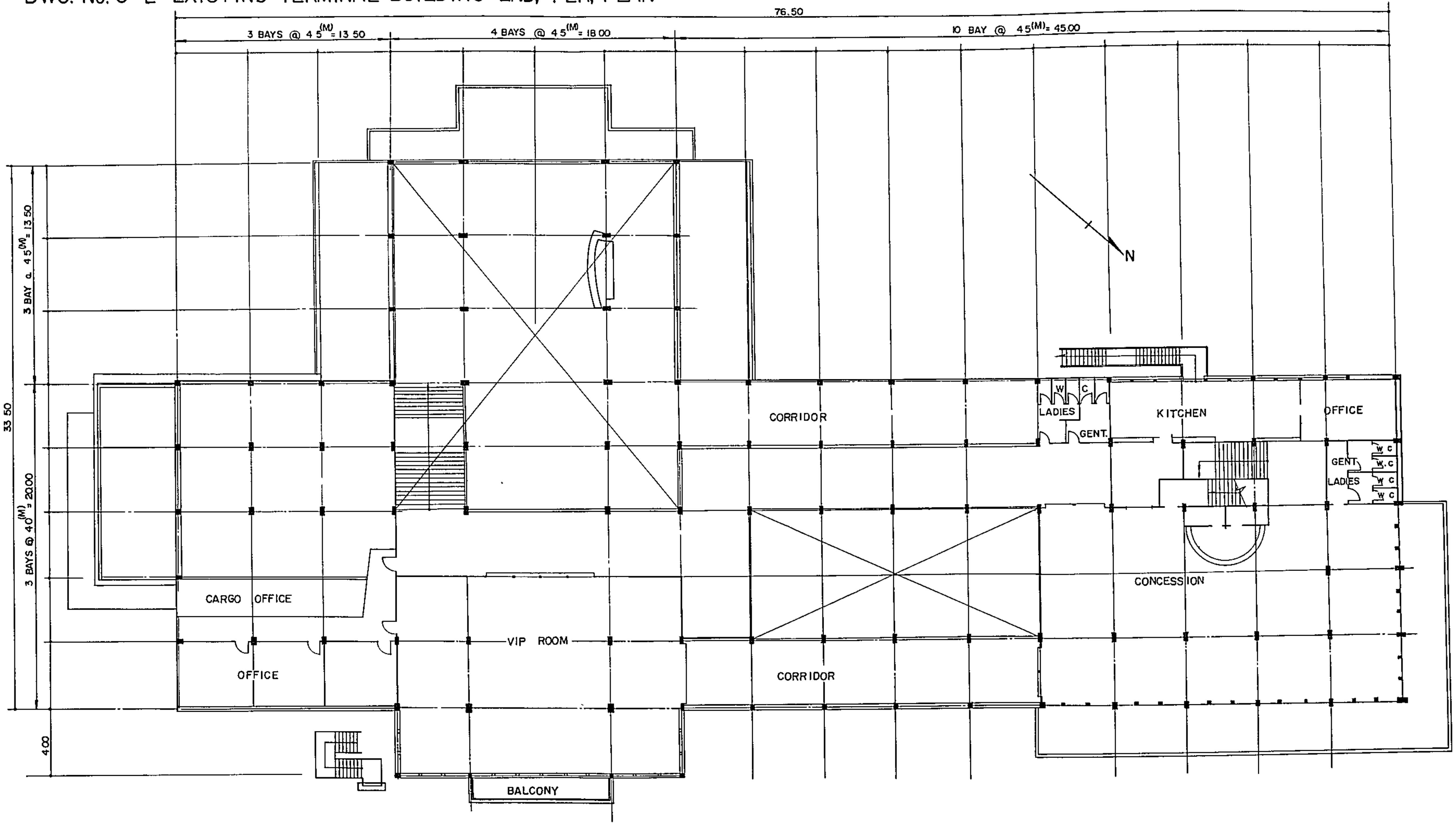

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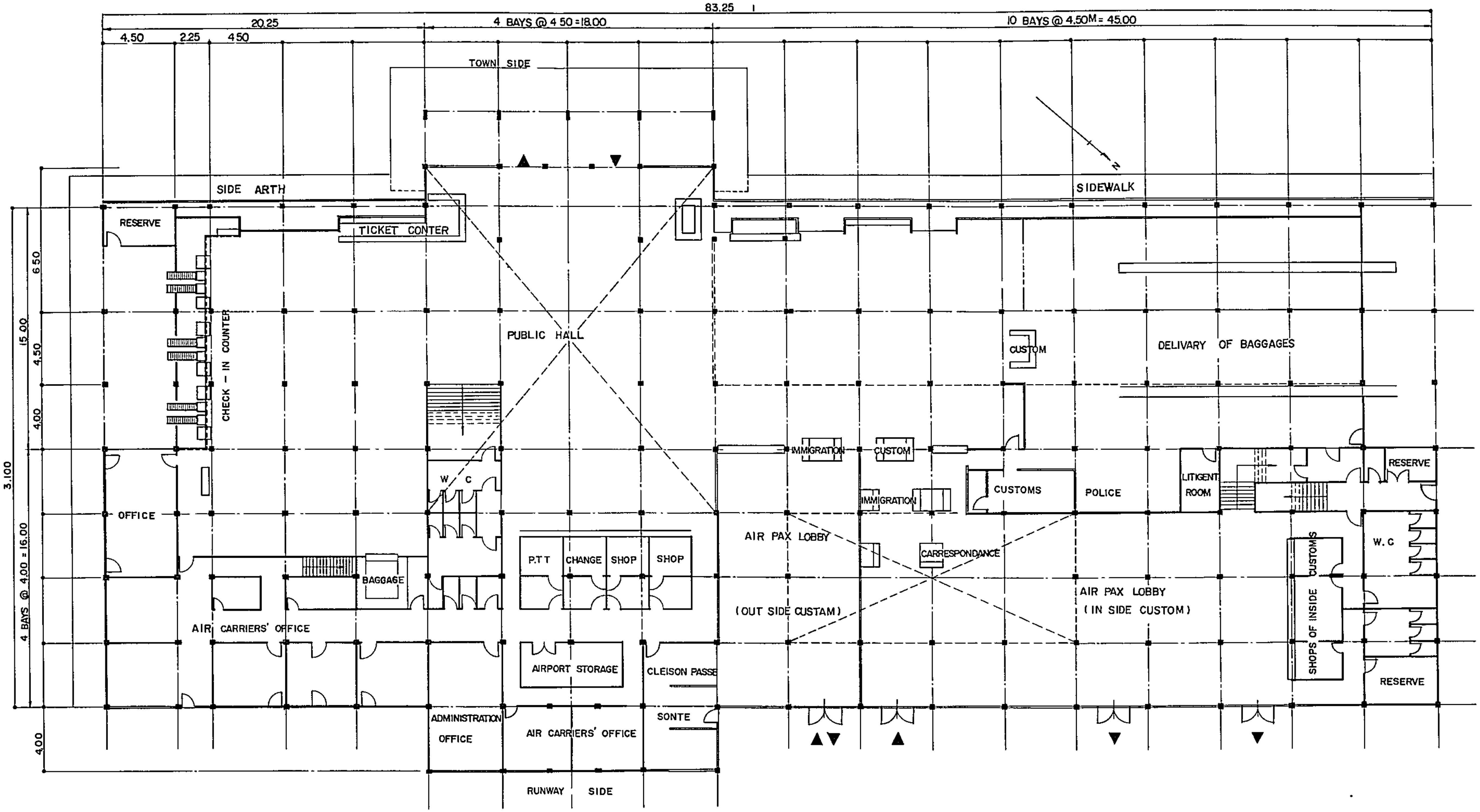

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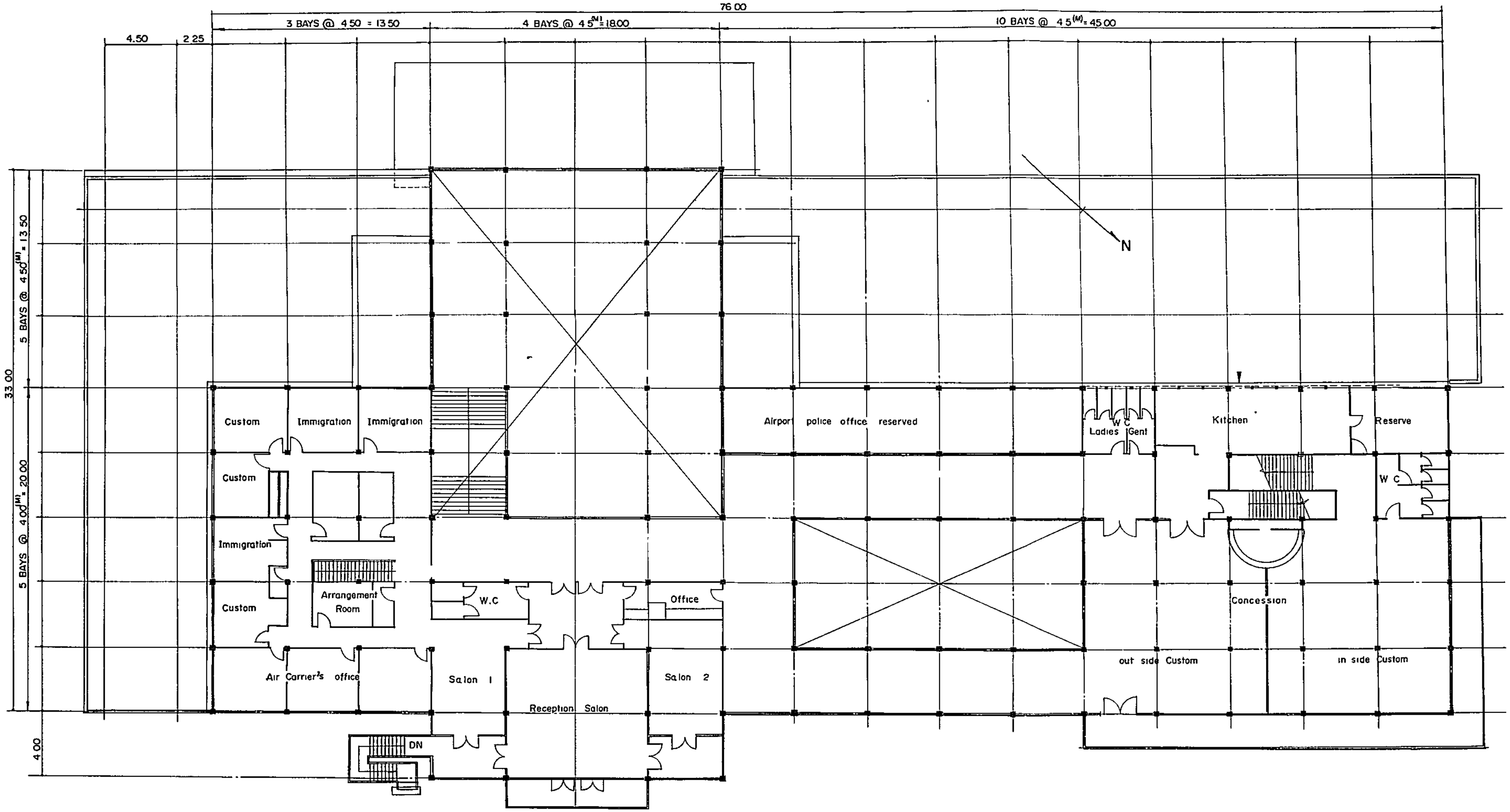

TABLE 8-1-1

SUMMARY OF SOIL TEST (FOR INVESTIGATION OF SOIL STRATE)

		Sumple Number	H.S.T.W.No.1 St No. 6R			H.S.T.W.No.1 St No. 15L			H.S.T.W. No.1 St No. 24L		
Sumpling Depth (m)			0 - 0.40	0.40 - 1.30	1.30 - 1.80	0.- 0.30	0.30 - 0.90	0.90 - 1.80	0 - 0.70	0.70 - 1.40	1.40 - 2.20
Observation			Dark Brown	Yellowish Brown	Reddish Brown	Yellowish Brown	Brown	Reddish White	Yellowish Brown	Yellowish Brown	Reddish White
Natural water content (%)			8.8	13.1	14.8	14.0	9.6	15.0	15.1	6.7	17.2
Specific Gravity (G)			2.63	2.60	2.56	2.63	2.64	2.65	2.61	2.61	2.63
Grain Size	Proportion	Gravel Part (%)	0	27.6	50.2	10.2	28.4	50.1	0	14.0	67.3
		Sand Part (%)	6.9	9.2	6.6	18.4	12.1	8.8	16.4	15.0	8.5
		Silt Part (%)	55.1	28.2	23.2	16.4	24.5	20.1	44.6	26.0	11.2
		Clay Part (%)	38.0	35.0	20.0	55.0	35.0	21.0	39.0	45.0	13.0
		Max. Diameter (m/m)	0.9	25.0	25.0	5.0	12.5	25.0	0.8	13.0	19.1
		Classification	Silty clay	Clay+Laterite	Laterite + Sandy Loam	Clay	Clay+Laterite	Lat.+silty clay loam	Clay	Clay+Laterite	Lat.+Sandy Loam
Consis-	tency	Liquid Limit L.L(%)	25.3	31.0	32.3	41.0	31.3	34.1	22.0	33.4	33.5
		Plastic Limit P.L(%)	16.2	17.4	19.3	20.2	16.5	18.2	13.7	19.8	20.6
		Plasticity Limit P.L Flow index	9.1	13.6	13.0	20.8	14.8	15.9	8.3	13.6	12.9
Unified classification			CL	CL	GC	CL	CL	GC	CL	CL	GC

TABLE 8-1-2

SUMMARY OF SOIL TEST (FOR INVESTIGATION OF FOIL STRATE)

Sample Number		H.S.T.W. No.2 St.No. 5 L				H.S.T.W. No.2 St. No. 14		H.S.T.W. No.2 St. No. 23 R	
Sampling Depth (m)		0 - 0.3	0.3 - 0.6	0.6 - 0.9	0.9 - 1.2	0.1 - 0.8	0.8 - 1.5	0 - 0.7	0.7 - 1.7
Ovservation		Dark Brown	Yellowish Brown	Reddish Brown	Reddish Brown	Reddish & White Brown	Reddish & White	Dark Brown	Brosn
Natural Water Content (%)									
Specific Gravity G		2.58	2.59	2.64	2.56	2.62	2.61	2.56	2.57
Grain Size Proportion	Gravel Part (%)	0.3	0.3	57.3	19.7	84.2	66.9	7.1	0
	Sand Part (%)	15.0	17.5	5.8	11.3	4.4	10.5	31,7	20.8
	Silt Part (%)	47.3	49.2	16.9	28.0	5.4	12.0	37.2	41.2
	Clay Part (%)	37.0	33.0	20.0	41.0	6.0	19.1	24.0	38.0
	Max. Diameter (m/m)	2.0	5.0	13.0	10.0	25.0	20.0	10.0	0.9
	Classification	Clay	Clay	Laterite + Sandy Clay Loam	Clay + Laterite	Laterite + Xlay	Laterite + Clay	Laterite + clay Loam	Clay
Consis-tency	Liquid Limit L.L. (%)	38.2	28.8	42.2	44.0	33.8	43.0	24.4	23.8
	Plastic Limit P.L. (%)	27.6	17.9	22.5	23.8	19.3	22.3	15.2	15.6
	Plasticity Index P.I.	10.6	10.9	19.7	20.2	14.5	20.7	9.2	8.2
	Flow Index								
Unified Classification		CL	CL	SC	CL	GC	GC	CL	CL

TABLE 8-1-3 SUMMARY OF SOIL TEST (FOR INVESTIGATION OF SOIL STRATE)

	Sumple Number	P.T.W. St. No. 2+17.0	P.T.W. St. No. 10	St. No. 10	P.T.W. No. 25 b	No. 25 b
	Sumpling Depth (m)	0 - 0.90	0.20 - 0.50	0.50 - 1.40	0.10 - 1.10	1.10 - 1.70
	Observation	Brown	Brown	Dark Yellowish Brown	Yellowish Br. - Reddish Br.	Reddish white
	Natural Water Content (%)					
	Specific Gravity (G)	2.65	2.59	2.58	2.63	2.57
Grain Size Proportion	Gravel Part (%)	48.6	36.4	0.9	38.2	1.4
	Sand Part (%)	20.1	22.8	2.5	18.0	3.6
	Silt Part (%)	12.0	19.8	68.9	27.3	67.0
	Clay Part (%)	19.3	21.0	28.0	16.5	28.0
	Max. Diameter (m/m)	30.0	25.0	5.0	25.0	9.5
	Classification	Grav + Lat. Sandy Loam	Gravel + Sandy clay Loam	Silty clay Loam	Grav + Lat. Sandy clay Loam	Silty clay Loam
Consistency	Liquid Limit L.L(%)	34.2	31.0	38.2	28.3	35.1
	Plastic Limit P.L(%)	21.1	20.4	27.9	17.7	25.9
	Plasticity Limit P.L	13.1	10.6	10.3	10.6	9.2
	Flow index					
	Unified Classification	S.C	S.C	C.L	S.C	C.L

TABLE 8-1-4

SUMMARY OF SOIL TEST (FOR INVESTIGATION OF SOIL STRATE)

	Sample Number	Apron A2R St.No.2R+10.0			Apron A4L St.No. OL		Apron A6L St.No.5L		Apron A7C St. No. 5C		Apron A8C St.No.2+10		
	Sampling Depth (m)	0 - 0.40	0.40-0.80	0.80-1.35	0-0.60	0.60-1.50	0-0.80	0.80-1.70	0.40-0.70	0.70-1.50	0.20-0.80	0.80+1.00	1.00-1.85
	Observation	Dark Brown	Yellowish Brown	Dark Brown	Dark	Dark	Dark	Dark Brown	Brown	Brown	Dark Brown	Yellowish Brown	Reddish White
	Natural Water Content (%)	17.2	14.1	17.0	18.5	25.6	26.0	19.1	8.8	9.4	15.4	16.3	20.3
	Specific Gravity (G)	2.64	2.64	2.56	2.63	2.63	2.67	2.66	2.65	2.70	2.64	2.58	2.64
Grain Size Proportion	Gravel Part (%)	0	0	0.5	4.7	0.5	0	0	0.4	66.9	0.2	1.3	0.3
	Sand Part (%)	3.3	6.8	9.6	6.0	1.5	1.2	0.4	4.3	2.5	0.9	3.0	1.9
	Silt Part (%)	48.7	49.2	51.9	54.3	50.0	53.8	40.6	63.3	16.6	58.9	44.7	35.9
	Clay Part (%)	48.0	44.0	38.0	35.0	48.0	45.0	59.0	32.0	14.0	40.0	51.0	62.0
	Max Diameter (m/m)	0.42	0.84	4.8	9.52	4.8	0.84	0.84	2.0	19.1	2.0	2.0	2.0
	Classification	Clay	Clay	Clay+Lat.	Clay+Grav.	Clay	Clay	Clay	Silty Clay	Lat.+Clay	Silty Clay	Clay	Clay
Consis-tency	Liquid Limit L.L.(%)	39.7	37.2	37.4	35.2	46.2	41.0	44.9	29.8	29.1	39.8	31.5	38.1
	Plastic Limit P.L(%)	26.8	22.9	18.3	23.4	31.0	27.3	28.3	20.3	18.0	26.3	20.4	22.9
	Plasticity Index P.I	12.9	14.3	19.1	11.8	15.2	13.7	16.6	9.5	11.1	13.5	11.1	15.2
	Flow Index												
	Unified Classification	CL	CL	CL	CL	CL	CL	CL	CL	LC	LC	CL	CL

RABLE 8-2

SUMMARY OF SOIL TEST (FOR INVESTIGATION OF FOUNDATION BED)

		H.S.T.W. No.1 St. No. 12 L	H.S.T.W. No.2 St. No. 14 C	P.T.W. St. No. 25 C	Apron St. No. -2 R	Apron St. No. OL
Sample Number						
Sampling Depth (m)		0.30	o.10	o.10	0.30	0.50
Observation		Yellow Brown	Reddish Brown	Yellow Brown	Dark Brown	Dark
Natural Water Content (%)		11.9	8.5	7.7	9.8	15.8
Specific Gravity		(2.61)	(2.62)	(2.63)		(2.63)
Grain Size Proportion	Gravel Part (%)	(0)	(84.2)	(38.2)		(4.7)
	Sand Part (%)	(16.4)	(4.4)	(18.0)		(6.0)
	Silt Part (%)	(44.6	(5.4)	(27.3)		(54.3)
	Clay Part (%)	(39.0)	(6.0)	(16.5)		(35.0)
	Max. Diameter (m/m)					
	Classification	Clay	Lat. + Clay	Gr.+Lat. Sandy Clay Loam		Clay + Gr.
Consis-tency	Liquid Limit (%)	(22.0)	(33.8)	(28.3)		(35.2)
	Plastic Limit (%)	(13.7)	(19.3)	(17.7)		(23.4)
	Plasticity Index	(8.3)	(14.5)	(10.6)		(11.8)
	Flow Index					
Unified Classification		CL	GC	SC		CL
	C.B.R. (at Field) (%)	21.2	58.0	69.0	48.0	10.8
	C.B.R. (Natural Water Content) (%)	33.3	55.3	63.0	52.0	17.0
	C.B.R. (Soaked for 4 days)	17.5	5.0	10.0	4.3	2.8
	Calcul. C.B.R. (%)	11.1	5.2	11.0	4.0	1.8
K-Value	K - 30 (kg/cm^3)	12.0	46.6	37.0	13.5	7.0
	K - 75 (kg/cm^3)	5.5	21.2	16.8	6.1	3.2

RABLE 8-3

SUMMARY OF SOIL TEST (FOR EMBANKMENT & BASE COURSE MATERIALS)

Sample Number		Borrow Pit No. 1-1	No. 1-2	No. 2-1	No. 2-2	No. 3-1	No. 3-2	No. 4-1	No. 4-2	No. 4-3
Sampling Depth (m)		0.20 - 1.00	1.00 - 2.20	0 - 0.90	0.90 -	0.0 - 1.00	1.00 - 1.70	0 - 0.70	0.70 - 1.00	1.00 -
Observation		Brown	Reddish Brown	Reddish Brown	Reddish Brown	Brown	Gray	Brown	Reddish Brown	Reddish Brown
Natural Water Content (%)		8.4	11.4	13.9	7.7	11.3	16.1	9.4	8.8	7.7
Spacific Gravity		2.62	2.65	2.56	2.66	2.59	2.53	2.66	2.64	2.62
	Gravel Part (%)	0.2	0.4	0.6	27.1	1.1	3.9	0.4	61.9	63.9
	Sand Part (%)	48.8	39.2	39.4	13.7	27.4	18.9	47.6	13.3	10.8
	Silt Part (%)	23.0	22.2	32.1	13.2	31.5	50.7	24.6	7.8	8.2
	Clay Part (%)	28.0	38.0	27.9	16.0	40.0	36.5	27.4	17.0	17.0
	Max. Diameter (m/m)	2.0	2.0	2.0	25.4	2.0	4.8	2.0	19.1	19.1
	Clasification	Clayey Loam	Clay	Clayey Loam	Gr.+Lat.+Clay	Clay Loam	Silty Clay Loam	Clayey Loam	Gr.+Lat.+Clay	Gr.+Clay
	Liquid Limit L.L (%)	27.1	32.8	36.5	38.5	31.3	32.8	31.5	36.0	41.1
	Plastic Limit P.L (%)	15.8	16.3	18.1	23.6	17.8	18.9	20.3	20.9	24.3
	Plasticity Index P.I.	11.3	16.5	18.4	14.9	13.5	13.9	11.2	15.1	16.8
	Folow Index F.I.									
Unified Classification										
Compaction Test	O.M.C.(%)	10.5	12.5	13.0	7.8	12.0	12.4	11.5	10.0	11.0
	Max. dry Density(kg/m^3)	1,936	1,949	1,840	2,061	1,933	1,904	1,944	2,176	2,003
Field Dens. Test	Dry Density (kg/m^3)	1,448	1,466	1,385	1,697	1,624	1,398	1,647	1,666	1,558
	Density Ratio (%)	74.8	75.2	75.3	82.3	84.0	73.4	84.7	46.6	77.8
Medified C.B.R Test — No Soaked	Water Content(%)	14.4	12.0	13.8	7.5	11.4	15.4	13.1	11.5	9.9
	Dry Density (kg/cm^3)	1,830	1,920	1,846	2.042	1,896	1,822	1,902	2.011	1,986
	C.B.R (%)	11.1	15.0	30.3	130.0	30.5	26.0	14.3	45.5	57.0
Medified C.B.R Test — 4 days Soaked	Water Content (%)	18.2	14.3	16.0	14.2	13.5	18.9	16.0	14.2	12.3
	Drv Density (kg/cm^3)	1,723	1,854	1,832	2,206	1,915	1,790	1,858	2,150	2,097
	Swelling Ratio (%)	0	1.2	0.9	0.2	3.4	3.9	1.1	0.3	0.1
	C.B.R (%)	4.2	5.2	8.1	24.0	6.4	4.0	4.0	17.0	20.4

SUMMARY OF SOIL TEST (Model 1)

No.______

LOCATION ____________, DATE. (APRON A6L) Apr. - May 1971, TESTED BY ____________

							(Remarks)
SAMPLE NUMBER No.		APLON A6L	" "	" "			
BORROW PIT AND DEPTH (m)		1.20	2.30	3.0			
OBSERVATION		Clay Brown	Clay Dark brown	Clay Black			
PROPERTIES	Natural water content w (%)	30.58	47.74	35.99			
	Specific gravity of soil G_s	2.68	2.63	2.60			
	Wet density rt (g/cm³)	1.778	1.652	1.723			
	Dry density rd (g/cm³)	1.362	1.157	1.267			
	Void ratio e	0.968	1.272	1.052			
	Degree of saturation S %	84.64	88.34	88.94			
GRAIN SIZE — PROPORTION	Gravel part (%)	0	0	0			
	Sand part (%)	2	0	1			
	Silt part (%)	28	29	29			
	Clay part (%)	70	81	70			
GRAIN SIZE	Max. diameter (mm)	0.84	0.84	0.84			
	60% diameter D_{60} (mm)	0.0020	-	0.0023			
	10% diamenter D_{10} (mm)	-	-	-			
	Uniformity coefficient	-	-	-			
	Classification	clay	clay	clay			
CONSISTENCY	Liquid limit L.L (%)	66.03	63.98	78.12			
	Plastic limit P.L (%)	29.06	32.40	27.48			
	Plasticity index P.I	36.79	31.58	50.64			
	Flow index F.I						
	Shrinkage limit S.L						
PERMEABILITY K (cm/sec)							
COMPACTION	Optimum water content						
	Max. density $\gamma_{t\ max.}$ (g/cm³)						
SHEARING STRENGTH — Unconfined compression	Compression strength (kg/cm²)	1.453	3.127				
	Sensitivity	1.02	4.61				
SHEARING STRENGTH — Direct compression	Cohesion C (kg/cm²)	0.50	0.54	0.80			
	Internal friction angle, φ°	26°34'	32°37'	22°47			
SHEARING STRENGTH — Triaxial compression	Cohesion C (kg/cm²)	0.90	1.10	1.12			
	Internal friction angle, φ°	5°43'	7°41'	7°51'			
CONSOLIDATION	Initial void ratio e_0	0.88	1.39	0.85			
	Preconsolidation load Po (kg/cm²)	1.25	3.50	2.15			
	Compression index Cc	0.171	0.330	0.218			
	Coef. of consolidation Cr (cm²/sec)	1.55×10^{-1}	5.6×10^{-1}	5.30×10^{-2}			
	Coef. of volume compressibility Mv (cm²/g)	1.70×10^{-2}	8.90×10^{-3}	1.23×10^{-2}			
	Coef. of permeability K (cm/sec)	2.70×10^{-6}	4.60×10^{-6}	6.50×10^{-7}			

N. K. Form No. 3100