UNITED NATIONS

COMMITTEE FOR COORDINATION OF INVESTIGATIONS

OF THE LOWER MEKONG BASIN

NONG KHAI / VIENTIANE BRIDGE PROJECT

LAOS — THAILAND

FEASIBILITY REPORT

PART I

SUMMARY AND RECOMMENDATIONS

OVERSEAS TECHNICAL COOPERATION AGENCY

Japan, September 1969

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PART I

SUMMARY AND RECOMMENDATIONS

OVERSEAS TECHNICAL COOPERATION AGENCY

Japan, September 1969

Tokyo, 29 September 1969

LETTER OF SUBMITTAL

His Excellency Mr. Kiichi Aichi
Minister of Foreign Affairs
Tokyo, Japan

Excellency,

I have the honor to present herewith to Your Excellency the Feasibility Report comprising three parts on the Nong Khai/Vientiane bridge project for which the works have been entrusted to the Overseas Technical Cooperation Agency by the Government of Japan.

The Government of Japan, fully cognizant of the importance of the economic cooperation with Laos and Thailand, offered in April 1967 to undertake the feasibility study on this project in response to the request of the Committee for Coordination of Investigations of the Lower Mekong Basin.

The Agency dispatched a team of engineers for two different periods of about two months from August to October 1967 and about four months from February to June 1968. Besides, an advisory party consisting of three members was concerned in technical advices for the feasibility study of the project.

The project envisages to construct a rail/highway bridge across the Mekong, to extend the existing railway from Nong Khai up to Vientiane, and to build a highway to connect the two parts of the Asian Highway A-12 now existing in Laos and Thailand.

In this report it was made clear that the Nong Khai/Vientiane bridge project is technically, economically and financially feasible and will play the most important role in the socio-economic development of both Laos and Thailand. Therefore, the implementation of the project is strongly required, and above all it is advisable that following the feasibility study the detailed design is immediately carried out.

In this occasion, I wish to express my sincere thanks to all concerned of the Governments of Laos and Thailand who have kindly extended their supports and cooperation. My appreciation also goes to the members of the Japanese Embassies, who cooperated with us during our investigation, and to the agencies of the Government of Japan and the consulting companies who assisted us in dispatching the survey team.

Respectfully submitted,

K. Tatsuke

Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency

NIPPON KOEI CO., LTD.

Consulting Engineers

TELEX: TK4557 (KOEICO)
CABLES: NIPPONKOEI TOKYO

1-11, UCHISAIWAICHO 2 CHOME, CHIYODA-KU,
TOKYO, JAPAN

TEL. TOKYO 502-7571

REFERENCE

DATE 27 September 1969

LETTER OF TRANSMITTAL

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

Dear Sir,

I have the great pleasure to submit herewith to you the Feasibility Report comprising three parts on the Nong Khai/Vientiane bridge project for which the works have been entrusted by you to Nippon Koei Co., Ltd.

The Nong Khai/Vientiane bridge project aims at constructing a bridge over the Mekong to complete the Asian Highway A-12 from Sara Buri in Thailand to Vientiane in Laos and to extend to Vientiane the existing railway in Thailand now linking Bangkok with Nong Khai.

The feasibility study of the project has been made from engineering, economic and financial viewpoints in accordance with the provisions of the Plan of Operation that was signed on April 14, 1967 between the Mekong Committee and the Japanese Government. The works have been divided into four phases and the purpose of each phase is as described below.

First phase:	To execute the preliminary investigation and study for the selection of the most favorable bridge site from among the three proposed sites, Nong Khai, Vientiane and Pa Mong.
Second phase:	To draw a conclusion as to which should be taken up, a rail/highway bridge or a highway bridge, from engineering, economic and financial points of view.
Third phase:	To provide a draft feasibility report regarding the selected bridge site and the selected kind of bridge.
Fourth phase:	To finally print the draft feasibility report in accordance with the decisions of the Mekong Committee based on the first, second and third phase reports.

NIPPON KOEI CO., LTD.
TOKYO, JAPAN

We are very happy to state that all of these works have been completed. The first-phase operation was carried out in 1967 and the second-phase operation in 1968. As a result, the following matters have already been decided by the Mekong Committee in accordance with the conclusions and recommendations given in the First-and Second-Phase Reports: (1) the bridge site is Nong Khai, (2) the kind of bridge is a rail/highway bridge and (3) the railway route is Route C/D.

According to the results of the feasibility study presented in this report, the Nong Khai/Vientiane bridge project is technically, economically and financially sound. The benefit-cost ratio is around 6 and the internal rate of return is 16 percent for the case that no toll is charged on the bridge. Even in the case of collecting bridge tolls equaling the current ferry charges the ratio is 1.3 and the internal rate of return is 12.9 percent.

It is advisable to immediately seek for a generous grant or a soft loan to finance the project. If it is difficult to raise a fund for the whole construction cost 21,500,000 U.S. dollars at the earliest moment, it is recommended that an appreciable action be first taken to finance only the detailed design of the project to be successively carried out, which is estimated at about 400,000 U.S. dollars inclusive of the preparation of the tender documents. It is effective to demonstrate the implementation of the project during the period of the execution of the detailed design which will take at least one year or one and a half years.

We wish to express our hearty thanks to the Mekong Committee, the Government authorities of the riparian countries, Laos and Thailand, the Japanese Embassies and other organizations concerned for their kind cooperation rendered to us during the investigations.

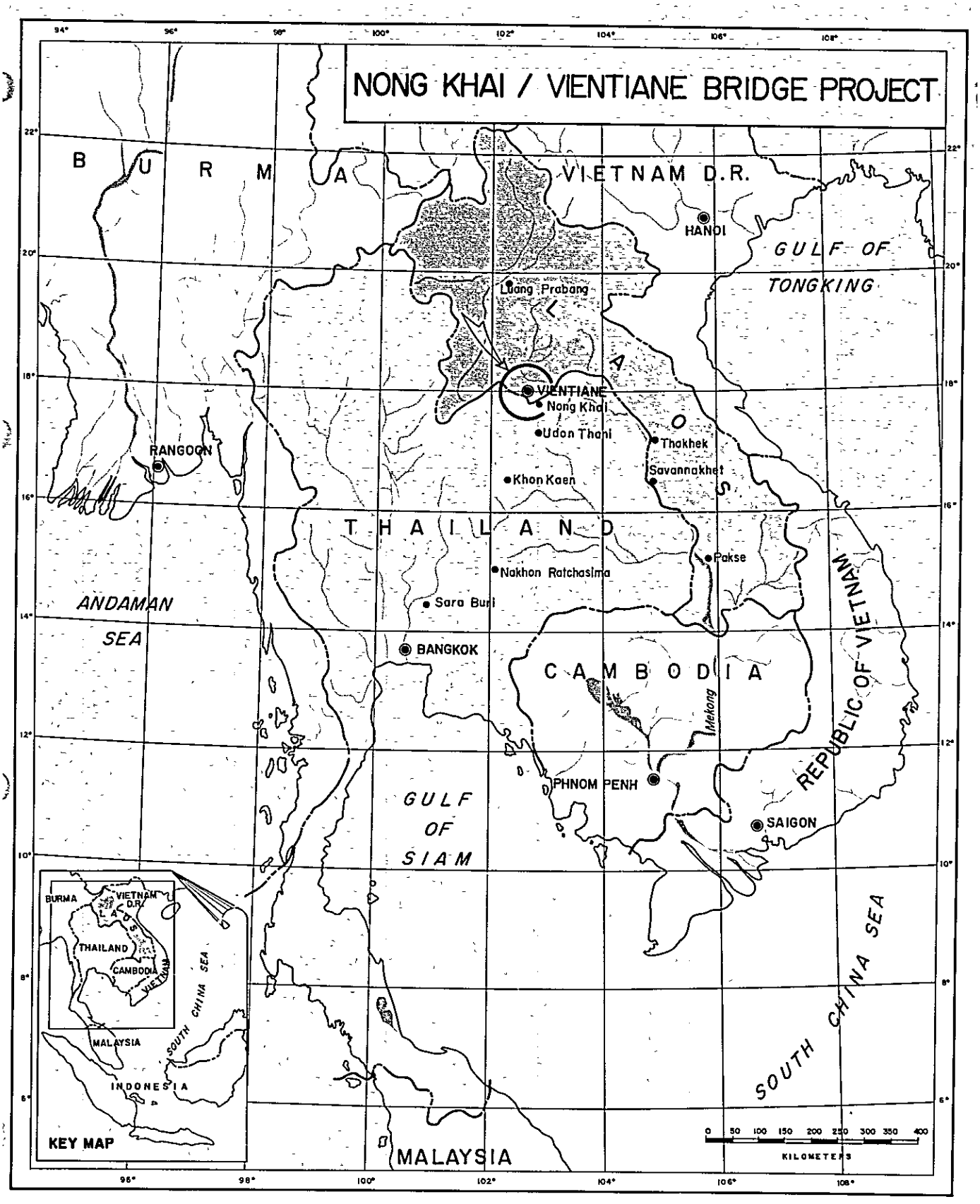
With our heartfelt gratitude for your constant support and encouragement, we remain,

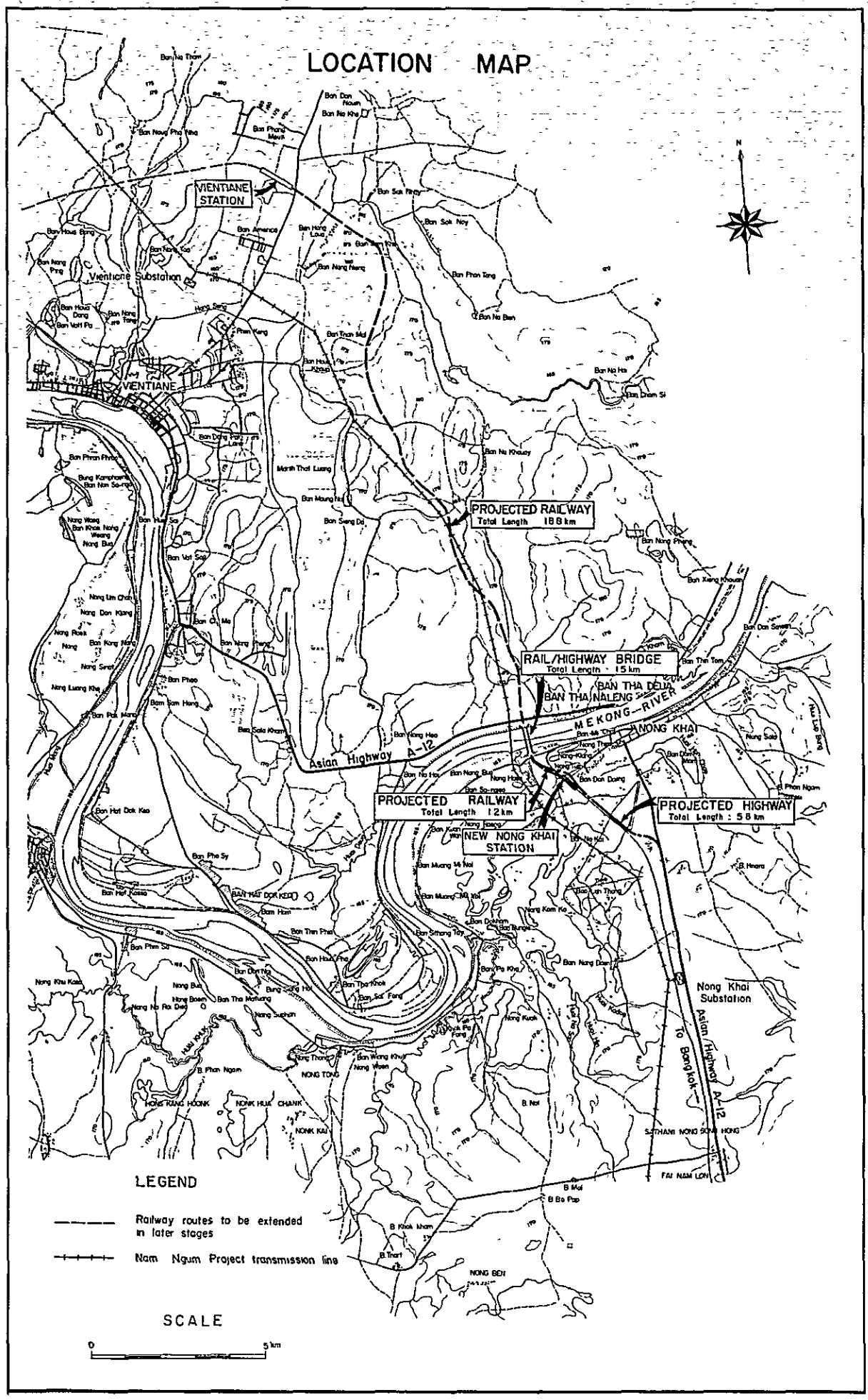
Yours most obediently

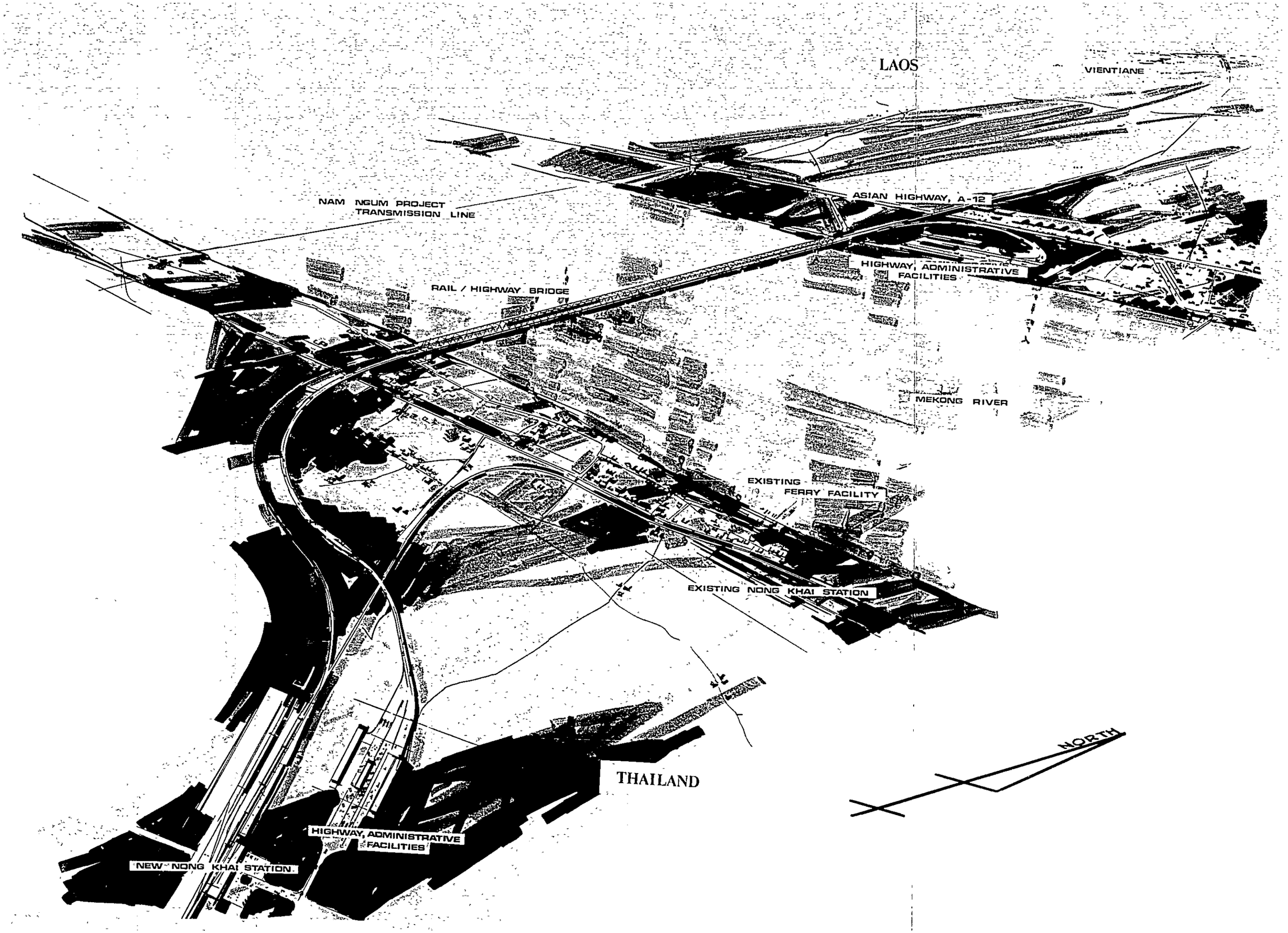
R. Komori

for Yutaka Kubota
President

Nippon Koei Co., Ltd.


NONG KHAI / VIENTIANE BRIDGE PROJECT
B U R M A
VIETNAM D.R.
HANOI
GULF OF TONGKING
Luang Prabang
L A O S
VIENTIANE
Nong Khai
Udon Thani
Thakhek
Savannakhet
Khon Kaen
RANGOON
T H A I L A N D
Pakse
Nakhon Ratchasima
Sara Buri
ANDAMAN SEA
BANGKOK
C A M B O D I A
Mekong
REPUBLIC OF VIETNAM
PHNOM PENH
SAIGON
GULF OF SIAM
SOUTH CHINA SEA
MALAYSIA
0 50 100 150 200 250 300 350 400
KILOMETERS
KEY MAP
BURMA
VIETNAM D.R.
L A O S
THAILAND
CAMBODIA
VIETNAM
SOUTH CHINA SEA
MALAYSIA
INDONESIA


LOCATION MAP
VIENTIANE STATION
Vientiane Substation
VIENTIANE
PROJECTED RAILWAY
Total Length 188 km
RAIL/HIGHWAY BRIDGE
Total Length : 1.5 km
BAN THA DEUA
BAN THA NALENG
MEKONG RIVER
NONG KHAI
Asian Highway A-12
PROJECTED RAILWAY
Total Length 12 km
NEW NONG KHAI STATION
PROJECTED HIGHWAY
Total Length : 5.8 km
Nong Khai Substation
To Bangkok
LEGEND
Railway routes to be extended in later stages
Nam Ngum Project transmission line
SCALE
0
5 km


LAOS
VIENTIANE
NAM NGUM PROJECT
TRANSMISSION LINE
ASIAN HIGHWAY, A-12
HIGHWAY, ADMINISTRATIVE
FACILITIES
RAIL / HIGHWAY BRIDGE
MEKONG RIVER
EXISTING
FERRY FACILITY
EXISTING NONG KHAI STATION
THAILAND
HIGHWAY, ADMINISTRATIVE
FACILITIES
NEW NONG KHAI STATION
NORTH

PROJECT FEATURES

Item			Description
I.	PROJECT		
	1. Location		670 kilometers northeast of Bangkok, 20 kilometers southeast of Vientiane and 3 kilometers upstream of Nong Khai
	2. Purpose		To build a rail/highway bridge across the Mekong, a highway, a new railway to be extended from Nong Khai to Vientiane, and two administrative facilities for immigration, customs and plant quarantine.
	3. Construction cost		U.S.$ 21,500,000
II.	BRIDGE		
	1. River width		640 m
	2. Type		
		(i) Main bridge	Steel Warren truss, two 3-span continuous and one 2-span continuous, besides a suspended span
		(ii) Approach viaducts	
		Railway part	Plate girder and reinforced-concrete 3-span-continuous rigid frame construction
		Highway part	Composite girder and reinforced-concrete 3-span-continuous hollow slab construction
	3. Bridge width		17.8 m
		(i) Railway part	4.0 m
		(ii) Highway part	8.0 m
		(iii) Sidewalk	1.5 m
		(iv) Gangway	1.5 m
	4. Bridge length		
		(i) Main bridge	650 m
		(ii) Approach viaducts	803.5m
		Railway part	473.5m
		Highway part	330 m
	5. Max. pier spacing		90 m
	6. Abutment and pier		2 open caissons on both banks, and 8 pneumatic caissons on the Mekong river-bed
III.	RAILWAY		
	1. Track		Single
	2. Track gauge		1.000 m
	3. Length		20 km
	4. Station		
		(i) Vientiane station	100,000 m^2
		(ii) New Nong Khai station	55,000 m^2
IV.	HIGHWAY		
	1. Length		5.8 km
	2. Width		
		(i) Roadway	7 m (two lanes)
		(ii) Shoulder	2.5 m each
V.	ADMINISTRATIVE FACILITIES		48,000 m^2

BENEFITS AND COSTS

	Item	Discount rate (%)	Unit	Characteristic value △
I.	FUTURE TRAFFIC			
	1. Vehicles			
	A.D. 1973		vehicles/day	1,353
	1990		"	9,025
	2000		"	13,538
	2. Railway freight			
	A.D. 1973		tons/day	606
	1990		"	2,737
	2000		"	3,991
	3. Railway passengers			
	A.D. 1973		persons/day	380
	1990		"	2,045
	2000		"	3,025
II.	ANNUAL BENEFIT	3	U.S.$	7,036,300
		7	"	5,619,100
		10	"	4,794,800
III.	ANNUAL COST	3	U.S.$	1,195,600
		7	"	1,886,900
		10	"	2,478,700
IV.	BENEFIT-COST RATIO	3		5.9
		7		3.0
		10		1.9
V.	INTERNAL RATE OF RETURN		percent	15.9
VI.	INDIRECT BENEFIT			
	1. Lumber industry		Much expedited	
	2. Mining		Much expedited	
	3. Urbanization		Rapid, especially around the Vientiane station	
	4. Rise in land value		Remarkable	
	5. Livestock industry		Self-sustaining expedited	
	6. Saving in stock		Much	

△: These characteristic values are given for the case that no toll is charged on the bridge.

NONG KHAI/VIENTIANE BRIDGE PROJECT

FEASIBILITY REPORT

PART I

SUMMARY AND RECOMMENDATIONS

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SEPARATE VOLUMES

Part II, ENGINEERING, ECONOMIC AND FINANCIAL STUDIES and Part III, ENGINEERING AND ECONOMIC DATA of the Feasibility Report, are presented in separate volumes.

CURRENCY EXCHANGE RATE

1 U.S. dollar = 20.5 Bahts = 500 Kips

CHAPTER I

INTRODUCTION

1.1. Necessity of the Project

The Kingdom of Laos is a landlocked country surrounded by Thailand, Cambodia, South Viet-Nam, North Viet-Nam, China and Burma. Owing to this geography, Laos's exports and imports are compelled to pass through the territories of neighboring countries.

Before World War II, Laos, along with Cambodia and Viet-Nam, had been a constituent of Indochina under French rule. In those days, all means of transport in Laos were linked with Viet-Nam and Cambodia. Several long highways connected principal cities in Laos with Hanoi, Hai Phong, Hue and Da Nang in Viet-Nam. And, an artery road along the Mekong connected Vientiane with Thakhek, Savannakhet and Paksé in Laos and entered into Cambodia toward Phnom Penh and Saigon. Therefore, most of the foreign trade to and from Laos was being made through Hanoi or Saigon or Phnom Penh and almost none through Bangkok in Thailand.

With the change in the situation in this part of the world after World War II, Laos is now making most of her foreign trade through the route from Bangkok. It is natural that Laos has chosen this route as it is the shortest among the conceivable routes. The route from Bangkok to Vientiane measures about 690 kilometers as compared with 800 kilometers from Hanoi or 1,200 kilometers from Phnom Penh. Moreover, the route from Hanoi or Saigon has virtually been shut off since the outbreak of hostilities in Viet-Nam.

The navigation on the Mekong from its mouth to Vientiane, a stretch of about 1,600 kilometers, at present cannot be expected as a means of transport. There are certain reaches on the way such as the Sambor rapids, Khone Falls, the Khemarat rapids and so on, where the river is not navigable, or is navigable only with difficulty.

Thus, the route from Bangkok is most advantageous and hence is being fully utilized. At present, most of the freight destined for Laos is carried from the port of Bangkok to Nong Khai either by trucks on the Asian Highway A-12 or by rail on the northeastern line of the Royal State Railway of Thailand. Both routes ensure smooth and speedy transportation. However, the rail freight must be transshipped at Nong Khai to trucks to be carried, after crossing the Mekong by the ferry, on the Asian Highway A-12 extensions that runs about 20 kilometers from Tha Naleng to Vientiane on the Laotian side.

The crossing of the Mekong by the ferry constitutes a bottleneck to the traffic to and from Laos. The existing vehicular ferry is no more able to serve the growing traffic. In these days, a long row of trucks awaits the ferry on the Nong Khai side.

It is a long-cherished desire of the people in these areas to replace the ferry with a bridge. The bridge will not only warrant a smooth and speedy flow of traffic but also greatly contribute to the promotion of the Laotian foreign trade and give stimulus to the socio-economic development of Laos as well as of the northeastern region of Thailand.

1.2. History of the Project

The project of bridging the Mekong in the Nong Khai-Vientiane area dates back to 1956, when the United States Operation Mission in Thailand first undertook a study for a favorable bridge site. And a little later, the Royal State Railway of Thailand has also made a similar survey.

The project was highlighted in 1965 when the Committee for Coordination of Investigations of the Lower Mekong Basin, which will be hereinafter referred to as the Mekong Committee, took it up at its 29th Session as one of the first priority projects in the Ten-Year Development Program of the Lower Mekong Basin.

In May 1966, at the Third Seminar on Navigation Improvement, discussions were made on three possible bridge sites – Nong Khai, Vientiane and Pa Mong – that had been considered promising at that time, and a resolution was made that a study on these three sites should be started.

In February 1967, the Mekong Committee requested assistance of friendly countries to the execution of the feasibility study of the bridge project. In response to the Mekong Committee's request, the Japanese government has offered at the 32nd Session in April 1967 to undertake the study. This offer was consented to by the Laotian and Thai representatives and the Plan of Operation was immediately provided and signed between the Mekong Committee and the Government of Japan. The Japanese Government Ministry of Foreign Affairs has entrusted the task of the said study to the Overseas Technical Cooperation Agency, which, in turn, assigned the execution of the study to Nippon Koei Co., Ltd.

The Plan of Operation stipulates that the feasibility study be made in four phases. The first-phase investigation was carried out during the period from August to October 1967 and the First-Phase Report was submitted to the Mekong Committee in December 1967. The Mekong Committee, at its 34th Session held in January 1968, requested the Advisory Board to review the report and, following the Advisory Board's advice, decided to choose the Nong Khai site in accordance with the conclusions and recommendations stated in the First-Phase Report.

As soon as the bridge site had thus been decided, the Japanese survey team started the second-phase study, making field investigations from February through June 1968. One major purpose of the second-phase investigation was to make study on, and to obtain data for deciding, the kind of the bridge, a rail/highway bridge vs. a highway bridge, to be built at the Nong Khai site. The Second-Phase Report was submitted to the Mekong Committee in November 1968. The Mekong Committee, at its 38th Session held in January 1969, decided to select a rail/highway bridge as the kind of bridge to be built at the Nong Khai site, according to the conclusions and recommendations stated in the Second-Phase Report.

The Plan of Operation stipulates that a draft feasibility report be submitted in the third phase, which will summarize the results of the first and second-phase investigations. Part I: Summary and Recommendations of the Draft Feasibility Report was submitted to the Mekong Committee in April 1969. Part II: Engineering, Economic and Financial Studies, and Part III: Engineering and Economic Data of the Draft Feasibility Report were submitted to the Mekong Committee in May 1969.

The Mekong Committee approved Part I of the said report at its 39th Session held in Singapore in April 1969, and also approved Parts II and III at its 40th Session held in Geneva in July 1969.

The Plan of Operation provides that the Draft Feasibility Report be printed in the fourth phase. Part I: SUMMARY AND RECOMMENDATIONS, that is the present volume, Part II: ENGINEERING, ECONOMIC AND FINANCIAL STUDIES, and Part III: ENGINEERING AND ECONOMIC DATA of the final Feasibility Report were submitted to the Mekong Committee in September 1969.

On the other hand, the Government of Japan dispatched five engineers forming a railway survey team for the period from November 1968 to February 1969 in order to execute a feasiblity investigation on the railway route about 20 kilometers long to be extended from Nong Khai to Vientiane, and to select the most promising route from among the five proposed routes A, B, C, D and C/D.

At the beginning of the feasibility study of the Nong Khai/Vientiane bridge project, the scope of the investigation pertinent to the railway was considered to be limited to the extent of pre-feasibility investigation. In fact, the railway investigation carried out in the first- and second-phase investigations in 1967 and 1968 was limited to the reconnaissance and no topographic survey was made along the routes.

The Mekong Committee resolved to make the Nong Khai/Vientiane bridge not a highway bridge but a rail/highway bridge in January 1969, and it became necessary to undertake the feasibility study of the railway.

A report recommending to take up Route C/D as the most favorable railway route was prepared in March 1969 in Japanese version. The English version of the report was submitted to the Mekong Committee in July 1969.

CHAPTER II

CONSTRUCTION

2.1. General

The feasibility investigations of the project were carried out in 1967 and 1968. Before the investigations were undertaken, the three favorable bridge sites, Nong Khai, Vientiane and Pa Mong, had been considered. The first-phase investigation, which was conducted in 1967, resulted in the selection of the Nong Khai bridge site as the most favorable. The second phase investigation, which was conducted in 1968, made clear that a rail/highway bridge is more advantageous than a highway bridge.

Consequently, the Nong Khai/Vientiane bridge project envisaged is to construct a rail/highway bridge at Nong Khai. The main project structures are a bridge, a railway, and a highway. In addition, special administrative facilities are necessary on the riverside terrains because the Mekong forms the border between Laos and Thailand in this region. Vehicles, passengers and freight to cross the Mekong have to go through due formalities for immigration, customs and plant quarantine.

The following is a brief description of the four major structures mentioned above.

The rail/highway bridge consists of a main bridge 650 meters long and approach viaducts 803.5 meters. The railway is an extension of the existing northeastern trunk line of the Royal State Railway of Thailand about 20 kilometers long from Nong Khai to Vientiane via the bridge. The highway will be built for the purpose of linking the bridge with the existing Asian Highway A-12 running near the bridge site in Laos as well as in Thailand. The length of the highway is 4.5 kilometers on the Thai soil and 1.3 kilometers on the Laotian side. The administrative facilities will be provided in each of both countries. The facilities include immigration offices, customhouses, plant quarantine offices, warehouses, booths, and so on.

These four major structures are quite feasible from the engineering point of view.

As for the construction of the bridge, it is not difficult to excavate the alluvial deposits covering comparatively thinly over the Jurassic reddish siltstone with shale layers intercalated, and to found the bridge piers on the fresh siltstone. The other structures are quite ordinary construction works, and no serious engineering problem seems to occur during construction as understood from the topographic features of the project area where is generally gentle and presents relatively firm ground.

The construction cost is estimated at 21,500,000 U.S. dollars in total. Table 2.1. presents the principal features of the project.

Table 2.1. Project Features

Item	Unit	Characterization
I. Project		
1. Location		670 kilometers northeast of Bangkok, 20 kilometers southeast of Vientiane and 3 kilometers upstream of Nong Khai
2. Purpose		To build a rail/highway bridge across the Mekong including the construction of a highway, a railway to be extended to Vientiane, and two administrative facilities for immigration, customs and plant quarantine.
3. Construction cost	US$	21,500,000
II. Bridge		
1. River width	m	640
2. Navigation requirements		
(i) Vertical clearance	m	10
(ii) Horizontal clearance	m	78
3. Design high-water level	m	EL. 167
4. Type		
(i) Main bridge		Steel Warren truss bridge, two 3-span continuous and one 2-span continuous, besides a suspended span
(ii) Approach viaducts		
Railway part		Plate girder and reinforced-concrete 3-span-continuous rigid frame construction
Highway part		Composite girder and reinforced-concrete 3-span-continuous hollow slab construction
5. Bridge width	m	17.8
(i) Railway part	m	4.0
(ii) Highway part	m	8.0
(iii) Sidewalk	m	1.5
(iv) Gangway	m	1.5
6. Bridge length		
(i) Main bridge	m	650
(ii) Approach viaducts	m	803.5
Railway part		473.5
Plate girder	m	60
Rigid frame	m	413.5
Highway part		
Composite girder	m	60
Hollow slab	m	270
7. Abutment and pier	m	2 open caissons on both banks 8 pneumatic caissons on the Mekong river-bed.
8. Span		
(i) Main bridge	m	(70-70-70)x2+2(70+70)x1+90
(ii) Approach viaducts		
Railway part		
Plate girder	m	(30) + (30)
Rigid frame		
Laotian side	m	(8-15-8-3)+(3-10-10-10-3)x4 +(3-7.5-7.5-7.5)
Thai side	m	(10-10-10-3)x2+(3-10-10-10-3)x4
Highway part		
Composite girder	m	(30) + (30)
Hollow slab	m	(15-15-15)x6
9. Summit of formation	m	EL. 179.270
10. Longitudinal grade		
(i) Main bridge	%	1.2
(ii) Approach viaducts		
Railway part		
Plate girder	%	1.2
Rigid frame	%	1.2
Highway part		
Composite girder	%	1.2
Hollow slab	%	4.0
III. Railway		
1. Length		
(i) Laotian side	km	18.8
(ii) Thai side	km	1.2
2. Track gauge	m	1.000
3. Radius of curvature	m	400 at min.
4. Station		Including administrative facilities
(i) Vientiane station	m^2	100,000
(ii) New Nong Khai station	m^2	55,000
IV. Highway		
1. Length		
Laotian side	km	1.3
Thai side	km	4.5
2. Width		
Roadway	m	7 (two lanes)
Shoulder	m	2.5 (each on both sides)
3. Radius of curvature	m	500
V. Administrative facilities		
1. Laotian side	m^2	22,000
2. Thai side	m^2	26,000

2.2. Bridge

Various studies were made to design such a bridge that can meet engineering, economic and esthetic requirements. The studies are summarized below item by item.

2.2.1. Design Criteria

The preliminary design of the bridge was conformed to the "Specification for the Supply of Steel Superstructure of Railway Bridge" of the Thai Royal State Railway and the "Standard Specifications for Highway Bridges" of the American Association of State Highway Officials.

The standard HS20-44 truck (W = 72,000 lbs) was taken as live loads for highway part of the rail/highway bridge, and the standard 15-ton loading was taken as live loads for railway part of the bridge. The vertical clearance for grade separation between railway and highway or between highways was taken at 4.5 meters.

2.2.2. Navigation Requirements

At and around the bridge site, the Mekong flows relatively deep on the Laotian side and shallow on the Thai side. The navigation course at this site lies therefore deviated toward the Laotian side.

The Plan of Operation states in regard to the Mekong's navigation that:
"The Mekong Committee's Advisory Board recommended at its Eighth Meeting in April 1967 that the bridge should have a minimum horizontal clearance of 78 meters and a vertical clearance of 10 meters above preponderant high-water level."

The problem lies in the selection of the preponderant high-water level. With a view of obtaining data for this selection, the high-water levels probable to occur at the bridge site were estimated based on the records observed at gaging stations located in the project area. The records made available are the 30-year (1937–67) data observed at the R.I.D. gaging station located at Wat Hai Sok in Nong Khai and the 4-year (1964–67) records at the Hydrographic Office at Nong Khai.

The 5-year probable high-water level of an elevation of 166.7 meters above mean sea-level was considered appropriate to be chosen as the preponderant high-water level. Making a margin of 0.3 meters, the design high-water level at the bridge site to be based upon in designing the bridge structures was set at E1.167.0.

In the tentative design of the main bridge, the top face of the piers of the 90-meter main span that provides a horizontal clearance of not less than 78 meters as stipulated in the Plan of Operation was set at E1.177.0. Then, if it is assumed that the bridge bearings will stand about 0.6 meters high, the bottom of the bridge members will become to lie at E1.177.6.

The main bridge that will measure 650 meters in total length will be divided into nine spans, one 90-meter span and eight 70-meter spans. The 90-meter span that will provide the main navigation course is not located at the center of the bridge. Instead, it constitutes the fourth span from the Laotian side conforming to the condition of the river channel previously noted. On both sides of the 90-meter span, the bridge will slope toward both ends at a straight-line grade of 1.2 percent, the maximum grade specified by the Thai State Railway. The highest point, or summit, of the roadway

surface lies at the midspan of the 90-meter span at an elevation of E1.179.27.

2.2.3. Type of Bridge

The type of bridge is to be selected from the engineering and economic points of view. A bridge must first suit local conditions and give the greatest service for the least money. It is also required to be durable, easy to maintain and agreeable in appearance.

With these in view, a comparative study on the type of the rail/highway bridge was made among five conceivable types: (1) a continuous box girders with battledeck floors; (2) simply-supported box girders; (3) continuous through trusses; (4) simply-supported through trusses; and (5) tied arches.

As a result, a continuous through truss bridge was taken up as shown on PLATE 3. The decisive reasons are that a continuous through truss bridge gives the least steel under the same design condition, and that a continuous box-girder will undergo much larger deflection accompanying vibrations due to its relatively small depth-span ratio than a continuous through truss, when the bridge is loaded with heavy and fast-running train loads.

An arch bridge requires for a span of 70 meters about 30 percent more steel than a continuous through truss bridge, and besides lacks rigidity. A suspension bridge was left out of consideration because no circumstances could be found that might hinder the construction of midstream piers. A prestressed-concrete bridge also was discarded because it requires much more material, cost and time than a steel bridge.

2.2.4. Layout of Bridge Floor

In order to find out the most desirable and economical way of providing the vehicular roadway and the railway track on the bridge, comparative studies were made on the five conceivable types shown in Fig. 2.1. The construction cost increases in the order of Types 1, 2, 5, 4 and 3. Type 1 was recommended in the Second-Phase Report because it is the most common practice and gives the least construction cost.

The Mekong Committee, however, requested the Japanese survey team to make further comparative study of Types 1 and 2, because the difference of construction costs between both types is not so much as expected, in connection with the layout of the administrative facilities and the problem that the direction of traffic flow has to be changed on or in the proximity of the bridge because in Thailand the highway traffic keeps to the left, and in Laos to the right.

Although many plans can be conceivable for the study, nine plans shown in Fig. 2.2. have been envisaged and studied in detail as presented in the Feasibility Report Part II, Chapter V. As a result, it was concluded that Type 1 is the most recommendable type of the floor layout of the rail/highway bridge to be built in the present project.

2.2.5. Pier Foundations

Bridge foundations are so important, a problem as would decide the engineering feasibility of the project. Unsuitable foundations will cause an unnecessary increase in the construction cost and inadequate foundations may lead to damages or destruction of the superstructures. For the

foundations of the Mekong bridge to be built at the Nong Khai site, pile foundations, footings to be built with cofferdams, open caissons and pneumatic caissons are conceivable and studies were made on these four types of foundations, as stated in detail in the Feasibility Report Part II, Chapter V.

As a result, though it was found that pneumatic caissons are rather costly as compared with other three types, considering the important meaning of the Mekong bridge, it was decided to use pneumatic caissons for the foundations of the midstream piers and open caissons for piers that will be built on land at both ends of the bridge.

2.2.6. Pier Protection Against Scouring

From the test boring carried out in the second-phase investigation, the geological formation of the river-bed at the bridge site can be assumed as shown in Fig. 2.3. The river-bed is composed of alluvial deposit of sand and gravel, 7 to 13 meters thick on the Thai side and 3 to 5 meters thick from the midriver toward the Laotian side. Underneath the alluvial layer lies a firm bedrock of siltstone, covered by a thin layer of weathered siltstone, at an elevation ranging from E1.145.0 to E1.150.0. The river-bed is subject to scouring in the high-water season, and when the bridge would be built, it is most certain that the river-bed around the piers would suffer severe scouring. And, the following measures were planned to cope with the scouring.

To sink caissons of the five midstream piers at sites that will lie always in water, temporary islands will first be built by enclosing the job sites by steel sheetpiles and filling the inside with the river's fine sand. Each island will be 16 meters square and will stand about 5 meters from the river bottom to an elevation of E1.156.5 to E1.157.0. The temporary islands will be left as they will have been built even after the foundation work will have been ended for the protection of the foundations. In addition, the river-bed around each pier will be covered with wooden mattresses that will extend about 6 meters from four sides of the island and will be weighted with lumps of laterite not less than 20 centimeters in size, as shown in Plate 6.

Three piers near the Thai side are located on a large sandbar that comes into appearance above the water surface in the low-water season. For these piers, instead of temporary islands, earth mounds will be built on the sand-bar for the caisson-sinking job. When the foundations will be completed, these mounds will be leveled off and wooden mattresses will be laid around the caissons in the same manner as noted above. The mattresses at each site will shape a square of about 36 meters as shown in Plate 6.

As for the two end piers that will be built on land, there will be no fear of scouring in ordinary times. Nevertheless, as a precaution against eventual scouring from extraordinary floods, the ground around the piers will be riprapped with laterite, extending about 5 meters from the circumference of the caissons and about 50 centimeters thick.

Furthermore, all caissons will be founded about two meters deep into the bedrock so that the piers would not lose their stability even if the river-bed soil, together with the islands, would all be washed away.

2.2.7. Bank Protection

The Mekong makes a bend, convex towards the Laotian side, in a stretch just upstream of the bridge site as shown in Plate 1. From a point about one kilometer upstream from the bridge site, the

river becomes nearly straight but the stream flows still deviated toward the Laotian side. Consequently, while silt deposition is growing on the Thai side, the river bank on the Laotian side is being incessantly eroded. At present, the erosion is estimated to proceed about 20 centimeters a year.

The two end piers are located on land several meters away from the bank-slope shoulders on both Laotian and Thai sides as shown in Plate 6. It is therefore necessary to protect the bank slopes against erosion. There are many ways of bank-slope protection. In the present project, considering the cost and the stream flow and other conditions at the site, it has been planned to cover the slopes with gabions.

Gabions of a dimension of 50-centimeter diameter by 6 meters will be laid over the bank slopes, extending along the slopes about 40 meters on the Laotian side and about 30 meters on the Thai side. The gabions will be anchored with timber piles that will be driven in two rows along the slopes and at an interval of about 10 meters in the direction of the river. On and beyond the toes of the gabion covering, concrete blocks of 50-centimeter cube will be riprapped 1.5 meters thick to a width of about 5 meters as shown in Plate 6.

The gabion covering will stretch on the Laotian side from 40 meters upstream to 80 meters downstream from the bridge center-line, and on the Thai side from 40 meters upstream to 110 meters downstream from the bridge center-line up to the compound of the Nong Khai Hydrographic Office.

Fig. 2.1. VARIOUS LAYOUTS OF BRIDGE FLOOR

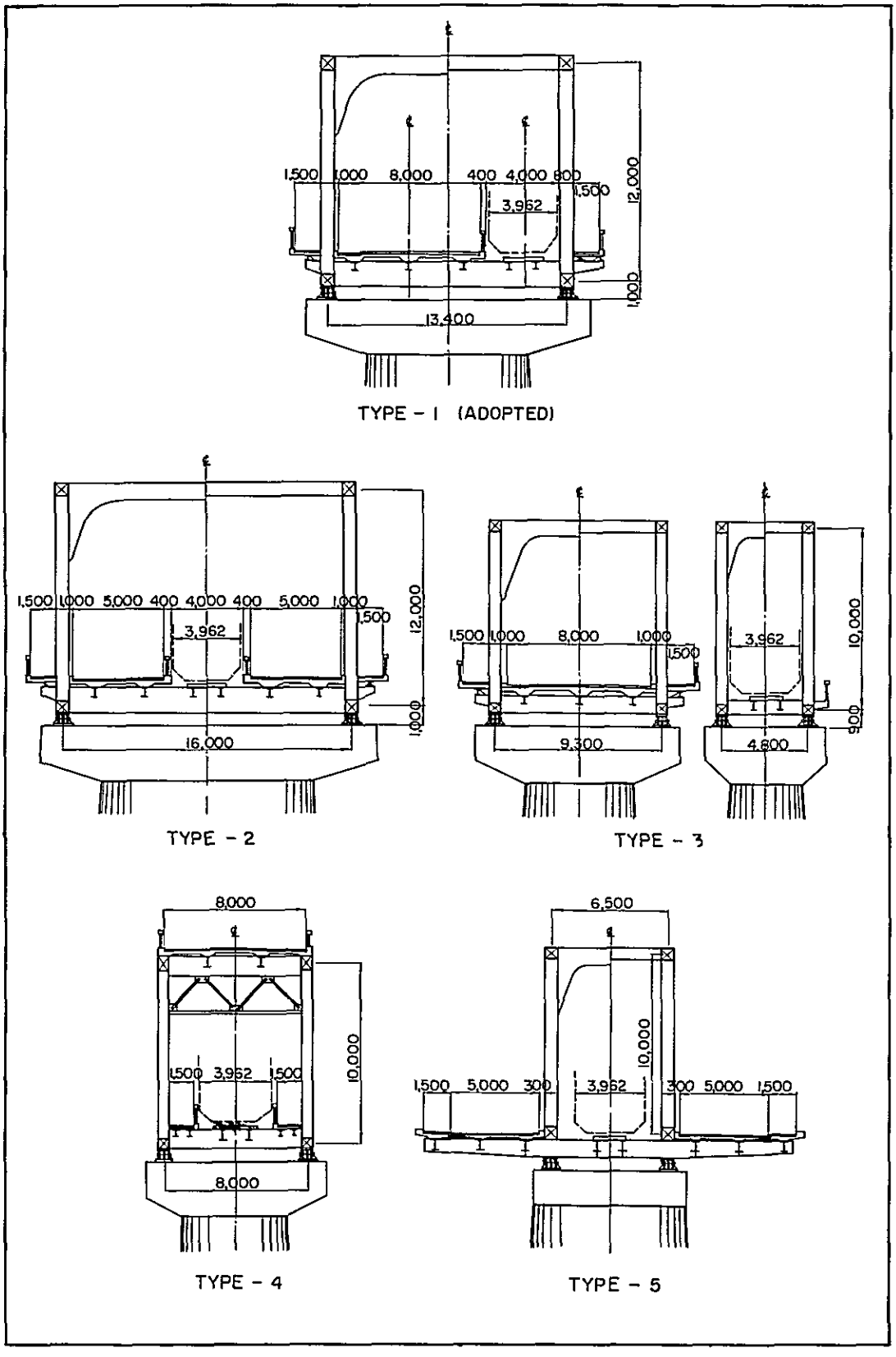
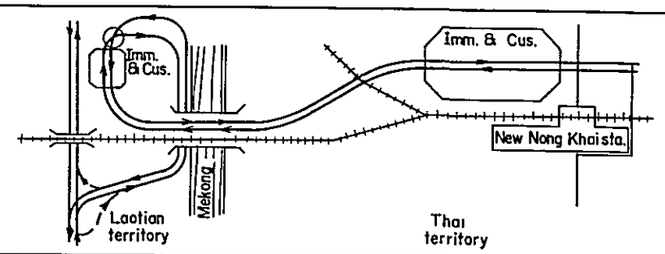
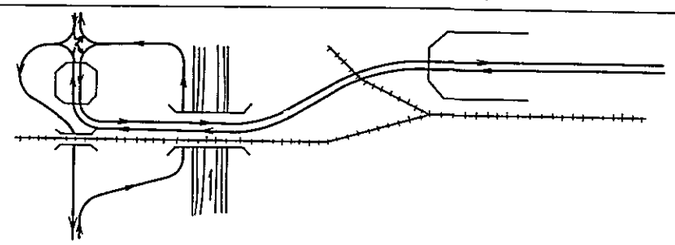
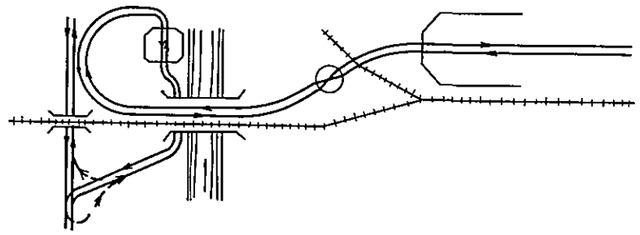
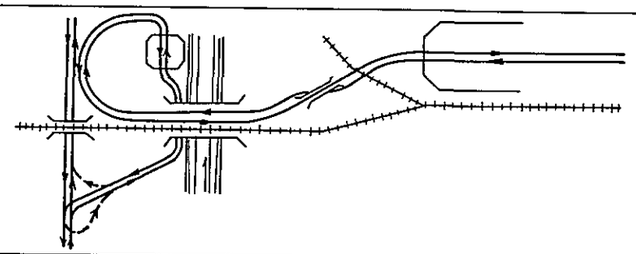
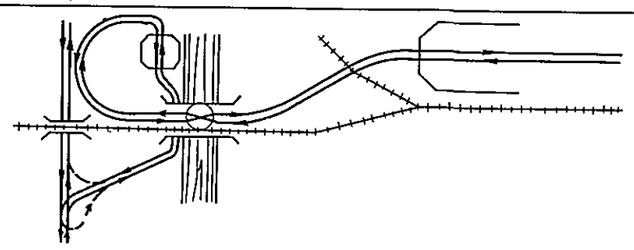
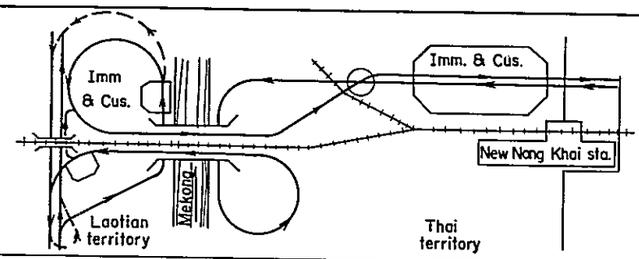
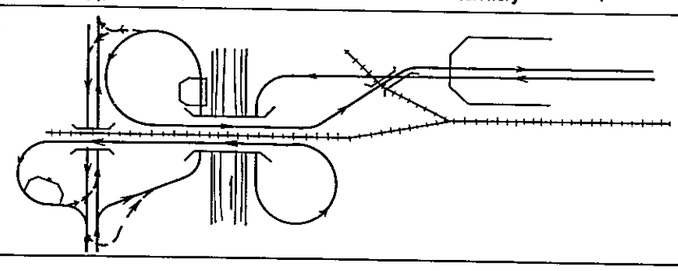
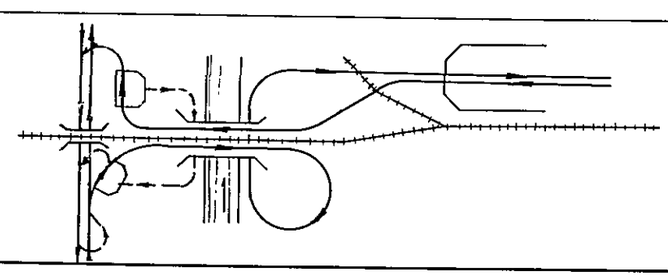


Fig. 2.2. LAYOUT PLANS OF ADMINISTRATIVE FACILITIES AND A CHANGE-OVER POINT IN RELATION TO THE BRIDGE-FLOOR LAYOUTS OF TYPES 1 AND 2

For Type 1

Location of change-over point	Type of crossing	Key plan
Laotian side	At-grade intersection	(a) 
	Grade separation	(b) 
Thai side	At-grade intersection	(c) 
	Grade separation	(d) 
Bridge	At-grade intersection	(e) 

For Type 2

Key plan
(f) 
(g) 
(h) The same as Plan (f)
(i) 

LEGEND

- Direction of traffic
- Change-over point
- Railway
- Imm & Cus — Immigration office and custumhouse
- Traffic from and to Tha Deua
- By-pass

Fig. 2.3. GEOLOGICAL PROFILE OF BRIDGE SITE

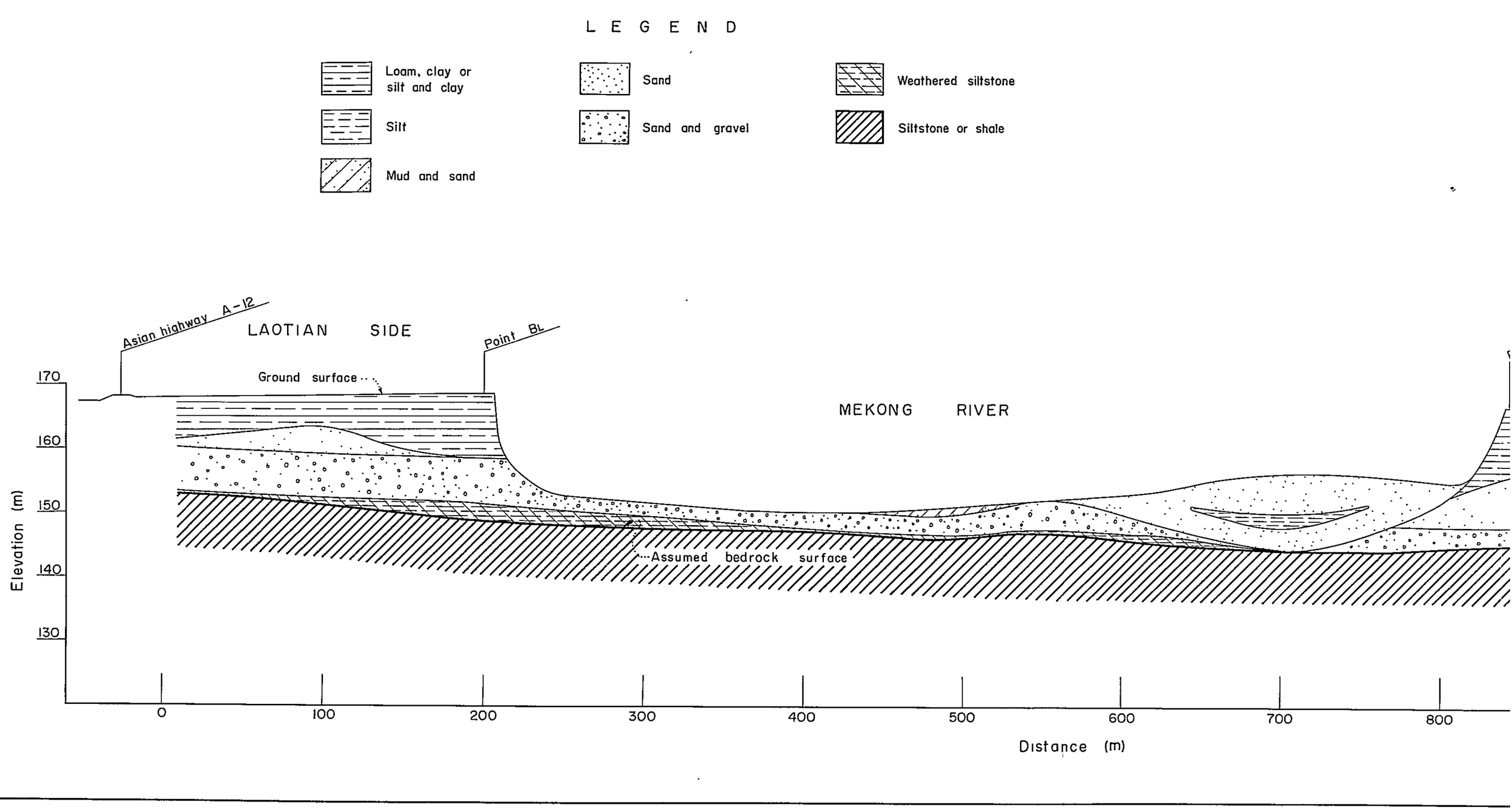
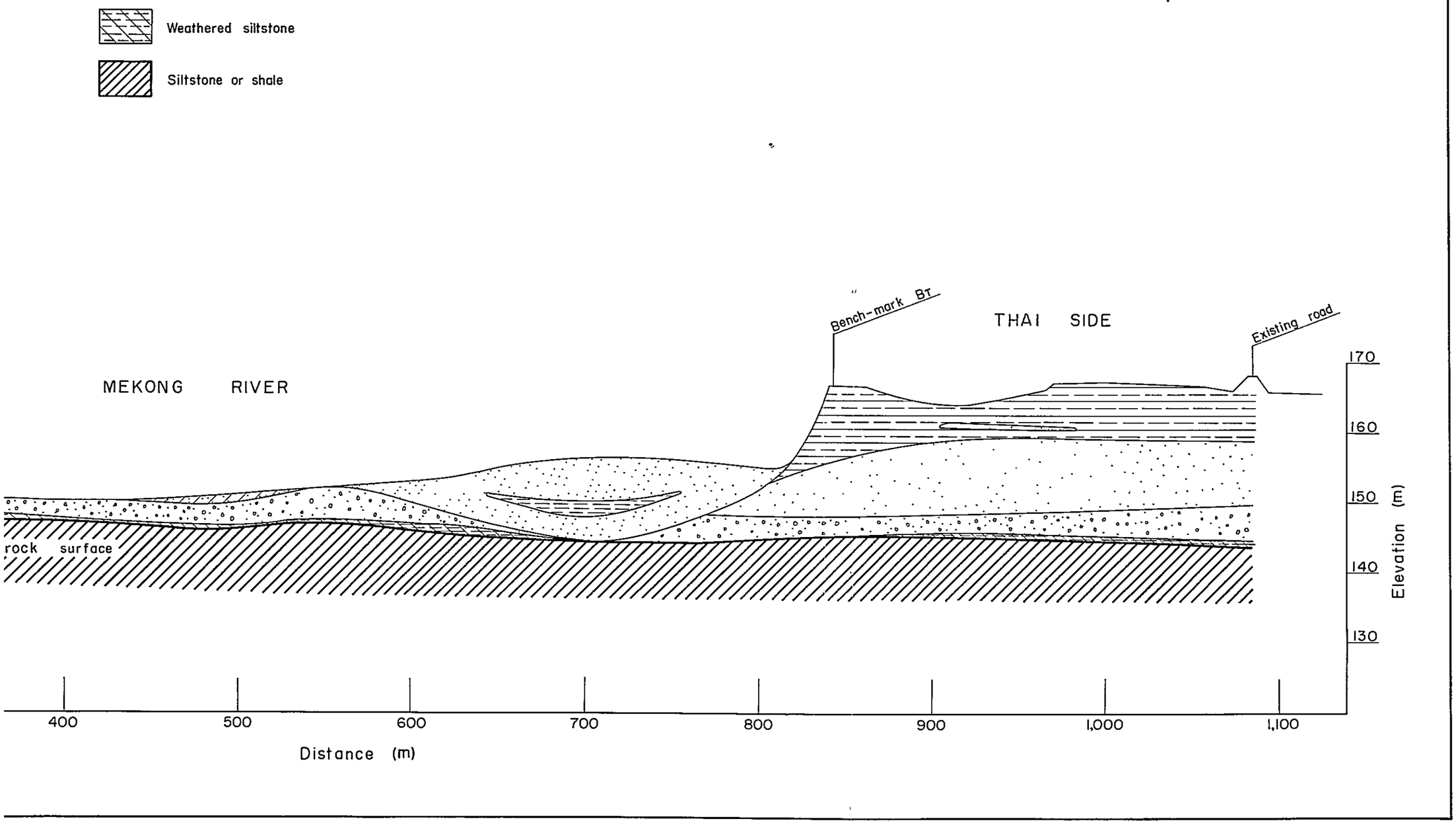


Fig. 2.3. GEOLOGICAL PROFILE OF BRIDGE SITE



2.3. Railway

When a rail/highway bridge would be completed across the Mekong as planned, the Northeastern Trunk Line of the Royal State Railway of Thailand will be extended 20 kilometers from Nong Khai to Vientiane. The construction itself of the railway will scarcely give rise to any serious engineering problem, because the topography of the project area is relatively flat and the ground will provide a comparatively good foundation.

2.3.1. Selection of Route

No comparative study is needed for the railway route on the Thai side, because it would measure relatively short and its route would be fixed more or less automatically when the bridge site would be determined. The projected railway on the Thai side will branch off where the existing railway begins to take a turn towards the present Nong Khai station. The new Nong Khai station will be located near the branch point. This site is very convenient to have communication with the town of Nong Khai.

On the Laotian side, five promising routes were considered at first as shown in Fig. 2.4. and sifted out after careful studies. The Second-Phase Report recommended that further study should be focused on the two routes, the so-called route C and combined route C/D. Afterwards the feasibility survey of the two routes was carried out, and as a result Route C/D was finally adopted by the Mekong Committee.

Route C/D is common to Route C over about half of the whole route, but clearly different from each other is the location of the Vientiane railway station. The proposed station site is about 4 kilometers away from the civic center of Vientiane in Route C and about 7 kilometers away in Route C/D.

The station in Route C is greatly convenient for service to the present City of Vientiane due to comparatively short distance. It, however, is difficult to take an enough tract for the station facilities because the site lies on a land that slopes from neighboring highlands and directly faces a low-lying land that will become a passage of flood water when such a flood as the 1966 flood would come.

The station site in Route C/D is much effective to direct future expansion of Vientiane toward inland, though it may be somewhat inconvenient to the people living at present in the urban area of Vientiane. Since it is located on the highlands, a sufficient tract can be obtained for the station yard and there is nothing anxious about floods.

Although Route C will bring about a slightly higher benefit-cost ratio at a little less cost than Route C/D as can be seen from Table 4.6 in the Feasibility Report Part II, Chapter IV, Route C/D seems preferable in view of the orientation of the future growth of Vientiane and the topographic attractiveness concerning the location of the station in Vientiane. Under such consideration Route C/D was finally selected by the Mekong Committee.

2.3.2. Design Criteria

The preliminary design of the projected railway was made in accordance with the Design Standards of the Royal State Railway of Thailand. Main provisions are as follows: design speed is 90 km/hr at max., track gage 1 meter, rail 80 lbs/yd, curve 400 m at min. in radius, longitudinal grade 1.2 percent, and right of way 40 m each on both sides.

2.3.3. Track

Typical track and roadbed cross sections are shown in Plate 5.

As regards embankment, it is a common practice to use as far as possible the excavated material on the job site. But, the soil that can be excavated at the job site has an undesirable nature to swell when saturated with water. After making studies to cope with this difficulty, it has been decided to use the so-called "composite section" in embankments that will stand high and will often be exposed to floods. Namely, the inner part of embankments will be built of fine sand of the Mekong and in the outer part will be used half-and-half mixture of the river sand and the soil from the job site, as shown in Plate 5. The sand-filled inner part will serve for inside drainage, reducing the adverse effect of the soil in the outer part, and thus will greatly contribute to the soundness of embankments. Embankments must of course be well compacted, and desirably to the extent that a CBR-value of greater than 10 percent can be obtained.

When embankments are not high, they can be built wholly with soil lying in the job area, as the effect of soil swell would not amount to much on account of the small height of the embankments and as it can be thought that part of crushed stone of track ballast would sink into the soil and would reduce the adverse effect of the soil to some extent. In this case, however, it is a matter of course that soils of the best possible quality should be sought for and be used.

2.3.4. Formation Level

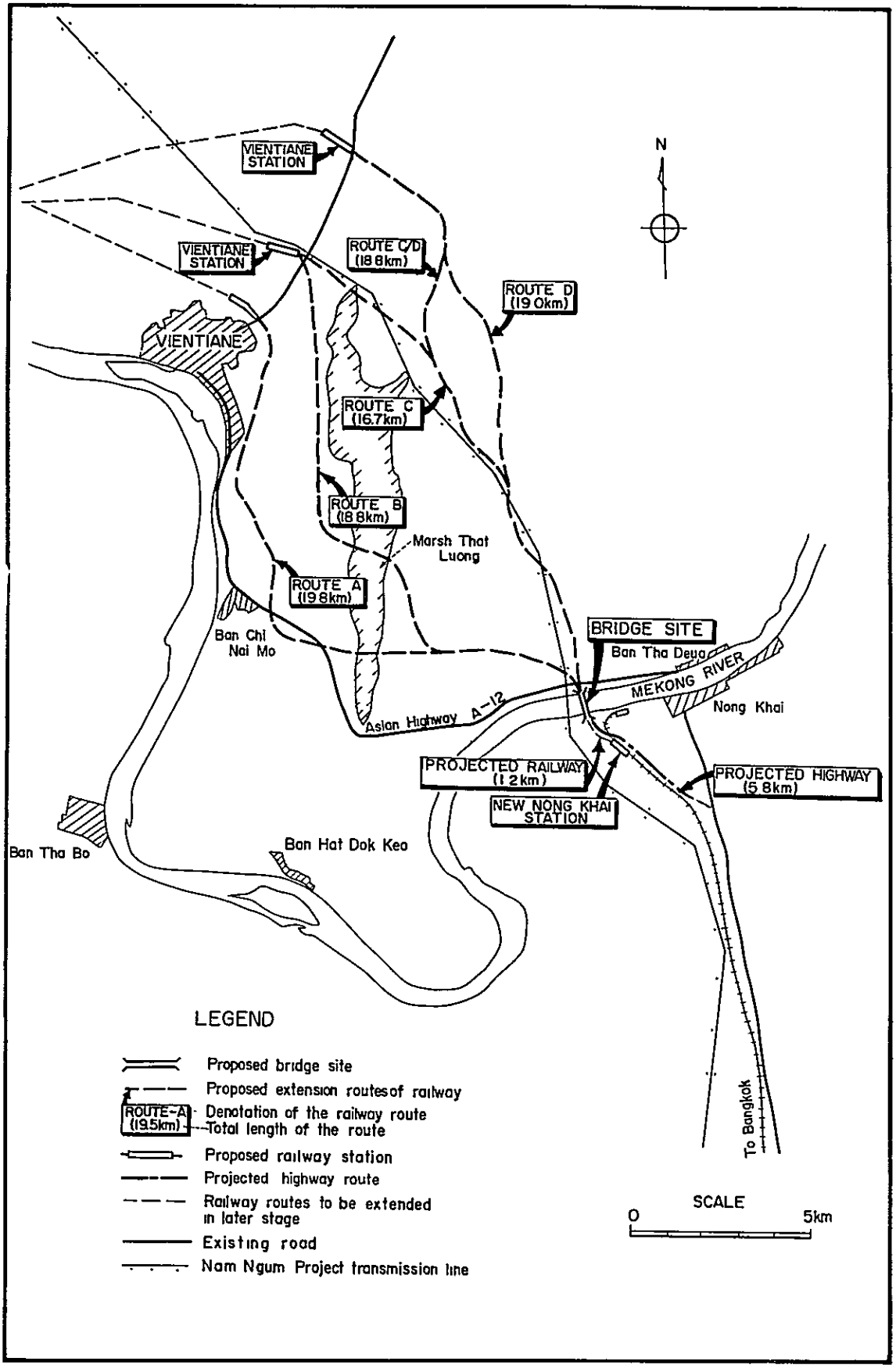
The formation level profile of the railway was so decided that the rail track would not be submerged by an abnormal flood that might occur once in 40 years, considering that the useful life of the railway is estimated at 40 years.

2.3.5. Stations

Although it is the terminal of the northeastern trunk line of the Thai State Railway, the present Nong Khai station is not provided with a switch-yard and car-sorting is now being carried out at the Na Tha station located about 6 kilometers south of the Nong Khai station. The Na Tha station had been the terminal until the line was extended to Nong Khai, but car-operation is still being carried out at the Na Tha station.with facilities such as a switchyard, an engine shed and repair shops located there. The new Nong Khai station and the Vientiane station have been designed under such consideration.

After the new Nong Khai railway station would be constructed, the present Nong Khai railway station will be made available only for the small-scale transportation of freight or may be put to no use.

Fig. 2.4. RAILWAY ROUTES



2.4. Highway

At present, the Asian Highway A-12 runs from Sara Buri to Nong Khai in Thailand and from Tha Naleng to Vientiane in Laos. In order to link the two separated parts of the Highway extending over both countries, two highways as well as the bridge will be constructed at Nong Khai and Tha Naleng. Various engineering feasibility studies were made of the projected highway as summarized below item by item.

2.4.1. Design Criteria

The preliminary design of the projected highway was made in accordance with the provisions of the "GEOMETRIC DESIGN STANDARDS FOR TWO-LANE PRIMARY HIGHWAYS (RURAL)" of the Highway Department of Thailand. The American Association of State Highway Officials' Standards and the Japan Highway Standards also were used as supplementary guide.

According to the Standards of the Highway Department of Thailand, the longitudinal grade of the highway is limited to 4 percent at maximum.

2.4.2. Cross Section

The Asian Highway A-12 is a two-lane primary highway in both Thailand and Laos. The road to be built is nothing other than what will become a section of the highway. Therefore, it shall be designed as a two-lane highway with the same cross-section as that of the highway. Thus, the basic features of the design cross-section, shown in Plate 4, have been fixed as follows.

Roadway:	7 meters, with two lanes;
Shoulder:	2.5 meters on both sides of the roadway;
Cross-slope:	2 % in roadway, 3 % on shoulders;
Side slope:	1 to 1 in cut, 2 to 1 on banking.

The roadway will be composed of a 5-centimeter cold-mix wearing course, 15-centimeter base course and 30-centimeter subbase. In shoulders will be used soil-cement mix, which in cuts measures 20 centimeters thick and on embankments extends downwards along the slopes and forms the outer parts of embankments.

Embankments will be made as far as possible from the excavated soil in the job site. But the soil lying along the projected route on the Thai side has, besides the nature of swelling when wetted as noted in regard to railway embankments, an undesirable characteristic that while it shows a considerably high shearing strength in the state of the optimum water content, it loses its shearing strength almost to nil when saturated with water. Therefore, it is necessary to build the roadway subgrade with soil of the best possible quality in the state of the optimum water content. The use of soil-cement mix, as noted, in shoulders and in the outer parts of banking has so planned with a view of protecting the inner part of the subgrade from infiltration of rain or flood water and keeping the subgrade always in or nearby the state of the optimum water content.

2.4.3. Formation Level

When a flood that would probably occur once in ten years comes to the project area, the existing Asian Highway on the Laotian and Thai sides gets partly submerged and loses its function for a time. In

order that the same shall not be repeated in the new road that will be built with much effort, the formation level of the roadway has been designed, in the tentative plan, to lie above the 10-year-probable high-water level at the project site, estimated at an elevation of 167.5 meters above mean sea level.

2.4.4. Change-Over of Traffic Direction

The vehicular traffic in Thailand keeps to the left, and in Laos to the right. Therefore, it is necessary to change the direction of traffic on or in the proximity of the bridge on the Mekong, which constitutes the Thai-Laotian border.

Change-over has a close relation to the roadway layout on the bridge floor and the location of administrative facilities. It is especially influenced by whether the roadway on the bridge is undivided as in Types 1, 3 and 4 shown in Fig. 2.1, or divided into two one-way parts separated by the middle-lying railway track as in Types 2 and 5. Although many plans of change-over can be conceivable, nine plans shown in Fig. 2.2 have been envisaged and studied in connection with the layout of the bridge floor and of the administrative facilities. Of these, plans (a) to (e) are those for the case of undivided roadway, and (f) to (i) for the case of divided roadway.

The comparative study of these nine plans was made in detail in the Feasibility Report Part II, Chapter V, Subparagraph 5.4.3. Finally it was decided by the Mekong Committee that the change-over should be carried out with at-grade intersection on the Laotian side, and if sometime in the future the necessity of a grade-separation change-over would arise, it should be implemented on the Thai side.

2.4.5. Administrative Facilities

The bridge is an international bridge that shall form the boundary between Laos and Thailand. All the traffic that will pass the bridge are therefore required to go through due formalities of immigration and customs. Accordingly, administrative facilities for the procedures must be provided at appropriate sites on either side of the bridge, which shall include an immigration office, a customshouse, a plant quarantine, warehouses, check booths for immigration and customs or to collect tolls if necessary, and so forth. These offices will be so designed that business can be transacted at a rate of five minutes or less per vehicle with a capacity enough for handling increasing traffic for the first fifteen years. Besides, ample spaces will be provided for the future extension.

2.5. Construction Cost

Construction jobs in Southeast Asia are with almost no exception affected by monsoons characteristic of this region. The present project will not of course be an exception. The job will probably be often disturbed by heavy rains in the rainy season and will be subjected to sweltering heat of the sun in the dry season.

The construction plan of the present project therefore should be scheduled conforming to such local climate. The time schedule shown in Fig. 2.5 is what has been prepared under such consideration. It is intended that the job be done concentrically in the dry season that usually lasts from November to April of the next year. The construction is estimated to take net two years. The period required for detailed designing, preparation of tender documents and decision of a contractor or a joint venture of contractors to whom the job shall be awarded is estimated at about one year and a half.

The net construction cost has been estimated at U.S. $14,390,000, dividing into U.S. $7,520,000 in foreign currency and U.S.$6,870,000 in domestic currency. The total cost has been estimated at U.S. $21,500,000, which divides nearly into halves in foreign and domestic currencies, namely, U.S.$10,900,000 in foreign currency and U.S.$10,600,000 in domestic currency.

Fig. 2.5. CONSTRUCTION TIME SCHEDULE

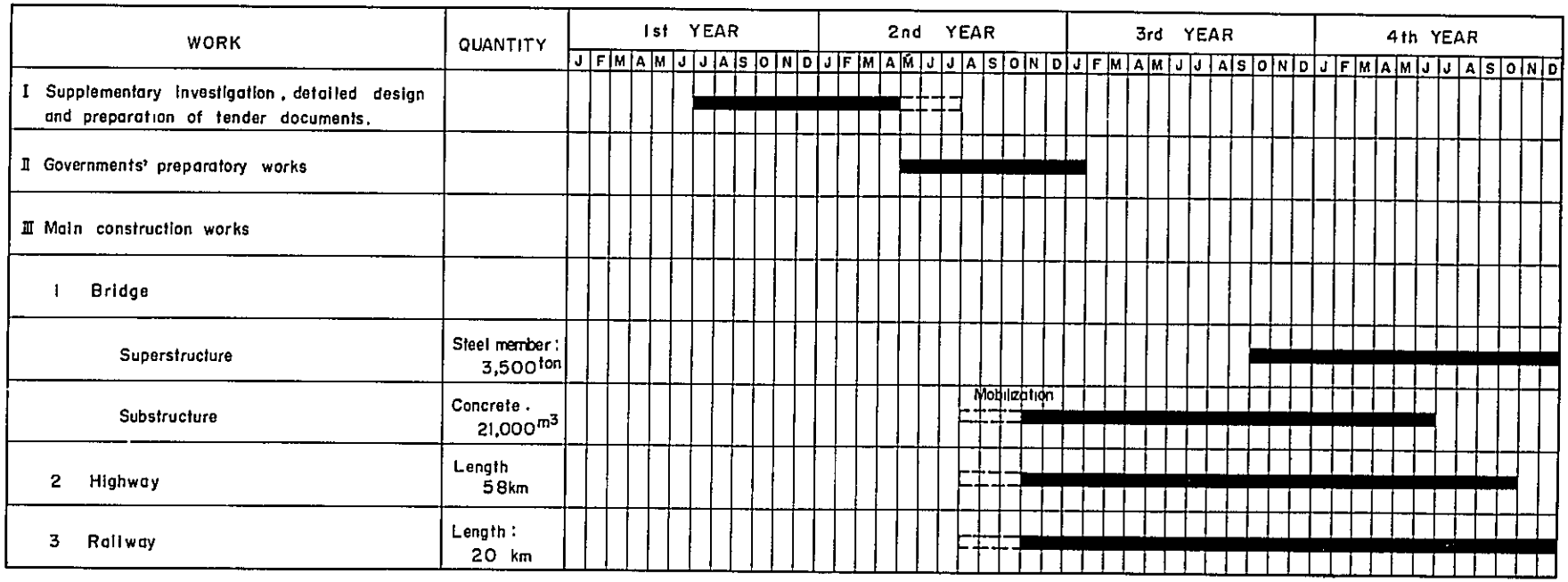


Table 2.2. Construction Cost (Summary)

	Work	Construction cost (US$) Foreign currency	Domestic currency	Total
I.	GOVERNMENTS' PREPARATORY WORKS	240,000	720,000	960,000
	1. Construction facilities	240,000	135,000	375,000
	2. Land and rights	-	585,000	585,000
II.	MAIN CONSTRUCTION WORKS	7,520,000	6,870,000	14,390,000
	1. Bridges	3,900,000	2,300,000	6,200,000
	(a) Main truss bridge			
	(i) Superstructure	2,000,000	550,000	2,550,000
	(ii) Substurcture	1,500,000	1,280,000	2,780,000
	(b) Approach viaducts	400,000	470,000	870,000
	2. Railways	2,730,000	2,820,000	5,550,000
	3. Highway	460,000	530,000	990,000
	4. Administrative facilities	400,000	1,050,000	1,450,000
	5. Permanent residential buildings	30,000	170,000	200,000
III.	CONTINGENCY AND RESERVE	1,400,000	1,300,000	2,700,000
IV.	ENGINEERING SERVICE	900,000	400,000	1,300,000
V.	GOVERNMENTS' ADMINISTRATIVE EXPENSE	240,000	710,000	950,000
VI.	INTEREST DURING CONSTRUCTION	600,000	600,000	1,200,000
	Total	10,900,000	10,600,000	21,500,000

Table 2.3. Itemized Construction Cost

Item No.	Work	Unit	Quantity	Foreign currency (US$) Unit price	Foreign currency (US$) Amount	Domestic currency (US$) Unit price	Domestic currency (US$) Amount	Total (US$)	Remarks
I.	GOVERNMENTS' PREPARATORY WORKS				240,000		720,000	960,000	
1.	Construction facilities				240,000		135,000	375,000	
(a)	Temporary buildings	m^2	1,500	20	30,000	40	60,000	90,000	
(b)	Water supply system	L.S.			20,000		10,000	30,000	
(c)	Electric power supply system								
c-1	Substation and 22 kV distribution line	L.S.			75,000		40,000	115,000	One 1,250 KVA trans. and a distr. line 500 m. long.
c-2	Diesel power plants	L.S.			100,000		20,000	120,000	
(d)	Communication system	L.S.			15,000		5,000	20,000	
2.	Land and rights	km^2	1.3			450,000	585,000	585,000	
II.	MAIN CONSTRUCTION WORKS				7,520,000		6,870,000	14,390,000	
1.	Bridges				3,900,000		2,300,000	6,200,000	650 m. long
(a)	Main truss bridge				3,500,000		1,830,000	5,330,000	
	(Superstructure)				(2,000,000)		(550,000)	(2,550,000)	
a-1	Steel for truss members	ton	3,320	530	1,759,600	120	398,400	2,158,000	
a-2	Concrete	m^3	2,250	10	22,500	30	67,500	90,000	Cement 300 kg/m^3
a-3	Reinforcement Steels	ton	500	160	80,000	90	45,000	125,000	
a-4	Asphalt pavement	m^2	7,150	0.5	3,575	1.5	10,725	14,300	
a-5	Rails for track	m	650	30	19,500	10	6,500	26,000	Including wooden sleepers
a-6	Miscellaneous	L.S.			114,825		21,875	136,700	5%
	(Substructure)				(1,500,000)		(1,280,000)	(2,780,000)	
a-7	Excavation, all classes, for piers	m^3	15,500	20	310,000	10	155,000	465,000	10 piers
a-8	Concrete for caissons	m^3	8,200	60	492,000	55	451,000	943,000	Cement 300 kg/m^3
a-9	Concrete for piers	m^3	6,700	30	201,000	30	201,000	402,000	Cement 250 kg/m^3
a-10	Reinforcement steels	ton	1,100	160	176,000	90	99,000	275,000	Floor slab: 25cm thick
a-11	Steel sheetpiles	ton	750	235	176,250	115	86,250	262,500	
a-12	Structural steels for temporary bridge	ton	200	210	42,000	110	22,000	64,000	H-shape
a-13	Wooden mattresses for pier protection	m^2	6,200	1	6,200	20	124,000	130,200	
a-14	Gabions for bank protection	m^2	1,000	25	25,000	75	75,000	100,000	
a-15	Miscellaneous	L.S.			71,550		66,750	138,300	5%
(b)	Approach viaducts				400,000		470,000	870,000	
	(Composite girder bridges for highway)				(60,000)		(30,000)	(90,000)	2 x 30 m. long
b-1	Steel for composite girders	ton	90	530	47,700	120	10,300	58,500	
b-2	Concrete	m^3	200	10	2,000	30	6,000	8,000	Cement 300 kg/m^3
b-3	Reinforcement steels	ton	50	160	8,000	90	4,500	12,500	
b-4	Asphalt pavement	m^2	500	0.5	250	1.5	750	1,000	
b-5	Miscellaneous	L.S.			2,050		7,950	10,000	5%
	(Concrete hollow slab bridges for highway)				(120,000)		(180,000)	(300,000)	2 x 135 m. long
b-6	Excavation, common, for piers	m^3	900	1.5	1,350	1.0	900	2,250	
b-7	Concrete for superstructure	m^3	1,500	10	15,000	30	45,000	60,000	Cement 300 kg/m^3
b-8	Concrete for substructure	m^3	1,200	5	6,000	30	36,000	42,000	Cement 250 kg/m^3
b-9	Reinforcement steels	ton	380	160	60,800	90	34,200	95,000	
b-10	Concrete piles for piers	No.	380	70	26,600	130	49,400	76,000	
b-11	Asphalt pavement	m^2	2,200	0.5	1,100	1.5	3,300	4,400	
b-12	Miscellaneous	L.S.			9,150		11,200	20,350	5%
	(Plate girder bridges for railway)				(50,000)		(20,000)	(70,000)	2 x 30 m. long
b-13	Steel for plate girders	ton	90	530	47,700	120	10,800	58,500	
b-14	Rails for track	m	60	30	1,800	10	600	2,400	Including wooden sleepers
b-15	Miscellaneous	L.S.			500		8,600	9,100	5%
	(Concrete rigid frame bridges for railway)				(170,000)		(240,000)	(410,000)	413.5 m. long
b-16	Excavation, common, for piers	m^3	2,300	1.5	3,450	1.0	2,300	5,750	
b-17	Concrete	m^3	2,860	10	28,600	30	85,800	114,400	Cement 300 kg/m^3
b-18	Reinforcement steels	ton	490	160	78,400	90	44,100	122,500	
b-19	Concrete piles for piers	No.	610	70	42,700	130	79,300	122,000	
b-20	Ballast for track	m^3	420	3	1,260	20	8,400	9,660	
b-21	Rails for track	m	420	30	12,600	10	4,200	16,800	Including wooden sleepers
b-22	Miscellaneous	L.S.			2,990		15,900	18,890	5%
2.	Railways				2,730,000		2,820,000	5,550,000	
(a)	Railway track				(1,590,000)		(1,680,000)	(3,270,000)	
a-1	Clearing for track	m	15,000			1.6	24,000	24,000	80 m wide
a-2	Excavation, common, for track	m^3	48,700	1.0	48,700	0.5	24,350	73,050	
a-3	Excavation, common, for flood bridges	m^3	1,700	1.5	2,550	1.0	1,700	4,250	
a-4	Embankment, earth	m^3	137,500	1.0	137,500	1.0	137,500	275,000	

– Continued –

Item No.	Work	Unit	Quantity	Foreign currency (US$) Unit price	Foreign currency (US$) Amount	Domestic currency (US$) Unit price	Domestic currency (US$) Amount	Total (US$)	Remarks
a-5	Embankment, soil-sand mix	m^3	187,300	2.0	374,600	1.5	280,950	655,550	
a-6	Ballast for track	m^3	19,500	3	58,500	20	390,000	448,500	
a-7	Subballast for track	m^3	36,450	3	109,350	6	218,700	328,050	Laterite
a-8	Rails for track	m	19,500	30	585,000	10	195,000	780,000	Including wooden sleepers
a-9	Concrete for bridges and culverts	m^3	4,170	10	41,700	30	125,100	166,800	Cement 280 kg/m^3
a-10	Reinforcement steels	ton	445	160	71,200	90	40,050	111,250	
a-11	Concrete piles for piers	No.	450	70	31,500	130	58,500	90,000	
a-12	Dumped riprap for slope protection	m^2	31,890	2	63,780	3	95,670	159,450	Wooden latticed frames with laterite
a-13	Miscellaneous	L.S.			65,620		88,480	154,100	
(b)	New Nong Khai Railway Station				(380,000)		(400,000)	(780,000)	
b-1	Embankment	m^3	51,000	1	51,000	1	51,000	102,000	
b-2	Rails for track including ballast	m	2,100	25	52,500	25	52,500	105,000	
b-3	Station building	m^2	540	50	27,000	100	54,000	81,000	71.5m x 8m
b-4	Platforms	m^2	2,750	15	41,250	55	151,250	192,500	
b-5	Points and crossings, and safety appliances	L.S.			153,000		7,000	160,000	
b-6	Warehouses	m^2	500	10	5,000	50	25,000	30,000	
b-7	Station plaza	m^2	6,600	13	19,800	4	26,400	46,200	Asphalt-paved, including approach
b-8	Underpasses	m	20	280	5,600	400	8,000	13,600	roads
b-9	Miscellaneous	L.S.			24,850		24,850	49,700	5%
(c)	Vientiane Railway Station				(760,000)		(740,000)	(1,500,000)	
c-1	Excavation, common, for station	m^3	45,500	1	45,500	0.5	22,750	68,250	
c-2	Embankment	m^3	20,400	1	20,400	1	20,400	40,800	
c-3	Rails for track including ballast	m	5,200	25	130,000	25	130,000	260,000	
c-4	Station building	m^2	1,000	50	50,000	100	100,000	150,000	100m x 10m
c-5	Platforms	m^2	7,000	7	49,000	30	210,000	259,000	
c-6	Points and crossings, and safety appliances	L.S.			250,000		20,000	270,000	
c-7	Warehouses, engine shed and others	m^2	1,800	10	18,000	50	90,000	108,000	
c-8	Station plaza	m^2	10,000	3	30,000	4	40,000	70,000	Asphalt-paved
c-9	Approach road	m	1,400	90	126,000	50	70,000	196,000	
c-10	Miscellaneous	L.S.			41,100		36,850	77,950	5%
3.	Highway				460,000		530,000	990,000	5.6 km long
3-1	Clearing and stripping	m^2	72,500	0.2	14,500	0.1	7,250	21,750	
3-2	Excavation, common	m^3	26,500	1.0	26,500	0.5	13,250	39,750	
3-3	Embankment, earth	m^3	59,800	1.0	59,800	1.0	59,800	119,600	
3-4	Embankment, soil-cement mix	m^3	44,300	2.0	88,600	4.0	177,200	265,800	
3-5	Subbase course	m^2	47,450	2.0	94,900	1.0	47,450	142,350	
3-6	Base course	m^2	38,850	1.0	38,850	0.5	19,425	58,275	
3-7	Asphalt pavement	m^2	44,520	0.5	22,260	1.5	66,780	89,040	
3-8	Concrete for box culverts	m^3	2,300	10	23,000	30	69,000	92,000	Cement 280 kg/m^3
3-9	Reinforcement steels	ton	230	160	36,800	90	20,700	57,500	
3-10	Guardrail	m	3,840	10	38,400	5	19,200	57,600	
3-11	Miscellaneous	L.S.			16,390		29,945	46,335	
4.	Administrative facilities				400,000		1,050,000	1,450,000	
4-1	Clearing and stripping	m^2	50,300	0.2	10,060	0.1	5,030	15,090	
4-2	Embankment	m^3	73,900	1.0	73,900	1.0	73,900	147,800	
4-3	Subbase course	m^2	39,700	2.0	79,400	1.0	39,700	119,100	
4-4	Base course	m^2	41,600	1.0	41,600	0.5	20,800	62,400	
4-5	Asphalt pavement	m^2	39,650	0.5	19,825	1.5	59,475	79,300	
4-6	Immigration offices and customhouses	m^2	6,500	20	130,000	100	650,000	780,000	
4-7	Warehouses, booths and others	m^2	3,000	10	30,000	50	150,000	180,000	
4-8	Miscellaneous	L.S.			15,215		51,095	66,310	5%
5.	Permanent residential buildings	m^2	2,000	15	30,000	85	170,000	200,000	
III.	CONTINGENCY AND RESERVE	L.S.			1,400,000		1,300,000	2,700,000	18% of (I) and (II)
IV.	ENGINEERING SERVICE	L.S.			900,000		400,000	1,300,000	
V.	GOVERNMENTS' ADMINISTRATIVE EXPENSE	L.S.			240,000		710,000	950,000	6% of (I) and (II)
VI.	INTEREST DURING CONSTRUCTION	L.S.			600,000		600,000	1,200,000	6% of (I) to (V)
	Total				10,900,000		10,600,000	21,500,000	

CHAPTER III

BENEFIT

3.1. General

If Nong Khai/Vientiane Bridge Project will be realized, much benefit will accrue from the project. The users of the bridge, as compared with the present ferry facilities, will get noticeable savings of travel time and vehicular operation cost and remarkable increase in carrying capacity, and will be able to enjoy comfortable traveling and less chance of accidents, and so forth. Furthermore, the project will bring about the drop of the price of the commodities, the rise in land value in Nong Khai-Vientiane area, the rise in development value of natural resources, progress in economic activities, promotion of tourism, and so on.

Owing to such direct and indirect benefits, bridge traffic will rapidly increase in the future. As shown in Table 3.1, vehicular traffic will be 9 times and a little more in 2000 as much as that in 1973, and railway passengers and freight 7 to 8 times in 2000.

The direct benefit comprising two kinds of the time and operation benefits is estimated at about 3,400,000 U.S. dollars per annum in the case of collecting bridge tolls equaling the current ferry charges on the conditions of 10-percent discount rate and the analysis period of 40 years. It also amounts to about 7,000,000 U.S. dollars per annum in the case that no bridge toll is collected, the discount rate 3 percent and the analysis period 40 years. On the other hand, the annual cost is about 2,500,000 U.S. dollars in the former case and about 1,200,000 U.S. dollars in the latter case.

Consequently, the benefit-cost ratio of the former case is 1.3 and the latter case 5.9, as given in Table 3.5. The benefit-cost ratio is thus greater than unity in any case. The internal rate of return also a little exceeds 12 percent which is widely recognized as the minimum acceptable value for this kind of project.

As regards the financial feasibility of the project, the total investment of the project can be repaid with the revenue from the bridge tolls. However, the most favorable loan is of 4 percent of the annual rate of interest and the amortization period of 21 years or 3 percent and 20 years, provided that the bridge tolls would be set at half the current ferry charges. It goes without saying that a generous grant is most preferable. Next comes a loan, the interest rate of which varies at a certain time of the useful life of the project, namely, a low annual rate of interest for the initial period when much traffic cannot be expected, and a high annual rate of interest for the latter period when the traffic will remarkably grow up.

As is clear from the above, the project is economically justified and is fully warranted from the financial viewpoint.

3.2 Future Traffic

Prior to the estimation of the future traffic, the imaginary initial traffic will first be estimated from the data that shall be obtained by the survey of the existing traffic. Then, after assuming possible growth rate, the possible future traffic will be estimated based on the imaginary initial traffic.

3.2.1. Present Traffic

An origin-destination traffic survey was carried out during the first-phase investigation in 1967. It was conducted at ten selected sites lying within the project area as shown in Fig. 3.1 on highway traffic as well as on waterway traffic.

3.2.2. Imaginary Initial Traffic

It is necessary for estimating the future traffic on the bridge to assume an imaginary traffic that would be initiated on the new bridge, if the bridge would be opened to traffic at the time when the "present" traffic is estimated, namely, in 1967 in the present case. This traffic is in no way the actual traffic in 1967, but an imaginary traffic to be expected in 1967 under the above assumption.

The imaginary initial traffic was estimated from the present traffic based on some assumptions. For instance, it was assumed that the present highway traffic that are now handled by the existing ferries will all be diverted to the bridge traffic and that the present railway traffic to and from the Nong Khai station may all be included in the imaginary railway traffic.

3.2.3. Traffic Growth Index

The growth of traffic in the future may be considered to consist of the natural growth of the present traffic and the sudden increase that will arise due to the impact of the opening of a new bridge.

In general, the natural growth of traffic can be estimated correlating to the growth of the gross national product, because traffic activity in an area is closely related to the production activity in the area, which, in turn, is influenced by the national production activity. And the relationship between the traffic and the gross national product is usually assumed linear. In the present case, the ferry passengers, the ferry freight and the railway arrival freight at Nong Khai were assumed to be expressed in terms of the gross national product of Laos.

It was assumed in the present report that the Laotian gross national product would increase at an average annual rate of 5 percent from 1965 to 1970, at 6 percent from 1970 to 1975, at 6.5 percent from 1975 to 1985, and at 7 percent after 1985. Based on this assumption indices of natural growth of traffic were figured out.

On the other hand, the sudden traffic increase that would be touched off by the completion of the Mekong bridge can be considered to be what would be induced by the reduction in the so-called economical distance of traffic due to the improvement that in the present case means the bridge. Such traffic increase can be estimated by the method of gravity model. The result was that the rate is 26 percent for buses, personal cars, taxis, motorcycles and railway passengers, and 13 percent for heavy trucks, light trucks and railway freight, provided that tolls of the same amount as the current ferry charges would be levied on the bridge.

3.2.4. Possible Future Traffic on the Bridge

The possible volumes of traffic that should be envisaged on the bridge in 1973 and 1990, i.e., after one year and 18 years after the completion of the bridge, respectively, when the bridge tolls

would be set at the same level as the current ferry charges, can be obtained by multiplying the imaginary initial traffic by the growth indices and the results are listed in Tables 3.1 and 3.2.

The traffic in the period from 1973 to 1990 was assumed to increase exponentially at a constant annual growth rate that shall be determined for each traffic from the estimated 1973 and 1990 volumes. From 1990 to 2000, the traffic was assumed to increase linearly at a rate that equals the average increase rate from 1973 to 1990. The annual growth rates for the period from 1973 to 1990 and the average increase rate for the period from 1990 to 2000 are shown in Table 3.1. Beyond 2000, the traffic was assumed to remain constant at the level as of 2000. The possible future traffic for each year from 1973 to 2000, as estimated, are listed in Table 3.2.

The above estimation is based on the assumption that the bridge tolls would equal the current ferry charges. The traffic growth in the future, however, will largely be influenced by the level of the tolls. This problem has been studied, as described in Paragraph 6.2, (5) in Part II.

After all, a future traffic corresponding to an arbitrary bridge toll can be figured out as a multiple of the future traffic in the case of collecting bridge tolls equaling the current ferry charges. Fig. 3.2. shows the future traffic corresponding to several typical bridge tolls.

Fig. 3.1. ORIGIN–DESTINATION SURVEY POINTS AND TRAFFIC FLOW AS OF 1967

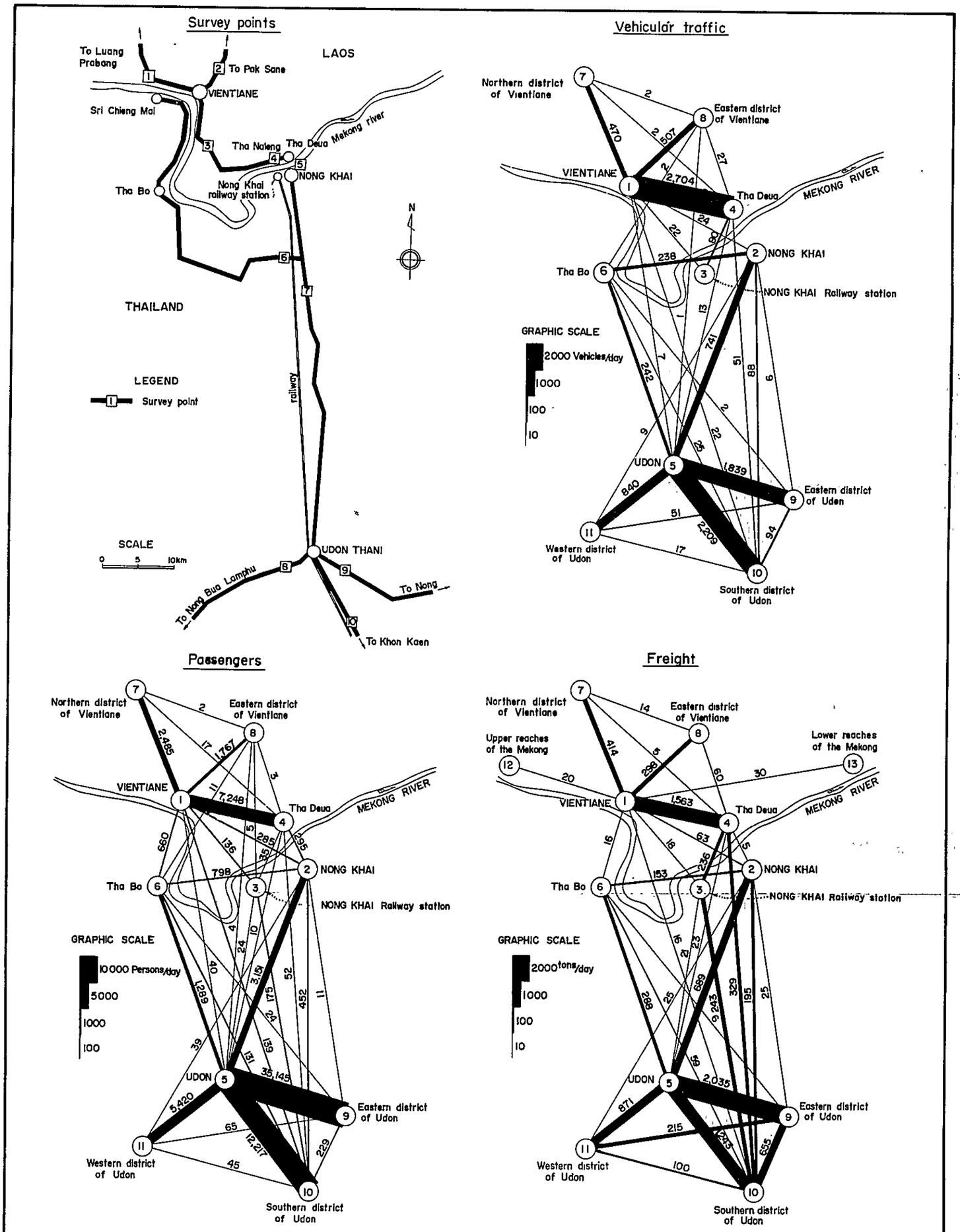


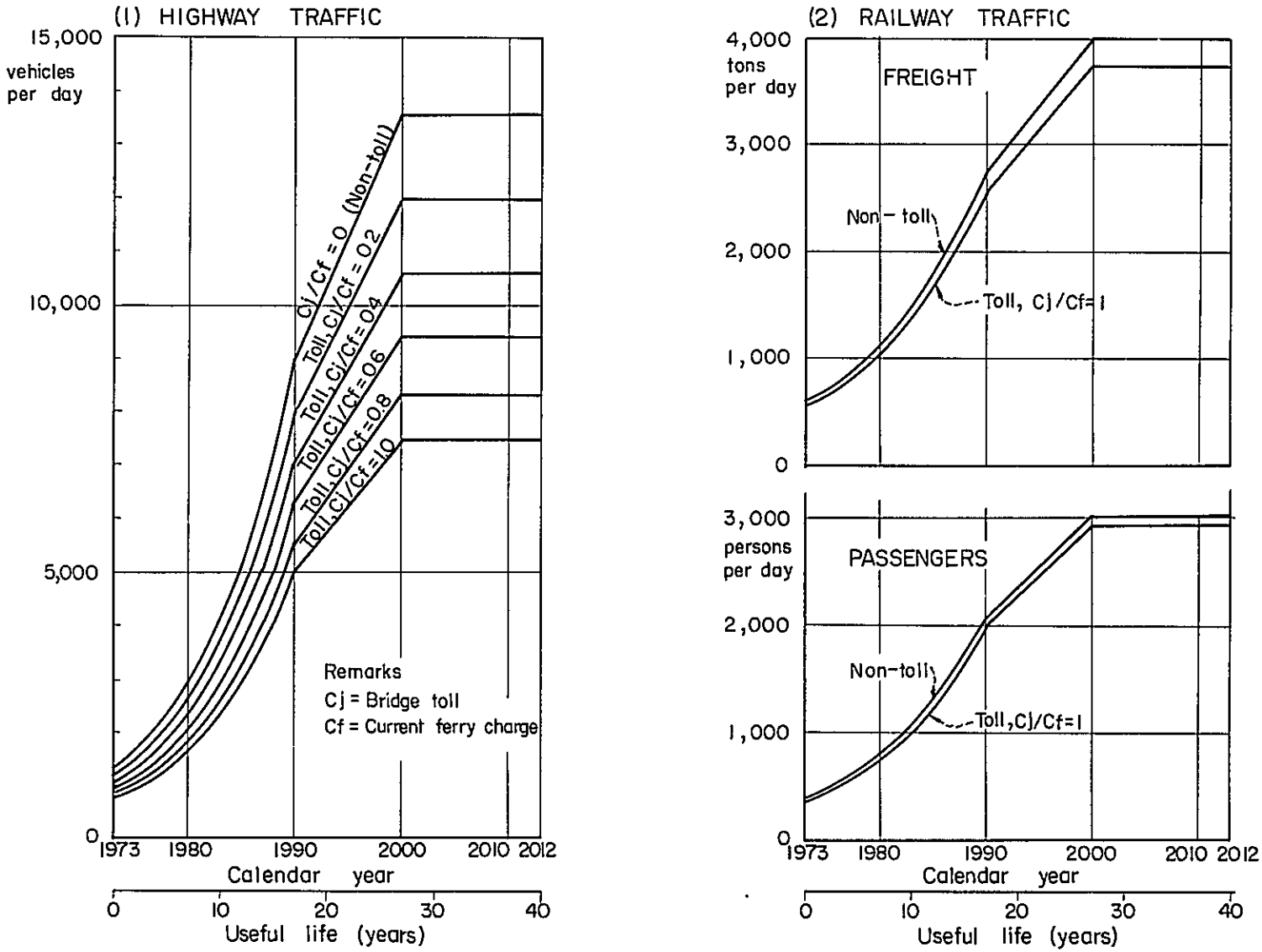
Table 3.1. Estimated Future Traffic, When Bridge Tolls Equal Current Ferry Charges

	Items		Unit	Imaginary Initial Traffic	Future Traffic			Growth Index			Annual Growth Rate (%)	Annual Growth Volume	
				1967	1973	1990	2000	1973	1990	2000	1973 to 1990	1990 to 2000	
Highway Traffic	Vehicles diverted from car ferry	Buses	vehicles/day	2	7	35	52	1.00	5.00	7.43	9.9	1.7	vehicles/day
		Personal cars	"	23	75	606	918	1.00	8.08	12.25	13.1	31.2	"
		Taxis	"	1	3	28	43	1.00	9.33	14.33	14.4	1.5	"
		Heavy trucks	"	93	203	804	1,158	1.00	3.96	5.71	8.4	35.4	"
		Light trucks	"	3	7	29	42	1.00	4.14	6.00	8.7	1.3	"
		Motorcycles	"	0	0	0	0	0	0	0	0	0	
		Sub-total	"	122	295	1,502	2,213	1.00	5.09	7.50	10.1	71.1	"
	Vehicles diverted from passenger ferries	Buses	vehicles/day	12	31	167	247	1.00	5.39	7.97	10.4	8.0	vehicles/day
		Personal cars	"	56	145	1,170	1,773	1.00	8.07	12.23	13.1	60.3	"
		Taxis	"	57	148	1,270	1,930	1.00	8.58	13.04	13.5	66.0	"
		Heavy trucks	"	2	4	15	21	1.00	3.75	5.25	8.1	0.6	"
		Light trucks	"	0	0	0	0	0	0	0	0	0	
		Motorcycles	"	62	161	864	1,278	1.00	5.37	7.94	10.4	41.4	"
		Sub-total	"	189	489	3,486	5,249	1.00	7.13	10.73	12.2	176.3	"
	Total traffic	Buses	vehicles/day	14	38	202	299	1.00	5.32	7.87	10.3	9.7	vehicles/day
		Personal cars	"	79	220	1,776	2,691	1.00	8.07	12.21	13.1	91.5	"
		Taxis	"	58	151	1,298	1,973	1.00	8.60	13.06	13.5	67.5	"
		Heavy trucks	"	95	207	819	1,179	1.00	3.96	5.69	8.4	36.0	"
		Light trucks	"	3	7	29	42	1.00	4.14	6.00	8.7	1.3	"
		Motorcycles	"	62	161	864	1,278	1.00	5.37	7.94	10.4	41.4	"
		Sub-total	"	311	784	4,988	7,462	1.00	6.36	9.51	11.5	247.4	"
Railway Traffic	Freight diverted from car ferry		tons/day	254	566	2,558	3,730	1.00	4.52	6.50	9.3	117.2	tons/day
	Passengers diverted from car ferry		persons/day	6	20	105	155	1.00	5.25	7.75	10.3	5.0	persons/day
	Passengers diverted from passenger ferries		"	135	350	1,881	2,782	1.00	5.37	7.96	10.4	90.1	"
	Total railway passengers		"	141	370	1,986	2,937	1.00	5.37	7.94	10.4	95.1	"

Table 3.2 Estimated Future Traffic For Each Year From 1973 to 2000, When Bridge Tolls Equal Current Ferry Charges

Calendar year	Ordinal year	Highway Traffic (vehicles/day)							Railway Traffic	
		Buses	Personal cars	Taxis	Heavy trucks	Light trucks	Motor-cycles	Total	Railway freight (tons/day)	Railway passengers (persons/day)
1973	1	38	220	151	207	7	161	784	566	370
1974	2	42	249	171	224	8	178	872	619	408
1975	3	46	281	194	243	8	196	968	676	451
1976	4	51	318	221	264	9	217	1,080	739	498
1977	5	56	360	250	286	10	239	1,201	807	549
1978	6	62	407	284	310	11	264	1,338	882	607
1979	7	69	460	323	336	12	291	1,491	964	670
1980	8	76	520	366	365	13	322	1,662	1,053	739
1981	9	83	588	416	396	14	355	1,852	1,151	816
1982	10	92	665	472	429	15	392	2,065	1,258	901
1983	11	102	751	535	465	16	433	2,302	1,375	994
1984	12	112	850	607	504	18	478	2,569	1,502	1,098
1985	13	124	961	689	547	19	527	2,867	1,642	1,212
1986	14	136	1,086	782	593	21	582	3,200	1,794	1,337
1987	15	150	1,228	888	643	23	642	3,574	1,960	1,476
1988	16	166	1,389	1,008	697	25	709	3,994	2,142	1,630
1989	17	183	1,570	1,144	756	27	783	4,463	2,341	1,799
1990	18	202	1,776	1,298	819	29	864	4,988	2,558	1,986
1991	19	212	1,867	1,365	855	30	906	5,235	2,675	2,081
1992	20	221	1,959	1,433	891	32	947	5,483	2,792	2,176
1993	21	231	2,050	1,500	927	33	988	5,729	2,910	2,271
1994	22	241	2,142	1,568	963	34	1,030	5,978	3,027	2,366
1995	23	250	2,233	1,635	999	36	1,071	6,224	3,144	2,461
1996	24	260	2,325	1,703	1,035	37	1,112	6,472	3,261	2,556
1997	25	270	2,416	1,770	1,071	38	1,154	6,719	3,378	2,652
1998	26	279	2,508	1,838	1,107	39	1,195	6,966	3,495	2,747
1999	27	289	2,599	1,905	1,143	41	1,236	7,213	3,613	2,842
2000	28	299	2,691	1,973	1,179	42	1,278	7,462	3,730	2,937

Fig. 3 2. FUTURE TRAFFIC VOLUMES, AS RELATED TO BRIDGE TOLLS



3.3. Benefit and Cost

The direct benefit of the bridge comprises savings in the cost and time of travel, economy in car operation, increase in carrying capacity, less chance of accidents, comfortable traveling, and so on, which are derived from the comparison with the present ferry facilities running between Tha Naleng and Nong Khai. The benefits from less travel time and the saving in the cost of car operation are called the time benefit and the operation benefit, respectively. While these two benefits can be estimated reasonably to some extent, the other benefits cannot be evaluated even in a rough estimate. In the present project, only the time and operation benefits are considered in estimating the direct benefit.

The annual benefit can be obtained by multiplying the benefit per unit of traffic, called "unit benefit", by the annual traffic volume.

A unit benefit comprises the operation and time benefits per unit of traffic in a zonal pair, and the unit benefit to be used in estimating the annual benefit is the average of the unit benefits in the following zonal pairs : Vientiane-Tha Bo and Sri Chieng Mai, Vientiane-Nong Khai station, Vientiane-Nong Khai, Vientiane-Udon, Tha Deua-Nong Khai station, Tha Deua-Nong Khai and Tha Deua-Udon.

As for the kind of traffic, nine kinds were considered, i.e., small-size buses, large-size buses, personal cars, taxis, heavy trucks, light trucks, motorcycles, railway freight and railway passengers.

Table 3.3 presents the unit benefits of the nine kinds of traffic, each of which averages the unit benefits of seven zonal pairs.

Table 3.3. Unit Benefit

Traffic	Unit	Unit benefit			
		Operation benefit	Time benefit	Total	As adopted
Small-size buses	Baht/No	38.63	3.12	41.75	
Large-size buses	"	189.33	3.06	192.39	117.1
Personal cars	"	38.53	0.87	39.40	39.4
Taxis	"	38.35	0.87	39.22	39.2
Heavy trucks	"	107.03	3.98	111.01	111.0
Light trucks	"	55.24	0.36	55.60	55.6
Motorcycles	"	4 78	0.48	5.26	5.3
Railway freight	Bahts/ton	25.58	1.05	26.63	26.6
Railway passengers	Bahts/person	7.17	0.26	7.43	7.4

Since the future traffic largely changes with bridge tolls, as mentioned before, the relations between bridge tolls and future traffic, and between bridge tolls and the direct benefit per annum about each of the traffic components are evidenced in Fig. 3.3. The bridge tolls are taken at a certain percentage of the current ferry charges of the respective traffic components.

Annual equivalent benefits and capitalized benefits are given in Fig. 3.3., and also in Table 3.4 provided that the discount rates are taken at 3 percent, 7 percent and 10 percent and the analysis period at 40 years of which the period is the useful life of the project.

The annual cost and the capitalized cost also are given in Table 3.4. The annual cost of the project comprises the annual fixed cost and the annual working expense. The annual fixed cost is the annual cost by which the total construction cost of the project would be amortized during its useful life, and the annual working expense indicates the annual expense which is required for operation, maintenance and replacement of the project. They are estimated in detail in the Feasibility Report Part III, Chapter VI, Paragraph 6.5.

The benefit-cost ratio of the project, which is the ratio of the annual equivalent benefit to the annual equivalent cost, lies between 4.0 and 5.9 for the discount rate of 3 percent and between 1.3 and 1.9 even for the discount rate of 10 percent. The internal rate of return, in which the total present worth of benefits equals the total present worth of costs, is 15.9 percent in the case of a non-toll bridge and 12.9 percent when the bridge tolls would equal the current ferry charges, as shown in Fig. 3.4.

Because the benefit-cost ratio is greater than unity in any case and the internal rate of return exceeds the minimum acceptable rate of 12 percent, the Nong Khai/Vientiane bridge project is feasible and worth being developed.

Table 3.4. Benefits and Costs

(Unit : U.S.$)

Item	Discount rate (%) [1]	Bridge toll [2]		
		Non-toll	Half-toll	Full-toll
Annual benefit	3	7,036,300	5,780,700	4,874,400
	7	5,619,100	4,635,500	3,924,300
	10	4,794,800	3,969,400	3,371,800
Annual cost	3	1,195,600	1,216,600	1,216,600
	7	1,886,900	1,907,900	1,907,900
	10	2,478,700	2,499,700	2,499,700
Benefit-cost ratio	3	5.9	4.8	4.0
	7	3.0	2.4	2.1
	10	1.9	1.6	1.3
Capitalized benefit [3]	3	234,540,000	192,690,000	162,480,000
	7	80,270,000	66,220,000	56,060,000
	10	47,950,000	39,690,000	33,720,000
Capitalized cost [3]	3	39,850,000	40,550,000	40,550,000
	7	26,960,000	27,260,000	27,260,000
	10	24,790,000	25,000,000	25,000,000
Capitalized net benefit	3	194,690,000	152,140,000	121,930,000
	7	53,310,000	38,960,000	28,800,000
	10	23,160,000	14,690,000	8,720,000
Internal rate of return		15.9%	14.1%	12.9%

Remarks :

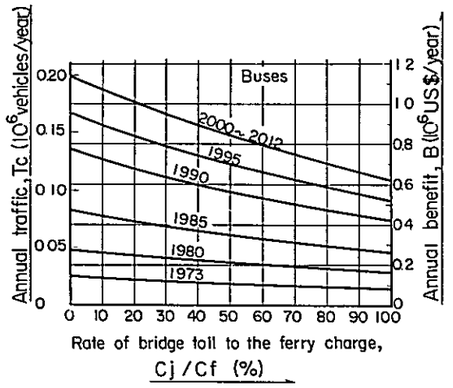
/1 The capital recovery factors for the analysis period of 40 years are 0.04326238 for the discount rate of 3 percent, 0.07500914 for 7 percent and 0.10225941 for 10 percent.

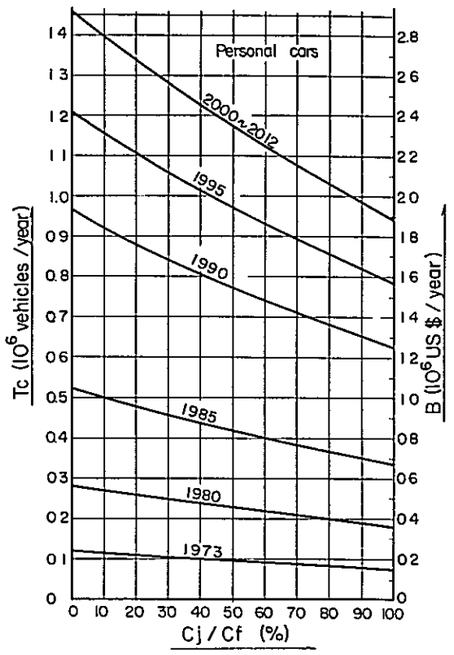
/2 The following three cases were considered as bridge tolls : (1) the case of free-of-charge (non-toll) ; (2) the case that half the current ferry charges will be collected (half-toll) ; and (3) the case that bridge tolls the same as the current ferry charges will be collected (full-toll).

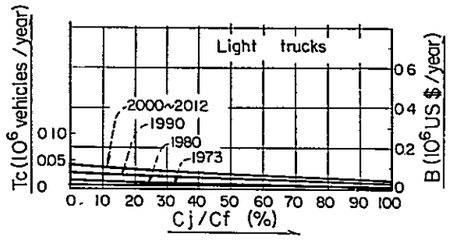
/3 The capitalized benefits and costs are figured out as of 1973 when the bridge is opened to traffic.

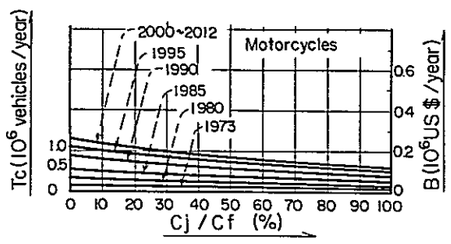
Fig. 3.3. TRAFFICS AND BENEFITS

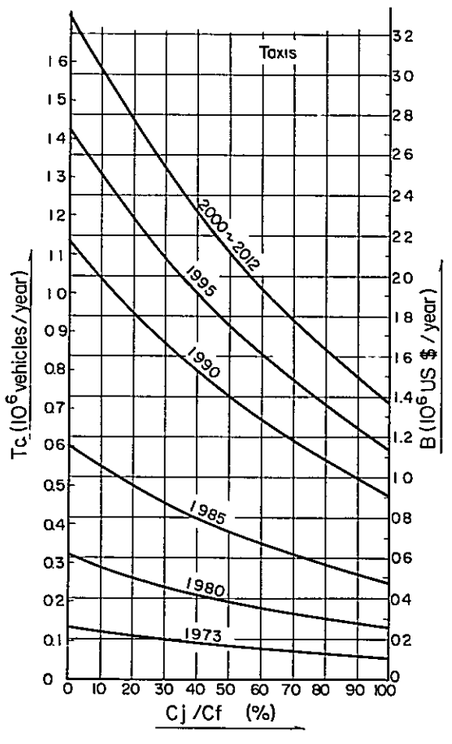
I Annual traffics and benefits

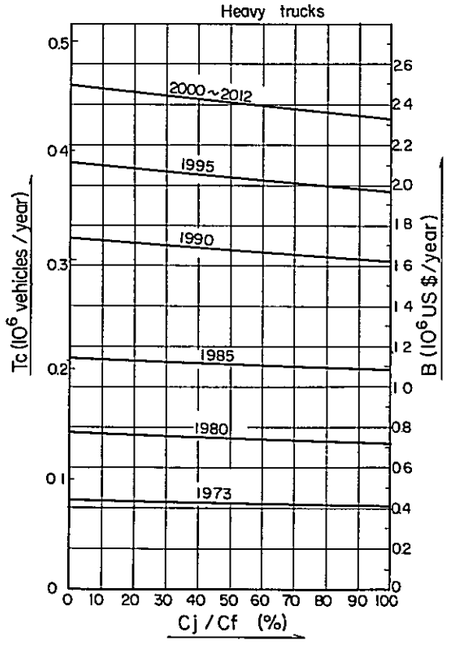


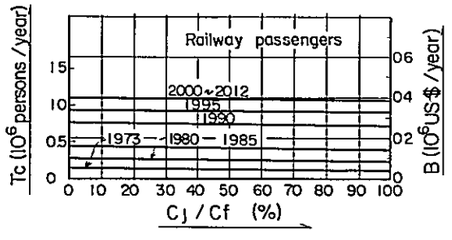




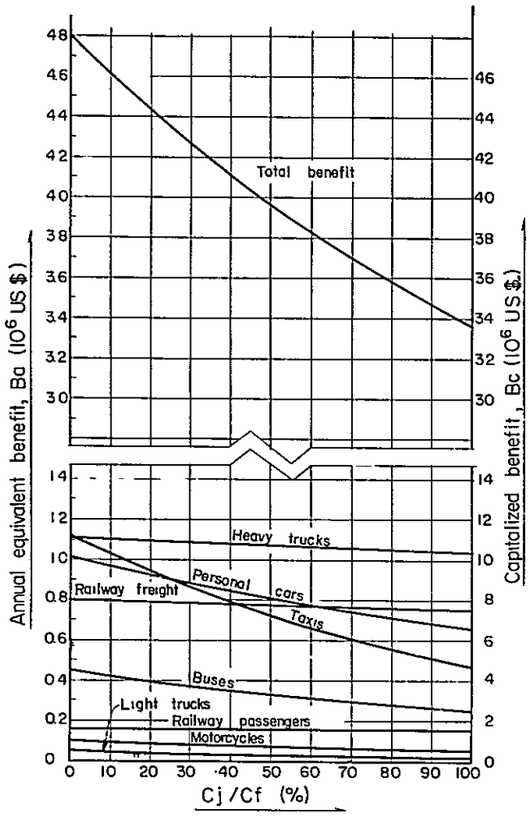








II Annual equivalent benefit and capitalized benefit
(Discount rate = 10 %)



Remarks .

$Tc = 365\, Q_f \alpha^{(1-Cj/Cf)}$

$B = Tc\ Bi$

$Ba = \left[r(1+r)^n / \{(1+r)^n - 1\} \right] \sum_{K=1}^{n} B/(1+r)^{K-1}$

$Bc = Ba/r$

where

Q_f = Daily traffic in the case that the bridge tolls equall the current ferry charges,

α = Coefficient of traffic variation,

Cj = Bridge toll,

Cf = Current ferry charge,

Tc = Annual traffic,

Bi = Unit benefit,

B = Annual benefit,

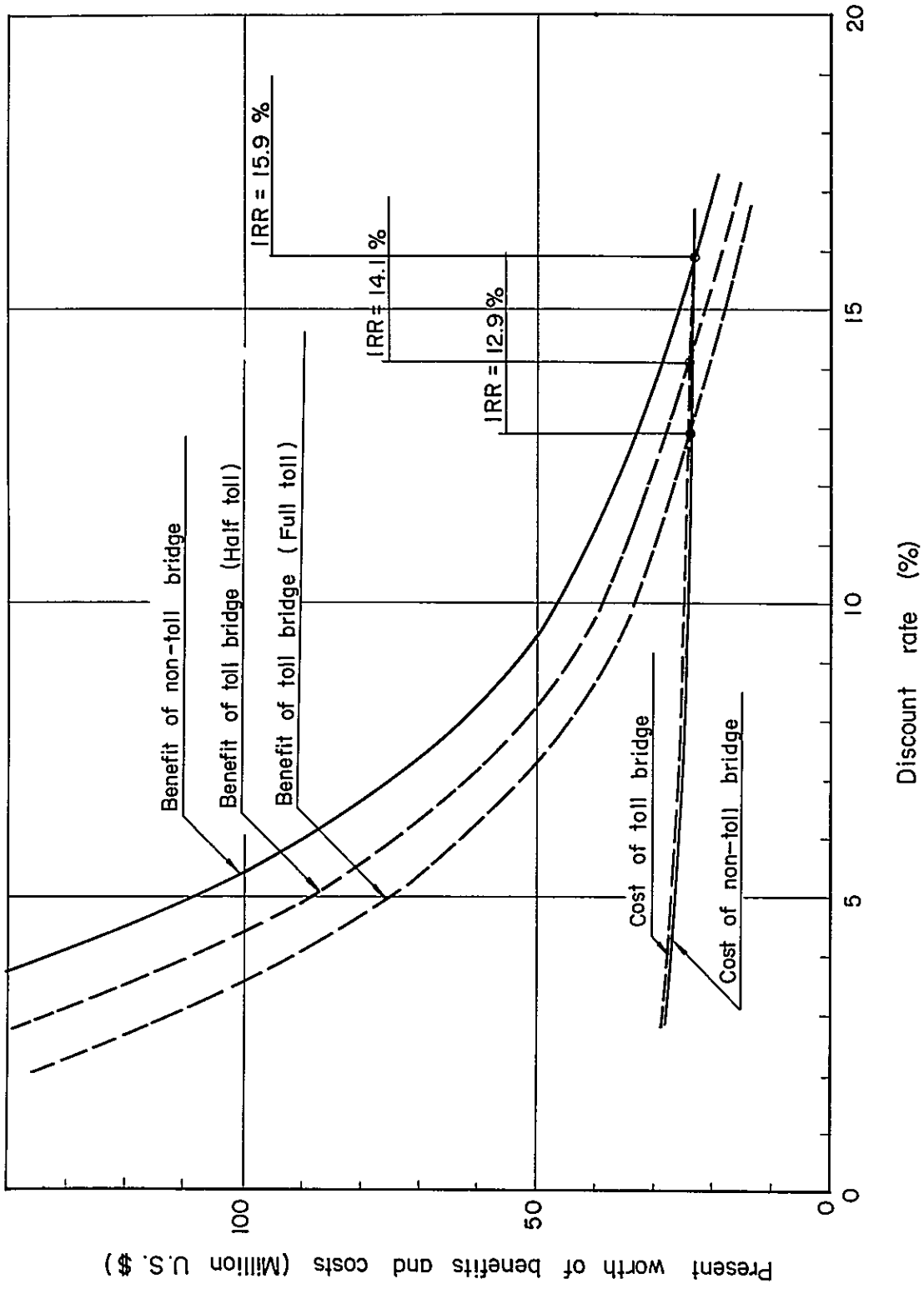
r = Discount rate

n = Analysis period, $n = 40$ years,

Ba = Annual equivalent benefit,

Bc = Capitalized benefit.

Fig. 3.4. INTERNAL RATE OF RETURN



3.4. Indirect Benefit

The project will produce many kinds of indirect benefits as well as the direct benefits. Most of the indirect benefits cannot be evaluated in monetary value, but they will contribute significantly to the well-being of Central Laos and Northeast Thailand.

The following are the major indirect benefits considered in the economic evaluation of the project.

(1) Contribution to the socio-economic development;
(2) Effect of reducing the volume of goods in stock; and
(3) Benefit in the field of consumption and production.

A brief description is given below of the above three.

(1) Contribution To the Socio-Economic Development

It is obvious that the project would remarkably promote the socio-economic development not only of the project area but also of Laos and Thailand. This effect, however, be effectuated in the long course of time.

(a) Lumber Industry

Laos is rich in lumber resources, about two-thirds of her land being convered with dense forests. So, the lumber industry in Laos can be expected to develop remarkably when the transportation would be improved. It is especially significant for the Laotian Lumber industry that a mass transportation system of railway would be introduced for the first time into Laos and would likely be extended farther inland. The Laotian lumber export is expanding being supported by the fact that Thailand is becoming short of forest resources and also by the favorable economic growth in Thailand. Therefore, the Laotian lumber export without fail will be promoted by the implementation of the project. Besides, new lumber industries of manufacturing secondary lumber products such as plywood will also develop.

If it could be assumed that the Laotian lumber export would increase at an annual rate of 10 percent on the average, it will increase from 32,400 tons in 1966 to about 300,000 tons in 1990.

(b) Mining

Mining, with the exception of tin, has not been developed in Laos, and no reliable survey nor prospecting has been carried out so far. Although the information is incomplete, there are some reports of the occurrence in Laos of gold, copper, lead, iron, limestone, gypsum, manganese, tungsten, antimony, graphite and salt. Among these, the most promising is the iron ore deposit in Xieng Khouang district, with an estimated reserve of several hundred million tons. These mineral resources, of great potential, have so far remained unexploited because Laos has no port for foreign trade as well as because of the lack of adequate transportation.

Accordingly, if a through rail route would be opened from Bangkok to Vientiane by the construction of a rail/highway bridge over the Mekong, and moreover, if the rail route would be extended in the future farther inland to the sites of promising mineral resources, mined ores would become to be carried easily to Bangkok, at present the main gateway for the Laotian

foreign trade, and as a result the development of the Laotian mining industry would be much accelerated.

(c) Rise of Land Value

After the completion of the project, the utility value of land will increase in areas lying along the highway and railway and around the bridge site. Particularly, it is anticipated that the district around the Vientiane railway station, which lies almost undeveloped at the present time, will be rapidly developed.

The demand for land in and around the project area for construction of factories, shops and residences will bring about a rise in land prices, which in turn will benefit landowners in the form of increased rentals. This can be considered an indirect benefit of the project.

(d) Agriculture and Stock-Raising

At present, most of foodstuffs such as rice, vegetables and meat consumed in the Vientiane area are imported from the Sri Chieng Mai-Tha Bo district on the opposite side of the Mekong. The bridge will place the economy of the Vientiane area in a much closer relation with the economy of the northeastern district of Thailand, and this will promote the development of agriculture and stock-raising in this area. For instance, it is said that the production of corn in northeastern Thailand has increased from 186,000 tons in 1958 to 1,200,000 tons in 1966, corresponding to 6.5 times, after the completion of the Asian Highway A-12. Thus, access to additional markets and reduction in transportation costs, which will result from the implementation of the project, will bring about an increase in the yield of farm produce as well as in farm income.

(e) Expected Contribution to Pa Mong Project

The Pa Mong project will need much cement for construction in the near future, and Laos is now planning to exploit limestone near the Nam Ngum project for manufacturing cement. If the railway would have been laid to Vientiane, it would be easy to extend the railway to Pa Mong along the Mekong (it should be understood that it is at present not easy to reach Pa Mong on the Thai side).

The railway, if realized, will contribute much to the transportation of cement and various other construction materials and machinery that shall be carried from abroad at the time of construction of the Pa Mong project.

(2) Effect of Reducing Goods in Stock

Time saving in transportation to be effectuated by the use of the Mekong bridge will reduce the volumes of goods and products to be stored in stock in shops or factories in Vientiane.

(3) Benefit in the Field of Consumption and Production

Cost saving in transportation will induce a drop in the cost prices of imported goods, an increase in production profit in manufacturing, and a drop in selling prices accompanied by a rise in demand and the resultant increase in sale.

Cost saving in transportation has already been counted in the direct benefit. It was appraised, item by item, for the Laotian imports and exports as of 1966 and are given in Table 6.14, Part III. This table shows that if all the imports and exports would have been carried from or to Bangkok via a non-toll bridge over the Mekong, a total of about U.S.$530,000 would have been saved. If it is assumed that the imports and exports would increase at an annual growth rate of 5 percent, the saving in the cost of transportation will almost triple in 1990.

3.5. Financial Aspect

If the construction cost of the project should be financed wholly by a loan, it is desirable that the project be self-liquidating.

Assuming that the bridge tolls would equal the current ferry charges, studies were made on loans of three different annual rates of interest, namely, 3-, 7- and 10-percent annual rates of interest, and it was found that these loans would be amortized in 14, 18 and 24 years, respectively, as shown in Table 3.5. However, it was also found that in the case of loans of 7-percent and 10-percent interest, a working capital amounting to about 11 percent and 58 percent, respectively, of the total construction cost would have to be provided.

Should no working capital be allowed, it is desirable to obtain a loan not harder than a loan of 4-percent interest and 15-year amortization period and to set the bridge tolls at the level of the present ferry charges.

If a working capital amounting to 15 percent of the total construction cost would be allowed for a period of the initial 7 years, it is possible to borrow a loan of 7-percent annual rate of interest and 18-year amortization period in the case of collecting bridge tolls equaling the current ferry charges.

Fig. 3.5 presents favorable loans that will be fully amortized with the income from the bridge tolls, when they would be set different from the current ferry charges. The method of amortization herein adopted is a method of repaying the loan annually from the revenue expected to exceed the interest on the invested capital plus the working expense, instead of repaying on the equal annual repayment basis. According to this figure, a loan of 4-percent annual rate of interest and the amortization period of 21 years can be fully amortized when the bridge tolls would be set at half the current ferry charges.

Table 3 5. Financial Statements in the Case of Collecting Bridge Tolls Equaling Current Ferry Charges

1. Annual rate of interest: 3 percent

Unit: U.S $

Ordinal Year	Calendar Year	Outstanding amount	Interest	Annual working expense	Total expenditure	Toll revenue	Balance
1	1973	21,500,000	645,000	309,100	954,100	1,164,817	210,717
2	1974	21,289,283	638,678	309,100	947,778	1,280,628	332,850
3	1975	20,956,433	628,693	309,100	937,793	1,406,987	469,194
4	1976	20,487,239	614,617	309,100	923,717	1,550,586	626,869
5	1977	19,860,370	595,811	309,100	904,911	1,705,123	800,212
6	1978	19,060,158	571,805	309,100	880,905	1,877,571	996,666
7	1979	18,063,492	541,905	309,100	851,005	2,068,378	1,217,374
8	1980	16,846,119	505,384	309,100	814,484	2,278,753	1,464,270
9	1981	15,381,849	461,455	309,100	770,555	2,511,007	1,740,451
10	1982	13,641,398	409,242	309,100	718,342	2,767,342	2,049,000
11	1983	11,592,397	347,772	309,100	656,872	3,050,130	2,393,258
12	1984	9,199,139	275,974	309,100	585,074	3,363,902	2,778,828
13	1985	6,420,311	192,609	309,100	501,709	3,712,667	3,210,958
14	1986	3,209,354	96,281	309,100	405,381	4,096,150	3,690,770

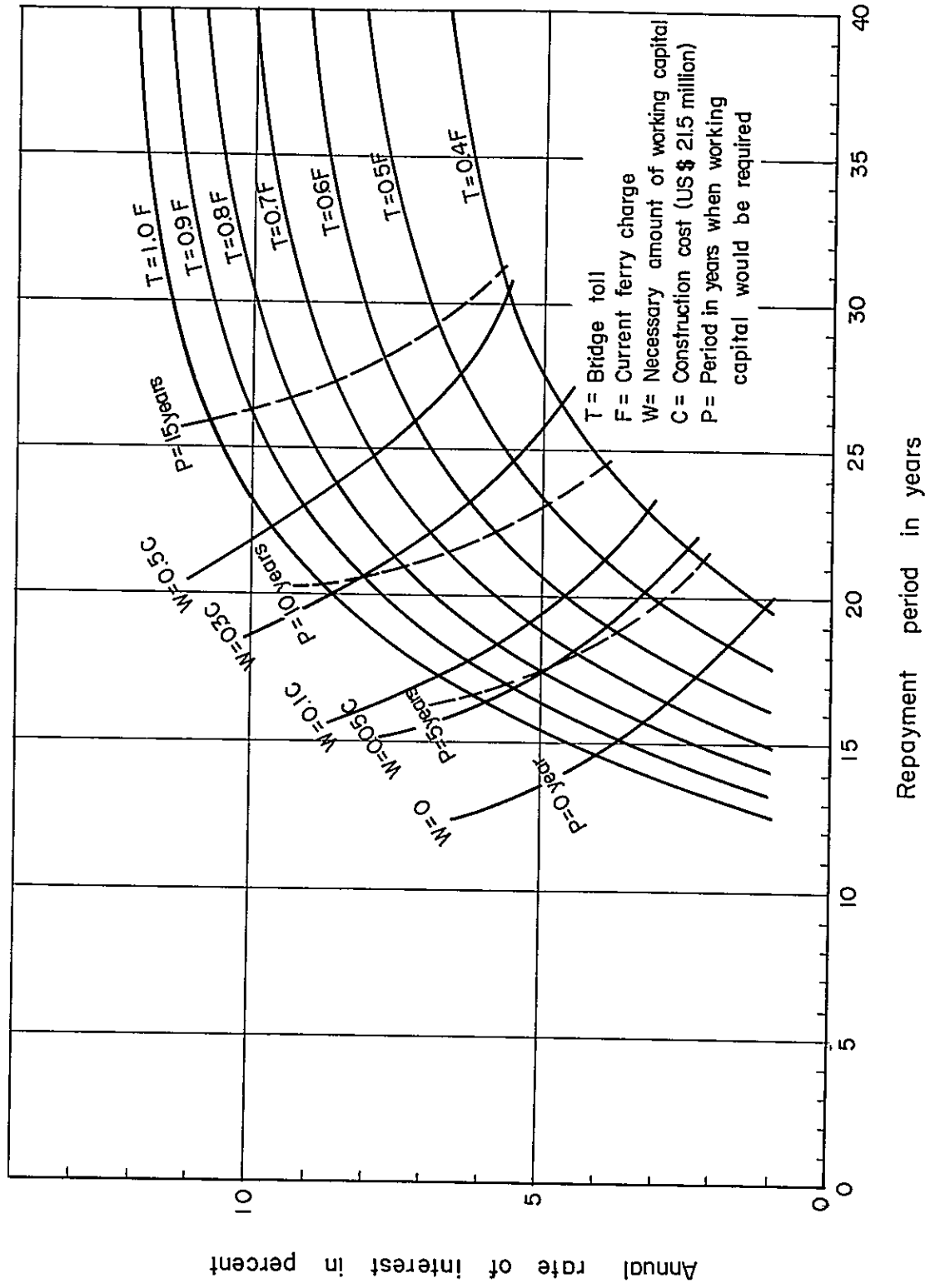
2. Annual rate of interest: 7 percent

1	1973	21,500,000	1,505,000	309,100	1,814,100	1,164,817	-649,283
2	1974	22,149,283	1,550,450	309,100	1,859,550	1,280,628	-578,922
3	1975	22,728,205	1,590,974	309,100	1,900,074	1,406,987	-493,087
4	1976	23,221,291	1,625,490	309,100	1,934,590	1,550,586	-384,005
5	1977	23,605,296	1,652,371	309,100	1,961,471	1,705,123	-256,348
6	1978	23,861,644	1,670,315	309,100	1,979,415	1,877,571	-101,844
7	1979	23,963,488	1,677,444	309,100	1,986,544	2,068,378	81,834
8	1980	23,881,654	1,671,716	309,100	1,980,816	2,278,753	297,938
9	1981	23,583,716	1,650,860	309,100	1,959,960	2,511,007	551,046
10	1982	23,032,670	1,612,287	309,100	1,921,387	2,767,342	845,956
11	1983	22,186,714	1,553,070	309,100	1,862,170	3,050,130	1,187,960
12	1984	20,998,754	1,469,913	309,100	1,779,013	3,363,902	1,584,889
13	1985	19,413,865	1,358,971	309,100	1,668,071	3,712,667	2,044,596
14	1986	17,369,269	1,215,849	309,100	1,524,949	4,096,150	2,571,202
15	1987	14,798,067	1,035,865	309,100	1,344,965	4,522,485	3,177,520
16	1988	11,620,547	813,438	309,100	1,122,538	4,995,492	3,872,954
17	1989	7,747,593	542,332	309,100	851,432	5,518,964	4,667,533
18	1990	3,080,060	215,604	309,100	524,704	6,097,913	5,573,208

3 Annual rate of interest: 10 percent

Ordinal Year	Calendar Year	Outstanding amount	Interest	Annual working expense	Total expenditure	Toll revenue	Balance
1	1973	21,500,000	2,150,000	309,100	2,459,100	1,164,817	-1,294,283
2	1974	22,794,283	2,279,428	309,100	2,588,528	1,280,628	-1,307,900
3	1975	24,102,183	2,410,218	309,100	2,719,318	1,406,987	-1,312,331
4	1976	25,414,514	2,541,451	309,100	2,850,551	1,550,586	-1,299,966
5	1977	26,714,480	2,671,448	309,100	2,980,548	1,705,123	-1,275,425
6	1978	27,989,905	2,798,990	309,100	3,108,090	1,877,571	-1,230,520
7	1979	29,220,424	2,922,042	309,100	3,231,142	2,068,378	-1,162,764
8	1980	30,383,188	3,038,319	309,100	3,347,419	2,278,753	-1,068,665
9	1981	31,451,854	3,145,185	309,100	3,454,285	2,511,007	-943,279
10	1982	32,395,132	3,239,513	309,100	3,548,613	2,767,342	-781,271
11	1983	33,176,403	3,317,640	309,100	3,626,740	3,050,130	-576,611
12	1984	33,753,014	3,375,301	309,100	3,684,401	3,363,902	-320,499
13	1985	34,073,513	3,407,351	309,100	3,716,451	3,712,667	-3,784
14	1986	34,077,297	3,407,730	309,100	3,716,830	4,096,150	379,321
15	1987	33,697,977	3,369,798	309,100	3,678,898	4,522,485	843,587
16	1988	32,854,389	3,285,439	309,100	3,594,539	4,995,492	1,400,953
17	1989	31,453,436	3,145,344	309,100	3,454,444	5,518,964	2,064,521
18	1990	29,388,915	2,938,892	309,100	3,247,992	6,097,913	2,849,921
19	1991	26,538,994	2,653,899	309,100	2,962,999	6,387,369	3,424,369
20	1992	23,114,625	2,311,463	309,100	2,620,563	6,678,160	4,057,598
21	1993	19,057,027	1,905,703	309,100	2,214,803	6,968,241	4,753,438
22	1994	14,303,589	1,430,359	309,100	1,739,459	7,259,120	5,519,661
23	1995	8,783,928	878,393	309,100	1,187,493	7,548,488	6,360,996
24	1996	2,422,933	242,293	309,100	551,393	7,839,280	7,287,887

Fig. 3.5. INTEREST RATE AND REPAYMENT PERIOD OF LOAN THAT CAN BE AMORTIZED BY TOLLS



CHAPTER IV

CONCLUSIONS AND RECOMMENDATIONS

4.1. Conclusions

Mentioned herein as conclusions are the feasibility of the Nong Khai/Vientiane bridge project and the decisions on various items made by the Mekong Committee or derived from studies made in compliance with the comments of the Mekong Committee and by the authorities concerned of the Laotian and Thai governments.

4.1.1. Feasibility

The Nong Khai/Vientiane bridge project is technically, economically and financially feasible. The project involves no serious engineering difficulty and will be of considerable benefit to both Laos and Thailand.

Engineering soundness of a bridge in general depends primarily upon its foundation. The test drilling carried out at the bridge site during the second-phase investigation revealed that underneath the alluvial river-bed lies a stratum of unweathered siltstone firm enough for supporting the bridge structures. The bridge substructures shall, of course, be founded on this siltstone stratum. The pneumatic caisson foundation was adopted in this report considering that, though it might be a little expensive, the job would be better controlled and would be executed exactly because it will enable one to visually inspect the bearing surface and ascertain satisfactory bearing of the caisson on the firm siltstone stratum. Wooden mattresses loaded with lumps of laterite will be placed around midstream piers to protect the river-bed around them from being scoured and thus to safeguard the foundation.

No serious engineering difficulties will occur in the course of the bridge construction, including the underwater works mentioned above.

The essential structures of the project comprise the main bridge across the Mekong with approach viaducts, the railway and highway as well as the administrative facilities, all of which are of ordinary construction.

The total cost of construction is estimated at U.S. $21,500,000, which divides into $9,000,000 for the main bridge and the approach viaducts, $8,500,000 for the railway and $4,000,000 for the highway and the administrative facilities.

When completed, the project will bring forth such a large direct benefit as to amount to about $7,000,000 at a discount rate of 3 percent, even if no toll would be collected. Even in the case of a 10-percent discount rate, the annual benefit will amount to $3,400,000, if tolls of the same amount as the current ferry charges would be collected.

The benefit-cost ratio is 5.9 in the former case and 1.3 in the latter case. The internal rate of return is estimated at 15.9 percent in the former and at 12.9 percent in the latter case, both exceeding 12 percent, the minimum acceptable rate widely recognized for this kind of project.

The project will accompany various indirect benefits that, though difficult to appraise in monetary value, will contribute to the development and well-being of the region in and around the project area. For instance, the savings in the cost and time of transportation will cause a drop in commodity prices accompanied by an increase in the demand and a decrease in the volume of goods in stock in shops or factories, which in turn will further the price drop.

To be mentioned further as the indirect benefits are the socio-economic development of the region in and around the project area, the rise in the land value, the rise in the development values of natural resources such as iron, copper, limestone and the like, the development of industry, forestry, stock-raising and so forth.

As regards the financial feasibility of the project, the following can be said as conclusions. If it would be allowed to collect bridge tolls equaling the current ferry charges, it will be quite possible to repay a loan within its amortization period even if the loan would be such a hard one as a loan of 10-percent annual interest rate and 23-year term. However, it is desirable that the bridge tolls be set at a level not higher than half the current ferry charges. In this case, the loan shall be much softer, for example, a 4-percent, 21-year loan or a 3-percent, 20-year loan.

It goes without saying that the most desirable fund hence to be sought first for financing the project is a generous grant. Next comes a loan, the interest rate of which varies at a certain time of the useful life of the project. An example that seems suitable for the present project is a 40-year-term loan, in which the annual interest rate is first set at 3 percent for the period, possibly 10 to 15 years, during which the traffic would remain relatively little as compared with the capacity of the project, and then raised to 10 percent for the remaining period when the traffic would grow to near capacity. Another example recommendable for financing the present project is to borrow a soft loan such as of 3-percent interest rate and 20- to 25-year term on condition that it is replaced in 10 to 15 years with a hard loan such as of 10-percent interest rate and 20-year term.

In conclusion, the Nong Khai/Vientiane bridge project is quite feasible from the economic and financial point of view, if it would be financed with a generous grant or with a suitable loan.

4.1.2. Decisions and Studies Made on Various Items

Concerning and based on the studies on the feasibility of the Nong Khai/Vientiane bridge project as presented in the First-Phase Report of December 1967 and the Second-Phase Report of November 1968, the Mekong Committee and the government authorities of Laos and Thailand have not only made decisions on key items such as the bridge site and the kind of the bridge but also presented useful comments and suggestions. The following are the decisions and the gist of studies made on various items.

(1) Bridge Site

The comparative study on three alternative locations of the bridge site, Nong Khai, Vientiane, and Pa Mong, has been described in detail in the First-Phase Report and is outlined in Chapter IV in Part II. The Mekong Committee, after deliberation, decided that the bridge be located at the Nong Khai site.

(2) Kind of Bridge

Whether the main bridge shall be a highway bridge or a dual-purpose rail/highway bridge had

been a key point of the project and detailed studies were made in the course of the first-phase and second -phase investigations as reported in the Second-Phase Report and outlined also in Chapter IV of Part II.

The Mekong Committee, to which the choice was committed, has finally made its choice of the rail/highway bridge, considering that it will be more advantageous in respect of the socio-economic development of both countries concerned.

(3) Bridge Floor Layout

Five types of bridge floor layout shown in Fig. 2.1 were studied and choice was made of the type shown in PLATE 3, in which a two-lane roadway and a single-track railway track are laid separately on the bridge floor between the main bridge trusses.

(4) Protection of River-Bed Against Scouring

Wooden mattresses filled with lumps of laterite will be placed around the bridge piers to guard the river-bed therearound from being scoured, as shown in PLATE 6.

In sinking pneumatic caissons for the pier foundations, temporary islands will be built enclosed by steel sheet-piles and filled with fine sand of the river. These islands will be left as they stand after the construction of the foundation so that they will contribute to the stability of the foundation.

(5) Bank Protection

To protect banks at the bridge ends against erosion, gabions will be laid over the bank slopes and concrete blocks will be dumped at their toes as shown in PLATE 6. The protection shall stretch about 120 meters on the Laotian bank and 150 meters on the Thai bank.

(6) Railway Route

As mentioned in detail in Chapter IV in Part II, the so-called combined route C/D shown in PLATE 1 has been selected by the Mekong Committee as the railway route on the Laotian side. This route, after crossing the Mekong, passes through the highlands covered with dense jungle east of the That Luong marsh and reaches the proposed Vientiane terminal located some 7 kilometers from the civic center of Vientiane.

(7) Change-Over of Traffic Direction

The traffic in Laos keeps to the right, whereas in Thailand it keeps to the left. It is therefore necessary to provide a site where the direction of the traffic shall be changed from the right to the left, and vice versa.

The problem of change-over was studied with relation to the layout of the administrative facilities to be built in the vicinity of both ends of the bridge and to the layout of the bridge floor. It has so far been concluded that at the present stage the change-over shall be provided on the Laotian side with at-grade intersection, though a grade separation would become necessary sometime in the future to cope with the increased traffic.

(8) Discount Rate

The economic feasibility of the project has been comparatively evaluated based on three different discount rates, 3%, 7% and 10%. It has been also studied by means of the internal rate of

return.

(9) Cost of Transshipment

The cost of transshipment at the Tha Naleng car ferry will be saved when the project would be implemented and, consequently, has been counted in the benefit of the project.

The Mekong Committee Advisory Board has commented that the possible present cost of intermediate trade might dissappear in case a railway would be laid up to Vientiane, and that in case direct shipment could be made from Bangkok to Vientiane either by rail or by road, the drop in the prices of imported commodities in Vientiane should be of much more importance than the savings in transportation and transshipment which would result from the use of the bridge. The survey team has been well aware of these benefits, but in the present report, they have been counted as indirect benefits.

4.2. Recommendations

It shall be recommended that the detailed design for executing the project be started as soon as possible and that a reasonable fund be sought for to finance the project. Besides, it is desired that measures be taken for some relevant items that have become to be noticed as indispensable in the course of the present feasibility study.

4.2.1. Financing

As already noted in Subparagraph 4.1.1, it is advisable for financing the project to get a generous grant or a soft loan of favorable condition at the earliest stage.

It is most desirable to raise at one time the fund needed for the whole cost of the project, U.S. $21,500,000, at the outset of the project. But it will take much time and such loss of time should be avoided.

Accordingly, it is recommended to start at the earliest moment the detailed investigations and the detailed design necessary for initiating the project at about U.S. $400,000 inclusive of the cost of preparation of tender documents. These preliminaries will take at least about one year and during this period, it is hoped, measures should be taken to raise the necessary fund. Anyway, the survey team strongly hopes that the detailed design be started as soon as possible because the present project will not fail to contribute to the benefit of both Laos and Thailand.

4.2.2. Detailed Investigations and Design

The following are needed for the detailed design.

(1) Detailed Topographic Survey

The plane-table survey made on a scale of 1:2,000 during the second-phase investigation is not sufficient for designing the details of the project structures. Therefore, a more detailed topographic survey of the whole project area shall be made on a scale of 1:500 or so.

It is first of all necessary to adjust the elevations of bench-marks located in and around the project area. For instance, the elevation of a bench-mark located in the compound of the Thai

Hydrographic Office at Nong Khai as surveyed during the second-phase investigation based on the bench-mark V-636 in Vientiane, registered to lie at El.170.105m, showed a discrepancy of 18 centimeters as compared with the elevation adopted by the Thai government. Such discrepancies in the elevations of bench-marks must be adjusted as they cause serious mistakes and unnecessary troubles in planning and construction of the project structures.

(2) Detailed Material Survey

Although detailed surveys regarding concrete aggregates, embankment materials and the like have been made as reported in the Second-Phase Report, more studies on these materials are required for making the detailed design of the project structures.

(i) Concrete Aggregates – To decide the design mix of concrete for different design compressive strengths and to make plans for supplying cement and aggregates, it is required to know the physical characteristics of the aggregate materials that lie in the pits to be finally selected.

(ii) River Sand and Gravel for Pavement Use – In general, crushed stone is preferred for use in wearing, base and subbase courses of highway pavement. But crushed stone is not obtainable in the vicinity of the project area. Accordingly, it is planned to use the Mekong's sand and gravel on the assumption that they would meet the requirements of the CBR test. It is therefore necessary to carry out the CBR test at site.

(iii) Embankment Materials – A survey on embankment materials made during the second-phase investigation revealed that the subsoil of the ground in the project area is not suited for highway or railway embankments for it has a tendency to swell when saturated with water.

As a measure to cope with the swelling, the use of soil-cement mix has been considered. Accordingly, it is necessary to make further studies on this problem and also to seek embankment materials of better quality from other sources.

(iv) Ballast Material – Material of sufficient hardness suitable for railway ballast cannot be found in the vicinity of the project area. It shall be supplied from the district around Sara Buri or Loei in Thailand. Further studies shall be made on the source and supply of railway ballast.

(v) Laterite and Stone – Further studies shall also be made on these materials.

(3) Test Drilling

Test drilling of the river-bed shall be carried out at the planned location of bridge piers.

(4) Hydraulic Model Test

It is recommended that a hydraulic model test be done to know the pattern of bank erosion.

(5) Preparation of Design Drawings, Design Report, Data Book and Specifications

(6) Exact Estimation of Work Quantities, Unit Prices and Construction Cost

(7) Preparation of Tender Documents

4.2.3. Pending Items

The following shall be projected or undertaken at the earliest stage for implementing the present project:

(1) To map out the course of the socio-economic development of the Vientiane plain, and to formulate the city planning of Vientiane taking into account the urbanization around the projected railway terminal.

(2) Widening of the Asian Highway A-3 (Laotian National Highway Route 13) on the stretch from Vientiane to the envisaged railway terminal. At present the road is 7 meters wide with no shoulders and is much inferior to the Asian Highway A-12 in its traffic capacity. Therefore, it is at least necessary to provide 2.5-meter shoulders on both sides of the roadway.

(3) To establish an organization for the operation, maintenance and replacement of the project after its completion. It is proposed that the organization be established under the direct jurisdiction of the Laotian and Thai governments and be authorized to assume the overall responsibility of administrating the operation and management of the project.

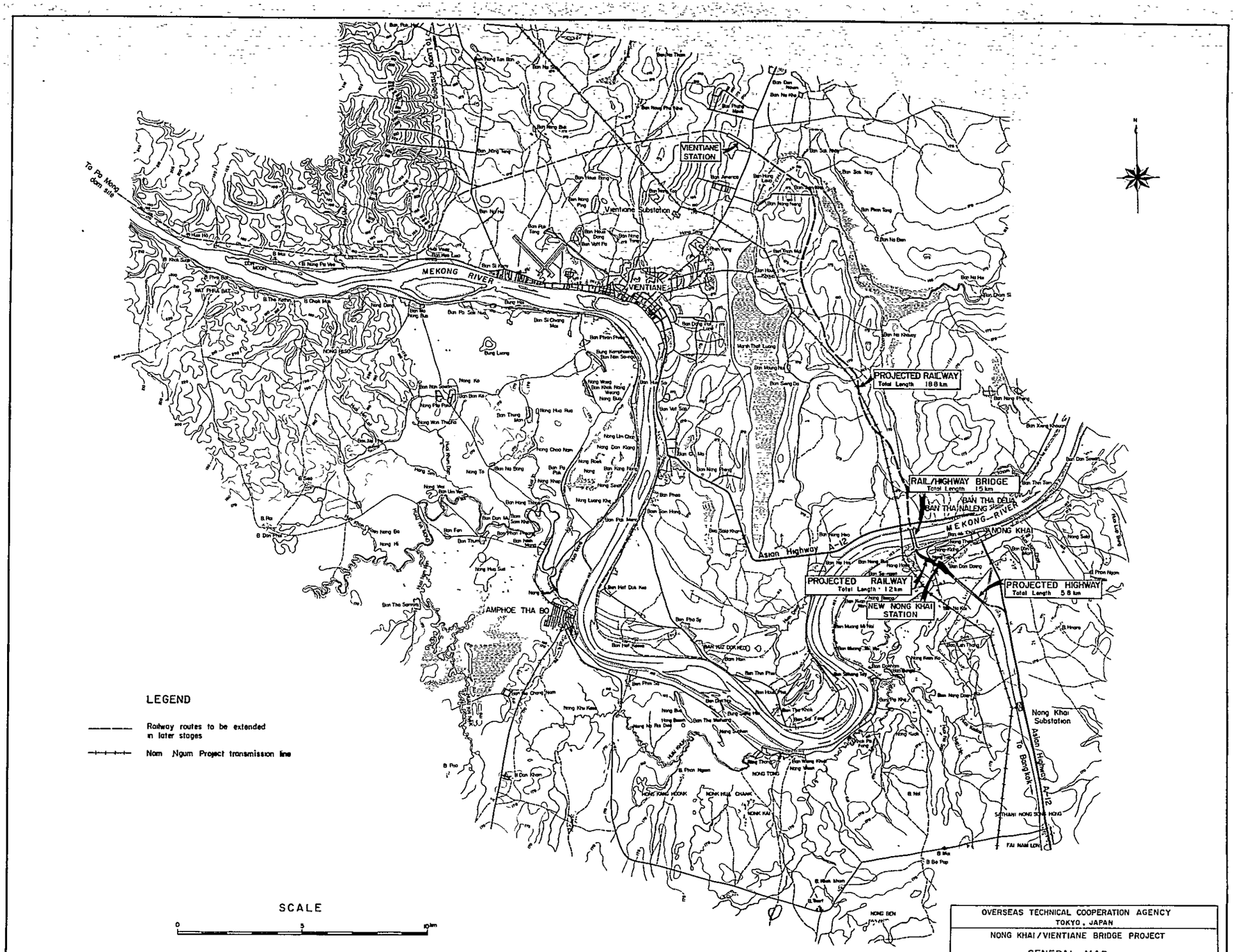
The organization shall be called the "Nong Khai/Vientiane Bridge Authority" and shall comprise a secretariat and various departments and sections to handle the operation and management, maintenance and improvements, financing, statistics, personnel affairs and general affairs.

The operation and maintenance of the project are recommended to be done under the guidance of qualified foreign engineering organizations.

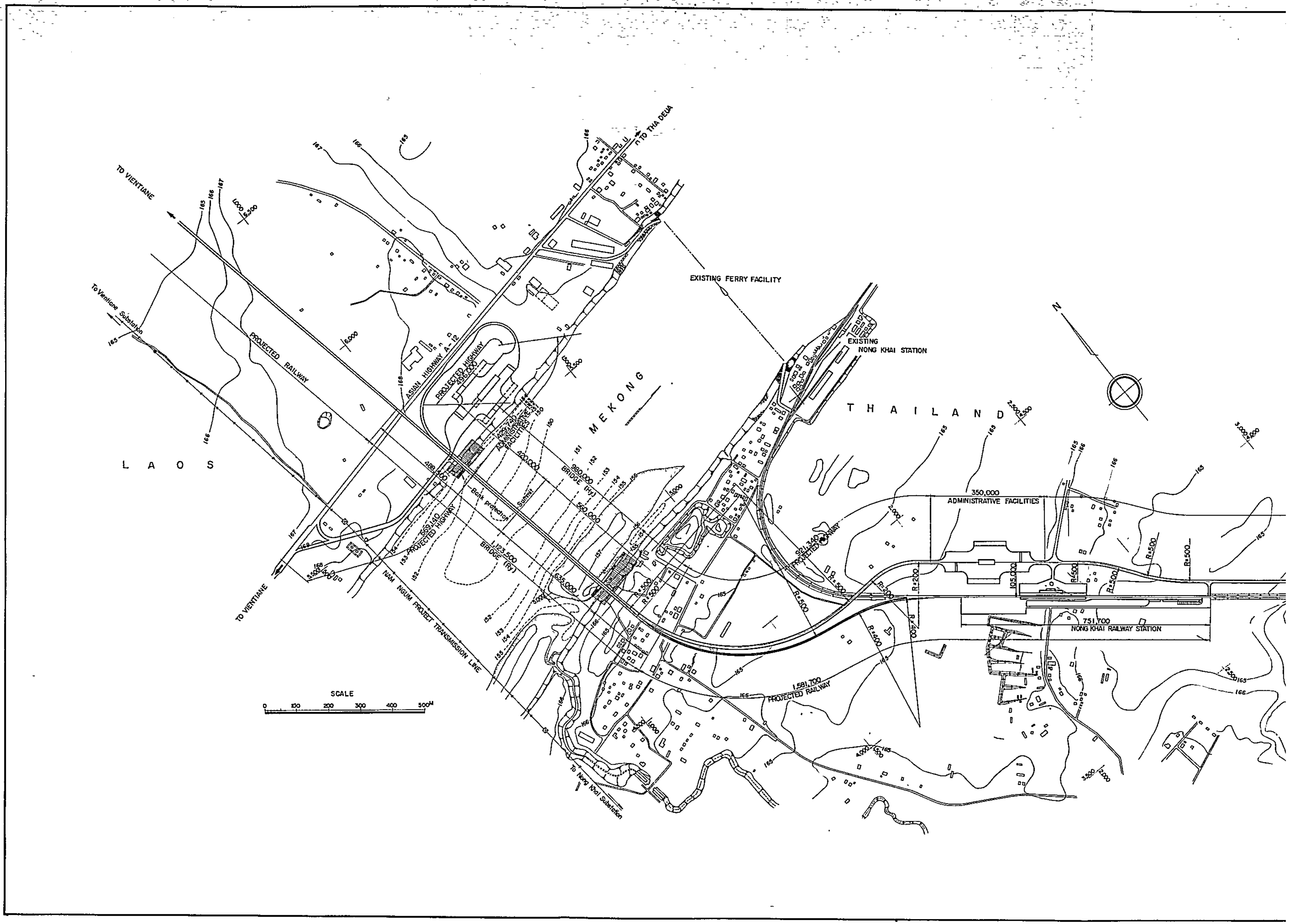
(4) To establish an organization for the operation and maintenance of the railway on the Laotian side. At present, there is in Laos no railway and naturally no governmental section concerned in railway. Therefore, when the railway would be extended into Laos, it is absolutely necessary to establish a new organization that should be called, for example, the "Royal State Railway of Laos". The new organization shall have a far-reaching ideal of extending the railway toward Luang Prabang and further north as well as toward the southern part of Laos and ultimately to realize a railway network all over Laos with rolling stocks of its own.

(5) To settle the problem of the ownership of the Nong Khai/Vientiane bridge before its completion.

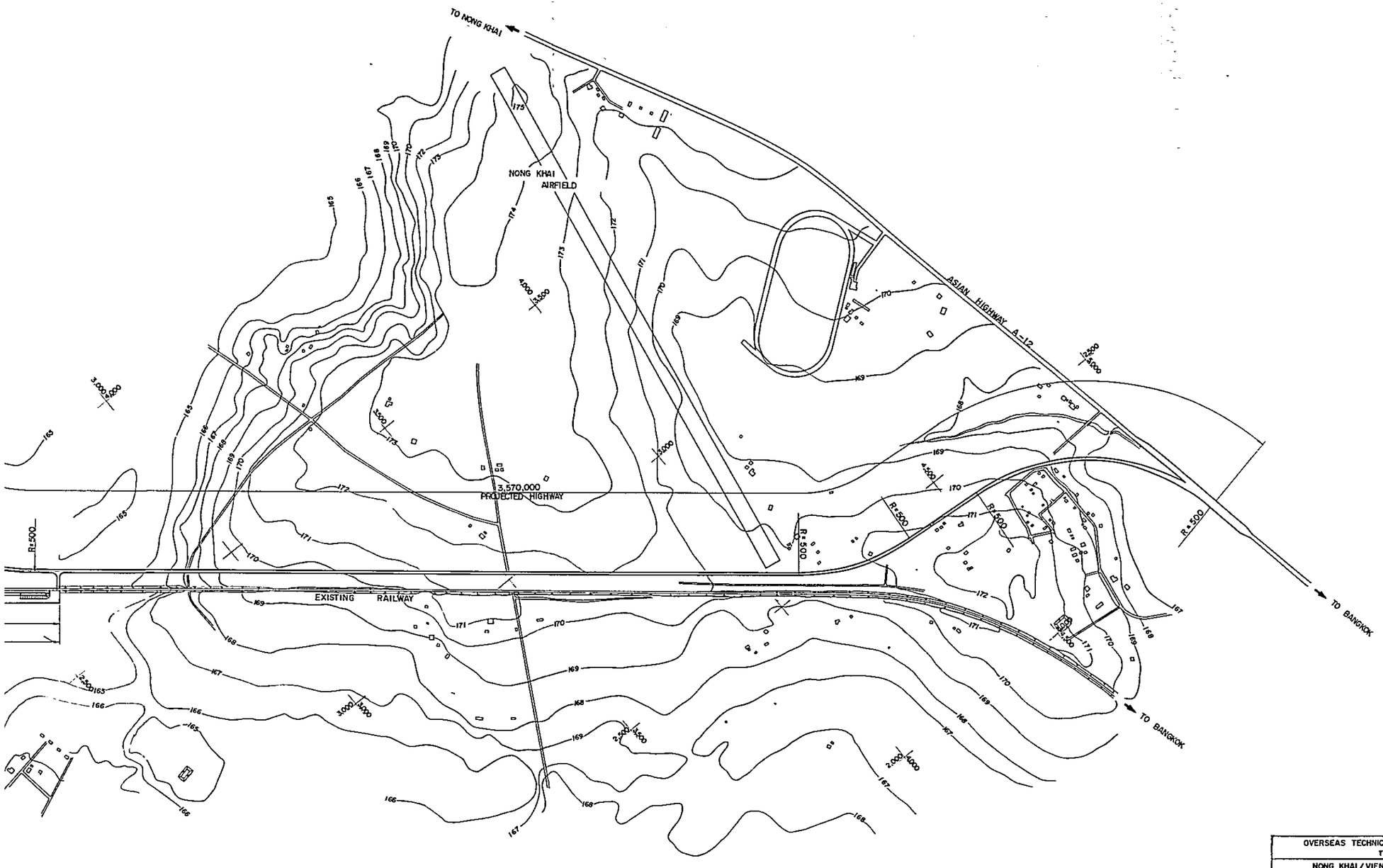
PLATE



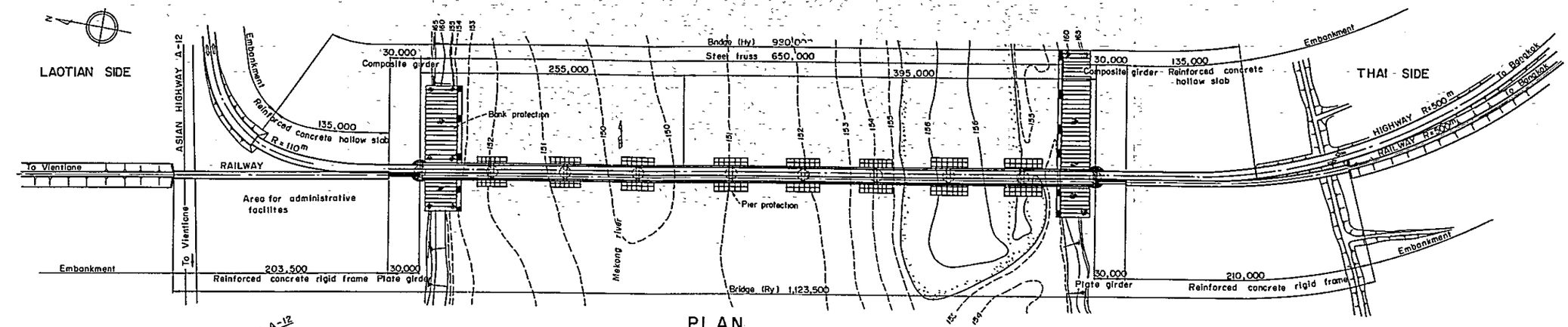
OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO, JAPAN	
NONG KHAI / VIENTIANE BRIDGE PROJECT	
GENERAL MAP	
NIPPON KOEI CO. LTD TOKYO (CONSULTING ENGINEERS)	
DRAWN T. Ito	DATE Sep 8, 1969.
CHECKED Y. Tokunaga	
SUBMITTED	PLATE I
APPROVED	



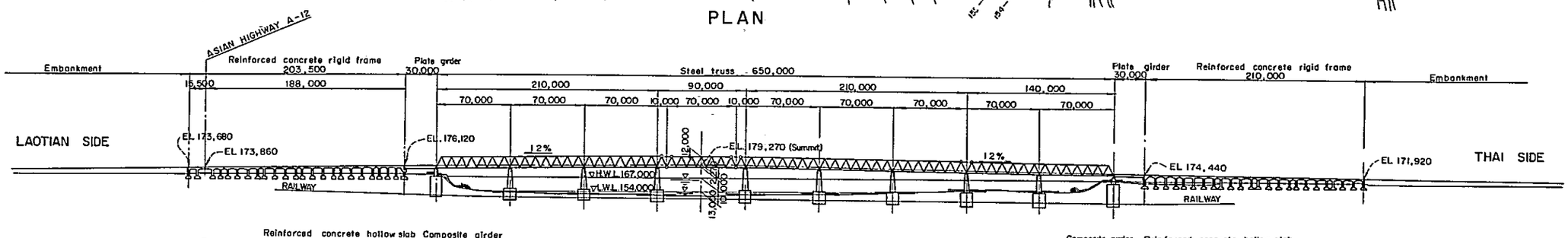
TO VIENTIANE
TO THA DEUA
EXISTING FERRY FACILITY
N
EXISTING
NONG KHAI STATION
THAILAND
LAOS
MEKONG
To Vientiane Substation
PROJECTED RAILWAY
ASIAN HIGHWAY A-12
PROJECTED HIGHWAY
ADMINISTRATIVE FACILITIES
BRIDGE (Ry)
Bank protection
Summit
350,000
ADMINISTRATIVE FACILITIES
751,700
NONG KHAI RAILWAY STATION
1,581,700
PROJECTED RAILWAY
NAM NGUM PROJECT TRANSMISSION LINE
TO VIENTIANE
To Nong Khai Substation
SCALE
0 100 200 300 400 500M

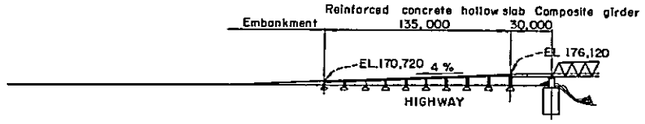


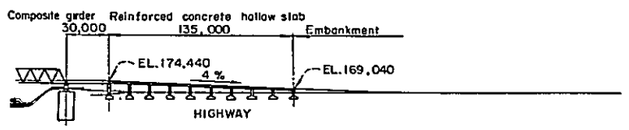
OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO, JAPAN	
NONG KHAI / VIENTIANE BRIDGE PROJECT	
GENERAL LAYOUT	
NIPPON KOEI CO. LTD TOKYO (CONSULTING ENGINEERS)	
DRAWN	DATE Sep 8, 1969
CHECKED	
SUBMITTED	
APPROVED	PLATE 2



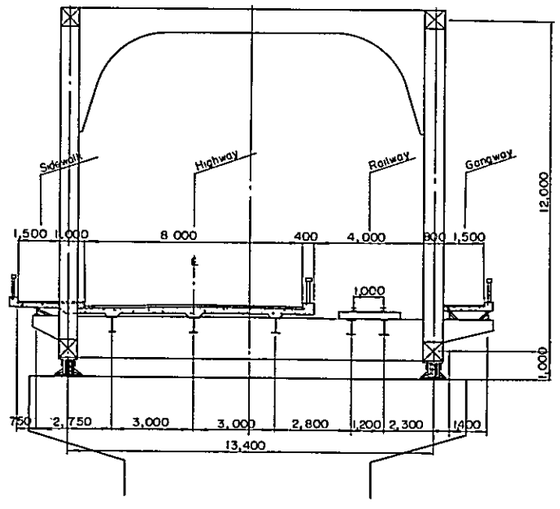
PLAN



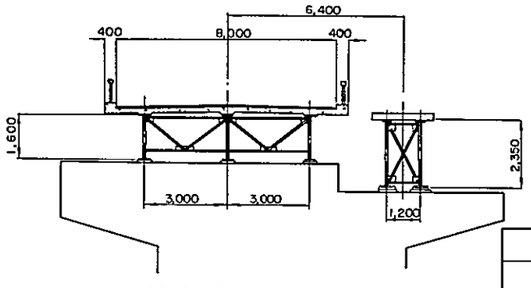




PROFILE



STEEL TRUSS PART

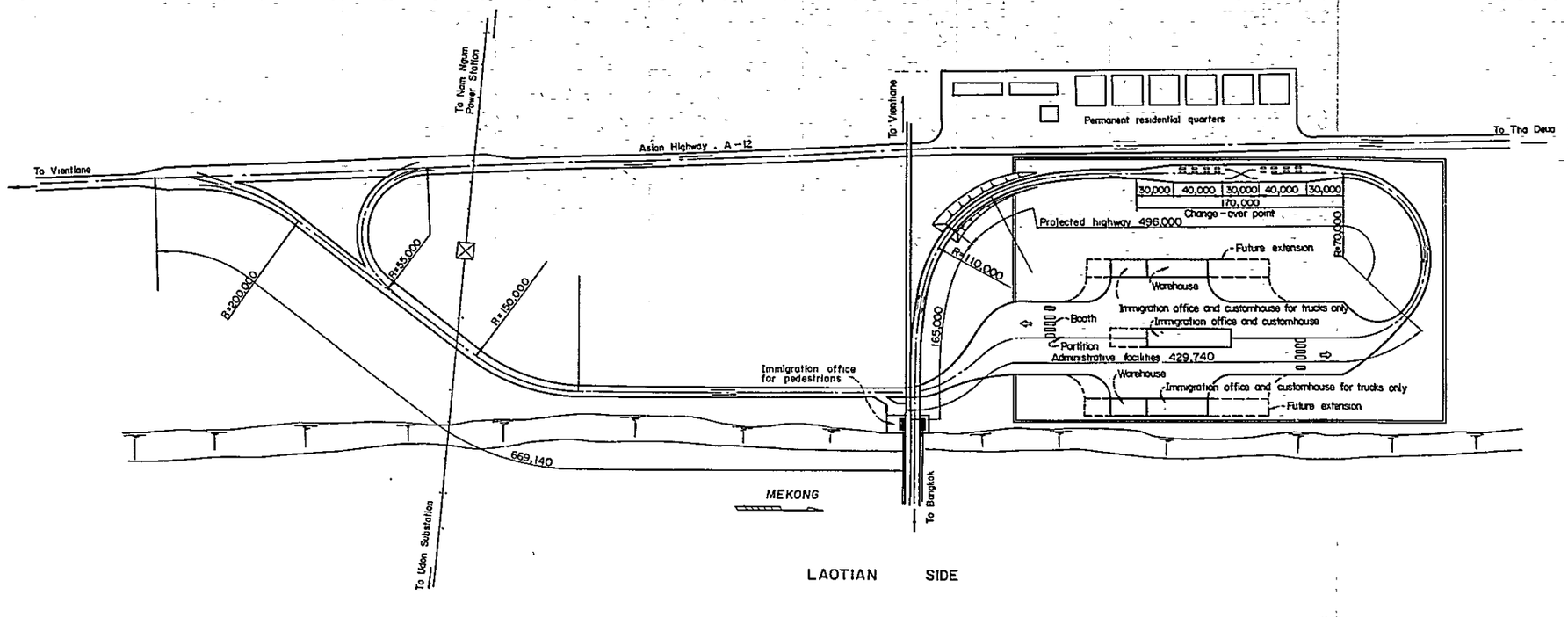


COMPOSITE GIRDER AND PLATE GIRDER PARTS

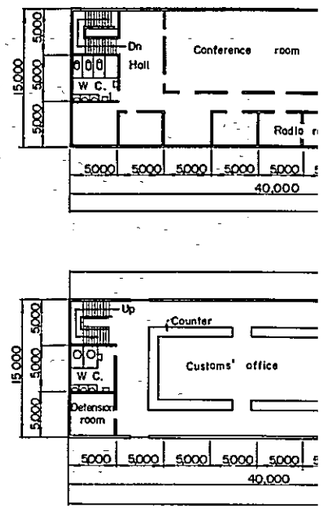
TYPICAL CROSS SECTIONS

(View from the Laotian side)

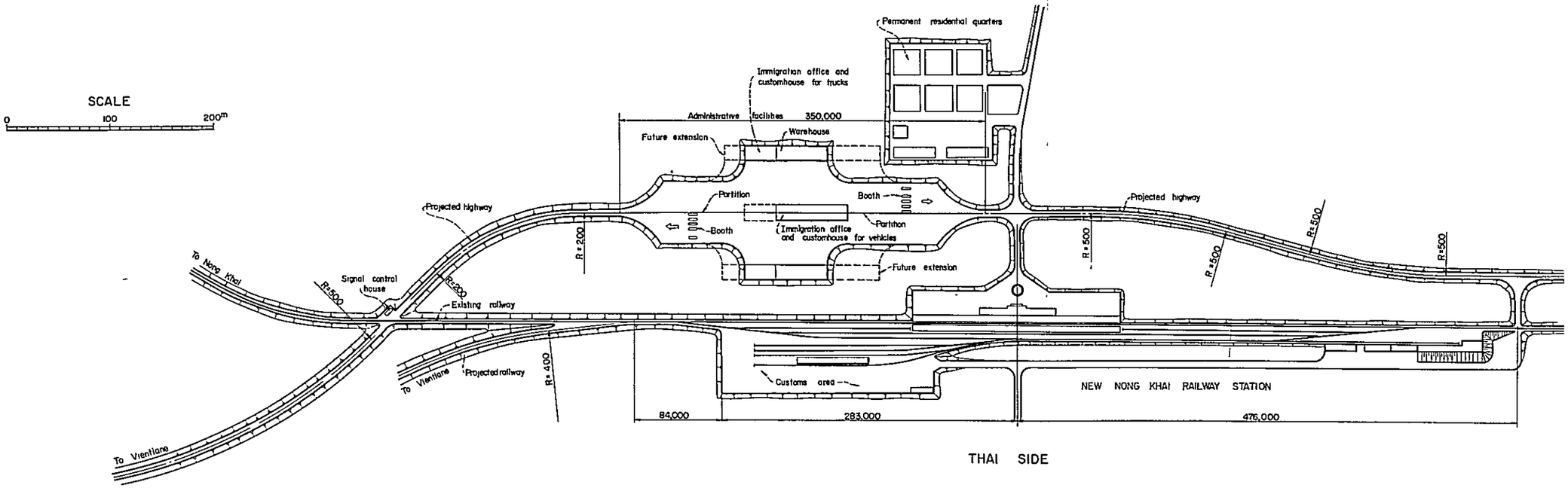
OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO, JAPAN	
NONG KHAI / VIENTIANE BRIDGE PROJECT	
BRIDGE: PLAN PROFILE AND TYPICAL CROSS SECTIONS	
NIPPON KOEI CO., LTD TOKYO (CONSULTING ENGINEERS)	
DRAWN T. Ito	DATE Sep. 8., 1969
CHECKED Y. Tokuda	
SUBMITTED Y. Omura	PLATE 3
APPROVED K. Yoshida	



LAOTIAN SIDE

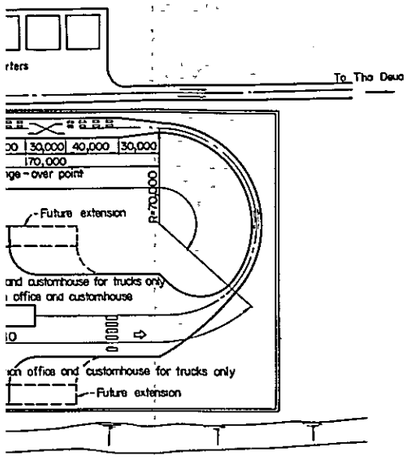


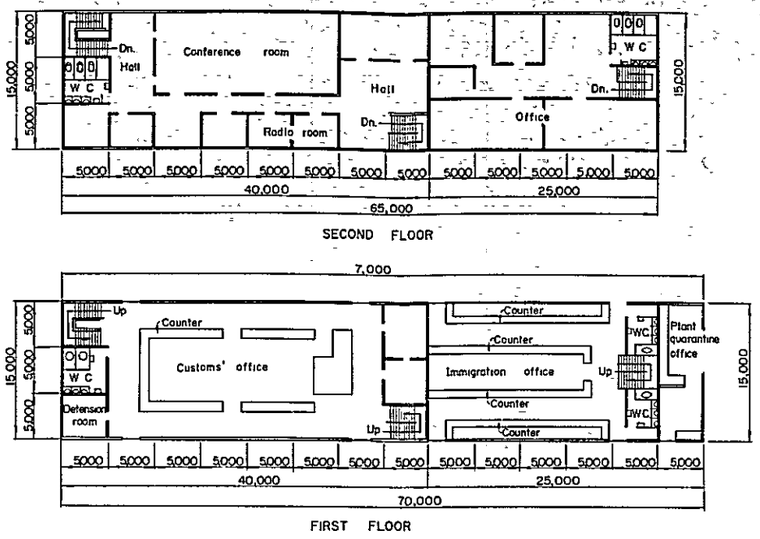
FOR VEHIC



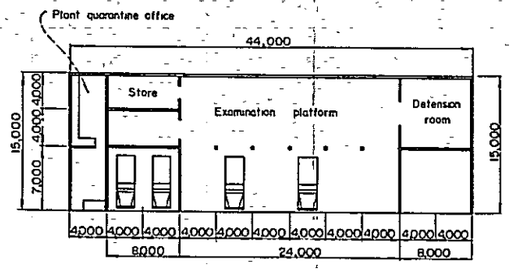
THAI SIDE

ADMINISTRATIVE FACILITIES





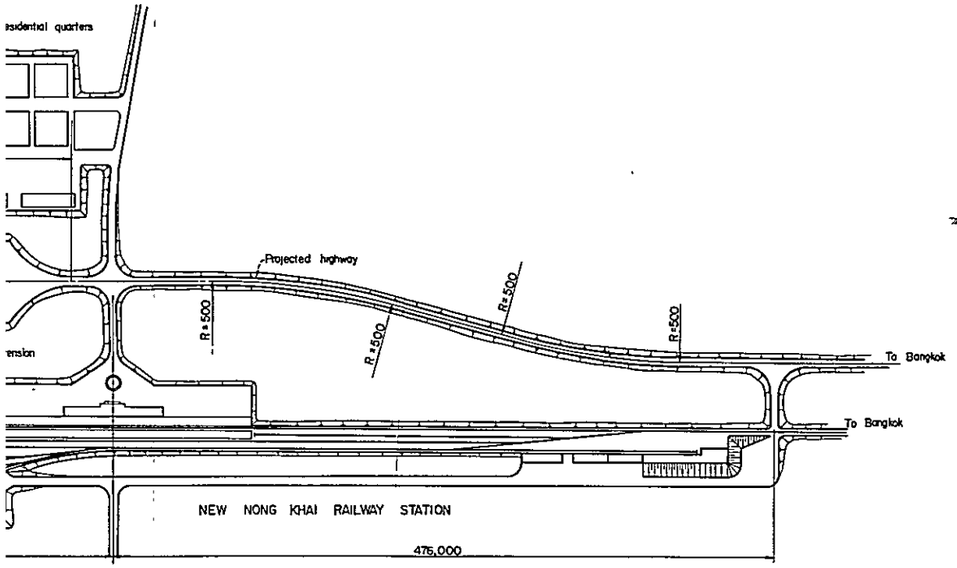
FOR VEHICLES EXCLUDING TRUCKS



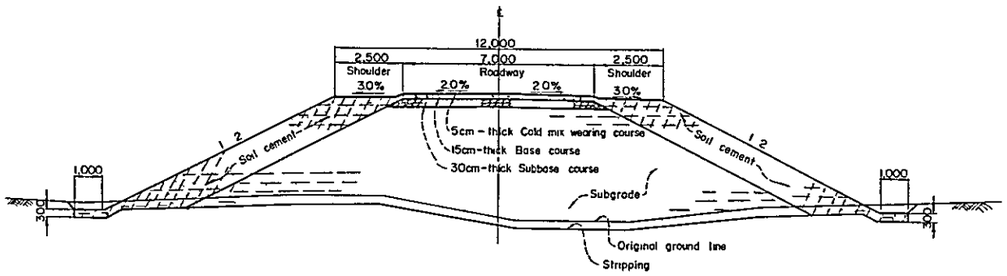
FOR TRUCKS ONLY

SCALE 0 10 20m

IMMIGRATION OFFICE AND CUSTOMHOUSE



THAI SIDE

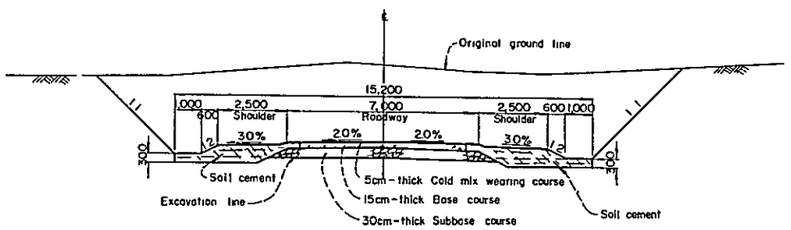


BANKING

Remarks Each embankment layer shall be so provided as to obtain the value of C B R shown in the following

(1)	Base course	80 to 90 (%)
(2)	Subbase course	20 to 30 (〃)
(3)	Subgrade	5 to 10 (〃)

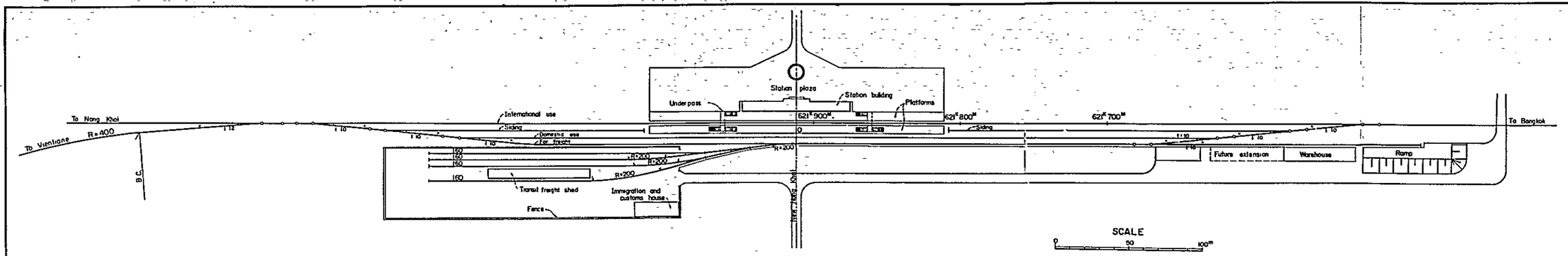
SCALE 0 5 10m



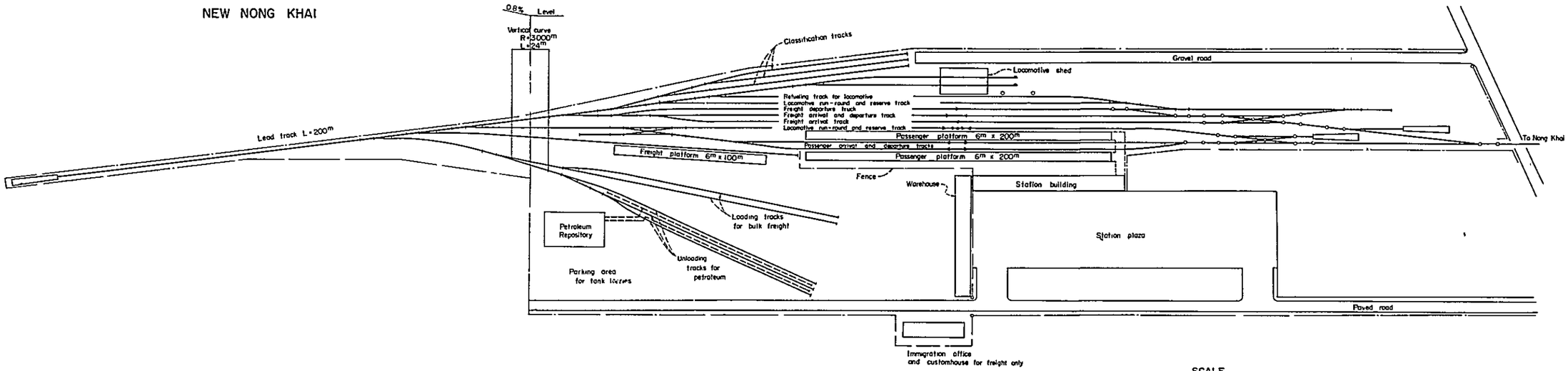
CUTTING

TYPICAL CROSS SECTIONS OF HIGHWAY

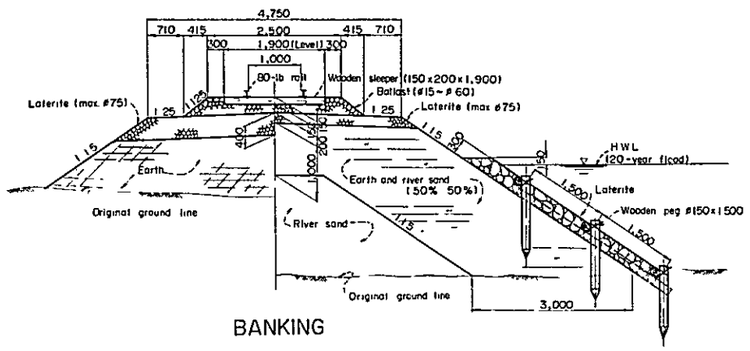
OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO, JAPAN	
NONG KHAI / VIENTIANE - BRIDGE PROJECT HIGHWAY : ADMINISTRATIVE FACILITIES AND TYPICAL CROSS SECTIONS	
NIPPON KOEI CO., LTD TOKYO (CONSULTING ENGINEERS)	
DRAWN T. Ito CHECKED Y. Tokuhiga SUBMITTED Y. Ohmi APPROVED R. Iyoshida	DATE Sep 8, 1969 PLATE 4



LAYOUT OF NEW NONG KHAI STATION



LAYOUT OF VIENTIANE STATION

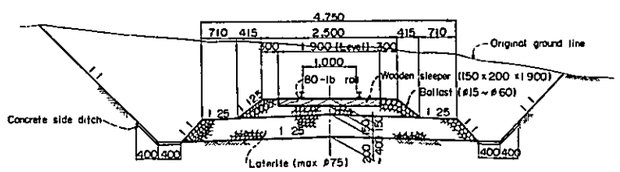


BANKING

Remarks

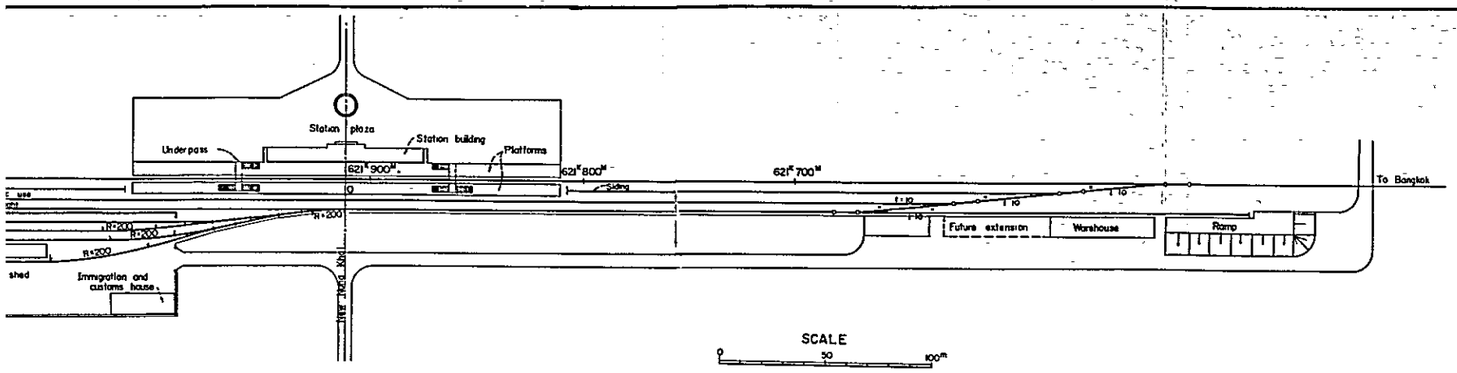
The embankment shall be so compacted as to obtain more than ten percent of the value of CBR

SCALE
0 1 2 3m



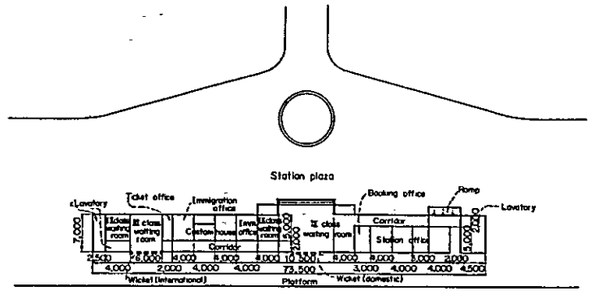
CUTTING

TYPICAL CROSS SECTIONS OF RAILWAY



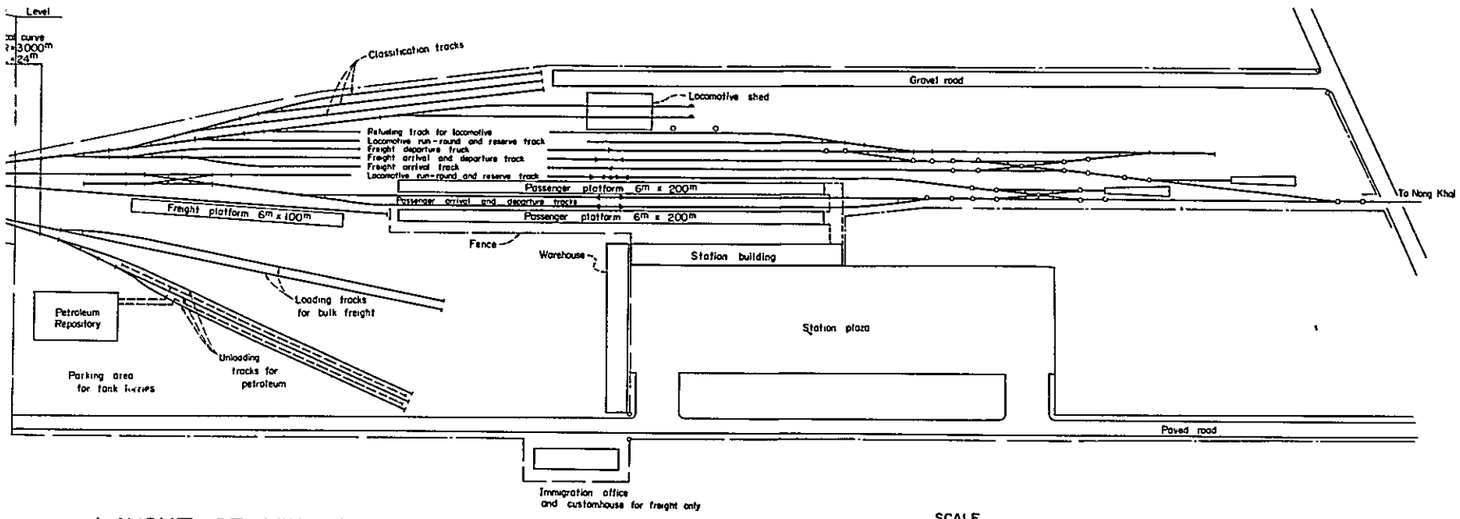
SCALE 0 50 100m

LAYOUT OF NEW NONG KHAI STATION



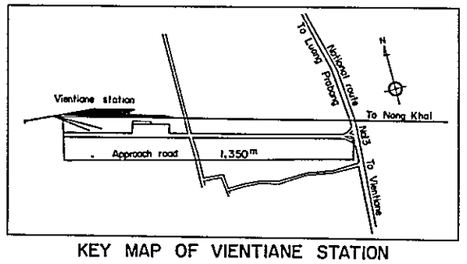
SCALE 0 10 20m

STATION BUILDING

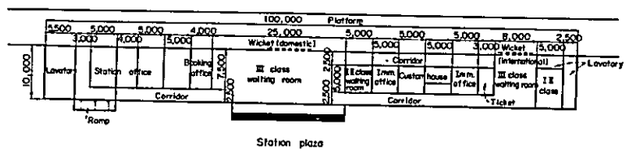


SCALE 0 50 100m

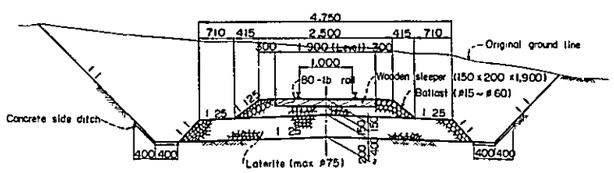
LAYOUT OF VIENTIANE STATION



KEY MAP OF VIENTIANE STATION



STATION BUILDING SCALE 0 10 20m



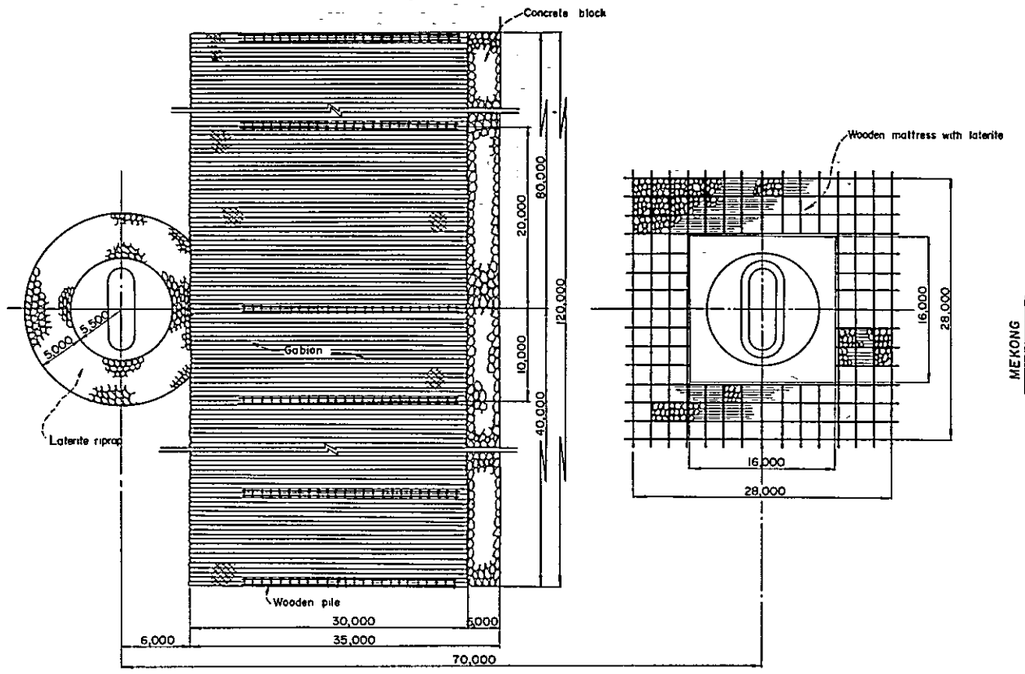
CUTTING

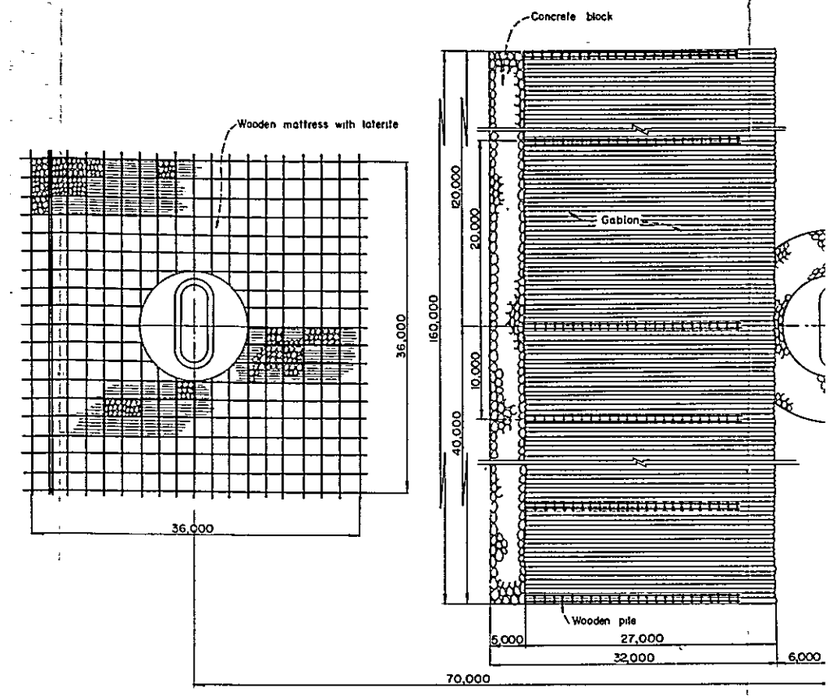
Remarks
The embankment shall be so compacted as to obtain more than ten percent of the value of CBR

SCALE 0 1 2 3m

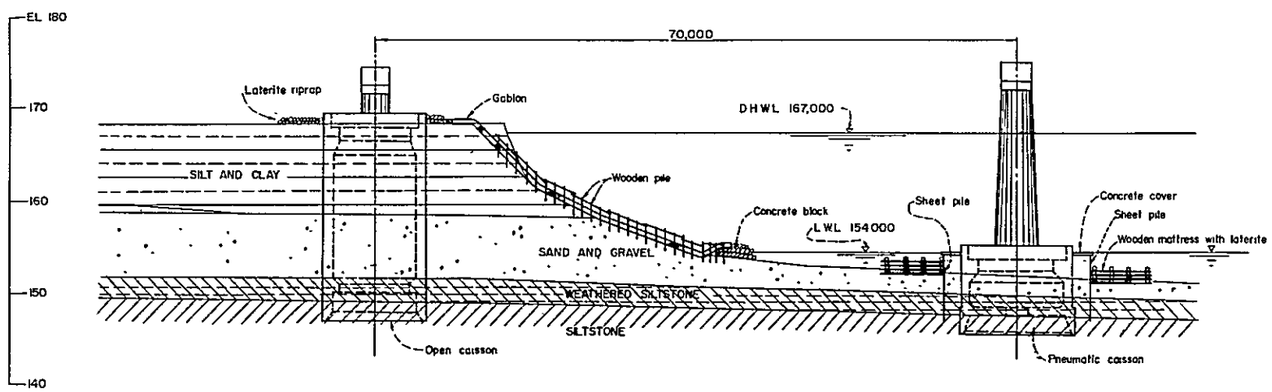
TYPICAL CROSS SECTIONS OF RAILWAY

OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO, JAPAN	
NONG KHAI / VIENTIANE BRIDGE PROJECT	
RAILWAY · STATIONS AND TYPICAL CROSS SECTIONS	
NIPPON KOEI CO, LTD TOKYO (CONSULTING ENGINEERS)	
DRAWN T. [illegible]	DATE Sep 8, 1969
CHECKED Y. Tokuriga	
SUBMITTED [illegible]	PLATE 5
APPROVED R. Yoshino	

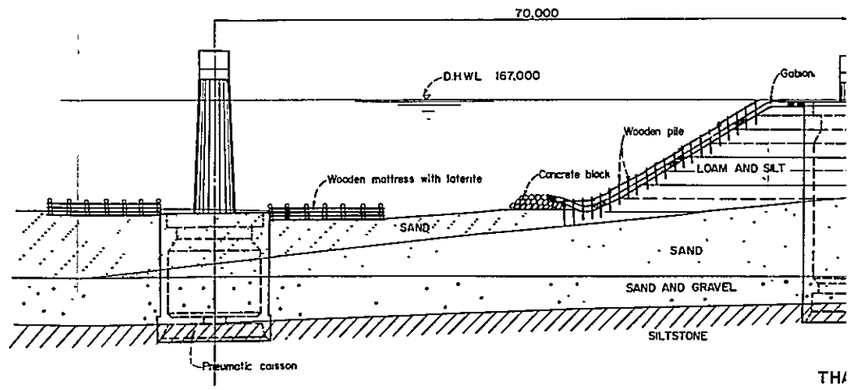




PLAN

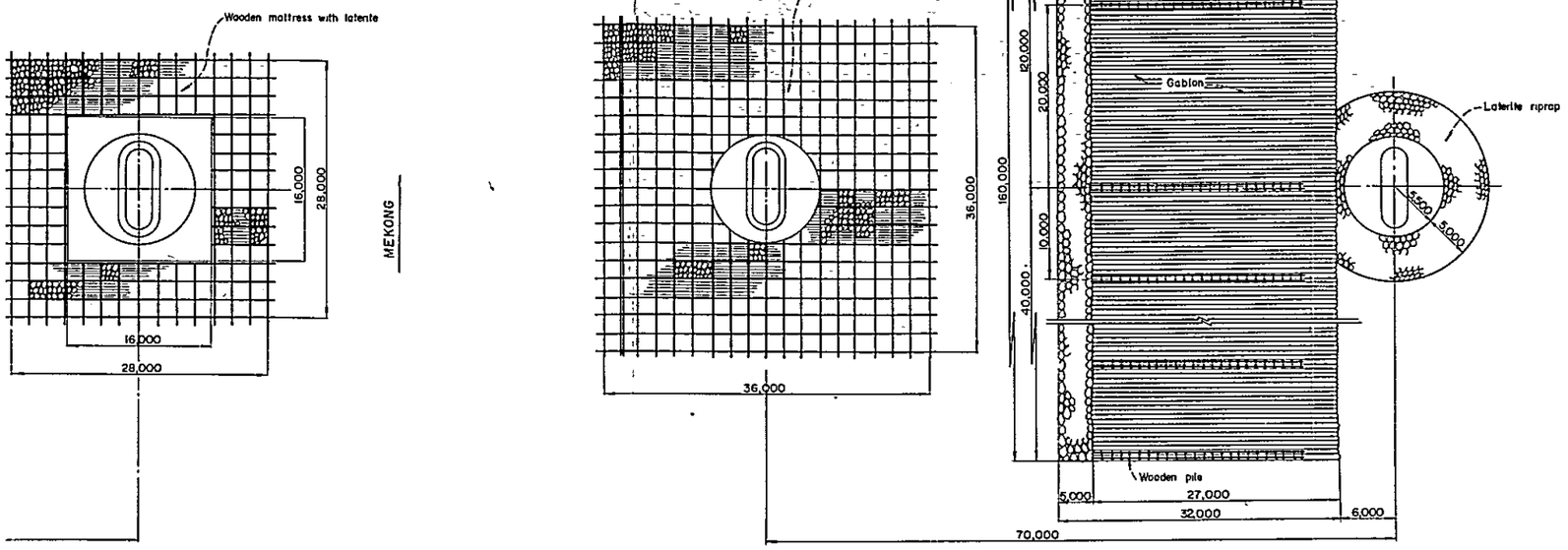


LAOTIAN SIDE

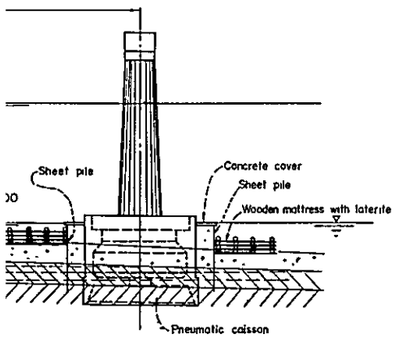


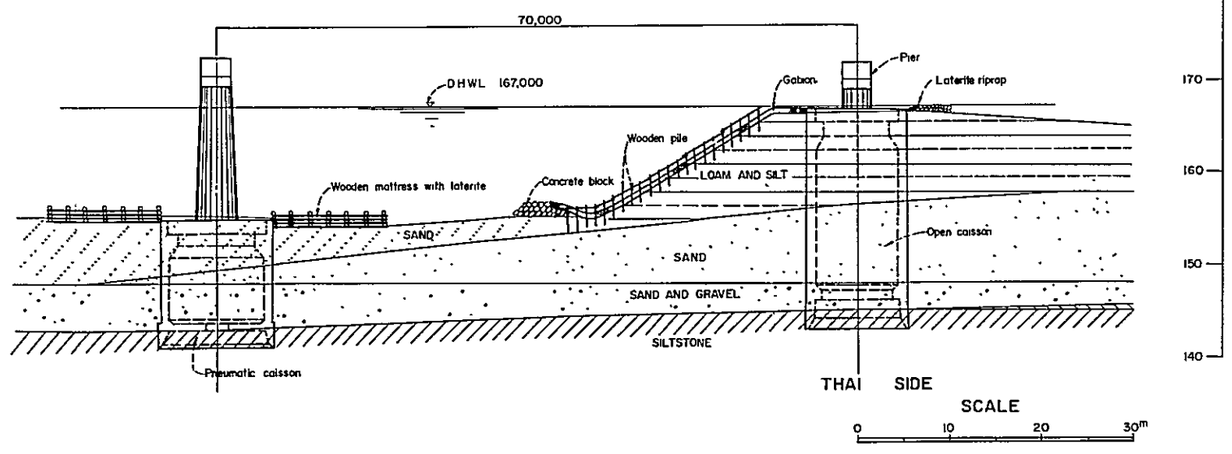
THA

PROFILE



PLAN





PROFILE

OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO, JAPAN	
NONG KHAI / VIENTIANE BRIDGE PROJECT	
BRIDGE : PIER AND BANK PROTECTIONS	
NIPPON KOEI CO., LTD TOKYO (CONSULTING ENGINEERS)	
DRAWN T. Ito	DATE Sep 8, 1969
CHECKED H. Tokuhiro	
SUBMITTED H. Inoue	PLATE 6
APPROVED K. Yoshida