ROYAL GOVERNMENT OF LAOS

DESIGN REPORT

ON

VIENTIANE AIRPORT EXTENSION PROJECT

May [illegible]

Nippon Koei Co., Ltd.
Consulting Engineers
Tokyo

LETTER OF SUBMITTAL

May, 1969

To His Excellency Mr. Kiichi Aichi
Minister of Foreign Affairs
Government of Japan

Excellency,

I have the honour to submit to your Excellency the "Detailed Design Report on Vientiane (Wattay) Airport Extension Project" together with the construction specifications and the necessary tender documents, the preparation of which have been entrusted to us, the Overseas Technical Cooperation Agency, by the Government of Japan.

Prior to this, the Agency submitted, in June 1967, the first phase investigation report on the extension work of the airport in which were recommended the necessary construction works for improving the airport to the scale and condition capable of accommodating large jet-propelled aircraft.

At a further request of the Government of Laos for the technical cooperation for this purpose, the Government of Japan decided to promote the preparation of the detailed design, and the plan of operation was signed in November, 1968 between the Government of Laos and the Embassy of Japan in Laos.

In accordance with the plan of operation, the Agency dispatched a field team for a period of three months. The team, after its return to Japan, prepared a detailed design under the control of the technical control committee formed of the government officials.

As demonstrated in this report, the extension work of the Wattay Airport will have no small effect upon the promotion of air transportation activities of the Laotian nation, and will contribute to the economic and social development of the country.

This significant construction work, which originated in the strong bonds of friendship existing between the two countries, can be accomplished at a moderate cost and without any technical difficulty. It is really a matter to be congratulated that the
panese Government has decided to provide part of the construction fund of this project
Japanese Government has decided to provide part of the construction fund of this project in the form of grant to the Government of Laos, and the realization of this project now became certain.

In submitting this report, we wish to express our sincere thanks to the Government authorities of Laos and Japan, the Japanese Embassy in Laos, and all persons concerned in Laos and Japan for the support and cooperation they have so generously extended to us to make this investigation a success.

Yours respectfully,

Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency

LETTER OF TRANSMITTAL

May 1969

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

Dear Sir,

I have the pleasure to submit herewith the "Design Report on Vientiane Airport Extension Project", together with the construction specifications and the necessary tender documents in accordance with the contract concluded on 9th November 1968 between the Overseas Technical Cooperation Agency and Nippon Koei Co., Ltd.

The detailed design for the airport extension work includes the works for extension of the existing 2,000 meters long runway by 1,000 meters, improvement of overruns and part of the holding apron and apron, and additional installation of lighting equipment in connection with the extension of runway. These works have previously been recommended as necessary to accommodate large size jet planes in the airport, in the First Report prepared and submitted in June 1967 by the first investigation team headed by Mr. Hayashi.

As the result of our study and detailed design, it was found that the extension work does not include any technical difficulty and can be accomplished within one dry season ranging from October to April of the following year, at a total construction cost of about 1,507,000 US dollars equivalent, of which 1,156,000 US dollars are foreign currency component.

In consideration of the merits of the extension work which would contribute directly to the development of air transportation of Laos and promote the goodwill between the Laotian and Japanese peoples, and in addition to the fact that such work would involve no technical difficulty as stated above and can be carried out at a moderate cost. It is gratifying to know that the Japanese Government has decided to provide part of the construction fund of this project and the realization of this project has now become certain.

On this occasion we wish to express our hearty thanks to the Government authorities and agents of Laos and Japan concerned and the Japanese Embassy in Laos for the cooperation and support extended to us during the investigation in Laos and design work in Japan.

Very truly yours,

Y. Kubota

Yutaka Kubota
President
Nippon Koei Co., Ltd.

Design Report

on

Vientiane Airport Extension Project

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SUMMARY

1. Project

The Wattay Airport is located in the suburbs about 3 km from Vientiane city, the capital of Laos. International air routes connect this airport with Bangkok, Pnom Penh, Saigon and Hongkong. Domestic air routes extend radially from this airport to the major cities in the country.

This airport, with a 2, 000 meters long runway, is of the scale capable of accommodating aircraft of the class of DC-3, DC-4, DC-6, etc. Thus the Wattay Airport serves as the main entrance by air to Laos and plays an important role in the air transportation of Laos.

The air traffic at this airport has been encreasing from year to year, and according to recent record, the number of operations in a year is 3, 441 flights, the number of passengers dealt with amounts to 47, 081 persons, and air cargo 1, 339 tons.

The Wattay airport has been constructed or improved stepwise into the present condition, with the parking aprons, taxiways, terminal building, main runway, etc. with the aid of U.S.A. and other countries.

Along with the growth of aeronautical demand, it has been the world-wide trend in these years to use larger and high-speed jet-propelled aircraft, which necessitated improvement of existing airports to cope with this situation.

In view of this situation the Government of Laos desired to extend this airport to a scale suited to accommodate such large, jet-propelled aircraft as DC-8, Boeing 707 and requested the Government of Japan for technical cooperation in this respect. In response to this the Japanese Government dispatched a team of investigators to the project site, and based on the result of the field investigation the "Investigation Report on the Vientiane Airport Extension Project, (First Report)" was prepared and sumbitted to the Government of Laos.

In the report it is recommended that the extension project be implemented in three stages in line with the increase of the number of operations of this airport. (Ref: Fig. 3-12)

1st Stage: Extension of runway from 2, 000 meters to 3, 000 meters; improvement of part of the holding apron and apron; increase and improvement of lighting equipment to be necessitated by the above works.

2nd Stage: Construction of high-speed exit taxiway and expansion of apron.

3rd Stage: Construction of parallel taxiways; re-expansion of the aprons and construction of a holding apron on the north side.

This report contains the detail designs for the works of the 1st stage recommodate large, jet-propelled planes. The detailed design was prepared based on the detailed investigation carried out from November 1968 to February 1969.

2. Major Construction Works

a) Extension of runway:

Length to be extended	1, 000 m (total length after extension: 3, 000 m)
Width of runway	45 m
Thickness of concrete pavement	25 - 28 cm

b) Over run:

Length	120 m (to be provided at both ends of runway)
Width	45 m
Thickness of concrete pavement	15 cm

c) Improvement of holding apron:

Area to be expanded	4, 226 m^2
Thickness of concrete pavement	28 cm

d) Improvement of apron:

Area to be expanded	2, 052 m^2
Thickness of concrete pavement	28 cm

e) Drainage:

Length of open ditch about 1, 400 m

Transverse concrete culvert 1.0 m x 1.0 m x 150 m x 2

f) Removal of fence

Length to be removed and transferred	1, 500 m

g) Lighting facilities:

Runway light	for 1, 000 m (including threshold and stopway lights)
Wind-cone light	1 set
Improvement of supply of power	1 ls

3. Construction period

Owing to the nature of this kind of work, the work progress decreases very much in rainy season which continues 5 months from June to October. Accordingly the construction work is advisable to be completed within one dry season of 7 months from November to May of the next year.

To perform the work within this short period of time, a large quantity of heavy duty machinery will be required for the earth work. The construction period may be broken down as: about 40 days for preparatory works, about 100 days for earth work and about 120 days for base course and concrete pavement work. Other minor works will be carried out in parallel to the main works. The installation of lighting equipment will be started about one month after the commencement of the earth work and completed in about 5 months.

The extended part of the airport will be put to use one month after the completion of the work.

4. Construction cost

Cost of the construction work will be US $ 1, 507, 000 equivalent which comprises about US $ 1, 156, 000 of foreign currency, and about US $ 351, 000 equivalent of domestic currency.

1. INTRODUCTION

The Wattay Airport in the suburbs of Vientiane, capital city of Laos, is not fit for the operation of large jet-propelled aircraft of the class of Douglas DC-8, Boeing 707 serving international air traffic, because the runway of this airport is only 2, 000 meters long. In view of this inconvenience the Royal Government of Laos has been considering to improve this airport up to the standard of international airport.

Meanwhile His Highness Prince Souvanna Phouma made a visit to Japan to attend the Ministerial Conference of the Countries for the development of Southeast Aisa held in Tokyo in April, 1966. On that occasion His Highness requested Mr. Eisaku Sato, Prime Minister of Japan, for Japan's cooperation in the implementation of this airport improvement project.

The Japanese Government, conscious of the goodwill of Laos shown to Japan when Laos voluntarily gave up her war reparations claims, decided to comply with this request, finding this airport extension project to be very effective to promote the air transportation of Laos and contribute to the economic and social development of the country. The Japanese Government therefore entrusted the Overseas Technical Cooperation Agency to undertake the necessary preliminary investigation for the extension of the Wattay Airport.

Thereupon the Agency organized a five-member investigation team headed by Mr. Kotaro Hayashi, then chief of the Construction Section, Civil Aviation Bureau, Ministry of Transportation and sent it to the project site. As a result "First Report" was prepared and submitted to the Government of Laos and the Government of Japan. In this report was recommended the scope of work necessary for the improvement of the airport to a scale capable of accommodating large jet-powered aircraft engaged in the international air service.

Later, in response to the further request of the Royal Government of Laos concerning promotion of this project, the Japanese Government decided to carry out the detailed design of the runway extension work recommended in the First Report, and once again entrusted Overseas Technical Cooperation Agency with the work. Overseas Technical Cooperation Agency requested Nippon Koei Co., Ltd. for cooperation concerning the work. With the cooperation of the Pacific Consultants K.K., Nippon Koei Co., Ltd. dispatched a field investigation team and carried out a field survey for a period of about five months from November, 1968 to March, 1969.

The following members constituted the field investigation team: -

Head of the Team:	Hirosuke TAKAHASHI	Nippon Koei Co., Ltd.
Member of the team:	Tatsuro TERAI	"
"	Yuzo MARUSUGI	"
"	Hanzaburo TAKEI	Pacific Consultants K.K.
"	Takayoshi NAKANO	"
"	Kiyoshi NISHIO	Nippon Koei Co., Ltd.
"	Akio KINUKAWA	"
	Tsuguo HIGASHIYOSHI	"
	Yoshitaka IMANISHI	"

Upon return to Japan after completing the survey, and on the basis of the findings of the survey, the investigation team prepared the detailed design of the project under the control of the Technical control comittee formed of nine officials of the Japanese Government.

This report, together with the attached drawings, specifications and tender documents, is submitted as the result of the field survey and the detailed design.

The Japanese Government has decided to provide the Royal Government of Laos with a grant of US $ 695, 000 (¥ 250, 000, 000) in foreign currency out of the national budget for 1969 fiscal year as a part of the funds required for this project. It is now certain that the project will be materialized, and this certainly is a matter of congratulation for the development of the aviation of Laos and for the promotion of friendly relations between the two countries.

2. INVESTIGATION

2-1 General

Investigation for the preparation of a detailed design for the Wattay Airport runway extension project was carried out for a period of five months from November 1968 to March 1969. The investigation included the works listed below.

(1) Topographic survey

(2) Obstruction survey

(3) Foundation exploration and soil test

(4) Investigation of construction materials

(5) Concrete test

(6) Investigation of existing airport facilities

(7) Collection of meteorological data, airport operational data, utilization data, study of water and electric power supply for the construction work, and others

2-2 Topographic survey

The topographic survey performed during the present investigation included, as seen in the drawings and plans attached herewith, taking of, the plans, profiles and cross sections, of the runway extension area, and the plan of the borrow area.

2-3 Obstruction survey

Survey of obstructions was conducted as to the approach surface and transit furface of the airport in the surrounding area, and it was revealed that there were no obstructive buildings or topographical features to interfere with the operation of the airport. Only a few trees were found to be obstructive and they are indicated in Fig. A. 6.

2-4 Foundation exploration and soil test

For the investigation of the foundation conditions in the runway extension site and for the selection of borrow area for obtaining the construction materials for the subgrade and base course, auger boring was conducted at 66 places in total and test pits were excavated at 9 places in all.

In the first phase investigation, establishment of borrow area was not considered, because the volume of excavation and the volume of embankment at the runway extension site has been removed so that it now became necessary to establish borrow area.

Therefore exploration was conducted at the proposed borrow sites.

The soil profiles obtained by the exploration are shown in Fig. A. 3. The grain-size distributions at the sites augered and at the test pits are shown in Fig. A. 2. Generally, the soil is formed of, from the ground surface downwards, original soil layer with the clay as the main component, sandy clay layer with the loam as the main component, clayey layer with clay and gravel as the main components and gravelly clay layer.

The results of the physical test, triaxial compression test, consolidation test and CBR test made on the samples taken by the auger boring and from the test pits are shown in Tables A. 1.

2-5 Investigation of construction materials

Considering the possibility of using the river sand and gravel of the Mekong, reconnaissance was carried out for a distance of about 50 km along the Mekong, starting at a site near the airport towards the downstream reaches. And grain size analyses were made on the samples taken at the sites indicated in Fig. A. 5. As seen from Table A. 4 only the materials obtained near the Government-operated gravel plant were fit both as fine and coase aggregates for concrete and the materials obtainable elsewhere were found to be below the grain-size distribution standard, being low in fineness module. The site near the Government-operated gravel plant was determined as the aggregate borrow area, because at this site the necessary volume of aggregates (12, 200 m^3 of coarse aggregate and 6, 000 m^3 of fine aggregate) is obtainable.

2-6 Concrete test

As for the cement to be used in the construction, two brands of Thai cement were checked and both brands of cement were found to be up to the international standard. Of these brands the Elephant was chosen for the concrete test. Using this brand of cement and the aggregates taken from the river side near the Government gravel plant, concrete test pieces were prepared for various mix proportion. (cement content: 320 kg/m^3 - 380 kg/m^3; sand-aggregate ratio: 30% - 34%; max. aggregate seize: 40 mm; slump: 1 - 2. 5 cm) and compression tests and flexure tests were made on the test pieces. The results are shown in Table A. 4. For the test pieces with cement content of 350 kg/m^3 or more, the strength tested at 28 days is 270 kg/m^3 in compressive strength and 45 kg/m^3 in flexural strength.

3. MASTER PLAN OF BASIC FACILITIES FOR LANDING AND TAKE-OFF

3-1 General

In planning the improvement of an airport it is necessary to establish a master plan taking into consideration the various requirements that may occur in future.

The master plan for the present project has been presented in the Investigation Report on the Vientiane Airport Extension Project 1) prepared after the initial investigation. In this report, however, further studies have been made based on the data subsequently obtained in order to justify the master plan presented in the last report on a more concrete basis.

1) Investigation Report prepared by Overseas Technical Cooperation Agency (hereinafter called the 1st report)

3-2 Present condition of the Vientiane Airport

3-2-1 Aeronautical circumstances in Laos

In Laos there are many small-scale airports, but there is no airport that has a runway of the length of more than 2,000 meters. Of the existing airports only ten odd number of them are available in the rainy season.

The major airports serving scheduled flights are listed in Table 3-1. However, their runways are of the length between 1,600 m - 2,000 m and none of them operate at night.

Types of aircraft using these airports are DC-6, DC-4, DC-3, AVRO-748, C-47 and CESNA.

The monthly average of operation of aircraft at the Vientiane airport is about 500 of civilian aircraft, and around 1,200 of military and other aircraft. Monthly average of passengers handled here are about 4,500 persons by scheduled flights and about 3,400 persons by other flights.

Similar data were not available for other airports, but the corresponding figures for other airports are presumed to be far less than those of Vientiane, since air-routes in Laos extend radially with the Vientiane airport as the hub. (Ref: Fig. 3-4)

3-2-2 Existing facilities

Table 3-1 List of Major Airports

Name authority	Vientiane	L. Prabang	Pakse	Savannakhet
Location	within city	3km from city	2km from city	2km from city
Coordinates	17°58N/102° 35'E	19°54/102°9'E	15°08'N/105° 45'E	16°35'N/104° 45'E
Elevation	170 m	300 m	130 m	160 m
Runway length	2,000 m	1,600 m	1,600 m	1,700 m
Runway width	45 m	25 m	40 m	40 m
Surface	Concrete pavement	Rolled stone, good drainage	Asphalt pavement	Asphalt pavement
Surface strength	40 t/single wheel	25 t/single wheel	30 t/single wheel	25 t/single wheel
Operating hour	6.00 - 18.00 (Spot time)	6.00 - 18.00 (Spot time)	6.00 - 18.00 (Spot time)	6.00 - 18.00 (Spot time)
Runway Orientation	130°/310°	60°/240°		40°/220°
Remarks				

3-2-2-1 Topography around the airport

The Vientiane Airport is located in the western suburbs of the Vientiane City. It is about 2 kilometers from the Mekong and is in the middle of the vast alluvial plain of the Mekong basin. Areas around the airport are flat farmland.

The water elevation of the Mekong varies greatly between the dry season and the

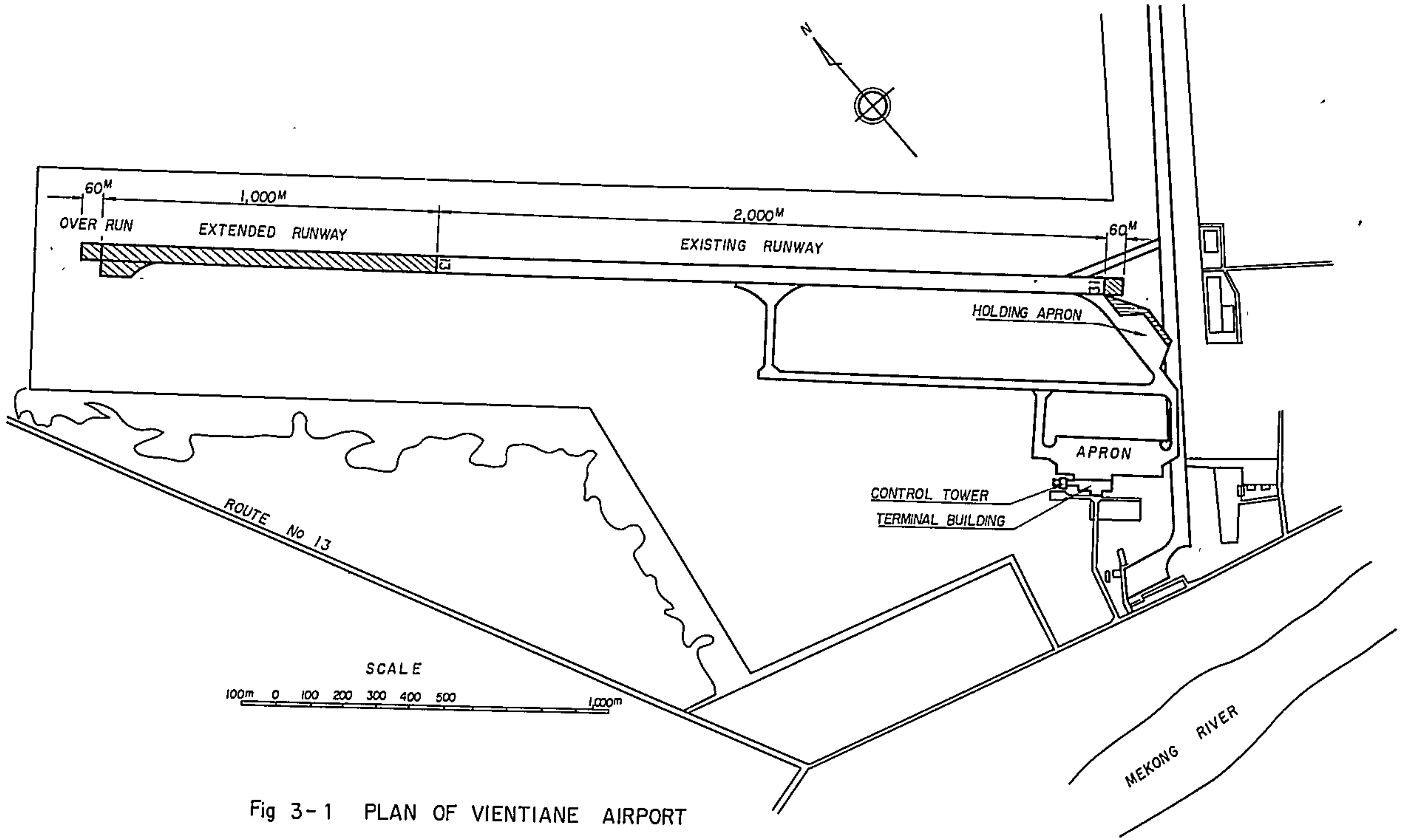


Fig 3-1 PLAN OF VIENTIANE AIRPORT

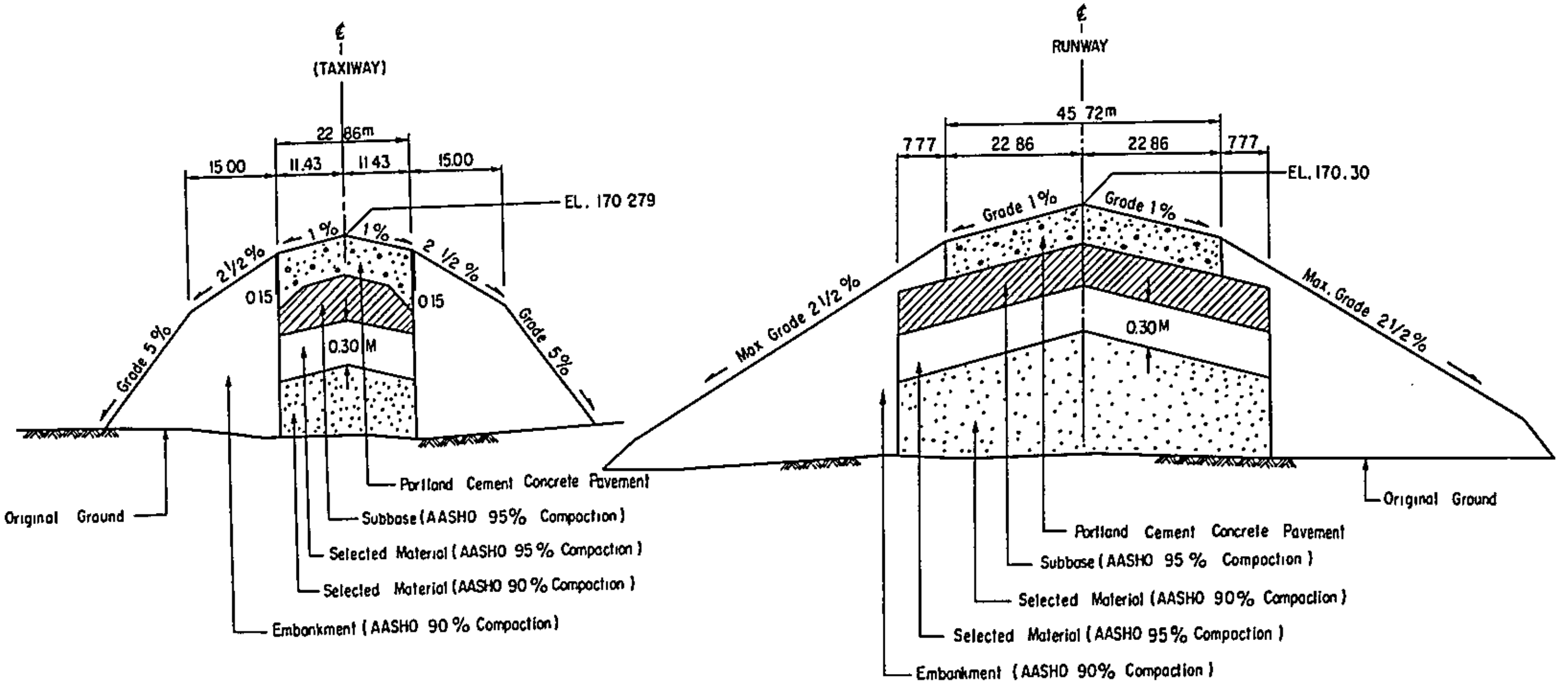


Fig 3 - 2 TYPICAL CROSS SECTION OF RUNWAY AND TAXIWAY rainy season. It rises nearly to 170 m above sea level in the rainy season, which nearly equals the elevation of the river bank.

The elevation of the runway of the Vientiane Airport is also about 170 m, and since there is little difference between the runway and the surrounding farmland which marks approximately 168 m - 169 m the drainage is quite unsatisfactory.

3-2-2-2 Basic facilities for landing and take-off

Configuration of the basic facilities of this airport, including the runway, taxiways, apron, etc. are shown in Fig. 3-1. According to the 1st report these facilities have been improved by U.S.A. during the period, 1958 - 1963, and they are still in use with almost no damage done to them.

(1) Runway

The existing runway is 2,000 m long and 45 meters wide, and is paved with cement concrete. The thickness of concrete slabs is 28 cm for the 300 meters at both ends of the runway and at the intersections with taxiways. In other parts the thickness is 25 cm. The flexural strength at 28 days of concrete is 46 kg/cm^2 (650 psi).

The thickness of the base course is 25 - 28 cm and its value of plate bearing (k-value) is: K = 7 kg/cm^2 (250 lb/in^2). The subgrade has been embanked on original ground with selected materials so as to equalize its elevation with the high water level of the Mekong. Typical section of the runway is shown in Fig. 3-2.

The existing runway markings are those used for instrument landing runway.

(2) Taxiways

The taxiways are 23 meters (75 ft) wide and cement concrete paved. The thickness of the concrete slabs is 28 cm (11 in) and thickened at the edges. Other structural features are similar to those of the runway. The typical cross section is shown in Fig. 3-2.

(3) Holding apron

Prior to take-off, most aircraft always make engine runups, and on all such occasions a cloud of dust is raised from the unpaved area behind the holding apron of this airport. Pavement structure of the holding apron is similar to that of taxiways.

(4) Apron

As shown in Fig. 3-1, the apron is 310 meters in length, 106 meters in width and of concrete pavement. The structural features of the pavement are similar to those of the taxiways. Cracks are scarcely found in the pavement as in the pavements elsewhere.

With no apron marking large and small aircrafts are parked in a disorderly manner.

3-2-2-3 Other facilities in the terminal area

The terminal building is two-story reinforced concrete building. On the first floor are the Immigration Bureau, Customs Office and Sanitary Room. On the second floor are a hall which serve as tea room as well as the waiting room and a terrace for welcoming and seeing off the passengers. In front of the building is a small parking place for motor cars.

Under the present operating condition the terminal building seems to leave some room in capacity.

There are two fuel storage tanks at about 100 m to the south of the control tower. Fuel is conveyed on lorry therefrom and fed to aircraft at the apron.

3-2-2-4 Navigation Aids

(1) Airport lighting

Airport lighting at Vientiane Airport comprises an aeronautical beacon, runway lights, runway thereshold lights and taxiway lights.

The runway lights are placed at regular intervals along both sides for the entire length of the runway. They are yellow in color and provide a maximum intensity of 40,000 c.c. (candela)

The green threshold lights are placed at the runway thresholds. Their structure is the same as the runway lights.

The blue taxiway lights are placed along both sides of taxiways.

The aeronautical beacon is installed on top of the control tower. It is of rotating-type throwing alternately blue and white flashes to indicate the location of the airport.

Three independent power generating units of 75 kVA are equipped as emergency power supply source for the airport lighting facilities stated above.

(2) Radio navigation aids

There is a N.D.B. (Non-directional radio beacon) on the southwest of the runway, giving the pilots the direction of the airport to make instrument approach possible. (Ref. Fig. 3-3)

3-2-2-5 Facilities and Equipment for Airport Traffic Control

Radiophones, operating on a frequency of 118 M Hz (Mega Helz), are used for

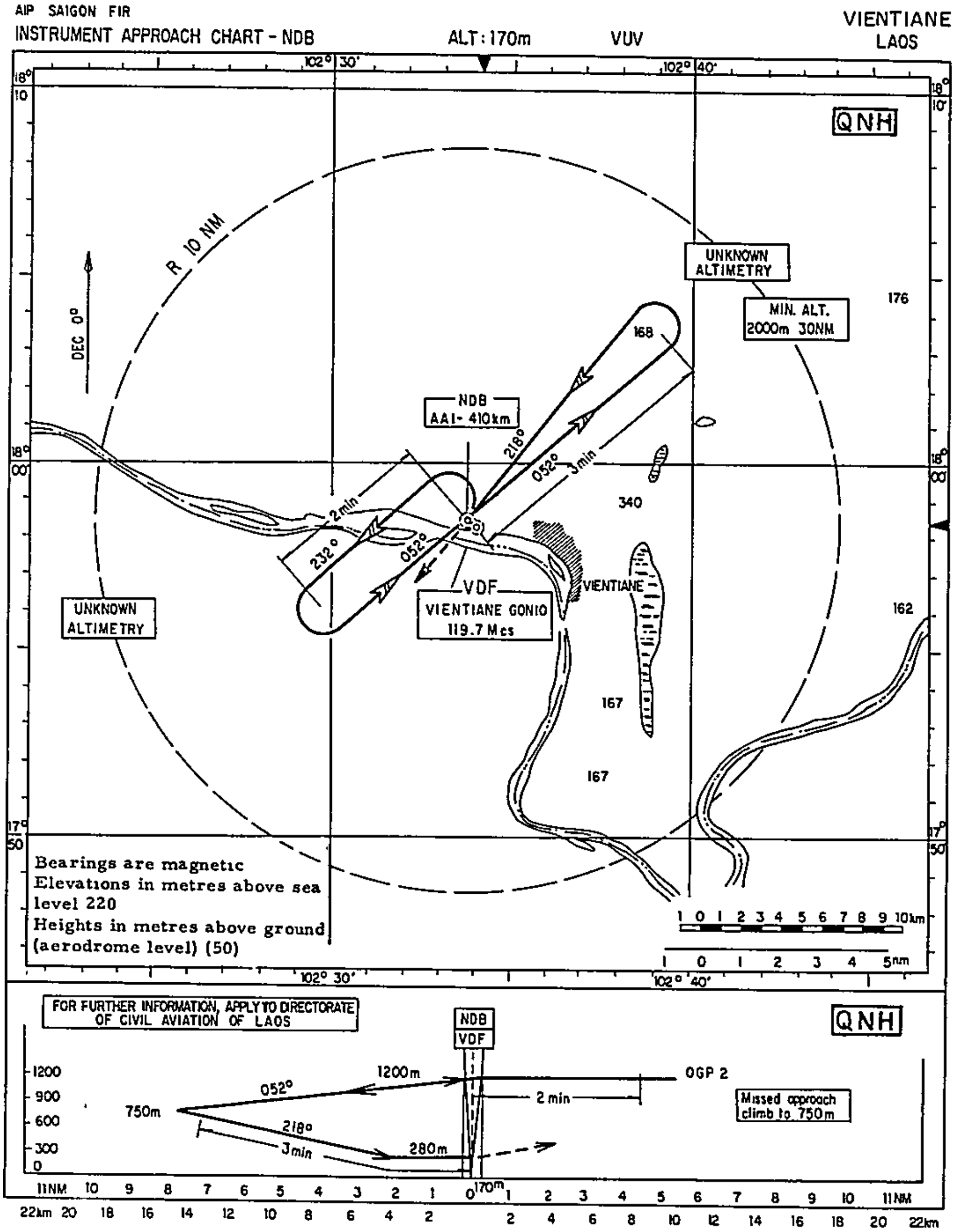


Fig 3 - 3 INSTRUMENT APPROACH CHART

air-ground communications. A direction finder (D. F.) is also equipped to show the direction of the airport, but none of radars of any kind.

The control tower is located near the western end of the apron. Generally the tower is desired to be located at about the middle of the length of the runway, but since this airport commands good visibility the existing tower can be utilized efficiently even after the runway is extended.

3-2-3 Present Operating Conditions

The existing 2,000 meter runway is used by civil, military and other aircrafts in common. Civil aircraft use this airport from sunrise till sunset and military aircraft use it from sunrise to 21 o'clock. The monthly average number of aircraft operations (landing and take-off) at Vientiane is about 500 (comprising 340 operations of scheduled flights) of civil aircrafts and about 1,200 per month of military and other aircraft. The monthly average number of passengers by scheduled flights is about 4,500 and about 3,400 by other flights.

Worthy of special mention is the fact that landing from the south side of runway and south-bound take-off are prohibited as a rule, except when such operation is inevitable for the reason of safety.

Such arrangement was made, in the first place, to eliminate the nuisance of noises to the people of Vientiane city located about 3 kilometers to the south of the airport but the mild weather conditions wherewinds are mostly of the class of breeze and there occurs scarcely any strong wind in this area, is making it possible.

The airlines engaged in scheduled international services at Vientiane Airport are Royal Air Lao, Lao Air Line, Thai Airways and Air Viet Nam. Royal Air Lao, Lao Air Lines and Lao United Air Lines operate domestic scheduled flights. Previously Cathay Pacific Airways also had a regular service to and from this airport.

The internationally operated routes to and from Vientiane are as follows:

Vientiane to Saigon	(Royal Air Lao:	3 flights a week)
	(Air Viet Nam:	2 flights a week)
Vientiane to Hongkong	(Royal Air Lao:	3 flights a week)
Vientiane to Bangkok	(Royal Air Lao:	4 flights a week)
	(Thai Airways:	4 flights a week)
Vientiane to Phnom Penh	(Lao Air Line:	1 flight a week)

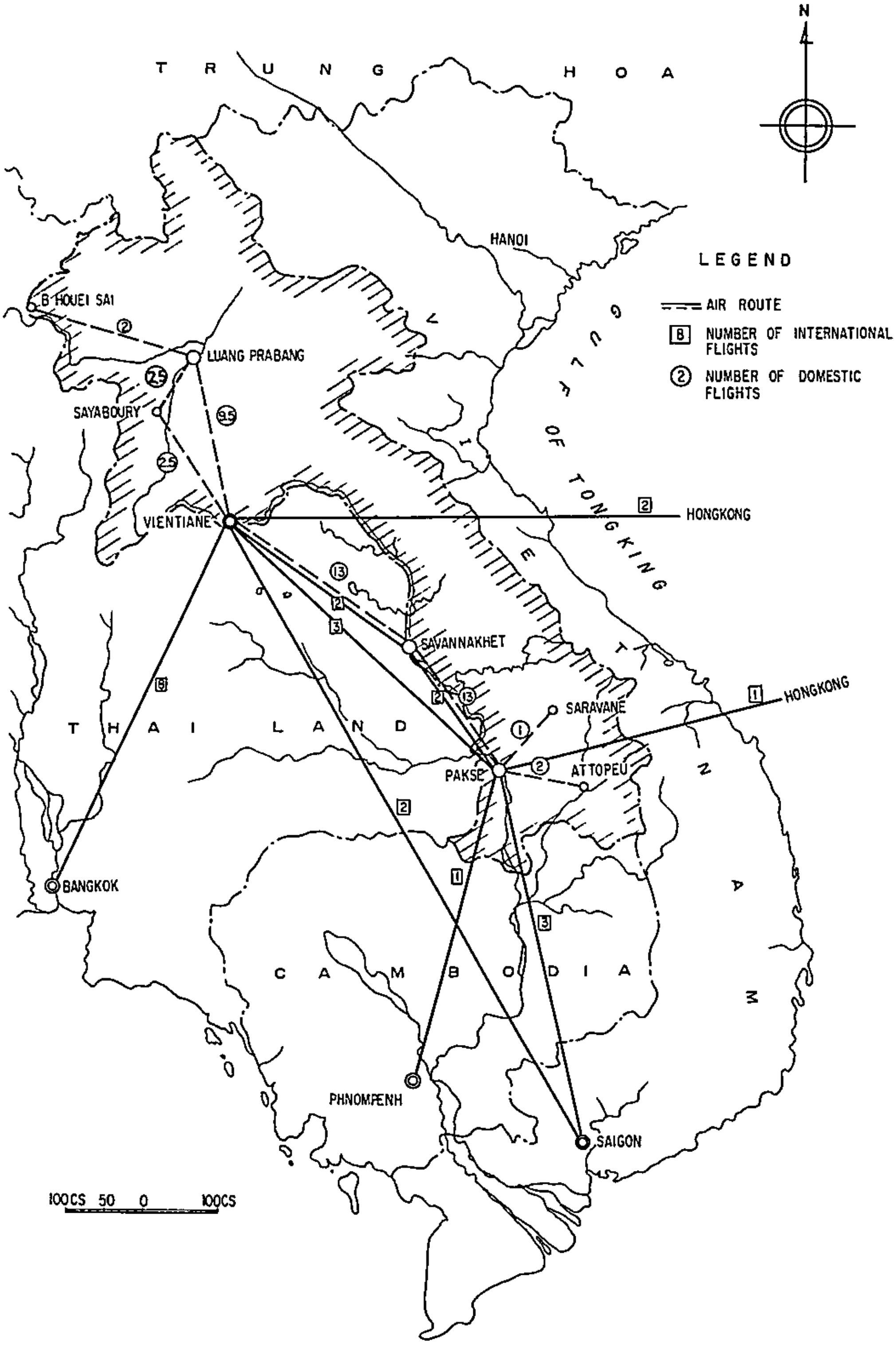


Fig 3-4 AIR ROUTES CENTERED AROUD VIENTIANE AND NUMBER OF SCHEDULED FLIGHTS FROM OR TO VIENTIANE

Table 3-2 International Flight Schedules at Vientiane Airport

	Departure			Arrival		
	Flight Number	Time	Destination	Flight Number	Time	Origin
MON	RY 418 DC-4	13:00	BANGKOK	TH521 AVRO	15:15	BANGKOK
	TH 531 AVRO	15:55	BANGKOK	RY 419 DC .4	17:40	BANGKOK
	RY 612 DC-68	16:30	HONGKONG			
TUE	RY 402 DC-4	7:00	SAIGON	RY 613 DC-6B	12:00	HONGKONG
	RY 600 DC-6B	13:00	BANGKOK	RY 601 DC-6B	17:30	BANGKOK
				RY 403 DC-4	17:50	SAIGON
WED	RY 408 DC-4	7:00	HONGKONG	VN 498 DC-4	11:15	SAIGON
	VN 499 DC 4	12:30	SAIGON	TH 523 AVRO	15:15	BANGKOK
	TH 533 AVRO	15:55	BANGKOK			
THU	WL 308 DC-3	6:30	PHNOMPENH	WL 309 DC-3	16:10	PHNOMPENH
	RY 600 DC-6B	13:30	BANGKOK	RY 409 DC-4	17:15	HONGKONG
				RY 601 DC 6B	17:30	BANGKOK
FRI	RY 622 DC-6B	7:00	SAIGON	TH 525 AVRO	14:45	BANGKOK
	TH 535 AVRO	15:25	BANGKOK	RY 623 DC-6B	15:30	SAIGON
	RY 612 DC-6B	16:30	HONGKONG			
SAT	VN 499 DC-4	12:30	SAIGON	VN 498 DC-4	11:05	SAIGON
	RY 600 DC-6B	13:30	BANGKOK	RY 613 DC-6B	12:00	HONGKONG
				RY 601 DC-6B	17:30	BANGKOK
SUN	RY 402 DC-4	7:00	SAIGON	TH 527 AVRO	15:15	BANGKOK
	TH 537 AVRO	15:55	BANGKOK	RY 403 DC-4	17:50	SAIGON

RY: ROYAL AIR LAO
TH: THAI AIRWAYS
VN: AIR VIETNAM
WL: LAO AIR LINES

Table 3-3 Domestic Flight Schedules at Vientiane Airport

	Departure			Arrival		
	Flight Number	Time	Destination	Flight Number	Time	Origin
MON	WL 300 DC-3	6:30	PAKSE	WL 301 DC-3	12:00	PAKSE
	RY 306 DC-3	7:00	SALAVANE	L.U.A DC-6	(13:30)	PAKSE
	L.U.A DC-6	8:00	PAKSE	L.U.A DC-6	(16:30)	L.PRABANG
	L.U.A DC-6	14:00	L.PRABANG	RY 307 DC-3	17:45	SARAVANE
TUE	L.U.A DC-6	8:00	PAKSE	RY 311 DC-3	12:30	L.PRABANG - SAYABOURY
	RY 310 DC-3	9:30	L.PRABANG - SAYABOURY	L.U.A DC-6	(13:30)	PAKSE
	L.U.A DC-6	14:00	L.PRABANG	L.U.A DC-6	(16:30)	L.PRABANG
WED	WL 300 DC-3	6:30	PAKSE	WL 301 DC-3	12:00	PAKSE
	L.U.A DC-6	8:00	PAKSE	RY 305 DC-3	12:30	SAYABOURY - L.PRABANG
	RY 304 DC-3	9:30	SAYABOURY - L.PRABANG	L.U.A DC-6	(13:30)	PAKSE
	L.U.A DC-6	14:00	L.PRABANG	L.U.A DC-6	(16:30)	L.PRABANG
THU	RY 306 DC-3	7:00	ATTOPEU	L.U.A DC-6	(13:30)	PAKSE
	L.U.A DC-6	8:00	PAKSE	L.U.A DC-6	(16:30)	L.PRABANG
	L.U.A DC-6	14:00	L.PRABANG	RY 307 DC-3	17:15	ATTOPEU
FRI	L.U.A DC-6	8:00	PAKSE	L.U.A DC-6	(13:30)	PAKSE
	KY 320 DC-3	9:30	HOUEISAI	RY 321 DC-3	15:45	HOUEISAI
	L.U.A DC-6	14:00	L.PRABANG	L.U.A DC-6	(16:30)	L.PRABANG
SAT	WL 306 DC-3	6:30	ATTOOPEU	RY 417 DC-4	12:10	PAKSE
	RY 416 DC-4	7:00	PAKSE	RY 311 DC-3	12:30	L.PRABANG - SAYABOURY
	L.U.A DC-6	8:00	PAKSE	L.U.A DC-6	(13:30)	PAKSE
	RY 310 DC-3	9:30	L.PRABANG - SAYABOURY	WL 307 DC-3	14:15	ATTOPEU
	L.U.A DC-6	14:00	L.PRABANG	L.U.A DC-6	(16:30)	L.PRABANG
	WL 300 DC-3	6:30	PAKSE	L.U.A DC-6	(11:30)	L.PRABANG
	RY 314 DC-3	8:30	HOUEISAI	WL 300 DC-3	12:00	PAKSE
	L.U.A DC-6	9:30	L.PRABANG	RY 315 DC-3	17:15	HOUEISAI

RY: ROYAL AIR LAO
WL: LAO AIR LINES
LUA: LAO UNITED AIR LINES

Remarks: Figures in the parentheses show the estimated time of arrival.

Domestic air routes originating from Viet Nam are as follow:

Vientiane to Pakse

Vientiane to Saravane

Vientiane to L. Prabang

Vientiane to Sayaboury

Vientiane to Attopeu

Vientiane to Houeisai

Vientiane to Savannakhet

Air routes centering on Vientiane Airport are given in Fig. 3-4. Types of aircrafts using this airport are DC-6, DC-4, DC-3, AVRO-748, C-47 and CESNA. The instrument approach course of this airport is shown in Fig. 3-3, and the flight schedules at this airport are shown in Table 3-2 and Table 3-3.

3-3 Climate

3-3-1 General

Climate in the Vientiane area is characterized by mild weather, except for the heavy rains in the rainy season. Precipitation is rather small as compared with other areas at similar latitude.

Meteorologically this area can be divided into the rainy season, beginning in May or June and lasting to September and the dry season, from October to April or May of the following year.

3-3-2 Rainfall

According to the records at the meteorological station at Vientiane, the annual rainfall ranges between 1,300 mm and 2,000 mm, while the annual average is around 1,700 mm.

The rainfall records covering 1957 - 1969 collected by the Vientiane Meteorological Station are summarized in Table 3-4 and Fig. 3-5.

As seen from the table, there was little rainfall in December, and the mean monthly rainfall of December is as small as below 1 millimeter and the number of days of 0.1 millimeter or more is one or null.

In August of the rainy season, however, the mean monthly rainfall is 350 millimeters and the maximum monthly rainfall is as much as 646 millimeters. Number of rainy days of more than 0.1 millimeters of rainfall is 21.5 days on an average and the maximum daily rainfall of 138.7 millimeters was recorded on September 2, 1959.

3-3-3 Temperature

Through the year there is not much variation in temperature and the temperatures range from a normal high of 34°C to a normal low of 17°C with 26.3°C as the average. Temperature records from 1956 to 1966 at the Vientiane Meteorological Station are listed in Table 3-5, and according to these records, the hottest month (that which has the highest mean daily temperature) falls on the month of April preceding the rainy season. The maximum temperature of 40.5°C was recorded on April 27, 1960.

On the other hand, the month which has the lowest mean daily temperature falls on December or January when the lowest temperatures of less than 10°C has been recorded.

3-3-4 Wind

According to the weather records at the Vientiane Meteorological Station for the period from 1966 to 1968, the wind of low velocity occurs frequently and the records show that the frequency of the wind of less than 3 meters per second in velocity accounts for as much as 97 percent of the number of observations and even the number of calms accounts for about 23 percent of the number of all observations.

3-3-5 Wind Rose

The wind rose made from the wind statistics for the 3 years from 1966 to 1968 is shown in Fig. 3-8.

As this airport is used by both large and small aircrafts, wind coverage for cross-wind components of 20 knots and that for the components of 13 knots should be examined. According to the wind rose, for the components of 20 knots, the existing runway shows 99 percent wind coverage, and for 13 knots, wind coverage of 100 percent. Therefore, the direction of the existing runway is such that winds scarcely preclude the landing or take-off of aircraft.

Table 3-4 Rainfall in the Vientiane Area

Observation period: 1956 - 1967

		JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	Total
Mean monthly rainfall (mm)		4.2	12.6	27.6	96.9	244.6	266.4	258.3	346.9	371.6	63.0	6.4	0.8	1,699.5
Max. monthly rainfall in a year (mm)		35.2 ('58)	45.8 ('56)	78.9 ('59)	241.5 ('65)	407.3 ('64)	430.7 ('61)	437.1 ('59)	646.7 ('66)	638.3 ('59)	152.1 ('64)	21.2 ('67)	6.3 ('63)	2,008.8 ('61)
Min. monthly rainfall in a year (mm)		0	0	0	25.3 ('58)	97.4 ('58)	116.4 ('60)	137.2 ('61)	188.7 ('63)	119.5 ('66)	0 ('67)	0	0	1,200.1 ('58)
	(mm) 0.1 - 0.9	0	0.6	0.9	1.0	1.9	2.2	2.7	2.3	1.8	1.2	0.3	0.1	15.0
	1.0 - 4.9	0.2	1.0	1.7	2.7	3.5	4.4	5.5	5.9	5.5	2.9	0.8	0.3	34.4
	5.0 - 9.9	0	0.8	0.8	1.4	2.5	4.7	2.5	3.6	1.6	0.9	0.1	0	18.9
	10.0 - 29.9	0.1	0.3	0.6	2.6	4.3	4.9	5.3	6.3	6.8	1.7	0.3	0	33.2
	30.0 - 49.9	0.1	0	0.2	0.7	2.2	1.6	1.7	1.8	1.8	0.3	0	0	10.4
	50.0 - 99.9	0	0	0	0.2	0.9	0.9	1.2	1.3	1.5	0.2	0	0	6.2
	100 -	0	0	0	0	0.1	0.1	0	0.3	0.4	0	0	0	0.9
	Total	0.4	2.7	4.2	8.6	15.4	18.8	18.9	21.5	19.4	7.2	1.5	0.4	119.0
Max. daily rainfall (date)		35.2 (31 JAN. '58)	25.6 (12 FEB. '56)	32.7 (29 MAR '59)	58.0 (11 APR. '56)	100.2 (18 MAY '62)	106.6 (3 JUN. '63)	88.9 (12 JUL. '59)	101.3 (27 AUG. '56)	138.7 (2 SEP. '59)	62.5 (9 OCT '61)	15.1 (25 NOV. '60)	3.1 (7 DEC. '63)	138.7 (2 SEP. '59)

Table 3-5 Temperature in the Vientiane Area

Observation period: 1956 - 1966

Degree (C°) \ Month	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	Total
Monthly mean of the mean daily temperature	21.5	23.9	27.0	28.8	28.4	28.1	27.8	27.7	27.2	26.6	24.7	22.5	26.3
Monthly mean of the max. daily temperature	28.2	30.1	32.9	34.3	32.6	31.5	31.0	30.9	30.6	30.9	30.0	28.5	30.9
Monthly mean of the min. daily temperature	17.4	19.3	21.0	23.5	24.2	24.7	24.6	24.2	23.8	22.4	19.4	16.3	21.7
Max. daily temperature	35.5	35.4	38.6	40.5	39.0	36.8	34.9	34.5	34.8	35.5	34.8	34.5	40.5
date	15 JAN. '57	18 FEB. '66	24 MAR. '60	27 APR. '60	1 MAY '60	13 JUN. '59	8 JUL. '66	16 AUG. '59	1 SEP. '65	14 OCT. '66	3 NOV. '59	20 DEC. '66	27 APR. '60
Min. daily temperature	4.7	10.5	11.1	16.9	20.1	21.5	21.2	21.9	20.8	16.6	8.5	9.5	4.7
date	19 JAN '61	1 FEB '63	2 MAR. '63	2 APR. '60	21 MAY '60	17 JUN. '61	12 JUL. '61	14 AUG. '65	27 SEP. '66	28 OCT. '58	28 NOV. '56	20 DEC. '64	19 APR. '61

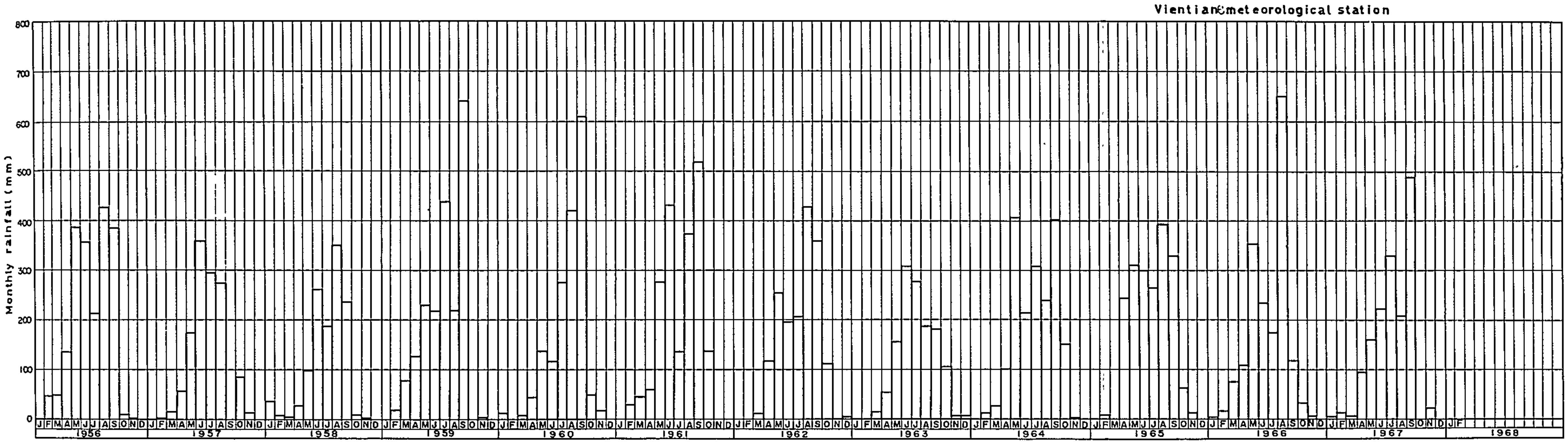


FIG. 3-5 MONTHLY RAINFALL

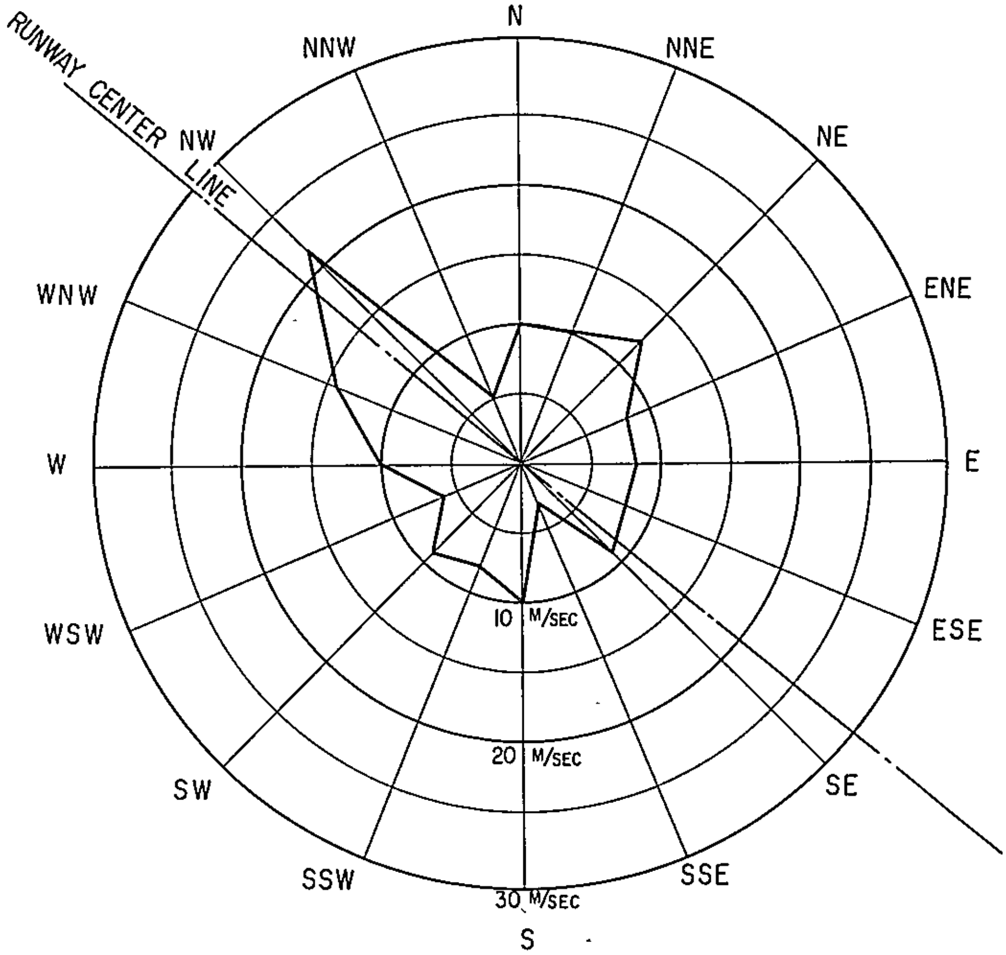


Fig 3 - 6 MAX. WIND. VELOCITY

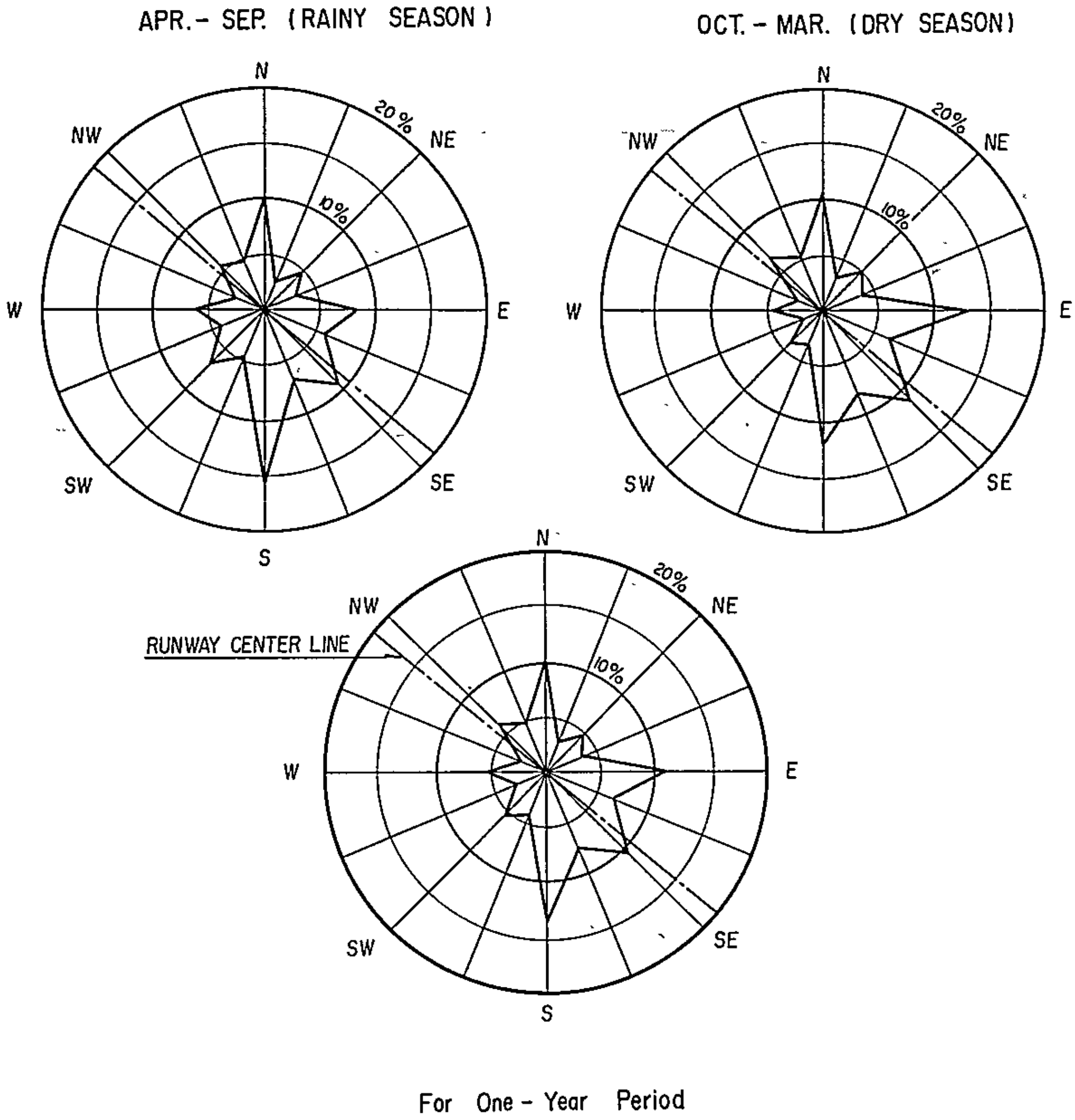


Fig 3 - 7 DAILY PREVAILING DIRECTION OF WIND

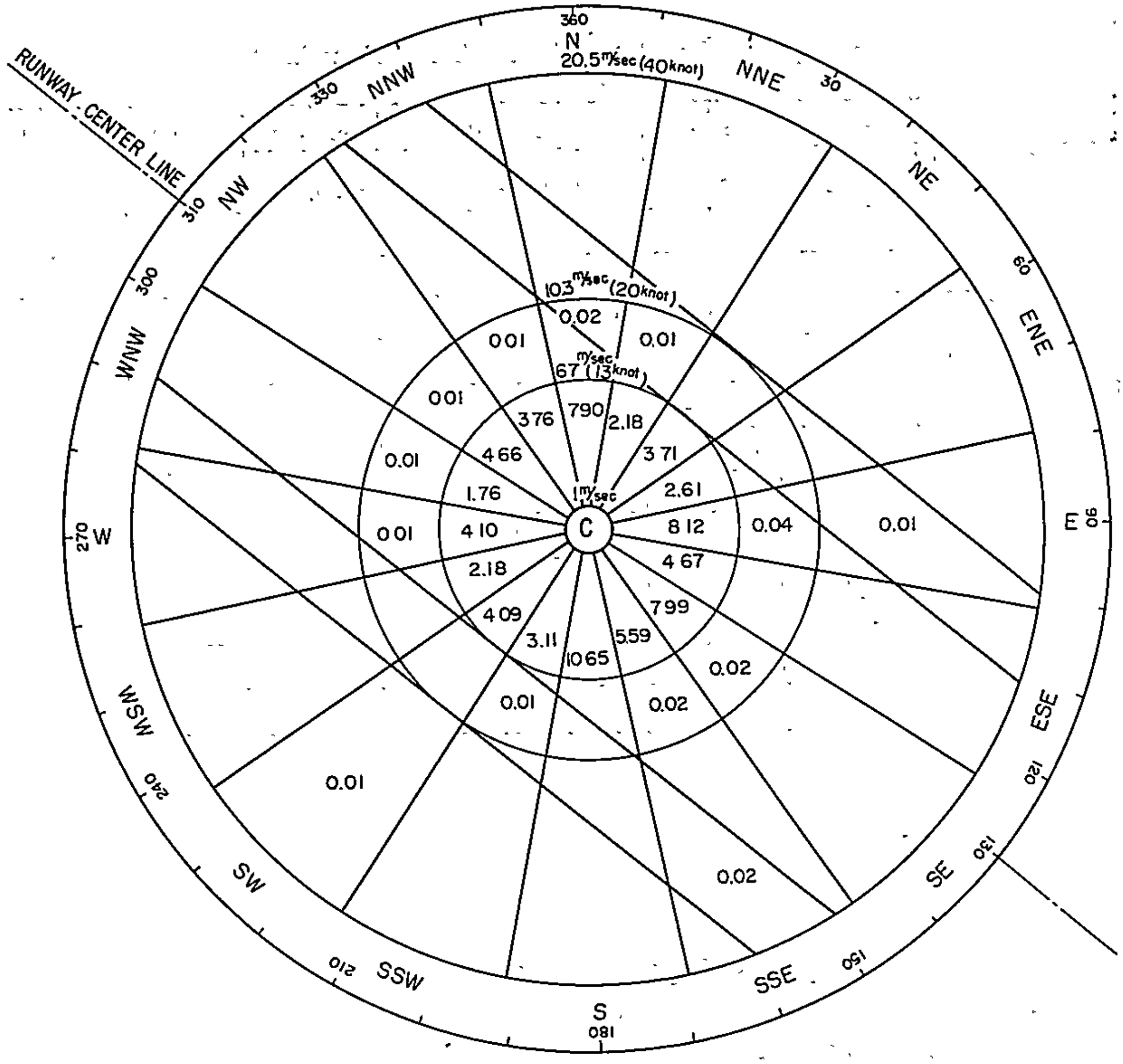


Fig 3-8 WIND ROSE

3-3-6 Humidity and Fog

Humidity and fog records from 1956 to 1966 accumulated by Vientiane Meteorological Station are summarized in Table 3-6.

Table 3-6 Humidity and Fog in the Vientiane Area

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Yearly
Monthly mean humidity %		68.5	67.9	66.7	68.7	75.0	79.5	80.2	80.8	80.3	75.3	72.0	70.5	
Number of foggy days	1956	0	3	0	1	0	0	0	1	1	0	1	1	8
	1957	5	4	0	0	0	0	3	0	0	0	0	2	14
	1958	0	1	0	0	0	1	0	0	0	1	0	0	3
	1959	0	0	0	0	0	0	0	2	0	0	0	1	3
	1960	5	1	8	2	0	0	1	1	0	2	0	6	26
	1961	2	1	1	0	0	0	0	1	0	1	0	0	6
	1962	3	0	0	1	0	0	0	0	0	0	1	6	11
	1963	3	0	3	0	0	0	0	0	0	0	0	1	7
	1964	0	0	0	0	2	1	0	0	0	1	0	1	5
	1965	0	0	0	0	0	0	0	2	0	0	0	0	2
	1966	0	0	3	0	0	0	0	0	0	0	1	0	4
	A.V.	1.6	0.9	1.4	0.4	0.2	0.2	0.4	0.6	0.1	0.5	0.3	1.6	

In reference to the Table, it will be noted that humidity is relatively high and fog is rare.

3-3-7 Cloud Amount and Horizontal Visibility

Monthly mean of mean daily cloud amounts and monthly mean of daily horizontal visibility from 1960 to 1966 are summarized in Table 3-7.

The histograms of daily mean cloud amounts in each season are given in Fig. 3-9.

Table 3-7 Cloud Amount and Horizontal Visibility in the Vientiane Area

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Yearly A.V.
Monthly Mean of mean daily cloud amounts		2.5	2.3	2.3	3.3	5.4	6.3	6.4	6.6	6.0	4.8	3.8	3.3	4.4
Horizontal visibility (km)	1:00	2.7	2.9	2.4	2.7	2.4	2.4	2.6	2.4	2.3	2.7	2.9	3.0	2.6
	7:00	3.6	5.1	4.9	5.3	3.9	8.9	9.6	8.9	7.6	9.4	10.6	7.2	7.7
	13:00	21.3	16.8	10.8	11.4	20.7	19.6	22.2	21.8	22.7	25.6	30.4	28.4	21.0
	14:00	3.7	3.7	3.4	3.7	6.1	5.7	8.9	6.9	4.9	4.6	4.4	3.9	5.0

3-3-8 Summary

In the preceding paragraphs, the meteorological conditions in the Vientiane area have been described on the basis of the weather records by the Vientiane Meteorological Station.

As full data on visibility and ceiling have not been collected, it is impossible to examine wholly the usability of the existing runway for all weather conditions.

However, as the weather in the Vientiane area is generally mild, it may be said that the operation of this airport is scarcely obstructed by adverse weather condition.

3-4 Selection of the Critical Aircraft and the Operating Route

3-4-1 General

Selection of the critical aircraft and the operating route are the most important factors for the planning of extension or improvement of the existing basic landing and take-off facilities.

3-4-2 Selection of the critical aircraft

The object of this extension work is to enable landing and take-off of the large jet craft engaged in international services, such as DC-8, Boeing 707. Therefore as the type of critical aircraft DC-8-55 was adopted for the study.

The type of aircraft now engaged in international service are shown for refer-

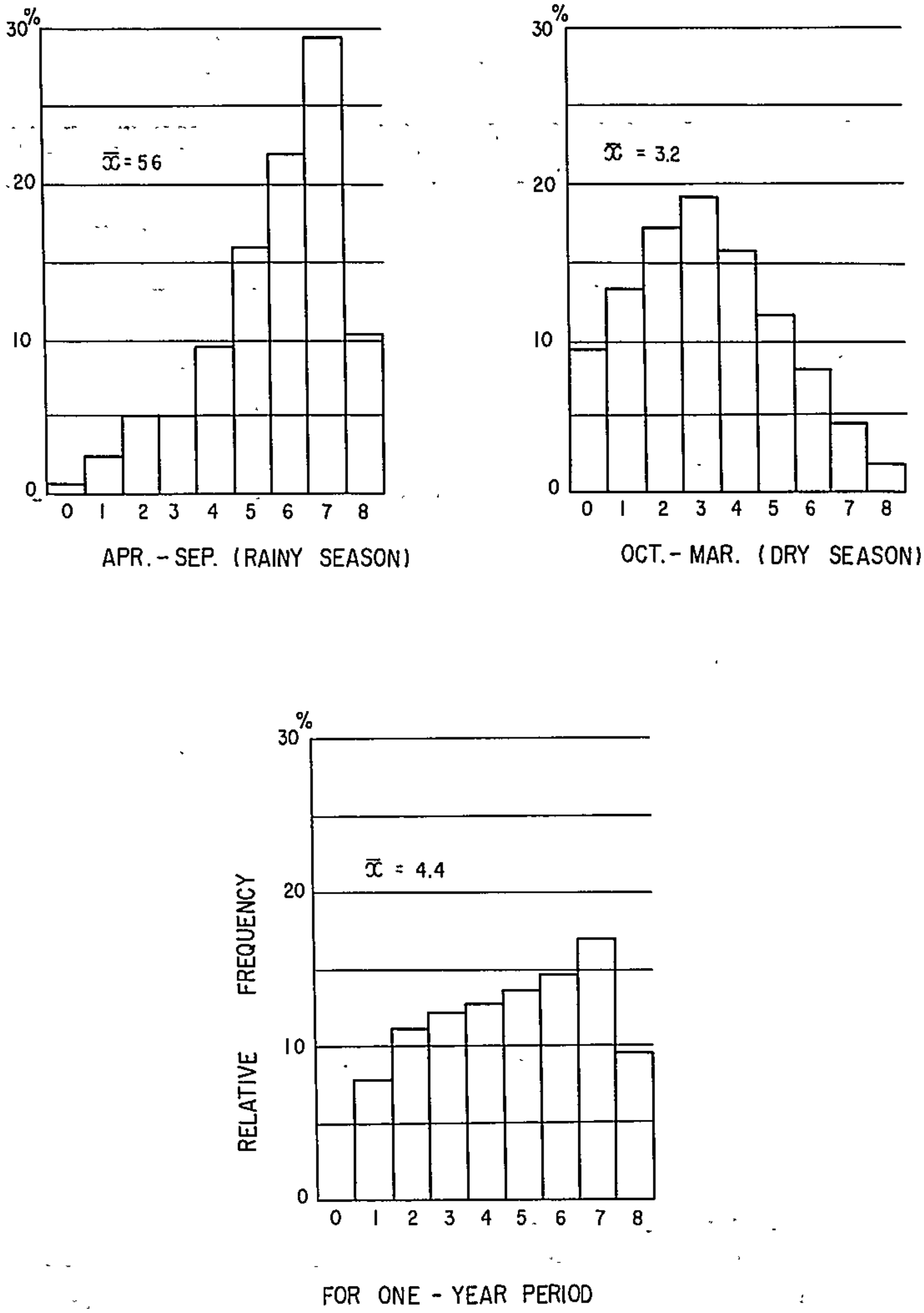


Fig 3 - 9 HISTOGRAM OF DAILY CLOUD AMOUNT ence in Table 3-8.

Table 3-8 Number of Aircrafts in The World

Aircraft	In Service May 1967	To be Delivered		Total by Type
		Rest of 1967	1968 Onwards	
BAC One-Eleven	86	6	39	131
BAC VC 10/Super VC 10	29	2	6	37
Boeing 707	402	62	96	560
Boeing 720	144	5	-	149
Boeing 727	405	82	111	598
Boeing 737	-	3	146	149
Boeing 747	-	-	112	112
Convair 880	60	-	-	60
Convair 990	36	-	-	36
Douglas DC-8	270	47	101	418
Douglas DC-9	109	144	179	432
Fokker F-28	-	-	1	1
HS Comet	57	-	-	57
HS Trident	31	-	15	46
Sud Caravelle	205	13	7	225
Topolev TU-104	5	-	-	5
Topolev TU-129	3	-	-	3
Topolev TU-134	-	-	23	23
Total	1,842	364	836	3,042

3-4-3 Selection of the Operating Route and Range

Airways in Southeast Asia are shown in Fig. 3-10, and the following several operating routes can be taken into consideration as the basis of estimating the runway length required.

Route	Range
Vientiane - Bangkok	500 km
" - Hongkong (Via. Bangkok and Da Nang)	2, 400 km
" - Karachi (Via. Bangkok)	4, 400 km
" - Djakarta (Via. Bangkok)	3, 000 km
" - Calcutta	1, 700 km

In general, to select the route between the specific airports and to determine the type of aircrafts to be flown along the route are the subjects to be decided by the airline companies which intend to operate the air services along the route, in consideration of future aeronautical demands and business profits.

Therefore, even if a route is selected in this report, this route may be different from the real routes which may be determined by the airline companies. Moreover, if a new airway between the specific airports is constructed, the trip length may be shortened.

In this project, it would be reasonable to adopt the route between Vientiane and Karachi which is the longest trip length (4, 400 killometers) among those routes shown in the table above, as the object for examining technically the extension of the existing runway, as are described in the 1st report.

3-4-4 Take-off Weight of the Critical Aircraft

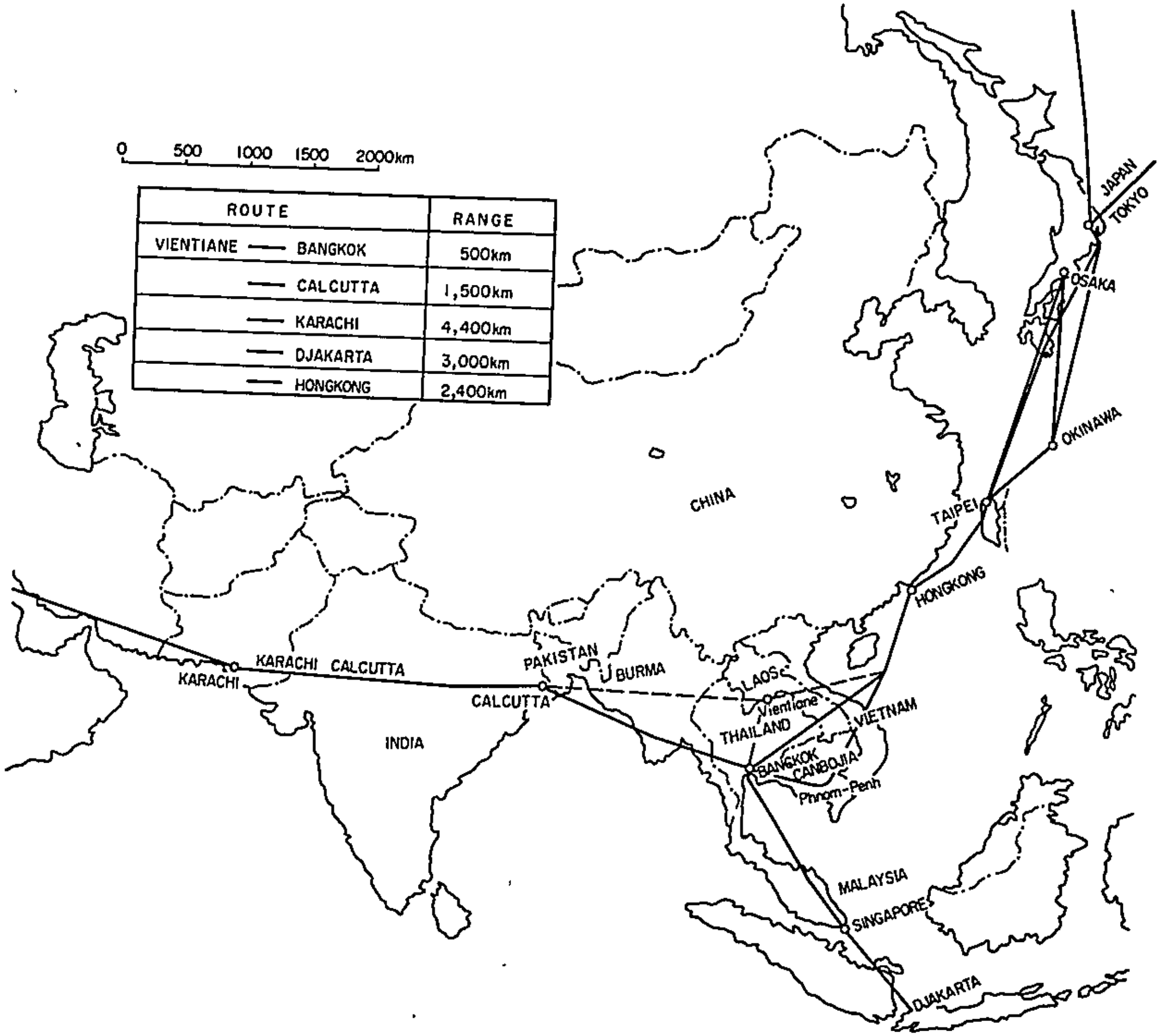
Take-off weight of the critical aircraft, DC-8-55, can be determined as follows:

a) Conditions and assumption for calculation:

Route	Vientiane - Karachi	
Range	4, 400 km	
Cruising altitude	31, 000 ft	
Cruising speed	474 knots (≒ 880 km/h)	
Meteorological conditions en route	Wind	No wind
	temperature -50°C - -60°C	

b) Take-off weight:

Operating weight, empty	140, 000 lbs.
Payload	35, 500 lbs.
Trip fuel	121, 800 lbs.
Total	297, 300 lbs



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

Fig.3-10 ROUGH PLAN OF AIRROUTES IN SOUTHEAST ASIA

c) Calculation of trip fuel:

The specific fuel requirement for the set of conditions mentioned above may be computed from fuel consumption data furnished by the manufacturers in accordance with the provisions of Special Regulation 427c established by Federal Aviation Agency (FAA).

In this report, trip fuel is computed conservatively on the side of safety, because the distance to an alternative airport for emergency landing is not decided and assumptions are made on optional meteorological conditions en route.

Therefore, take-off weight of the critical aircraft, DC-8-55, is 297,000 lbs. and similarly the maximum landing weight is 217,000 lbs.

3-5 Estimate of Future Volumes of Air Traffic

3-5-1 General

A key requirement in developing a master plan is the estimate of future volumes of air traffic, besides the type of aircraft to use the airport, etc.

The estimate of future volumes of air traffic requires information on:

1. Area served by the airport
2. Growth-rate of population of the area to be served by the airport
3. Economic characteristics of the area
4. Origin and destination of residents and non-residents of the area.

For this project, data for estimating the future volumes of air traffic is not sufficient. However, an estimate was made based on the data so far available, and adequacy of the extension project is examined in the following paragraphs based on the estimated air traffic volume.

3-5-2 Future Volume of Air Traffic

The increase rate of air traffic volume is greatly affected by the increase of population and the economic development in the area served by the airport. For this reason the growth rate of future traffic volume will be estimated in consideration of these growth rates.

The estimated growth of the population of Laos as a whole and that of Vientiane and the growth of Gross National Product (G.N.P.) for the 10 years from 1969 to 1979 are, estimated on the basis of those for the period from 1962 to 1967, and shown in

Table 3-9. Growth of air traffic for the same period is estimated on the basis of these figures and shown in Fig. 3-11 and Table 3-9.

Year	Rate of Increase in G.N.P.	Rate of Increase in Population
1967	100	100
1969	109.8	105.1
1974	138.8	118.3
1979	175.5	134.5

Data on air traffic of the Vientiane Airport in the past are nearly null so that estimation of future air traffic volume was made assuming that the growth rate is approximately midway between the growth rate of G.N.P. and the growth rate of population. The future air traffic volume (number of aircraft operations and number of passengers in future) thus estimated is shown in Table 3-10.

This airport is also used by military aircrafts as mentioned above and the number of their operations is relatively large. However, their operations in the future may be considered not to change considerably from the present condition.

Table 3-9 G.N.P. and Population of Laos

Year	G.N.P. (10^6 US$)	Increasing Rate (%)	Population of Laos (10^3 persons)	Increasing Rate (%)	Population of Vientiane (10^3 persons)	Increasing Rate (%)
1962	159.6		2,450			
1963	166.9	4.6	2,509	2.4		
1964	174.5	4.6	2,569	2.4		
1965	182.9	4.8	2,635	2.6		
1966	187.4	2.5	2,698	2.4	132	
1967	196.1	4.6	2,765	2.5	135	2.5
1969	215.3	4.8	2,906	2.5	142	2.5
1974	272.2	4.8	3,271	2.5	160	2.5
1979	344.2	4.8	3,719	2.5	182	2.5

Table 3-10 The Future Air Traffic Volumes

Year	Number of Operations of Civil Aircrafts per Month	Number of Passengers per Month
1967	450	7,900 persons (4,500)
1969	500 - 470	8,700 - 8,300 (5,000) (4,700)
1974	630 - 530	11,000 - 9,400 (6,300) (5,300)
1979	790 - 600	13,900 - 10,600 (7,900) (6,000)

Remarks: Figures in the parentheses show the number of scheduled flights.

3-6 Master Plan of the Basic Facilities for Landing and Take-Off

3-6-1 Peak-hour Operations (The number of Operations per Hour in Peak Hour)

The monthly numbers of aircraft operation at Vientiane Airport as of present, after 5 years (1974) and after 10 years (1979) have been estimated and shown in Table 3-11.

Table 3-11 Number of Operations

Year	Civil Operation per Month	Military Operation per Month	Total
Present (1969)	500 - 470	1200	1700 - 1670
After 5 years (1974)	630 - 530	1200	1830 - 1730
After 10 years (1979)	790 - 600	1200	1990 - 1800

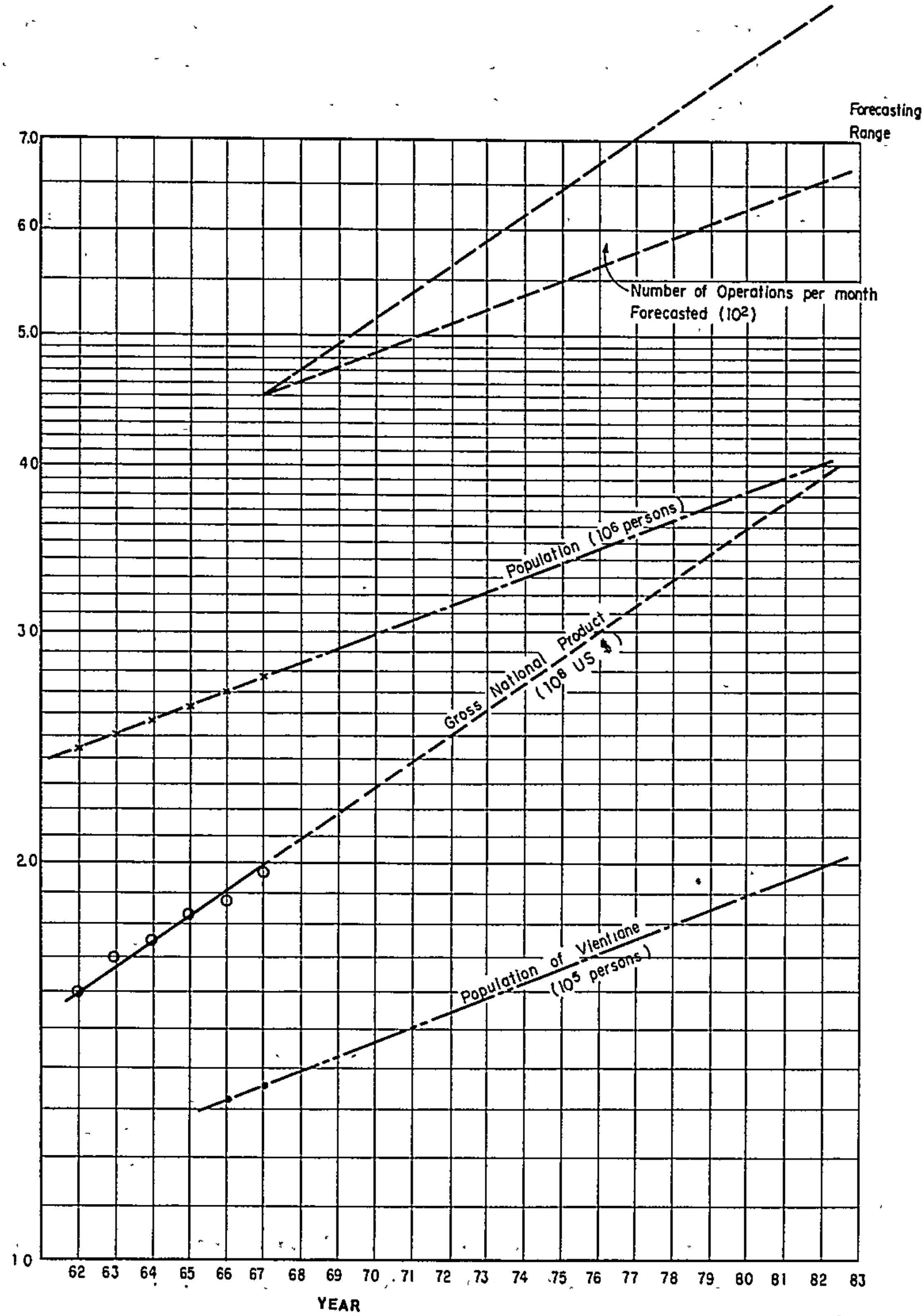


Fig-3·11 CHART FOR FORECASTING FUTURE OPERATIONS

According to Table 3-2 and Table 3-3 the maximum hourly number of operation totals 4, comprising 2 of domestic flights and 2 of international flights. From this and judging from the increase-rate of monthly number of civil operations shown in Table 3-11, the maximum number of peak-hour operations of scheduled flights is estimated at about 7.

The time the military aircrafts use this airport is about 12 hours. Increase-rate of hourly number of operation during peak hours in terms of the average hourly number of operation is not clear because of the lack of data, but if the rate is assumed at around 30%, hourly number of operation of military aircraft is calculated to be 5.

In the estimation of future civil aircraft operation it may not be necessary to take into account the non-scheduled flights, because nonscheduled flights may be arranged so as not to interfere with the scheduled flights.

Number of peak-hour operations after 10 years, therefore, may be estimated at 12.

3-6-2 Planning of Runway Extension and Configuration of Taxiways

The runways of the international airports in other countries used by large turbine-powered aircrafts such as DC-8 or B-707 are mostly 3, 000 meters in length. As for the runway of Vientiane Airport, its appropriate length was studied on a set of conditions mentioned before and on the assumption that DC-8-55 will be used and it was concluded that the existing 2, 000 meters-long runway should be extended to a length of 3, 000 meters. (Ref: Chapter 5).

Effective capacity of an airport is greatly affected by the number of the runways and by the configuration of their appurtenant taxiways. In Table 3-12 are shown the standard capabilities of landing and take-off of the various configurations in the case where the number of the runway is one.

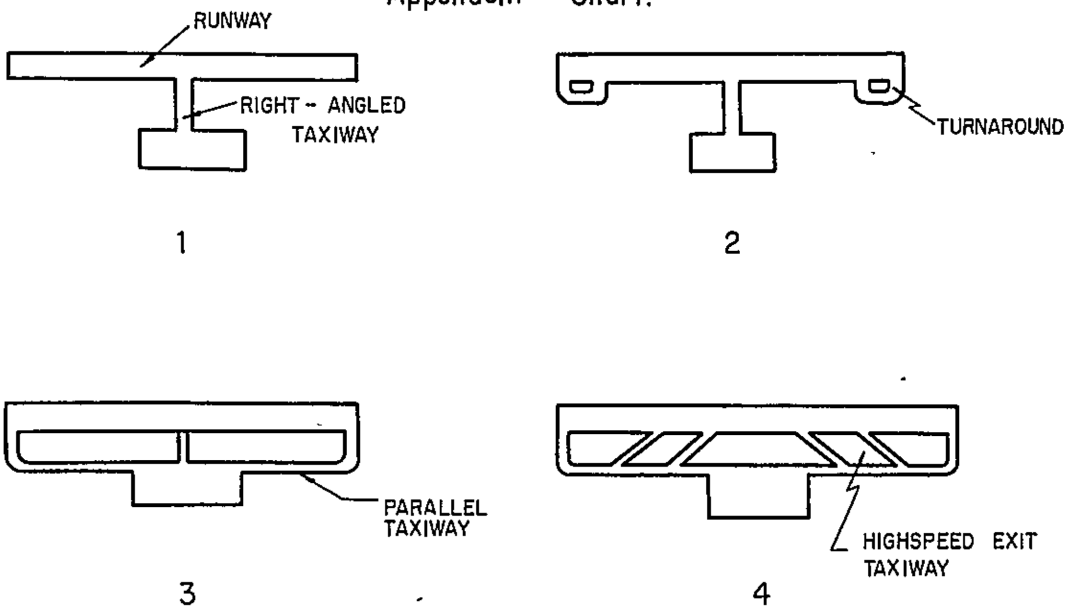
As seen in Fig. 3-1 the configuration of the existing taxiways at Vientiane Airport is an intermediate type between (1) and (3) in Table 3-12, and therefore it is presumed that the effective capacity of this airport is the mean of the values of the cases of (1) and (3). Therefore the capacity of this airport is considered to be about 20 movements in VFR (visual flight rule) condition and about 15 in IFR (instrument flight rule) condition.

As stated before the maximum number of peak-hour operation at this airport after 10 years is estimated at about 10, so the present configulation would suffice as far

TABLE 3-12 PEAK-HOUR CAPACITIES OF A SINGLE RUNWAY

Configuration of Taxiways	Number of Operations / hr	
	V. M. C.	I. M. C.
1 With a right - angled taxiway	12	10
2 With turnarounds at both thresholds	18	15
3 With a parallel taxiway	35 ~ 40	20 ~ 30
4 With highspeed exit taxiways	45 ~ 60	30 ~ 40

Appendent Chart.



as the taxiways are concerned. However, to provide for the landing and take-off in the reverse way it is necessary to widen the northern end of the runway so as to enable large aircraft to turn around with ease.

When the air traffic volume increases in future, it will be necessary, as stated in the First Report to construct a high-speed exit taxiways in the 2nd stage, and a parallel taxiway in the 3rd stage. However, these successive stage should be undertaken after the 1st stage project is completed and the increase in the number of movements calls for such improvement of the airport. (Ref: Fig. 3-12). It is also necessary to provide the so-called over-runs beyond both ends of the runway for supporting over-run aircraft without inducing structural damage of the aircraft and also to prevent the erosion by the blast of the jet engine of the aircraft.

3-6-3 Planning of Improvement of Holding Apron and Apron

Holding-aprons are required to be provided at or near the end of the runways for the aircraft to make engine runups or final checks prior to take-off without interfering with other aircraft.

The existing holding apron is 60 meters in width, except the part of taxiway, and 122 meters in length.

In general, the holding apron for an individual runway should be planned to accommodate 2 to 4 aircrafts and to allow sufficient space for another aircraft to bypass. In this project it would be sufficient if the existing holding apron is widened so as to be capable of accommodating 2 aircraft of DC-8 class, for the volume of air traffic at this airport is relatively small.

As stated before, the landing and take-off is limited to one direction for the sake of noise prevention. For this reason the per-hour operation capacity it is necessary to improve the existing holding apron as the entrance would be angled at 30° or less to enable the aircraft to roll onto the runway, when the runway is cleared, without once stopping at the runway end, and immediately take to take-off motion.

As recommended in the First Report the existing apron should be improved as shown in Fig. 3-13 in order to meet the above requirements and to prevent the dusts to rise at the rear of the aircraft at the time of engine runup.

Aprons are provided to accommodate aircrafts for loading and unloading passengers and cargo, fueling, parking, and servicing. Aprons can be classified roughly as follows:

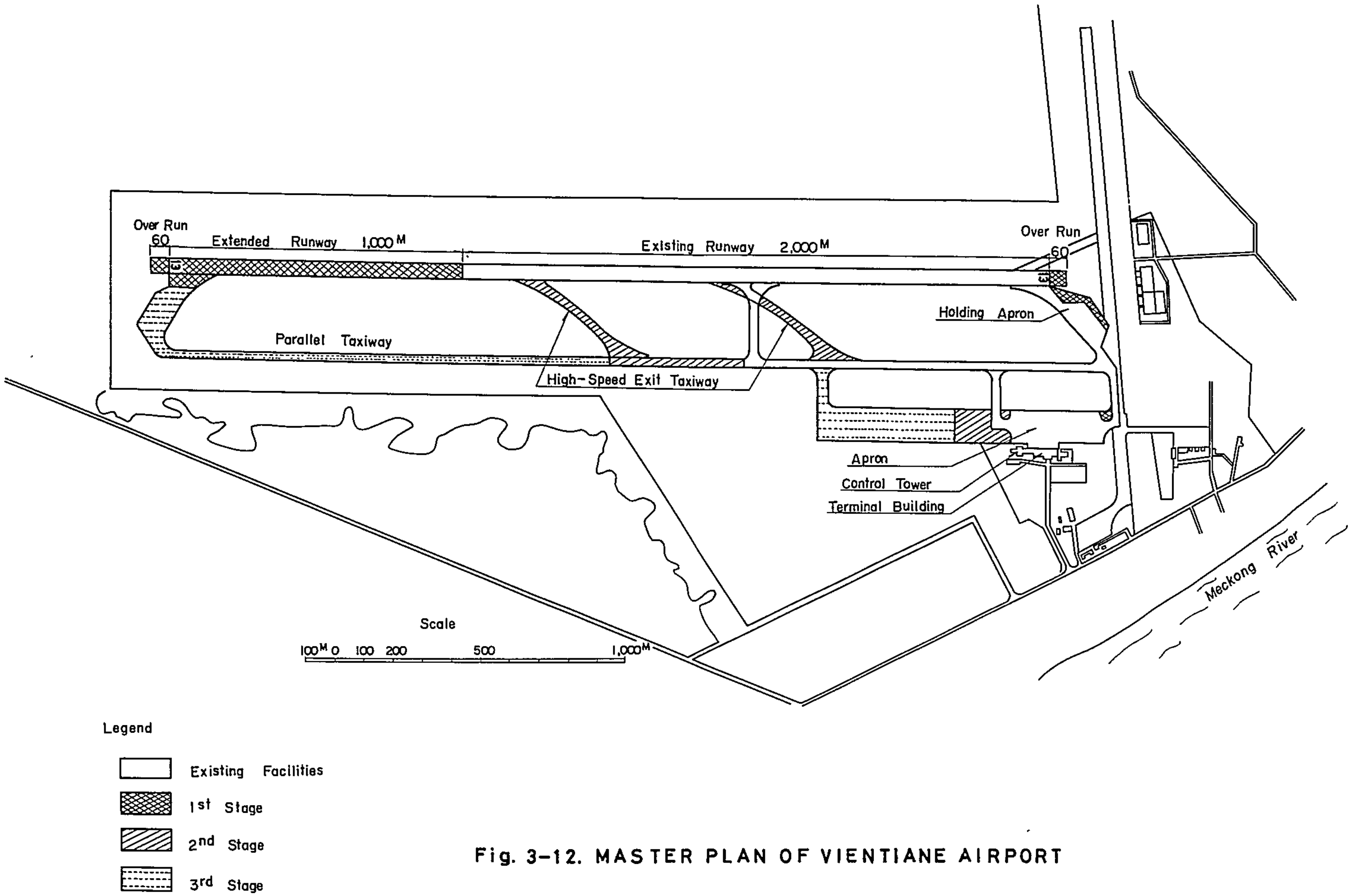


Fig. 3-12. MASTER PLAN OF VIENTIANE AIRPORT

(a) Terminal apron for the loading and unloading of passengers and their baggages.

(b) Cargo apron for loading and unloading cargo only.

(c) Service apron provided near the repair hangers.

(d) Parking apron for layovers.

At present, the existing apron is used indiscriminately by large and small aircrafts for loading and unloading of passengers and cargo, and for servicing and even layover.

The number of gate positions required in a terminal apron can be determined by the following equation.

Number of gate positions:

$$= \frac{\text{Capacity of runways in aircraft per hour } 60}{\text{Average gate occupancy time}} \times 2$$

The capacity of the existing runway is around 20 operations per hour in VFR condition and number of operation of military aircrafts is around 5 per hour. Therefore the capacity of the runway for civil aircrafts is 15 operations per hour.

The number of gate positions required for civil aircrafts will be 7.5 according to the above equation, if the average gate occupancy time is assumed to be 60 minutes. Accordingly, if seven or eight gate positions are provided to the existing apron, the capacity of the apron, as a terminal apron, and the capacity of the runway will be nearly balanced.

As the peak-hour operations of civil aircrafts after 10 years are estimated to be about 7, the number of gate positions required at that time is 4. Therefore, if the existing apron is to be used simply as a terminal apron, the capacity of the existing apron will suffice even for the time to come. However, as the existing apron is used not only for loading and unloading of passengers but for aircraft servicing and even for layover, it is not adequate to study the future capacity of the existing apron merely as a simple terminal apron.

If the number of gate positions required and the flight schedule are processed into graphs respectively from Table 3-2 and Table 3-3, they will be as shown in Fig. 3-14. From this figure it is found that as of present the required space for the layover, including the space for the gate positions, is a space that can accommodate five (5) aircrafts comprising DC-3 x 2, DC-4 x 1, DC-6 x 2 and the number of gate positions necessary at present for loading and unloading of passengers and cargo totals three (3) (that is: DC-3 x 1, DC-4 x 1, DC-6B x 1).

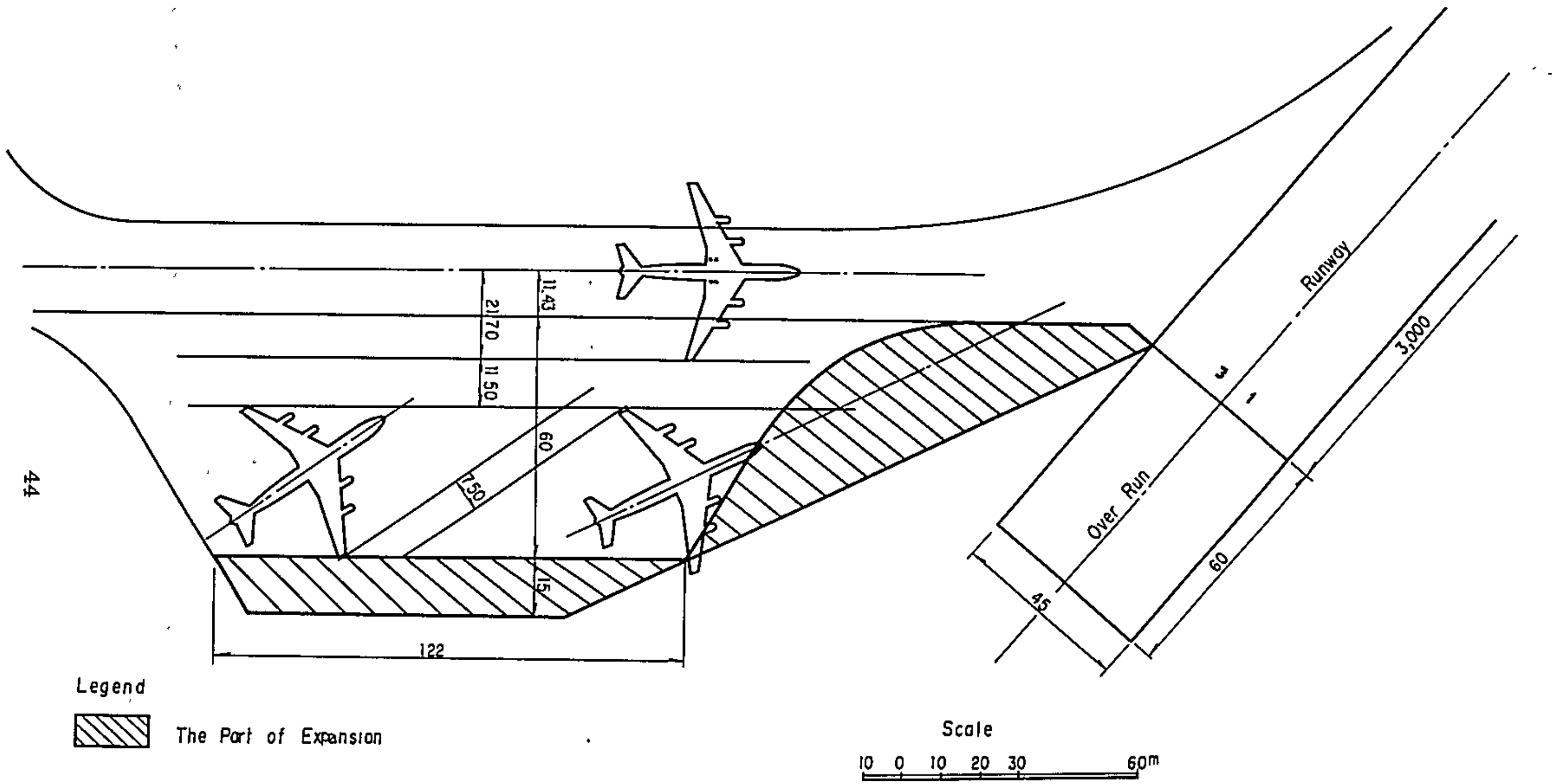


Fig 3 - 13 HOLDING APRON EXPANSION

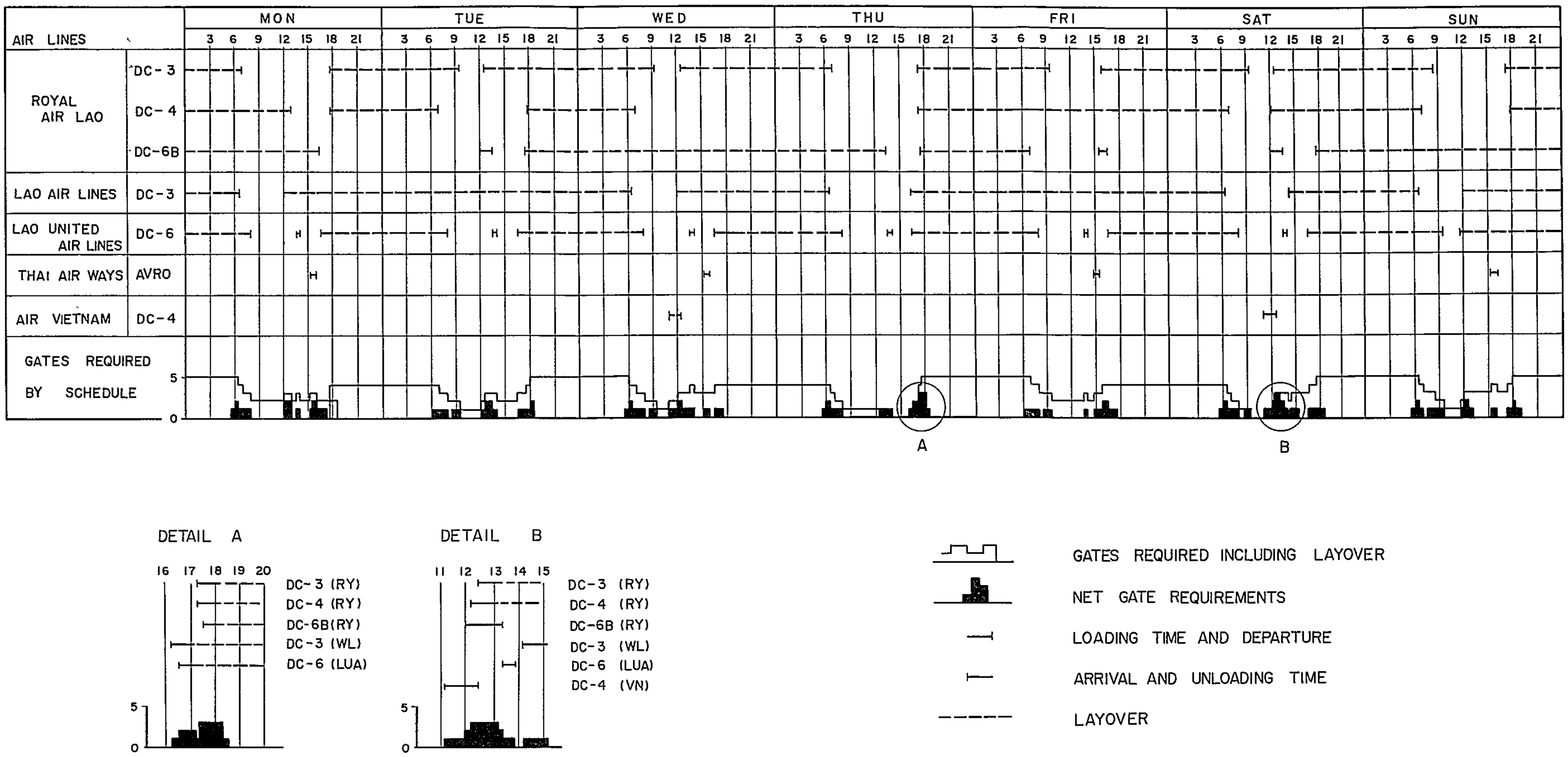


Fig. 3-14 SCHEDULED GATE REQUIREMENTS

Therefore, using the values in Table 3-11, the number of gate positions sufficient to meet the increased air traffic volume after 10 years, including those necessary for the layover purpose, is worked out to be eight (8), as follows:

$$5 \times \frac{790}{500} = 8$$

This number is considered to balance with the capacity of the runway. If the apron is improved as recommended in the 1st report, that is if the gates are located as shown in Fig. 3-15, 7-8 gate positions will be provided (that is: for DC-8 x 2, DC-7C x 4-3, DC-3 or DC-4 x 2) and furthermore more parking space would be available for accommodating small aircrafts.

Therefore, as the 1st stage project the expansion plan shown in Fig. 3-15 would suffice to handle the increased air traffic volume 10 years hence. However, with the further increase of traffic demand it would be necessary to expand the apron as shown in Fig. 3-12 for the purpose of servicing as well as layover.

The improvement plan shown in Fig. 3-15 is stated in detail in Chapter 5.

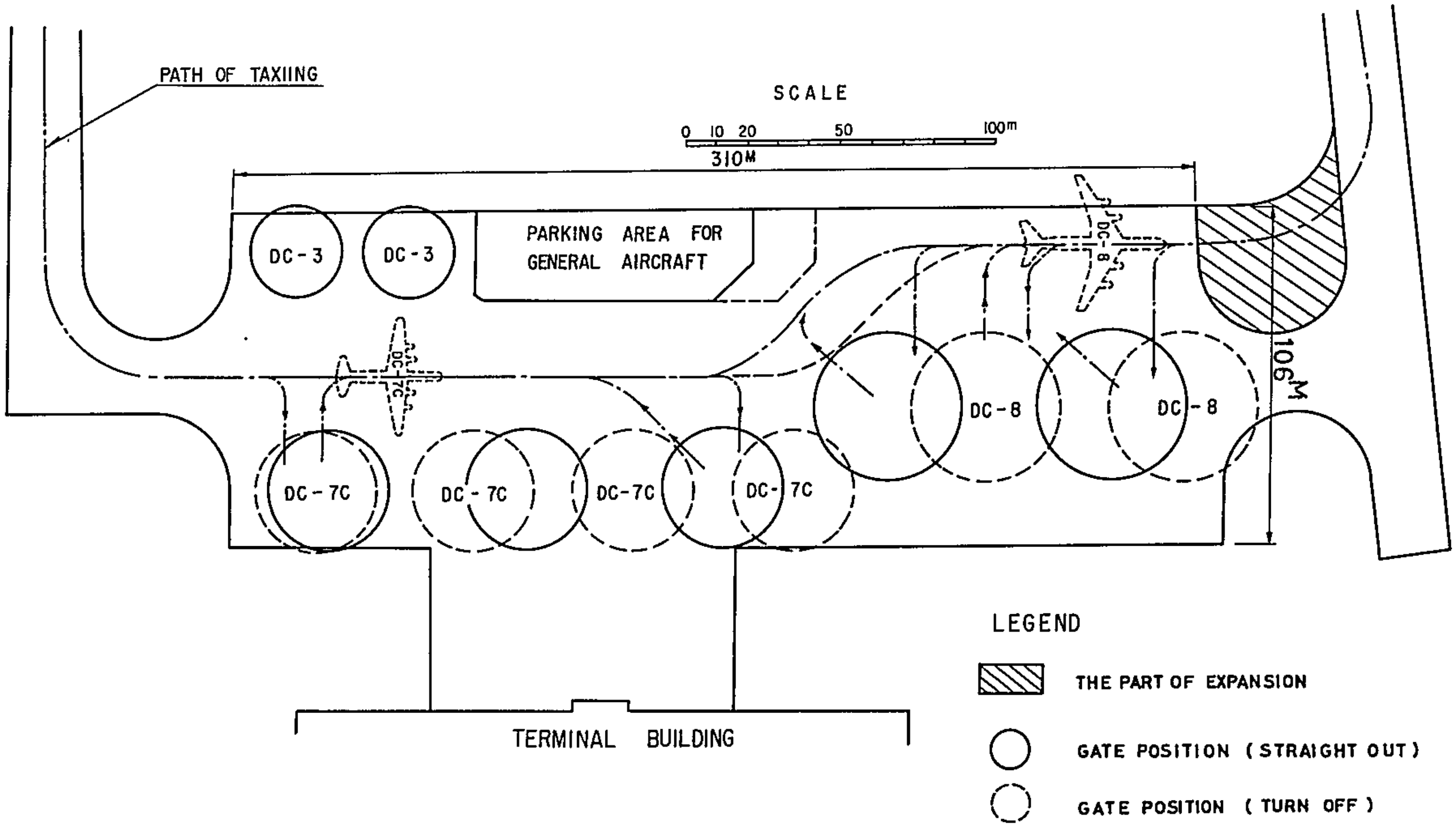


Fig 3-15 PLANNING OF EXPANSION OF APRON

4. DESIGN CRITERIA AND OBSTRUCTION CRITERIA

4-1 General

For planning and design of international aerodromes, International Civil Aviation Organization (ICAO) has prepared the "Aerodrome Design Criteria and Obstruction Criteria" for determining obstructions to air navigation, in order to provide safety of operation in the aerodromes.

ICAO design criteria apply to all member nations of the Convention on International Civil Aviation and are published as Annex 14 to that Convention.

In this Chapter, parts of those criteria, considered to have direct connection with this project, will be mentioned.

4-2 Design Criteria (Standards and Recommendations)

The geometric design criteria for runways and taxi-ways specified in the Annex 14 are summarized in Table 4-1 and in Table 4-2, and lateral clearance standards are listed in Table 4-3.

4-3 Restriction on and Removal of Obstructions

To provide uniform criteria for determining obstructions to air navigation, Annex 14 gives explanations on restriction on and Removal of Obstructions, and the restrictions are as shown in Table 4-4 and Fig. 4-1.

As the result of the investigation conducted on obstructions in this aerodrome, it was found out that only a few trees would be the obstructions, but no structures would fall under the abovementioned restriction.

Table 4-1 Runway Geometric Design Standards

Code Letter	Runway: Selected base length (m)[a]	Runway: Min. width (m)	Runway: Max. longitudinal grade (%)[b]	Runway: Max. effective grade (%)[c]	Runway: Max. transverse grade (%)	Runway: Rate of change of grade[d]	Runway: Sight distance	Landing Strip: min. width (m) Instrument[f]	Landing Strip: min. width (m) Non-instrument	Landing Strip: Grading beyond runway end (m)	Landing Strip: Max. longitudinal grade (%)[g]	Landing Strip: Max. transverse grade (%)
A	2550 and over	45	1.25	1.0	1.5	0.1 per-cent		300	150	Strip	1.75	75 meters
B	2150 - 2549	45	1.25	1.0	1.5	per 30 m		300	150	extends	1.75	from 4
C	1800 - 2149	45	1.25	1.0	1.5	(R 30,000m)	e	300	150	60 meters	1.75	2.5%
D	1500 - 1799	45	1.5	1.0	1.5	———		300	150	beyond	2.0	remaining
E	1280-1499	45	1.5	1.0	1.5	0.2%/30m		300	150	end of	2.0	distance
F	1080-1279	30	1.5	1.0	1.5	(R-15,000m)		300	150	runway	2.0	5.0%
G	900-1079	30	1.5	1.0	1.5	0.3%/30m (R 10,000m)		300	150		2.0	

a: All runway lengths are based upon sea level, standard atmospheric conditions, zero runway gradient.

b: Additionally for runways of code letter A, B or C for the first and last quarter of the length of the runway the slope shall not exceed 0.8 per cent.

c: The difference in elevation between the highest and the lowest profile elevations is divided by the entire runway length.

d: Where grade change cannot be avoided, a grade change between two consecutive grades should not exceed 1.5 percent.

e: Any two points 3 meters above the runway must be mutually visible within a distance of half the runway length.

f: Instrument means the strip including a precision or an instrument approach runway.

g: Within a distance of 75 meters from 4, remaining not specified.

Table 4-2 Taxiway Geometric Design Standards

Code Letter	Taxiway width (m)	Longitudinal gradient (%)	Subject distance	Rate of change of longitudinal slope	Horizontal Radius (m)	Transverse slope (%)	Taxiway shoulder width	Taxiway shoulder transverse slope	Radius of fillet
A	23	1.5	Surface of	1% per		1.5	Turfed or		
B	23	1.5	taxiway	30 meters		1.5	paved		
C	23	1.5	must be	(R_3,000 m)	a	1.5	shoulder	hot speci-	b
D	23	1.5	visible			1.5	are not	fied	
E	15	3.0	from a			1.5	man-		
F	15	3.0	3m height			1.5	datory,		
G	12.5	3.0	for a dis-			1.5	but are		
			tance of				suggested		
			300m				if need		
							exist		

a: With changes in direction the centerline radius shall not be less than 1.5 times the width of the taxiway. The distance between main wheels and edge of pavement shall not be less than 4.5 meters where code letter is A, B, C or D and 3.0 meters where code letter is E, F, or G.

b: For large turbojet aircraft, the following values are recommended:-

Intersection angle of paved area	Minimum fillet radius
Less than 45°	23 meters
45° to 135°	30 meters
More than 135°	60 meters

And for other aircraft

Less than 45°	7.5 meters
45° to 135°	15 meters
more than 135°	60 meters

Table 4-3 Lateral Clearance Standards

Code Letter	Distance (m) from runway centerline to:						Distance (m) from Taxiway centerline to:		Distance from edge of apron to fixed or movable obstruction
	Parallel taxiway		Parallel runway		Building line		Parallel taxiway center line	Fixed or movable obstruction	
	Instrument	Non-instrument	Instrument	Non-instrument	Instrument	Non-instrument			
	a	a	b		c		a	a	
A	184	107	1500	210	150	75	75	41.5	
B	184	107	1500	210	150	75	75	41.5	
C	184	107	1500	210	150	75	75	41.5	not shown
D	184	107	1500	150	150	75	75	41.5	
E	180	103	1500	150	150	75	58	33.5	
F	167.5	91.5	1500	150	150	75	58	33.5	
G	166.3	90.3	1500	150	150	75	52.5	30.3	

a: In the Annex 14 these clearances are presented in relation to the edge of pavement.

b: The Annex 14 does not specify the distances for simultaneous instrument landings on parallel runways, nut in airodrome manual Part 2 (prepared by the secretariat and published by authority of the secretarygeneral, ICAO) the guidance materials are presented.

c: The distances shown here are for the strip width clear area as defined in Annex 14.

OBSTRUCTION RESTRICTION

Romoval and Marking

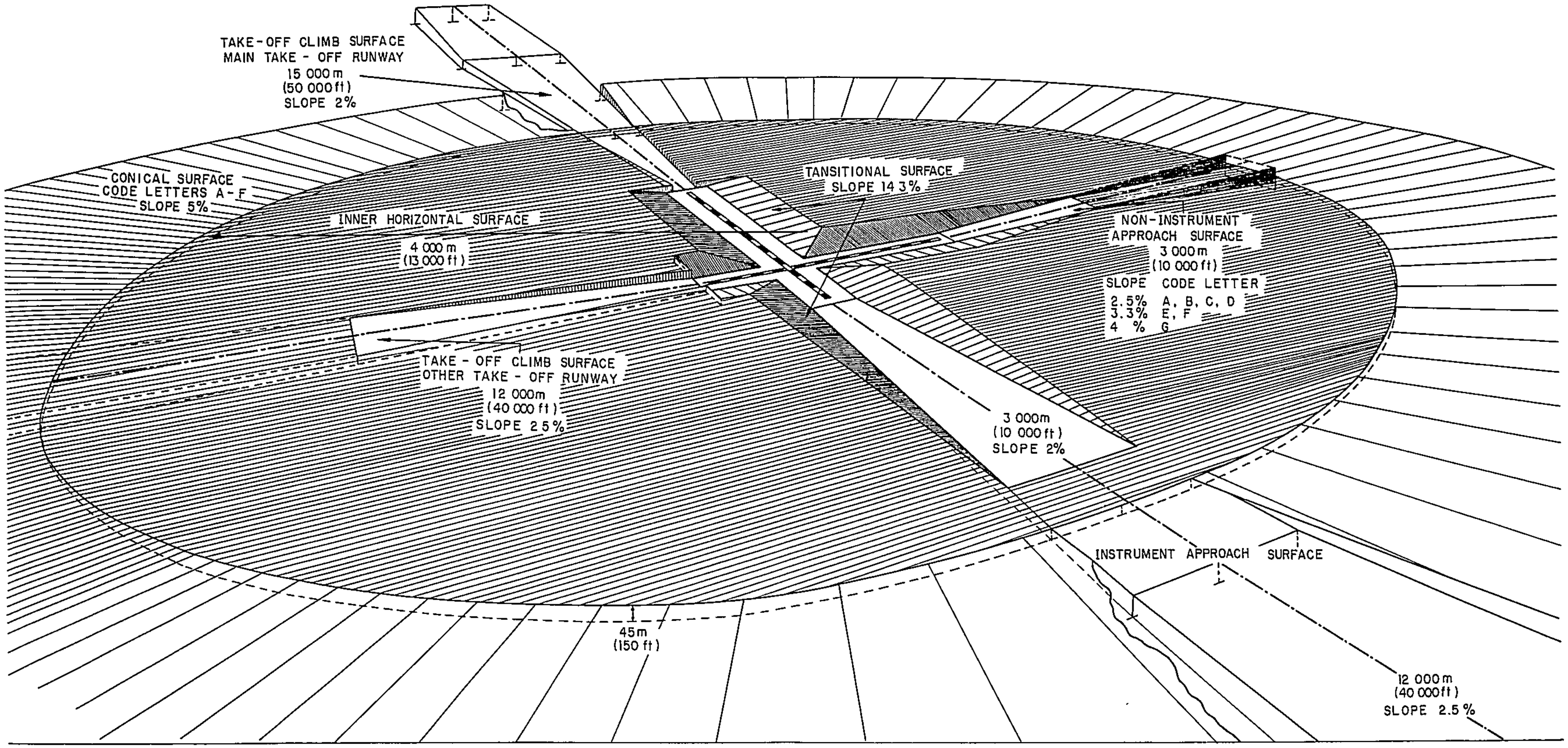


Fig. 4-1 Plan View Perspective of Tipical Land Aerodrome

Table 4-4 Dimensions and Slopes of Airport Referenced Imaginary Surfaces

Surface		Code Letter	A	B	C	D	E	F	G
Approach surface	Length of inner edge	Instrument				300 m			
		Non-instrument				150 m			
	Divergence	Instrument				15 %			
		Non-instrument				10 %			
	Length of approach area	Instrument				15, 000 m			
		Non-instrument				3, 000 m			
	Slope for inner 3, 000 m of length	Instrument				1/50 (2%)			
		Non-instrument		1/40 (2. 5%)			1/30 (3. 33%)		1/25(4%)
	Slope beyond 3, 000 m a	Instrument				1/40 (2. 5%)			
		Non-instrument							
Inner horizontal surface	Height above the elevation datum					45 m			
	Radius from airport reference point					4, 000 m			
Conical surface	Slope				1/20 (5%)				
	Radius of outer limits			6, 000 m			5, 500 m		
Transitional surface	Slope					1/7 (14. 3%)			
Take-off climb surface	Length of inner edge	Main take-off runways				180 m			
		Other runways				180 m (150 m)			
	Divergence	Main take-off runways				12. 5 %			
		Other runways				12. 5% (10%)	b		
	Final width	Main take-off runways				1, 200 m			
		Other runways				1, 200 m	b		
	Length of climb area	Main take-off runways				15, 000 m			
		Other runways				12, 000 m	b		
	Slope	Main take-off runways				1/50 (2%)			
		Other runways				1/40 (2. 5%)			

a: The approach surface shall be horizontal beyond whichever is the higher of: a) the point at which the 2. 5% slope intersects a horizontal plane 150 m above the threshold elevation, or b) the horizontal plane passing through the top of any object that governs the final approach minimum altitude.

b: 1, 800 m when the intended track includes change of heading greater than 15 degrees for operations conducted in IMC or VMC by right.

5. GEOMETRIC DESIGN OF BASIC FACILITIES AND STRUCTURAL DESIGN OF PAVEMENTS

5-1 Design of Runway Extension

5-1-1 Determination of the Required Runway Length

In Chapter 3, the type of the critical aircraft and its take-off weight are determined. The following factors must also be taken into account in determining the runway length.

(1) Regulations concerned with runway length requirements.

(2) The airport environment.

In this chapter, the required runway length is determined from the take-off field length chart for DC-8-55, furnished by the manufacturer according to the regulations established by Federal Air Agency (FAA), for the environment of this airport. (ref. Fig. 5-1)

a) Ambient temperature:

For airport reference temperature the ambient temperature of this airport is used for design purposes. Reference temperature (T) is calculated as follows:

$$T = T_1 + \frac{T_2 - T_1}{3} = 30.63°C$$

where T_1 = monthly mean of the mean daily temperatures for the hottest month of the year.
= 28.8°C (ref. Chapter 3)

T_2 = monthly mean of the max. daily temperature for the same month
= 34.3°C (ref. Chapter 3)

b) Airport elevation:

The highest point of the runway is adopted,

172 meters (570 feet) above sea level

c) Runway slope:

Maximum effective grade is adopted

$$G = \frac{171.7 - 169.7}{3,000} = 0.001$$

d) Wind velocity:

Velocity of zero is adopted for design purposes.

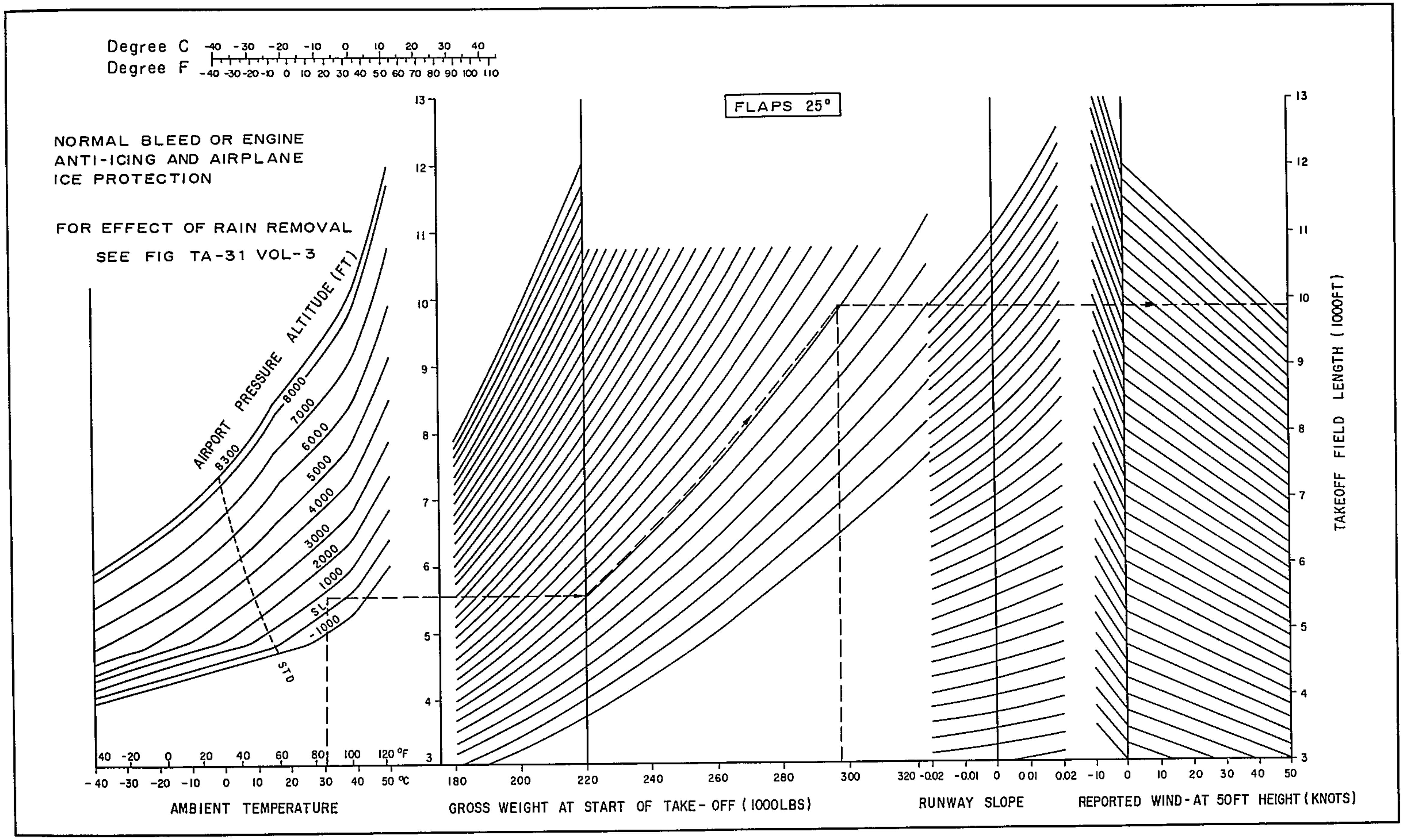


Fig 5-1 TAKE-OFF FIELD LENGTH
JT3D-3 ENGINES

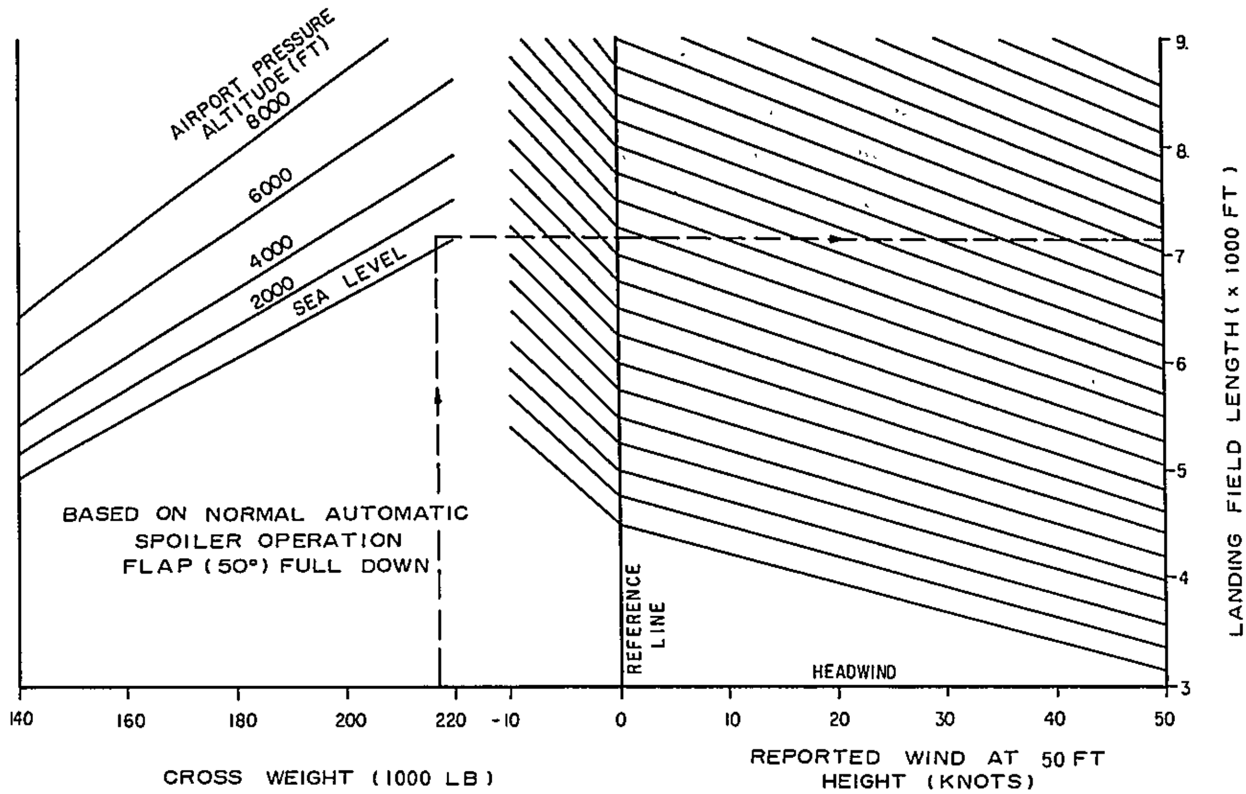


Fig 5-2 LANDING FIELD LENGTH

e) Take-off weight of the critical aircraft:

Maximum weight of 297,000 lb is adopted (ref. Chapter 3)

f) Landing weight:

Max. landing weight of 217,000 lb is adopted. (ref. Chapter 3)

With the numerical values given above, the runway lengths required for take-off and landing can be obtained from the take-off field length chart and landing field length chart (Ref. Fig. 5-1, Fig. 5-2) as follows:

The runway length required:

For take-off: 9,800 feet. (2970 meters 3,000 meters)

For landing: 7,200 feet. (2,160 meters)

Therefore, the runway length of 3,000 meters would be reasonable, and hence, the length of extension is 1,000 meters.

5-1-2 Determination of Geometric Cross Section of Runway

The basic length of the extension runway falls under Code Letter A in Annex 14. In referring to Table 4-1, the design criteria applied to the runway which falls under Code Letter A are as follows:

a) The runway width is 45 meters or more

b) The max. longitudinal grade is 1.25 percent but for the first and last quarter of the length of the runway the slope should not exceed 0.8 percent.

c) The max. effective grade is 1.0 percent

d) The max. transverse grade is 1.5 percent

e) The max. rate of change of longitudinal grade is 0.1 percent per 30 meters (min. radius of curvature: 30,000 meters)

f) The distance between the points of intersection of two successive curves should not be less than the sum of the absolute numerical values of the corresponding grade changes multiplied by 30,000 meters.

g) The sight distance: The grade change should be such, where unavoidable, that any two points 3 meters above the runway must be mutually visible within a distance of at least half the runway length.

h) The min. width of the landing strip is 300 meters for instrument runway and 150 meters for non-instrument runway.

i) The length of the landing strip should be extended at least 60 meters beyond the end of the runway.

j) The max. longitudinal grade of the landing strip is 1.75 percent within a distance of 75 meters from the center line of the runway.

k) The max. transverse grade of the strip is 2.5 percent within a distance of 75 meters from the centerline of the runway and 5 percent beyond this distance.

According to the above design criteria, the width and transverse grade of the extension part of the runway are decided at 150 feet (45.72 meters) and 1%, respectively, being equal to those of the existing runway.

The longitudinal grade of the part of extension should be decided so as the earth work will be the minimum. The longitudinal grade of 0.2 percent is adopted, taking into account the existence of a hill 3-4 meters high and about 600 meters off the east end of the runway and after study of drainage, soil conditions and earth work arrangement. Therefore, the transition from the existing runway to the extended part must be accomplished by a curved surface at a rate of change not exceeding 0.1 percent per 30 meters. And there is no question about the sight distance.

The width of the landing strip necessary for the instrument approach is adopted, i.e., 300 meters, and the slopes on the strip are designed in accordance with the criteria mentioned above.

On both sides of the extension part, shoulders (turfed surface) of 7.5 meters wide will be constructed.

5-1-3 Design of "End 13" Widening

In this airport, only one taxiway is provided to run from "End 13" of the runway to the apron, and no parallel taxiway is provided at present.

However, it is necessary to prepare sufficient space for aircraft to turn around at "End 13" (ref. Fig. 5-3) for exceptional take-offs or landings and interrupted take-offs.

As mentioned in Chapter 3, another holding apron immediately adjacent to "End 13" will be constructed in the future. Therefore, it would be reasonable to pave a part of the future holding apron site in advance so as to allow sufficient space to enable the aircraft to turn around safely.

The min. turning radius of Boeing 707-320 is adopted for this design purposes, because it is larger than that of DC 8-55.

It is assumed that the centerline of the aircraft taxiing from "End 13" coincides with that of the runway. Characteristics of B-707-320 are as follows:

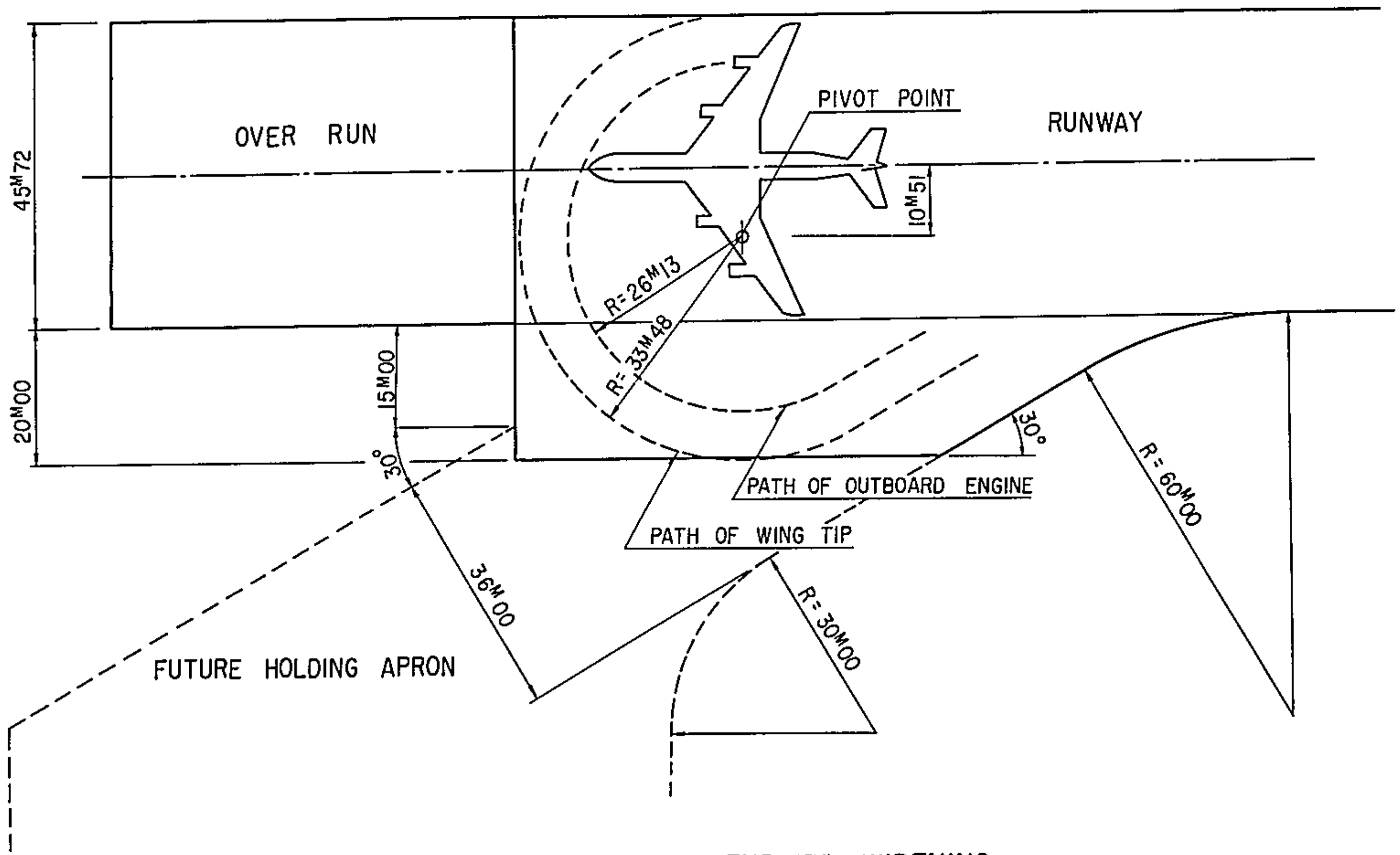


Fig 5-3 PLAN OF "END 13" WIDENING

(a) Wing span .... 43.40 meters

(b) Distance from the centerline of the airplane to the outboard engine .... 15.62 "

(c) Min. turning radius .... 33.48 "

(d) Distance from the centerline of the airplane to the pivot point .... 10.51 "

(e) Min. turning radius of the outboard engine .... 26.13 "

If, for the design purposes, max. breakaway thrust of 55% MCT is adopted, the distance from the outboard engine to edge of the pavement, required for protecting the turfed surfacing shoulder from blast erosion, is 2.4 meters, as described in Section 5-4.

Therefore, min. widening required is given by the following formula:

W = (The distance from the centerline of the airplane to the pivot point)
+ (Min. turning radius of the outboard engine)
+ (The distance from the outboard engine to edge of the pavement)
- (Half the runway width)
= 16.18 meters

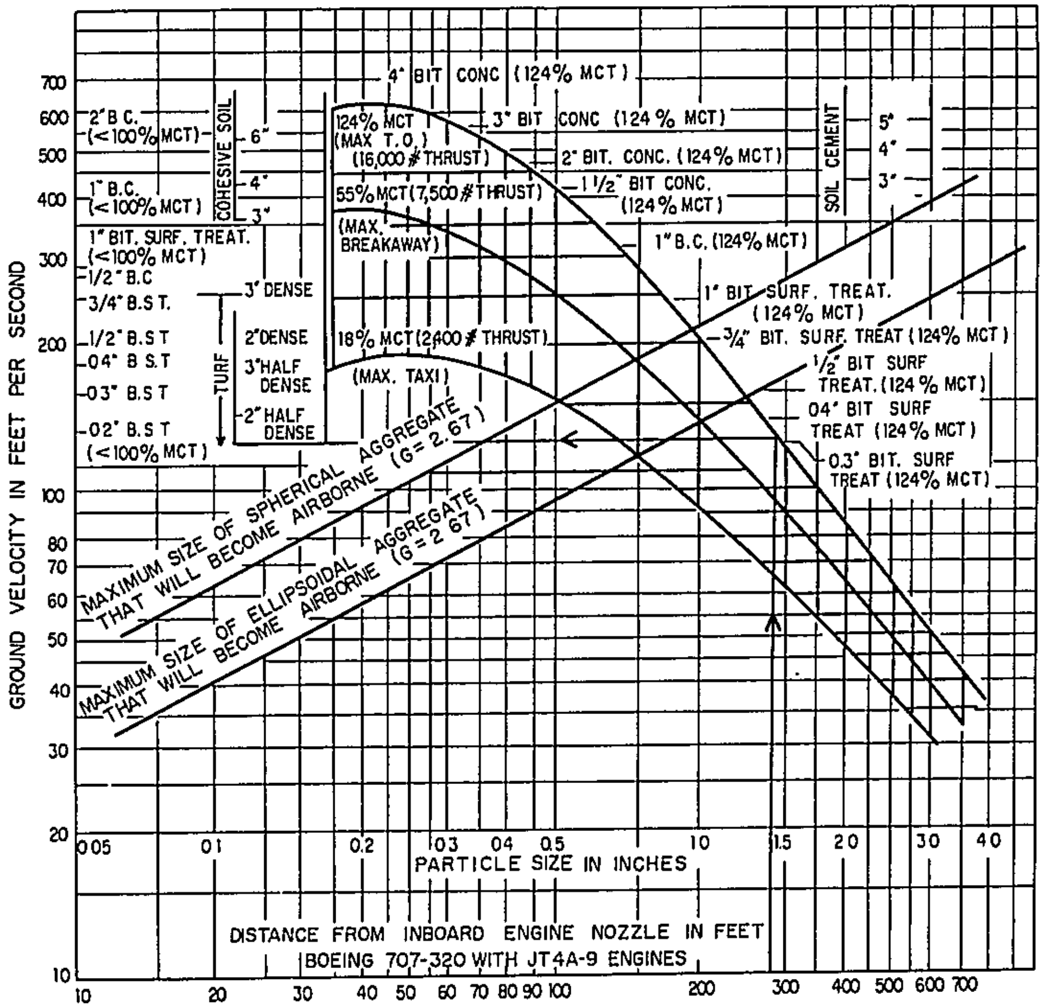
The entrance from the future holding apron into the runway has been designed so as to permit a large aircraft such as Boeing 707 to roll onto the runway and initiate the take-off without coming to a complete stop, and to protect the accompanying shoulder from blast erosion.

5-2 Design of Overrun

5-2-1 Dimensions and Pavement Structure

In general, the overrun should be extended from the end of the runway to that of the strip, i.e., for a length of 60 meters at minimum length. As the overrun should have the same characteristics as those specified by ICAO for a stopway, the width and pavement structure of the overrun has been designed so as to conform with the recommendations specified in Annex 14 (1.17; 1.19; 1.20) to the Convention of ICAO.

The width of the overrun will be at 45.72 m i.e. same as the runway, the same type of concrete of 15 centimeters thick will be used to enable the overrun to withstand the wheel load of the aircraft and to protect the surface from the damages of blast; its sub-base structure will be the same as that of the runway.



VELOCITY VS. PARTICLE SIZE, SURFACE, AND DISTANCE FROM NOZZLE

Fig 5 - 4

NOTES

VELOCITIES SHOWN ARE MAXIMUM GROUND VELOCITIES WITH ALL FOUR ENGINES OPERATING

THESE VELOCITIES ARE NOT NECESSARILY IN LINE WITH THE ENGINES.

BITUMINOUS CONCRETE SPECIFIED SHOULD BE SMOOTH TEXTURED

BITUMINOUS SURFACE TREATMENT WAY BE ROUGH TEXTURED.

5-2-2 Elimination of Blast Erosion

At the runway ends as the jet wake reaches the max. take-off thrust (124% MCT), the effect of 124% MCT on the blast pad of the overrun pavement was examined as follows:

In aircraft of the class of DC-8, 707-320, if the distance from the tail of the aircraft to the inboard engine nozzle is about 30 m (80 ft) and the length of the overrun pavement is 60 meters (= 180 ft), the distance from the inboard engine nozzle to the edge of overrun pavement will be at least 90 m (280 ft); then, the blast velocity at a point 280 feet from the engine nozzle will, if worked out from Fig. 5-4, be 40 m/sec (130 ft/sec). Then a 5 cm (2 inches) thickness of dense turf would be sufficient around the end of the overrun pavement to protect it from blast erosion.

5-3 Design of Holding Apron Expansion

5-3-1 General

According to "Airport Design" published by FAA, space requirements for an aircraft varies from about 45 m (150 ft) for the twin-engine type to about 75m (250 ft) for the large four-engine type, including swept-back wing turbojet. Generally the diameter of the space required for maneuvering and holding aircraft equipped with dual-wheel undercarriages may be closely approximated by multiplying the wing span by factors varying between 1.35 and 1.50, and factors between 1.60 and 1.75 will suffice for dual tandem gear aircraft.

The existing holding apron is 122 meters long and 60 meters wide, excluding the part of taxiway. Therefore, the space of the existing facility is not considered adequate for large turbojet aircraft used in international air navigation. Hence it is necessary to be improved to have sufficient space.

If the shape of the holding apron can be designed so as to permit the waiting aircraft to roll onto the runway at an angle of 30° and initiate the take-off without coming to a complete stop at the end of the runway when take-off clearance is given, it will contribute to increase the maximum number of operations of the runway. In consideration of the above two factors, the shape of the existing holding apron will be improved as shown in Fig. 5-5.

5-3-2 Determination of Dimensions

The size of the holding apron should be determined taking into account the number of aircraft to be held, the spacing between holding positions, the wing span of bypassing aircraft and the minimum clearance between bypassing aircraft and holding aircraft.

Now, as the basis of the study it has been assumed that the holding apron will be expanded so as to accommodate 2 large turbojet aircraft with sufficient space to allow 1 large turbojet aircraft of similar size to bypass any of them.

To begin with the spacing between holding positions is calculated by the following equation (Ref. Drawing 5-6).

$$D = (B + S) \operatorname{cosec} A \quad \text{.................... (1)}$$

or $$D = (F + a + R) \operatorname{cosec} A \quad \text{................. (2)}$$

Where D = spacing between holding positions.

B = clearance between a parked aircraft and the aircraft outgoing in a straight line from the adjoining holding position.

S = wing span of aircraft.

A = holding angle.

F = clearance between a parked aircraft and the aircraft maneuvering from the adjoining holding position.

a = the distance perpendicular to the center line of the aircraft from the pivot point to the wing tip.

R = turning radius of maneuvering aircraft.

Table 5-1 shows some characteristics of the similar large type aircraft such as DC-8-55 and Boeing 707-320, which are used for calculation of the spacing between holding positions as mentioned above; according to this table, there is little difference between these two types of aircraft.

Table 5-1 Some Characteristics of Large Turbojets

Aircraft	Wing span S	Dist from pivot point to of air-plane	Dist. of a	Juring radius R	a + R
DC-8-55	m 43.40	m 4.70	m 17.00	m 27.77	m 44.76
Boeing 707-320	m 43.40	m 10.51	m 11.19	m 33.48	m 44.67

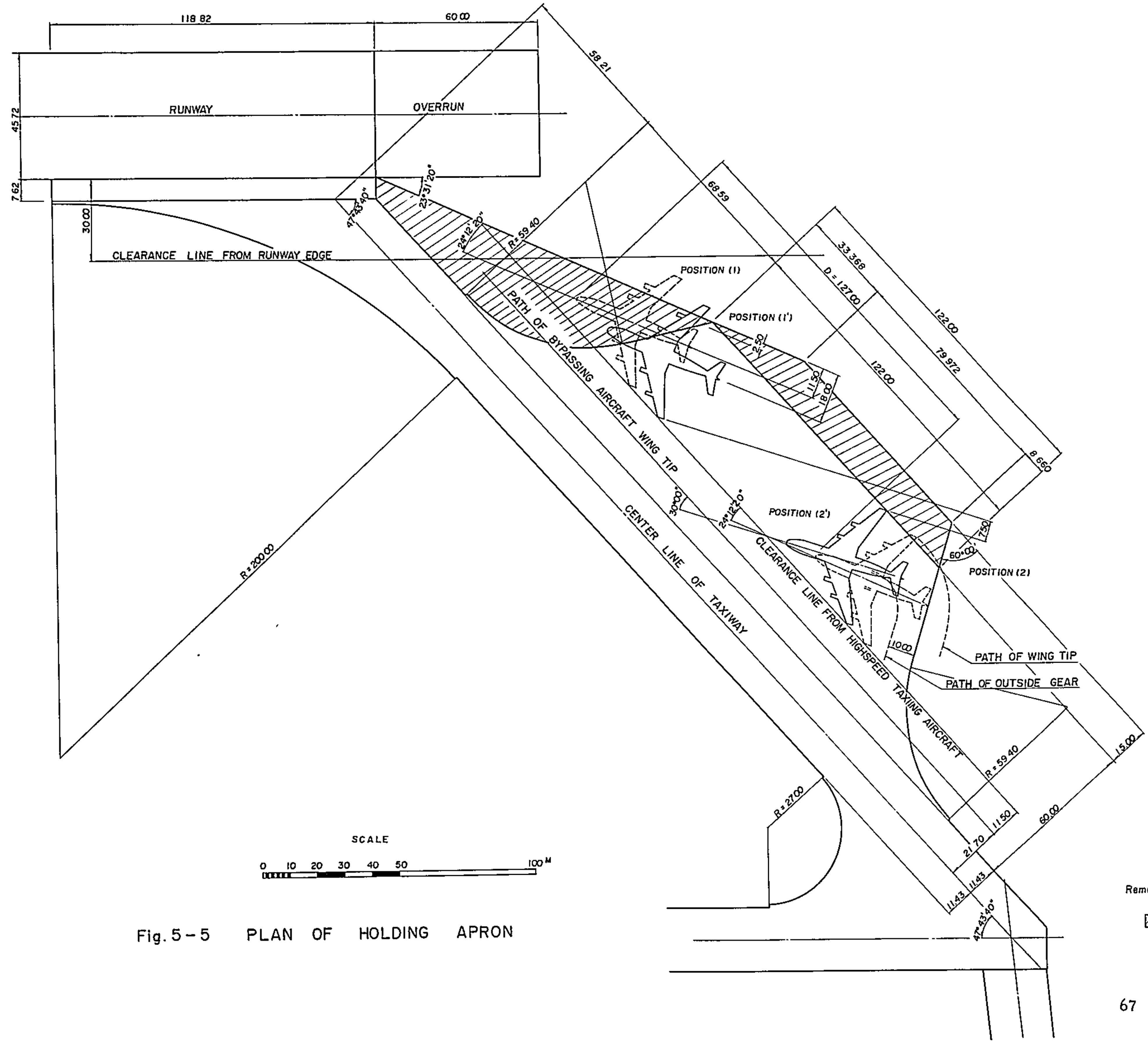


Fig. 5 – 5 PLAN OF HOLDING APRON

Remarks

---- Improved Area

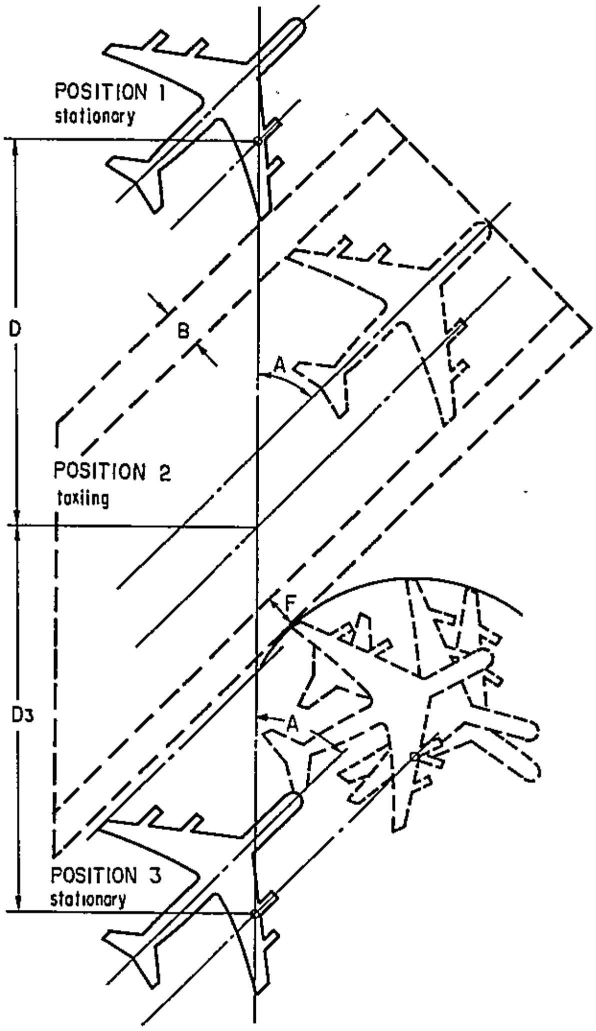


Fig 5 - 6 APRON PARKING CONFIGURATIONS

As the angle of intersection of runway and taxiway is 47°-43'-40" and that of runway and diagonal edge of holding apron is 23°-31'-20", the holding angle to the center-line of the taxiway will be 24°-12'-20".

Because if both clearances B and F are assumed at 7.5 m and the spacing is calculated by the above two equations, the value obtained by the equation (2) is 127 m and is larger than the value obtained by the equation (1). Therefore the spacing, expressed as D, is determined at 127 meters.

As shown in Fig. 5-5, a holding apron configuration such as positions (1) and (2) may be obtained for a set of conditions mentioned above, namely with a minimum clearance of 30 meters from the runway edge and a clearance of 11.5 meters between an aircraft on the taxiway and the parked aircraft.

In the case of position (2), the distance between the path of the outside main wheel and the pavement will be about 10 m., this will be sufficient, as the minimum requirement is 4.5 m according to the Annex 14 (Recommendation 1.22) to the convention on ICAO. Therefore, the holding apron will be improved as shown by broken lines in Fig. 5-5.

5-3-3 Study of Jet Blast

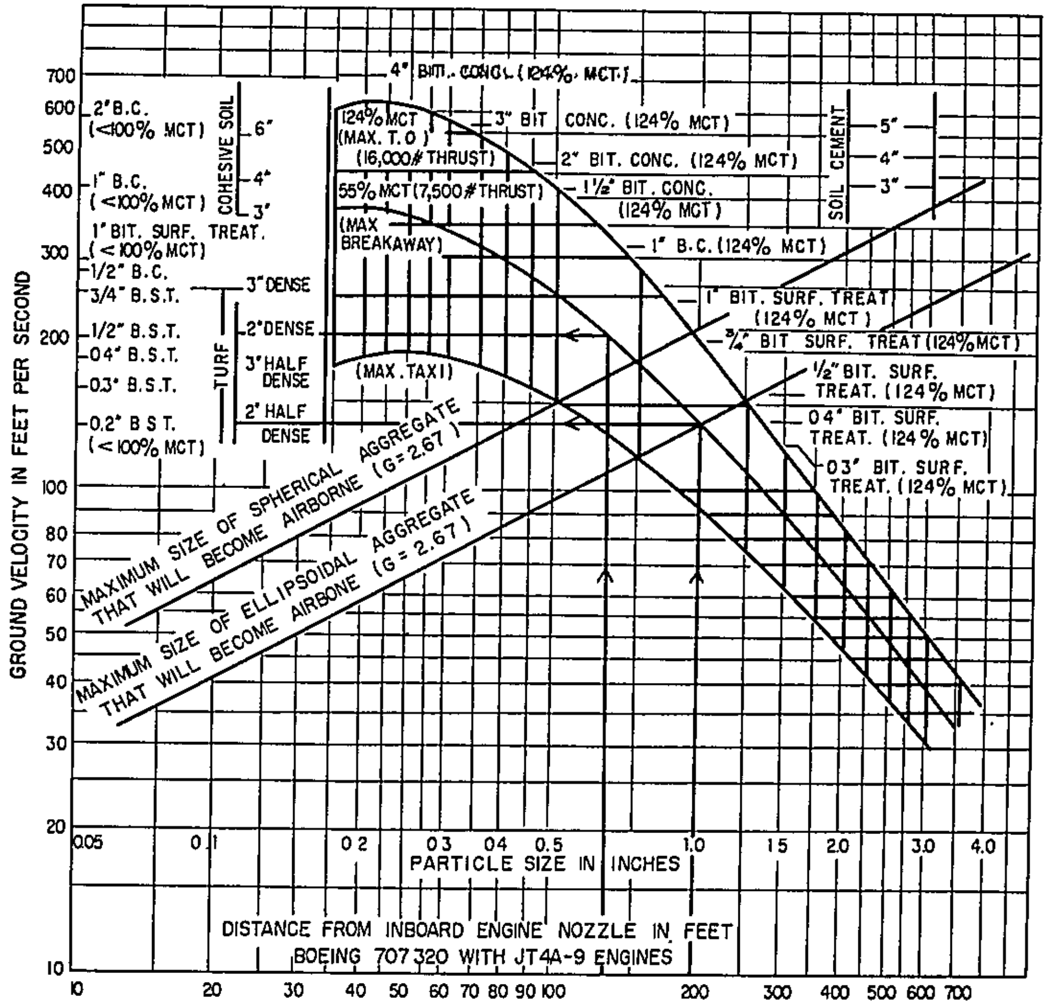
Although there are some differences among various jet aircrafts according to their weight, shape, etc., generally the maximum breakaway thrust at the apron varies from 50 to 60 percent of MCT (maximum continuous thrust, the maximum maneuvering power from 25 to 35 percent of MCT and the maximum taxiing power from 15 to 25 percent of MCT.

If the holding apron is extended to 15 m in width, the distance from the inboard engine nozzle to the edge of pavement will be about 60 m. (= 180 ft) when an aircraft is holding at position (1') and about 40 m. (= 120 ft) at position (2') (shown in Fig. 5-5); then the effects of 55% MCT on the edge of pavement was examined using Figs. 5-7 and 5-8 for the condition that the jet wake reaches the maximum take-off thrust and it was found out that according to Fig. 5-8, dense turf of 7.5 m in thickness would be sufficient for the protection of the shoulders from blast erosion.

5-4 Design of Apron Improvement

5-4-1 General

In general for determining the size of an apron, the principal factors to be taken



NOTES:

VELOCITIES SHOWN ARE MAXIMUM GROUND VELOCITIES WITH ALL FOUR ENGINES OPERATING.

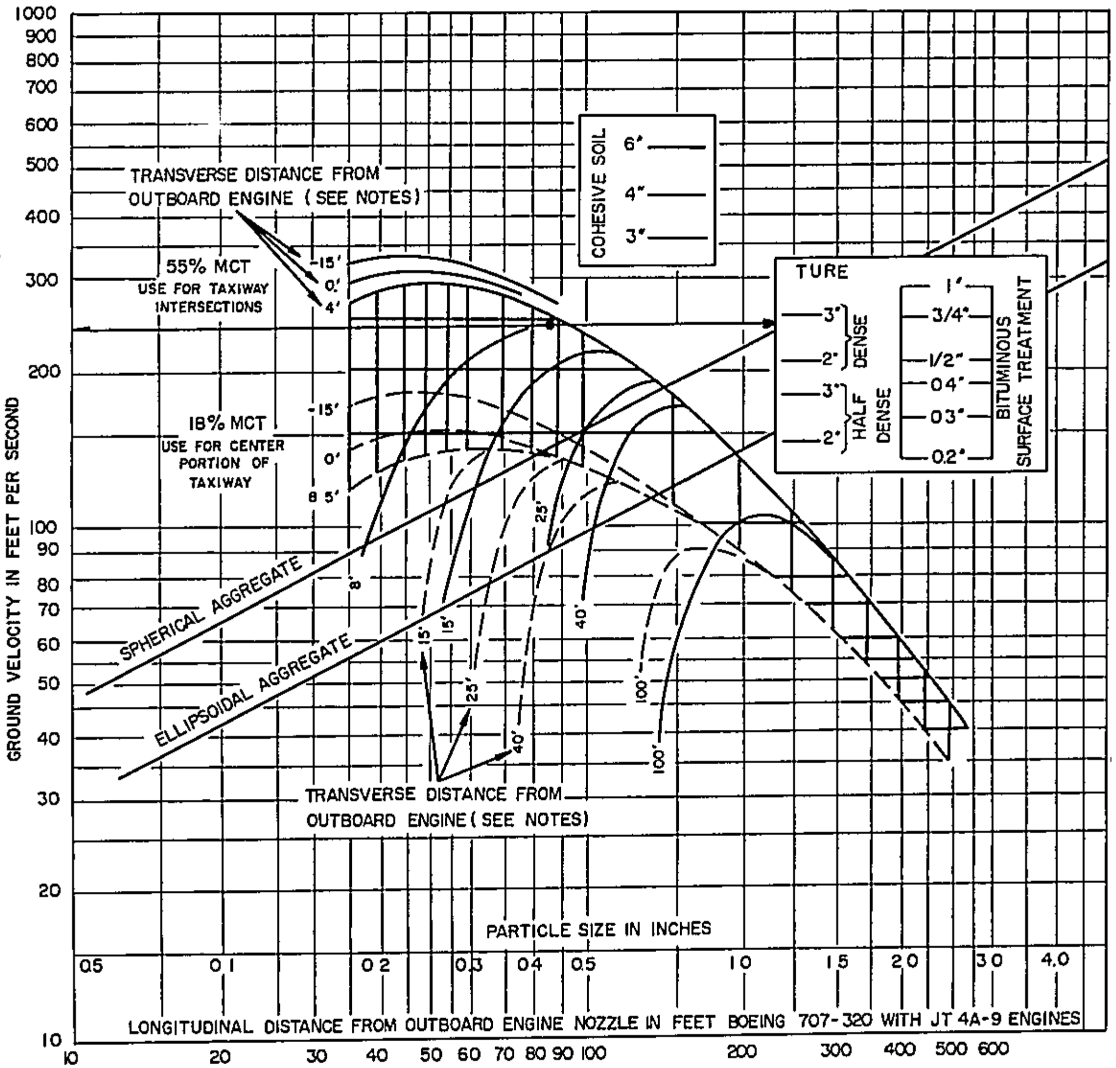
THESE VELOCITIES ARE NOT NECESSARILY IN LINE WITH THE ENGINES.

BITUMINOUS CONCRETE SPECIFIED SHOULD BE SMOOTH TEXTURED

BITUMINOUS SURFACE TREATMENT WAY BE ROUCH TEXTURED.

VELOCITY VS. PARTICLE SIZE, SURFACE, AND DISTANCE FROM NOZZLE

Fig 5 - 7



NOTES

A zero to 20 knot crosswind was assumed

All 4 engines are operating.

Negative distances on the curve represent distances inboard of the outside engine

Positive values are outboard of the outside engine.

Shoulder stabilization requirements are established by the point on the shoulder that receives the maximum ground velocity.

EXAMPLE

Given:
Transverse distance from centerline of aircraft to outboard engine = 51′-5″

Taxiway width = 75′

Aircreft side sway - 3′

Find·
Maximum shoulder treatment required for taxiways (other than at intersections).

Solution:
Before entering the graph, find the transverse distance from the outboard engine to the critical shoulder edge with the aircraft in a maximum side sway in the direction of the critical shoulder edge.

75/2-3-51 41 = -16.91 = -17′

Interpolate for the 18 per cent MCT velocity curves for -17′ transverse distance of the maximum ground velocity point which is about 45′ longitudinal distance from the out board engine Extend this point horizontally and read the stabilization required In this case, less than 2 inches of thickness of dense turf is required, use 2 inches of dense turf.

Fig 5-8 Ground velocities at various transverse and longitudinal distances from the outboard engine.

into consideration are the number of gate positions required, the aircraft parking configuration, and the size of the gate position for each type of aircraft.

In the succeeding paragraphs, the design of the apron improvement has been made by taking these three factors into account.

(1) Number of Gate Positions Required

As described in Chapter 3, the number of gate positions required, including the space required for layover, will be 7 or 8.

In this report, the apron will be designed so as to provide a total of 7 or 8 gates, consisting of 2 for turbine-powered aircraft of DC-8 class, 3 or 4 for DC-7C which is the largest airplane among the piston-engine aircraft, and 2 for twin-engine type of DC-3 class.

(2) Factors Affecting the Size of Gate Position and Parking Configuration

The International Air Transport Association (IATA) recommends to have aircraft maneuver in and out of a gate position by their own power, whenever the space of the gate position permits them to do so.

In this report, the nose-out or angled nose-out configuration is adopted so as to allow aircraft maneuver by their own power, taking into account the ground support capacity and the intermediate location of the airport on the international operating routes.

The size of the gate position and the spacing between gate positions depend on the minimum turnig radius, parking angle, clearance, and the like.

The types of aircraft adopted for design are as previously described in Chapter 3, as follows:

(1) DC-8-55 or Boeing 707-320 for turbine-powered aircraft.

(2) DC-7C for large piston-engine transport aircraft.

(3) DC-3 for small piston-engine transport aircraft.

Some principal characteristics of these aircraft are listed in Table 5-2.

Table 5-2 Data on Aircraft Features for Design

Aircraft		DC-8-55	Boeing 707-320	DC-7C	DC-3
Wing span	(S)	43.40 m	43.40 m	38.80	28.96
Length	(L)	45.95 m	46.61 m	34.21	19.66
Nose to & Main Gear	(N)	22.38 m	23.29 m	14.66	5.64
Pivot point to & Aircraft	(P)	4.70 m	10.51 m	5.19	2.82
Turn radius	(R)	27.77 m	33.48 m	24.73	17.45

The clearance between a maneuvering aircraft and the fixed or moving obstructions in an apron is given as follows by ICAO:

Wing Span	Clearance
30 m or greater	7.5 m
23 to 30 m	6.0 m
15 to 23 m	4.5 m
Less than 15 m	3 m

(3) Calculation of distances required for determining gate arrangement

Based on the sizes of aircraft and the clearances mentioned above, the distance (T) between the center of the gate and the centerline of the taxiways and the distance (P) between the center of gate and the building line are calculated for each type of aircraft as follows: (Refer to Fig. 5-9).

a) Calculations of T and P

As shown in Fig. 5-11, T and P are calculated by the following equations.

For swept wing:

$T = H\ nose + \eta \sin A - p \cos A + S/2$

or $T = H\ wing + a \cos A \sin \alpha + S/2$

For straight wing:

$T = H\ nose + \eta \sin A - p \cos A + S/2$

or $T = H\ wing + a \cos A + S/2$

For swept wing and straight wing:

$P = G + K \sin A + R$

where

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

H : clearance between an aircraft on the taxiway and a parked aircraft

A : aircraft parking angle

P : perpendicular distance from the centerline of the aircraft to the pivot point

S : aircraft wing span

a : distance perpendicular to the centerline of the aircraft from the pivot point to the wing tip

α : angle between the line perpendicular to the aircraft centerline passing from the pivot point to the wing tip

G : Clearance between an incoming turning aircraft and a building line

R : turning radius of the aircraft

K : Forward roll, 3.0 m for aircraft weighing 150,000 lb or more, 1.5 m for aircraft weighing less

T and P for specific aircraft can be computed by the above formula as follows:

Aircraft	T (m)	P (m)	Remarks
DC-8-55	41.60	37.39	Parking angle: 45°
Bo -707-320	38.24	43.10	- do -
DC-7C	36.95	33.29	- do -

The adopted values from the above table are 41.60 m and 43.10 m for the distances expressed as T for the DC-8-55 and as P for the Boeing 707-320 respectively.

b) Calculation of D

As shown in Fig. 5-10, the spacing between the parking positions D_1, D_2, and D_3 can be computed by the following formula:

$$D_1 = a \cdot \operatorname{cosec} A + C + R + K \cdot \cos A$$

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

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

where

a : distance perpendicular to the center line of the aircraft from the pivot point to the wing tip ($\doteqdot S/2-p$)

C, E, F: clearances shown in Fig. 5-10

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

Distanced between the similar large-type aircraft is calculated as shown in the next table.

Type	D_1 (m)	D_2 (m)	D_3 (m)	Descriptions
DC-8-55	61.43	56.53	73.18	Adopted value D = 73.2 m
Bo-707-32	58.92	66.99	73.04	
DC-7C	53.30	47.33	65.67	Adopted value D = 65.70 m
DC-3	41.00	30.49	49.65	Adopted value D = 49.70 m

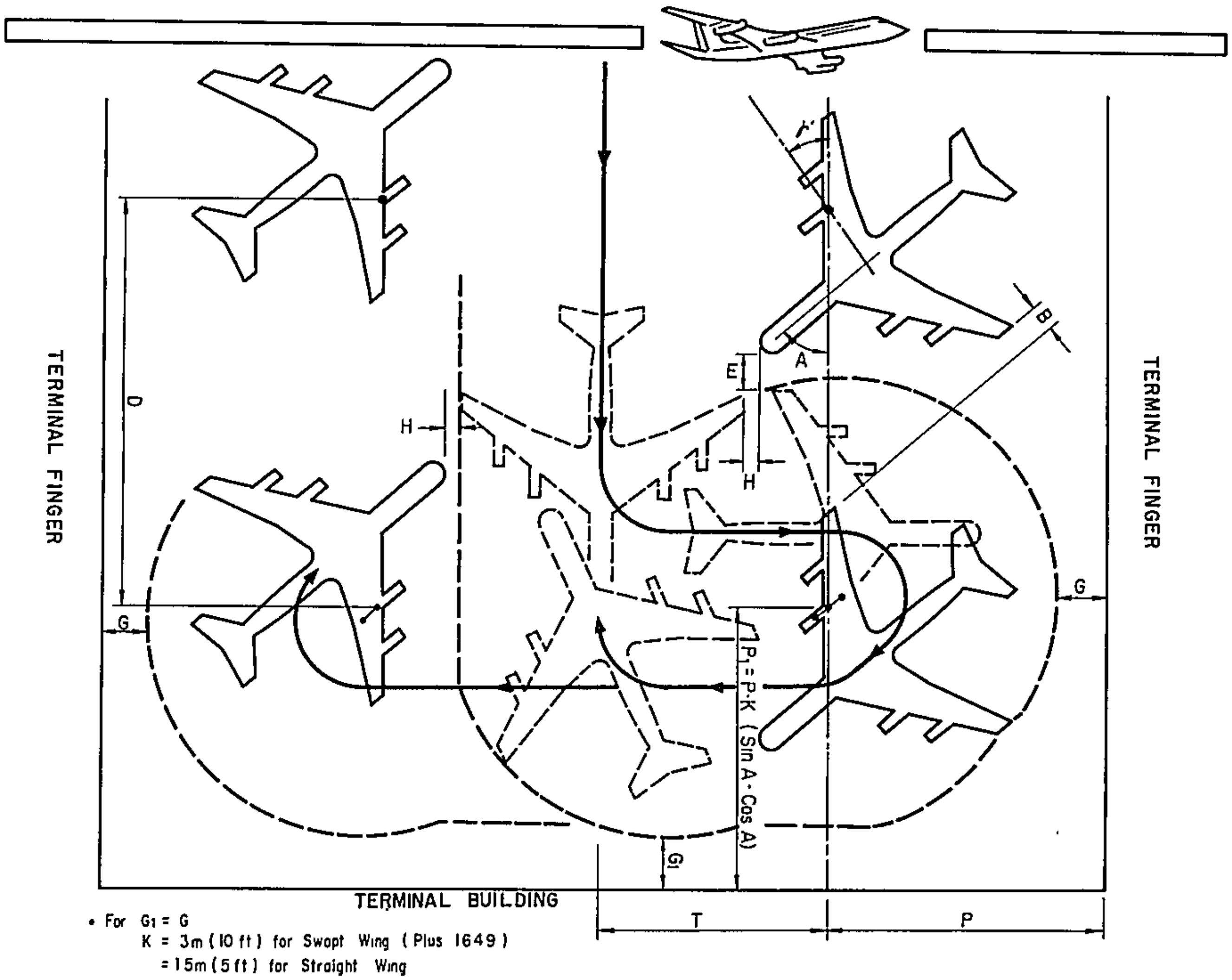


Fig 5 - 9 TERMINAL BUILDING APRON PARKING CONFIGURATION

If the case is limited to the case where an aircraft turns and taxis off the parked position by turning the D_1 and D_2 will be as follows:

$$D_1 = a + c + R = 35.11 \text{ m}$$

$$D_2 = R + E + p = 26.27 \text{ m}$$

In this case, therefore, the spacing D can be reduced to a distance of 35 meters which is less than that adopted in case of straight out.

And judging from the existing usage of apron, these gates may be used even for layover. In this case the airplane must be towed into and out of the gate position, and then the spacing D will be:

$$D = S + C \doteqdot 35 \text{ m}$$

c) Calculation of the spacing D between DC-8 and DC-7C (or Boeing 707)

As shown in Fig. 5-11, the spacing D become the maximum, when a DC-7C taxies into the gate position which adjoins a parked Dc-8 or Boeing 707.

The spacing can be obtained as follows:

$$\begin{aligned} D\ (\text{DC-7C - Bo-707}) &= K\ (\text{DC-7C}) \cos A + R\ (\text{DC-7C}) + E \\ &\quad + \eta(\text{Bo-707}) \cos A + p\ (\text{Bo-707}) \sin A \\ &= 57.19 \text{ m} \end{aligned}$$

(4) Design of Apron Improvement

By improving the east side intersection of the apron and the connecting taxiway as shown in Fig. 5-11, 7 gate positions composed of 2 for large turbine-powered aircraft, 3 for large piston-engine aircraft and 2 for small transport aircraft can be prepared, based on the numerical values obtained above. (Ref. Fig. 5-11)

When aircraft are regulated to turn and taxi out of the parked position, the spacing D can be reduced to 61.4 m for large turbine-powered aircraft and 53.3 m for DC-7C. (Ref.: Fig. 5-11)

In this case the distances between the gates can be reduced so that there can be provided gate positions for 6 aircraft in total including 2 large turbine-powered aircraft and 4 DC-7C class.

Space for the maintenance and parking of aircraft of smaller size like DC-6B can also be secured as shown in Fig. 5-11.

5-5 Structural Design of Pavements

5-5-1 General

In designing pavement structures for runway, taxiway, apron, etc., the type of

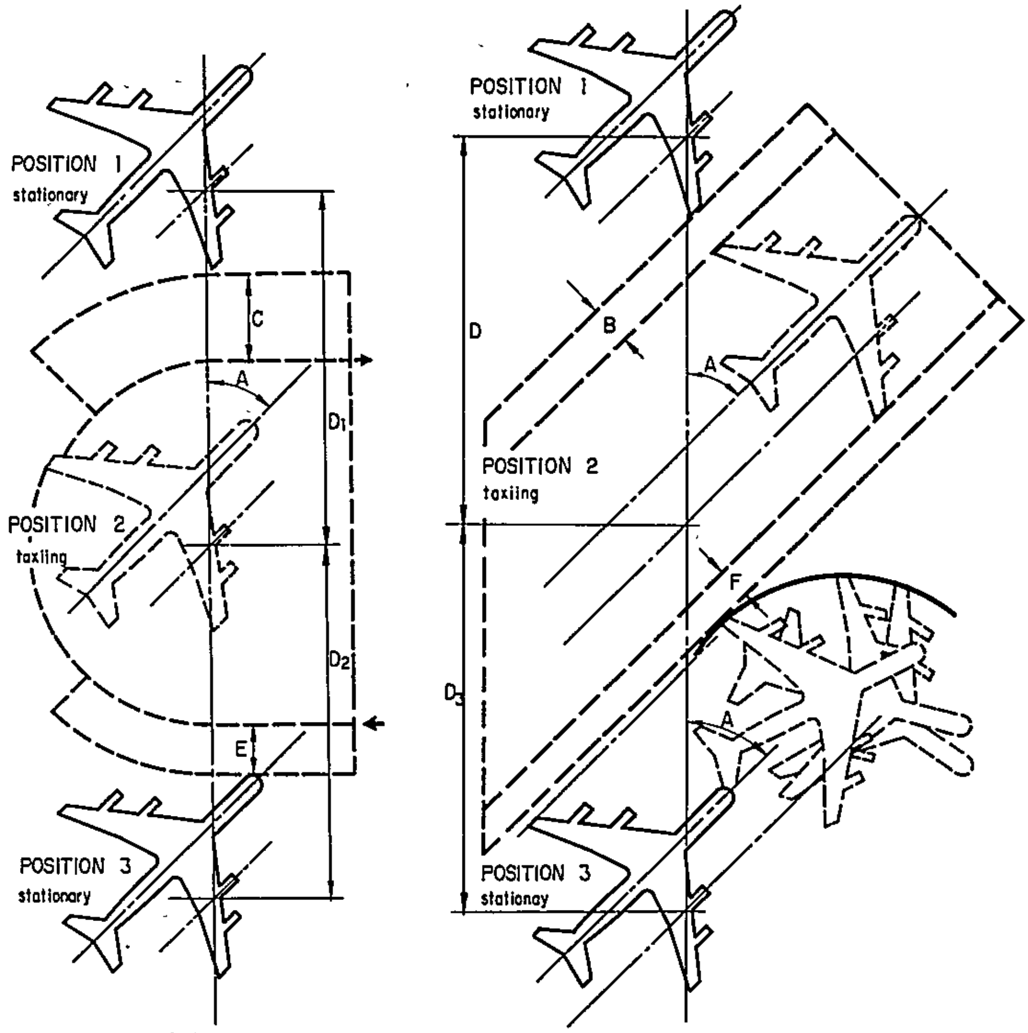


Fig 5 - 10 APRON PARKING CONFIGURATIONS

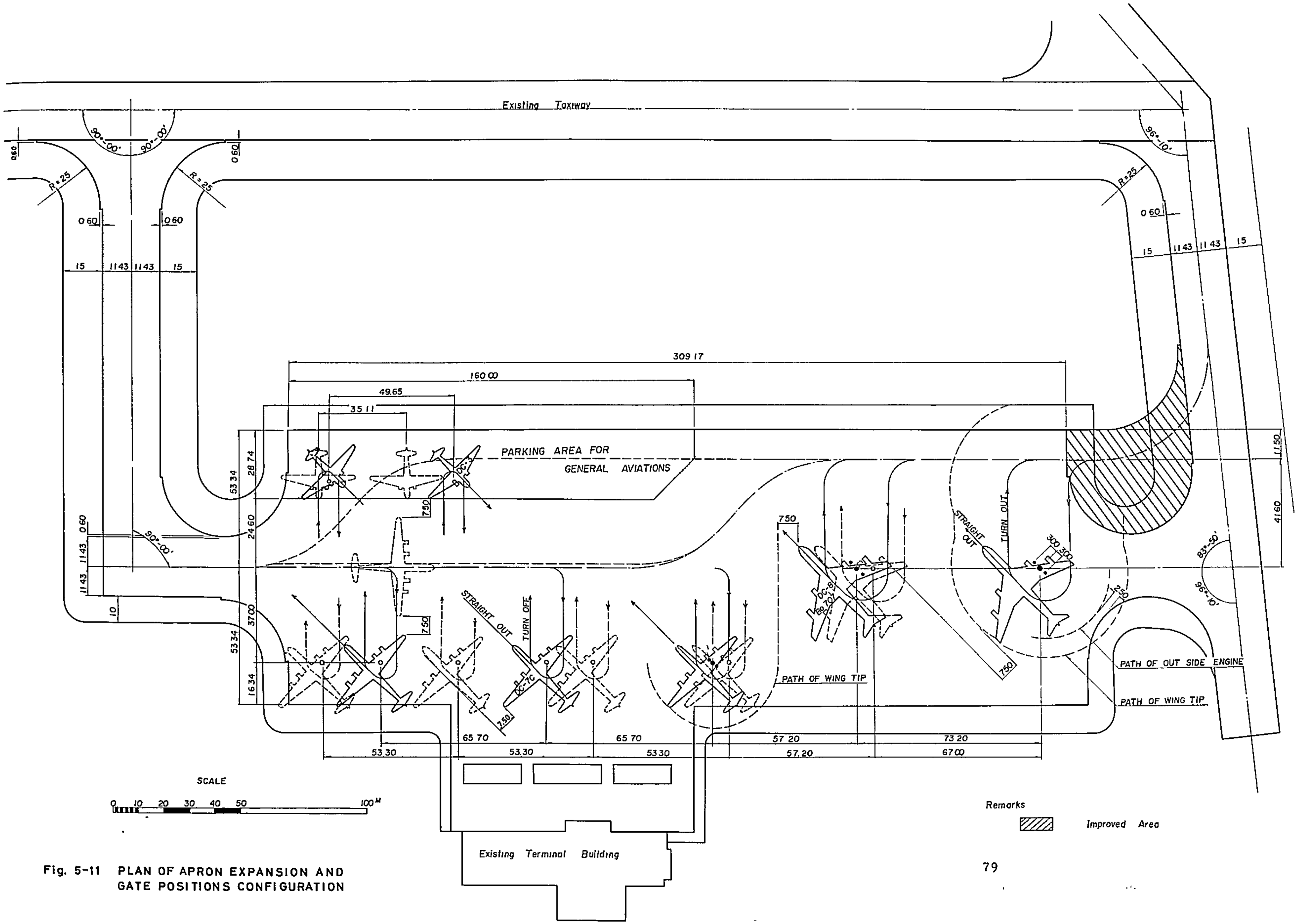


Fig. 5-11 PLAN OF APRON EXPANSION AND GATE POSITIONS CONFIGURATION

pavement should be determined first. The types of pavements can be classified into the following three types: rigid pavement (cement concrete pavement), flexible pavement (asphalt concrete pavement), and special pavement. In determining the type of pavement, the following factors should be taken into consideration:

a) Wheel load and maneuvering performance of the aircraft.
b) Characteristics of materials used for paving the surface and base course, and the availability of local materials.
c) Characteristics of subgrade soil.
d) Construction period and the construction cost.

The asphalt pavement is presumed to be not appropriate for the extension work for the following defects.

a) Difficulty of securing abundant supply of crushed stone for use on the surface and basecourse.
b) The asphalt concrete pavement requires more maintenance work and repair, and their costs are higher than those for cement concrete pavement.
c) Difficulty of control of the construction, and difficulty of obtaining locally skilled workmen and the engineers familiar with asphalt pavement.
d) Maintenance of stability of the paved surface is rather difficult due to high temperatures.

On the other hand, cement concrete pavements make up for the defects mentioned above and the pavements are more resistant to damages from jet blasts. The existing pavements in this airport are cement concrete pavements. Furthermore, no significant defects have been found in the existing pavements ever since they were constructed a few years ago.

Taking into account the conditions mentioned above, the cement concrete pavement will be used for runway and apron.

5-5-2 Design of embankment and subgrade

5-5-2-1 A study of the embankment foundation

Runway embankments must be constructed on stable foundation so that the operation of aircraft will not be interfered by undesirable settlement of ground.

Therefore, in order to investigate the characteristics of the foundation, consolidation tests and triaxial compression tests were made on the undisturbed soils sample by means of thin-wall sampler from test pits No. 1 and 2, as shown in Fig. A.1. Summary of the findings of the tests is as shown in Table 5-3.

(1) A study of settlement due to consolidation

As shown in Fig. A.3 "SOIL PROFILE OF RUNWAY EXTENSION", the heights of the embankments from Station 6 to Station 20 are within the range of 1.9 m to 2.2 m the typical cross section of the embankment including its foundation is as illustrated in Fig. 5-12.

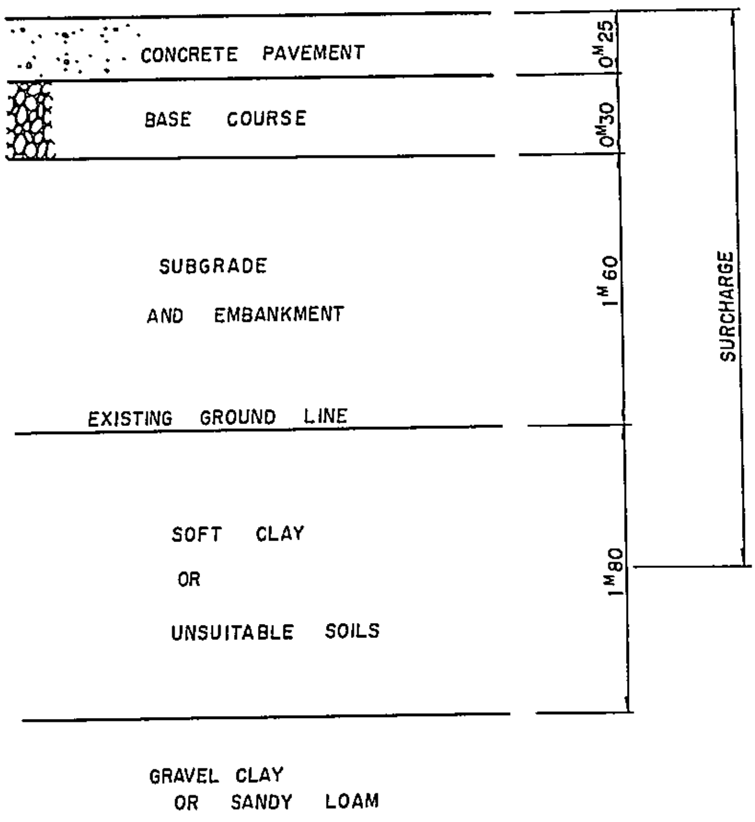


Fig 5-12 TYPICAL SECTION OF EMBANKMENT

The surcharge classified by material calculated on the basis of Fig. 5-12 is as shown in Table 5-4.

Table 5-4 Total Surcharge

Materials	Thickness (m)	Unit Weight (t/m^3)	Surcharge (t/m^2)
Concrete pavement	0.25	2.35	0.59
Base course	0.3	2.26	0.68
Embankment	1.6	2.13	3.41
Unsuitable soils	0.9	2.00	1.80
Total surcharge		p =	6.48

(2) Calculation of consolidation settlement

This sub-paragraph shows the calculated consolidation settlement at test pit No. 2 calculated from the test results given in Table 5-3.

Consolidation settlement can be calculated as 1.1 centimeters by the following formula.

$$S = \frac{eo - e}{1 + eo} Ho = 1.1 \text{ cm}$$

where,
- S : consolidation settlement
- eo : initial void ratio of soil at pre-loading pressure in "e - log p" curve
- e : final void ratio of soil at pressure p in "e - log p" curve
- Ho : thickness of consolidatable soil layer

(3) A study of the bearing capacity of embankment foundation

It is assumed that the gear load of an aircraft on the runway is distributed through the embankment uniformly as shown in Fig. 5-13.

Therefore, the intensity "q" of total load on the clayey soil layer is calculated from Fig. 5-13 as shown in Table 5-4.

$$q = q_1 + q_2 = 6.56 \text{ t/m}^2$$

where,
- q_1: intensity of load ($\frac{P}{L \times W}$) on unsuitable soil
- q_2: intensity of load due to pavement, base course and embankment

(a) Calculation of bearing capacity

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

For general shear failure

$$q_z = 1.26\, C.Nc + 0.413,\ r.B.N_r + r,\ D_f,\ Nq$$

For local shear failure

$$q_d = 1.26\, C.Nc' + 0.413,\ r.B.N_r + r,\ D_f,\ N_q'$$

where,	q_z, qd	:	ultimate bearing capacity of clay
	C	:	cohesion of soil
	r	:	bulk density of soil
	Nc, Nr, Nq	:	coefficient determined from the internal
	Nc', Nr', Nq'	:	friction angle of soil
	B	:	width of footing
	D_f	:	depth of footing

(b) Safety factor of bearing capacity

The safety factors are calculated from the ultimate bearing capacities and the loading intensities, and the calculated results are indicated in Table 5-5.

The results of the calculations are shown in Table 5-5.

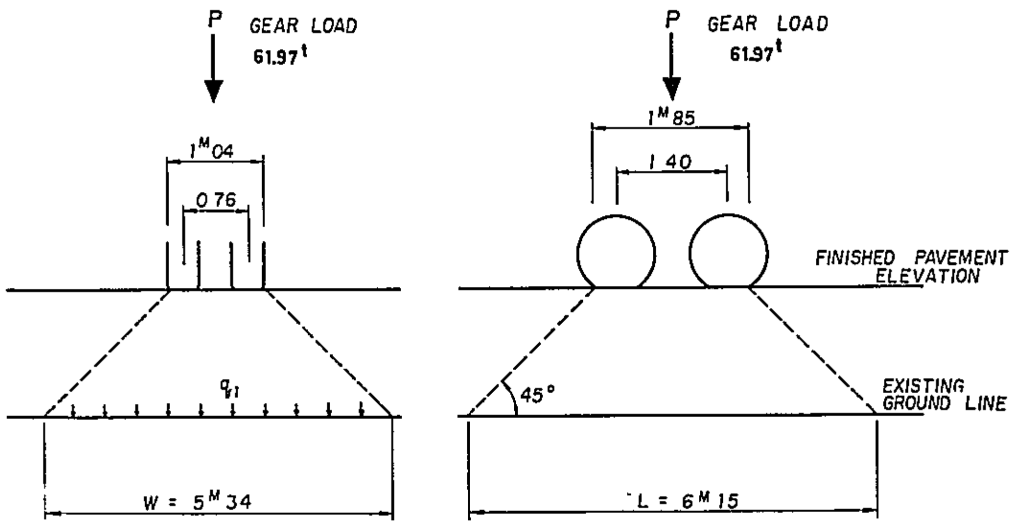


Fig 5-13 DISTRIBUTION OF AIRCRAFT GEARLOAD IN SOILS

TABLE 5-3 SUMMARY OF SOIL TEST							
STATION NUMBER			10			20	
SAMPLE NUMBER			TP 1 - 1	TP 1 - 2	TP 1 - 3	TP 2 - 1	TP 2 - 2
DEPTH (M)			1.10 - 1.30	2.00 - 2.20	3.00 - 3.20	0.70 - 0.9	1.40 - 1.60
COLOUR			MILK WHITE	MILK WHITE	MILK WHITE	MILK WHITE	MILK WHITE
PROPERTIES	NATURAL WATER CONTENT W %		25.31	17.37	26.00	18.59	18.19
	SPECIFIC GRAVITY OF SOIL G		2.72	2.66	2.74	2.67	2.66
	WET DENSITY (g/CM^3)		1.956	2.025	2.005	2.025	2.013
	DRY DENSITY (g/CM^3)		1.561	1.725	1.591	1.708	1.703
	VOID RATIO		0.742	0.542	0.722	0.563	0.562
	DEGREE OF SUTURATION S (%)		92.78	85.25	98.67	88.16	86.10
GRAIN SIZE	PROPOR-TION	GRAVEL (%)	1	1	0	0	0
		SAND (%)	16	62	14	39	43
		SILT (%)	45	29	50	43	48
		CLAY (%)	38	9	36	18	19
	MAX DIAMETER (MM)		4.8	2.0	2.0	2.0	2.0
	60% DIAMETER D_{60} (MM)		0.05	0.135	0.052	0.072	0.09
	10% DIAMETER D_{10} (MM)		-	0.0093	-	-	-
	UNIFORMITY COEFFICIENT		-	14.52	-	-	-
	CLASSIFICATION		CLAY	SANDY LOAM	CLAY	LOAM	LOAM
	LIQUID LIMIT		54.71		63.60	22.45	25.24
	PLASTIC LIMIT		16.28		16.58	11.25	11.51
	PLASTICITY INDEX		38.43		47.02	11.20	13.73
	FLOW INDEX		17.00		14.70	5.01	9.46
TRIAXIAL COMPRESSION	COHESION C (kg/CM^2)		0.100	0.360	0.140	0.167	0.45
	INTERNAL FRICTION ANGLE		1° - 43'	27° - 12'	4° - 28'	10° - 59'	7° - 08'
CONSOLIDATION	INITIAL VOID RATIO		0.666	0.523	0.664	0.510	0.498
	PRECONSOLIDATION LOAD Po (kg/CM^2)		1.37	0.78	1.94	0.98	0.46
	COMPRESSION INDEX Cc		0.133	0.040	0.142	0.173	0.076

Table 5-5 Safety Factor of Clayey Soil Layer in Terms of Bearing Capacities

ITEM			TP1-1	TP2-1
General Shear Failure	Ultimate bearing capacity (t/m^2)		11.50	32.74
	Safety Factor	For Aircraft Gear Load + Dead Load	1.75	5.00
		For Dead Load only	2.46	6.95
Local Shear Failure	Ultimate Bearing Capacity (t/m^2)		9.10	19.74
	Safety Factor	For Aircraft Gear Load + Dead Load	1.39	3.00
		For Dead Load only	1.95	4.20

As shown in this table, any safety factors of foundation shear failure for total load except that of general shear failure at TP1-1 is less than 3.0, the standard value for the embankment work. Accordingly some countermeasure to improve the value is necessary to be taken.

(4) Measures against clayey soil layer

To sum up the results calculated in paragraphs (1) and (2), consolidation settlement of clayey soil layer is found to be satisfactorily small. However, the bearing capacity of this layer is not sufficient to support the new runway embankment, and some measures should be taken as stated above.

As shown in Fig. A.3 "SOIL PROFILE OF RUNWAY EXTENSION", the thickness of clayey soil layer is rather small and easy to remove. Therefore it is decided to replace the layer with some suitable material to improve the bearing capacity.

Since the groundwater table is about 50 cm below the existing ground surface, sand or excavated gravel would be most suitable as the material for the replacement.

The layer of the subgrade to be replaced will be the portion between Sta. 6 - Sta. 20, and under the extended runway including the shoulders as shown in Fig. 5-14.

5-5-2-2 A study of materials for embankment and subgrade

1) Embankment and subgrade materials

It is expected that the earthwork will amount to about 110,000 m^3 in this runway extension project. It would be most economical to construct the embankment in the section of Sta. 3 to Sta. 29 with the materials obtained from the cutting in the area between Sta. 30 and Sta. 53. Accordingly the characteristics of the soil in the cutting area to be used for embankment material are studied hereinafter.

The test results of the embankment materials are summarized in Table 5-6. As shown in Table 5-6 and Fig. A.3 "SOIL PROFILE OF RUNWAY EXTENSION", the materials to be obtained from cut area are mostly cohesive soils including clay, loam, clayey loam and sandy loam etc., and as the liquid limits are less than 50%. These soils are usable as the embankment materials if these are compacted to specified densities.

Between the optimum moisture content of the each material and the natural moisture content, there is little difference between them, as shown in Table 5-7.

Table 5-7 Natural Moisture Content and Optimum Moisture Content of the Embankment Materials

Sample Number	Classifications	Wn (%)	O.m.c. (%)
TP 4-1	Clay	8.0	11.2
TP 5-1	Loam	12.2	8.5
TP 8	Sandy clayey loam	8.4	8.6

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

In connection with the subgrade materials a study was made in order to find out the suitable materials and CBR tests were made on the soils samples from TP 4, 5 and 8. Relations between soaked CBR value and compacted density of each material are shown in Table 5-8.

TABLE 5-6 SUMMARY OF SOIL TESTS ON EMBANKMENT MATERIALS

						REMARKS
STATION NUMBER NO.		45		53		
SAMPLE NUMBER NO.		TP4-1	TP4-2	TP5-1	TP5-2	
DEPTH (M.)		1.00 - 1.20	2.50 - 2.70	1.0 - 1.20	1.50 - 1.70	
PROPERTIES	NATURAL WATER CONTENT W (%)	7.96	11.43	12.24	14.50	
	SPECIFIC GRAVITY OF SOIL G	2.70	2.70		2.69	
	WET DENSITY r_t (g/CM^3)					
	DRY DENSITY r (g/CM^3)					
	VOID RATIO e					
	DEGREE OF SATURATION S %					
GRAIN SIZE	PROPOR-TION: GRAVEL (%)	0		0		
	PROPOR-TION: SAND (%)	16.0		44.0		
	PROPOR-TION: SILT (%)	39.0		37.0		
	PROPOR-TION: CLAY (%)	45.0		19.0		
	MAX. DIAMETER (M.M.)	2.0		2.0		
	60% DIAMETER (M.M.)	0.016		0.084		
	10% DIAMETER (M.M.)	-		-		
	UNIFORMITY COEFFICIENT	-		-		
	CLASSIFICATION	CLAY	CLAY WITH GRAV-EL	LOAM	LOAM	
CONSIST-ENCY	LIQUID LIMIT	24.20	28.90	18.95	20.65	
	PLASTIC LIMIT	14.32	20.51	15.22	17.03	
	PLASTICITY INDEX	9.88	8.39	3.73	3.62	
	FLOW INDEX	4.65	8.80	7.60	7.25	
COMPACTION TEST	O.M.C. (%)	11.20		8.50		
	MAX. DRY DENSITY (g/CM^3)	1.955		2.083		
C.B.R. TEST (%)	10 FLOWS	8.54	16.27	7.73	4.52	NATURAL WATER CONTENT DISTURBED, SOAKED FOR 4 DAYS
	25 FLOWS	9.35	14.23	5.21	5.94	
	55 FLOWS	7.86	15.56	6.81	5.10	
	DESIGN C.B.R.	7.86	14.23	5.21	4.52	

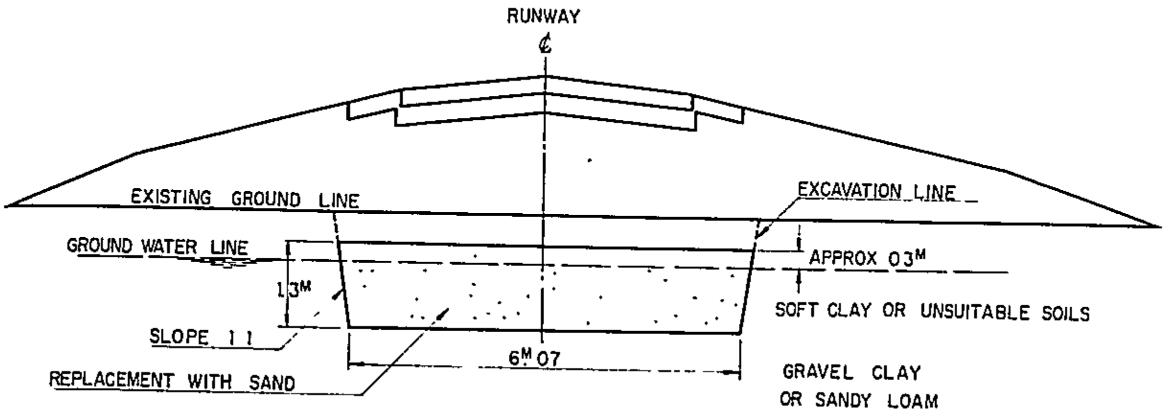


Fig 5-14 TYPICAL SECTION OF REPLACEMENT PORTION

Table 5-8 Relations between CBR and Compacted Density

Sample Number	CBR soaked for 4 days (%)	
	90% density	95% density
TP 4-1	12.7	17.2
TP 5-1	11.3	13.0
TP 8	17.5	21.5

In consideration of the CBR value and the consistency of the materials, the materials available in the cutting area can be used for the subgrade if handled with due care.

As regards the cut-off portion of the subgrade, sufficient bearing capacity can be obtained through appropriate compaction because the nature of the soil is such as mentioned above. Therefore the abovementioned soil will be used as embankment material and also as subgrade material in this project.

2) Design CBR value and K-value of the subgrade

As shown in Fig. A. 3 "SOIL PROFILE OF RUNWAY EXTENSION", the materials excavated in the cutting area covering Sta. 30 to Sta. 52 are mostly sandy loam, loam, and clay.

As shown in Table 5-6, the CBR value of the soils sampled from each test pit was 7.86% at maximum, 4.52% at minimum, and 5.86% on an average. Therefore, design CBR value of runway subgrade can be determined as follows according to the method shown in "Asphalt Pavement Manual" published by Japan Road Institute.

$$\text{Design CBR} = \text{avarage value of each CBR value} - \frac{\text{Maximum CBR value} - \text{Minimum CBR value}}{d_2}$$

$$= 4.1\% = 4\%$$

where, d_2: the coefficient determined from the number of samples.

Therefore, design CBR of 4% will be used for the subgrade.

In general, the K-value of the subgrade is measured by platebearing test, but the test was not carried out during the field investigation because the test involves a large cost and long time. Therefore the K-value were estimated from the CBR value of the subgrade soil.

Fig. 5-15 has been quoted from Design of Concrete Pavement (PCA), in which the curves show the relations between CBR and K-value. From this Figure, design K-value, K75, was decided as 3.5 kg/cm^3 from design CBR of 4% of the subgrade.

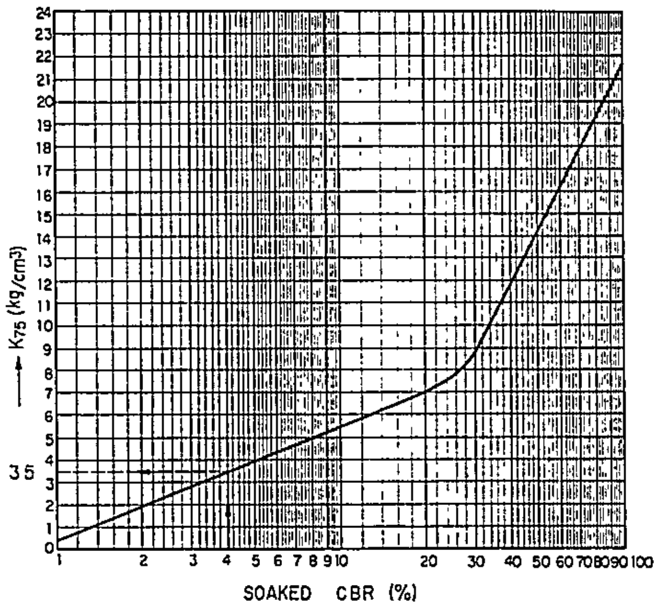


Fig 5-15 RELATION BETWEEN C.B.R.VALUE AND K. VALUE

5-5-3 Design of Base Course

5-5-3-1 Base Course Materials

As mentioned in "Concrete Pavement Manual" published by Japan Road Institute, usually the material to be used in the base course for concrete pavement will be of the C. B. R. value of not less than 30%.

Crusher-run material seems to be suitable for the base course material in this project. However, if suitable selected material can be obtained from borrow pits adjacent to the site, the use of such material will enable to reduce the construction cost.

Therefore, in order to check its usability for the base course material, C. B. R. tests were performed on several samples made of mixture of sand and selected material.

The test results are summarized in Table 5-9.

Table 5-9 C. B. R. Values of Mixed Material (Disturbed Samples of 95% Density, Soaked for 4 Days)

Sample Number	Depth (m)	Classification	Sand Content (%)			
			0	20	30	40
TP. 9	2.0 - 2.5	Gravel with clay	31.4	38.3	40.7	-
TP. 10-1	1.3 - 1.5	Silty clay	15.5	18.2	20.8	28.6
TP. 10-2	1.5 - 1.7	Gravel with clay	30.5	-	-	-
TP. 10-3	2.5 - 2.7	Gravel with clay	27.8	34.5	39.5	46.0

As shown in this table, the C. B. R. values of the selected material obtained from the proposed borrow pits in TOM BOM village shown in Fig. A. 2 are about 30% even without mixing it with sand. However, taking into account the severer moisture condition at the site in rainy season than the condition of the C. B. R. test with soaking period of 4 days, the borrow pit material will be used as base course material after being mixed with 20% of sand in order to lower the plasticity index of the said material.

5-5-3-2 Determination of base course composition and its thickness

For determination of the base course composition and its thickness, it is important to design the most economical base course by taking in consideration the material characteristics, the climate conditions at the site and the availability of the material, etc. In general, the determination of the base course thickness is made by the following methods:

(a) the plate-bearing test on the compaction pits of several compositions in the site.

(b) experimental estimation of subgrade K value

In this report, the latter method is used for the determination of base course thickness.

The relationship between subgrade K-value, base course K-value and the base course thickness can be represented experimentally by the following equation.

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

where, h: base course thickness (cm)

a: diameter of the bearing-plate (cm)

: constant

: coefficient determined from the base course material

By substituting the values determined experimentally in this equation, the curves shown in Fig. 5-16 can be obtained.

In general, the bearing capacity of the base course is represented by using the K-value obtained from plate-bearing tests while it is assumed from past experiences that the K-value of 7kg/cm^2 (250 lb/square inch) is sufficient for the base course for concrete pavement.

The thickness of the base course with the K-value of 7kg/cm^2 on the subgrade having a K-value of 3.5kg/cm^2 can be determined as shown in the Fig. 5-16. Then from Fig. 5-16, the proposed base course compositions will be determined and shown in Fig. 5-17.

As described in Chapter 3, the rainy season in Vientiane area lasts five months in the year. Therefore, it is expected that the bearing capacity of the base course will decrease by soaking in that season. For this reason, the value of 7.0 x 0.8 = 5.6kg/cm^3 (200 lb/square inch) is adopted for the design K-value in calculation of concrete stress.

5-5-4 Calculations of Concrete Slab Thickness and Stresses in Concrete Slab

The thickness of the existing pavement of this airport is 11 inches in each runway end portion of 300 m length and taxiways, apron and holding apron, and 10 inches elsewhere. If the different thickness from the existing one is adopted for the design, it will make future overlay projects more intricate. Therefore, the thickness of new concrete

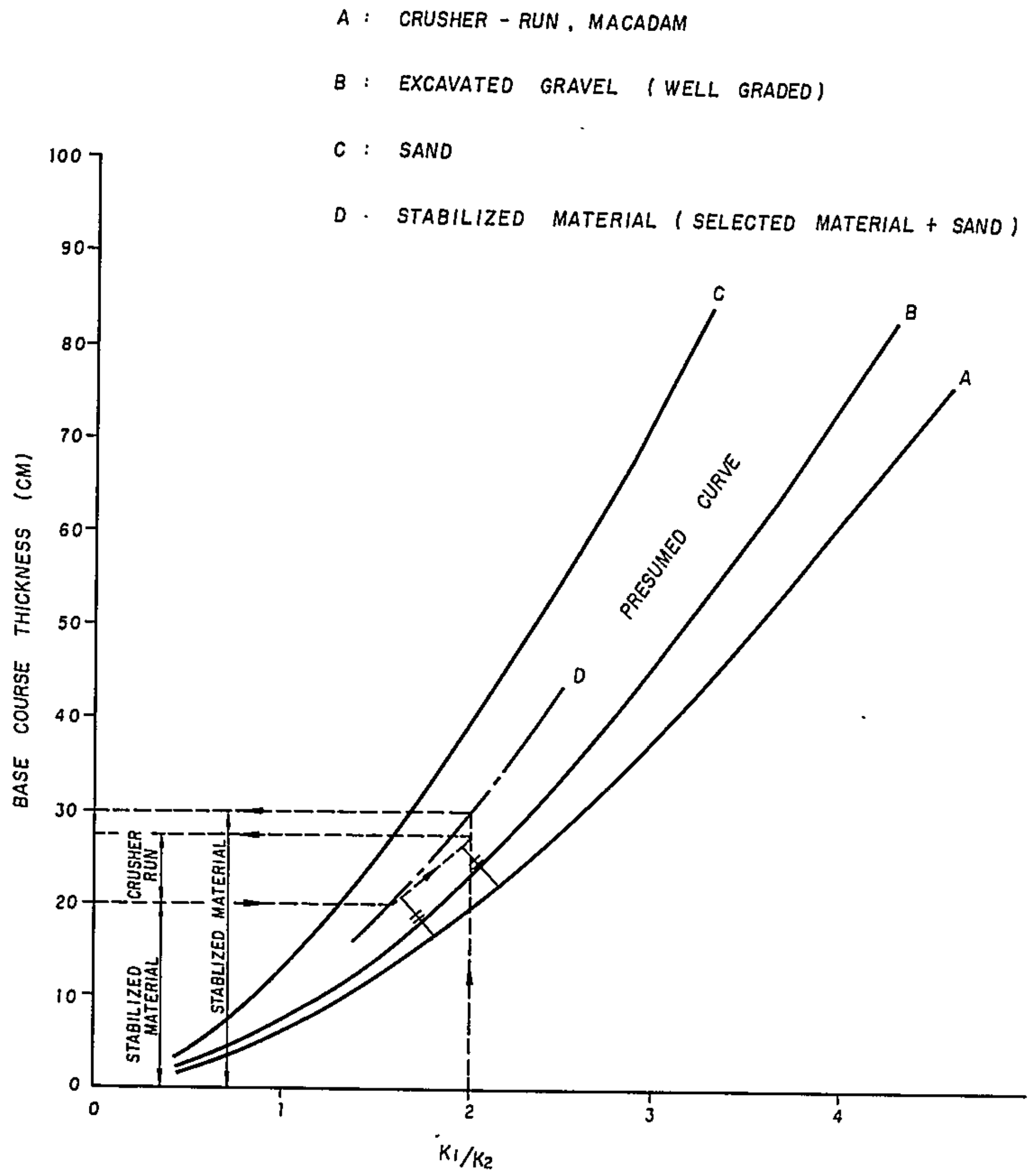


Fig 5-16 RELATIONSHIP BETWEEN BASE COURSE THICKNESS AND K_1/K_2 FOR SEVERAL MATERIALS

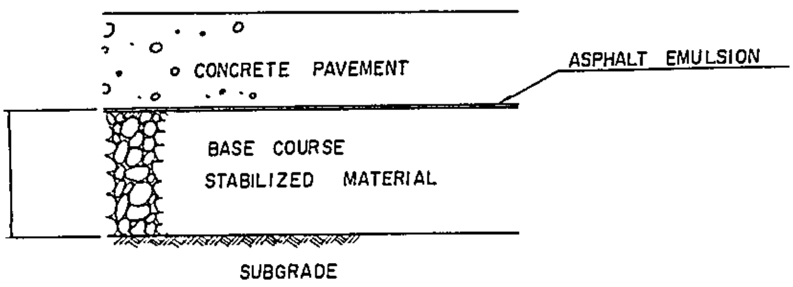


FIG.5-17 PROPOSED BASE COURSE COMPOSITIONS

pavement is designed equal to that of the existing pavement, and then, the calculations of stresses in concrete slabs and safety factor are calculated in this paragraph. In this paragraph the trial estimation is also made of allowable number of aircraft operations for the various safety factors.

The factors to be considered for the calculations are as follows:

Critical aircraft	DC-8-55
Gross weight	297,000 lb
Tire pressure	175 psi
Type of gear	dual - tandem
Tire arrangement	S = 30 inches
	ST = 55 inches
	SD = 62.7 inches
Base course K-value	200 pci (5.6 kg/cm^3)
Flexural strength of concrete at 28 days	645 psi (45 kg/cm^2)

i) Determination of equivalent single-wheel load (E.S.W.L.)

(This is based on the F.A.A. method used)

In the case of pavement thickness, h = 11 inches:

Radius of relative stiffness: 38.81 inches

Total contract area: 702.62 sq. in

From the above values and Fig. 5-18,

E.S.W.L. = 48,600 lbs

In the case of pavement thickness, $h = 10$ inches:

Radius of relative thickness: 36.14 inches

Total contact area: 702.62 inches

From the above

E.S.W.L. = 46, 600 lbs

ii) Calculation of tensile stress

a) When Westergaard's formula for center-loading is used:

$$\left.\begin{matrix}\sigma y \\ \sigma x\end{matrix}\right\} = \left[\frac{p}{h^2}\ 0.275\,(1+\mu)\log_{10}\frac{E\,h^3}{K\left(\frac{a+b}{2}\right)^4} \mp 0.239\,(1+\mu)\frac{a-b}{a+b}\right]$$

In the case h (thickness) = 11 inches:

From the above equation:

$$\left.\begin{matrix}\sigma x \\ \sigma y\end{matrix}\right\} = 420.52 \text{ psi } (29.4 \text{ kg/cm}^2)$$

or 461.50 psi (32.3 kg/cm^2)

where,

$$A = \frac{E.S.W.L.}{\text{Tire pressure}}$$

$$a = \sqrt{\frac{A}{0.6 \times \pi}} \qquad b = a \times 0.6$$

In the case h (thickness) = 10 inches:

$$\begin{matrix}\sigma x \\ \sigma y\end{matrix} = 475.32 \text{ psi } (33.3 \text{ kg/cm}^2)$$

or 522.9 psi (36.6 kg/cm^2)

b) When G Pichett and G.K Ray's "Influence Charts" are used in the calculation:

Calculation of stress

Using the Influence Chart No. 2 "Influence Chart for the moment M in a concrete pavement due to a load in the interior of the slab", the stress is calculated from Fig. 5-19 as shown below:

In the case h (thickness) 11 inches:

$$M = \frac{q.N.1^2}{10,000} = 909.85$$

$$\sigma = \frac{6\,M}{h^2} = 451 \text{ psi } (31.6 \text{ kg/cm}^2)$$

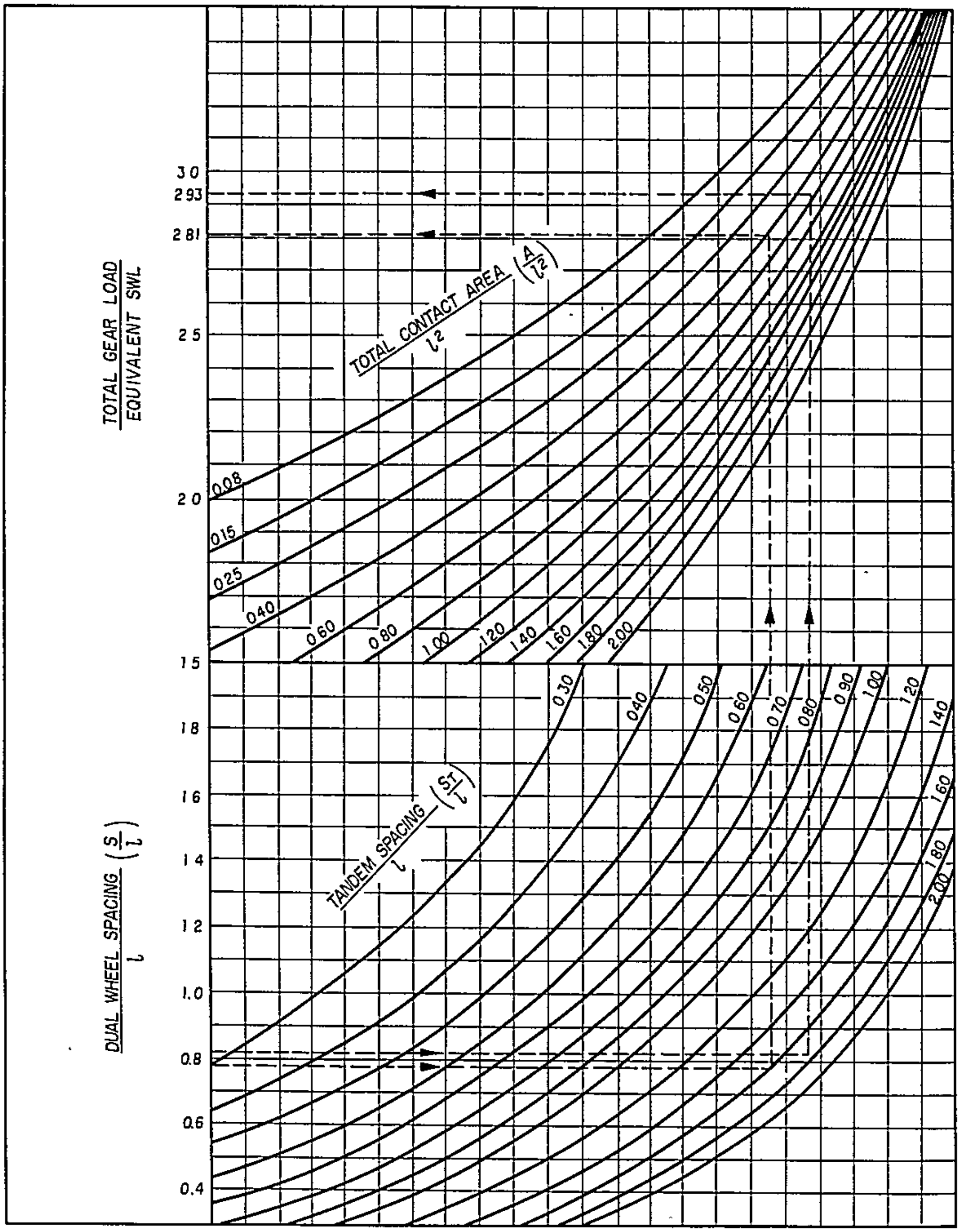


Fig 5-18 Chart for Determination of Equivalent Single Wheel Load-Rigid Pavements-Dual Tandem Gear

where: q: contact pressure (psi)

N: number of blocks

l: radius of relative stiffness

In the case h (thickness) = 10 inches:

Using the "Influence Chart No. 2" the stress is calculated on the basis of Fig. 5-20 as shown below.

M = 969.42

σ = 522 psi (36.5 kg/cm^2)

iii) Estimations of safety factors and allowable number of aircraft operations

The values of safety factor of concrete slab under various conditions are as shown in the table below, when design flexural strength σ_{ba} = 645 psi

Pavement thickness (inch)	Flexural strength (psi)	H. M. Westergaard		G. Pickett, G.K. Pay	
		σ (psi)	Safety factor	σ (psi)	Safety factor
11.0	645	462	1.40	451	1.43
10.0	645	523	1.23	522	1.24

From these values of safety factor the allowable number of stress repetitions can be obtained as follows by using Fig. 5-21.

Allowable number of stress repetions = about 4,000 coverage.

Since one coverage is equivalent to 16 operations for large, turbine-power aircraft such DC-8, allowable number of aircraft operations becomes 64,000 operations (4,000 x 16 = 64,000). As mentioned in Chapter 3, the number civil aircraft operations at this airport will be from 530 to 790 operations per month, or 22 operations per day on an average, for the 5 or 10 years to come. Therefore, if the average number of operation of DC-8-55 at this airport is assumed at 17 operations/day (on the assumption that 80% of the daily operations at this airport is that of DC-8) the annual number of operation will be 6,200 operations/year, and

$$64,000 \div 6,200 \doteqdot 10 \text{ years}$$

so that the extended runway will have a usable life of 10 years. However, the remaining life of the existing runway is not known, and other factors also be taken into account, care must therefore be taken to carry out the improvement or repair of the overlay when necessary.

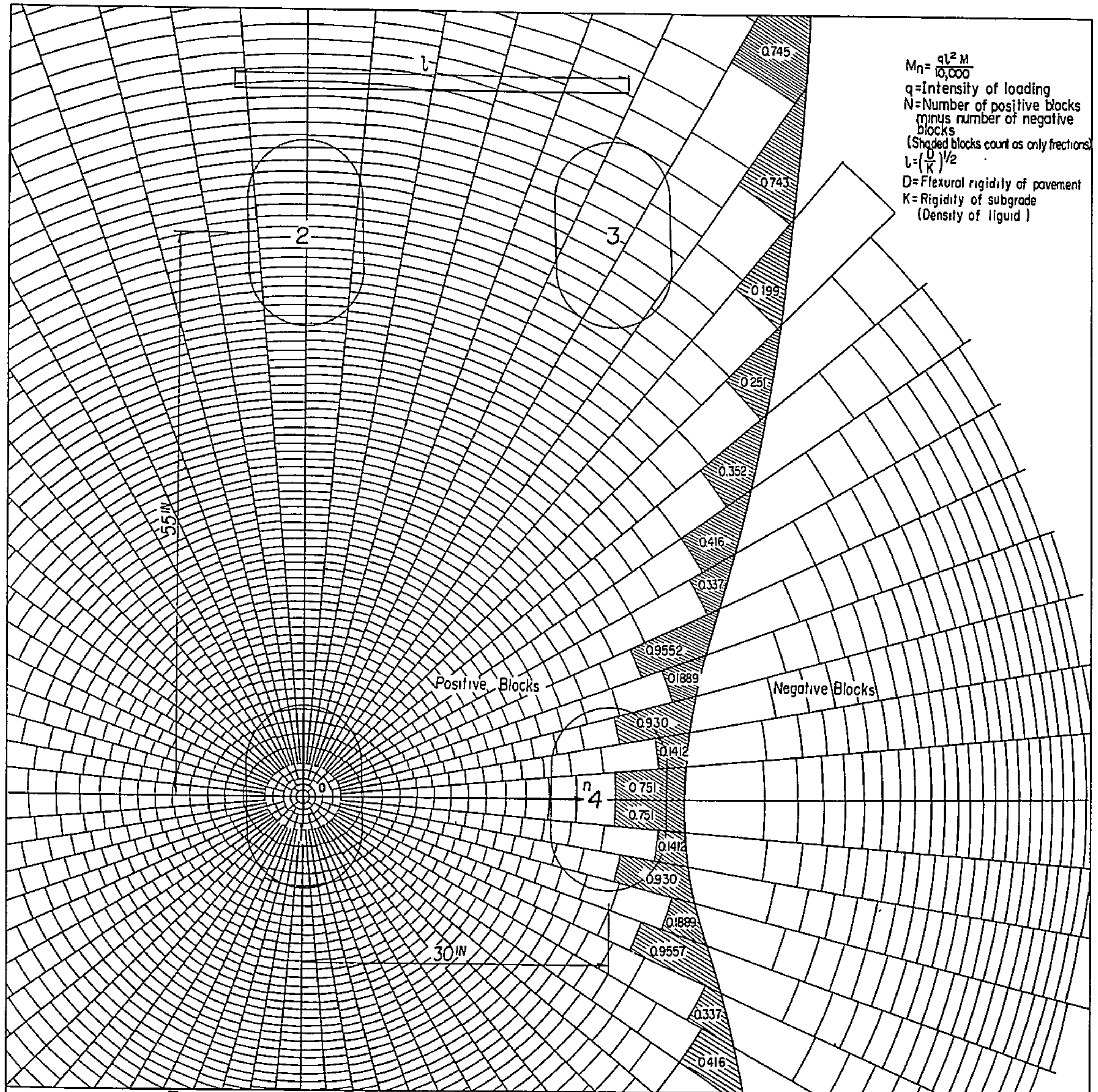


Fig 5-19 INFLUENCE CHART FOR THE MOMENT Mn IN A CONCRETE PAVEMENT DUE TO A LOAD IN THE INTERIOR OF THE SLAB

(Subgrede assumed to be a dense liquid. Poisson's ratio for pavement assumed to be 015)

2

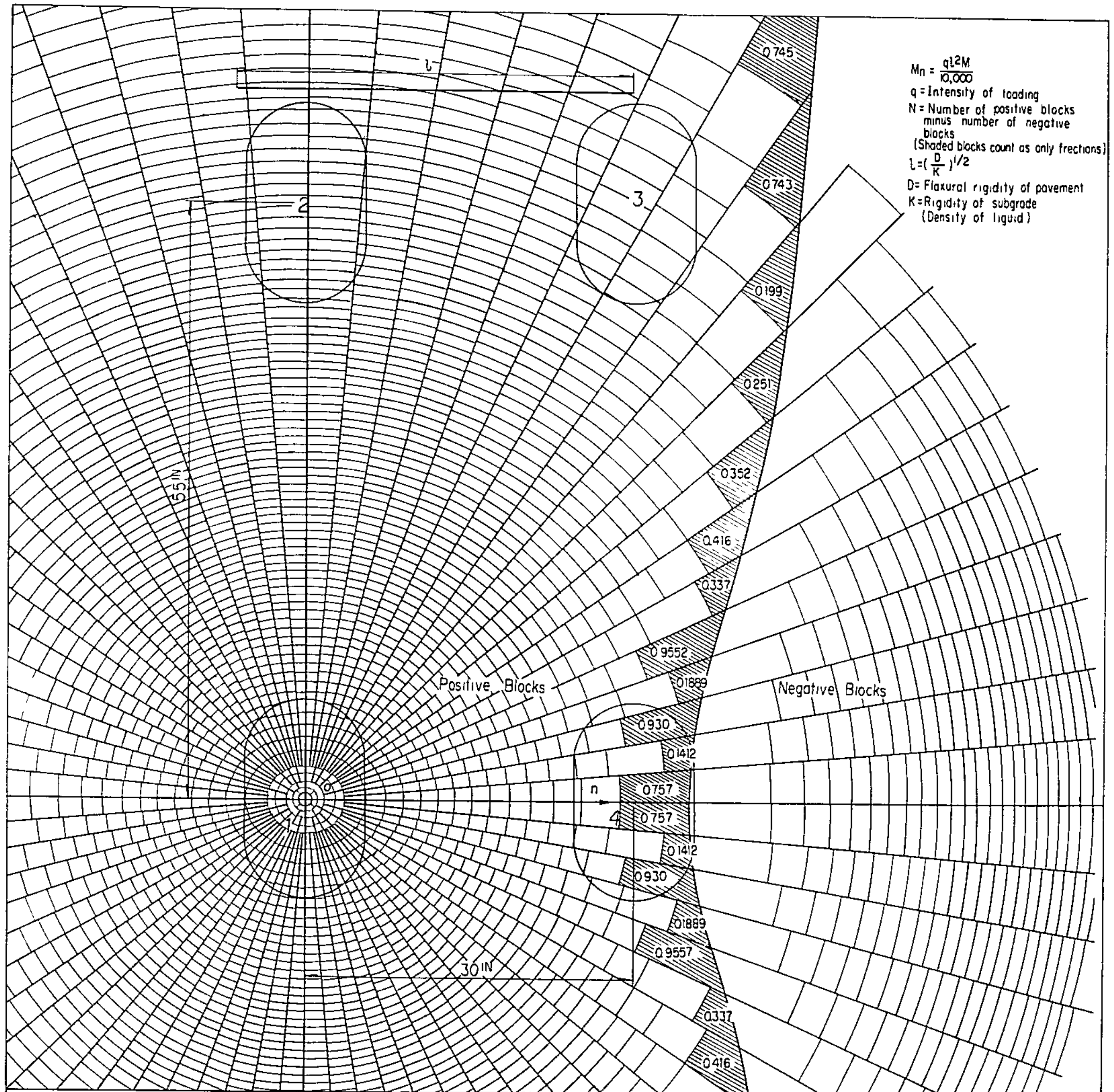
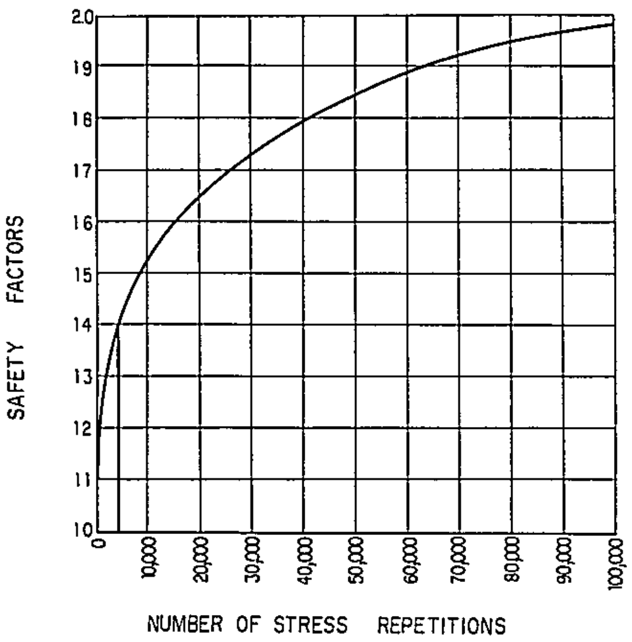


Fig 5 – 20	INFLUENCE CHART FOR THE MOMENT Mn IN A CONCRETE PAVEMENT DUE TO A LOAD IN THE INTERIOR OF THE SLAB (Subgrede assumed to be a dense liquid Poisson's ratio for pavement assumed to be 0 15)	2



From ; " Principles of Pavement" (Road Departoment, State of California)

Fig 5-21 RELATIONSHIPS BETWEEN SAFETY FACTORS AND STRESS REPETITIONS

5-5-5 Design of Joints

(1) Longitudinal joints

(i) Longitudinal construction and center joints

Longitudinal construction and center joints are keyed and sawed type to provide load transference, and the joint spacing is 3.81 m, equal to that of the existing pavement.

(ii) Longitudinal extension joint

Since longitudinal extension joints cannot make load transfer, thickened-edge type joints are adopted. The abutting edges of both pavements are thickened to 38 cm, and tapered off to normal thickness in a distance of a joint spacing. And, thickened-edge type joint is used for abutting edge on the existing pavement, permitting wheel loads to cross.

(2) Transverse joints

(i) Transverse contracting joints

The transverse contraction joints are of the sawed dummygroove type, and are provided at intervals of 5 meters.

(ii) Transverse construction joints

The transverse construction joints are necessary at the end of each day's run or where paving operations are suspended for 30 minutes or more, and are of the butt type containing dowel bars for transferring the load across the joint.

(iii) Transverse extension joints

The transverse extension joints are provided at the interval of 100 m in consideration of the load transfer capacity of the dummy groove joints, blow-up of paving slab and extension of the width of joint.

6. DRAINAGE OF THE AIRPORT

The topography of the airport area is almost flat as mentioned in Chapter 3, so that natural drainage condition of the area is poor. In order to improve the condition, the drainage system will be constructed for the extension portion of the runway in a similar way as the existing runway. The drainage system consists of extension of the drainage ditches now running parallel to the existing runway on both side and a twin-box culvert constructed under the extended runway to connect them. The drain ditches northeast side from Sta. 51 lead water to the swamps lying northeast of the extended runway, whereas the ditches from the end of existing runway to Sta. 51 have base slopes so that water is led to Sta. 12, and the water collected at the point will be drained through twin-box culvert constructed under the extended runway to the existing small stream.

The design precipitation for the drainage system is taken at 100millimeters per day and 65 millimeters per hour, based on past rainfall record of 12 years measured at Vientiane Meteorological Station given in Table 3-4. The drain capacity of the system is decided at 3.6 m^3/sec, based on the design precipitation and the catchment area of 0.55 km^2 of the system.

7. ELECTRICAL INSTALLATIONS

7-1 Present Condition of the Electrical Equipment

7-1-1 Illumination Systems

(1) Aeronautical beacon.

On the roof of the control tower, a 36 inch beacon (115V, 1,000W) was installed and is in operation.

(2) Wind cone

One set was installed between the runway and the taxiway, but the lights are not in service and the streamer to show the wind-direction does not work at the specified wind velocity. Maintenance is impossible as the site is not accessible.

(3) Runway lights

On both sides of the runway, 2,000 m in length, 62 runway lights (200W) were installed and in use at present. However, the color arrangement of the lights such as white-yellow, white-white, was not in accordance with the standards.

(4) Runway threshold lights

On each end of the runway were installed 8 lights, a total of 16 lights (green, 200W).

(5) Taxiway lights

On both sides of the taxiway, there were installed 195 lights (blue 45W), but at present all these are inoperative due to damage.

(6) Obstruction lights

Obstruction lights (600W x 2) were installed and are in operation on the water tank (40 m high) in the premises of the airport.

(7) General illumination facilities

General illumination systems were installed in the terminal building of the airport and in the control tower, and are in service now.

7-1-2 Electric Power Source

(1) Pole transformers

A commercial, 6,600V 50Hz, 3-phase, 3-wire system power supply is fed to the receiving transformers (37.5kVA x 3). The secondary side supply is

3-phase, 4-wire system, 50 Hz, 380/220V

(2) Independent power generating equipment
Three independent power generating units of 75 kW are installed. However, only one of them can be operated. The generating voltage is 380/220V, 50 Hz.

(3) Lighting systems for the runway lights and the runway threshold lights:
A single-phase 37.5 kVA transformer (primary 380V, secondary 2,400V) and a 30 kW constant current regulator are installed. However, none are in service, and so as a temporary measure a 15 kW constant current regulator was installed and is in service.

(4) Lighting system for the taxiway light:
Six sets of current regulating equipment of 4 kW are installed, but none of them are in use.

(5) Power supply for the operation control:
Control source for power supply to the various lights in the airport, one single-phase transformer 220V/110V, 1,500VA was installed. However as it was not in use, one single-phase transformer of 500VA was installed and is temporarily in service.

(6) Power supply for the aeronautical beacon:
One single-phase transformer, 220V/110V, 2 kVA, is installed and is in service.

(7) Power supply for the electrical facilities in the terminal building:
One 3-phase transformer of 75 kVA (380V/220-127V) is installed and is in service.

7-1-3 Control Equipment for the Illumination of the Airport

One set of control equipment for the airport illumination system was installed at Vault Room, and another at the control tower. However, the control panel in the control tower is inoperative.

7-1-4 Power Distribution System of the Airport

The Distribution System is installed as shown in the accompanying wiring diagrams.

7-1-5 Present Condition of the Installed Cable Ducts

Cable ducts are installed from the power room to the runway for a distance of about 700 m. 13 hand-holes are provided where access is necessary. 3 hand-holes near the power room are located in the damp area, and in the rainy season, almost all hand holes are filled with water.

7-2 Illumination for the Runway

Proposed runway illumination includes the following four kinds of lights.

(1) Runway lights

(2) Runway threshold lights

(3) Stopway lights

(4) Taxiway lights for turning pans.

7-2-1 Selection of the Runway Lights

The runway is classified and equipped according to the landing mode as a non-instrument landing runway, so the installation of medium luminous intensity runway lights may be considered in accordance with the ICAO standards. On the other hand for the planned landing and take-off of high speed and larger aircraft in the near future, the runway lights should be recognizable in the air from as far away as possible. The present equipment, was installed also for high intensity lights (Type H-6) will be adopted in the runway extension plan. There are two kinds of high intensity runway lights, surface type and the underground (nonprotruding) type, In this plan the surface type is specified because of efficiency of maintenance.

7-2-2 Selection of Runway Threshold

In order to make the best use of present installed threshold lights, this plan specifies high intensity runway lights (Type H-6, with green filter).

7-2-3 Selection of Stopway Lights

Accompanying the establishment of the over-run zone, stopway lights will be installed. The light selected will be the same type H-6, high intensity runway lights except that the filter color is red.

7-2-4 Taxiway Lights for Turning Pan

At the Runway End No. 13, the turning pan which will be constructed in the expansion plan, will be provided with taxiway lights (M-1 type).

7-2-5 Arrangement of Runway Lights

(1) The Runway Lights should be placed in line with the exist installation, 1.5 meters outside the concrete paved portion, and the separation of the new light-line of the runway lights will be arranged at about 59 meters.

(2) Two runway lights, one each at the north side and the south side in section 31 of the existing runway and one runway light in section 13 which will be positioned south of the newly constructed runway are located at the intersection with the taxiway and these lights are to be eliminated.

(3) Those runway lights situated within 600 meters from the end of section 31 of the existing runway and from section 13 of the new runway, will be arranged for indication by variable yellow in accordance with LCAU standards.

7-2-6 Arrangement of Runway Threshold Lights

(1) The threshold lights will be arranged on a straight line one meter off from the end of the runway perpendicular to the runway center line axis.

(2) 14 lights will be installed on each end of the runway, that is 28 lights in total.

7-2-7 Arrangement of Stopway Lights

(1) The stopway lights will be arranged on the extended line of the runway light line one meter off the runover zone.

(2) Three stopway lights will be arranged on each sides of the runway, totaling 6 lights to be installed.

7-2-8 Arrangement of Taxiway Lights for Turning Pan

The lights for the turning pan will be arranged on a line 1.5 meters off the periphery of the turning pan.

7-2-9 Illumination Circuit System for the Runway

Power for all lighting for the runway, the threshold, the stopway, the taxiway for the turning pan will be supplied through insulating transformers and a constant current regulator in one series connection.

7-2-10 Selection of Constant Current Regulator

Two types of constant current regulators, namely CR type regulator and SR type regulator, could be applied. However this plan specifies the CR type constant current regulator, as it is simple in construction requiring a minimum of adjustment, and, moreover, it is lower in cost.

The total load of the runway lighting amounts to about 30 kW, so that in this case a type CR-30 regulator will be installed to serve the abovementioned purpose.

7-2-11 Control of Light Intensity of the Runway Illumination

Control of the light intensity will be made possible so that suitable adjustment in 5 steps can be made by limiting the output current of the constant current regulator.

7-2-12 Underground Laying of Cables

Cable laying for the lighting systems will be performed by utilizing vinyl tubes in order to protect the cables from weed-root growths.

7-3 Wind Cone

7-3-1 Present Condition of Wind Cone Already Installed

The presently installed wind cone was found obsolete and inoperative so that we recommend their removal and installation of a new wind cone with power supply cables, we recommend, in addition, removal of the weed growths in the vicinity of the lights at the time of preparation of the maintenance area.

7-3-2 Selection of Wind Cone

(1) Type-1 Wind Cone will newly be installed.

(2) As for power supply to the wind cone, power source will be assembled on the newly installed distribution cabinet, and may cover the requirement of 4 incandescent lights (100V, 200W) for the illumination of the streamer, and an incandescent lamp (100V, 100W) for the obstruction light.

(3) The maintenance path will be constructed from the taxiway toward the wind cone post as far as approximately 100 meters and serve the purpose of maintenance of the wind cone.

7-4 Approach Lights

In the implementation of the extension project, the installation of an approach-light system is excluded from the first phase of the project and will be taken into consideration in the second phase or later.

7-5 Taxiway Lights

The entire taxiway lighting system is out of order and inoperative at present. Installation of taxiway lights meeting the ICAO regulations is desirable, but the installation of taxiway lights is excluded from the present first phase of the project, and will be considered in the second phase.

7-6 Utilization of Existing Cable Ducts

The portions in the damp area were not surveyed yet. However, judging from the conditions of other hand-holes, they might be considered usable. The main ducts will be dewatered by pumping and the plan specifies the use of existing ducts. For maintenance of the cable duct and hand-holes it will be necessary to pile up earth and to construct a maintenance lane in the future.

7-7 Independent Power Generation Present Condition of the Existing Independent Power System

The present independent power system consists of three generators, but only one generator is serviceable. Power output is 75 kW. The present independent power supply is not sufficient to meet the increased load after the extension of the runway. However, it is conceivable to reduce power consumption by adjusting the intensity of illumination of the runway lights. The installation of additional generating system will be take up in the second phase or later.

7-8 Control Panel and Distribution Cabinet for Illumination

7-8-1 Control Panel for Airport Illumination

(1) Present condition of the control panel installed in the vault room and the control tower.

The control panel now in use is deteriorated in many parts and considered inconvenient to operate, so that a new operation control panel is required.

(2) New control panel

The new control panel should be designed in the same dimensions as the panel now installed as installation space is rather limited. The operation method to control the intensity of the runway lighting should be by switch-control in 5 steps.

(3) Control cable

The existing control cable is 18-core cable. However, this will be removed and new control cable of 22 cores and 3.5 mm^2 in sectional area will be laid between the vault room and the control tower. Of these 22 cores, 5 are standbys.

7-8-2 Distribution Cabinet (Including Relay Equipment)

The 15 kW constant-current regulating equipment now installed in the vault room will be removed. Adjacent to the newly installed CR-type constant current regulating equipment, a new distribution cabinet (including the relay equipment) of the same height and depth will be installed in one row.

The following parts will be mounted on this panel.

(1) Terminal block

(2) CR-type CCR, and distribution circuit breakers for the wind cone, aeronautical beacon, obstruction lights, control power supply, etc.

(3) Transformers for the wind cone and control power supply.

(4) Relays

(5) Other accessories

7-9 Power Supply

The electric system now in service comprises three single-phase 37.5 kVA transformers, the total capacity amounting to 112.5 kVA. In the future, the change of supply voltage may be considered. However, as for the first phase project, the design voltage will be 6 kV, the same as that of the present system.

Meanwhile, the power load will increase with the extension of the runway lighting system. Then about 30 kW in single-phase power supply will be required. Thus if the existing electrical equipment will be used it will have to operate at a great unbalance between the load and supply, and it is feared that normal power supply in that amount would be impossible. Hence, it is required that the load on each distribution system should be balanced at the respective distribution panel in three-phases with regard to the load attached.

At present, as the change-over switch for the change-over from the commercial supply to the independent power is manually operated. The power system of this airport should be able to change-over within the specified time to meet the ICAO Regulation in the second phase project. For the first phase, only the capacity increase for the change-over switch will be specified.

7-9-1 Balancing of Equipment Load

The present equipment, equipment to be provided in the first phase and facilities to be provided in the future are summarized as follows.

(1) Present equipment

The table in the below shows the load distnibution as observed during the investigation.

	Items	Phase A	Phase B	Phase C	
		VA	VA	VA	
1.	Illumination for Vault Room	2550	-	-	1ϕ 220V
		-	2690	-	" "
		-	-	2370	" "
2.	Water pump in the well	3500	3500	3500	3ϕ 380V
3.	Ventilation fan	7500	7500	7500	" "
4.	Terminal Bldg. (including Control Tower)	20230	20230	20230	" "
5.	Wind cone		900		1ϕ 220V
6.	Aeronautical beacon		1500		" "
7.	Control power transformer		500		" "
8.	Taxiway lighting	-	-	-	
9.	Obstruction lighting	-	1200	-	1ϕ 220V
10.	Runway lighting	7200	-	7200	1ϕ 380V
	Total	VA 40.980	VA 38,020	VA 40,800	VA 119,800

(2) Equipment of 1st Phase Project.

The following table gives the load distribution in the sequence after construction of the First phase.

	Items	Phase A	Phase B	Phase C	
		VA	VA	VA	
1.	Illumination in Vault Room	-	2550	-	1ϕ 220V
		-	2690	-	" "
		-	2370	-	" "
2.	Water pump in the well	3500	3500	3500	3ϕ 380V
3.	Ventilation fan	7500	7500	7500	" "
4.	Terminal Bldg. (including Control Tower)	20230	20230	20230	" "
5.	Wind-cone	-	1500	-	1ϕ 220V
6.	Aeronautical beacon	-	1500	-	" "
7.	Transformers for Control Tower	-	1500	-	" "
8.	Taxiway lighting	-	-	-	
9.	Obstruction lighting	-	1200	-	1ϕ 220V
10.	Runway lighting	14000	-	14000	1ϕ 380V
	Total	VA 45,230	VA 44,540	VA 45,230	VA 135,000

(3) Equipment of future extension

The anticipated increase of load as estimated is as follows:

a)	Taxiway lighting equipment	15 kVA
b)	Approach lighting equipment	20 kVA
c)	Others	35 kVA
		70 kVA

Therefore, the load distribution should be readjusted in future in order to minimize the unbalance of load distribution.

7-9-2 Receiving Cubicle

To meet the larger future power demand resulting from increased equipment load, the power receiving system presently in service (37.5 kVA x 3 sets) will be insufficient, so that new receiving equipment for 75 kVA x 3 sets should be installed.

The receiving equipment mounted on a pole at present (three transformers) should be removed and an outdoor-type cubicle in which the ammeters, volt-meters, watt-hour meters, etc. are provided, should be installed as a receiving system for the airport.

7-9-3 Power Demand and Load Factor of the Airport Equipment

(1) Present Demand and Load Factor

Average load	Approx. 20 kVA (daytime)
Maximum load	Approx. 45 kVA (nighttime)
Demand factor	about 37.5% (= 45 kVA ÷ 119.8 kVA x 100)
Load factor	about 44.5% (= 20 kVA ÷ 45 kVA x 100)

(2) Estimation of Power Demand and Load Factor in the First Phase

Average load	about 20 kVA (daytime)
Maximum load	about 65 kVA (nighttime)
Demand factor	about 48.5% (65 kVA ÷ 135 kVA x 100)
Load factor	about 31.0% (20 kVA ÷ 65 kVA x 100)

7-10 Others

7-10-1 Tools for Maintenance Operation

Tools and maintenance equipment will be provided in sufficient quantities to assure the efficiency of daily maintenance.

7-10-2 Spare Parts

Spare parts, such as electric bulbs, lighting fixtures, each kind of cables, insulated transformer etc. should be provided for maintenance service.

7-10-3 Maintenance Lanes

Permanent and reliable maintenance is especially needed in the maintenance of airport equipment and systems. Therefore, approaches should be secured to the handholes along the main duct, and it is important that the station authority should provide adequate maintenance lanes.

7-10-4 Weed Growths

As the runway shoulders are unpaved at present, the runway lights, etc., might be concealed by grass and weeds. For this reason, permanent measures for grass mowing must be established, so that this can be done during the daily inspection and maintenance work.

7-10-5 Training of Maintenance Personnel

Training of maintenance personnel would be required for the reliable maintenance of the various electrical equipment of the airport.

7-10-6 Temporary Installations for the Duration of Works

While the works outlined for the first phase of the project are in progress, it will most probably not be allowed to interrupt the use of the runway, so that certain temporary installations should be provided.

7-10-7 Transportation Inlet of Vault Room

For transportation of electrical equipment such as CCR and distribution cabinet into the vault room, the existing inlet should be enlarged.

8. CONSTRUCTION

8-1 Construction Time Schedule

The construction period for the construction of the runway extension is estimated at 8 months from the award of contract for construction.

The construction schedule is tentatively presented in the attached Figure 8-1. Planned in the schedule are 1 month for the preparatory works, 3.3 months for earth works, 4 months for base course and concrete pavement works and 5 months for electrical installation. Key point of this construction is that the construction period is relatively short, so in the execution of works it is desirable to complete the whole work during one dry season. Therefore, it is recommended that the contract of construction will be awarded in October so that, after one month of preparatory works comprising establishing of camp buildings, construction plants and facilities, the actual construction activities can be started in November.

8-2 Construction

As a principle, the way of runway extension construction will be determined at contractor's option, excepting the method prescribed in the specifications. Then, mentioned hereinafter is an example of the practicable method adoptable in actual construction.

Construction yards will be located by the extended section from the existing runway. The required area is estimated at about 440, 000 m^2.

8-2-2 Earth Works

Prior to the excavation and embankment works in the runway extension areas, top soil in this area shall be stripped and deposited in the landing strip. Total volumes of the excavation and embankment are calculated approximately at 152, 000 m^3. The excavation and embankment works shall consist of excavating, loading, transporting, grading and compacting as well as removal from the cut area to the fill area as shown on the drawings.

In these works shall be employed suitable bulldozer, scraper, shovel and dump truck as planned. Soft clay stratum, situated in paddy field area, lying at the embankment foundation site, shall be removed and be replaced with sand hauled from the nearest Mekong river bed. Base course on the prepared subgrade shall consist of filling with stabilized materials transported by dump trucks from the borrow area as shown on the drawing, and the filling materials shall consist of the mixture of coarse granular aggregate and binder sand.

8-2-3 Concrete Works

Aggregate to be used in concrete will be available from river deposits of the Mekong, about 50 kilometers downstream from the site (near the Government's gravel plant). Concrete batching and mixing plant will be installed in the runway extension area and the product will be transported by dump trucks and placed in position directly.

8-2-4 Construction Materials, Machinery, and Equipment

8-2-4-1 Construction materials

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

		Runway extension	Holding apron & apron	Drainage & others	Lighting	Total
1.	Cement (t)	4,700	680	180	60	5,620
2.	Reinforcement bar (t)	25	5	40		70
3.	Gravel for concrete (m^3)	10,240	1,480	430	150	12,300
4.	Sand for concrete (m^3)	4,930	710	260	200	6,100
5.	Sand for base course (m^3) of mixed materials	7,000	600			7,600
6.	Gravel and sand (m^3) of bed			600		600
7.	Electrical installation (ls)				1	1

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

8-2-4-2 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	11	"
Swampdozer	D-50 p	1	"
Power shovel	0.6 m^3 class	4	"
Scraper	9.0 m^3 class	5	"
Grader	MG-III	1	"
Roller	WMB-10, WT-82	2	Compaction
Tire roller	WP-15	3	"
Dump truck	6 ton class	12	Earth & concrete transport
Water tanker	6,000 ℓ	2	Earth, concrete works
Batcher plant	28 cf x 2	1	"
Concrete spreader	CF-S	1	"
Concrete finisher	CS-S	1	"
Concrete cutter	RSC-2	3	"
Concrete vibrator		6	"
Ordinary truck	6 ton class	1	"

9. COST ESTIMATE

9-1 General

Construction cost of the Vientiane airport extension project is estimated at 1,507,000 US dollars equivalent, of which 1,156,000 US dollars is in foreign exchange and 351,000 US dollars equivalent in local currency.

The estimate of cost in local currency is based on the labor wages and material prices as of the December, 1968 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 foreign 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	Foreign US$	
Foreman	1,500	Cement	47/ton	
Common labour 1	500	Sand (Dry)		300/m^3
Common labour 2	450	" (Wet)		500/m^3
Carpenter	1,500	Gravel (Dry)		1,000/m^3
Steel worker	800	" (Wet)		2,500/m^3
Driver 1	700	Reinf. bar	158/ton	
Driver 2 (Dump)	1,000	Hard wood (log)		30,000/m^3
Operator	1,400	" (sawn)		40,000/m^3
Operator's assistant	1,000	Soft wood (log)		14,000/m^3
Mechanic	1,200	" (sawn)		15,000/m^3
Electrician	1,500	Nail	0.24/kg	
Welder	2,000	Gasoline		48/ℓ
Plumber	2,000	Diesel oil		19/ℓ
Store keeper	600	Mobile oil		190/ℓ
		Gear oil		
		Grease		265/kg
		(Electric Power)		30/kWh

FIG. 8-1 CONSTRUCTION TIME SCHEDULE OF VIENTIANE AIRPORT EXTENSION PROJECT

WORK ITEM			QUANTITY	DESCRIPTION	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	REMARKS
PREPARATORY WORK		CAMP FACILITIES											
		BATCHER PLANT		28^{cf}x2-1									
RUNWAY & OVERRUN	EARTH WORKS	STOPPING OF TOP SOIL	52,300m^3										
		REMOVAL OF SOFT CLAY	32,500m^3										
		SAND EMBANKMENT	32,000m^3	REPLACE-MENT WITH SAND									
		EXCAVATION AND EMBANKMENT	110,500m^3										
		EXCAVATION TO BE REJECTED	7,100m^3										
	BASE COURSE FOR PAVEMENTS AND SHOULDERS		71,300m^2	30^{cm} THICK									
	CONCRETE PAVEMENTS		47,350m^2	R/W 28^{cm}, 25^{cm} THICK O/R 15^{cm} THICK									
	SHOULDER SODDING AND GRADED AREA SEEDING		17,700m^2 96,100m^2										
	PAINT MARKING		4,600m^2										
DRAINAGE WORKS	EARTH WORKS	EXCAVATION	1,600m^3										
		BACKFILLING	690m^3	COBBLE STONE SAND GRAVEL									
	CONCRETE, BOX CULVERT		500m^3	R.C 1.0^mx1.0^mx 150^m-2									
HOLDING APRON & APRON (IMPROVE-MENT)	EARTH WORKS	STRIPPING OF TOP SOILS	3,400m^3										
		EXCAVATION AND EMBANKMENT	1,800m^3										
	BASE COURSE FOR PAVEMENTS AND SHOULDERS		8,700m^2	30^{cm}, THICK									
	CONCRETE PAVEMENTS		6,280m^2	28^{cm}, THICK									
	SHOULDER SODDING AND GRADED AREA SEEDING		2,370m^2 1,700m^2										
ELECTRICAL INSTALLA-TIONS	LIGHTING FACILITIES, - RUNWAY												
	LIGHTING FACILITIES, - WIND CONE												
	IMPROVED POWER SOURCE												
SHIFTING OF EXISTING FENCE			1,500^m										

9-3 Breakdown of Cost Estimate

Presented herewith in Table 11-1 and Table 11-2 are the summary and the breakdown of the estimated costs, expressed inUS dollars, and in KP currency.

Table 9-1

Estimate of Construction Cost

Item No.	Work	Foreign Currency (U.S.$)	Local Currency (KP)	Total (U.S.$)	Remarks
A	Runway Extension	241,276	72,746,530	386,769.06	
B	Improvement of Holding Apron & Apron	35,482	5,019,980	45,521.96	
C	Drainage, Concrete Culvert	14,582	4,743,690	24,069.38	
D	Electrical Installations	98,800	12,125,000	123,050.00	
E	Miscellaneous works	5,100	1,415,800	7,931.60	
F	Construction Facilities for Construction Use		4,700,000	9,400.00	
G	Machinery Cost during Construction	144,800	980,000	146,760.00	
H	Transportation cost of construction Plant & Equipment	397,000	-	397,000.00	
	Total	937,040	101,731,000	1,140,502.00	
I	Engineering Service & General Expenses	190,600	53,769,000	298,138.00	
J	Government Administrative Expenses		5,700,000	11,400.00	
K	Contingency & Reserves	28,360	14,300,000	56,960.00	
	Grand Total	1,156,000	175,500,000	1,507,000.00	

Table 9-2 Breakdown of Construction Cost

Item No.	Work	Unit	Quantity	Foreign Currency (US$)		Local Currency (KP)		Remarks
				Unit Price	Amount	Unit Price	Amount	
A	Runway Extension							
A-1	Stripping, top soil	m^3	52, 300			80	4, 184, 000	
A-2	Removal, soft clay	m^3	32, 500			180	5, 850, 000	
A-3	Replacement with sand	m^3	32, 000			300	9, 600, 000	
A-4	Excavation, to be used for embankment	m^3	110, 500			166	18, 343, 000	
A-5	Excavation, to be rejected	m^3	7, 100			120	852, 000	
A-6	Subgrade incl. grading & compacting	m^2	71, 300			2	142, 600	
A-7	Base course incl. filling, compacting & finishing	m^2	71, 300			108	7, 700, 400	
A-8	Concrete pavement, 28cm thick	m^2	15, 350	5. 30	81, 355	485	7, 444, 750	Including jointing and filling of joints
A-9	Concrete pavement, 25cm thick	m^2	32, 000	4. 50	144, 000	435	13, 920, 000	- do -
A-10	Concrete pavement, 15cm thick	m^2	5, 490	2. 90	15, 921	272	1, 493, 280	- do -
A-11	Shoulder sodding	m^2	17, 750			100	1, 775, 000	
A-12	Graded area seeding	m^2	96, 100			15	1, 441, 500	
	Sub-total				241, 276		72, 746, 530	
B	Improvement of Holding Apron and Apron							
B-1	Stripping, top soil	m^3	3, 400			80	272, 000	

Item No.	Work	Unit	Quantity	Foreign Currency (US$)		Local Currency (KP)		Remarks
				Unit Price	Amount	Unit Price	Amount	
B-2	Excavation, to be used for embankment	m^3	1,800			160	288,000	
B-3	Subgrade incl. grading & compacting	m^2	8,700			2	17,400	
B-4	Base course incl. filling, compacting & finishing	m^2	8,700			108	939,600	
B-5	Concrete pavement, 28cm thick	m^2	6,280	5.65	35,482	516	3,240,480	Including jointing and filling of joints
B-6	Shoulder sodding	m^2	2,370			100	237,000	
B-7	Graded area seeding	m^2	1,700			15	25,500	
	Sub-total				35,482		5,019,980	
C	Drainage, Concrete Culvert							
C-1	Unclassified excavation	m^3	1,600			180	288,000	
C-2	Filling, cobblestone		160			2,750	440,000	
C-3	Backfilling, sand & gravel	m^3	530			1,000	530,000	
C-4	Concrete including form	m^3	500	16.00	8,000	6,000	3,000,000	
C-5	Reinforcing steel bar	ton	40	164.00	6,560	12,100	484,000	
C-6	Miscellaneous	ls	1		22		1,690	
	Sub-total				14,582		4,743,690	
D	Electrical Installations							
	Lighting facilities, runway	ls	1		58,400		7,150,000	

Item No.	Work	Unit	Quantity	Foreign Currency (US$)		Local Currency (KP)		Remarks
				Unit Price	Amount	Unit Price	Amount	
D-2	Lighting facilities, wind cone	ls	1		12,800		1,600,000	
D-3	Improved power source	ls	1		27,600		3,375,000	
	Sub-total				98,800		12,125,000	
E	Miscellaneous Works							
E-1	Shifting of existing fence	m	1,500	1.10	1,650	720	1,080,000	
E-2	Marking for runway & taxiways	m^2	4,600	0.75	3,450	73	335,800	
	Sub-total				5,100		1,415,800	
	Total for A-E				395,240		96,051,000	
F	Construction Facilities for Construction Use							
F-1	Foundation of batcher plant incl. erection & removal	ls	1				2,000,000	
F-2	Access roads	ls	1				300,000	
F-3	Temporary building	ls	1				1,500,000	
F-4	Power & Water supply system						900,000	
	Sub-total						4,700,000	
G	Machinery Cost during Construction	ls	1		144,800		980,000	

Item No.	Work	Unit	Quantity	Foreign Currency (US$)		Local Currency (KP)		Remarks
				Unit Price	Amount	Unit Price	Amount	
H	Transportation Cost of Construction Plant & Equipment	ls	1		397,000			
	Total for A-H				937,040		101,731,000	
I	Engineering Service & General Expenses (about %)				190,600		53,769,000	
J	Government Administrative Expenses (about 1%)						5,700,000	
K	Contingency & Reserves (about 5%)				28,360		14,300,000	
	Grand total				1,156,000		175,500,000	

APPENDIX

A. 1-1 SUMMARY OF SOIL TESTS (For Investigation of Soil Strata) I

LOCATION WATTAY TESTED BY

		1-2	1-3	1-4	1-5	1-6	2-1	2-2	2-3	2-4	3-5	3-6	4-1	4-2	4-3	4-5
	SAMPLE NUMBER NO.	1-2	1-3	1-4	1-5	1-6	2-1	2-2	2-3	2-4	3-5	3-6	4-1	4-2	4-3	4-5
	SAMPLING DEPTH (m)	0.50-0.60	1.30-1.40	2.15-2.30	2.45-2.55	4.50-4.60	0.30-0.40	0.80-0.90	2.70-2.80	3.60-3.70	2.10-2.20	3.20-3.30	1.00-1.10	1.80-1.90	2.10-2.20	3.30-3.40
	OBSERVATION	Grey brown	Grey	Reddish white	Reddish white	Reddish brown	Brown	Whitish brown	Whitish brown	Whitish brown	Yellow	Reddish yellow	Light brown	Whitish brown	Yellow brown	Whitish yellow brown
GRAIN SIZE PROPORTION	Natural water content w(%)	12.49	12.73	20.40	21.56	24.43	4.29	16.23	22.36	24.01	20.32	27.87	31.48	23.44	24.82	18.31
	Specific gravity G		2.63		2.65		2.66	2.68	2.69	2.70			2.67	2.63	2.66	2.68
	Gravel part (%)	-	-	-	-	-	-	-	-	-			-	-	-	-
	Sand part (%)	47	26	25	11	7	7	36	19	56			16	54	43	47
	Silt part (%)	34	36	43	33	46	31	37	39	31			39	22	39	25
	Clay part (%)	19	38	32	56	47	62	27	42	13			45	24	18	28
	Max diameter (mm)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0			2.0	2.0	2.0	2.0
CONSIS-TENCY	Grain size classification	Loam	Clay	Clay	Clay	Clay	Clay	Clayey loam	Clay	Sandy loam			Clay	Sandy clay loam	Loam	Clayey loam
	Liquid limit L. L. (%)		23.72	27.05	32.40	31.60	17.27	21.05	22.80	42.30			51.30	23.70	19.25	30.30
	Plastic limit P. L. (%)		10.97	17.54	10.41	21.29	15.10	19.85	18.14	23.94			18.59	14.83	15.94	16.80
	Plasticity index P. I.		12.75	9.51	21.99	10.31	2.17	1.20	4.66	18.36			32.71	8.87	3.31	13.50
	Flow index F. I.		5.05	5.50	8.40	8.70	2.97	3.25	9.50	17.20			11.50	14.40	5.50	14.10
	UNIFIED CLASSIFICATION		ML	ML	ML	ML	ML	ML	ML	SC			MH	SC	ML	ML

Remarks:

		5-1	5-2	5-4	7-1	7-3	8-1	8-2	10-1	10-2	10-3	10-5	10-6	10-7	11-1	11-2
	SAMPLE NUMBER NO.	5-1	5-2	5-4	7-1	7-3	8-1	8-2	10-1	10-2	10-3	10-5	10-6	10-7	11-1	11-2
	SAMPLING DEPTH (m)	0.20-0.30	0.80-0.90	1.80-1.90	0.20-0.30	1.80-1.90	0.20-0.30	0.60-0.70	0.20-0.30	0.60-0.70	1.10-1.20	2.00-2.10	2.80-2.90	3.00-3.10	0.50-0.60	0.90-1.00
	OBSERVATION	Whitish brown	Brown	Brown	Light brown	Yellow brown	Light brown	Light brown	Light brown	Light brown	Light brown	Light brown	Brown	Light brown	Light brown	Brown
GRAIN SIZE PROPORTION	Natural water content w (%)	20.12	21.38	21.16	6.45	25.97	10.41	10.67	7.21	9.13	11.45	13.02	10.93	16.92	8.00	13.69
	Specific gravity G	2.65			2.67	2.68		2.66	2.64	2.68	2.71	2.66				2.66
	Gravel part (%)	-	-		-	-	-	-	-		-	-			-	-
	Sand part (%)	46	43		57	48	53	45	63		56	34			49	47
	Silt part (%)	33	36		26	34	23	41	29		30	33			37	18
	Clay part (%)	21	21		17	18	24	14	8		14	33			14	35
	Max diameter (mm)	2.0	2.0		2.0	2.0	2.0	2.0	2.0		2.0	2.0			2.0	2.0
CONSIS-TENCY	Grain size classification	Clayey loam	Clayey loam		Sandy loam	Loam	Sandy loam	Cleyey loam	Sandy loam		Sandy loam	Clay			Loam	Clay
	Liquid limit L. L. (%)	19.65			17.90	20.60		23.40	21.68		22.40	27.40			19.85	21.70
	Plastic limit P. L. (%)	10.06			13.71	14.38		13.67	16.44		15.90	14.50			17.07	17.04
	Plasticity index P. I.	9.59			4.19	6.22		9.73	5.24		6.50	12.90			2.78	4.66
	Flow index F. I.	8.80			6.60	12.00		12.15	4.25		6.80	11.70			2.93	10.50
	UNIFIED CLASSIFICATION	ML			SC	ML		ML	SC		SC	ML			ML	ML

Remarks:

A. 1-2 SUMMARY OF SOIL TESTS (For Investigation of Soil Strata) I

LOCATION, WATTAY TESTED BY

	SAMPLE NUMBER NO.	11-3	11-4	13-1	14-1	14-2	16-4	17-3	18-2	20-2	22-2	23-3	23-4	30-1	30-2	33-4
	SAMPLING DEPTH (m)	1.40-1.50	2.00-2.10	0.20-0.30	0.45-0.55	0.70-1.00	2.30-2.40	2.10-2.20	0.70-0.80	1.10-1.20	1.70-1.80	1.75-1.85	2.40-2.50	0.20-0.30	0.70-0.80	1.90-2.00
	OBSERVATION	Light brown	Reddish brown	Light brown	Brown	Light brown	Whitish brown	Whitish brown	Light brown	Light brown	Light grey	Reddish brown	Light brown	Whitish brown	Brown	Yellow brown
GRAIN SIZE PROPORTION	Natural water content w (%)	12.45	13.10	7.19	10.12	11.27	17.60	20.17	22.22	11.35	12.20	22.70	23.62	25.69	24.86	14.07
	Specific gravity G		2.67													
	Gravel part (%)	-	-	-	-			-		-			-	-	-	-
	Sand part (%)	45	39	52	52			16		48			35	33	37	31
	Silt part (%)	33	27	26	24			55		33			51	55	36	48
	Clay part (%)	22	34	22	24			29		19			14	12	27	21
	Max diameter (mm)	2.0	2.0	2.0	2.0			2.0		2.0			2.0	2.0	2.0	2.0
	Grain size classification	Clayey loam	Clay	Sandy clay loam	Sandy clay loam			Silty clay loam		Loam			Silty loam	Silty clay loam	Clayey loam	Clayey loam
CONSISTENCY	Liquid limit L. L (%)	23.65	25.85		24.60	23.67	26.60	20.00		18.50			17.00	21.40		21.95
	Plastic limit P. L. (%)	18.04	18.86		17.95	17.45	17.70	13.41		14.90			15.41	15.92		14.65
	Plasticity index P. I.	5.61	6.99		6.65	6.22	8.83	6.59		3.60			1.59	5.48		7.30
	Flow index F. I.	2.40	7.30		6.65	6.15	3.80	7.15		4.65			7.55	1.60		4.40
	UNIFIED CLASSIFICATION	ML	ML		SC			ML		ML			ML	ML		ML

Remarks:

	SAMPLE NUMBER NO.	34-5	43-5	43-6	2	3	6	76	77	78	79	T. P. 1	T. P. 1	T. P. 1	T. P. 2	T. P. 2
	SAMPLING DEPTH (m)	3.40-3.50	2.30-2.40	2.90-3.00	0.40-0.60	0.40-0.60	0.40-0.60	0.40-0.60	0.30-0.50	0.20-0.40	0.20-0.40	1.10-1.30	2.00-2.20	3.00-3.20	0.70-0.90	1.40-1.60
	OBSERVATION	Yellow brown	Yellow brown	Yellow brown	Whitish brown	Yellow brown	Grey	Light brown	Brown	Light brown	Light brown	Reddish brown	Yellow brown	Reddish brown	Grey brown	Grey brown
GRAIN SIZE PROPORTION	Natural water content w (%)	25.42	24.04	26.32	4.53	19.20	26.18	3.22	10.05	5.73	7.91	25.31	17.37	26.00	18.59	18.19
	Specific gravity G				2.66	2.71	2.66	2.72	2.70	2.71	2.66	2.72	2.66	2.74	2.67	2.66
	Gravel part (%)			-	-	-	-	-	-	-	-	1	-	-	-	-
	Sand part (%)			26	37	19	54	35	6	2	36	16	62	14	39	43
	Silt part (%)			43	39	44	27	52	57	63	35	45	29	50	43	48
	Clay part (%)			31	24	37	19	13	37	35	29	38	9	36	18	19
	Max diameter (mm)			2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	4.8	2.0	2.0	2.0	2.0
	Grain size classification			Clay	Clay	Clay	Sandy loam	Silty loam	Silty clay	Silty clay	Clayey loam	Clay	Sandy loam	Clay	Loam	Loam
CONSISTENCY	Liquid limit L. L. (%)	40.90	27.62	32.70	18.10	38.80	25.30	22.71	28.40	37.60	27.28	54.71		63.60	22.45	25.24
	Plastic limit P. L. (%)	24.20	21.07	23.11	16.40	27.62	20.16	20.52	21.55	28.20	21.94	16.28		16.58	11.25	11.51
	Plasticity index P. I.	16.70	6.55	9.59	1.70	11.18	5.14	2.19	6.85	9.40	5.34	38.43		47.02	11.20	13.73
	Flow index F. I.	13.60	11.00	13.75	3.20	4.05	18.20	3.60	7.10	12.10	11.70	17.00		14.70	5.01	9.46
	UNIFIED CLASSIFICATION			ML	ML	ML	SC	ML	ML	ML	ML	MH		MH	ML	ML

Remarks:

A. 1-3 SUMMARY OF SOIL TESTS (For Investigation of Soil Strata) I

LOCATION WATTAY TESTED BY

	SAMPLE NUMBER NO.	T. P. 4	T. P. 4	T. P. 5	T. P. 5	T. P. 6	T. P. 7	T. P. 7	T. P. 8	T. P. 8	T. P. 9	T. P. 9	T. P. 10	T. P. 10	T. P. 10
	SAMPLING DEPTH (m)	1.00-1.20	2.50-2.70	1.00-1.20	1.50-1.70	2.10-2.30	0.30-0.50	1.80-2.00	1.00-1.20	2.20-2.40	0.80-1.60	2.90-3.10	1.25-1.45	1.70-1.90	2.60-2.80
	OBSERVATION	Grey brown	Light brown	Light brown	Light brown	Yellow brown	Yellow brown	Reddish brown	Brown	Light brown	Yellow brown	Yellow brown	Grey brown	Brown	Brown
GRAIN SIZE PROPORTION	Natural water content w (%)	7.96	11.43	12.24	14.50	4.97	6.32	6.58	8.35	12.82	7.03	10.51	11.34	12.79	16.33
	Specific gravity G	2.70	2.70		2.69	2.69			2.66		2.67				2.72
	Gravel part (%)		-	-		-					-		-	-	-
	Sand part (%)		43	44		46					54		35	35	43
	Silt part (%)		28	37		28					28		46	36	30
	Clay part (%)		29	19		26					18		19	29	27
	Max diameter (mm)		2.0	2.0		2.0					2.0		2.0	2.0	2.0
CONSISTENCY	Grain size classification		Clayey loam	Loam		Clayey loam					Sandy loam		Loam	Clayey loam	Clayey loam
	Liquid limit L. L. (%)	24.20	28.90	18.95	20.65	14.48	30.80	28.80	22.70		18.30		23.50	37.25	36.30
	Plastic limit P. L. (%)	14.32	20.51	15.22	17.03	14.02	22.66	21.56	17.40		17.50		16.44	22.83	26.43
	Plasticity index P. I.	9.88	8.39	3.73	3.62	0.46	8.14	7.24	5.30		0.80		7.06	14.43	9.87
	Flow index F. I.	4.65	8.80	7.60	7.25	3.85	10.10	4.60	9.10		3.05		7.30	6.50	12.50
	UNIFIED CLASSIFICATION		ML	ML		ML					SC		ML	ML	ML

Remarks:

A. 1-4 SUMMARY OF SOIL TESTS (For Investigation of Subgrade & Bed Material) II

LOCATION WATTAY TESTED BY

	SAMPLE NUMBER NO.	A. B 76	A. B 77	A. B 78	A. B 79	T. P 4	T. P 4	T. P 5	T. P 5	T. P 6	T. P 7	T. P 7	T. P 8	T. P 8	T. P 9	T. P 9
	SAMPLING DEPTH (m)	0.40-0.60	0.30-0.50	0.20-0.40	0.20-0.40	1.00-1.20	2.50-2.70	1.00-1.20	1.50-1.70	2.10-2.30	0.30-0.50	1.80-2.00	1.00-1.20	2.20-2.40	0.80-1.00	2.90-3.10
	OBSERVATION	Light brown	Brown	Light brown	Light brown	Grey brown	Light brown	Light brown	Light brown	Yellow brown	Yellow brown	Yellow brown	Brown	Light brown	Yellow brown	Yellow brown
	Natural water content w (%)	3.22	10.05	5.73	7.91	7.96	11.43	12.24	14.50	4.97	6.32	6.58	8.35	12.82	7.03	10.51
GRAIN SIZE PROPORTION	Specific gravity of Soil G	2.72	2.70	2.71	2.66	2.70	2.70		2.69	2.69			2.66		2.67	
	Gravel part (%)	-	-	-	-		-	-		-					-	
	Sand part (%)	35	6	2	36		43	44		46					54	
	Silt part (%)	52	57	63	35		28	37		28					28	
	Clay part (%)	13	37	35	29		29	19		26					18	
	Max. diameter (mm)	2.0	2.0	2.0	2.0		2.0	2.0		2.0					2.0	
	Grain size classification	Silty loam	Silty clay	Silty clay	Clayey loam		Clayey loam	Loam		Clayey loam					Sandy loam	
CONSIS-TENCY	Liquid limit L. L (%)	22.71	28.40	37.60	27.28	24.20	28.90	18.95	20.65	14.48	30.80	28.80	22.70		18.30	
	Plastic limit P. L. (%)	20.52	21.55	28.20	21.94	14.32	20.51	15.22	17.03	14.02	22.66	21.56	17.40		17.50	
	Plasticity index P. I.	2.19	6.85	9.40	5.34	9.88	8.39	3.73	3.62	0.46	8.14	7.24	5.30		0.80	
	Flow index F. I.	3.60	7.10	12.10	11.70	4.65	8.80	7.60	7.25	3.85	10.10	4.60	9.10		.05	
	UNIFIED CLASSIFICATION	ML	ML	ML	ML		ML	ML		ML						
	CBR (at field density %)	10.36	5.84	9.05	7.86	7.86	14.23	5.21	4.52	15.69	16.94	16.94		16.26		31.40
	CBR (at compacted state %)												17.50	23.50	18.80	38.30
	CBR (at sand content ratio 20%)															40.70
	CBR (" " 40%)															
	CBR (" " 60%)															

Remarks:

1) CBR (at field density) is obtained for Soil compacted to field density where the soil is Sampled.
2) CBR (at compacted state) is obtained for Soil compacted to 90 and 95% of maximum dry density of the Soil.
3) CBR (at any sand content ratio) is obtained for soil mixed with Sand at mentional persent and compacted, to 90 and 95% of maximum dry density of the soil.
4) * tested for bed material of H/A.
   ** tested for bed material of R/W.
   *** tested for sub grade of H/A & R/W.

A. 1-5 SUMMARY OF SOIL TESTS (For Investigation of Subgrade & Bed Material) II

LOCATION WATTAY TESTED BY

SAMPLE NUMBER NO.	T. P. 10	T. P. 10	T. P. 10										
SAMPLING DEPTH (m)	1.25-1.45	1.70-1.90	2.60-2.80										
OBSERVATION	Grey brown	Brown	Brown										
Natural water content w(%)	11.34	12.79	16.33										
GRAIN SIZE PROPORTION: Specific gravity of Soil G			2.72										
Gravel part (%)	-	-	-										
Sand part (%)	35	35	43										
Silt part (%)	46	36	30										
Clay part (%)	19	29	27										
Max. diameter (mm)	2.0	2.0	2.0										
Grain size classification	Loam	Clayey loam	Clayey loam										
CONSISTENCY: Liquid limit L. L (%)	23.50	37.25	36.30										
Plastic limit P. L. (%)	16.44	22.83	26.43										
Plasticity index P. I.	7.06	14.43	9.87										
Flow index F. I.	7.30	6.50	12.50										
UNIFIED CLASSIFICATION	ML	ML	ML										
CBR (at field density %)													
CBR (at compacted state %)	15.50	30.50	27.80										
CBR (at sand content ratio 20%)	18.20		34.50										
CBR (at " 40%)	20.80		39.50										
CBR (" 60%)	28.60		46.00										

Remarks:
1) CBR (at field density) is obtained for Soil compacted to field density where the soil is sampled.
2) CBR (at compacted state) is obtained for soil compacted to 90 and 95% of maximum dry density of the soil.
3) CBR (at any sand content ratio) is obtained for soil mixed with sand at mentional percent and compacted to 90 and 95% of maximum dry density of the soil.
4) * tested for bed material of H/A.
** tested for bed material of R/W.
*** tested for sub grade of H/A & R/W.

A. 1-6 SUMMARY OF SOIL TESTS (For Investigation of Foundation Material) III

LOCATION WATTAY TESTED BY

		T. P. 4	T. P. 5	T. P. 7	T. P. 8	T. P. 8	T. P. 9	T. P. 10	T. P. 1	T. P. 1	T. P. 1	T. P. 2	T. P. 2
	SAMPLE NUMBER NO.	T. P. 4	T. P. 5	T. P. 7	T. P. 8	T. P. 8	T. P. 9	T. P. 10	T. P. 1	T. P. 1	T. P. 1	T. P. 2	T. P. 2
	SAMPLING DEPTH (m)	1.00-1.20	1.00-1.20	0.30-0.50	1.00-1.20	2.20-2.40	0.80-1.00	1.25-1.45	1.10-1.30	2.00-2.20	3.00-3.20	0.70-0.90	1.40-1.60
	OBSERVATION	Grey brown	Light brown	Yellow brown	Brown	Light brown	Yellow brown	Grey brown	Reddish brown	Yellow brown	Reddish brown	Grey brown	Grey brown
	Natural water content w (%)	7.96	12.24	6.32	8.35	12.82	7.03	11.34	25.31	17.37	26.00	18.59	18.19
	Specific gravity G	2.70			2.66		2.67		2.72	2.66	2.74	2.67	2.66
GRAIN SIZE PROPORTION	Gravel part (%)		-				-	-	1	1	-	-	-
	Sand part (%)		44				54	35	16	62	14	39	43
	Silt part (%)		37				28	46	45	29	50	43	48
	Clay part (%)		19				18	19	38	9	36	18	19
	Max diameter (mm)		2.0				2.0	2.0	4.8	2.0	2.0	2.0	2.0
	Grain size classification		Loam				Sandy loam	Loam	Clay	Sandy loam	Clay	Loam	Loam
CONSISTENCY	Liquid limit L. L. (%)	24.20	18.95	30.80	22.70		18.30	23.50	54.71		63.60	22.45	25.24
	Plastic limit P. L. (%)	14.32	15.22	22.66	17.40		17.50	16.44	16.28		16.58	11.25	11.51
	Plasticity index P. I.	9.88	3.73	8.14	5.30		0.80	7.06	38.43		47.02	11.20	13.73
	Flow index F. I.	4.65	7.60	10.10	9.10		3.05	7.30	17.00		14.70	5.01	9.46
UNIFIED CLASSIFICATION			ML				SC	ML	MH		MH	ML	ML
COMPACTION	Optimum water content (%)	13.30	12.40	11.60	11.50	13.10	12.40	11.10					
	Maximum drydensity (g/cm^3)	1,943	1,937	1,932	1,910	1,886	1,945	1,969					
SHEARING STRENGTH	Cohesion C (kg/cm^2)								0.100	0.360	0.140	0.167	0.450
	Internal friction angle ø (o)								1°43'	27°12'	4°28'	10°59'	7°08'
CONSOLIDATION	Initial void ratio eo												
	Preconsolidation load Po (kg/cm^2)								1.370	0.780	1.940	0.980	0.460
	Compression index Cc								0.133	0.040	0.142	0.173	0.076
	Coef of consolidation Cv (cm^2/sec.)												
	Coef of volume compressibility Mv (cm^2/g)												
	Coef of permeability K (cm/sec)												

Remarks:
1) Shearing strength is obtained by triaxial compression test at non-consolidated and non-drained condition and analysed by total stress method.
2) Initial voidratio means void ratio at preconsolidation load Po on e-log P curve.

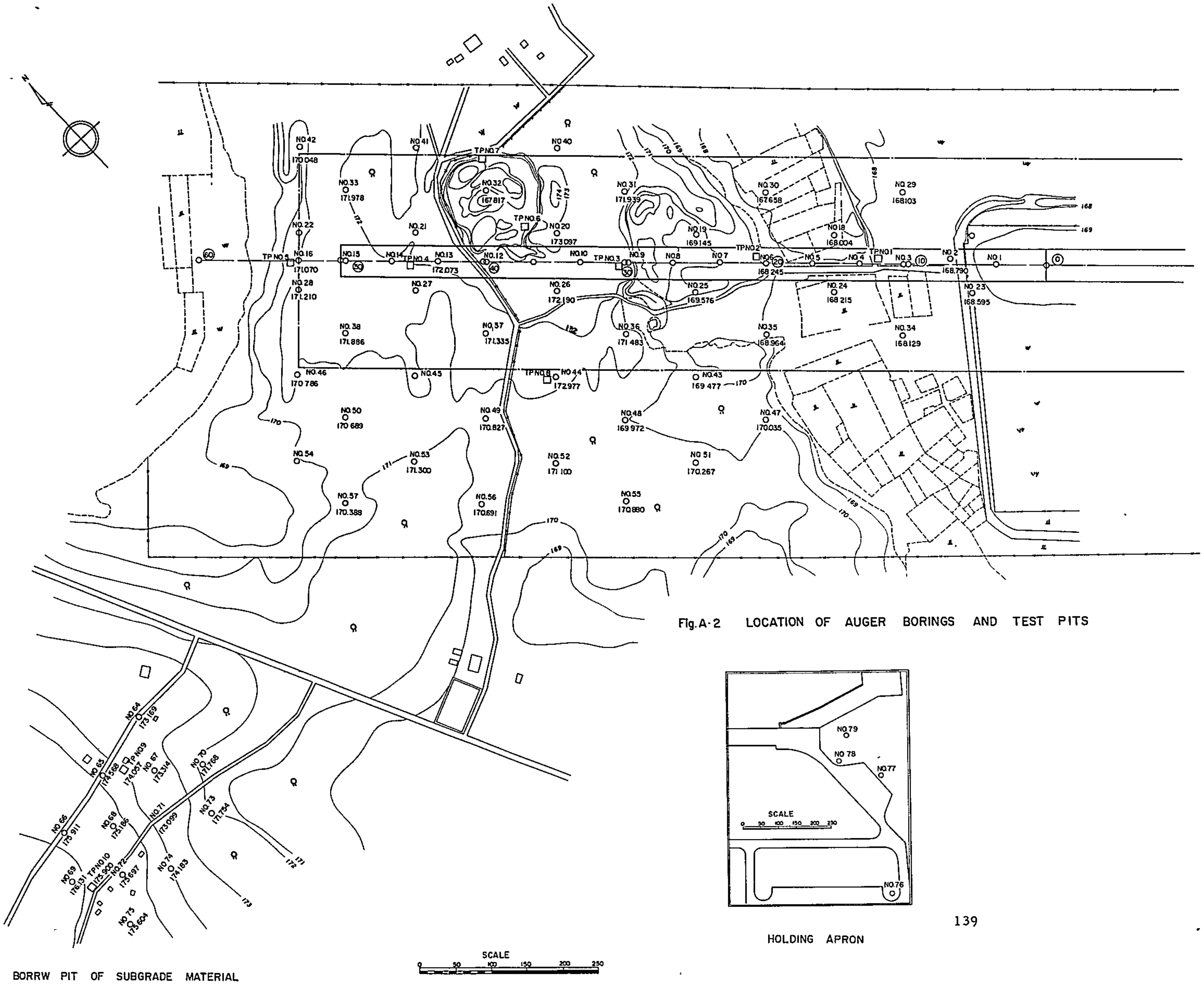


Fig. A-2 LOCATION OF AUGER BORINGS AND TEST PITS

BORRW PIT OF SUBGRADE MATERIAL

HOLDING APRON

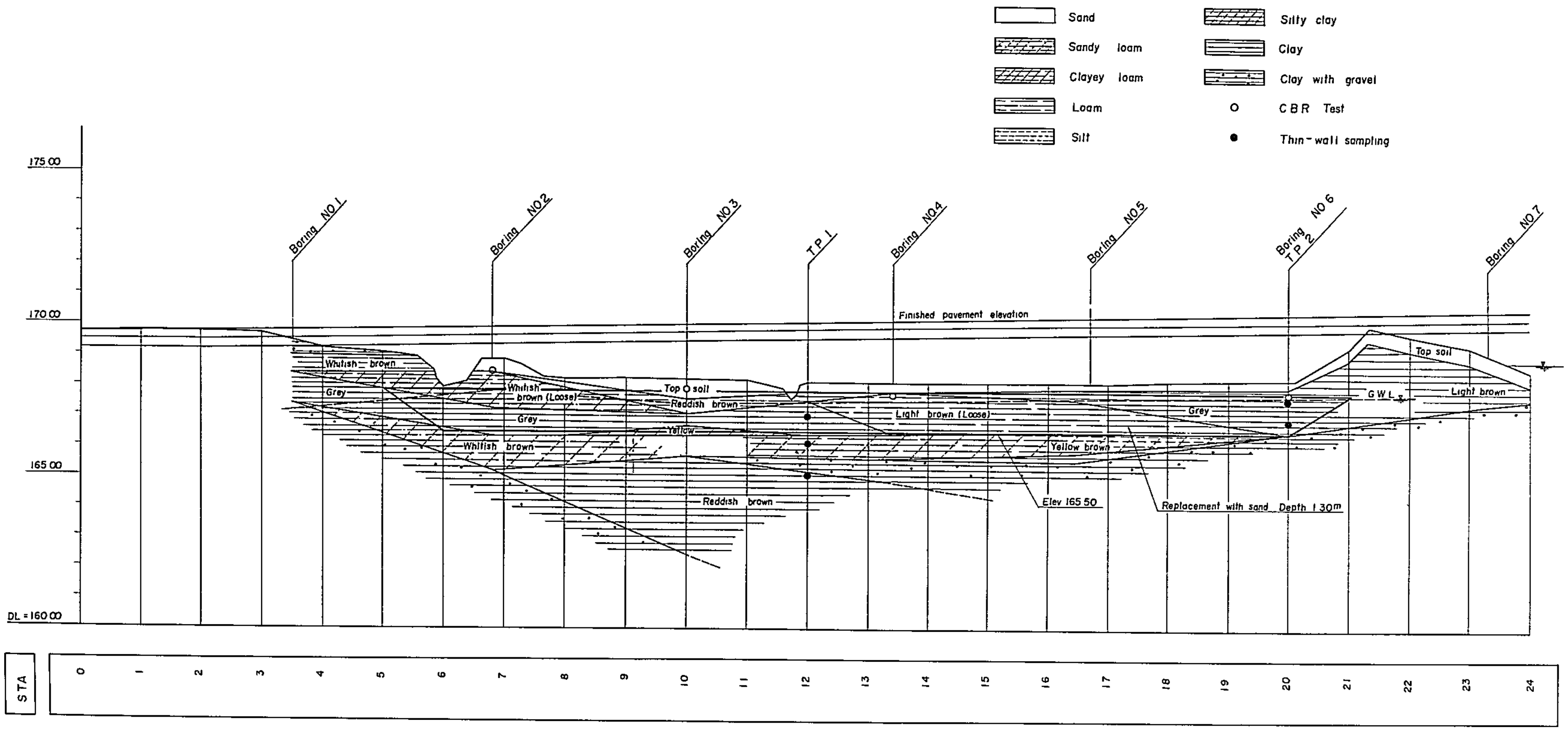


Fig. A-3-1 SOIL PROFILE OF RUNWAY EXTENSION

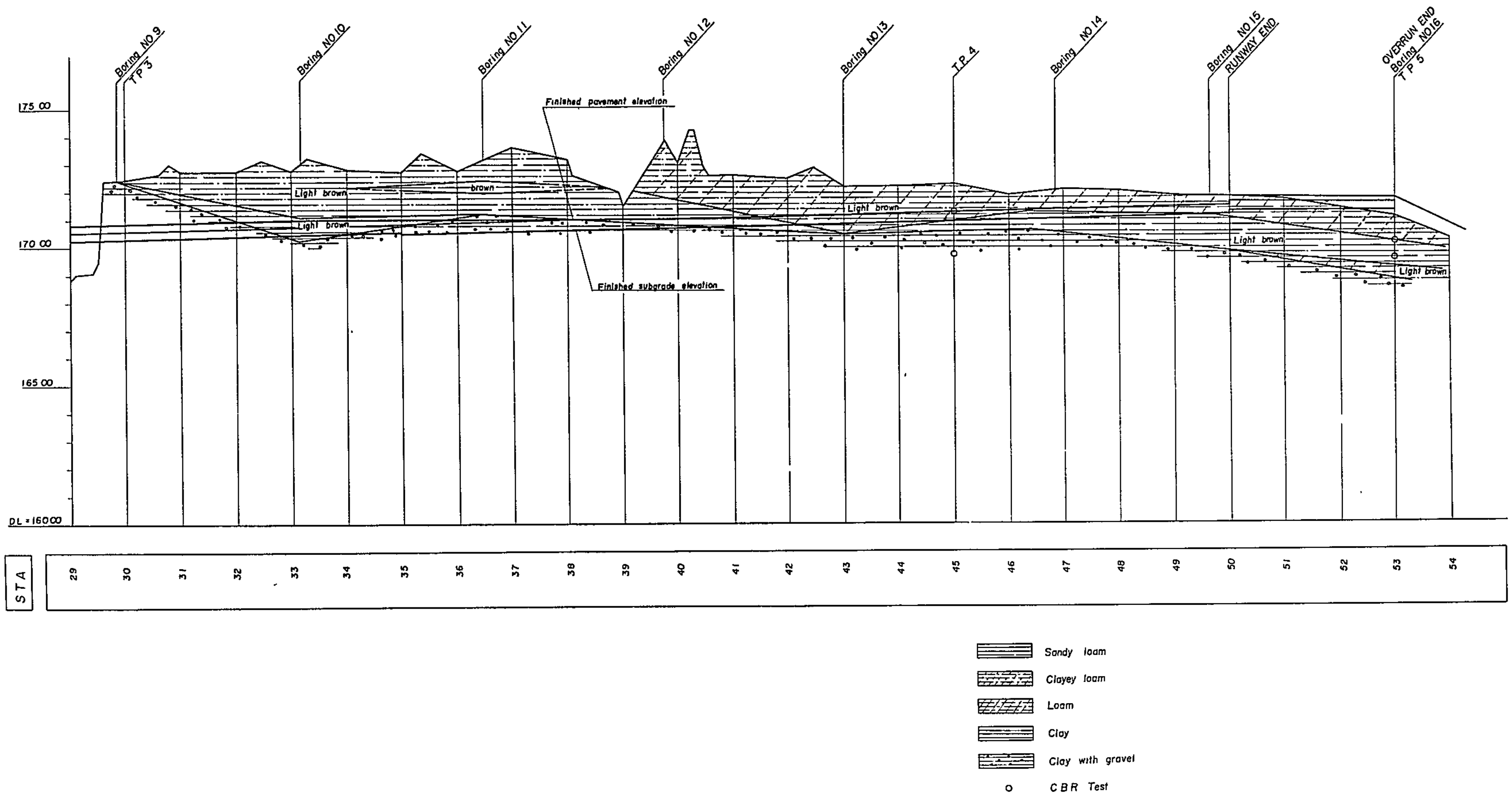


Fig. A-3-2 SOIL PROFILE OF RUNWAY EXTENSION

A. 4 - SUMMARY OF AGGREGATE & CONCRETE TEST

1) Aggregates

Sampling site		Ⓐ	Ⓑ	Ⓒ
F.M	fine	2.04	2.45	2.74
	coarse			7.30
P(%)	fine			0.80
	coarse			2.60
GS	fine			2.63
	coarse			2.65
A(%)	fine			2.63
	coarse			1.40
W (t/m^3)	fine			1.666
	coarse			1.723

2) Concrete

Specimen No.	Wc (kg/m^3)	P (%)	σ_c 7 days (kg/cm^2)	σ_c 28 days (kg/cm^2)	σ_b 7 days (kg/cm^2)	σ_b 28 days (kg/cm^2)
T - 1	380	40	160 or 256	180	35	46
T - 2	380	40	289	379	43	49
T - 3	350	45	270	371	38	45
T - 4	350	40	278	396	38	42
T - 5	350	40	266	353	38	47
T - 6	320	40	262	292	35	44
T - 7	320	40	100 or 233	224	31	37
T - 2*	350	43		296		32
T - 4*	350	43		245	37	42

Remarks

FM: Fineness modulus. P: Percentage passing # 200 mesh.

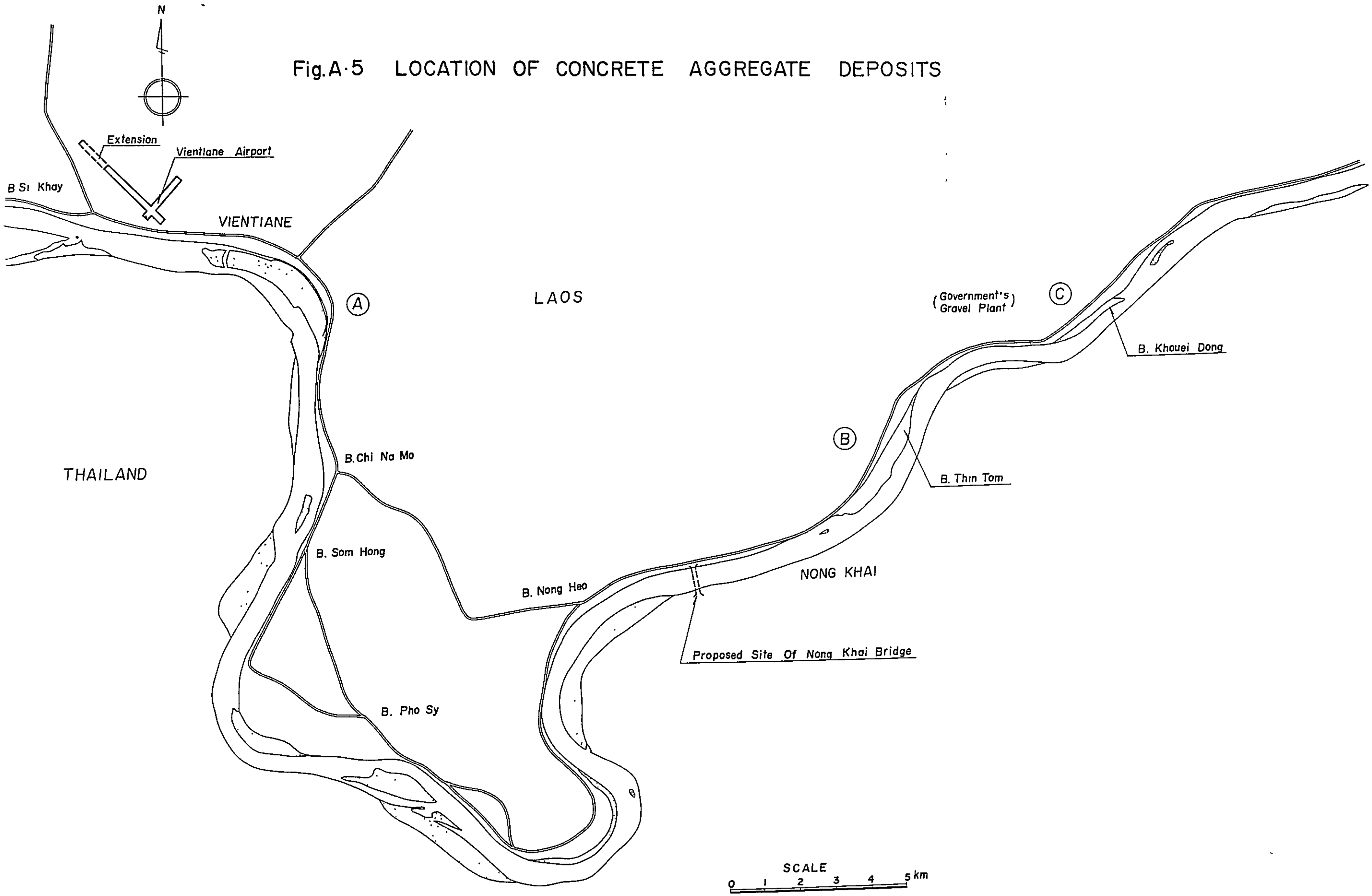
GS: Specific gravity. A: Absorption W: Unit weight.

Wc: Unit cement content. P: Water cement ratio.

σc: Compressive strength. σ_b : Flexural strength.

*: Aggregates of these specimen are crushed stone

Fig.A·5 LOCATION OF CONCRETE AGGREGATE DEPOSITS



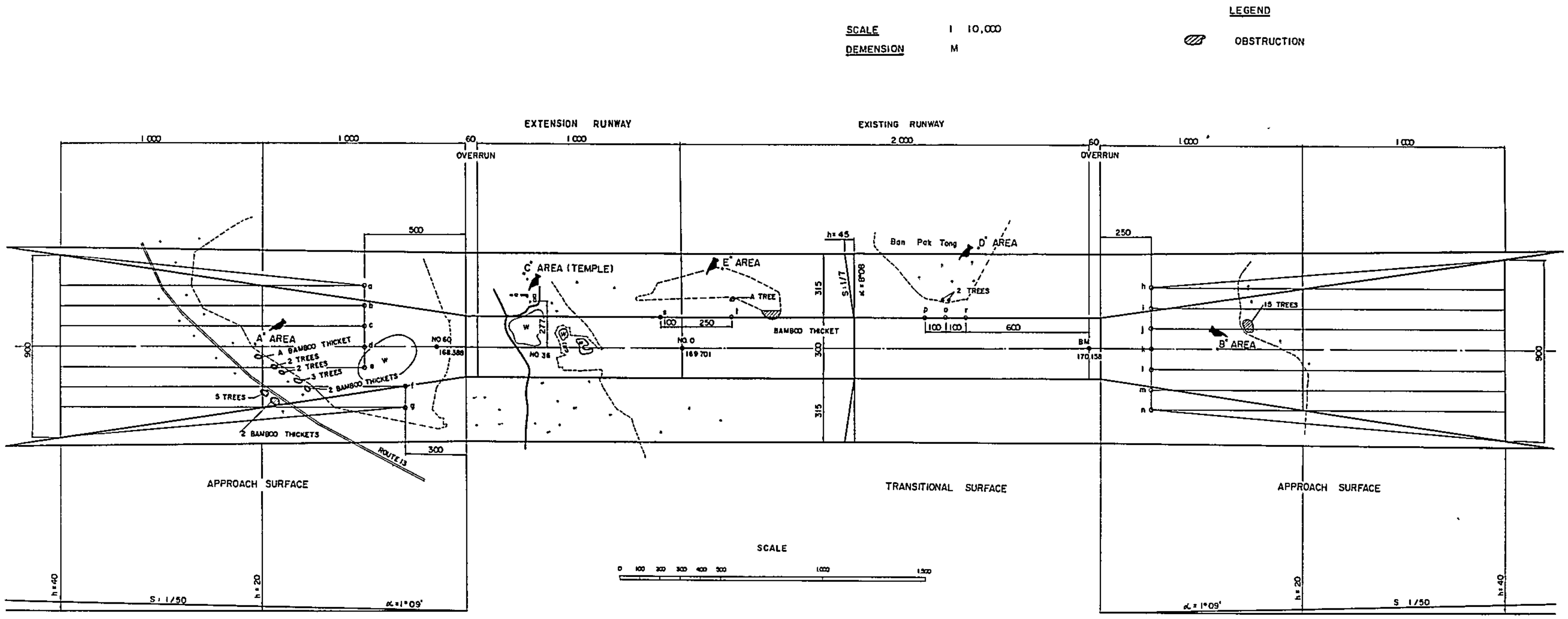


Fig. A-6 CHART OF OBSTRUCTIONS