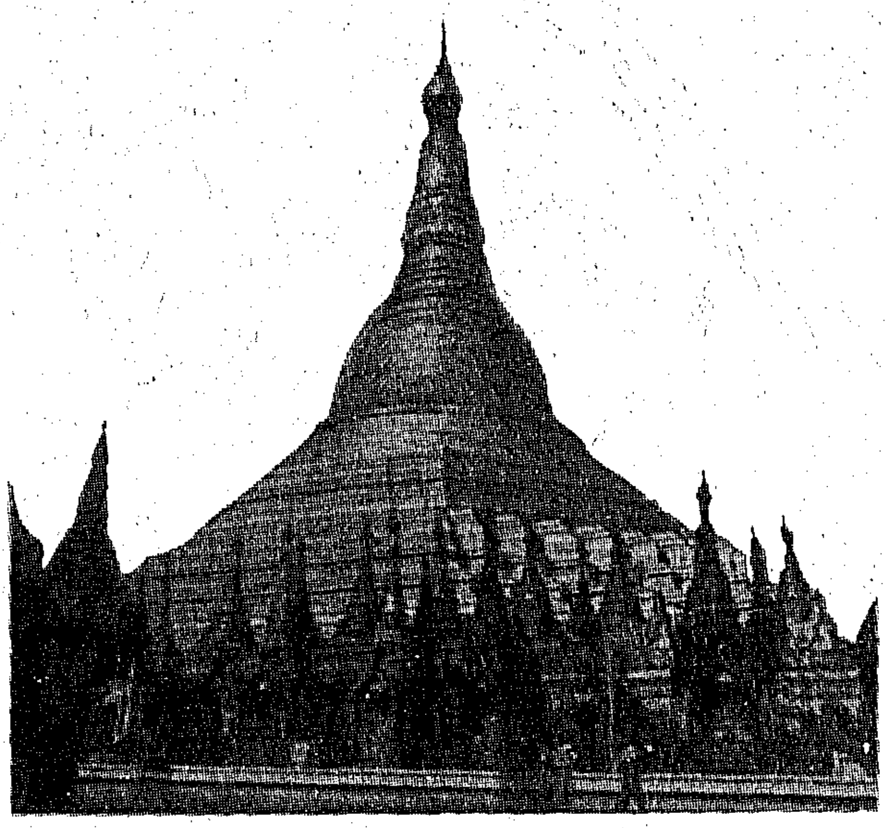
THE SOCIALIST REPUBLIC OF THE UNION OF BURMA

# FINAL REPORT OF FEASIBILITY STUDY
# FOR
# IRRAWADDY RIVER BRIDGE
# CONSTRUCTION PROJECT



NOVEMBER, 1975

JAPAN INTERNATIONAL COOPERATION AGENCY

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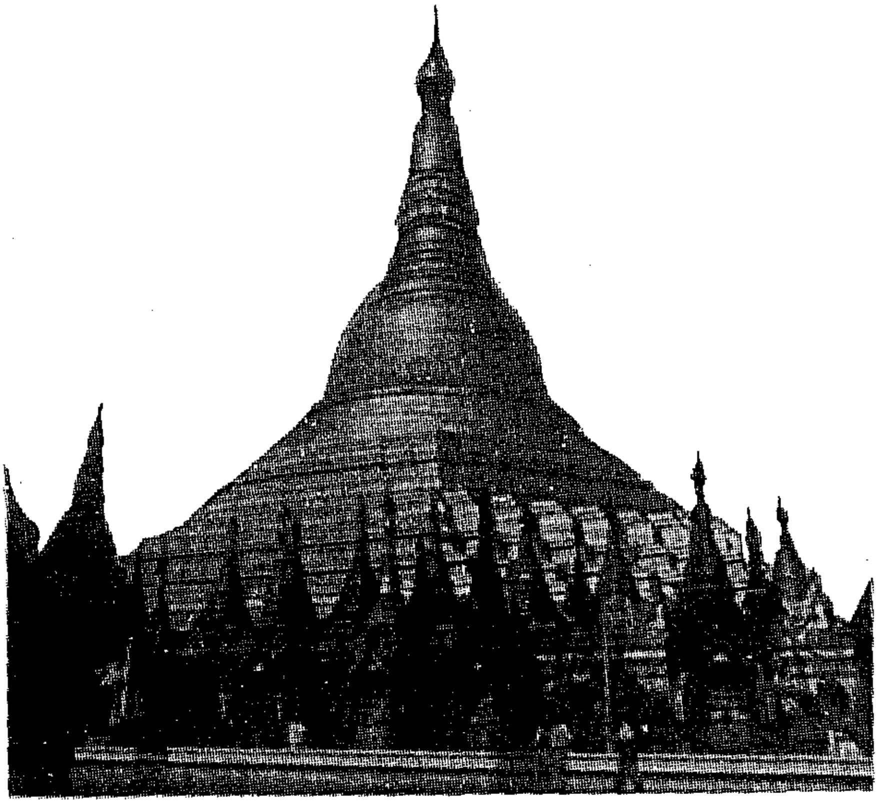
# FINAL REPORT OF FEASIBILITY STUDY FOR IRRAWADDY RIVER BRIDGE CONSTRUCTION PROJECT



NOVEMBER, 1975

JAPAN INTERNATIONAL COOPERATION AGENCY

# PREFACE

The Government of Japan, in response to the request of the Socialist Republic of the Union of Burma, decided to conduct a feasibility study on the Irrawaddy River Bridge Construction Project and Japan International Cooperation Agency carried out this study.

The Agency organized and dispatched a survey team consisting of experts in bridge engineering, railway engineering, highway engineering, transportation economics and regional economics in February, 1974, in the recognition that the construction of the Irrawaddy River Bridge would have a great influence on the social and economic development of the Socialist Republic of the Union of Burma.

The field survey in Burma was carried out very smoothly due to the all-out cooperation of the Burmese Government authorities concerned. The interim report and the draft final report were prepared and explained in Burma in December 1974, and September,1975, respectively. They were reviewed and re-examined carefully in Japan and this report is now submitted as a final outcome of the study.

This report includes route selection, traffic demand estimation, preliminary engineering, economic evaluation and the result of the technical and economic feasibility of the construction of this highway-railway bridge project which was planned for the purpose of the development of the west region of the River Irrawaddy Mid-Stream.

I sincerely hope that this report would contribute to the progress of this project in future and promote friendly relations between Japan and Burma.

Finally, I would like to express my deep appreciation to all the staff who participated in this study and also to express my heatfelt gratitude to the authorities concerned in the Socialist Republic of the Union of Burma.

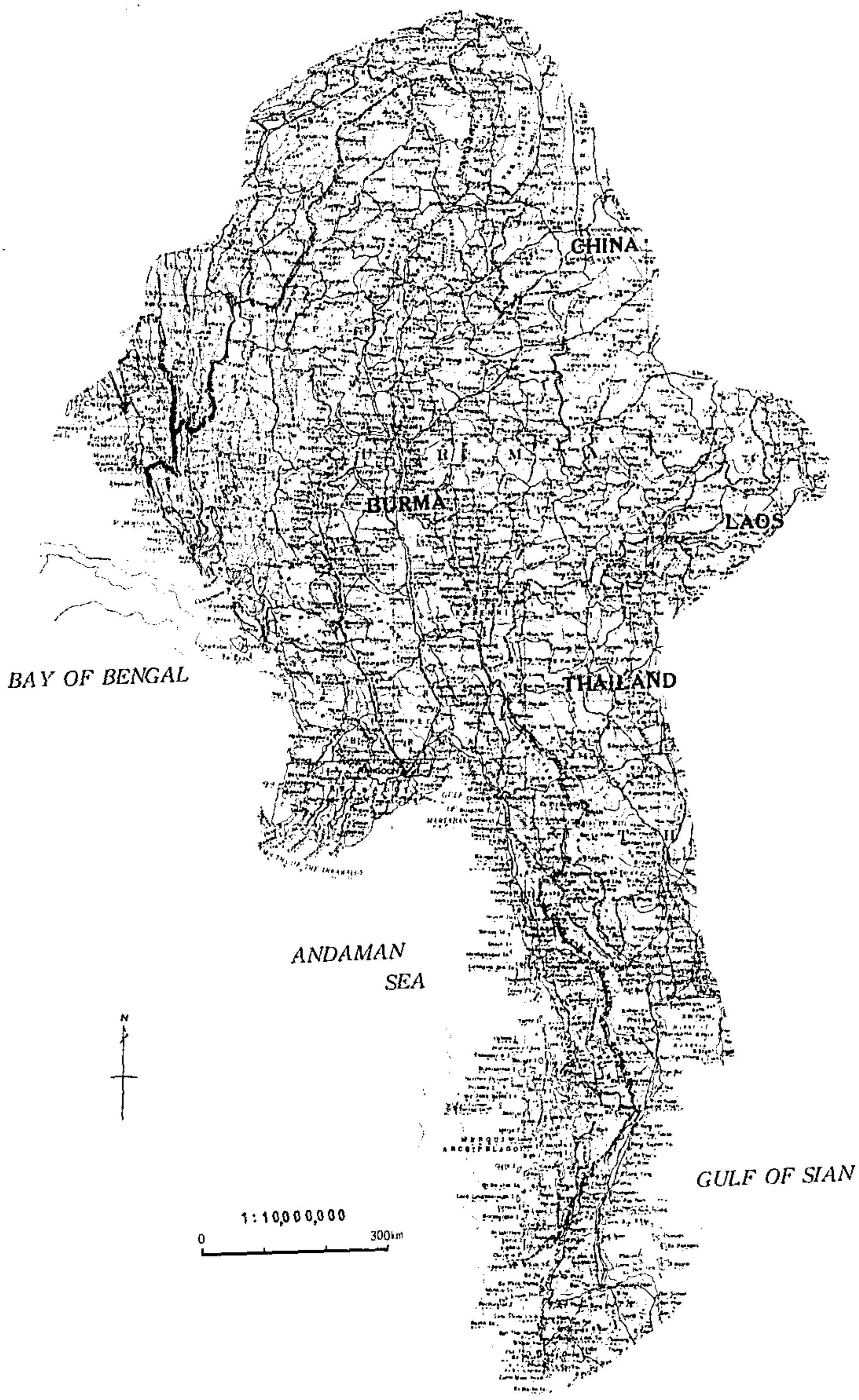
Shinsaku Hogen

November , 1975

President

Japan International Cooperation Agency

# Map of Burma


CHINA
BURMA
LAOS
THAILAND
BAY OF BENGAL
ANDAMAN SEA
GULF OF SIAN
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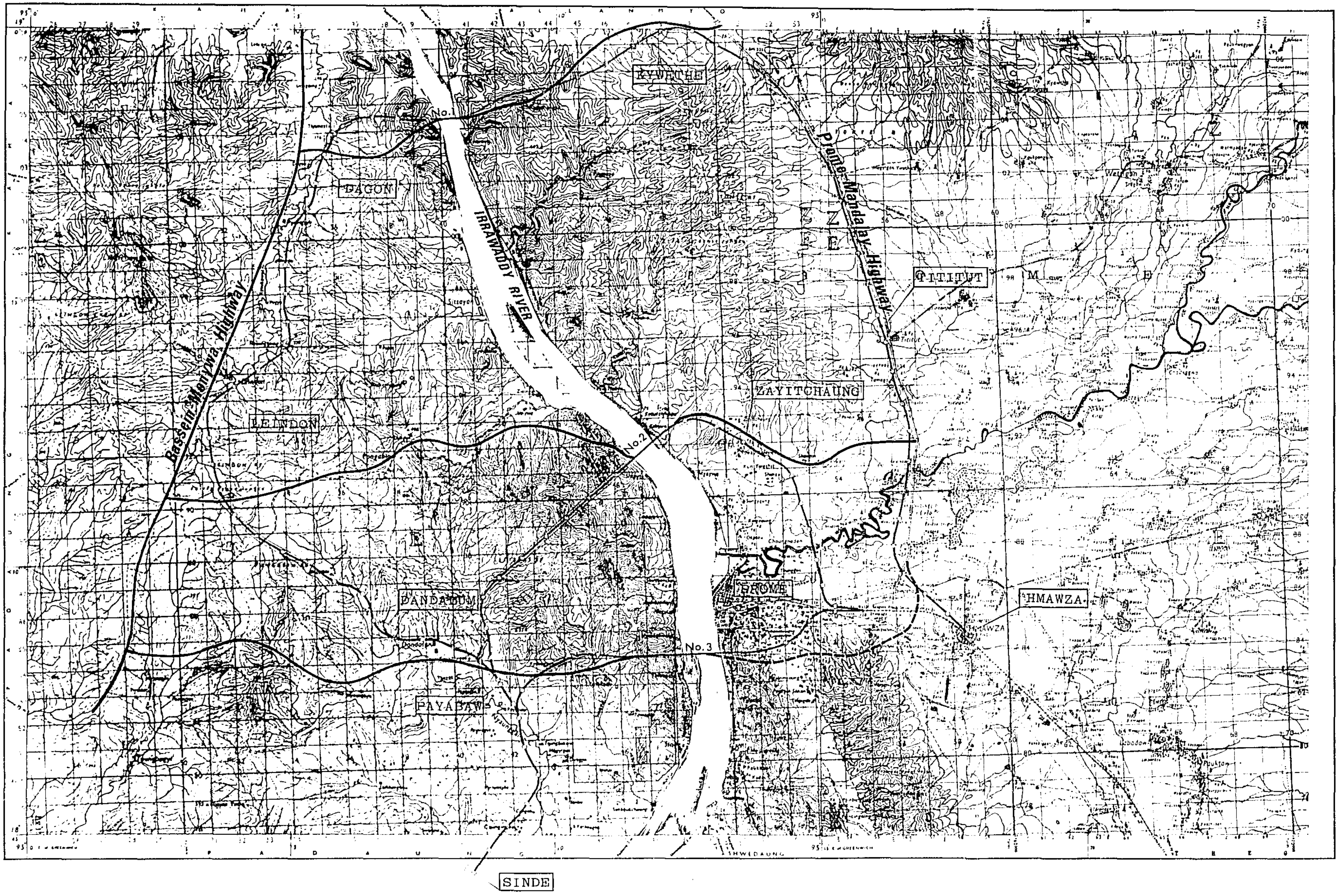
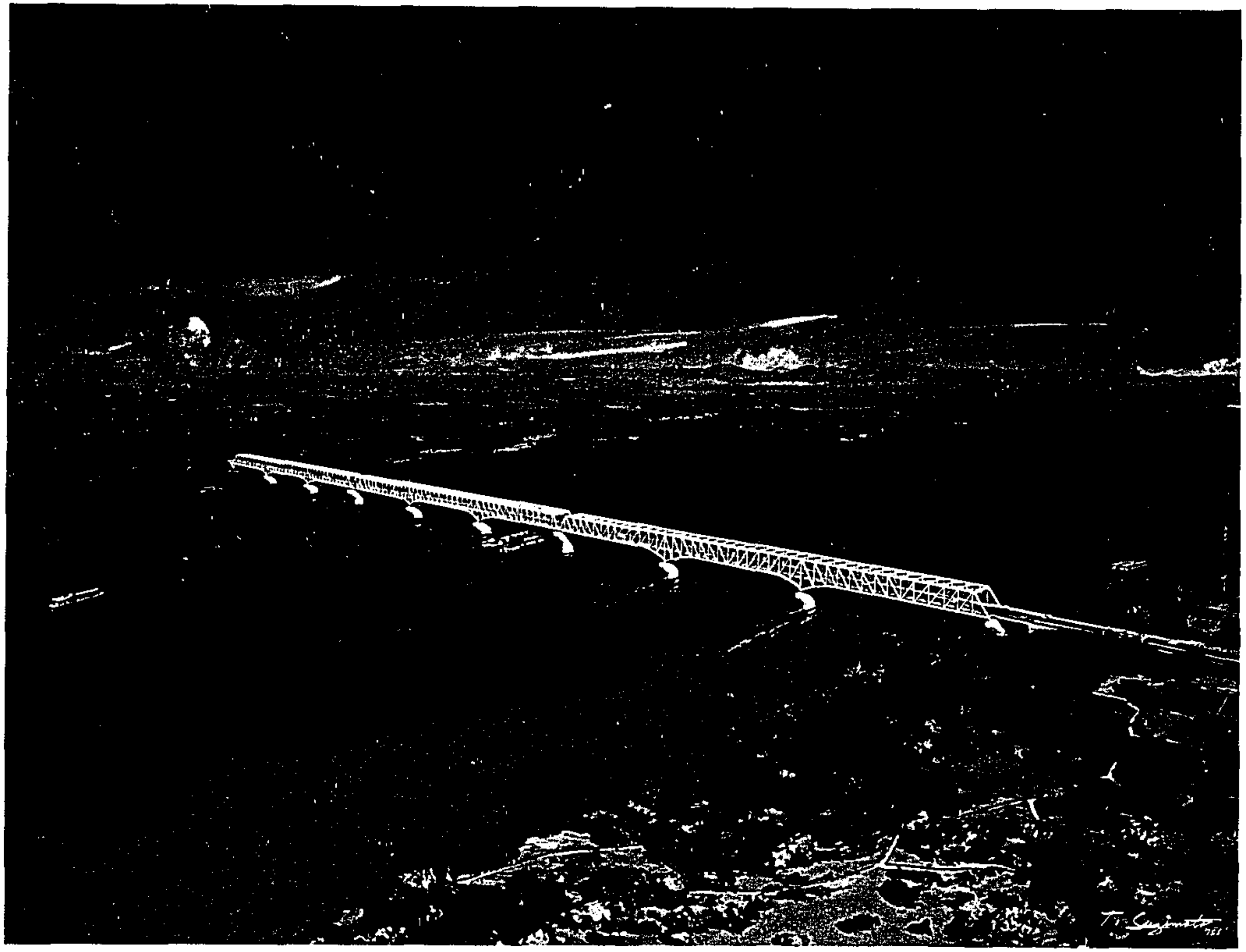
300km

# Project Location Map





Proposed Irrawaddy River Bridge at Site NO.3

# SUMMARY,CONCLUSION AND RECOMMENDATION

# SUMMARY, CONCLUSION AND RECOMMENDATION

## 1. Summary

In the selection of one railway-highway bridge site out of the three sites proposed by the Burmese Government (hereinafter the upper, middle and lower sites along the Irrawaddy are referred to as Sites No.1, No.2 and No.3, respectively), economic analysis on this Project was made on the basis of the engineering study.

In the engineering study, an alignment of the access railway connecting the existing Prome Line with Sinde was studied at each site, considering its extension to Kyangin. Once an alignment of access railway was selected, engineering study on the railway-highway bridge was carried out, taking account of soil and hydrologic conditions. At the same time the access road was designed considering the future highway plans.

Although there were many questions, criticisms and discussions on the design standards requested by the Burmese Government, the following design criteria were approved as a general rule:

### (1) Bridge

(a) The AASHO Specifications shall be applied to the design of highway bridge. The live load consists of HS20-44 and pedestrians.

(b) Loading of trailer-track carrying a heavy equipment (total weight 60t) shall be considered in the design of floor system and/or deck slab.

(c) The live load for railway-highway bridge shall consist of the live load specified for highway bridge and the applied moving load of trains specified by the Indian Ministry of Railways (Standard Gauge M.L.). The amount of impact allowance shall be taken into account.

(d) Minimum clear span length of 350 ft shall be maintained except for the both end approach spans.

(e) Minimum clearnace above design high water level shall be 55 ft.

(f) The fundamental seismic coefficient shall be assumed to be 0.12. Considering the unfavourable effect of the height of pier, the design seismic coefficient shall be increased by 25% at 150% of the basic unit stress.

(2) Railway

(a) The railway standard for the Prome Line shall be applied for the access railway as well as the new railway between Kyangin and Sinde.

(b) Track gauge is 1.00 m.

(c) Minimum curve radius shall be 300 m.

(d) Maximum gradient shall be 5 in 1,000.

(3) Access road 80 Km/hr

(a) Design speed of 80 km/hr is adopted.

(b) Two lanes of 3.6 m each and two shoulders of 2.4 m. each at both sides shall be provided.

(c) Radius of a horizontal curve shall be greater than 500 m.

(d) Gradient shall be less than 4 percent.

In the engineering study, a number of possibilities were put under study and the following engineering features were obtained.

| | Site No. 1 | Site No. 2 | Site No. 3 |
|---|---|---|---|
| Bridge Length (km) (Over the Irrawaddy) | 0.72 | 1.07 | 1.25 |
| Access Railway (km) | 70.2 | 30.8 | 20.0 |
| Access Road (km) | 14.2 | 26.4 | 23.7 |
| Length of Railway between Kyangin and Sinde: about 74 km | | | |

The total construction cost of this Project, including railway-highway bridge, access railway and road, was estimated on the basis of the exchange rates between Japanese Yen, Burmese Kyat and US Dollar being set at 308 and 4.81 in one, respectively, as of 1974. The results are shown in the following table.

Total Construction Cost

| Case | Steel Bridge | | | P.C. Bridge | | |
|---|---|---|---|---|---|---|
| Currency | Local | Foreign | Total | Local | Foreign | Total |
| Site No.1 | 183.7 | 396.0<br>(82.3) | 579.7 | 204.4 | 440.4<br>(91.6) | 644.8 |
| Site No.2 | 161.8 | 403.6<br>(83.9) | 565.4 | 191.9 | 468.1<br>(97.3) | 660.0 |
| Site No.3 | 148.2 | 390.4<br>(81.2) | 538.6 | 171.9 | 427.6<br>(88.9) | 599.5 |

Note:
1) Unit: 1,000,000 Kyats
2) Figure in parenthesis represents equivalent of U.S. Dollar in $1,000,000.
3) The total construction cost was calculated on the basis of combining the following items.
    a) Direct construction cost with 15% surcharge for administration fee
    b) Engineering fee estimated at 10% of item (a)
    c) Contingency estimated at 15% of the sum of items (a) and (b)

Under a stage construction program at Site No. 3, that is, construction of substructure, highway bridge superstructure and access road at the first stage, and construction of railway bridge superstructure supported on the previously constructed substructure and access railway at the second stage, the total construction cost was estimated as follows:

Total Construction Cost
(Stage Construction Programme at Site No. 3)

| | Substructure, High-way Bridge Superstruecture & Access Road | | | Railway Bridge Superstructure & Access Railway | | |
|---|---|---|---|---|---|---|
| Case | Currency | | | Currency | | |
| | Local | Foreign | Total | Local | Foreign | Total |
| Steel Bridge | 104.0 | 292.8<br>(60.9) | 396.8 | 47.3 | 110.7<br>(23.0) | 158.0 |
| P.C. Bridge | 134.6 | 373.1<br>(77.6) | 507.7 | 48.3 | 89.7<br>(18.6) | 138.0 |

Note 1) Unit: 1,000,000 Kyats

2) Figure in parenthesis represents equivalent of millions of U.S. Dollars.

On the basis of the field survey and the data supplied by the Burmese Government, the traffic forecast and the economic growth expected from the construction of the Irrawaddy Bridge were studied.

The analysis of future inter-regional flow of passengers and goods, passing over this Bridge made the following projection possible:

In view of the benefit derived from the completion of this Bridge, it was foreseen that Site No. 3 is the most beneficial, which is followed by Site No. 2. While, Site No. 1 is the least advantageous.

Therefore, Site No.3 is considered to be the most suitable one, provided that a railway-highway bridge is to be constructed. The economic analyses were made only for Site No.3.

The opening of the bridge to traffic was assumed to be in 1983 which is the possible earliest year from the technical point of view. However, the necessity of simultaneous opening of the highway bridge and the railway bridge would be doubtful and the most economical dates for opening the railway bridge and the highway bridge were analysed under a stage construction programme. The following three cases were studied to seek for the most suitable time lag.

Case 1: Railway-highway bridge is opened to traffic in 1983.

Case 2: Highway bridge is opened to traffic in 1983 and railway bridge in 1988.

Case 3: Highway bridge is opened to traffic in 1983 and railway bridge in 1993.

Though the construction of the railway between Kyangin and Sinde is fundamentally a separated project from this Project, an analysis was performed for the case where this railway is united with the Irrawaddy Bridge Project and for the cases where this railway construction will be completed in 1988 (case 2-2) and in 1993 (case 3-2).

In the study, only direct benefits which could be evaluated in terms of monetary value were estimated on the following items:

a) Benefit derived from diverted passenger traffic.

b) Benefit derived from generated passenger traffic.

c) Benefit derived from diverted goods traffic.

d) Benefit derived from generated goods traffic.

e) Benefit derived from diverted motor vehicle.

f) Operation cost saving of existing railway between Bessein and Kyangin.

g) Benefit derived from completion of railway between Kyangin and Sinde.

The results of overall analysis of cost and benefit carried out for Site No.3 could be summarised as follows:

1) Internal rates of return calculated under various combination of bridge types, different exchange rates and different cases of stage construction, are shown in the following table.

Internal Rate of Return

Unit: percent

| Exchange Rate | | Type<br>Case | Steel Bridge | P.C. Bridge |
|---|---|---|---|---|
| Official Rate | | 1 | 2.44 | 2.32 |
| | | 2 | 2.60 | 2.33 |
| | | 3 | 2.81 | 2.48 |
| | | 2-2 | 3.30 | 2.89 |
| | | 3-2 | 3.38 | 2.92 |
| Shadow Rate | 1.50 | 1 | 1.63 | 1.56 |
| | | 2 | 1.75 | 1.56 |
| | | 3 | 1.91 | 1.67 |
| | | 2-2 | 2.41 | 2.09 |
| | | 3-2 | 2.49 | 2.12 |
| | 1.75 | 1 | 1.36 | 1.31 |
| | | 2 | 1.46 | 1.31 |
| | | 3 | 1.62 | 1.41 |
| | | 2-2 | 2.07 | 1.74 |
| | | 3-2 | 2.15 | 1.76 |

2) On the whole, the economic effects are not so high in terms of the direct benefit.

3) The steel bridge is comparatively more beneficial than the prestressed concrete bridge.

4) Every 25 percent increase in the shadow rate over the official rate decreases the rate of cost and benefit by about 10%.

5) The simultaneous opening of the railway bridge and the highway bridge to the traffic is not advantageous, particularly in the case of the steel bridge.

6) On the assumption that the railway between Kyangin and Sinde will be constructed separately from this Project, the economic effects of this Project would become a little higher.

## 2. Conclusion and Recommendation

### 2.1 Conclusion

The following conclusions are based on the results of the feasibility study which are summarised in the previous chapter.

1) Site No.3 is the most suitable in respects of construction cost and benefit, provided a railway-highway bridge is constructed.

2) The steel bridge is more beneficial than the prestressed concrete bridge so far as the construction cost is concerned.

3) In this study, the social impact caused by the construction of this bridge was not evaluated in terms of monetary value. If only the direct benefit brought about by the realisation of this Project is considered, the economic effects could not be expected so high as compared with the necessary construction cost.

4) Even if this Project including the construction of railway between Kyangin and Sinde could be realised in the future, the simultaneous opening of railway bridge and highway bridge to the traffic is not advantageous in respect to the economic effects of investment.

5) Engineering study based on the design requirements, requested by the Burmese Government, shows that the construction of this bridge is quite possible from the technical point of view.

### 2.2 Recommendation

The following recommendations are presented on the basis of the overall results of this study.

1) The construction of this bridge is possible from the technical point of view. However, in order to reduce the construction cost of this Project, it would be desirable to reconsider the design standard concerning the loading, especially railway

loading and also the gradient and the construction gauge of railway.

2) According to the result of hydrological study, the river channel is considered to be rather stable at Site No.3 as compared with that of downstream from Sinde. Therefore, there would be not necessary to keep the minimum clearance of 55ft over the design high water level along the whole length of bridge satisfying navigability anywhere underneath the bridge. In the future study, it would be desirable to reconsider the possibility of reducing the clearance in some spans where navigation requirements are not necessary.

3) In order to reduce the direct construction cost, replacement of Japanese skilled labourers with Burmese ones which will result in prolongation of construction period is recommended.

4) Because of few valid master plans for industrial development in the direct influence area, there would be the possibility of underestimation of the benefits. Making these plans is duly recommendable.

5) Without limiting the Project to the construction of railway-highway bridge, the more reasonable transportation means across the Irrawaddy should be studied.

6) So far as the construction of railway-highway bridge is concerned, it is desirable to postpone the construction until the overall level of industrial development in the surrounding areas becomes higher. For the time being, the following transportation means across the Irrawaddy could be considered appropriate:
   a) Reinforcement of existing ferries
   b) Construction of highway bridge

   Further study on these problems would be recommended.

## REMARK

The official conversion rate of Burmese Kyat to SDR was devaluated by 25 percent on 25th January 1975. Therefore the construction cost, ratio of cost and benefit and internal rate of return were recalculated on the basis of the new rate. The results are shown in the following tables.

Total Construction Cost

Unit: 1,000,000 Kyats

| | In Case of Steel Bridge | In Case of P.C. Bridge |
|---|---|---|
| Site No. 1 | 696.6 | 774.9 |
| Site No. 2 | 684.5 | 798.2 |
| Site No. 3 | 653.9 | 725.8 |

Total Construction Cost in Case of Stage Construction Programme at Site No. 3

Unit: 1,000,000 Kyats

| | Substructure, Highway Bridge Superstructure & Access Road | Railway Bridge Superstructure & Access Railway |
|---|---|---|
| Steel Bridge | 483.2 | 190.7 |
| P.C. Bridge | 617.8 | 164.5 |

Ratio of Cost and Benefit, and Internal Rate of Return

| Type<br>Exchange Rate |  | Case | Steel Bridge |  | Prestressed Concrete Bridge |  |
|---|---|---|---|---|---|---|
|  |  |  | Ratio of cost and benefit (discount rate: 9%) | Internal rate of return (%) | Ratio of cost and benefit (discount rate: 9%) | Internal rate of return (%) |
| Official Rate |  | 1 | 0.210 | 1.82 | 0.195 | 1.80 |
|  |  | 2 | 0.231 | 2.01 | 0.201 | 1.80 |
|  |  | 3 | 0.252 | 2.21 | 0.212 | 1.92 |
|  |  | 2 - 2 | 0.275 | 2.71 | 0.231 | 2.32 |
|  |  | 3 - 2 | 0.282 | 2.80 | 0.232 | 2.35 |
| Shadow Rate | 1.50 | 1 | 0.157 | 1.19 | 0.146 | 1.15 |
|  |  | 2 | 0.173 | 1.27 | 0.150 | 1.15 |
|  |  | 3 | 0.188 | 1.42 | 0.158 | 1.24 |
|  |  | 2 - 2 | 0.204 | 1.79 | 0.171 | 1.55 |
|  |  | 3 - 2 | 0.209 | 1.86 | 0.172 | 1.60 |
|  | 1.75 | 1 | 0.140 | 0.94 | 0.130 | 0.93 |
|  |  | 2 | 0.154 | 1.02 | 0.133 | 0.93 |
|  |  | 3 | 0.167 | 1.16 | 0.141 | 1.01 |
|  |  | 2 - 2 | 0.181 | 1.49 | 0.152 | 1.30 |
|  |  | 3 - 2 | 0.186 | 1.55 | 0.153 | 1.32 |

# BACKGROUND OF PROJECT AND SEQUENCE OF STUDY

# BACKGROUND OF PROJECT AND SEQUENCE OF STUDY

The Government of the Socialist Republic of the Union of Burma had been thinking of constructing a railway-highway bridge at Prome for development of the regions west of the Irrawaddy, which was materialised in the Cabinet in 1973. The Burmese Government decided to request the Japanese Government to perform the feasibility study of the said project.

The Ministry of Foreign Affairs of the Burmese Government submitted a letter of request with the Application for Expert (A-1 Form) to the Embassy of Japan in Rangoon on February 20, 1973. The letter was immediately sent to the Japanese Government by H.E. T. Suzuki, Esq., the then Ambassador of Japan. The request of the Burmese Government was accepted by the Japanese Government. The Overseas Technical Cooperation Agency (OTCA, which has been renamed the "Japan International Cooperation Agency", JICA) has taken care of the implementation of the proposed study thereafter.

The OTCA despatched the Survey Team for preliminary study of this project in August 1973. The members of the team were:

| | | |
|---|---|---|
| Team Leader | Mr. Y. Miyazawa | |
| Member | Mr. F. Sagano | Transport Economist |
| do. | Mr. Y. Mogi | Railway Eng. |
| do. | Mr. M. Sasanuma | Highway Eng. |
| do. | Mr. M. Okawara | River Eng. |
| do. | Mr. M. Kiryu | Regional Economist |
| do. | Mr. T. Kitani | Survey Eng. |
| do. | Mr. K. Matsuoka | Coordinator |

They collected data, investigated the proposed sites and had meetings with the relevant Burmese officials for efficient execution of the feasibility study. They worked out the report in Japanese which was very useful for the forthcoming study.

The OTCA organised the Supervisory Committee for this project and the first meeting was held on November 19, 1973. The members of the Committee are:

| | | |
|---|---|---|
| Chairman | Mr. G. Yokoyama | |
| Member | Mr. T. Kawaguchi | |
| " | Mr. F. Sagano | |
| " | Mr. M. Sasanuma | (Lately succeeded by Mr. A. Komuro) |
| " | Mr. M. Kato | |
| " | Mr. M. Okahara | |
| " | Mr. Y. Kitani | (Lately succeeded by Mr. K. Sasanami) |
| " | Mr. M. Kiryu | |

The Supervisory Committee nominated the members of the Survey Team of Feasibility Study for this Project and the members of the Survey Team were appointed on January 7, 1974 by the OTCA. The members of the Survey Team are:

| | | |
|---|---|---|
| Team Leader | Dr. S. Inomata | |
| Deputy Team Leader | Mr. S. Tsukahara | Transport Economist |
| do. | Mr. H. Shima | Railway Eng. |
| Member | Mr. T. Nakauchi | Bridge Eng. |
| " | Mr. N. Tsuruta | " |
| " | Mr. S. Aikawa | Railway Eng. |
| " | Mr. M. Koyama | " |
| " | Mr. K. Yoshida | Highway Eng. |
| " | Mr. S. Onuma | Hydrologist |
| " | Mr. Y. Shirai | Construction Material Eng. |
| " | Mr. A. Asahi | Regional Economist |
| " | Mr. K. Suzuki | Soil Eng. |
| " | Mr. M. Watanabe | Boring Eng. |
| " | Mr. M. Sugimoto | Coordinator |

The Survey Team for the feasibility study was despatched to Burma on February 11, 1974. They stayed in Burma until the end of March though some of the members stayed shorter or longer. At the beginning of their stay they investigated the general situation of the proposed site and had several meetings with the Burmese officials to decide the design conditions with the further required studies. Some members of the Supervisory Group attended these earlier surveys and meetings, in which Messrs. Yokoyama, Kawaguchi, Kato, Kiryu and Sasanami were included. Many valuable instructions by way of advice have been given, for which the Survey Team would like to offer its sincere thanks.

The Burmese Supervisory Committee and the Burmese Survey Team were organised to cooperate with Japanese Team. The members were:

Supervisory Committee

| | |
|---|---|
| Chairman | U Aye Maung |
| Deputy Chairman | U Aye Pe |
| do. | U Myint Swe |
| Member | U Ba Yin |
| do. | U Than Aye |
| Secretary | U Sin Han |

Survey Team

| | | |
|---|---|---|
| Leader | Mr. C. X. de Souza | |
| Member | U Kyaw Myint | Railway Eng. |
| " | U Saw David | Bridge Eng. |
| " | U Sin Han | " |
| " | U Tin Ohn | Railway Eng. |
| " | U Kyi | Highway Eng. |
| " | Com. Khin Mg Myint | Hydrologist |
| " | Dr. Chit Aung | " |
| " | U Thein Nyunt | " |
| " | U Tun Zan Kyaw | " |

Survey Team (cont.)

| | | |
|---|---|---|
| Member | U Kyaw Zaw | Construction Material Eng. |
| " | U Shwe Tun Mg | Soil Eng. |
| " | U Than Aung | " |
| " | U Zaw Moe | " |
| " | U Tin Tun | Boring Eng. |
| " | U Aung Nyunt Hlaing | Surveyor |
| " | Cap. Win Myint | " |
| " | U Nyunt | Coordinator |
| " | U Tin Htwe | " |
| " | Daw Mya Mya Kyi | Economist |

Each member of the two Burmese organizations carried out the required investigations and collection of the necessary data with Japanese Team. Without their appropriate advice and assistance the Survey Team would not have made such fruitful investigations. The Japanese Team wishes to express its heartfelt gratitude to them and to their assistants.

On their return to Japan, the members of the Survey Team made the Interim Report with frequent meetings between the Survey Team and Supervisory Committee. The Burmese important officers and engineers including U Aye Maung, U Kyaw Myint, U Saw David and U Sin Han were invited to Japan by the OTCA. They arrived in Tokyo on June 26, 1974. U Aye Maung stayed in Japan for about a month and the other three gentlemen for about two months. They visited major bridge construction sites and factories. During their stay in Tokyo several conferences on the Irrawaddy Bridge were held with attendance of the members of the Survey Team and Supervisory Committee.

The Interim Report was completed at the beginning of November and was submitted to the Burmese Government immediately thereafter. The Japanese Delegation for explaining the Interim Report was organised by the JICA (the succeeding organization to OTCA) and despatched to Rangoon on December, 1974. The members were Messrs. Yokoyama, Kiryu and Komuro from the Supervisory Group; Messrs. Inomata, Shima, Nakauchi and Asahi from the Survey Team; and Mr. Matsuoka from the JICA. They explained the contents of the Interim Report and discussed important issues with the Burmese officials concerned to dicide the various matters relative to the Final Report. The conferences were held from 3 through 6 of December, 1974 and the Record of Discussion was signed by U Any Maung, Chairman of the Burmese Supervisory Committee, and Dr. Inomata, Team Leader of the Survey Team, at the last conference held in the afternoon of December 6, 1974.

At the discussion meeting on the Interim Report, Japanese Survey Team proposed four means to reduce the direct costs:

(a) Fabrication of the steel cason shells in Simalaik Dockyard
(b) Fabrication of the secondary members of steel truss bridge in Sinmalaik Dockyard
(c) The same as item (b) but in a newly installed workshop near Prome
(d) Replacement of Japanese skilled labourers with Burmese ones, prolonging the construction period by 3 years

The first method above (a) was found not to be appropriate for want of drydock in Sinmalaik. The fourth method above (d) seemed to be promising among these proposals. The Burmese side replied that they would refer to the higher authority and inform the results through the Japanese Embassy in Rangoon by the middle of January, 1975. The Team could not, however, receive any comment in this regard and no alteration along with these matters was accordingly attempted. Therefore, the Final Draft Report was prepared without any fundamental modification.

The Explanation Team for the Final Draft Report composed of Mr. G. Yokoyama and Dr. S. Inomata arrived in Rangoon on September 6, 1975. They submitted the Final Draft Report and had an explanation and discussion meeting at Construction Corporation on September 9. There were some comments from both sides and discussions for long hours continued. Small alterations and corrections of misspellings were made for preparing the Final Report, based on the discussions but no fundamental modification was effected.

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# 1. INTRODUCTION

# 1. INTRODUCTION

## 1.1 Objective

The purpose of this study is to examine the technical and economic feasibility of constructing a bridge across the Irrawady, access railway and road connecting Prome and Sinde.
The study also aims at recommending one bridge site as the most optimum one out of the three sites proposed by the Burmese Government.

## 1.2 Scope of Work

The studies necessary to accomplish the objectives set out above included field investigations, and engineering, traffic and economic studies.

The study was divided into two phases to examine the technical and economic feasibility of constructing a bridge across the Irrawaddy.

The first phase consisted, for each proposed site (hereinafter the upper, middle and lower sites along the river are referred to as Site Nos.1, 2 and 3, respectively), of selecting the most feasible alignment of access railway connecting existing Prome Line with Sinde, considering its extension to Kyangin and a future north link railway along the west side of the river. Once an alignment of access railway at each site was determined, study on the bridge was carried out, taking account of soil and hydrologic conditions. At the same time the access road was designed considering the geographical features and the future highway plans. On the basis of field surveys, the traffic forecasts and regional economy affected by the construction of a bridge were studied. The rough construction cost estimation and preliminary economic studies were carried out to propose the most optimum site of a bridge.

The second phase consisted of a refined economic analysis based on the elaborate design for one specific proposed site. The report includes the construction schedule together with the annual amount of investments for the various construction works, the total construction costs and their present value. Based on these calculations, the benefit-cost ratio and the internal rate of return were calculated under an assumed condition.

## 1.3 Report Outline

Chapter 1 contains a brief description of this project and general conditions of the project area.

Chapter 2 provides a summary of the findings in respect of the regional economic studies.

Chapter 3 deals with the traffic studies and forecasting.

Chapter 4 contains all aspects of the engineering study on the soil and geology.

Chapter 5 gives all the hydrologic facts necessary for planning the bridge.

Chapter 6 contains all aspects of the engineering study on the access road.

Chapter 7 provides the results obtained from the engineering studies on each access railway as well as railway between Kyangin and Sinde. Railway operating planning is also described.

Chapter 8 deals with all aspects of the engineering study on the bridge construction for each site. Construction method is also discussed.

Chapter 9 contains a summary of the quantities of the raw materials of construction and their unit costs. Quality of the raw materials available in Burma is described.

Chapter 10 gives the methodology applied for the computation of unit costs of various construction items and the calculation of the project construction costs.

Chapter 11 provides how a specific site is selected as the most suitable site from the results described in Chapter 10 and economic considerations, and also contains the results of detailed economic analysis on this specific bridge project.

## 1.4 Project Area

The related area for the construction of a proposed bridge across the Irrawaddy is located near Prome,about 410 km upstream from its mouth. The location map for the proposed bridge construction site is shown in Fig. 1-1.

The Irrawaddy basin lies between 93°-37' and 98°-43' east longitude and 15°-42' and 28°-26' north latitude. The catchment area of the basin is 376,200 $km^2$ that occupies about 55% of the total area of the country and the total length of the Irrawaddy is 1,820 km.

In accordance with the topographical observation, the related area is divided into five regions;

| No. | Region | Elevation (in feet) |
|---|---|---|
| 1 | mountainous | over 500 |
| 2 | hilly | over 250 to 500 inc. |
| 3 | high land | over 100 to 250 inc. |
| 4 | low land | below 100 |
| 5 | the Irrawaddy River bed | |

Fig. 1-1 shows each region in the related area.

The average annual rainfall in the related area of 340,000 $km^2$ situated upstream from Prome gauge was estimated at about 2,200 mm.

The recorded average monthly rainfall at 17 gauges during the 1954-1973 period shows that a single rainy season and a single dry season are clearly defined. The rainy season lasts six months from May to October during which the total rainfall is about 94% of the annual rainfall. The dry season starts from November and ends in next April.

The yearly mean temperature in the basin varies from 23.9°C in the northern mountain region to 27.8°C in the middle reaches of the river. The highest temperature is observed in May and the lowest in January. The annual difference of the monthly mean temperature varies from 6.4°C in the plain area to 12.7°C in the mountain area.

The relative humidity is very high throughout a year except for the plain area of the basin. It becomes the highest in August and the lowest in March/April. The annual mean humidity is 61% and 91% in the plain area and the northern mountainous zone, respectively.

The records of the average monthly percentage of wind direction at Prome gauge observed during the 1956-1970 period, clearly show that the basin area is affected by the monsoon, namely, north or northeast wind prevailing from November to next February changes to south or southeast wind from March to November. The recorded monthly maximum wind velocity at Mandalay, Minbu and Prome during the 1960-1972 period shows that the strongest wind generally prevails in April, May and June. The maximum velocity recorded at the time of observation hours was 8.5 m/sec at Prome.

## 1.5 Transport System

### 1.5.1 General Description

The long term development plan of Burma aims at expanding the production of agricultural, fishery and livestock industries, establishing the consumer industry to substitute the import goods, utilising effectively mineral resources and developing the heavy industry. In order to achieve these aims, it is very urgent to improve and maintain the transport sector to meet with the ever enlarging demands for such fundamental phases of infrastructure. Therefore, it is necessary to propose such practical measures as realisation of reasonable optimum transport planning, full use of the given public transport capacity currently available, maximum utilisation of transport means belonged to the producers as well as to the consumers.

Taking the significance of these transport roles for the general community into consideration, the current situation of transport status in Burma can be summarised as follows.

The total transport demand quantity has increased, as shown in the Table 1-1, from 32.3 million tons in 1961-1962 to 44.4 million tons in 1973-1974 by the annual increase ratio of 2.7%. Where: The total transport demand quantity = Total output quantity - (consumed and utilised quantity of output at the place of production + quantity of commodity not needing transport) + imported quantity of commodity. The constituents of transport demand are broken down into 70% of agriculture, livestock, forestry and fishery products, and the remaining 30% into mineral and manufacturing industries. This categorical percentage has not shown any significant changes according to available past statistical records.

The constituent ratio of the short, midium and long haul transport for 1973-1974 was 60.0%, 20.5% and 19.5%, respectively, which again reveals no big annual change in their constituent percentages.

The transport means of Burma consist of the public transport means run by Government such as the Burma Railways Corporation, Inland Water Transport Corporation, Road Transport Corporation, Rangoon Port Authorities, Five Star Line, Burma Port Corporation, Burma Airways Corporation and the transport means under the management of the private sectors.

The transport means run by the private managements handle much short-haul transport as their main activity, however, the exact volume has not been assessed. According to the records of transport services rendered by the public-owned traffic means, a percentage picture could be broken down into:

a) Passenger Traffic:

| | | | |
|---|---|---|---|
| 1) | Railway | ...... | 58% approx. |
| 2) | Roadway | ...... | 28% " |
| 3) | Inland Waterway | ...... | 8% " |
| 4) | Airway | ...... | 6% " |

Note: The percentage of airway has rather a similar percentage to that of inland waterway because the average transport distance of airway covers a long distance of 210 miles which is 9 times that of inland waterway.

b) Cargo Transport:

| | | | |
|---|---|---|---|
| 1) | Railway | ...... | 50.0% |
| 2) | Inland Waterway | ...... | 40.0% |
| 3) | Roadway | ...... | 9.7% |
| 4) | Airway | ...... | 0.3% |

In brief, in the category of passenger transport, the railway and roadway play the main roles, whereas in cargo transport the railway and inland waterway take the important shares. Furthermore, it is well worth noting that in Burma the inland waterway commonly carries a great volume of commodities. As indicated in Table 1-2, the average distances of the passenger transport are:

| | |
|---|---|
| Roadway | 3 miles |
| Railway and Inland Waterway | 20-30 miles |
| Domestic Airway | 200 miles |
| International Airway | 500-650 miles |

Note: Transport distance is almost constant in each year, except for airborne transport.

The transport distance for airway is increasing every year. International airway records an increased annual ratio of 4.0% for 1971-1972/ 1973-1974, and this figure indicates the enlargement of airway traffic with foreign countries.

The average distance for cargo transport:

| | |
|---|---|
| Roadway | 50 miles |
| Railway | 160 miles |
| Inland Waterway | 200 miles |
| Domestic Airway | 250-350 miles |
| International Airway | 800 miles |

The transport distance for cargo normally greatly surpasses the distance for passengers.

Cargo transport by means of railway increased at the rate of 4.5% annually up to 1961-62/1965-66, then decreased instead.

In comparison with the steady increase ratio for long-haul transport and passenger transport in general, passenger transport by means of the metropolitan circular railway line within the city of Rangoon, shows a tendency to decline due to decreased maintenance services. These have decreased because of shortage of foreign currency to allow renovation of transport-related equipment and facilities.

Table 1-1 Total Transport Demand in Burma

Unit: 1,000 tons

| Year / Particulars | 1961/62 | 1971/72 | 1972/73 | * 1973/74 |
|---|---|---|---|---|
| 1. Domestic Output for Transport | 31,099 | 42,373<br>(3.1) | 41,335<br>(-2.5) | 43,687<br>(5.7) |
| 2. Import | 1,174 | 798<br>(-3.8) | 589<br>(-26.2) | 703<br>(19.4) |
| 3. Total | 32,273 | 43,171<br>(3.0) | 41,924<br>(-2.9) | 44,390<br>(5.9) |
| 4. Short Haulage (up to 25 miles) | 19,701 | 25,771<br>(2.7) | 24,769<br>(-4.0) | 26,653<br>(7.6) |
| 5. Medium Haulage (up to 50 miles) | 7,011 | 8,868<br>(2.4) | 8,616<br>(-2.9) | 9,096<br>(5.6) |
| 6. Long Haulage (50 miles or more) | 5,561 | 8,532<br>(4.4) | 8,539<br>(0.0) | 8,641<br>(1.2) |
| 7. Transport by State Transport Organizations | 4,221 | 6,931<br>(5.1) | 6,025<br>(-13.1) | 6,474<br>(7.5) |
| 8. Transport by other Organizations | 28,052 | 36,240<br>(2.6) | 35,899<br>(-0.9) | 37,916<br>(5.6) |

Note: * Provisional

The figures within ( ) show the annual increase ratio (%).

Source: Report to the Pyithu Hluttaw, 1974-1975.

## Table 1-2 Transport Volume and Ratio by Transport Means

### I. Passenger Transport

| Description | Year / Transport Means | 1961/62 | 1971/72 | 1972/73 | 1973/74* |
|---|---|---|---|---|---|
| No. of Passengers (1,000 passengers) | 1. Railway | 43,078 | 53,389<br>(2.2) | 55,060<br>(3.1) | 42,334<br>(-23.1) |
| | 2. Roadway | - | 310,812 | 219,627<br>(-29.3) | 243,395<br>(10.8) |
| | 3. Inland Waterway | 5,260 | 9,834<br>(6.5) | 9,650<br>(-1.9) | 9,462<br>(-2.0) |
| | 4. Marine Transport (Coastal lines inclusive) | 13.0 | 28.5<br>(8.2) | 26.6<br>(-6.7) | 16.1<br>(-39.5) |
| | 5. Domestic Airway | 133 | 399<br>(13.4) | 409<br>(2.5) | 472<br>(15.4) |
| | 6. International Airway | 34 | 50<br>(3.9) | 55<br>(10.0) | 74<br>(34.5) |
| | 7. Total | 48,518 | 374,512.5 | 284,827.6<br>(-23.9) | 295,753.1<br>(3.8) |
| Passenger Transport (Million passenger-mile) | 1. Railway | 953 | 1,625 | 1,887 | 1.264 |
| | 2. Roadway | - | 777 | 691 | 798 |
| | 3. Inland Waterway | 147 | 231 | 214 | 210 |
| | 4. Marine Transport (Coastal line incl.) | - | - | - | - |
| | 5. Domestic Airway | 26 | 84 | 88 | 100 |

| Description | Year / Transport Means | 1961/62 | 1971/72 | 1972/73 | 1973/74* |
|---|---|---|---|---|---|
| | 6. International Airway | 17 | 30<br>(1.0) | 35<br>(1.2) | 48<br>(2.0) |
| | 7. Total | 1,143 | 2,747<br>(100) | 2,915<br>(100) | 2,420<br>(100) |
| Average Transport Mileage (Mile) | 1. Railway | 22 | 30 | 34 | 30 |
| | 2. Roadway | - | 3 | 3 | 3 |
| | 3. Inland Waterway | 28 | 24 | 22 | 22 |
| | 4. Marine Transport (Coastal Line incl.) | - | - | - | - |
| | 5. Domestic Airway | 196 | 211 | 215 | 212 |
| | 6. International Airway | 500 | 600 | 636 | 649 |

Notes: * Provisional

The figures within ( ) for No. of passengers indicate annual increase ratio (%).

Source: Report to the Pyithu Hluttaw, 1974-1975.

## II. Cargo Transport

| Description | Year / Transport Means | 1961/62 | 1971/72 | 1972/73 | 1973/74* |
|---|---|---|---|---|---|
| Tonnage Transported (1,000 tons) | 1. Railway | 2,938 | 2,925<br>(-0.0) | 2,486<br>(-15.0) | 2,893<br>(16.4) |
| | 2. Roadway | - | 1,844 | 1,651<br>(-10.5) | 1,595<br>(-3.4) |
| | 3. Inland Waterway | 1,283 | 2,162<br>(5.4) | 1,888<br>(-12.7) | 1,986<br>(5.2) |

| Descrip-tion | Year / Transport Means | 1961/62 | 1971/72 | 1972/73 | 1973/74* |
|---|---|---|---|---|---|
| | 4. Marine Transport (Coastal Line incl.) | 527 | 834<br>(4.7) | 627<br>(-24.8) | 489<br>(-22.0) |
| | 5. Domestic Airway | 2.9 | 6.5<br>(8.4) | 5.9<br>(-9.2) | 8.2<br>(39.0) |
| | 6. International Airway | 0.3 | 0.9<br>(11.6) | 1.0<br>(11.1) | 1.0<br>(0) |
| | 7. Total | 4,751.2 | 7,772.4 | 6,658.9<br>(-14.3) | 6,972.2<br>(4.7) |
| Cargo Transport Volume (Million ton-mile) | 1. Railway | 458 | 484 | 388 | 390 |
| | 2. Roadway | - | 81 | 84 | 78 |
| | 3. Inland Waterway | 244 | 412 | 376 | 255 |
| | 4. Marine Transport (Coastal Line incl.) | - | - | - | - |
| | 5. Domestic Airway | 1 | 1.6 | 1.5 | 2.0 |
| | 6. International Airway | 0.2 | 0.7 | 0.8 | 0.8 |
| | 7. Total | 703.2 | 979.3 | 850.3 | 725.8 |
| Average Transport Mileage (Mile) | 1. Railway | 156 | 166 | 156 | 135 |
| | 2. Roadway | - | 44 | 51 | 49 |
| | 3. Inland Waterway | 190 | 191 | 199 | 128 |
| | 4. Marine Transport (Coastal Line incl.) | - | - | - | - |
| | 5. Domestic Airway | 345 | 246 | 254 | 244 |
| | 6. International Airway | 667 | 779 | 800 | 800 |

Notes: * Provisional

The figures within (     ) for tonnage transported indicate the annual increase ratio (%).

Source: Report to the Pyithu Hluttaw, 1974-1975.

### 1.5.2 Railway

The total mileage of railway which is managed by Burma Railway Corporation is 1,950 miles as of the end of September 1973. The route mileage for each line is indicated in Table 1-3.

Table 1-3 Railway Line

Unit: Miles

| Section | | Date put into Public Service | Single Line | Double Line | Triple Line* | Total |
|---|---|---|---|---|---|---|
| Prome-Wanetchaung | Main Line | 1-5-1877 | 380.75 | 164.50 | 1.50 | 546.75 |
| Wanetchaung-Kyungon | | 1-5-1888 | | | | |
| Kyungon-Mandalay | | 1-3-1889 | | | | |
| Pegu-Moulmein (up to Ye)** | | 25-9-1907 | 219.50 | - | - | 219.50 |
| Nyaunglebin-Madauk | | 15-8-1929 | 11.25 | - | - | 11.25 |
| Pyinmana-Kyaukpadaung | | 17-7-1930 | 139.00 | - | - | 139.00 |
| Kyaunkpadaung-Kyeni | | 1-3-1969 | 24.50 | - | - | 24.50 |
| Thazi-Myingyan | | 15-11-1899 | 70.00 | - | - | 70.00 |
| Thazi-Heho (Southern Shan State Branch) | | 10-3-1921 | 98.00 | - | - | 98.00 |
| Heho-Shwenyaung | | 2-5-1928 | | | | |

| Section | Date put into Public Service | Single Line | Double Line | Triple Line* | Total |
|---|---|---|---|---|---|
| Myohaung-Lashio (Northern Shan States Branch) | 1-3-1903 | 178.00 | - | - | 178.00 |
| Mandalay-Madaya | 5-2-1927 | 17.00 | - | - | 17.00 |
| Paleik-Tada U | 5-10-1929 | 7.00 | - | - | 7.00 |
| Myohaung-Myitkyina | 1-1-1898 | 340.00 | - | - | 340.00 |
| Katha-Naba | 2-10-1895 | 15.00 | - | - | 15.00 |
| Letpadan-Tharrawaw Shore | 20-3-1903 | 108.50 | - | - | 108.50 |
| Henzada-Bassein | 15-12-1902 | | | | |
| Henzada-Kyangin | 14-12-1908 | 64.75 | - | - | 64.75 |
| Ywataung-Ye U (up to Buddalin) | 1-7-1926 | 85.00 | - | - | 85.00 |
| Mahlwagon-Mingaladon Cantonment | 6-3-1926 | - | 8.75 | - | 8.75 |
| Rangoon-Suburban Line | 15-7-1890 | 9.00 | - | - | 9.00 |
| Mandalay-Shore Line | 13-4-1889 | 3.00 | - | - | 3.00 |
| Circular Railway (Mingaladon Cantonment to Danyingon) | 1-5-1959 | - | 4.25 | - | 4.25 |
| Total | | 1,770.25 | 177.50 | 1.50 | 1,949.25 |

Note: * Quadruplicate line.

** Includes 4.01 miles from Abya to Nyaungkashe

Source: Data from Burma Railway Corporation

The railway network of whole Burma is shown in Fig. 2-1.

Table 1-3 indicates that 91% of the total mileage is of single line while the remaining 9% is double line or more. The track gauge is one meter. The BRC is exerting every effort to increase diesel locomotives as far as circumstances permit. Number of stations is 499.

There are two kinds of railway fares: ordinary and upper class rates, respectively;4 2/3 pyas for ordinary and 13.5 pyas for upper per mile. The upper class fare is more than three times the ordinary fare. The cargo tariff is classified into the commodity class rates and the schedule rates. By class, rates have five grades, according to type of commodity and according to the gradual decrease rate system corresponding to the increase of mileage to cover as shown in Table 1-4.

Lower rates can be applied to schedule rates than the commodity class rates together with the adoption of the similar mileage diminution system to class tariff.

Table 1-4 Cargo Tariff

Unit: 100 Viss · Pyas

| Class / Mileage | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1-20 | 32 | 40 | 46 | 58 | 74 |
| 21-80 | 24 | 32 | 38 | 50 | 64 |
| 81-200 | 18 | 24 | 30 | 40 | 52 |
| 201 and more | 14 | 20 | 22 | 28 | 40 |

Source : Data from Burma Railway Corporation

### 1.5.3 Roadway

Since the establishment of the Road Transport Corporation in 1963, the quantity of cargo handled by the Corporation and the number of passengers had increased in the succeeding six years by the annual upward rate of 4.4% and 2.9%, respectively. However, this favourable trend stopped from 1969. Since then, the cargo volume and number of passengers from 1969-70 up to 1972-73 have been declining and the annual decrease rate has been 8.6% and 5.0%, respectively.

The cause of this tendency may not be attributable to the decline of traffic demand of the public, but to diminished handling capacities, especially to the decreased ability for the requirements to maintain and renovate the facilities, vehicles, associated equipment and materials indispensable to run the whole transport system at the optimum conditions and orders.

The master plan of the roadway dictates the construction and renovation of the second-grade highways of approximately 150 miles every year, but the shortage of construction equipment has put restraint on the carrying out of proposed repair-works to be applied to the trunk-line highways.

The highway network is classified into four categories in accordance with the grade of construction.

1) Bitumen Road
2) Gravel Road (Passable by car in the dry season)
3) Earth Road (Passable partly by ox-cart)
4) Minor Road

Table 1-5 indicates the highway network classified into the aforementioned categories.

About 85 percent of the total length is of one lane road.

Table 1-5 Mileage of Road by Year

Unit: km

| Grade \ Year | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 |
|---|---|---|---|---|---|---|
| Bitumen | 6,568 | 6,693 | 7,230 | 7,392 | 7,529 | 7,800 |
| Gravel | 8,069 | 8,698 | 9,106 | 9,333 | 9,229 | 8,915 |
| Earth | 7,279 | 6,702 | 7,381 | 7,213 | 7,375 | 7,693 |
| Minor | 760 | 1,005 | 1,827 | 1,504 | 1,460 | 1,575 |
| Total | 22,676 | 23,098 | 25,044 | 25,442 | 25,593 | 25,882 |

Note: The highway network of Burma is indicated in Fig. 2-1.

The width of highway is normally 14 feet or less, and the design load for the bridges is set at 6 tons in general.

The number of motor vehicle in 1973 is stated in Table 1-6.

The number of each type of vehicle has increased steadily and in linear pattern from 1964 to 1973.

### Table 1-6 Registered Number of Motor Vehicle

(1973)

Unit: Vehicles

| No. of Vehicles | Type of Vehicle / District | Car | Truck | Bus | Motor cycle | Others | Total |
|---|---|---|---|---|---|---|---|
| Regis-tered No. | Burma, whole country | 21,606 | 29,130 | 9,488 | 7,803 | 22,258 | 90,285 |
| | Percentage (%) of each types | 23.9 | 32.3 | 10.5 | 8.6 | 24.7 | 100.0 |
| | Rangoon | 15,561 | 12,126 | 3,868 | 3,151 | 10,437 | 45,143 |
| | Percentage (%) of each type | 34.5 | 26.9 | 8.6 | 7.0 | 23.0 | 100.0 |
| No. in use | Burma, whole country | 18,523 | 22,487 | 7,321 | 6,182 | 17,691 | 72,204 |
| | Rangoon | 14,439 | 11,251 | 3,590 | 2,925 | 9,684 | 41,889 |
| Ratio of No. of vehicles in operation; (%) Rangoon/Burma, whole country | | 78 | 50 | 49 | 47 | 55 | 58 |
| Operation ratio (%) (average for 1962/1973) | | 85 | 70 | 76 | 82 | 82 | 78 |

Source: Department of Road Transport Administration, Rangoon.

As Table 1-6 indicates, the number of motor vehicles in use in the whole of Burma is 72,204 and approximately 58% of the total number of vehicles is concentrated in Rangoon. The holding ratio per capita for 1971 is only 0.0022 vehicle/capita which is almost similar to that of India and one fifth of that of the Philippines.

The average operation ratio of all types of vehicle for 12 years; 1962/1973, (No. of vehicles in use/No. of vehicles registered), is 78%, among which the operation ratio of cars is the highest, with 85% and trucks is the lowest, with 70%.

Vehicles in Burma tend to be very old; viz. the vehicles-age of 16 - 19 years amounts to 46.6% and that of 32 - 35 years to nearly 7% against the total number of vehicles owned.

The average daily traffic over the main trunk highways in Burma has been observed and recorded every two years since 1966 with the resultant figures as shown in Table 1-7.

Table 1-7 Average Daily Traffic over Main Trunk Highways

Unit: No. of Vehicles/day

| Year | Rangoon ~ Pegu | Pegu ~ Toungoo | Rangoon ~ Tharrawaddy | Tharrawaddy ~ Prome | Prome ~ Thayet | Thayet ~ Magwe | Mandalay ~ Ava Bridge |
|---|---|---|---|---|---|---|---|
| 1966 | 612 | 749 | 813 | 1,051 | 945 | 441 | 2,869 |
| 1968 | 321 | 593 | 663 | 747 | 703 | 394 | 2,718 |
| 1970 | 538 | 692 | 1,229 | 1,163 | 1,316 | 2,335 | 2,635 |
| 1972 | 1,448 | 1,712 | 1,177 | 1,554 | 1,298 | 860 | 2,743 |

Source : Data from Construction Corporation

The figures in Table 1-7 are based on the number of car-conversion; viz. Car/Truck - 1 : 2; Car/Heavy-duty Truck & Bus - 1 : 3; Car/Bicycle - 1 : 0.5; Car/Oxcart - 1 : 8; Car/Horse-drawn Carriage - 1 : 6.

In Burma, the number of cars owned is very small, and the oxcarts and horse-drawn carriages take the main role of traffic, therefore, the figures in Table 1-7 indicate greater figures that the actual figures.

### 1.5.4 Inland Water Transport

Inland waterway traffic is one of the very important transport means parallel with railway transport. The Inland Water Transport Corporation (IWTC) contributes transport services to the public along the Irrawaddy river in the delta area as well as by the following routes.

| | | |
|---|---|---|
| 1. | Rangoon - Mandalay (Irrawaddy River) | 960 km |
| 2. | Mandalay - Bhamo (Irrawaddy River) | 440 km |
| 3. | Bhamo - Sinbo (Irrawaddy River)<br>(only for January) | 37 km |
| 4. | Sinbo - Myitkyina (Irrawaddy River) | 130 km |
| 5. | Pakokku - Homalin (Chindwin River) | 640 km |
| 6. | Moulmein - Shwegoon (Salween River, Dondami R.) | 90 km |
| 7. | Moulmein - Kya-in (Ataran River) | 120 km |
| 8. | Moulmein - Kyondo (Gyaing River) | 70 km |
| 9. | Moulmein - Moulmein Estuary (Moulmein River) | |

Total length of all the waterway routes amounts to 5,440 km, and the total service traffic accounts for the length of 11,600 km.

The navigable waterways in the wet season are calculated at 8,050 km at high water and in the dry season 6,000 km at low water.

There are 411 river ports throughout the waterway routes under public service.

In 1972/1973, the IWTC maintained 11,732 employees, 867 water crafts (powered - 364, dumb - 374, station flat - 129), and carried 9,650,000 passengers, 1,086,000 tons of petroleum oil, 185,000 tons of cement and 617,000 tons of general cargo. Total expenditure, including fuels, wages for the crews, maintenance of crafts, was 50.949 million Kyats. The fares are: Cargo - 10.1 pyas per ton/mile, and passenger - 6.8 pyas per capita/mile.

The number of crafts under private ownership registered to the Nautical Department amounts to 1,496 and nearly all of them have the length of 50 feet to 80 feet. Small crafts with the length of 30 feet are not included in the above number of 1,496. The total estimated cargo carrying capacity or dead-weight is assumed at 56,050 tons.

The IWTC does not provide the cross-river services, such ferryboat services being conducted by the private organizations, except some ferry services provided by the Burma Railway Corporation.

### 1.5.5 Harbour

The quantity of export and import cargo in the port of Rangoon is indicated in the Table 1-8. The figures stated include not only the foreign trade cargo but also the quantity of cargo shipped to and from domestic ports such as Akyab, Kyaukpyu, Sandoway, Bassein, Moulmein, Tavoy, Mergui and Kawthaung.

## Table 1-8 Cargo Handled in Rangoon Port

Unit: Tons

| Items / Year | 1968/69 | 1969/70 | 1970/71 | 1971/72 | 1972/73 |
|---|---|---|---|---|---|
| Export | | | | | |
| P.O.L. | 73,033 | 69,417 | 69,231 | 78,254 | 64,448 |
| Rice & Rice Products | 319,175 | 572,504 | 697,316 | 763,114 | 321,569 |
| Mineral | 21,468 | 13,252 | 15,466 | 17,134 | 21,893 |
| Timber | 126,430 | 102,633 | 90,099 | 142,704 | 288,936 |
| General Cargo | 215,448 | 263,697 | 310,172 | 427,672 | 428,624 |
| Total for Export | 755,554 | 1,021,503 | 1,182,284 | 1,428,882 | 1,125,470 |
| Import | | | | | |
| Coal & Coke | 265,275 | 241,333 | 254,046 | 150,847 | 142,331 |
| P.O.L. | 123,811 | 307,200 | 285,872 | 285,177 | 98,376 |
| Salt | 24,387 | 29,105 | 24,297 | 24,705 | 34,674 |
| General Cargo | 584,016 | 505,022 | 486,130 | 424,509 | 396,862 |
| Total for Import | 997,489 | 1,082,660 | 1,050,345 | 885,238 | 672,243 |
| Total* of Export & Import | 1,753,000 | 2,104,000 | 2,233,000 | 2,314,000 | 1,798,000 |

* Rounded at the order of 1,000 tons.

Source : Data from Burma Ports Corporation

# 2. REGIONAL ECONOMY

# 2. REGIONAL ECONOMY

## 2.1 Contents of Regional Economic Survey

### 2.1.1 Survey Purpose

The purpose of the survey is to forecast the national economy of whole Burma and the economic growth expected from the construction of the Irrawaddy River Bridge based on the analysis of the past and present pattern of whole Burma and seven regions (Magwe, Minbu, Thayet, Prome, Tharrawaddy, Sandoway, Henzada), which are considered as direct influence areas shown in Fig. 2-1.

### 2.1.2 Survey Method

According to the flow chart shown in Fig. 2-2, the future pattern of industrial economic development of the direct influence area of the bridge construction and of whole Burma was forecasted.

For this future forecast, the annual variation pattern of industry and economy at regional, state and national level as well as the concrete figures of future plans are necessary. However, partly because sufficient data were unable to be obtained by some reasons and partly because some data were considered to be unreliable, some portion of the forecast had to be roughly estimated.

The present pattern of the direct influence area was analysed for population, labour force, agriculture, forestry, mining, manufacturing industry, transportation, communication, distribution and other items. At the same time, the mutual relationships among these items were analysed quantitatively utilising multi-variable analysis method. In addition to the above analysis, qualitative examinations were carried out.

However, it is not sufficient to analyse the present and future patterns of economy and industry only for the direct influence area of this project. It is necessary to examine these results of analyses from the view point of analysis for whole Burma. Therefore, the present pattern of whole Burma was analysed both quantitatively and qualitatively for such fields as population, labour force, agriculture, forestry, mining, manufacturing industry, transportation, communication, distribution, etc.

The examination of the development pattern of the direct influence area is very important since the difference of the pattern resulting from the existence and non-existence of the bridge is directly related to the effect of the bridge construction.

Since it is dangerous to judge the development pattern of direct influence area only from a microscopic viewpoint restricted to the subject area, the results of the analysis of national economy forecast of whole Burma was conferred with as the checkpoint of estimated development pattern of direct influence area.

In addition to the above, the present and future industrial and economic status of such Southeast Asian countries whose industrial and economic structures are similar to those of Burma was analysed in order to check the results of national economy forecast of whole Burma.

The future of direct influence area of the bridge construction was forecasted both quantitatively and qualitatively from both microscopic and macroscopic viewpoints for the cases with the bridge and without the bridge.

No quantitatively supported development plan of the west side of the Irrawaddy was available, and the 4-Year Plan and 20-Year Plan of Burma only define planned target (target rate of growth) for each industrial sector.

Thus, for the future forecast, various conceivable development patterns (future pattern based on target rate of growth, future pattern forecast by means of multi-variable analysis and multiple regression based on past pattern data, future pattern derived from territory comparison method, forecasted value by outside source such as UN or others) were considered comprehensively. As a result, the future pattern for each industrial sector was forecasted and the difference between the cases with the bridge and without the bridge was related to the effect of the bridge construction.

## 2.2 Characteristics of Regions Surveyed

### 2.2.1 Population

According to the population census of 1973, 4,360,000 out of 28,900,000 Burmese or 15% of the nation's population live in the seven regions.

Of the seven regions which occupy 9.4% or 63,687 $km^2$ of the total area of Burma, Prome and Tharrawaddy situated in the eastern part of the Irrawaddy and Henzada in its western part are the most densely populated.

Table 2-1 Population and Area of 7 Regions

| Region | Population | Area ($km^2$) | Density (Persons/$km^2$) |
|---|---|---|---|
| Magwe | 866,435 | 9,630 | 89.9 |
| Minbu | 432,222 | 9,314 | 46.4 |
| Thayet (east) | 199,622 | 4,727 | 42.2 |
| Thayet (west) | 247,899 | 7,268 | 34.1 |
| Prome (east) | 532,338 | 5,136 | 103.6 |
| Prome (west) | 101,962 | 2,507 | 40.7 |
| Tharrawaddy | 821,000 | 7,260 | 113.1 |
| Sandoway | 206,082 | 10,754 | 19.2 |
| Henzada | 956,141 | 7,091 | 134.8 |
| Total of 7 Regions | 4,363,701 | 63,687 | 68.5 (Average) |
| Whole Country | 28,885,867 | 676,570 | 42.7 |

Source: Population Census of 1973

Generally speaking, the eastern part of the Irrawaddy and lower Burma are thickly populated, and the population in Sandoway situated in the western part of the Irrawaddy is thinnest. The population density there is about 19.1 persons to the square kilometer or about one-seventh of that of Henzàda. In the eastern part of the Irrawaddy the population is dispersed over the entire area except for the mountainous zone, whereas the population is concentrated near the small rivers including the tributaries of the Irrawaddy in the west of the Irrawaddy.

### 2.2.2 Land Utilisation

General land utilisation in the seven regions is shown in Fig. 2-3. The agricultural land there is further classified according to purposes of its use in Fig. 2-4. As is clear from Fig. 2-3, the land utilisation characteristically differs from one region to another. In Sandoway, Thayet (west), Thayet (east) and Minbu, forest covers 81, 83, 80 and 62% of the surface, respectively, and of these areas Sandoway has the largest area of not reserved forests of 1,910,000 acres, followed by Thayet (west) having 1,200,000 acres of not reserved forest area. Not reserved forests are generally concentrated near the Arakan Yoma on the west of the Irrawaddy. In its eastern part, on the other hand, forest development is more advanced so that the reserved forests exist in a larger proportion. Magwe and Minbu situated in the dry zone are characterized by Ya land which covers 35 and 9% of the surface of the two regions, respectively. These regions are under cotton, groundnut, sesame and pulses which are suited to the dry zone.

On the other hand, in Tharrawaddy and Henzada situated in southern Burma a vast area of fertile alluvial lands of the delta of the Irrawaddy is occupied by rice. The paddy land occupies 36 and 35% of the surface of the two regions, respectively, and rice production in the two regions alone account for as much as 12% of total Burmese rice production (1973-1974), indicating that the delta of the Irrawaddy is the rice granary of Burma.

In Tharrawaddy and Henzada, only 5 and 2% of the surface are covered by not reserved forests, respectively, whereas reserved forests occupy 39 and 33% of the total area of each region. This indicates that forest development is more advanced in these regions than in those surrounding the Arakan Yoma.

In Prome in the eastern part of the Irrawaddy there are 277,833 acres of cultivable land or 22% of its total area in addition to the land now under crop. As shown in Fig. 2-4, Ya land occupied 79% (860,489 acres) and 46% (206,607 acres) of the total agricultural land of Magwe and Minbu north of Prome. Of these Ya lands, 65% were sown to crops and nearly 35% lay fallow.

In the eastern part of the Irrawaddy rice is the most important crop. The paddy land is 652,690, 599,873 and 352,376 acres in Tharrawaddy, Henzada and Prome, occupying 88, 78 and 88% of the total agricultural land of each region. In the three regions, 90.5, 96.5 and 97.6% of the paddy lands are under crop, and the remaining 9.5, 3.5 and 2.4% lie fallow.

### 2.2.3 Industries and Economy

The seven regions covered by the present survey are separated from other regions by the Pegu Yoma on the east and the Arakan Yoma on the west, and the Irrawaddy is a great obstacle to the smooth traffic among the seven regions.

The geographic features and climatic conditions are different to some extent between the east and the west of the Irrawaddy. The temperature and humidity are high in the western part of the Irrawaddy, but the rainfall is somewhat smaller in the eastern part. A plateau mostly under rice and jute stretches in the southern area of both the western and eastern parts of the Irrawaddy, whereas the northern area both on the west and east of the river consists of gentle hills which are for the most part devoted to dry field crops with sporadic paddy fields in the low land.

The western part of the Irrawaddy which rises toward the Arakan Yoma is covered by forest and is partly under maize and sugarcane.

#### 1. Agriculture

Production of main crops in the regions for the years 1973-1974 is shown in Table 2-2. Rice growing is so advanced in Tharrawaddy and Henzada situated in the delta of the Irrawaddy that rice production in these two regions alone account for as much as 12% of the nation's total rice production. Magwe predominates in groundnut production, followed by Tharrawaddy and Henzada.

The largest sesame producing regions are Magwe and Minbu. Sesame and raw cotton production is generally larger in the northern part than in the southern part of the seven regions.

Pulses production is large in Minbu and Magwe situated in the northern part and Tharrawaddy and Henzada in the southern part, and pulses production in Thayet and Prome in the intermediate part is as small as 18 and 12% of that of Minbu. Agriculture is more developed in Tharrawaddy and Henzada than in other five regions.

Table 2-2 Production of Main Crop
(1973-1974)

Unit: tons

| Crop<br>Region | Rice | Groundnut | Sesame | Cotton | Pulses | Maize Seed |
|---|---|---|---|---|---|---|
| Magwe | 46,535 | 57,127 | 18,800 | 1,498 | 7,378 | 5,985 |
| Minbu | 117,743 | 8,125 | 6,402 | 4,257 | 19,319 | 2 |
| Thayet (east) | 16,513 | 5,586 | 3,268 | 1,489 | 1,482 | 11 |
| Thayet (west) | 32,494 | 5,661 | 3,792 | 1,496 | 2,032 | 40 |
| Prome (east) | 269,746 | 7,740 | 1,267 | 1,011 | 1,995 | 27 |
| Prome (west) | 33,761 | 3,386 | 163 | 57 | 496 | 678 |
| Tharrawaddy | 544,169 | 24,783 | 278 | 6 | 16,919 | 1,466 |
| Sandoway | 67,148 | 1,316 | 27 | 4 | 28 | - |
| Henzada | 489,435 | 22,630 | 242 | - | 16,165 | 4,534 |
| Total | 1,617,544 | 136,354 | 34,239 | 9,818 | 65,814 | 12,743 |
| Whole Country | 8,583,000 | 452,000 | 166,000 | 40,000 | 210,000 | 84,000 |
| 7 Regions/ Whole Country (%) | 18.8 | 30.2 | 20.6 | 24.5 | 31.3 | 15.2 |

Source: Whole country: Report to the Pyithu Hluttaw, 1974-1975
7 Regions : Planning Department, Ministry of Planning and Finance, 1974

## 2. Forestry

Main forestry productions in the regions for 1973-1974 are shown in Table 2-3.

Teak production is larger in the earthern part of the Irrawaddy in 1973-74. Tharrawaddy takes predominance with production of 40,800 tons and Thayet second place with production of 22,000 tons. Prome situated in the eastern part of the Irrawaddy ranks third with production of 15,200 tons. In the western part, however, the teak resource has hardly been developed. If a logging network is built to haul out teak logs from the east foot of the Arakan Yoma and bamboos from its west foot, teak and bamboo production in these areas will contribute a great deal to the forestry in Burma.

Since the volumes of hardwood and bamboo in the Arakan region are estimated at 1,176,000 and 20,544,000 tons, forestry there holds a good promise.

Hardwood production for the years 1973-1974 was largest in Sandoway and Tharrawaddy, standing at 21,900 tons for Sandoway and 21,000 tons for Tharrawaddy, and in the eastern part of the Irrawaddy Prome produced 12,700 tons of hardwood, followed by Magwe with production of 12,000 tons.

Bamboo production was the largest (17,620,000 numbers) in Thayet situated in the western part of the Irrawaddy, far exceeding the production of 230,000 numbers in Sandoway. In the future, however, bamboo production will grow as forestry development takes place in the western part of the Irrawaddy.

Table 2-3 Main Forestry Product

(1973-1974)

Unit: tons

| Product / Region | Teak | Hardwood | Bamboo (1,000 Nos.) | Charcoal | Firewood |
|---|---|---|---|---|---|
| Magwe | 7,000 | 12,000 | 1,150 | - | 11,900 |
| Minbu | 5,000 | - | 3,300 | 1,000 | 2,500 |
| Thayet (east) | 4,000 | 3,000 | 2,000 | - | - |
| Thayet (west) | 22,000 | 3,000 | 17,620 | - | 3,500 |
| Prome (east) | 15,200 | 12,700 | 1,350 | 830 | 19,000 |
| Prome (west) | 8,400 | 4,000 | - | - | - |
| Tharrawaddy | 40,800 | 21,000 | 3,412 | - | 13,050 |
| Sandoway | - | 21,900 | 230 | - | 160 |
| Henzada | 5,000 | 2,000 | - | - | - |
| Total | 107,400 | 79,600 | 29,062 | 1,830 | 50,110 |
| Whole Country | 345,000 | 1,035,000 | - | - | - |
| 7 Regions/Whole Country (%) | 31.1 | 7.7 | | | |

Source: Whole Country: Report to the Pyithu Hluttaw, 1974-1975

7 Regions : Planning Department, Ministry of Planning and Finance, 1974

### 3. Mining

In the Magwe region there are two major oil fields, Yenangyaung (discovered in 1889) and Chauk (1901). In 1972, these oil fields produced 4,226 and 2,400 barrels per day of crude oil, respectively. In addition, there are such minor oil fields as Myanang (discovered in 1964), Prome (1965) and Mann (1967) which produce 6,734, 2,114 and 4,100 barrels per day of crude oil. The oil occurs mainly in the Tertiary rocks which stretch from south to north along the Irrawaddy and crude oil is processed at the refineries of Chauk and Syriam. Refined oil is distributed to 23 installation depots, 83 filling stations with a storage capacity of 20,000 to 30,000 gallons, 58 FS/PS (combination filling station and packed shop) and 128 packed shops across the country by truck, railway and river barge.

Sandoway, Akyab, Maulmein, Tavoy and Mergui are supplied with petroleum from Syriam via the sea. The refineries of Syriam and Chauk can process 17,500 and 6,750 U.S. barrels of crude oil per day, respectively. In 1972 the total production was 217 million gallons of refined oil. For the years 1974-1975, production has attained at 56,000,000 gallons of petroleum, 89,900,000 gallons of kerosene and 92,100,000 gallons of heavy oil. With this oil production, Burma is near self-sufficiency in oil supply. Burmese crude oil production is shown in Table 2-4.

Table 2-4 Crude Oil Production

Unit: U.S. barrels

| No. | Oil Field | 1970-1971 | 1971-1972 | 1972-1973 |
|---|---|---|---|---|
| 1 | Chauk/Lanywa | 785,392 | 660,000 | 565,562 |
| 2 | Yenangyaung | 1,556,117 | 1,480,000 | 1,453,817 |
| 3 | Myanaung | 2,442,462 | 1,990,000 | 1,240,841 |
| 4 | Prome | 795,862 | 740,000 | 720,972 |
| 5 | Mann & Others | 649,806 | 2,330,000 | 3,484,902 |
|  | Total | 6,229,639 | 7,200,000 | 7,466,094 |

Five oil fields shown in Table 2-4 are producing the crude oil of more than 96% of the national output and major oil fields are concentrically located from Chauk to Myanaung in the central part of Burma along the Irrawaddy. In recent years, however, it has been clarified that the offshore oil fields found from Martaban Gulf off Rangoon to Andaman Sea and those in Arakan Sea off Akyab in the western part of Burma are considered greatly promising, and the test drilling has been commenced. Table 2-5 shows the production and utilisation of natural gas.

Table 2-5 Production and Utilisation of Natural Gas

Unit: Million ft$^3$ day

| Place<br>Production & Utilisation | Chauk | Ayadaw | Yenang-yaung | Mann | Prome | Myanaung | Shwe Pyitha |
|---|---|---|---|---|---|---|---|
| 1. Production | 8.0-8.5 | 4.0-5.0 | 2.7-3.0 | 20.0 | 5.0 | 3.5-4.0 | |
| 2. Utilisation | | | | | | | |
| 1) Fertiliser Plant | 4.0-5.0 | 4.0-5.0 | - | - | - | - | Shut is Temporary Potential 10.0 MC-FD for Cement Mill and EPC Power Station |
| 2) Refinery | 2.0 | - | - | - | - | - | |
| 3) Power Station | 1.0 | - | 0.85 | - | - | - | |
| 4) Workshop | 0.3 | - | - | - | - | - | |
| 5) Domestic | 0.2 | About 0.05 | 0.1 | 0.1 | 0.15 | 0.1 | |
| 6) Field Boiler Rest is Flared | - | - | 0.20 | 0.2 (About 19.7) | - | 0.4 | |
| 7) Injection | - | - | - | - | - | 2.5 | |

The industrial zone with the overall length of 200 miles is now being constructed in the middle region of the Irrawaddy and most of industrial projects have been constructed in the west-side region of the Irrawaddy.

The industrial projects in the middle region of the Irrawaddy are shown in Table 2-6.

Table 2-6 Industrial Project in Middle Region of the Irrawaddy

| Project Name | | Industrial Products |
|---|---|---|
| 1 | Pakokku Cigarette Factory | Tobacco |
| 2 | Kyungchaung Gas Generating | Natural gas |
| 3 | Kyungchaung Chemical Fertiliser | Chemical fertilizers |
| 4 | Waji Project | Minting |
| 5 | Sale Chemical Fertiliser | Chemical fertilisers |
| 6 | Malun Tractor Project | Large-size tractors and trailors |
| 7 | Sinde Project | Motors, diesel engines, farming equipment, electrical appliances and small-size vehicles |
| 8 | Tonbo Project | Small-size vehicles, plastics and electrical appliances |
| 9 | Kyangin Cement | Cement |
| 10 | Myanaung Gas Generating | Natural gas and power generation |

It seems that the progress of industrialisation in the middle regions of the Irrawaddy does not provide outstanding predominance from the view point of the industrial situation except for the fact that these regions are the sources of supply of raw materials and energy. However, the inland industrialisation free from the export and import can be considered as far as the basic thought of the industrialisation is intended to ensure effective utilisation of domestic resources and encouragement and promotion of the consumer industries to substitute imports.

The following three points can be the merits resulting from the promotion of the industrialisation along the middle regions of the Irrawaddy.

1. Raw materials and energy are easily available and the transport costs and time can be saved.
2. The labour force can be easily supplied.
3. The industrialisation in these regions will be the foundation for comprehensive development of the west-side regions of the Irrawaddy in the future.

## 2.3 National Economy Forecast in Case without Bridge

### 2.3.1 Outline

The future national economy without the bridge was forecasted following the flow chart shown in Fig. 2-5.

Basic idea can be summarised as follows:

Statistical data of whole Burma (mainly the REPORT TO THE PEOPLE BOOK 1, 1973-74 and 1972-73) were used as basis of the selection of nearly 200 economic and industrial indices which were considered to be basic ones. They are population, labour population by industry sector, gross output, net output (total and by sector), income, consumption, investment, changes in the public service expenses, major agricultural production volume and amount, plant area of major agricultural crops, movement of cultivated land space, land utilisation, forestry and stock-breeding production volume and amount, mining production volume and amount, manufactuing industry production volume and amount, export and import volume and amount by item, number of vehicles registered and vehicles in use by type, inland transportation volume (person and cargo), etc. In order to analyse correlation among these items, a simple correlation matrix among the economic and industrial indices was made and examined to grasp quantitative relationship among each item. Later, qualitative considerations were given and future estimation was carried out utilising multi-variable analysis (principal component analysis, multiple regression analysis and etc.) and other methods.

Furthermore, the estimated values were corrected through multi-stage examination from macroscopic viewpoint (comparison with nearby Southeast Asian countries, balance of demand and supply, etc.) and from microscopic viewpoint (unit analysis such as harvest per unit, labour productivity etc.).

Fig. 2-6 shows the chain relationship among the economic indices in Burma. The secondary and tertiary industries were developed based on the primary industries, which represents the development process of Burmese national economy, namely the resulted expansion of trade scale and the relaxation of import restriction.

Future forecast was made based on the chain relationship shown in Fig. 2-6 and utilising the methods shown in flow chart of Fig. 2-5.

### 2.3.2. Future Population Forecast of Whole Burma

Future forecast of the population in whole Burma was carried out in accordance with the flow chart shown in Fig. 2-7. The annual change of the population in last 10 years (1962 - 1972) is almost linear (correlation coefficient of year to year change: 0.9987), and it is expected to follow the same pattern in the future. However, the ratio against the previous year (1961 - 62: 2.07 %, 1972 - 73: 2.38 %) is inclined to increase from year to year. It seems, therefore, unreasonable to apply the past linear pattern of population increase for future growth considering the pyramid type break down of the population by age and the diffusion of birth control.

The future population was therefore forecasted based on geometric and arithmetic analyses of the past pattern in the whole country and in each state as well as with reference to the forecasted figures provided by UN and other organizations.

### 2.3.3 Future Forecast of Major Product

#### 2.3.3.1 Agricultural Product

The production volume was forecasted for 6 items (paddy, groundnut, sesame, cotton, pulses and maize seed) which were considered to be the most important crops.
Basic idea is shown in flow chart of Fig. 2-8.

For the recent five or six years, the production followed stable gradual increase pattern almost for any product. Therefore, the growth in the same pattern was assumed for a certain period in the future.

For later long-term trend, increasing production based on the following factors were also assumed.

- (a) Promotion of irrigation
- (b) Introduction of high yielding varieties as well as the increase of unit yield with the progress of technology
- (c) Demand growth
- (d) Importance of agricultural products as one of key industries

The results of estimation by crop are shown in Table 2-7 and Fig. 2-9.

Table 2-7 Future Agricultural Production of Whole Country

Unit: 1,000 tons

| Fiscal Year / Item | 1974 | 1978 | 1983 | 1988 | 1993 | 2003 | 2012 |
|---|---|---|---|---|---|---|---|
| Paddy | 8,411 | 8,846 | 9,861 | 10,994 | 12,293 | 15,525 | 19,372 |
| Groundnut | 551 | 687 | 825 | 1,003 | 1,187 | 1,583 | 2,000 |
| Sesame | 114 | 124 | 133 | 150 | 164 | 207 | 256 |
| Cotton | 49 | 59 | 70 | 88 | 110 | 172 | 260 |
| Pulses | 348 | 417 | 502 | 624 | 766 | 1,028 | 1,285 |
| Maize Seed | 71 | 87 | 106 | 134 | 165 | 273 | 370 |

### 2.3.3.2 Forestry Production

The basic idea for estimation is shown in the flow chart of Fig. 2-10.

For only teak and hardwood, future trend was assumed based on the following factors:

(a) Rich resources

(b) Increase in felling capacity

(c) Rehabilitation and improvement of transportation facilities

(d) Maintenance of security

(e) Export expansion to introduce foreign currency

If these conditions are satisfied, the production of teak and hardwood is considered to grow greatly in the future.

The results of the estimation are given in Table 2-8.

Table 2-8 Future Forestry Production of Whole Country

Unit: 1,000 tons

| Fiscal Year / Item | 1971 | 1978 | 1983 | 1988 | 1993 | 2003 | 2012 |
|---|---|---|---|---|---|---|---|
| Teak | 362 | 500 | 589 | 701 | 813 | 1,037 | 1,238 |
| Hardwood | 928 | 1,077 | 1,152 | 1,246 | 1,339 | 1,526 | 1,694 |

The forecast of future production volume of mining products could not be carried out because of the lack of information on the deposit distribution, quantity and development plan.

However, if efforts now made for the development of crude oil come to fruition, it is considered to have enough export capacity even after meeting with the domestic consumption demand.

For other mining resources, it is expected to show a trend that the production volume will grow as the demand grows.

### 2.3.4 Forecast of Net Output of Nation and Others

An estimation mainly of net output of the nation and of other economic and industrial indices was carried out from a macroscopic viewpoint. Basic idea of the estimation is shown in the flow chart of Fig. 2-11.

#### 2.3.4.1 Net Output of Nation

Following two cases were assumed in relation to the future pattern of growth:

(a) Past pattern of growth remains unchanged (low rate of growth).

(b) The pattern of growth will gradually reach various levels in other countries in Southeast Asia which have higher rate of growth than Burma. (High rate of growth).

Observing the trend for the last ten years in Burma, both the absolute volume and the rate of growth are considerably low in comparison with those of the other Southeast Aian countries. It is considered that this situation is derived from the peculiar economic system or structure in Burma.

Therefore, it seems reasonable to assume that the growth will follow the past pattern or the pattern (a) for coming few years.

As to the trend in later years, it is assumed the pattern (b) or the new development stage other than the past pattern due to the coupled effect of positive investments, including foreign investments as seen in 20-Year Plan and of the change in the economic system from closed type to open type. The results of the estimation are shown in Table 2-9.

### 2.3.4.2 Net Output by Sector

The development trend in each sector was grasped by means of the following steps based on the macroscopic viewpoint:

(a) Expansion of export capacity based on the development and promotion of basic industries, such as agriculture, forestry, mining, livestock farming, fishery, etc.

(b) Promotion of manufacturing industry based on the expansion of the export capacity expressed in item (a).

(c) Development of service industry resulting from the progress of primary and secondary industries.

Thus, the percentage of primary industry in the net output of the nation is large at early stage, but it is expected that the difference between primary and manufacturing industry will gradually decrease as far as resulting in a complete turning point of the economic structure.

The results of the estimation are shown in Table 2-9.

### 2.3.4.3 Percentage of Employment

With the progress of various industries, the scale of employment will naturally be enlarged. Here, the population and percentage of employment were forecasted mainly based on the following factors:

(a) Future economic development pattern

(b) Progress in labour productivity

(c) Changes in working population by age

Results of the estimation are shown in Table 2-10.

Table 2-9 Estimated Net Output of Nation and by Sector

(At Constant Price of 1969 - 70) Unit: 100,000 Kyats

| | 1974 | 1978 | 1983 | 1988 | 1993 | 2003 | 2012 |
|---|---|---|---|---|---|---|---|
| Net output of the nation | 114,586 | 130,477 | 148,571 | 179,070 | 215,954 | 343,654 | 560,823 |
| Agriculture | 30,743 | 34,761 | 39,436 | 46,964 | 56,382 | 76,389 | 103,024 |
| Livestock & Fishery | 9,121 | 10,919 | 12,809 | 15,976 | 19,753 | 26,315 | 34,751 |
| Forestry | 2,933 | 3,207 | 3,525 | 4,147 | 4,883 | 6,085 | 7,551 |
| Mining | 1,948 | 2,490 | 2,965 | 3,614 | 4,417 | 6,074 | 8,086 |
| Processing & Manufacturing | 13,180 | 15,467 | 18,252 | 22,403 | 27,442 | 46,768 | 84,455 |
| Power | 859 | 1,091 | 1,380 | 1,927 | 2,518 | 4,292 | 7,751 |
| Rental & Other Service | 8,454 | 9,565 | 10,989 | 13,726 | 16,865 | 28,741 | 51,903 |
| Construction | 2,076 | 2,408 | 2,748 | 3,280 | 3,946 | 7,056 | 12,742 |
| Trade | 26,162 | 28,162 | 30,061 | 33,058 | 37,220 | 65,157 | 117,663 |
| Transportation | 6,432 | 7,189 | 8,043 | 9,653 | 11,579 | 20,708 | 31,645 |
| Communication | 339 | 382 | 426 | 501 | 594 | 1,012 | 1,827 |
| Financial Institution | 1,483 | 1,709 | 1,945 | 2,328 | 2,806 | 4,781 | 8,635 |
| Social & Administrative Service | 10,856 | 13,127 | 15,992 | 21,493 | 27,549 | 50,276 | 90,790 |
| Average per Capita Net Output(Kyats) | 371 | 398 | 417 | 451 | 489 | 622 | 818 |

Table 2-10 Estimated Working Population and Percentage of Employment

| | 1974 | 1978 | 1983 | 1988 | 1993 | 2003 | 2012 |
|---|---|---|---|---|---|---|---|
| Working people (Unit: 1000) | 11,675 | 12,752 | 13,928 | 15,552 | 17,365 | 21,889 | 26,977 |
| Percentage of employment (%) | 38.8 | 38.9 | 39.1 | 39.2 | 39.3 | 39.6 | 39.4 |

## 2.3.5 Future Forecast of Number of Vehicle in Use by Type

Reviewing the past trend in conjunction with the number of vehicles in use, it is shown that the pattern of very stable rising pattern when viewed in time series, and further, hand in hand with the economic development, despite of import restriction, the domestic productivity may be safely predicted of its steady increase by means of a step-by-step basis.

Therefore, in this report, the number of vehicles in use by type was estimated by means of correlation analysis of net national product and other economic indices.

To induce the estimation of the number of vehicles in use, there are two cases to be taken into consideration:

1) When the current policy of import restriction may be continuously adopted throughout the coming years
2) When the import restriction may be partially relaxed in the gradual pace and in the end, at a certain time in future, be totally made free to import

But the time of such relaxation of import restriction is largely dependent upon the Government policy, thus it is very hard to predict the time when such relaxation may be put into effect.

As the circumstances are as such, approach with the aid of analysis methods for economy or industry is highly difficult to predict the time of relaxation of import restriction.

Taking the above-stated situations, this report takes up, for its basis of analysis, a few cases as follows:

1) The import restriction may continue to a certain extent.
2) The relaxation of import restriction is expected to start from 1978 and 1988.

With these given premises, the number of vehicles in use is computed repeatedly by considering various circumstances that may arise, and the results thus obtained are carefully reviewed for the traffic demand and concurrence whether they actually reflect the Burmese traffic situations or not.

To add this, correlation analysis of the compositional percentage of vehicle types and the related economic indices has been conducted, applying considerations toward the domestic conditions of Burma, in order to presume the future pattern of vehicle types and, as a result, the reviewing data and information for the estimation values of the number of vehicles in use are finally obtained.

These individual estimation values have undergone for many phases of comprehensive evaluation and they gave the resulting estimated values as indicated in the Table 2-11 representing the number of vehicles in use for the future.

For reference, the number of vehicles by type only illustrates the estimation of the future traffic volume; to make the matters more concrete, the number is merely utilized for the purpose of review of the estimated value of future traffic volume availing Z-craft as well as for the evaluation of the balance of passengers those who use the bus transport via bridges under planning and other transport means. Besides, the sensitivity given to the benefit of those estimated values is said to be small.

Table 2-11. Future Number of Motor Vehicle in Use by Type

Unit: 1,000 Vehicles

| Year / Type | 1974 | 1978 | 1983 | 1988 | 1993 | 2003 | 2012 | 2012/ 1974 |
|---|---|---|---|---|---|---|---|---|
| Car | 18.9 | 19.8 | 24.4 | 29.6 | 39.4 | 79.7 | 174.6 | 9.2 |
| Bus | 7.5 | 8.3 | 9.3 | 10.8 | 13.4 | 24.7 | 44.9 | 6.0 |
| Lorry | 23.2 | 26.7 | 30.6 | 37.5 | 45.8 | 75.3 | 127.4 | 5.5 |
| Others | 23.6 | 24.8 | 26.2 | 28.4 | 34.1 | 61.1 | 101.1 | 4.3 |
| Total | 73.2 | 79.6 | 90.5 | 106.3 | 132.7 | 240.8 | 448.0 | 6.1 |

Notes: 1. "Others" include motor-cycle, jeep, station wagon, van and three-wheeler.

2. The above estimated values are exclusive of military automobile, tractor for agricultural use and special automobiles.

## 2.4 Forecast on Direct Influence Area in Case without Bridge

### 2.4.1 Outline

Forest resources are rich in the west side of the direct influence area. In lower Burma, the agricultural production especially that of paddy is large. It is desirable to estimate the future of direct influence area based mainly on the data of the area itself since the area has its own territorial characteristics. However, the available data obtained from the Planning Department, the Ministry of Planning and Finance were only for fiscal year 1973/74, which were not sufficient to forecast independently the direct influence area. For this reason, the forecast had to be carried out based on the national figures and the data of the each of 14 states. However, since the data at state level lacked in balance with national tendency, the forecast had to be based mainly on national figures and later be checked qualitatively and quantitatively with reference to the data of each state. About 240 major economic and industrial indices such as production and consumption by industry by commodity, population, land utilisation and others were selected for the direct influence area judging from the obtained data, and about 100 of the same were selected at state level. Correlation analysis and multi-variable analysis were carried out for the direct influence area, the east side, the west side and at state level in order to establish correlation among each economic and industrial index.

Future population and the output by sector were estimated based on the results of the above analysis. The future population was estimated based on 1973 population census reflecting upon the trend of future estimation of whole country population, and was checked quantitatively and qualitatively with the current population in the direct influence area and in each state.

The output by sector was also calculated through the multiplication of forecasted population by production base unit based on the correlation between economic and industrial indices reflecting upon the territorial characteristics of the direct influence area and of each state. The resulted figures were checked with current output to obtain the forecast figures.

### 2.4.2 Estimation of Future Population of Each Region

Future population of each region in the direct influence area in the case without the bridge was worked out from breaking down the future population estimated at nationwide level, reflecting upon the population census in 1973 because of the following two reasons:

1) Available data on population at region level were limited to a single fiscal year 1973/74, which made it impossible to estimate independently the future population in the direct influence area.
2) Although year to year population data were available at state level, they seemed not to be compatible with the nationwide data.

Results of the estimation for each region are shown in Fig. 2-13.

### 2.4.3 Estimation of Production by Sector in Each Region

Base unit analysis was carried out according to the flow chart of Fig. 2-14. The production volume by sector was obtained by multiplying the base unit with the future population in each region.

Base units were obtained from the results of production volume by sector and future population at nationwide level which had been given utilising multi-variable analysis and other statistic analysis as described before, and later checked qualitatively and quantitatively comparing them with the data of other countries in Southeast Asia.

Estimation flow chart of future population and the production volume by sector is shown in Fig. 2-14.

The aggregate volume of the major agricultural and forestry production in seven regions is shown in Fig. 2-15.

## 2.5 Development Effect due to Construction of Bridge

The development effects herein stated do not mean the direct effects, namely the benefits given to those who utilise the bridge directly, but the indirect effects, namely the development effects that would have been caused by the new investments to the various sectors of industry as the consequence of construction of bridge.

If the bridge would not be constructed, the economic resources such as land, forestry resources and the like, that would have never been utilized or utilised in an incomplete manner, will give the net effects to the direct influence area depending on a newly initiated economic development or a concentrated utilisation of the economic resources through the improvement of transport system, rearrangement of labour force and population (concentration to the direct influence area) which may be triggered by the construction of new bridge.

These development effects may be reviewed qualitatively, but the quantitative review and analysis based upon such very little data or information available will be difficult.
Even the given data or information is well ordered, the quantitative analysis of development effects is not very easy.
Theoretically, an overall picture illustrating the directly extended effects upon agriculture, forestry and mining industries, and the secondary and tertiary effects derived from the directly extended effects can be drawn. But, in practice, quantitative tracing of the effects from the primary to secondary, secondary to tertiary effects, in other words, the chain reaction effects, is not easy. Even from such insubstantial quantitative analysis, it would be not so easy to draw the line between the benefits directly attributable to the investment in the bridge and those attributable to investments in those other than the bridge. For the sake of convenience, there is a method of analysis for the categorisation of benefits derived from the new construction of bridge classified into:

1) Benefits attributable to investment for bridge

2) Benefits attributable to other investments

The practical method for classification of benefits mentioned above is to use percentage of the investment, namely:

1) Quantity of investment in bridge

2) Quantity of investment in other socio-economic projects

However, what might be obtained through this kind of analysis gives only little reliability.

Furthermore, this method is based on the premise that the benefits derived from unit quantity of investment is always the same without relation to the quality of investment, so that its validity is very limited.

The benefit accruing to the directly influenced area through the construction of bridge, viz., the increased net output, may contain the simply transferred increase of the net output that would have been caused by the investment to the other sectors or regions if the bridge would not be constructed.

It is not easy from the theoretical viewpoints to separate net output increase from total net output increase resulting from the construction of bridge.

Considering difficulties of measuring or analysing development benefit, quantitative analysis is to be abandoned. However, attempts have been made to obtain a quantitative analysis simply for reference purposes.

The outline of the quantitative analysis is described as follows: Of the directly related areas, the districts of lower Burma, such as Henzada and Tharrawaddy regions and the eastern regions of the Irrawaddy are comparatively more developed than the western regions of the Irrawaddy in the viewpoint of industry and economy. Therefore, the regional difference in the economic development, especially the difference between the western and eastern regions of the Irrawaddy, has been noted and taken as the basis of review.

Thus, the case of socio-economic development, which will be brought into the relatively under-developed western region of the Irrawaddy through the introduction of new bridge to connect the region to the developed eastern region, has been carefully studied.

For the numerical analysis, the economic difference in the form of the net output in both cases, has been indicated:

1) With bridge

2) Without bridge

For accurate analysis, it is desirable to utilise the economic indices of respective regions under review, but little or no information related to regional net output was available. Therefore, population density of respective regions was adopted as a barometer for indicating economic development.

The construction of bridges will stimulate inflow of population into the western region of the Irrawaddy. This population will, in turn, contribute to the development of agriculture, forestry, mining and industries. These developed primary industries will then stimulate the directly-correlated industries, viz., commerce and transportation sectors of industry.

The measured development benefits are illustrated in 11.5.1.

The analytical measurement has taken much effort and time as well as much trial and error, but circumstances have ultimately not allowed the desired satisfactory and reliable results of analysis. Thus the analysis of the development benefits given herein may suffice only for reference.

The development effects in the qualitative method will be reviewed as follows.

The development effects due to the construction of bridge, as illustrated in Fig. 2-16, are derived not only from the direct benefits such as saving of vehicle operating cost and time saving, but also from the effects stimulated through the development of agricultural, forestry, mining and manufacturing industries. Especially, the industrialisation programmes currently under progress in the western region of the Irrawaddy may be accelerated.

Benefits arising from industrial development are as follows:

1) Development of material for manufacturing industry

2) Rationalised distribution system

3) Increased employment opportunity

4) Raising of professional skill learned in manufacturing

industry and development of related industry through the inflow of experienced and skilled man-power

5) Effective utilisation of domestic resources
6) Saving of foreign currency through progress of import substitute industries
7) Raising of economic level through development of export-oriented industries
8) Multiplying effects and stimulating effects toward related industries with the concentration of the manufacturing industries into the western region of the Irrawaddy

In order to realise the industrial development, as well as the various latent effects derived from the above-mentioned industrial development, better and effective rearrangement of the infrastructure comes to be of primary importance, especially the construction of bridge across the Irrawaddy which hitherto played the role of natural barrier to obstruct the smooth and easy traffic of east west communication.

When the development of the western region of the Irrawaddy is thought to be based on the construction of bridges, the investments in agricultural, forestry, mining and manufacturing industries combined together with the construction of bridges can progress the industrial development.

The proposed site of the construction of bridge, Prome, is one of the most important junction of commodity distribution between west and east regions of the Irrawaddy and also between upper and lower Burma.

When the bridge is completed at the proposed site in Prome, the comparatively developed south-north flow of commodities may be dispersed to east-west. Thus the latent socio-economic potentiality of the underdeveloped regions will be actualised thanks to the improved traffic capacity of the east-west route.

When the proposed bridge is accomplished, the main highway which runs throughout the community centres, Sandoway-Taungup-Sinde-Prome-Toungoo, will then be effectively connected, and the flow of commodities that would have previously been brought down once to Rangoon and then distributed to Sandoway, Akyab and other localities by means of the marine transport crafts, may be directed along the shortest-cut route from Prome to Sandoway across the Irrawaddy.

This new route will enable the lower transport cost, highly rationalised commodity distribution system and other factors to achieve the desirable effects from the national economy's viewpoint.

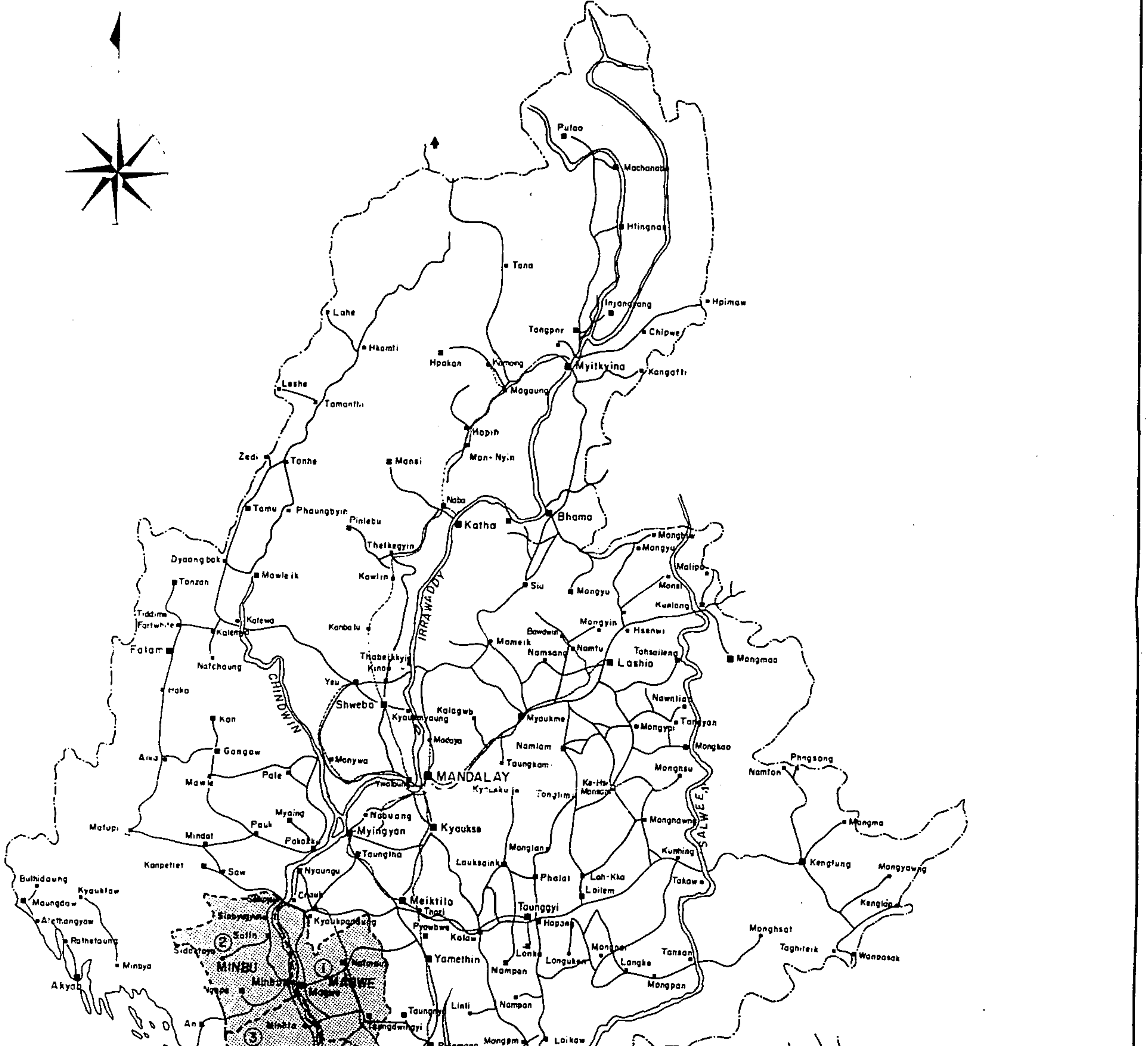
However, to achieve the full effects of the construction of bridge, it is desirable to realise a series of the following construction works:

1) Improvement of horizontal and vertical alignment, widening and paving for the mountainous portion of the Sandoway-Taungup-Sinde Road.
2) Construction of bridges across the small and medium-sized rivers where the ferry-baots are currently the only means to cross the river
3) Improvement and renovation of the related roadways in the east and west regions of the Irrawaddy

It is considered that the construction of bridge across the Irrawaddy is highly necessary from the viewpoint of the national economy. This particular project calls, however, for the enormous investment. It is absolutely indispendable to re-evaluate this project after taking careful considerations into the investment effects of the other important projects when the same amount is invested in them and also considerations into relations of this project and others. Furthermore, it is desirable to consider the profit, or opportunity cost attributable to other projects which would be cancelled as the Irrawaddy Bridge Project would be chosen.

In evaluating this project, not only the economic side but also the much more overall side of positioning in the technical, management, finance, organization and national development planning, as well as environmental and social phases should be reviewed as far as possible.

Fig. 2-1 BRIDGE CONSTRUCTION SITE AND TRANSPORT NETWORK



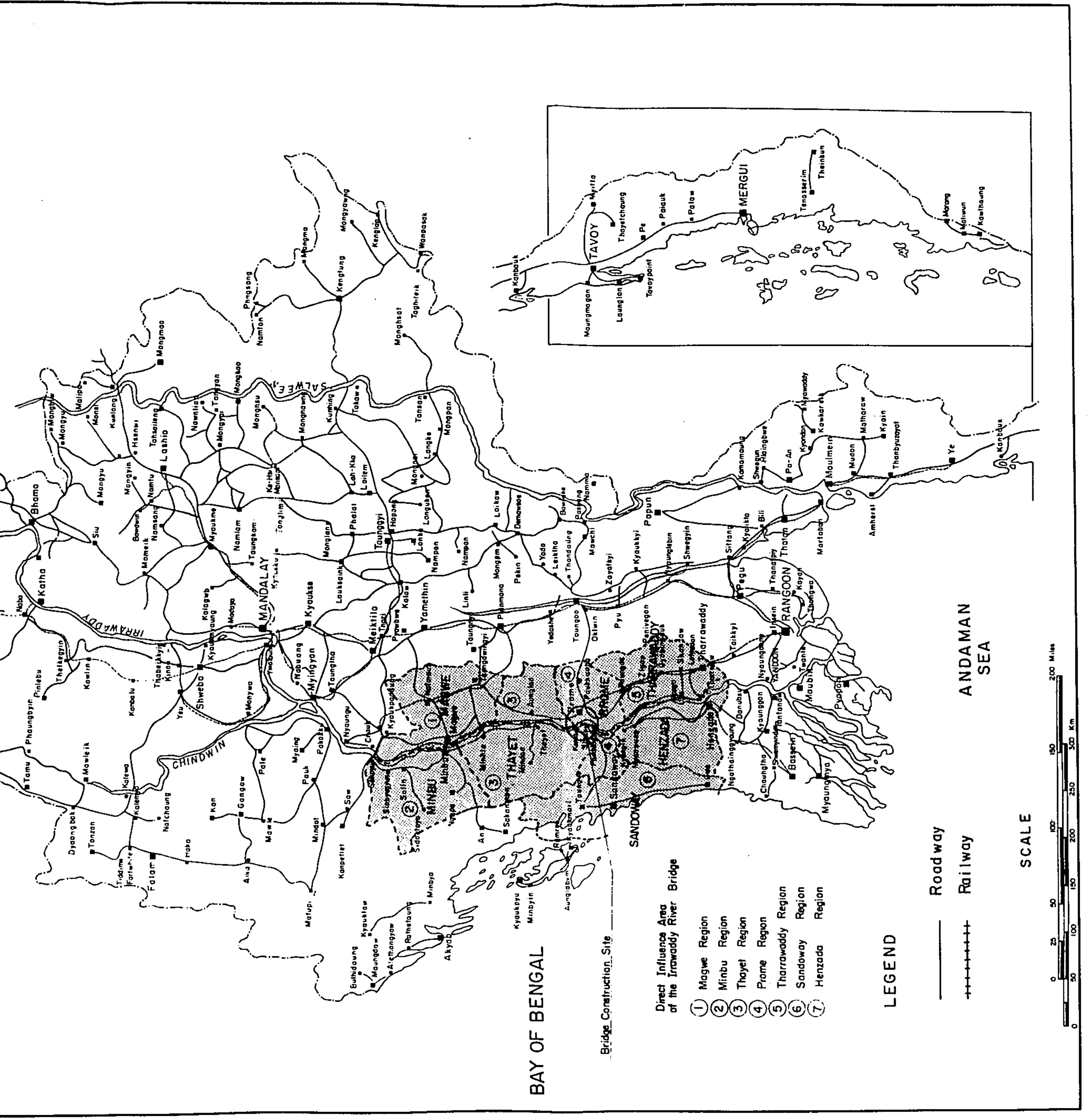

BAY OF BENGAL
ANDAMAN SEA
LEGEND
Roadway
Railway
SCALE
0 25 50 100 150 200 Miles
0 50 100 150 200 250 300 Km
Direct Influence Area of the Irrawaddy River Bridge
① Magwe Region
② Minbu Region
③ Thayet Region
④ Prome Region
⑤ Tharrawaddy Region
⑥ Sandoway Region
⑦ Henzada Region
Bridge Construction Site
MANDALAY
RANGOON
MERGUI
TAVOY
SANDOWAY
MAGWE
MINBU
THAYET
PROME
THARRAWADDY
HENZADA
IRRAWADDY
CHINDWIN
SALWEEN
Bhamo
Katha
Lashio
Taunggyi
Meiktila
Myingyan
Shwebo
Kengtung
Moulmein
Bassein
Akyab
Falam
Pegu
Toungoo
Thaton

Fig. 2-2 CONSIDERATION FLOW OF REGIONAL ECONOMIC SURVEY

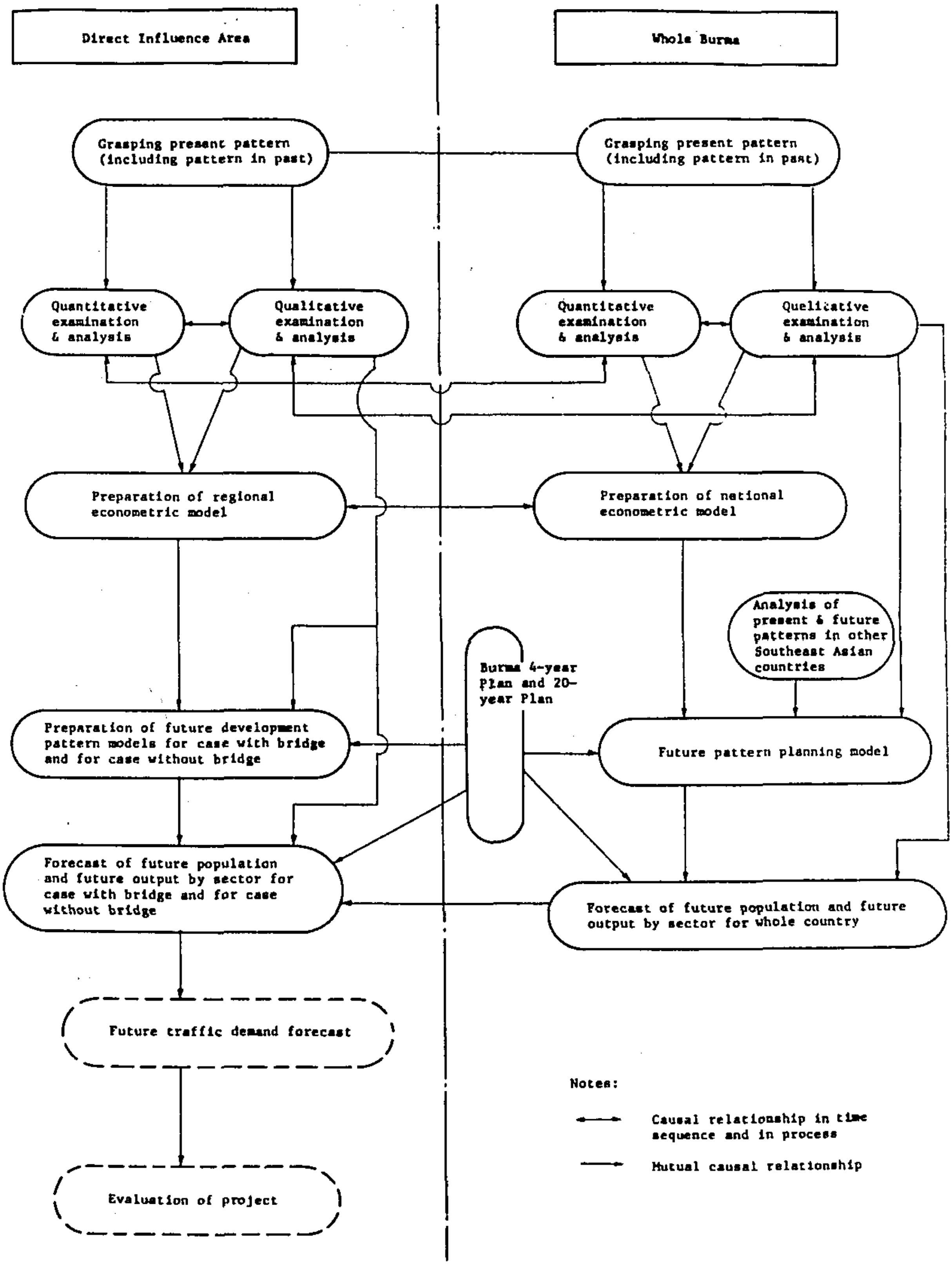


Fig.2- 3 LAND UTILISATION OF 7 REGIONS
——— TOTAL LAND STOCK ——— (YEAR 1971-72)

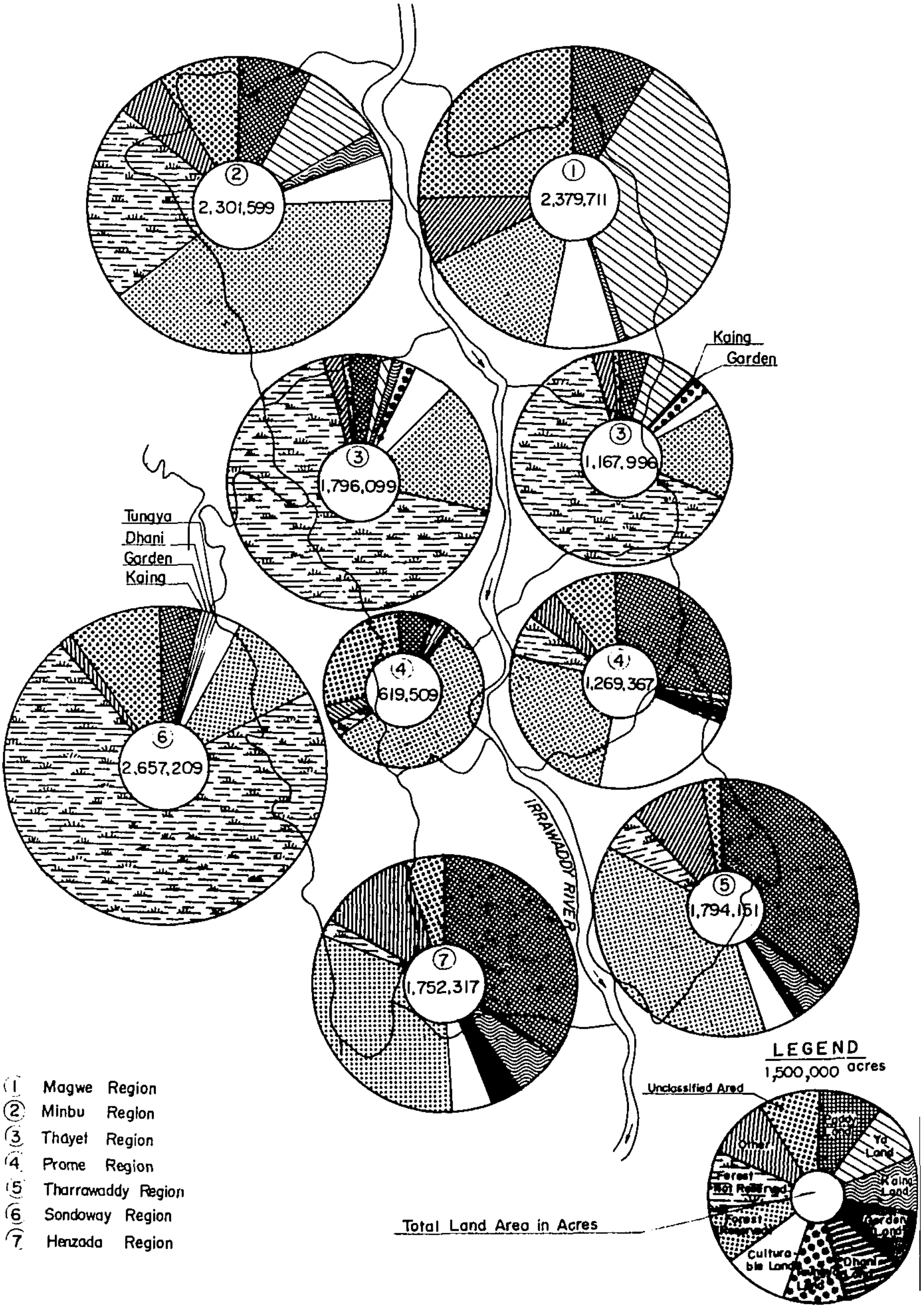


Fig.2- 4 LAND UTILISATION OF 7 REGIONS
——— AREA OCCUPIED ——— (YEAR 1971-72)

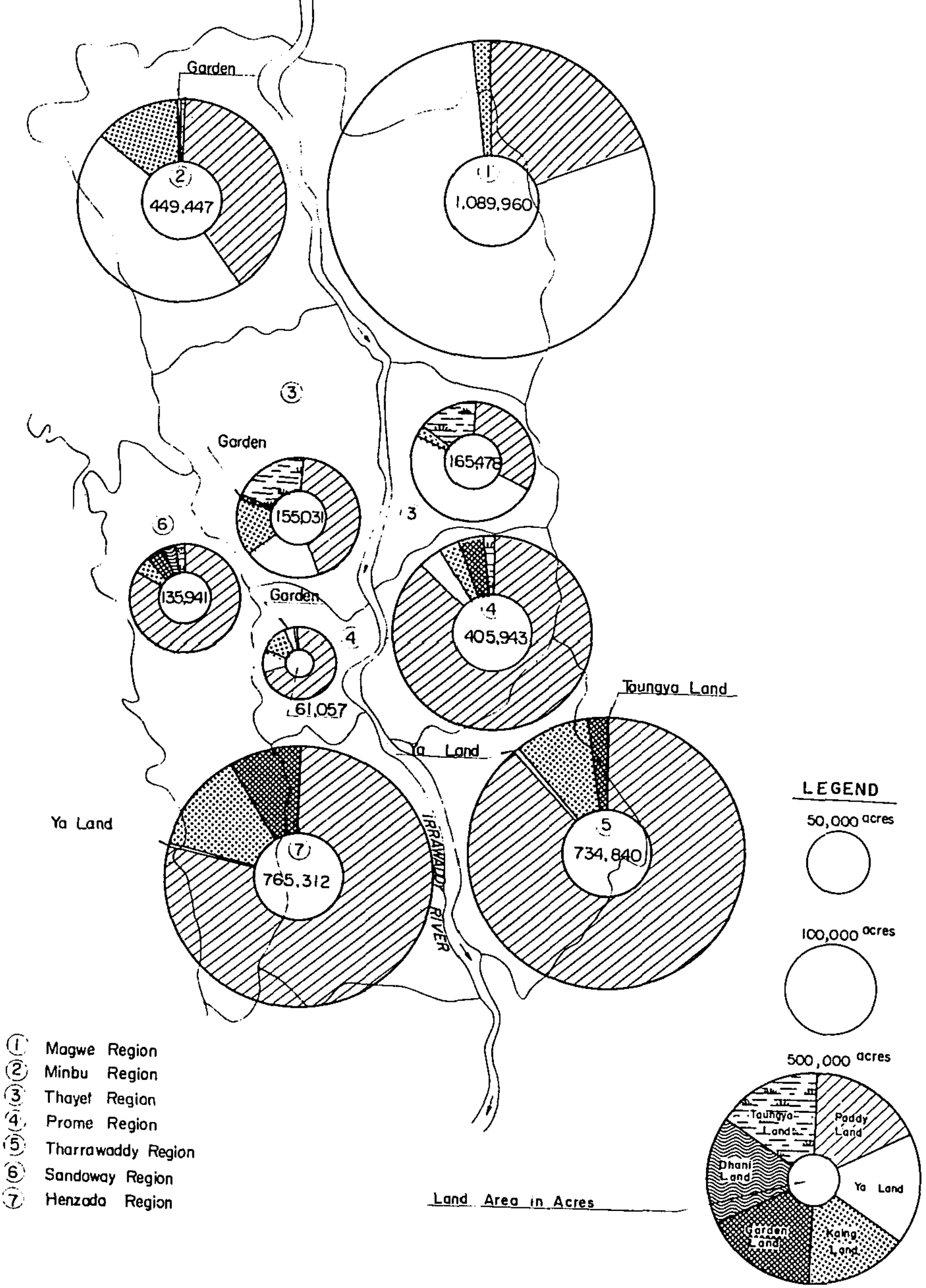


Fig. 2-5 FUTURE ESTIMATION FLOW CHART OF WHOLE BURMA (CASE WITHOUT BRIDGE)

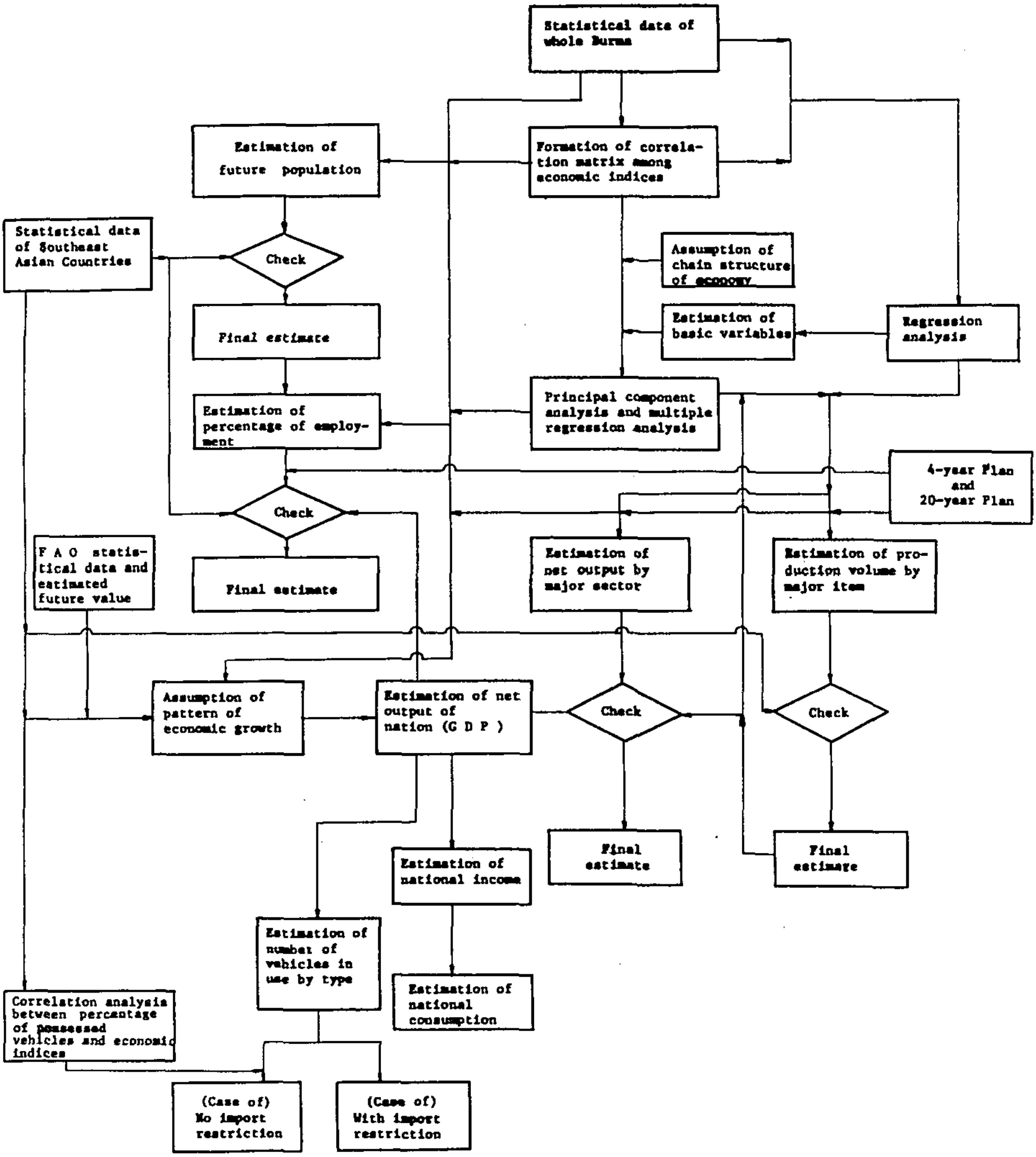


Fig. 2-6 ASSUMPTION ON ECONOMIC STRUCTURE OF BURMA IN FORECASTING PURPOSE

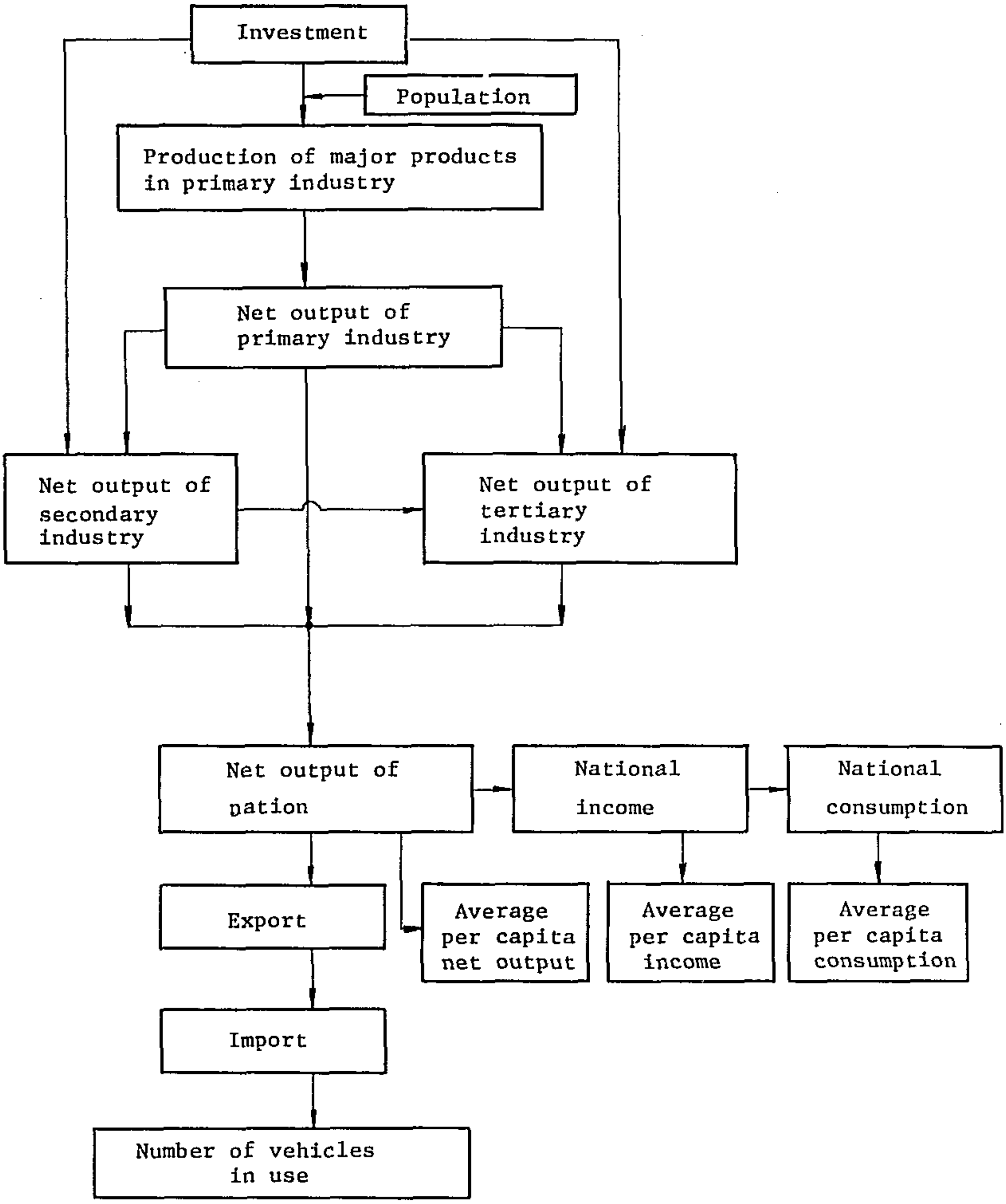


Fig. 2-7　FLOW CHART OF FUTURE POPULATION ESTIMATION

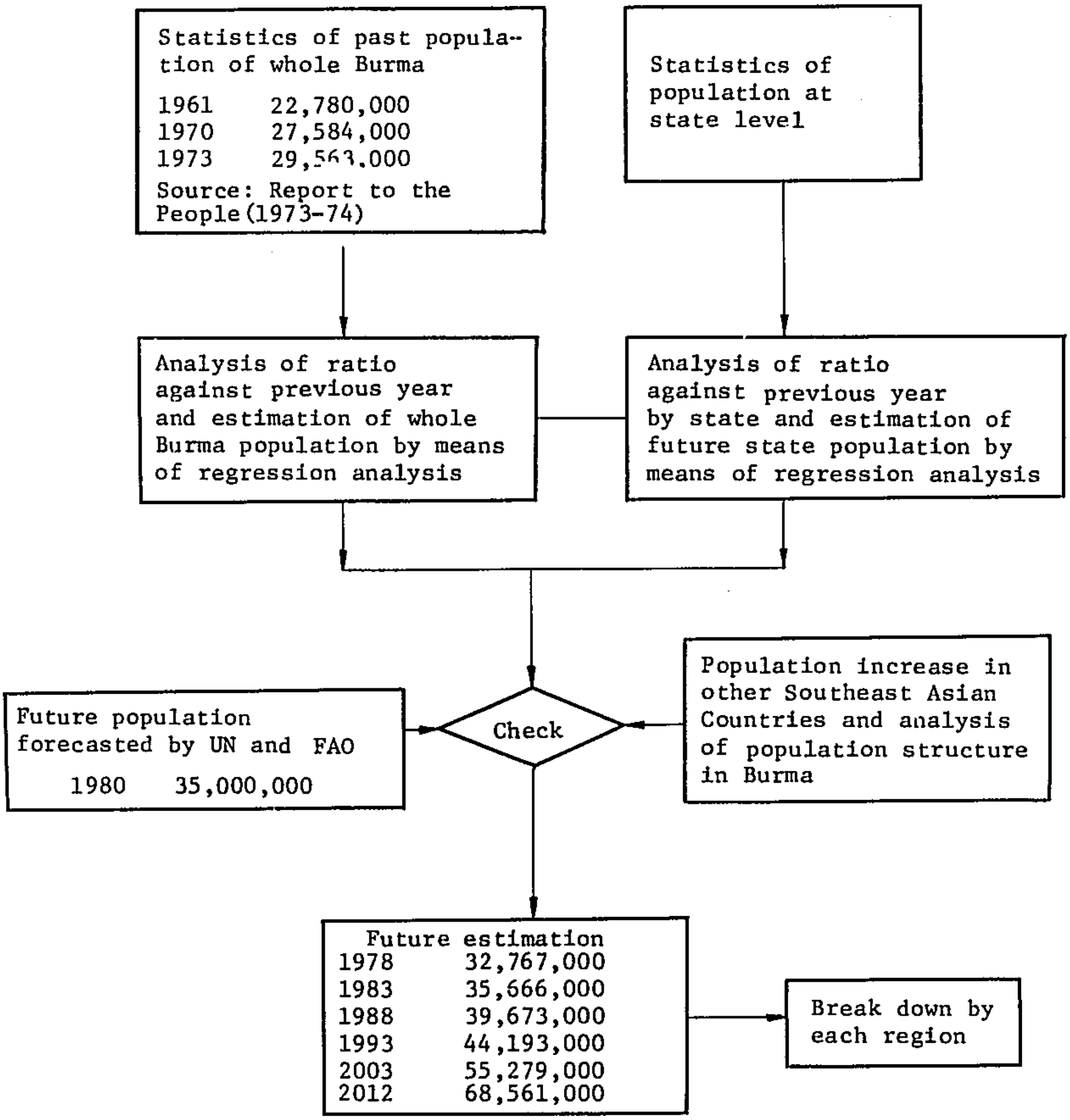


Fig. 2-8 FORECAST FLOW OF PRODUCTION OF AGRICULTURAL PRODUCTS

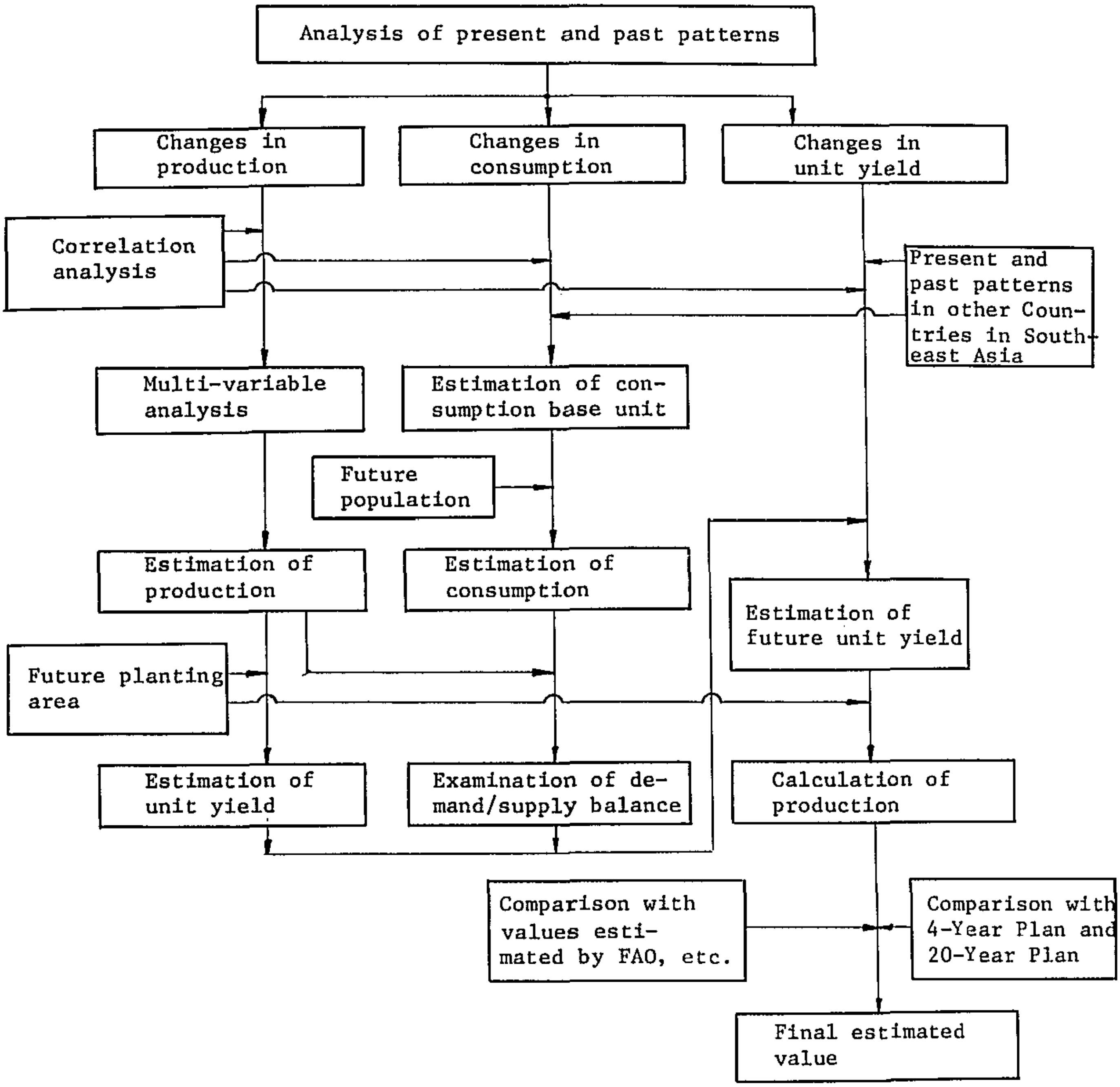


Fig. 2- 9 ESTIMATE OF AGRICULTURAL PRODUCTION OF WHOLE COUNTRY

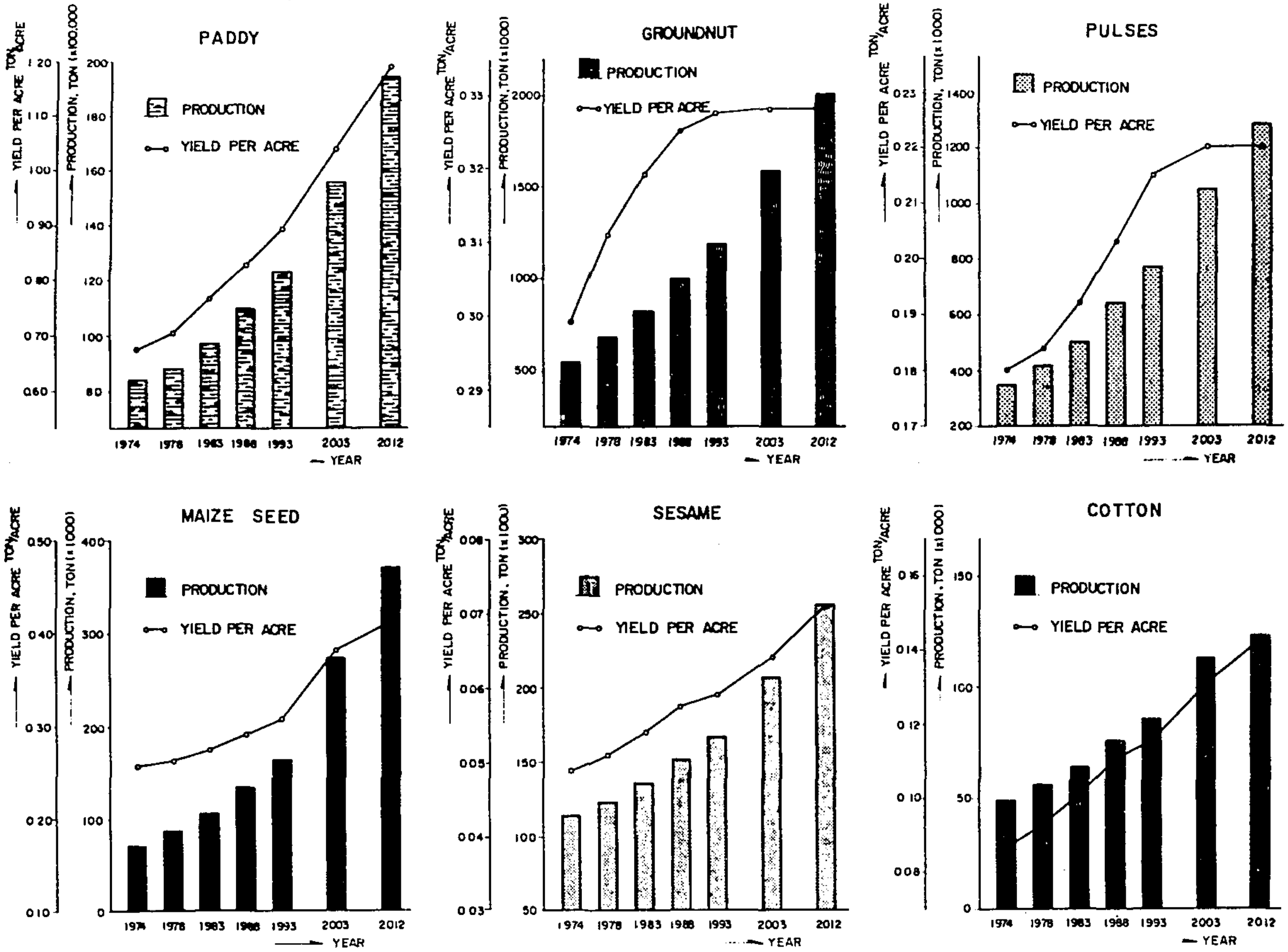


Fig. 2-10 FORECAST FLOW OF FORESTRY PRODUCTS

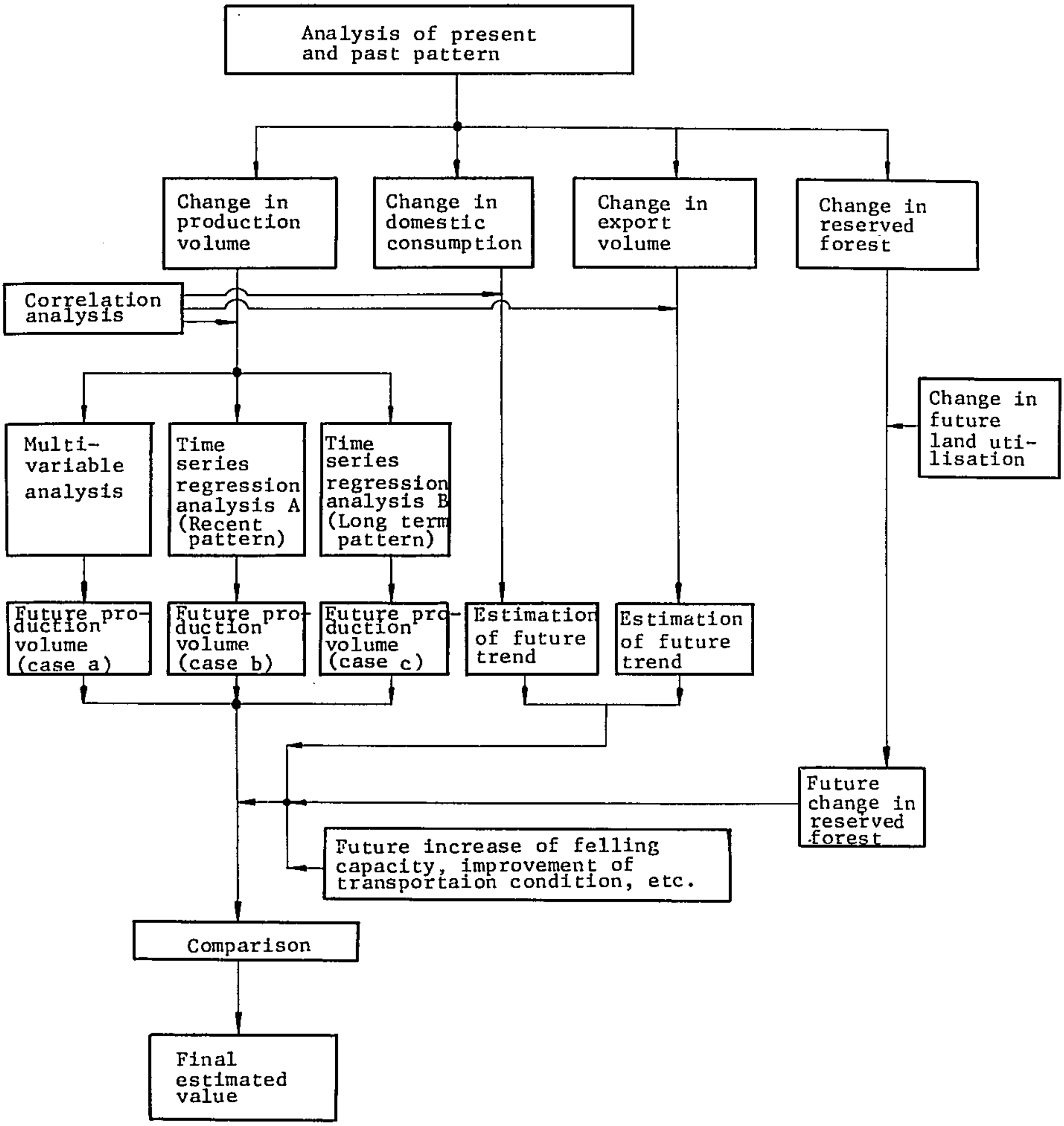


Fig. 2-11 ESTIMATION FLOW OF NET OUTPUT OF NATION AND OTHERS

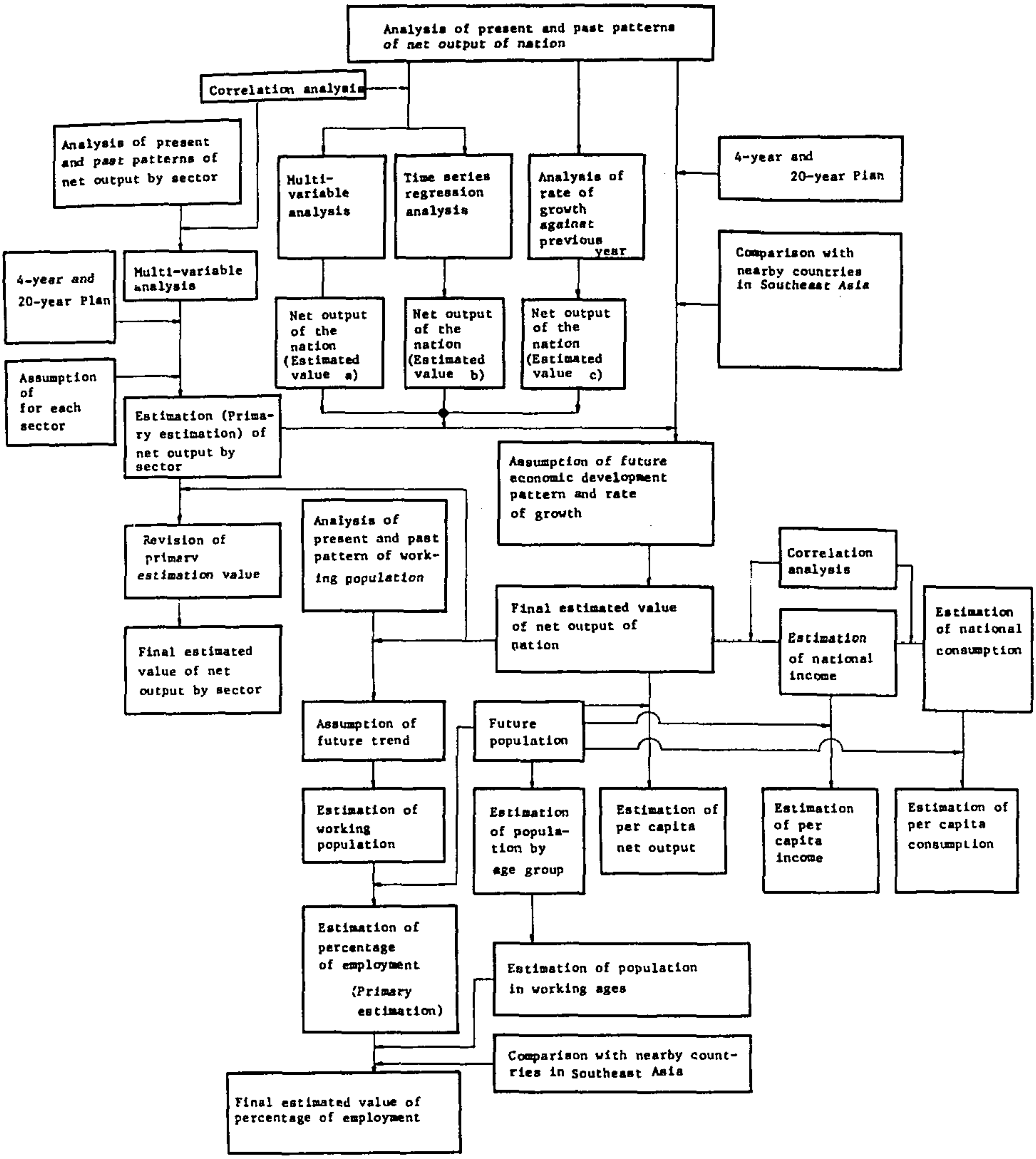
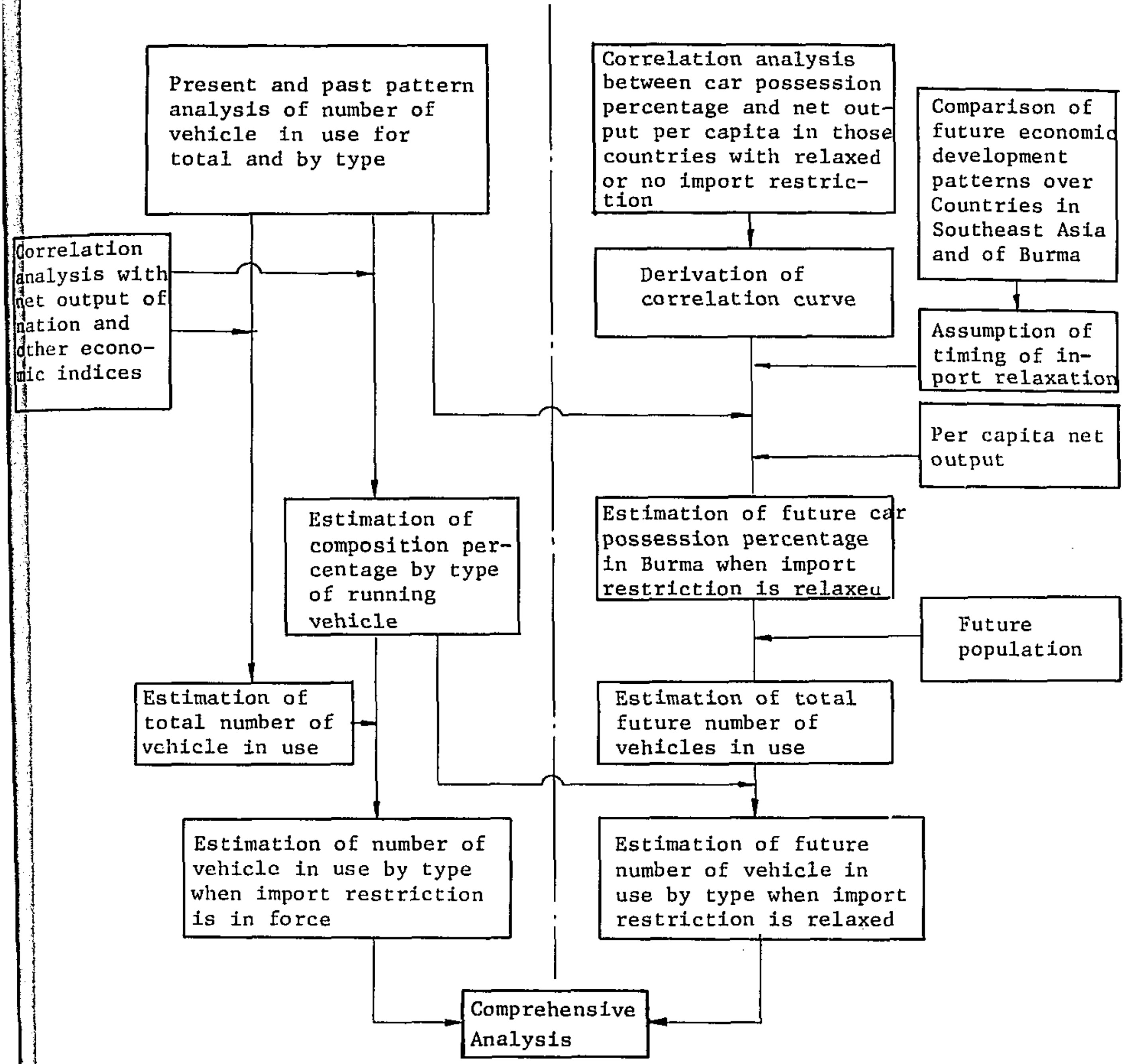
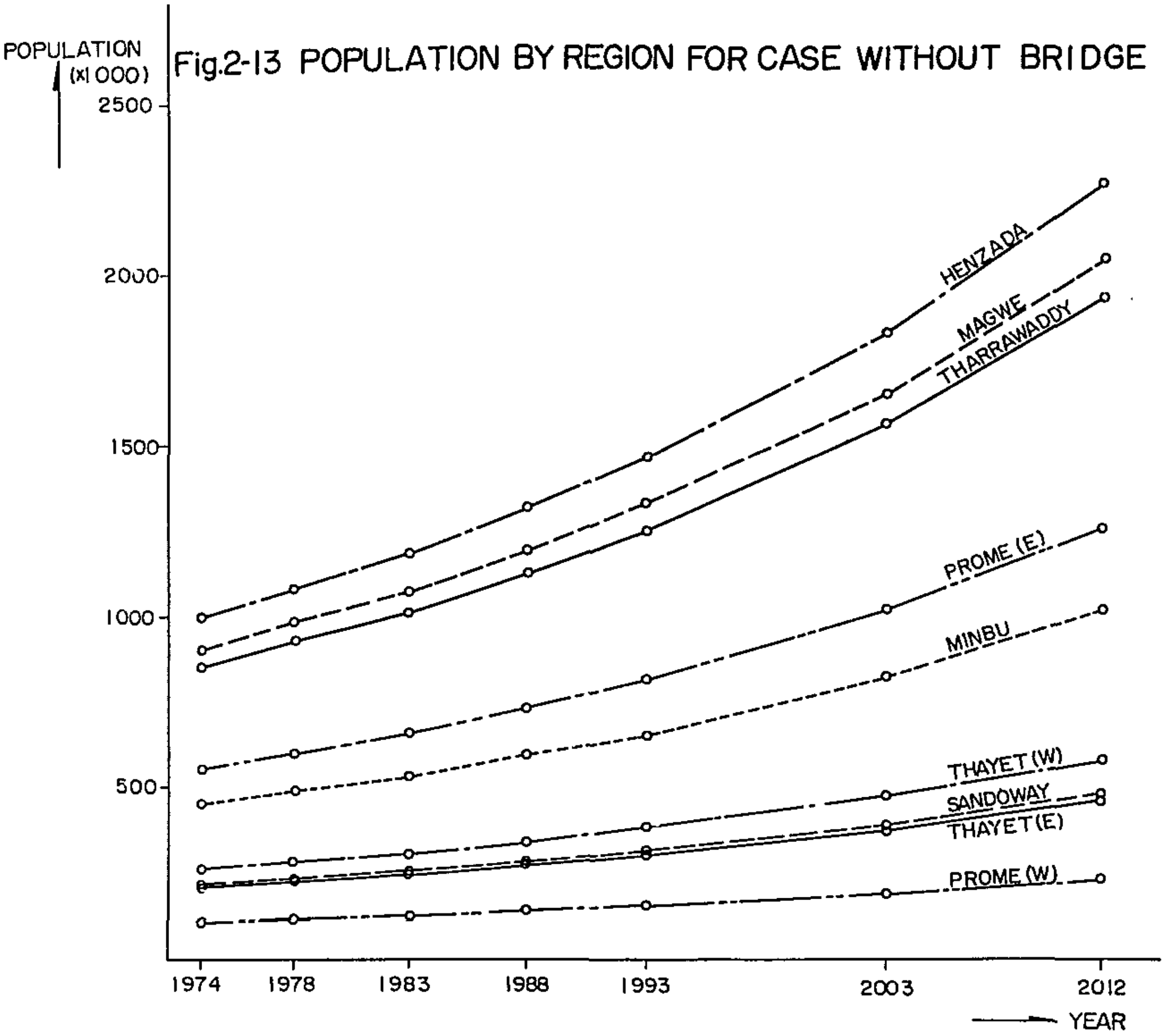


Fig. 2-12 ESTIMATION FLOW OF FUTURE NUMBER OF VEHICLE IN USE BY TYPE



## Fig.2-13 POPULATION BY REGION FOR CASE WITHOUT BRIDGE



Unit : Person

| YEAR / REGION | 1974 | 1978 | 1983 | 1988 | 1993 | 2003 | 2012 |
|---|---|---|---|---|---|---|---|
| MAGWE | 902 600 | 982 800 | 1 069 700 | 1 189 800 | 1 325 500 | 1 657 800 | 2 056 300 |
| MINBU | 450 300 | 490 300 | 533 700 | 593 600 | 652 200 | 827 100 | 1 025 900 |
| THAYET (E) | 207 900 | 226 400 | 246 400 | 274 100 | 305 400 | 381 900 | 473 700 |
| THAYET (W) | 258.300 | 281 200 | 306 200 | 340 500 | 380 200 | 474 400 | 588 300 |
| PROME (E) | 554 600 | 603 800 | 657 300 | 731 000 | 814 300 | 1 018 500 | 1 263 200 |
| PROME (W) | 106 200 | 115 600 | 125 900 | 140 000 | 156 000 | 195 100 | 242 000 |
| THARRAWADDY | 852 200 | 927 900 | 1 009 900 | 1 123 400 | 1251 400 | 1 565 300 | 1 941 400 |
| SANDOWAY | 214 700 | 233 700 | 254 400 | 283 000 | 315 300 | 394 200 | 489 000 |
| HENZADA | 996 200 | 1 084 600 | 1 180 500 | 1 313 200 | 1462 600 | 1 829 600 | 2269 100 |
| TOTAL | 4543 000 | 4946 300 | 5 384 000 | 5 988 600 | 6662900 | 8 343 900 | 10348 900 |

Fig. 2-14 ESTIMATION FLOW OF POPULATION AND PRODUCTION VOLUME BY SECTOR WITHOUT BRIDGE

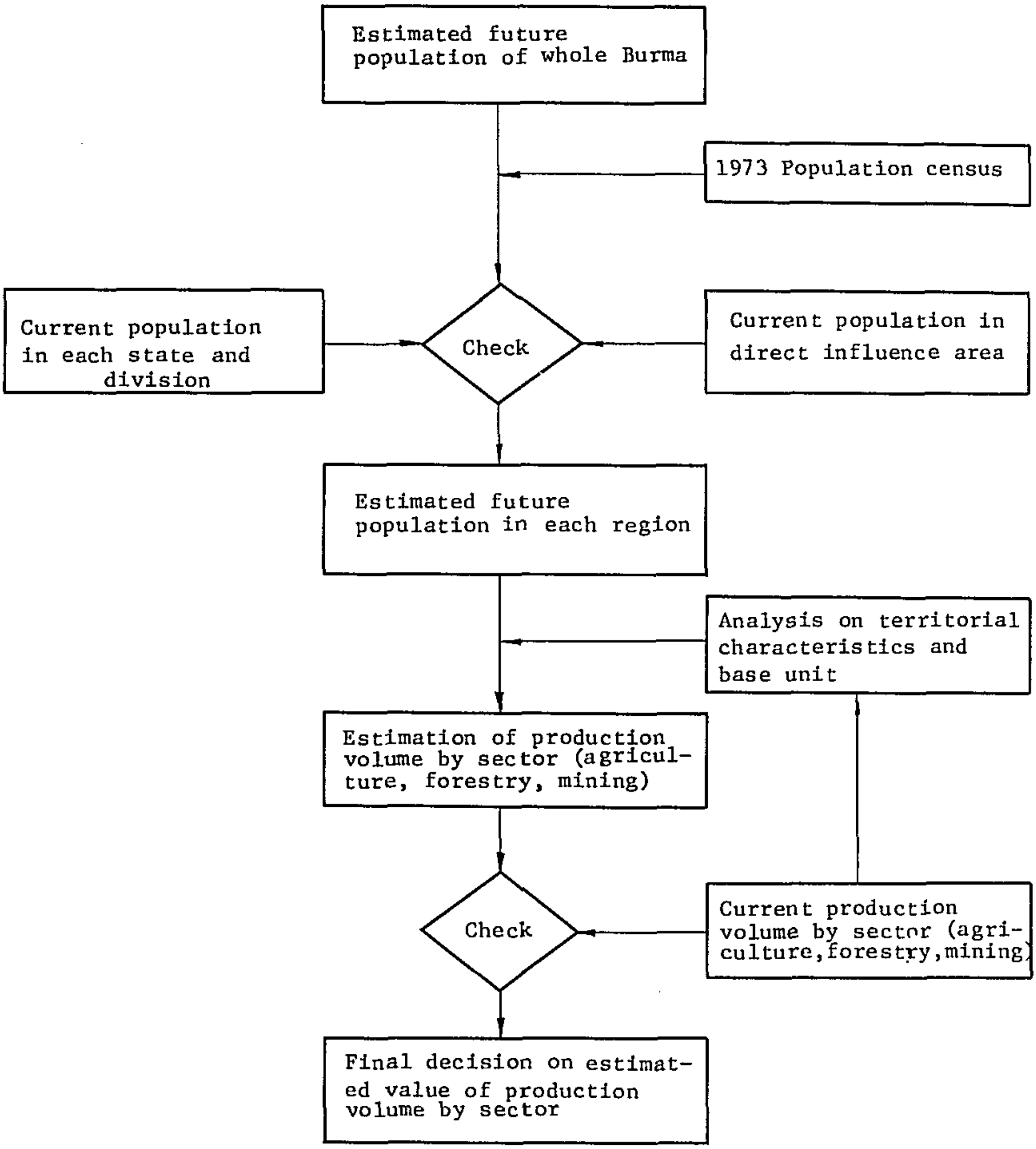


Fig. 2-15 ESTIMATE OF AGGREGATE VOLUME OF MAJOR AGRICULTURAL AND FORESTRY PRODUCTS IN 7 REGIONS

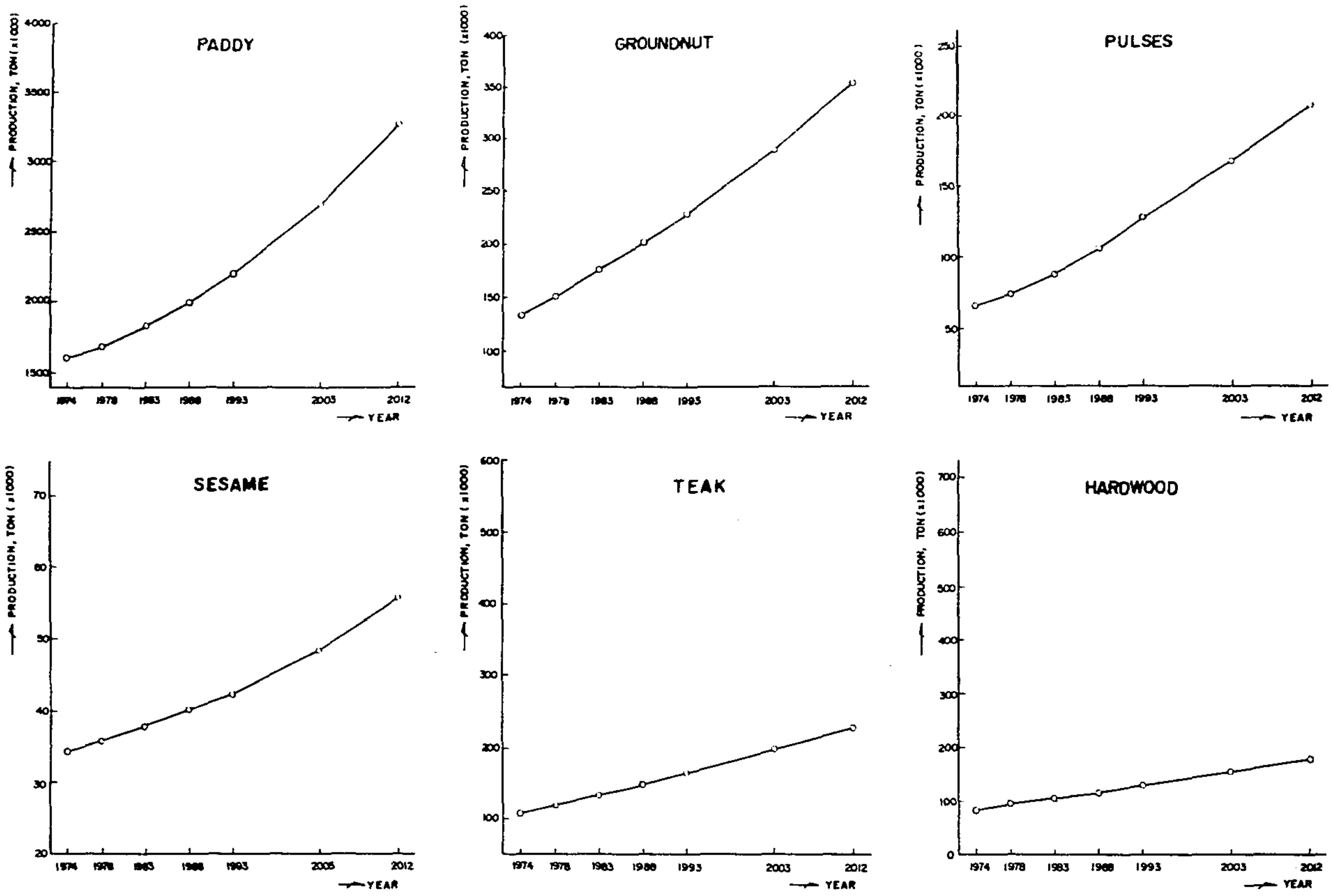
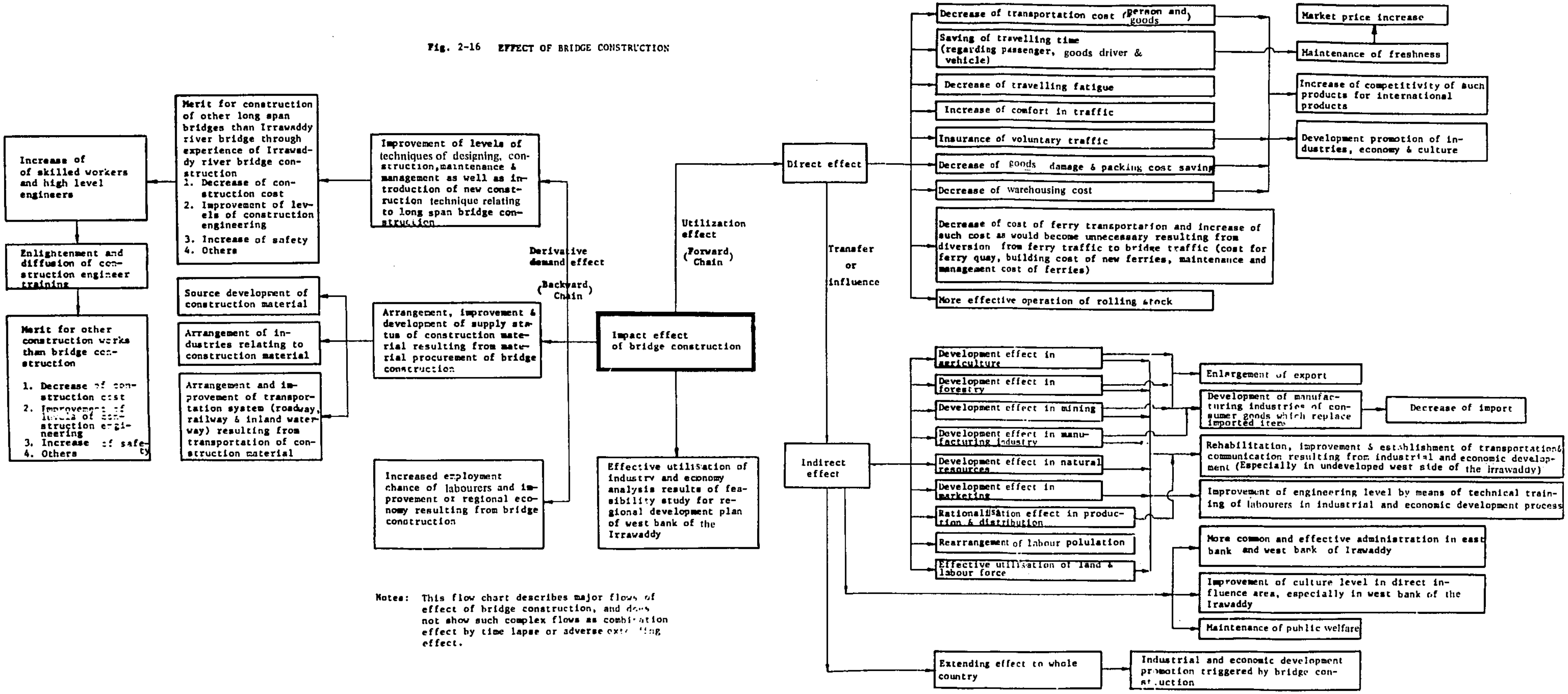
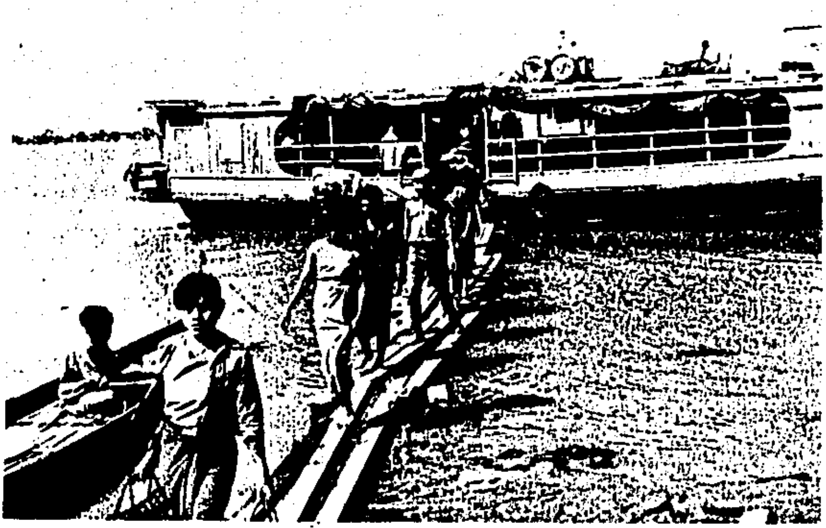


Fig. 2-16 EFFECT OF BRIDGE CONSTRUCTION



Notes: This flow chart describes major flows of effect of bridge construction, and does not show such complex flows as combination effect by time lapse or adverse extending effect.

# 3. TRANSPORT ECONOMY



# 3. TRANSPORT ECONOMY

## 3.1 Prediction of Transport Demand

### 3.1.1 Estimation and Analysis of Present Pattern of Transport

A survey of the transport pattern of passengers, goods and motor vehicles now crossing the Irrawaddy was performed to collect basic data for predicting the transport demand on the bridge under consideration. Then, the necessary analyses of the survey results were carried out for the study of future predictions.

#### 3.1.1.1 Estimation of Present Pattern

The present pattern for the period from January to December 1973 was worked out from the results of the field survey performed in March 1974 and related data collected in Burma.

#### A. Passenger transport

The number of passengers by origin-destination (OD) among various regions considered to be necessary for this study is shown in Table 3-1.

#### B. Goods transport

The volume of goods transport as classified by commodity and by OD between jetties related to this study was estimated.

Tables 3-2-A and 3-2-B show the total transport volume between jetties, while Table 3-3 shows transport volume as classified by commodity.

#### C. Motor vehicle transport by ferryboat

The transport volume of motor vehicle carried by the Z-craft between Prome and Sinde is classified by type and OD as shown in Table 3-4.

### 3.1.1.2 Analysis of Present Pattern

As a preparatory work for predictions of the future transport demand, the following analyses were carried out on the basis of the present pattern:

### A. Passenger transport

The following gravity model was selected to estimate the future transport demand classified by OD after careful study of various estimation models:

$$T_{ij} = 0.2426Y^{0.764} \cdot \frac{P_i \cdot P_j}{P} \cdot D_{ij}^{-1.63} \cdot Q_k \qquad (3.1)$$

where,

$T_{ij}$ : Passenger transport demand between areas i and j

$Y$ : Average net output per capita (at constant price in 1969-70)

$P_i$, $P_j$ and $P$ : Population of areas i, j and the national population, respectively

$D_{ij}$ : Average travelling time required between areas i and j by the fastest mode

$Q_k$ : Dummy variables to be changed with the different kinds of OD as follows (k = 1 to 4):

$Q_1$ = 1.00 (OD between the two different local city areas)

$Q_2$ = 144.58 (OD between the principal city of a local region and its peripheral area)

$Q_3$ = 3.94 (OD where Rangoon is either origin or destination)

$Q_4$ = 4.54 (the other OD)

### B. Goods transport

The aforementioned present pattern is the transport volume between jetties, but the jetty is not always the actual origin nor the destination. In other words, it is not necessarily the site of production nor that of consumption of commodities. Therefore, an analysis on the relation of the volume transported among jetties to the volume distributed among actual origins and destinations was carried out prior to the prediction work. In this analysis, the information collected through interviews with those concerned with each jetty, and data on production and consumption of the commodities in each region were taken into account. The transport pattern of rice, which is one of the principal products in Burma, as of 1973 was adjusted for the further study on the assumption that the production of rice and the target volume of the purchase by the Government were accomplished just as planned.

### C. Motor vehicle transport by ferryboat

Almost all motor vehicles transported by Z-craft between Prome and Sinde belong to the army and defense industries.

Therefore, it was very difficult to obtain the data on the transport demand necessary for future predictions. But it became clear by looking into a current record on the motor vehicle transport by Z-craft that the number of motor vehicles transported by Z-craft increased by about 37 percent in 1973 as compared with that in 1972 and is still increasing.

## 3.1.2 Prediction of Transport Demand after Completion of Bridge

### 3.1.2.1 General Description

The objective of predicting the transport demand is to get the basic data for the cost-benefit analysis to be dealt with in Chapter 11.

In this report, such analyses shall be carried out for the following three cases and so transport demand studies were also worked out for the same cases:

(a) Assuming that the railway-highway bridge is opened to traffic in 1983 (Case 1)

(b) Assuming that the highway bridge is opened to traffic in 1983 and railway bridge in 1988 (Case 2)

(c) Assuming that the highway bridge is opened to traffic in 1983 and railway bridge in 1993 (Case 3)

As the cost-benefit analysis was planned to cover the period of 30 years after the completion of the bridge, predictions of the transport demand were worked out for the years of 1983, 1988, 1993, 2003 and 2012.

The predicted transport volume may vary with the site of the bridge to be selected from among the Sites No. 1, No. 2 and No. 3. But the difference among three sites will not be so large that prediction was performed on the basis of the Site No. 3.

### 3.1.2.2 Method of Prediction

The prediction was worked out concerning three kinds of items, i.e., passengers, goods and motor vehicles carried by Z-craft.

The transport demand was predicted in terms not only of the total transport volume crossing over the bridge of highway and railway, but also the following two items as classified by OD, so that the benefit from the bridge construction might also be estimated:

(a) Transport demand to be diverted from other route (Diverted Traffic)

(b) Transport demand to be newly created by the bridge consturction (Generated Traffic)

A summary of the prediction method is given below.

A. Passenger

(1) Diverted traffic

The prediction was performed according to the following steps:

(a) Prediction of the transport demand by OD on the assumption that the bridge is not constructed.

(b) Estimation of the transport demand to be diverted to the bridge route from the prediction in Step (a).

(c) Allocation of the transport demand estimated in Step (b) to railway and highway.

The transport demand in Step (a) can be predicted by putting the estimated values of the variables, Y, $P_i$, $P_j$, P and $D_{ij}$ into Eq. 3.1.

The rate of diversion in Step (b) and the allocation in Step (c) will depend on what kind of the Government policy is to be taken for the allocation of transport modes in the future. In this work, the assignment of transport demand to each transport mode by OD was carried out in a manner that the transport cost and estimated monetary value of time loss may be minimised.

The average net output of a passenger might be higher than the average net output per capita, because the rate of non-labour such as children and old people in group of passengers might be smaller than that in the total population, though data concerning this were unavailable.

In this work, the average net output per hour of a passenger is obtained with the following equation assuming daily working duration of seven hours:

$$\frac{\text{Net output}}{P_1 - 0.5 \times P_2} \quad \times \quad \frac{1}{365 \times 7} \qquad (3.2)$$

where,

$P_1$ : National population of Burma
$P_2$ : Population of 15-years old or younger and 65-years old or older

In this case, the evaluated value of time loss was assumed to be equivalent to 50 percent of net output of a passenger obtained from Eq. 3.2. This is because Burma is not in the situation of full employment and the amount of income to be earned by a marginally added labour may be lower than the average income and because travelling time may not necessarily be directed fully to labour.

(2) Generated traffic

The generated traffic demand by OD is obtained as the difference between the transport demand by OD when the bridge is completed and the diverted traffic by OD.

The estimation of transport demand, when the bridge is completed, was obtained by the same method used in estimating the diverted traffic, except the difference in variables which were put into Eq. 3.1.

In this work, the road transport is represented by bus transport. But, in estimation of the number of motor vehicle passing over the bridge, passenger vehicles were classified into buses and the other vehicles consisting mostly of jeeps owned by public agencies.

In the period of this survey, most of motor vehicles were those used by Government agencies or their local offices for official trips, except buses operated for passengers and it was assumed that a small number of motor vehicles were being used for private business.

Therefore, under the present situation of motor vehicle ownership, the number of passengers using motor vehicles other than buses was estimated at five percent of the total passengers assuming that such passengers were about one fourth or one third of "official business passengers" (17.1% in the estimation based on the factual survey), and for the estimation thereafter, the rate of increase in the number of buses and other vehicles was taken into account.

The flow chart for the estimation of the passenger transport passing over the bridge is shown in Fig. 3.1.

B. Goods

The goods transport demand was predicted for each major commodity using the same method mentioned in the case of passenger transport, except for some differences as follows:

(1) Prediction of transport demand by OD

In this prediction, data on the present transport pattern and the values predicted for future production and consumption by area were used.

As long as the future production and consumption of a commodity can be predicted by area as shown in Chapter 2 and the regional weight thereof in the future may not change to a great extent from the present situation, the quantity of future distribution and transport volume can be estimated by area and by OD relatively easily through estimated changes in the production and consumption by area, considering the present transport pattern.

As to the above-mentioned kind of commodity, the following equation can be used for the actual application, disregarding special conditions.

$$T_{ij}^{t} = T_{ij}^{o} \cdot \frac{K_i \cdot K_j}{K} \qquad (3.3)$$

where,

$T_{ij}^{o}$ : Distribution quantity from area i to area j in 1973

$T_{ij}^{t}$ : That in a predicted year

K : Ratio of total distribution quantity of a commodity in predicted year to that in 1973

$K_i$ : Ratio of production volume of a commodity in area i in predicted year to that in 1973

$K_j$ : Ratio of consumption volume of a commodity in area j in predicted year to that in 1973

The above-mentioned method of estimation was applied to rice, cereals, vegetables, fruits, aquatic products, other foodstuff, livestock products, tobacco leaves and textiles.

In cases where the present transport pattern of such commodities is not available or may change remarkably in the near future such as oil, cement, other manufacturing products and timber, a pattern of distribution and transport by OD for the related area at the specific point of time when the change will occur was assumed. The pattern thus assumed was used for prediction purposes instead of the present transport pattern.

In case of industrial manufactures, long-term prediction of products by area was not possible. The only alternative was worked out by such a way that the assumed pattern mentioned just above was modified in proportion to the change in the national indices concerned.

### (3) Evaluation of time loss

The time loss consumed in the goods transport leads to making no use of the resources. This kind of time loss per ton per day is equivalent to the result of the following equation:

$$\text{Price of goods per ton} \times \text{Interest rate} \div 365 \quad (3.4)$$

When various commodities of different prices are included in the same category, an accurate average price cannot be obtained. In such a case, the average price of the representative commodities was used.

The price used in this study was market price in Rangoon or elsewhere in 1974. Only in case of rice, the recent international price of US $400 was used. The interest rate was supposed to be 10 percent per annum.

### (3) Kind and loading efficiency of motor vehicles

A diesel lorry with loading capacity of five tons was taken as the basis of calculation. Though the considerable overloading is rather common practice in the current situation, one hundred percent efficiency in future was taken, assuming improvement in sufficient supply of transport means.

The flow chart for the estimation of the goods transport passing over the bridge is given in Fig. 3.2.

C. Transport of motor vehicles by ferryboat

The motor vehicles currently transported between Prome and Sinde by ferryboat shall fully be diverted to self-driving transport via the highway bridge when the Irrawaddy Bridge is completed. But no basic data to predict the transport demand in future was availabe. Therefore, the future transport demand was predicted based on rough assumptions as follows:

(a) The transport demand in 1977 was supposed to be three times of the demand in 1973, assuming increased transport demand to be accompanied with the increased facilities in the Sinde Industrial Area in the coming few years hence.

(b) After 1977, increase of transport demand parallel to the increase in the number of motor vehicles was assumed. The number of car possession used for the above assumption was based on the predicted value in Chapter 2.

### 3.1.2.3 Result of Prediction

Through the prediction work the transport volume crossing over the bridge in each year is obtained as shown in Table 3-5.

## 3.2 Analysis of Transport Cost by Transport Mode

The data on the present transport cost of the railway, inland waterway and highway including lorry and bus were supplied by BRC, IWTC and RTC, respectively.

Analysis and necessary modification of the data were required for the basis of economic cost for each year in the future when the cost-benefit analysis will be worked out, as the economic cost will increase or decrease parallel to the traffic volume.

A. Elimination of cost not included in economic cost

The transport cost data supplied by the Burmese agencies were based on the financial accounting, in which such costs not to be added in proper economic cost as interest, registration fee, insurance and tax were included. These costs shall be eliminated from the supplied figures.

B. Correction in relation to improved circumstance

(a) Train operation cost

The BRC now owns many idle diesel locomotives because of lack of spare parts. It is planned to make full use of these locomotives in future so that the steam locomotives may be replaced by diesel ones.

The necessary correction of the train operation cost was made based on the assumption that the present 49 percent ratio of operation hauled by diesel locomotives will be increased to reach 70 percent or thereabout in the future.

(b) Motor vehicle operation cost on improved road

As the data on the motor vehicle transport cost were based on the present road conditions, necessary correction was made in accordance with the improved road surface due to the future road construction and rehabilitation work as well as the improved operation speed. For this correction, the average speed of a motor vehicle on the road at present and that in the future on the road which are planned to be newly constructed or improved, were assumed as follows:

Motor Vehicle Average Speed (mile/hr)

| | At Present | In Future |
|---|---|---|
| Bus | 25 | 40 |
| Lorry | 30 | 45 |

(c) Loading efficiency of lorry

The supplied data on the transport cost of a lorry was based on the present circumstances in which overloading is prevailing to such a great extent as 140 percent. However, when the supply of transport capacity becomes relatively enough, such abnormal loading cannot be kept for the proper services required by the transport demand in the future.

Therefore, necessary correction was made on the transport cost supposing that the improved average loading efficiency would be one hundred percent of the nominal capacity.

C. Variable cost with fluctuation of transport volume

The transport costs can be divided into as follows:

(1) Fixed cost

General administrative expenses, expenses for maintenance of buildings, etc.

(2) Terminal cost

Cost which may vary with number of passengers and number of tons of goods carried

(3) Movement cost

Cost which may vary with the transport volume and distance of passengers and goods

The total cost was distributed among the categories of fixed cost, terminal cost and movement cost according to the substance of costs. In cases where a certain cost was difficult to allocate for these three categories, the analysis was carried out referring to the analysis made in Japan.

D. Evaluation at price of 1974

The supplied data on the transport cost were based on prices as of 1973, and it might have risen to some extent in 1974 due to the current economic inflation.

In the cost and benefit analysis to be made in Chapter 11, all prices shall be based on prices in 1974. Therefore, the transport cost obtained at the price of 1973 was eventually converted into that based on the price of 1974.

As enough data were unavilable, the evaluation was made on the basis of the rough assumptions mentioned below.

(1) No fluctuation on the personnel costs

(2) In regard to the material costs, the evaluation is uniformly made on every item related to the costs by applying the implicit price deflator which is being used in calculation of the gross input on the basis of data of "Value of Goods and Services, Consumption and Investment of the Nation" published in "REPORT to the PEOPLE, 1974-75".

The terminal cost and movement cost of each transport mode estimated from the above work were as follows:

| | Unit | Railway | Road | Inland Waterway |
|---|---|---|---|---|
| Passenger: | | | | |
| Terminal cost | Pyas/Passenger | 29.47 | 5.44 | 15.47 |
| Movement cost | Pyas/Passenger-mile | 1.75 | 3.23 | 6.21 |
| Goods: | | | | |
| Terminal cost | Pyas/ton | 947.48 | 143.08 | 567.19 |
| Movement cost | Pyas/ton-mile | 4.76 | 23.41 | 5.28 |

In inland waterway transport of goods, a great difference in terminal and movement cost between mass transport by barge, oil lift and cement lift, and small shipment by liner was anticipated. As no data were available the transport costs by barge were estimated at 95 percent of the above cost and those of small shipment were three times

Table 3 - 1 Estimates of Passenger Traffic by Inter-Regional Origin - Destination in 1973

| | | West Side of the Irrawaddy | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | OHIN PAKOKKU | MINBU | MINHLA | THAYETMYO | KAMMA | AKYAB KYAUPYU | SANDOWAY | PADAUNG | KYANGIN | MYANAUNG | HENZADA | BASSEIN | TOTAL |
| West Side of the Irrawaddy | KYANGIN | | 2, 742 | | | 868 | | 210 | 13, 664 | | | | | 17, 484 |
| | MYANAUNG | | 1, 224 | 4, 300 | 56 | 641 | | 2, 677 | 8, 953 | | | | | 17, 851 |
| | HENZADA | | 4, 393 | 1, 920 | 1, 233 | | | 1, 920 | 857 | | | | | 10, 323 |
| | BASSEIN | | 3, 942 | 956 | | | | | 299 | | | | | 5, 197 |
| | SUB-TOTAL | | 12, 301 | 7, 176 | 1, 289 | 1, 509 | | 4, 807 | 23, 773 | | | | | 50, 855 |
| East Side of the Irrawaddy | KACHIN | | | | | | | | | | | | | |
| | SAGAIN | | 4, 113 | 881 | | | | | | 2, 412 | 6, 050 | 210 | | 13, 666 |
| | SHAN | | 2, 057 | | 1, 170 | | | | | | | | | 3, 227 |
| | MANDALAY | | 37, 770 | 2, 530 | 1, 729 | | | 893 | 387 | 278 | 279 | 1, 511 | 179 | 45, 556 |
| | MAGWE | | 214, 212 | 88, 966 | 12, 650 | 868 | | | 10, 713 | 4, 534 | 11, 982 | 60 | | 343, 985 |
| | AUNGLAN | | 2, 651 | 32, 787 | 212, 389 | 868 | | 387 | 242 | 1, 162 | 837 | 156 | | 251, 479 |
| | KAYAH | | | | | | | | | | | | | |
| | PROME | | 22, 873 | 7, 933 | 90, 236 | 284, 270 | | 6, 990 | 787, 227 | 31, 212 | 41, 135 | 30, 326 | 7, 252 | 1, 309, 454 |
| | THARRAWADDY | | 5, 027 | 4, 175 | 3, 120 | 4, 715 | | | 1, 165 | 5, 533 | 39, 826 | 146, 685 | 18, 356 | 228, 602 |
| | TOUNGOO | | 4, 113 | | | | | | | | | | | 4, 113 |
| | PEGU | | 3, 153 | | 390 | | | | 204 | | | 1, 234 | | 4, 981 |
| | RANGOON | | 22, 826 | 3, 884 | 13, 701 | 3, 471 | | 2, 768 | 26, 979 | 18, 343 | 38, 462 | 281, 661 | 101, 403 | 513, 498 |
| | KAREN | | | | | | | | | | | | | |
| | MON TENASSERIM | | | | | | | | | | | | | |
| | SUB-TOTAL | | 318, 795 | 141, 156 | 335, 385 | 294, 192 | | 11, 038 | 826, 917 | 63, 474 | 138, 571 | 461, 843 | 127, 190 | 2, 718, 561 |
| TOTAL | | | 331, 096 | 148, 332 | 336, 674 | 295, 701 | | 15, 845 | 850, 690 | 63, 471 | 138, 571 | 461, 843 | 127, 190 | 2, 769, 416 |

Note: Only those sites which are directly affected through construction of the Irrawaddy Bridge and the railway between Kyangin and Sinde are mentioned herein.

Table 3-2-A **Traffic Volume of Goods from East Side Jetties to West Side Jetties of the Irrawaddy in 1973**

Unit: ton

| TO / FROM | NYAUNG | SINBYU-GYUN | MINBU | MINHLA | THAYET | KAMMA | SINDE | PADAUNG | TONBO | KYANGIN | MYAN-AUNG | HENZADA | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MANDALAY | | | 1,042.01 | 172.39 | 52.27 | | | | | 75.60 | 131.10 | 21.08 | 1,494.45 |
| CHAUK | | | 105.35 | 3.99 | 47,390.89 | | | | | | 110.73 | 2.77 | 47,613.73 |
| SALU | | | 7.56 | 6.88 | 1.41 | | | | | | 14.68 | 52.67 | 83.20 |
| YENANGYANG | | 2.73 | 573.51 | 6.75 | 3.18 | | | | | 4.58 | 15.89 | 0.81 | 607.45 |
| MAGWE | 9.33 | 10.02 | 95.02<br>22.21 | 35.12<br>18.08 | 174.70 | | | | | 153.91 | 15.55 | 5.89 | 130.14<br>409.69 |
| MINGUN | | | | 24.89 | | | | | | | | | 24.89 |
| MIGYAUNGYE | 0.07 | 0.31 | 0.74 | 10.80 | 2.05 | | | | | 0.29 | 0.19 | 0.72 | 15.17 |
| SINBAUNGWE | 0.19 | 0.05 | 0.08 | 0.03 | | | | | | | 0.01 | 0.24 | 0.60 |
| AUNGLAN | 82.78 | 10.13 | 26.21 | 169.62<br>32.34 | 1,551.60<br>201.39 | | | | | 0.02 | 0.81 | 15.31 | 1,721.22<br>368.99 |
| PROME | 121.05 | 145.11 | 307.03 | 198.43 | 145.88 | 195.99 | 5,657.33 | 3,925.87 | 293.92 | 311.01<br>443.08 | 563.35<br>289.58 | 652.85 | 10,947.50<br>2,303.31 |
| MONYO | | | | | | | | | | | 308.60 | 120.84 | 429.44 |
| THARRAWAW | | | | | | | | | | | | 280.86 | 280.86 |
| RANGOON | | | 1,708.70 | 439.00 | 231.53 | | | | | 1,506.37 | 1,883.57 | 1,202.42 | 6,971.59 |
| TOTAL | 213.42 | 168.65 | 95.02<br>3,793.40 | 229.63<br>888.69 | 1,551.60<br>18,203.30 | 195.99 | 5,657.33 | 3,925.87 | 293.92 | 311.01<br>2,183.85 | 871.95<br>2,462.11 | 401.70<br>1,954.76 | 13,531.05<br>59,868.18 |

Note: Figures in the lower row show goods traffic volume by IWTC, the upper row by others.

Table 3-2-B **Traffic Volume of Goods from West Side Jetties to East Side Jetties of the Irrawaddy in 1973**

Unit: ton

| FROM / TO | NYAUNG | SINBYU-GYUN | MINBU | MINHLA | THAYET | KAMMA | SINDE | PADAUNG | TONBO | KYANGIN | MYAN-AUNG | HENZADA | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MANDALAY | | | 75.25 | 1.75 | 14,184.83 | | | | | 0.61 | 58.36 | 127.31 | 14,448.11 |
| CHAUK | | | 6,588.43 | 1.20 | 51,462.85 | | | | | 0.47 | 2.50 | 10.30 | 58,065.75 |
| SALU | | | 3.30 | 1.57 | 1,902.37 | | | | | 4.87 | | 24.50 | 1,936 61 |
| YENANGYANG | | | 12.71 | 5.17 | 772.35 | | | | | 16 63 | 34.69 | 9.18 | 850.73 |
| MAGWE | | | 104.52 | 25.16 | | | | | | | | | 129.68 |
| | 0.64 | 1.88 | 0.37 | 26 39 | 1,171.68 | | | | | | 31.02 | 8.66 | 1,240.64 |
| MINGUN | | | | 29.15 | | | | | | | | | 29.15 |
| MIGYAUNGYE | 0.02 | 0.05 | 0 01 | 1.68 | 0.03 | | | | | | 0.09 | 0.37 | 2.25 |
| SINBAUNGWE | 0 27 | 0.07 | | 8.78 | 0.12 | | | | | 0.47 | | 0.01 | 9.72 |
| AUNGLAN | | | | 68.18 | 1,571.22 | | | | | | | | 1,639.40 |
| | 12.23 | 23.21 | 12.05 | 3.46 | 1,133.88 | | | | | 58.49 | 2.91 | 36 72 | 1,312.98 |
| PROME | | | | | | 88.18 | 7,535.66 | 981.72 | 431.08 | 400.04 | 481.71 | | 9,918.39 |
| | 176 21 | 172.34 | 385.23 | 73.91 | 9,613.50 | | | | | 128.70 | 444.93 | 671.08 | 11,665.90 |
| MONYO | | | | | | | | | | | 253.14 | 101.23 | 354.37 |
| THARRAWAW | | | | | | | | | | | | 702.18 | 702.18 |
| RANGOON | | | 161 80 | 105.77 | 47,370.88 | | | | | 516 12 | 83,217.77 | 830 49 | 132,505.83 |
| TOTAL | | | 101 52 | 122 49 | 1,571 22 | 88 18 | 7,535.66 | 981 72 | 431.08 | 400.04 | 734.85 | 803.41 | 12,773.17 |
| | 219 37 | 197.58 | 7,512 15 | 229.68 | 127,612 49 | | | | | 726 36 | 83,792.27 | 1,718.62 | 222,038.52 |

Note: Figures in the lower row show goods traffic volume by IWTC. the upper row by others.

Table 3-3 Estimated Traffic Volume by Commodity between East Side and West Side of the Irrawaddy in 1973

Unit: ton

| COMMODITY | From East to West | | | From West to East | | |
|---|---|---|---|---|---|---|
| | IWTC | OTHERS | TOTAL | IWTC | OTHERS | TOTAL |
| RICE & RICE PRODUCT | 520.92 | 754.21 | 1,275.13 | 837.08 | 431.75 | 1,268.83 |
| GRAIN | 626.77 | 570.14 | 1,196.91 | 1,096.76 | 4,847.99 | 5,944.75 |
| VEGETABLE & FRUIT | 1,837.17 | 4,081.71 | 5,918.88 | 979.03 | 646.89 | 1,625.92 |
| ACUATIC PRODUCT | 1,425.48 | 1,297.52 | 2,723.00 | 637.52 | 533.68 | 1,171.20 |
| OTHER FOODSTUFF | 2,904.51 | 2,669.14 | 5,573.65 | 632.41 | 1,009.72 | 1,642.13 |
| TOBACCO LEAVES | 393.93 | 75.69 | 469,62 | 256.12 | 740.32 | 996.44 |
| PETROLEUM | 47,412.54 | 1,035.39 | 48,447.93 | 88,982.61 | 101.70 | 89,084.31 |
| CEMENT | | | | 126,482.84 | | 126,482.84 |
| TEXTILES | 562.44 | 603.15 | 1,165.59 | 469.75 | 189.76 | 659.51 |
| SALT | 603.17 | 396.69 | 999.86 | | 1,308.65 | 1,308.65 |
| LIVESTOCK | 36.85 | 131.18 | 168.03 | 446.23 | 1,836.44 | 2,282.67 |
| OTHERS | 3,544.40 | 1,919.23 | 5,463.63 | 1,218.17 | 1,126.27 | 2,344.44 |
| TOTAL | 59,868.18 | 13,534.05 | 73,402.23 | 222,038.52 | 12,773.17 | 234,811.69 |

Table 3-4 Inter-Regional OD Estimate of Motor Vehicle Traffic carried by Ferryboat between SINDE and PROME (1973)

| TYPE OF MOTOR VEHICLE | LORRY | JEEP |
|---|---|---|
| ↓→ | SINDE | |
| AUNGLAN | 42 | |
| PROME | 4, 753 | 5, 052 |
| PEGU | 42 | |
| RANGOON | 782 | 489 |
| TOTAL | 5, 619 | 5, 541 |

Table 3 - 5 **Forecast of Traffie Volume Crossing over Bridge**

| Item | | | 1983 | | 1988 | | 1993 | | 2003 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | A | B | A | B | A | B | A | A |
| Number of Passengers (in thousand) | Railway | Diverted | 392.6 | | 438.2 | | 451.0 | | 760.7 | 905.5 |
| | | Generated | 1,189.0 | | 1,390.6 | | 1,754.5 | | 2,347.6 | 2,860.3 |
| | | Total | 1,581.6 | | 1,828.8 | | 2,205.5 | | 3,108.3 | 3,765.8 |
| | Highway | Diverted | 1,387.2 | 1,563.3 | 1,657.8 | 1,856.4 | 2,080.3 | 2,354.9 | 3,347.3 | 5,692.4 |
| | | Generated | 5,767.2 | 6,612.7 | 7,799.0 | 8,687.1 | 10,863.8 | 12,120.6 | 23,583.3 | 46,894.3 |
| | | Total | 7,154.4 | 8,176.0 | 9,456.8 | 10,543.5 | 12,944.1 | 14,475.5 | 26,930.6 | 52,586.7 |
| Goods Tonnage (in ton) | Railway | Diverted | 80,521 | | 93,543 | | 111,174 | | 177,146 | 294,803 |
| | | Generated | | | 18,990 | | 22,457 | | 32,690 | 46,507 |
| | | Total | 80,521 | | 112,533 | | 133,631 | | 209,836 | 341,310 |
| | Highway | Diverted | 28,290 | 39,012 | 31,951 | 44,091 | 36,820 | 50,794 | 48,282 | 54,335 |
| | | Generated | | | 54,747 | 59,215 | 68,509 | 72,252 | 98,529 | 142,326 |
| | | Total | 28,290 | 39,012 | 86,698 | 103,306 | 105,329 | 123,046 | 146,811 | 196,661 |
| Number of Motor vehicles (per one way, day) | Diverted from Z rafts | Lorry | 27 | 27 | 32 | 32 | 40 | 40 | 65 | 110 |
| | | Jeep | 24 | 24 | 26 | 26 | 31 | 31 | 56 | 93 |
| | Used for the Carriage of Passengers and Goods predicted above | Loory | 8 | 11 | 24 | 28 | 29 | 34 | 40 | 54 |
| | | Bus | 309 | 353 | 408 | 455 | 556 | 622 | 1,150 | 2,216 |
| | | Jeep, etc. | 130 | 149 | 180 | 200 | 263 | 294 | 597 | 1,387 |
| | T o t a l | Lorry | 35 | 38 | 56 | 60 | 69 | 74 | 105 | 164 |
| | | Bus | 309 | 353 | 408 | 455 | 556 | 622 | 1,150 | 2,216 |
| | | Jeep, etc. | 154 | 173 | 206 | 226 | 294 | 325 | 653 | 1,480 |
| | | Total | 498 | 564 | 670 | 741 | 919 | 1,021 | 1,908 | 3,860 |

Note : 1) "A" represents a Railway - Highway Bridge, and "B" represents a Highway Bridge.

2) Passengers and goods on the Vehicles by Z raft are excluded in both items of number of passengers and goods tonnage.

Fig. 3-1 Forecast Flow of Inter-Regional Passenger Traffic

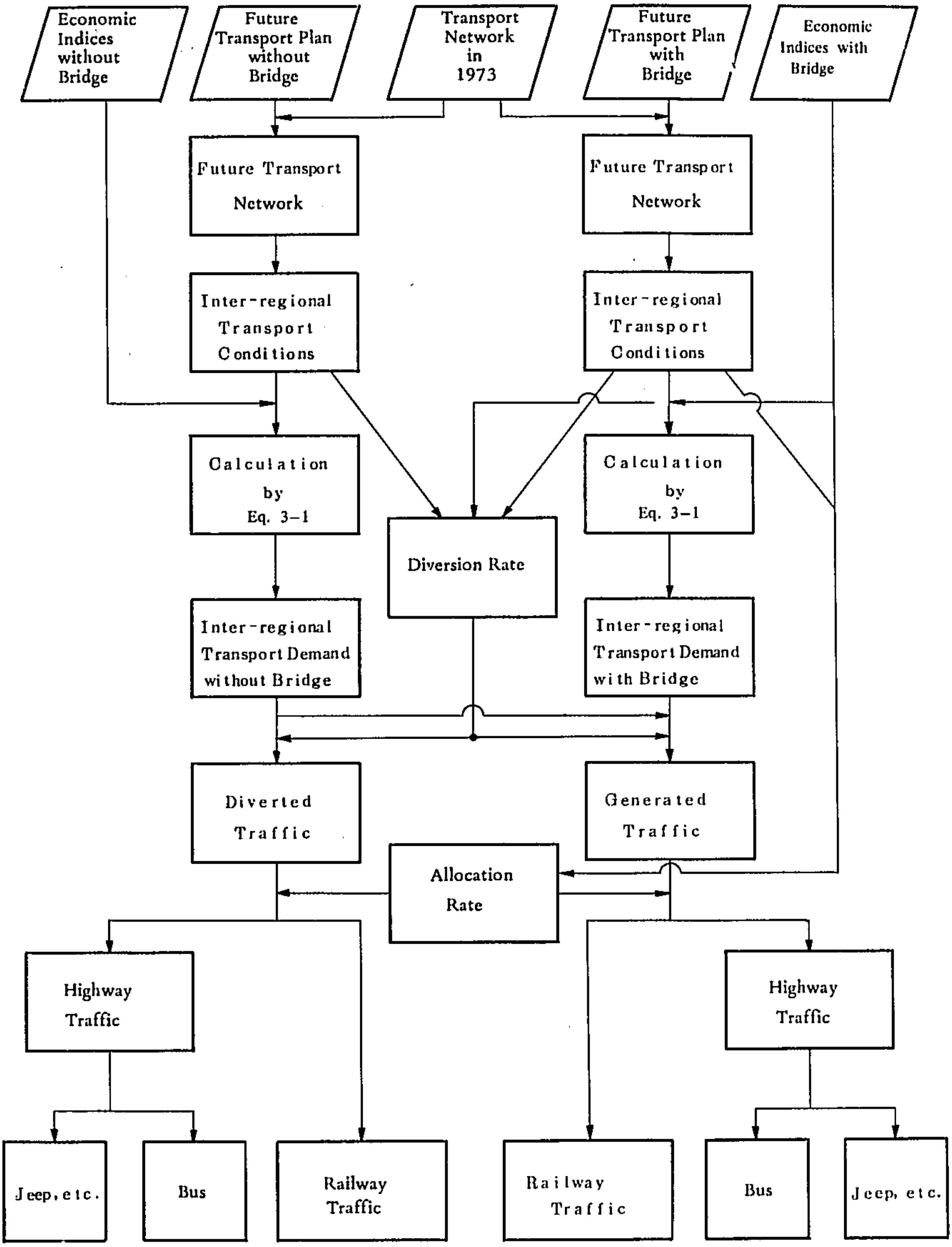
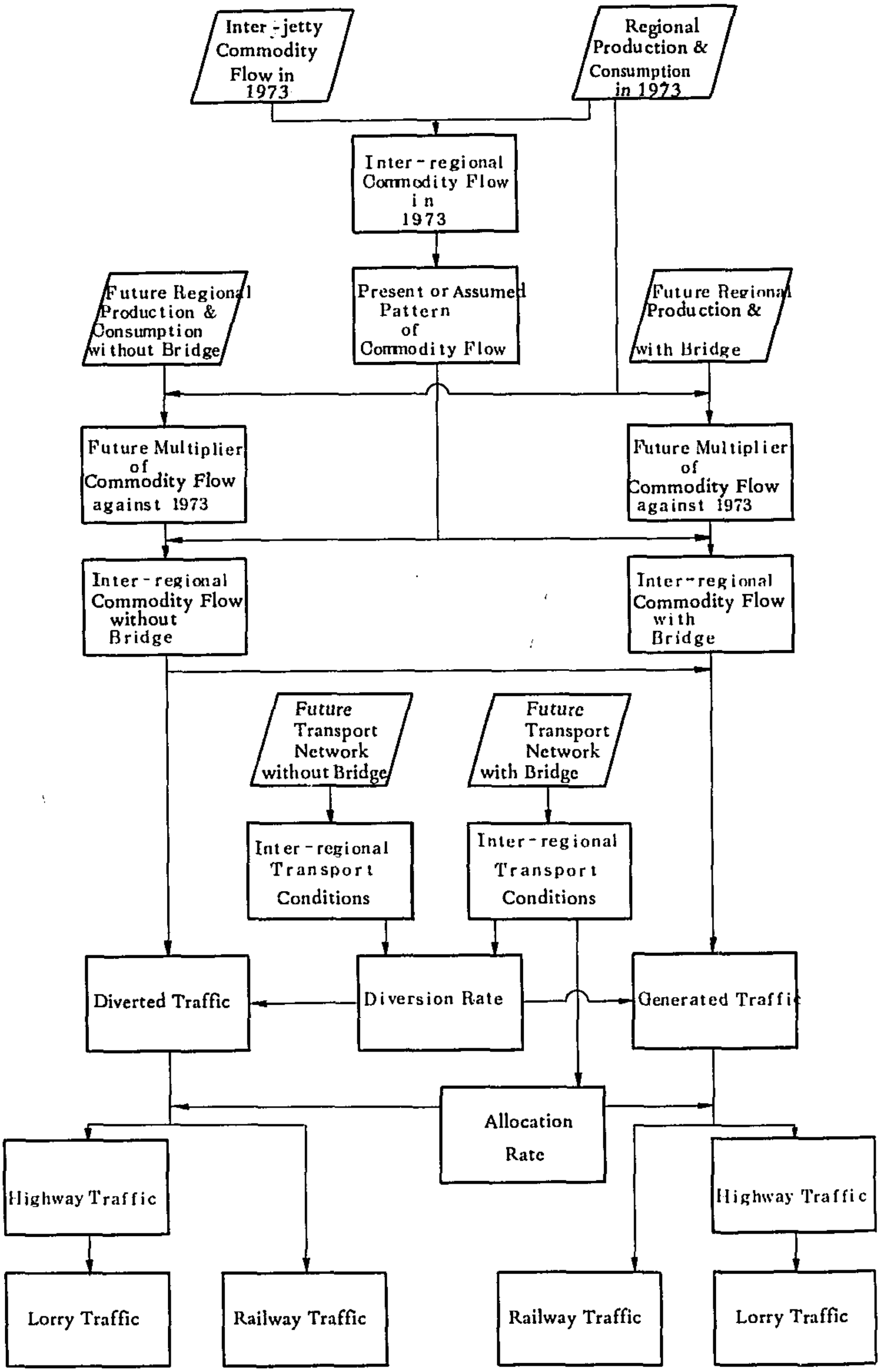


Fig. 3-2 Forecast Flow of Inter-Regional Goods Traffic



# 4. SOIL AND GEOLOGY

# 4. SOIL AND GEOLOGY

## 4.1 General Description

The various soil and geological investigations were carried out in Burma during the period from Feburuary to the end of May in 1974. The field and laboratory data obtained by that time were already submitted in the Soil Investigation Report.

The conditions of the proposed three bridge sites and related area as well as recommendations for foundation design are described here based on the report mentioned above.

Geological map of the related area based mostly on the available data including governmental publications is as shown in Fig. 4-1.

## 4.2 Field Investigation

### 4.2.1 Investigation along Access Railway

Hand auger tests at 27 localities and Swedish sounding tests at 3 sites were carried out along access railway alignment, as shown in Fig. 4-2, the results of which are shown in Fig. 4-3. After performing the tests, the alignment of each line was slightly modified. As these investigation methods are generally suitable for soft ground, soil profiles interpreted from the investigation results are in limited extent at the east side of the Irrawaddy. However the profiles well cover the alluvial plain where the high embankment will be constructed on the soft ground.

Depth of the free ground water table measured at auger holes and nearby wells during field survey is also shown in Fig. 4-3. It is evident that the soil profile in the lowland area and some parts of the highland area can be divided into following two layers:

1. Brownish grey to bluish grey coloured clayey soil with trace of sand. (Alluvium)
2. Mottled yellowish brown to reddish brown coloured sandy soil or clayey soil with trace of gravel. (Irrawaddy Formation)

Most of the highland area excluding valleys are underlaid exclusively by the Irrawaddy Formation.

The cross sections drawn from the results of investigations of banks and river bed of the Nawin Chaung are shown in Fig. 4-4. Fine to medium grained sand is located at the river bed of the Nawin Chaung in many cases but yellowish brown to dark grey coloured shale is exposed at some places.

### 4.2.2 Subsurface Condition at Each Bridge Site

Nine boreholes were drilled by three drilling machines at the points indicated in Fig. 4-2.

From the results of the boring test as well as field survey, studies on the geological data and information, geological maps and cross-sections at each site were prepared.

Figs. 4-5 and 4-6 show those at Site No. 1.

Figs. 4-7 and 4-8 show those at Site No. 2.

Figs. 4-9 and 4-10 show those at Site No. 3.

The geological conditions at each site could be summarised as follows:

#### 4.2.2.1 Abutment Site

(i) Site No. 1

(a) East bank ..... Massive and homogeneous, medium to fine grain sandstone, mostly poorly cemented, friable and moderately soft, dipping at 25-30 degrees towards opposite to the river.

(b) West bank ..... Sandstone and shale alternations with varying degrees of compactness and hardness coupled with faulting dipping at 22-26 degrees towards upstream.

(ii) Site No. 2

- (a) East bank ..... No outcrop could be seen in the vicinity. No hard rock was detected up to 4 meters depth below the residual soil.
- (b) West bank ..... Rocks are generally similar to those exposed at the west bank of Site No.1, dipping 30-35 degrees towards river.

(iii) Site No. 3

- (a) East bank ..... Gritty Shale and conglomeratic sandstone and moderately soft, moderately hard to hard, dipping at 45-55 degrees towards opposite to the river.
- (b) West bank ..... Moderately hard and slightly metamorphosed shale and moderately hard to hard sandstone alternations, dipping at 45-50 degrees towards river.

#### 4.2.2.2 River Bed

The bedrock under the river deposit was confirmed at Site No. 2 and Site No. 3 by the drilling test. The bedrock at both sites is bluish grey to grey coloured mudstone. At Site No. 1 no rock could be encountered up to the depth of 40 meters below sea level. Therefore, bottom of the old river channel might be located at lower than this level.

The overlying layers are fully composed of sandy soil, mostly containing small gravel and the thickness varies from 30 to over 50 meters.

## 4.3 Result of In Situ Test and Laboratory Test

### 4.3.1 In Situ Test

Results of the test for two typical soil samples collected by auger boring along the access railway alignment are shown in Table 4-1.

Standard penetration tests and pressio meter tests were carried out. The results of the former test are shown in Figs. 4-6, 4-8 and 4-10. The pressio meter tests were performed at four boring holes at Site No. 3 and the results are shown in Table 4-2.

### 4.3.2 Laboratory Test

The results of the laboratory tests applied to the cores extracted from drilling holes and rock samples collected from outcrops are shown in the Tables 4-3 and 4-4, respectively.

The test results including supersonic wave test for the rock cores performed in Japan are shown in Table 4-5.

Only specific gravity test and sieve analysis were performed for the disturbed sandy soil samples obtained by the split spoon sampler. The specific gravity is from 2.62 to 2.66 and proportion of sand and gravel in sieve analysis exceeds 90 percent. The grain size distribution of sandy soil samples from the surface to the depth of 20 meters is given in Fig. 4-11. These soils are very likely to suffer liquefaction during earthquake.

## 4.4 Foundation of Structure

### 4.4.1 Embankment of Access Railway

As mentioned in 4.2.1, the field investigation was accomplished with hand auger and Swedish sounding apparatus. Information obtained from field investigation and laboratory test was not sufficient. General behavior of the subground which shall support embankment, may, however, be estimated as follows.

|  | Height of Embankment | Low Land Area |  | High Land Area excluding Valleys |
|---|---|---|---|---|
|  |  | mostly | partly |  |
| Swelling | $5^m >$ | Medium | Questionable | Low |
|  | $5^m <$ | Low | Medium |  |
| Settlement | $5^m >$ | Negligible | Questionable | Negligible |
|  | $5^m <$ | Small amount | Questionable |  |
| Stability | $5^m >$ | Safe | Safe | Safe |
|  | $5^m <$ | Safe | Questionable |  |

### 4.4.2 Bridge Site

### 4.4.2.1 Abutment

Spread foundation may be constructed at each abutment site except one located in the east bank of Site No. 2. The sites should be excavated at least to the following depth in order to eliminate weathered rock.

Excavation Depth below ground surface

| Site | Abutment |  |
|---|---|---|
|  | East side | West side |
| No. 1 | To depth of basement | $10^m$ |
| No. 2 | Not confirmed | $5^m$ |
| No. 3 | To depth of basement | $9^m$ |

Judging from the results of the field investigation and laboratory test, the bearing capacity of rock at excavated surface at each abutment site is sufficiently larger than the load intensity estimated from the foundation design.

### 4.4.2.2 Pier

The term liquefaction as used here is the phenomenon in which cohesionless saturated soils become fluid caused by earthquake vibration. This phenomenon falls in the ground failure category in the design of foundation. Liquefaction can result in surface movement from inches to tens of feet.

Three conditions are necessary for liquefaction.

(a) Cohesionless soils as a whole
(b) Groundwater
(c) Moderate or major earthquake

For liquefaction to occur under these conditions, it is necessary for the shear stresses caused by the earthquake at the zone of liquefaction to exceed to liquefaction strength of the soil. Thus, severe earthquake is required to cause liquefaction for denser soils.

The liquefaction potentiality in the project area has been studied by the method of Seed and Idriss. (cf. Simplified Procedure for Evaluating Soil Liquefaction Potential, Journal of SMFD, Proc. of ASCE, Sep., 1971)
These studies indicate that liquefaction might occur in zones of each location as described below.

| Location | B1-2 | B2-2 | B3-1 | B3-2 | B3-3 |
|---|---|---|---|---|---|
| Depth below Ground Surface (m) | 2.0 | 6.0 | 7.0 | 12.0 | 4.0 |

### 4.4.2.3 Design Soil Parameters

The generalised procedure for foundation design with the pressio meter method is given in Fig. 4-12. The pressio meter mesurements were carried out only at Site No. 3. From correlation between N-values of the standard penetration test and the soil parameters with the pressio meter test, the design soil profile is determined as shown in Fig. 4-13.

The basement should be lowered to the depth of the forth zone to get sufficient bearing capacities and horizontal resistance. In view of this condition, the following allowable bearing capacity and horizontal reaction modulus shall be applied to the design.

| Foundation Type | Allowable Bearing Capacity (Zone IV) | Modules of Horizontal Reaction ($kg/cm^3$) | |
|---|---|---|---|
| Steel Pipe Pile<br>ϕ 1200mm | 450 t | Zone II | 3.0 |
| | | III | 4.3 |
| Caisson<br>25m x 11m<br>or 22m x 14m | 100 $t/m^2$ | II | 0.80 |
| | | III | 1.00 |
| | | IV | 2.10 |

Probable settlement of the caissons due to the loadings was estimated to be small. Most of settlement will occur during the foundation construction, therefore, the settlement will be negligible after the completion of the foundation.

Table 4-1 Laboratory Test Results of Soils Collected in Relatively Low Land Area

| | Clayey soils (Upper layer) | Sandy soils (Lower layer) |
|---|---|---|
| Main Distribution Area | Low land | High land |
| Colour | Bluish grey to dark grey | Yellowish brown to reddish brown |
| Natural Water Content (%) | above water level<br>15 - 20 (35)<br>below water level<br>30 - 35 (40) | <br>6 - 18<br><br>17 - 28 |
| Liquid Limit (%) | 40 - 60 (70) | 28 - 35 |
| Plastic Limit (%) | 18 - 30 (30) | 17 - 21 |
| Plasticity Index | 20 - 30 (40) | 10 - 18 |
| Specific Gravity | 2.64 - 2.68 | 2.62 - 2.69 |
| Wet Density ($t/m^3$) | 1.9 - 2.1 | |
| Void Ratio | above water level<br>0.5 - 0.7<br>below water level<br>* 0.9 | |
| Percent of Sand Particle (%) | < 25 | 40 < |
| Unconfined Compression Strength ($kg/cm^2$) | above water level<br>1.6 - 3.6<br>below water level<br>* 0.83 | |

Note: Values in parenthesis indicate the results of A2-7 and A2-8 located near the bushes situating between the Nawin Chaung and the high land area.

*) Only one data obtained at A1-1.

## Table 4-2 Results of Pressio Meter Test

| Bore Hole No. | Sampling | | Soil Type | N (blows/ft) | Ep (kg/$cm^2$) | P (kg/$cm^2$) | $P_f$ (kg/$cm^2$) |
|---|---|---|---|---|---|---|---|
| | Depth (m) | Elevation (m) | | | | | |
| 3-2 | 25.0 | -10.9 | Sand | 27 | 198.5 | 3.40 | 18.20 |
| | 30.0 | -15.9 | " | 40 | 885.6 | 4.00 | 36.10 |
| | 35.0 | -20.9 | " | 41 | 193.8 | 1.70 | 9.80 |
| | 41.0 | -26.9 | Siltstone | 70 | 275.3 | 1.60 | 18.10 |
| 3-3 | 5.0 | 17.5 | Sand | 7 | 93.3 | 1.10 | 5.14 |
| | 10.0 | 12.5 | " | 12 | 94.2 | 1.67 | 5.97 |
| | 14.5 | 8.0 | " | 16 | 47.2 | 0.30 | 4.10 |
| | 20.0 | 2.5 | " | 21 | 111.1 | 1.00 | 8.55 |
| | 25.0 | -2.5 | " | 19 | 125.9 | 0.93 | 10.77 |
| | 30.0 | -7.5 | " | 24 | 143.5 | 1.35 | 11.60 |
| | 35.0 | -12.5 | " | 33 | 85.1 | 1.70 | 7.30 |
| 3-4 | 13.8 | 59.7 | Sandstone | | 4,689.0 | 1.10 | 22.00 |
| | 15.0 | 58.5 | " | | 4,675.0 | 3.60 | 27.60 |
| | 17.0 | 56.5 | " | | 8,650.0 | 5.10 | 59.50 |
| | 19.2 | 54.3 | " | | 26,250.0 | 5.50 | 50.50 |
| 3-5 | 7.2 | | Sandstone | | 4,225.0 | 3.60 | 31.80 |
| | 10.8 | | " | | 1,080.0 | 6.90 | 30.30 |
| | 16.2 | | Sandy Shale | | 5,379.0 | 4.20 | 34.22 |
| | 19.5 | | " | | 4,896.0 | 4.41 | 28.35 |

Table 4-3 Results of Laboratory Tests on Core

| Sample No. | Bore Hole No. | Depth (m) | Moisture Content (%) | Dry Density (t/m$^3$) | Specific Gravity | Void Ratio | Degree of Saturation(%) | Strain (%) | * U.C.S. (kg/cm$^2$) | E$_{50}$ (kg/cm$^2$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1-1 | 12.92-13.22 | 6.6 | 2.17 | 2.67 | .229 | 58 | 3.3 | 8.7 | 1098 |
| 2 | 2-1 | 12.02-12.32 | 7.0 | 2.29 | 2.66 | .198 | 68 | 2.3 | 8.3 | 488 |
| 3 | 2-1 | 15.22-16.22 | 4.7 | 2.22 | 2.67 | .167 | 52 | 0.7 | 23.1 | 4154 |
| 4 | 2-2 | 38.20-38.40 | 15.7 | 1.95 | 2.63 | .361 | 97 | 3.8 | 8.7 | 283 |
| 5 | 2-2 | 40.00-42.00 | 12.1 | 1.93 | 2.63 | .287 | 87 | 3.5 | 12.7 | 575 |
| 6 | 3-1 | 42.00-43.00 | 20.6 | 1.65 | 2.62 | .580 | 98 | 4.6 | 2.2 | 75 |
| 7 | 3-1 | 46.00-47.00 | 19.4 |  | 2.62 |  |  | 6.9 | 3.0 | 125 |
| 8 | 3-4 | 5.25- 7.42 | 5.9 | 2.15 | 2.65 | .313 | 40 | 1.5 | 11.5 | 767 |
| 9 | 3-4 | 16.80-17.10 | 1.8 | 1.90 | 2.64 | .393 | 10 | 1.5 | 19.4 | 1617 |
| 10 | 3-4 | 17.42-17.72 | 2.8 | 1.81 | 2.67 | .475 | 14 | 0.5 | 8.6 | 1433 |
| 11 | 3-4 | 19.52-19.72 | 1.4 | 1.92 | 2.66 | .387 | 8 | 1.0 | 14.5 | 1813 |
| 12 | 3-5 | 12.02-12.32 | 8.3 | 2.06 | 2.64 | .287 | 61 | 0.8 | 7.6 | 1584 |
| 13 | 3-5 | 15.52-15.82 | 6.9 | 2.12 | 2.66 | .253 | 55 | 1.5 | 17.5 | 2917 |
| 14 | 3-5 | 17.72-18.02 | 5.2 | 2.19 | 2.64 | .209 | 48 | 1.5 | 32.0 | 2286 |
| 15 | 3-5 | 19.82-20.12 | 4.3 | 2.22 | 2.65 | .189 | 43 | 1.3 | 35.5 | 3944 |

| Sample No. | Consistency |  |  | Percentage of Sand (%) |
|---|---|---|---|---|
|  | LL (%) | PL (%) | PI |  |
| 5 |  |  |  | 40 |
| 6 | 75 | 26 | 49 | 2 |

Remark: * Unconfined Compression Strength

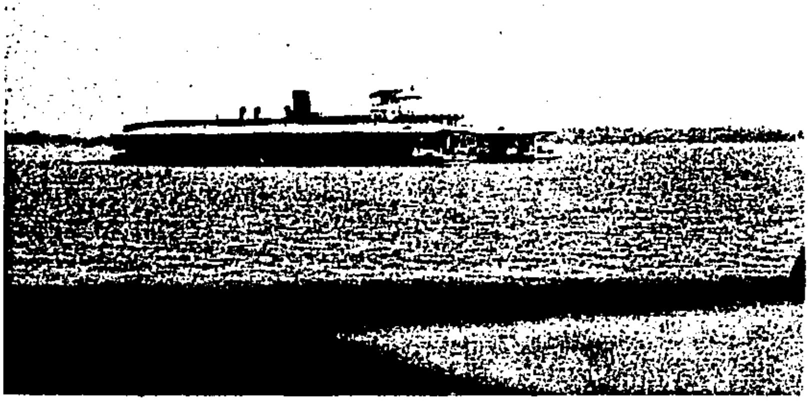
Table 4-4 Results of Laboratory Tests on Rock Sample

| Sample No. | Site No. | Source | Compressive Strength ($kg/cm^2$) | Apparent Specific Gravity | Bulk Specific Gravity |
|---|---|---|---|---|---|
| $A_1$ | 1 | East Abutment | 27.4 | 2.46 | 1.95 |
| $A_2$ | " | - do - | 22.5 | 2.50 | 1.99 |
| $A_3$ | " | " | 16.9 | 2.48 | 1.97 |
| $A_4$ | " | " | 23.6 | 2.51 | 2.00 |
| $A_5$ | " | " | 16.5 | 2.45 | 1.95 |
| $A_6$ | " | " | 27.4 | 2.49 | 1.97 |
| $B_1$ | " | West Abutment | 158.5 | 2.68 | 2.30 |
| $C_1$ | " | East Abutment | 164.5 | 2.75 | 2.40 |
| $C_2$ | " | " | 119.5 | 2.68 | 2.36 |
| $C_3$ | " | " | 147.6 | 2.67 | 2.37 |
| $C_4$ | " | " | 147.6 | 2.70 | 2.32 |
| $C_5$ | " | " | 159.6 | 2.73 | 2.42 |
| $C_6$ | " | " | 161.0 | 2.72 | 2.38 |

## Table 4-5 Results of Laboratory Test on Rock Cores (Carried out in Japan)

| Point | Depth (ft) | Rock Type | Elastic Wave Velocity | | Dynamic Poisson's Ratio | Bulk Density (g/cm$^3$) | Compressive Strength (kg/cm$^2$) | Modulus of Elasticity (kg/cm$^2$) | |
|---|---|---|---|---|---|---|---|---|---|
| | | | P (m/sec) | S (m/sec) | | | | Dynamic | Static |
| B.1-1 | 38.5 | Silty Stone | 1670 | 810 | 0.35 | 2.32 | 37.4 | 4.2x10$^4$ | |
| B.2-1 | 47.2 | Very Fine Sandstone | 1810 | 780 | 0.39 | 2.15 | 82.1 | 3.7x10$^4$ | 2.9x10$^4$ |
| B.3-2 | 40.4 | Mudstone | 1580 | 750 | 0.35 | 2.35 | 31.7 | 3.7x10$^4$ | |
| B.3-4 | 61.0 | Medium Grained Sandstone | 1760 | 700 | 0.41 | 1.94 | 38.8 | 2.7x10$^4$ | |
| B.3-5 | 34.7 | Silty Stone | 2810 | 1540 | 0.29 | 2.46 | 153.5 | 1.5x10$^5$ | 9.0x10$^4$ |
| | 41.4 | Silty Stone | 2680 | 1560 | 0.24 | 2.47 | 154.6 | 1.5x10$^5$ | 3.8x10$^4$ |
| | 58.5 | Silty Stone | 1750 | 700 | 0.40 | 2.49 | 111.4 | 3.5x10$^4$ | 6.9x10$^4$ |
| Site No.1 | (1) | Fine Grained Sandstone | 1360 | 600 | 0.38 | 2.15 | 16.8 | 2.3x10$^4$ | 2.4x10$^3$ |
| East bank | (2) | " | 1320 | 710 | 0.30 | 2.09 | 13.9 | 2.8x10$^4$ | 2.8x10$^3$ |
| | (3) | " | 1320 | 670 | 0.33 | 2.13 | 18.5 | 2.6x10$^4$ | 1.7x10$^3$ |
| | (4) | " | 1440 | 660 | 0.37 | 2.03 | 22.1 | 2.5x10$^4$ | 7.9x10$^3$ |
| | (5) | " | 1550 | 720 | 0.36 | 2.09 | 18.3 | 3.0x10$^4$ | 5.9x10$^3$ |
| Site No.3<br>West Bank | | Fine to Medium Grained Sandstone | 5030 | 2900 | 0.25 | 2.63 | 757.2 | 5.7x10$^5$ | 3.6x10$^5$ |

# 5. HYDROLOGICAL STUDY



# 5. HYDROLOGICAL STUDY

## 5.1 General Description of the Irrawaddy Basin

The regime of the Irrawaddy with a 376,200 $km^2$ drainage area is determined to a considerable extent by the behaviour of the monsoon. The river discharge during this time is heavy, and coupled with high tides in the delta leads to extensive flooding. The maximum flood at Prome in August averages about 1,250,000 cusecs (35,500 $m^3$/sec) with a maximum around 2,250,000 cusecs (63,800 $m^3$/sec). The tide in the lower delta ranges between 2.2 m and 10.7 m and islands not protected by embankments are regularly flooded. At the end of the monsoon and with a decrease in river discharge, tidal flooding with salt water occurs in the coastal areas of the delta. Flood control works, mainly protection embankments, have been concentrated in the coastal areas. In the upstream basin of Prome, however, there are no immediate flood control plans at present.

The water level and discharge measurements in the Irrawaddy main stream and its tributary have been made at 14 water level gauges and 4 discharge gauges under the organizations of Department of Meteorology and Hydrology. The location of these gauges is shown in Fig. 5-1.

The Prome gauge, established in 1868, where the Irrawaddy has a drainage area of 340,390 $km^2$ with a river length of 1,412 km, is located between the alternative bridge sites No.2 and No.3. The hydrologic works such as the measurements of water level, river discharge, sediment discharge and water temperature have been regularly carried out by the Department of Meteorology and Hydrology. Fig. 5-2 shows the daily mean water surface elevation at the Prome gauge during the 1966 - 1973 period, together with that at other gauges along the Irrawaddy and the Chindwin during the rainy season in the same period. Among 14 water level gauges, the rating curve is available at Hkamti and Kalewa gauges in the Chindwin, and Sagaing and Prome gauges in the Irrawaddy. Fig. 5-3 shows the discharge hydrograph at these gauges during the 1965 - 1973 period estimated by applying the water level record to the rating curve.

The river width of the Irrawaddy varies largely not only from place to place but also from year to year. Especially, the river width at the sharp bend and also at the confluence with tributary varies from some km to some ten km. Many shoals are frequently encountered in the river channel throughout the stretch of the Irrawaddy downstream from Bhamo. The river water in the shoal areas is discharged through the channels divided into several lanes. When the flood occurs, the river channel varies again, together with disappearance of those shoals, and the side erosion at the river bank and sediment deposit are repeated.

The river cross sections at Sagaing, Chauk, and Prome are available for the study on the variation of river bed in the Irrawaddy. In addition, the river cross sections near Kyangin and Thayet, which were drawn based on the water depth in the river channel maps prepared by the Waterway Department, were incorporated for this study. However, since the measurement period of these survey data almost concentrates within the dry season, the maximum degradation or aggradation of the river bed, which might occur at the highest flood time during the rainy season, is unknown.

As far as the river cross sections at the above-mentioned Sagaing, Chauk, Prome, Kyangin and Thayet are concerned, it can be said that the river bed in the Irrawaddy stretch varies largely, especially at the river stretch near Thayet where the large scale variation of river bed accrues from the shift of the main channel due to the movement of shoal, and the maximum extent of the river bed movement in the Irrawaddy was the order of 7 to 8 m throughout the measurement period.

Data and records available for hydrological and river engineering study are insufficient compared with the large area of the basin and the complicated hydrological mechanism, especially rainfall-runoff mechanism and river bed mechanism. However, the data and records used for studies included in this Chapter are listed in Table 5-1.

## 5.2 Lowest Elevation of Superstructure of Bridge

For determination of the lowest elevation of the superstructure of bridge, it is required to determine the design high water level and the clearance above that.

### 5.2.1 Design High Water Level

The hydrologic conditions related to the Prome gauge can be described as follows, based on the examination of Fig. 5-2 and Fig. 5-3:

1) The water level at the Prome gauge varies from about 17 m to 30 m above mean sea level throughout a year. It becomes generally maximum in August/September and minimum in March. Comparing this fact with the rainfall at the gauges located at upstream of Prome, where the monthly rainfall is generally the highest in June to August and the lowest in February, it may be said that a large part of the rainfall is once retained as the basin storage especially at an early time of the rainy season, and gradually it discharges to the river through tributaries.

2) The Chindwin joins the Irrawaddy at downstream of the Sagaing gauge. High flooding time at the Monywa gauge located at the downstream stretch of the Chindwin almost coincides with that at the gauges downstream of the Sagaing. Besides, the water level and discharge at the Sagaing gauge have almost the same pattern as those at the gauges located at its downstream during the high flooding time. These facts mean that the high water level in the Irrawaddy is mainly attributable to the flood discharge in the Irrawaddy main stream itself and it is further heightened by the Chindwin flood.

3) The recession curves of the water level at the Nyaung Oo., Katha and Bhamo gauges seem to be flatter than those at the other gauges along the Irrawaddy. 'This phenomenon may be explained as follows. It is presumed that there are large habitual inundation areas between the Nyaung Oo and Sagaing, and Katha and Myitkina. The flood discharge once retained in these inundation areas is gradually drained to the Irrawaddy when the water level in the Irrawaddy lowers during the recessing period of flood.

The habitual inundation area in the upper reaches of the Prome was roughly estimated to be 30,000 ha in total based on one inch to 4 miles maps.

The hourly water level record at the Prome gauge at the highest flood time during the 1966-1971 period observed by the automatic water gauge was evaluated. The result of this evaluation clarified that the water level hydrograph at Prome during the flood peak time is very flat, and of elongated pattern. The flood peak lasts more than 24 hours in most cases. Thus, it is considered that the daily mean water level during the flood peak time is almost the same value as that of the hourly maximum water level.

The estimation of design high water level should, in principle, be based on probability analysis of related hydrological parameters by using the established rainfall-runoff mathematical model. However, it is difficult to apply this method to the Irrawaddy at present, partly because of the scarcity of continuous hydrological observation data such as rainfall, discharge, etc. and also because of the complicated hydrological mechanism at the Prome gauge being affected by the large retardation area in the upstream reaches, the tidal effects in the lower reaches and the large river bed variation.

Therefore, it is considered practical and reasonable to take the maximum water level observed in the past as the design high water level. For this purpose, the following matters were studied:

(1) At the Prome gauge, the maximum water level records are available as listed in Table 5-2. From this table, it could be seen that the flood water would be usually recorded in the year when the relatively large flood occurred, and not be recorded in the year when the water level might be relatively lower than a certain level. It may be considered, therefore, that the data available during the last 100-year period from 1875 to 1974 show the relatively large floods. On this assumption, it may be given that the highest water level record at the Prome gauge during 100-year period is 30.25 m in 1974.

(2) According to the Waterway and Irrigation Departments which are the administrative agencies for river channel management, they have no immediate plan for large scale flood control in the river stretch between Prome and Mandalay except for the small scale plans near Mandalay. Therefore, it can be judged that the present run-off mechanism in the upstream reaches of the Irrawaddy will not be changed to the extent to raise the water level at the Prome gauge in near future.

(3) From the Table 5-3, it can be judged that the river bed elevation at the Prome gauge during the rainy seasons has not long-term tendency of river bed rising.
Therefore, it can be considered that the river bed elevation during the rainy seasons will be stable even in future.

(4) As described in the next section, it is planned to take a fairly large clearance above the design high water level. In addition, the duration of flood peak was short, i.e., one or two days. Therefore, it can be considered that there will be no serious hinderance on navigation activity even if the design high water level is understimated by about 0.5 m.

Taking into account the above-mentioned matters, it is considered appropriate to adopt the maximum water level at the Prome gauge, 30.25 m, as the basis for estimation of design high water level at the alternative bridge sites. Using the result of water surface slope survey between the alternative bridge sites and the Prome gauge as shown in Fig. 5-4, the design high water level was estimated as shown below.

| Site | No.1 | No.2 | No.3 |
|---|---|---|---|
| Design high water level (m) | 31.29 | 30.81 | 30.22 |

### 5.2.2 Clearance above Design High Water Level

I.W.T.C. applies the following design criteria on clearance for navigation;

(1) The horizontal clearance between inside faces of piers except for approach span shall be 350 feet or more, taking into account about three times allowance for the overall width of the largest peddler cum cargo flats employed in the Irrawaddy at present.

(2) The vertical clearance for bridge planning at Prome site shall not be less than 55 feet, taking into account the allowance of about 10 feet for the maximum height above draught of the largest pedlar steamer in the Irrawaddy at present.

According to the I.W.T.C's long term policy to improve the present navigation condition, I.W.T.C. intends to gradually improve the cargo flat in near future by installing the engine and propeller for self-travelling. It suggests that the overall width of the pedlar steamer cum cargo flats in use will not be further widened for future navigation activity. Therefore, it is considered that the design criteria above-mentioned are applicable for bridge planning.

### 5.2.3 Lowest Elevation of Superstructure of Bridge

The lowest elevation of superstructure of bridge can be obtained by adding the clearance of 55 feet (16.78 m) to the design high water level estimated in 5.2.1 including the dam-up effect due to the sub-structures. The results are as shown below:

(Unit: m)

| Site | No.1 | No.2 | No.3 |
|---|---|---|---|
| Lowest Elevation of Superstructure | 48.50 | 48.02 | 47.43 |

## 5.3 Flow Velocity Distribution

The flow velocity at the alternative bridge sites and at the Prome gauge was measured during the survey period in 1974. In addition, the measurement data of flow velocity at the Prome gauge during the high water and low water seasons in 1970 are available. The flow velocity distribution maps were drawn based on these measurement data. The mean calculated flow velocity was 0.3 to 0.4 m/sec at the alternative bridge sites during the survey period in 1974 and 2.2 to 2.3 m/sec at the Prome gauge in August, 1970.

For designing bridge substructure, it is necessary to estimate the maximum flow velocity at the alternative bridge sites. The maximum mean flow velocity when the design water level occurs at each site was estimated based on the river cross section given in Fig. 5-5, assuming the flood discharge at each site is the same as that at the Prome gauge. The estimated maximum mean flow velocity was about 3.0 m/sec at site No.1, 2.8 m/sec at Site No.2 and 2.7 m/sec at Site No.3.

## 5.4 Stability of River Channel

### 5.4.1 Stability of River Bank

The alternative bridge sites, No.1, No.2 and No.3, are located at relativiely straight and narrow gorge with low hills extending along both banks of the River. The river cross sections of each site given in Fig. 5-5 show that no shift of river banks occurred during 1973 and 1974. In addition, the river cross sections at Prome during the 1966 - 1974 period clarify that there are no shifts of river banks. Judging from the two facts above-stated, it is considered that the river banks of each alternative bridge site are stable against the side erosion by the river flow.

### 5.4.2 Variation of River Bed

The variation of river bed at Sites No.1 and No.2 was studied based on the river cross sections given in Fig. 5-5. Comparing with the river cross sections obtained in 1973 and 1974 at both sites, the status of river bed movement can be expressed as shown in Table 5-2. Table 5-3 and Fig. 5-5 clarify that the partial aggradation and degradation of river bed occurred at Sites No.1 and No.2 during the rising period of water level.

The past river bed variation at Site No.3 is not clear since the river cross section at Site No.3 was surveyed only one time in 1974. But, judging from the status of the river bed movement at Site No.2 where the river channel conditions are similar to those at Site No.3 except for the deepest portion, and from the result of geological investigation at Site No.3, it is considered that local aggradation or degration of river bed at Site No.3 will be similar to those at Site No.2 and that the deepest portion at Site No.3 will not shift further to Sinde side.

### 5.4.3 River Bed Material and Sedimentation

#### (1) River Bed Material

To investigate the characteristics of the river bed material in the Irrawaddy, the samples of bed material at Site No.3 were collected by means of spread spoon during the survey period in 1974. Fig. 5-6 shows the results of sieving analysis of the collected bed materials. This figure shows that the grain size of the bed material distributes from 0.002 to 0.9 mm. The average mean diameter(dm) and middle diameter($D_{50}$) for No.2 and No.3 samples estimated from Fig. 5-5 were 0.18 mm and 0.054 mm, respectively.
The specific gravity of No.1 to No.3 samples was calculated at 2.62 on an average.

#### (2) River Sediment Load

The river sediment may, in general, be classified into two group i.e., bed load and wash load. The bed load material is found in both the river bed and water. Its movement causes either aggradation or degradation depending on the discharge at given river section. The majority of the wash load material is suspended in water and found in the river bed to negligible degree.

The result of the sieving analysis as given in Fig. 5-6 shows that the grain size below 0.002 mm can be hardly found in the river bed material. Thus, finer bed material below 0.002 mm in size is called here the wash load.

The river sediment in the Irrawaddy has been measured only at the Prome gauge since 1966. During the survey period in 1974, the sampling data at the Prome gauge during the 1968-1972 period were provided by the Department of Meteorology and Hydrology at Rangoon.

The sediment concentration in these data comprises the bed loads and wash loads. However, the composition ratio of these loads is unknown since the result of sieving analysis for such loads is not available. Then, assuming that all of the sediment concentration in these data comprised the bed load material, the relation among the bed load transported, hydrologic parameter and characteristics of bed material was studied by using Kalinske-Brown formula.

Assuming that the characteristics of bed material at the Prome gauge are the same as those at Site No.3, the relation between the tractive force and bed load was obtained. In this calculation, it is assumed that the average hydraulic gradient between the sites is 1/21,000.

The annual sediment discharge transported through the river cross section at each bridge site can be estimated when the hydraulic mean depth and its duration period are given. Then, the water level duration curve at the Prome gauge was calculated based on the record during the 1966-1970 period. The water levels at the bridge sites corresponding to those during arbitrary duration period at the Prome gauge was estimated based on the result of water surface slope between the sites as given in Fig. 5-4. The river width and hydraulic mean depth corresponding to the water levels thus estimated were calculated by using the river cross section at each bridge site, assuming that the river bed elevations are those surveyed in 1974 and the dischages at each site are the same as those at the Prome gauge.

Table 5-4 shows the annual sediment discharge transported through the river cross section at the proposed bridge sites. The bed load discharge in the stretch between Site No.2 and Site No.3 ranges from about 45 to 90 million $m^3$ per annum. The sediment carrying capacity at Site No.1 is so large as about 10 times of that at Site No.2 and 20 times of that at Site No.3. This means that the river bed at Site No.1 is liable to scour when the sediment yield from upstream stretch decreases.

## 5.5 Estimation of Scouring around Pier Structure

There are two methods to estimate the maximum scouring depth around pier structure; one is Andru's method and the other is Lausen's method.

In Andru's method,the scouring depth measured from the water surface is expressed in relation to the river discharge per unit width of channel. Applying the water depth in case that the design high water level occurs at each alternative bridge site to Andru's formula, the maximum scouring depth was estimated as shown in Fig. 5-7, assuming the pier structure is constructed at arbitary place. This figure shows that the maximum scouring depth at three alternative bridge sites ranges from 17 m to 25 m.

In Laursen's method, the scouring depth around pier structure is determined by the relation among the length, width, shape and friction velocity of pier. Assuming that the pier width is 4 m or 6 m and that a coefficient as a friction of shape of pier is 0.9, the scouring depth at each alternative bridge site was estimated by applying the same river conditions applied to Andru's formula. The results are given in Fig. 5-7.

In order to check the applicability of the above-mentioned two calculation methods, a comparison between the actual scouring depth record in the past and the maximum scouring depth estimated by two formulae at the existing Ava bridge site located across the Irrawaddy at about 480 km upstream from Prome was made as described hereunder.

The river cross section along the center line of the Ava bridge is not available at present. Then the comparative study on the maximum scouring depth due to pier structures of the Ava bridge was made by incorporating the available river cross section at the Sagaing gauge surveyed in 1966, 1967 and 1974. Judging from the river profile and assuming that the local river bed variation at the Sagaing gauge means the scouring depth due to the piers of the Ava bridge, it is presumed that the scouring depth occurred in the past was the order of 11 to 13 m at its maximum.

The maximum scouring depth at the Ava bridge site can be estimated by applying both the Andru's and Laursen's methods, when the hydraulic parameters, pier width and river bed profile are given. The maximum water depth at the Ava bridge site during the highest flood can be estimated from the water level record during the 1965 - 1972 period at the Sagaing gauge. Assuming that the average pier width at the Ava bridge is 4 m and the river bed profile before the highest flood is the same as that surveyed at August 4th, 1967, the maximum scouring depth was estimated by using the Andru's and Laursen's methods. The maximum scouring depth estimated by the Andru's method was 14 to 16 m while that estimated by the Laursen's method was 10 to 12 m.

In addition to the above comparative study, the relation between the estimated scouring depth and the river flow conditions at the existing Ava bridge and No. 3 sites was studied. The ratio between water depth and river width at the existing Ava bridge site under high floods was estimated at about 1:70 while that estimated for the proposed Site No. 3 is 1:70. The result of the scouring depth estimate at the Ava bridge site showed that the maximum scouring depth estimated by the Laursen's method almost coincides with that presumed from the observation of river bed variation. The maximum scouring depth estimated for the Ava bridge site was the order of 10 to 12 m while that estimated for Site No. 3 was 11 to 12 m when the Laursen's method is applied for the pier width of 4 m. As far as these estimations and presumption are concerned, it seems appropriate to adopt the maximum scouring depth obtained by the Laursen's method for designing bridge substructure.

## 5.6 Appraisal of Alternative Bridge Sites

The several factors affecting the appraisal of bridge sites were studied from the viewpoints of hydrology, river engineering and navigation in the foregoing sections. The following shows the summary of the results of study on these factors.

| | | |
|---|---|---|
| 1. | Stability of river bank | No.1, No.2, No.3 |
| 2. | Stability of river bed | No.2 No.3 No.1 |
| 3. | Degree of difficulty for bridge construciton | No.1 No.2, No.3 |
| 4. | Stability for navigation | No.1, No.2, No.3 |
| 5. | Topographic condition | No.1 No.3 No.2 |

Remarks: Bar means the same order.

In view of the results in this table, it will be considered that the favourable bridge site is either Site No. 1 or Site No. 3.

## 5.7 Rivetment Works

### 5.7.1 Additional Scouring due to Degradation of River Bed and Installation of Mattress

The study on the river bed variation clarifies that the river bed at the alternative bridge sites varies from about 5 to 8 m at its maximum during a year from the beginning of 1973. Such situation implies that the river bed itself, if the pier structure is constructed, may lower or rise in course of time, independent of the probable scouring due to the construction of pier structure.

In order to protect the pier footing from the additional scouring due to such degradation of river bed, it is necessary to install the mattress above the river bed around pier structure. In this case, the most practical method for the mattress work seems to adopt the bamboo gabions which are constructed by packing the boulders inside the cylindrical bamboo baskets. The typical mattress work is given in Fig. 5-8. The quantity of boulder required for this mattress work was estimated at 41,000 $m^3$ for the prestressed concrete bridge and 30,000 $m^3$ for the steel truss bridge.

In this method, it is presumed that even after the mattress is installed, the mattress itself gradually degrades from year to year due to the scouring of river bed at the bottom part of the mattress. To cope with such degradation, it may be necessary to reinforce and supplement the mattress by piling the boulders above it, which is to be carried out during the low water season in every year. The quantity of boulder required annually for such reinforcement work was estimated at 10,000 $m^3$ for the prestressed concrete bridge and 8,000 $m^3$ for the steel truss bridge, assuming the annual piling depth of boulder is 0.4 m on an average.

### 5.7.2 Rivetment Work

In order to prevent the foot of the abutment structure from the scouring due to the flood flow, the river banks at the bridge site shall be protected by the rivetment works consisting of the works of slope pavement, toe protection and foot protection. It is considered to be the practical way at the present stage that the design criteria for planning of rivetment are decided taking into account the topograpphic and hydrological conditions, and the stability of river banks against the scouring at the proposed bridge site.

The factors affecting the stability of the river bank are the hydrological and geological conditions at the bridge site. The alternative bridge sites are located at relatively straight river channel. Then, it is considered that the river banks are seldom eroded due to the turbulent flow during the rainy season. However, the local bank erosion may occur due to the river flow or waves caused by the vessels, because the river banks seems to be mostly covered with sand or mud with certain thickness. To cope with such situation, it may be necessary to protect the toe of the slope pavement by suitable method.

Generally, the river stretch is classified into two, depending on its hydraulic gradient. They are the gentle flow river stretch where the hydraulic gradient is flatter than 1:5,000 and the steep flow river stretch which is steeper than the above-mentioned gradient. In the gentle flow river stretch, the rivetment for the flood flow is not always necessary from the hydraulic viewpoint and its execution is usually limited to the minimum extent from the economic standpoint. The river stretch at Site No.3 belongs to the gentle flow river course, where the average slope of the water surface is about 1:20,000, and the average velocity in this stretch is not so rapid as about 0.3 to 0.4 m/sec during the low water season and 2 to 2.4 m/sec even at the highest water time during the rainy season.

Taking the above-mentioned factors into consideration, the design criteria for rivetment planning were decided as follows:

(1) The slope pavement shall be provided along the original river banks.

(2) The extent of the slope pavement along the river cross section shall be limited to the range from the suitable elevation below the design high water level to the foot of the abutment structure.

(3) The extent of the slope pavement along the river longitudinal direction shall be limited to the range of 10 m long for both the up-and down-stream strectches from the bridge abutment.

(4) The concrete block method and wet masonry method shall be employed as the slope pavement at Sinde side and Prome side, respectively.

(5) The sheet pile of about 5 m long shall be driven along the toe of the slope pavement for protecting it from the scouring.

(6) In addition, the cobble shall be piled at the toe portion as the foot protection for the slope pavement.

Fig. 5.9 shows the details of the rivetment method at Prome side and Sinde side banks at Site No.3. The construction quantity and materials required for this rivetment work were estimated as shown below.

| Item | Unit | Quantity |
|---|---|---|
| <u>Construction quantity</u> | | |
| Concrete block work | $m^2$ | 1,500 |
| Wet masonry work | $m^2$ | 1,000 |
| <u>Construction material</u> | | |
| Cobble | $m^3$ | 2,000 |
| Gravel | $m^3$ | 3,000 |
| Sheet pile | ton | 40 |

Table 5-1 Data and Records used for Hydrological Study

| Subject | Contents | Period | Prepared by | Related Table or Fig. |
|---|---|---|---|---|
| Water Level and Discharge | 1. Daily mean water level records at 14 gauges | 1966 - 1973 | Dept. of Meteorology and Hydrology | Fig. 5-2 |
| | 2. Daily mean discharge records at 4 gauges | 1965 - 1973 | - do - | Fig. 5-3 |
| | 3. Annual maximum water level records at the Prome gauge | 1875 - 1958 | | |
| | 4. Map showing the hourly water level at highest flooding time at the Prome gauge | 1966 - 1971 | Dept. of Meteorology and Hydrology | |
| | 5. Flow velocity survey record at the Prome gauge | 1970 | - do - | |
| | 6. Flow velocity survey record at the Prome gauge | 1974 | JICA Team | |
| | 7. Water surface slope survey record | 1974 | JICA Team | Fig. 5-4 |
| River Cross Section | 1. River cross section at Thayet, Kyangin, Chank | 1965 - | Dept. of Waterway | |
| | 2. River cross section at Sagaing, Chank, Prome | 1966-1974 | Dept. of Meteorology and Hydrology | |
| | 3. River cross section at alternative bridge sites<br>(Water depth survey by echo sounder) | 1973, 1974 | JICA Team | Fig. 5-5 |
| Sedimentation | 1. Sediment load survey at Prome gauge | 1968 - 1972 | Dept. of Meteorology and Hydrology | Fig. 5-6 |
| | 2. Sampling survey of bed material at No.3 | 1974 | JICA Team | Fig. 5-6 |
| Navigation | 1. Investment program "Inland Water Transport Requirements by World Bank" | 1972 | I.W.T.C. | |

## Table 5-2 Maximum Water Level During 1875 - 1974 Period

| Order | Year | W.L. (m) | Month |
|---|---|---|---|
| 1 | 1875 | 29.44 | |
| 2 | 1877 | 30.08 | |
| 3 | 1880 | 30.05 | |
| 4 | 1886 | 29.25 | |
| 5 | 1890 | 29.54 | |
| 6 | 1905 | 29.06 | |
| 7 | 1939 | 29.57 | |
| 8 | 1947 | 29.63 | |
| 9 | 1952 | 29.63 | |
| 10 | 1953 | 29.14 | |
| 11 | 1955 | 29.38 | |
| 12 | 1958 | 29.08 | |
| 13 | 1966 | 29.90 | Sep. |
| 14 | 1967 | 27.82 | Oct. |
| 15 | 1968 | 29.46 | Aug. |
| 16 | 1969 | 28.32 | Aug. |
| 17 | 1970 | 29.37 | Aug. |
| 18 | 1971 | 29.82 | Sep. |
| 19 | 1972 | 28.21 | Aug. |
| 20 | 1973 | 29.78 | Aug. |
| 21 | 1974 | 30.25 | Aug. |

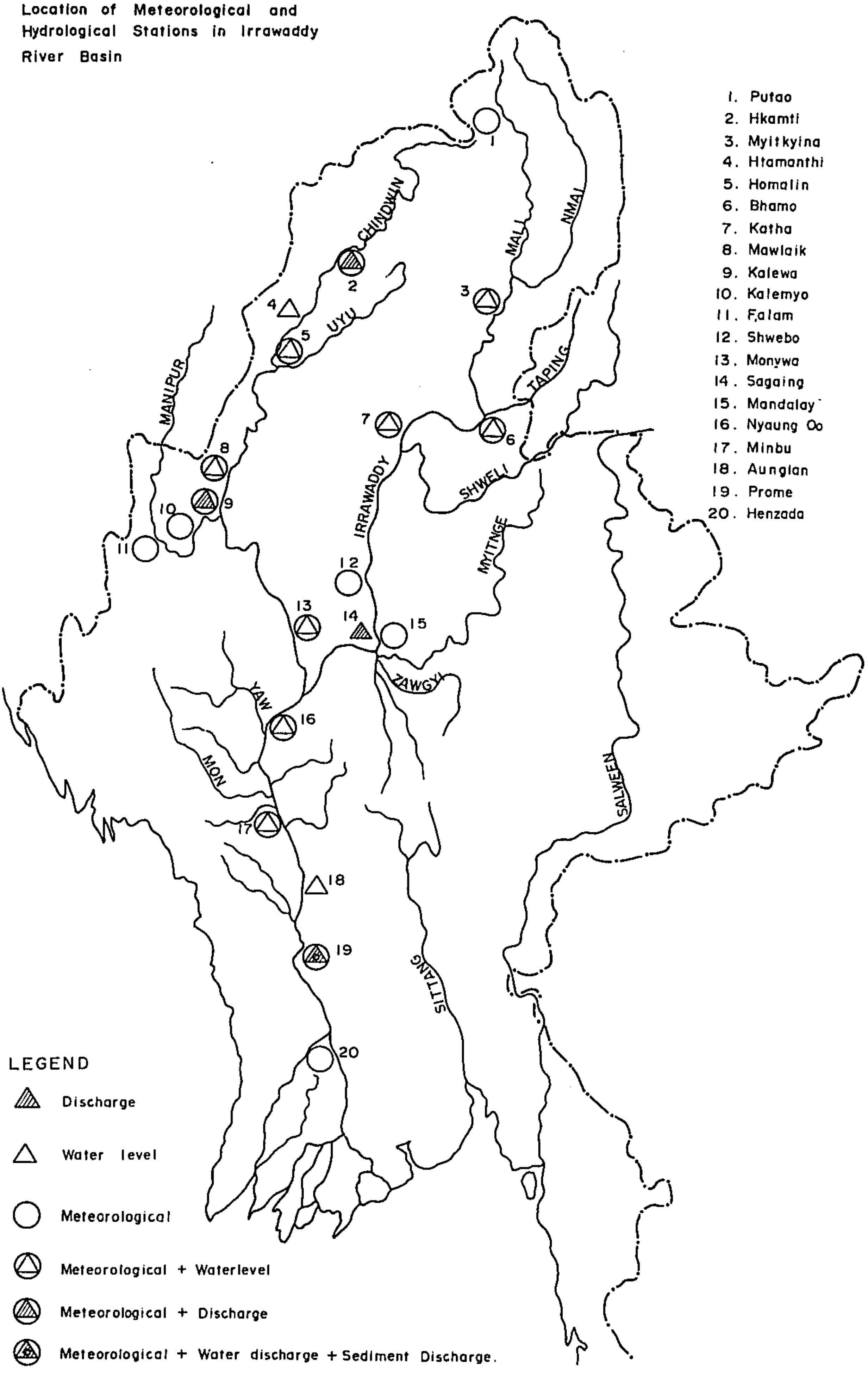
Table 5-3 River Bed Movement at Site No.1 and No.2

| Site | From Jan., 1973 to Aug., 1973 | From Aug., 1973 to Feb. or Mar., 1974 |
|---|---|---|
| No.1 | Degradation at centre portion and right side. Degradation is about 5 m at maximum. Aggradation at left side. Aggradation is about 5 m at maximum. | Aggradation through whole river channel. Aggradation is about 7 m at maximum. |
| No.2 | Degradation at both sides. Degradation is about 4 m at maximum.<br>Aggradation at centre portion. Aggradation is about 3.5 m at maximum. | Aggradation at right side. Maximum aggradation is about 3 m. Almost no movement at centre portion and left side. |

Table 5-4 Annual Sediment Discharge Transported Through Each Bridge Site

| Prome gauge | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| W.L. (m) | 28.867 | 27.467 | 25.617 | 22.617 | 19.867 | 18.167 | 17.167 | |
| Duration (day) | 15.2 | 51.2 | 46.1 | 46.1 | 41 | 150.8 | 14.6 | 365 |
| Site No.1 | | | | | | | | |
| $U_*$ | 0.1028 | 0.0995 | 0.0986 | 0.0917 | 0.0860 | 0.0815 | 0.0787 | |
| $q_B(m^3/sec/m)$ | $17.518x10^{-2}$ | $11.264x10^{-2}$ | $9.961x10^{-2}$ | $37.317x10^{-3}$ | $15.659x10^{-3}$ | $7.565x10^{-3}$ | $4.713x10^{-3}$ | |
| $Q_B(10^6m^3)$ | 161.9 | 348.8 | 277.7 | 102.6 | 37.8 | 66.5 | 4.0 | 999.3 |
| Site No.2 | | | | | | | | |
| $U_*$ | 0.0858 | 0.0821 | 0.0785 | 0.0691 | 0.0692 | 0.0651 | 0.0612 | |
| $q_B(m^3/sec/m)$ | $15.168x10^{-3}$ | $8.353x10^{-3}$ | $4.556x10^{-3}$ | $8.106x10^{-4}$ | $8.267x10^{-4}$ | $36.159x10^{-5}$ | $15.672x10^{-5}$ | |
| $Q_B(10^6m^3)$ | 21.8 | 40.1 | 19.6 | 3.4 | 2.3 | 3.5 | 0.1 | 90.8 |
| Site No.3 | | | | | | | | |
| $U_*$ | 0.0819 | 0.0778 | 0.0722 | 0.0646 | 0.0652 | 0.0626 | 0.0585 | |
| $q_B(m^3/sec/m)$ | $8.085x10^{-3}$ | $40.339x10^{-4}$ | $14.678x10^{-4}$ | $32.576x10^{-5}$ | $36.917x10^{-5}$ | $21.283x10^{-5}$ | $8.510x10^{-5}$ | |
| $Q_B(10^6m^3)$ | 12.7 | 21.3 | 6.9 | 1.5 | 1.0 | 2.0 | 0.1 | 45.5 |

5-1 Location of Meteorological and Hydrological Stations in Irrawaddy River Basin



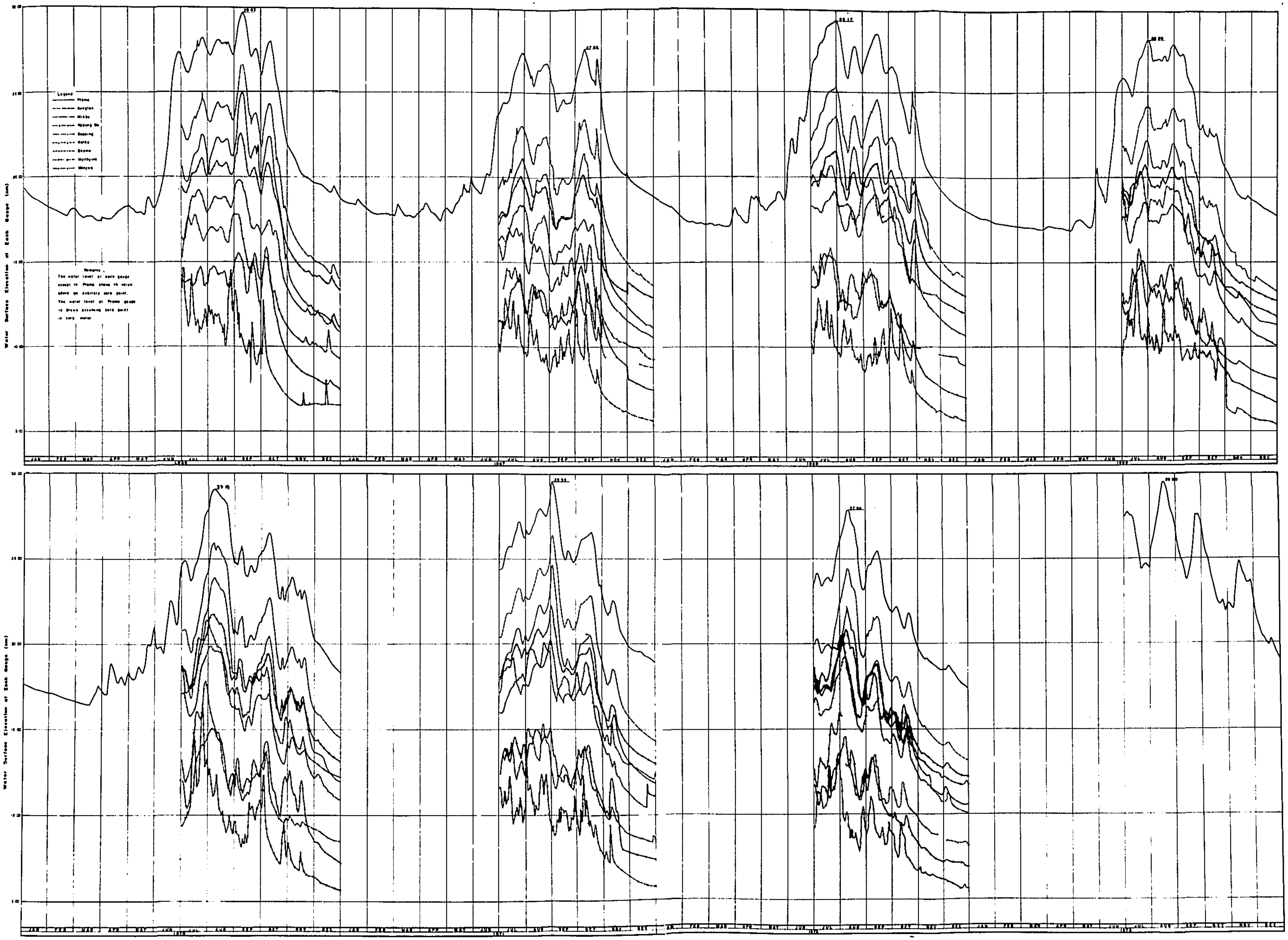


Fig. 5-2 Water Level at Each Gauge

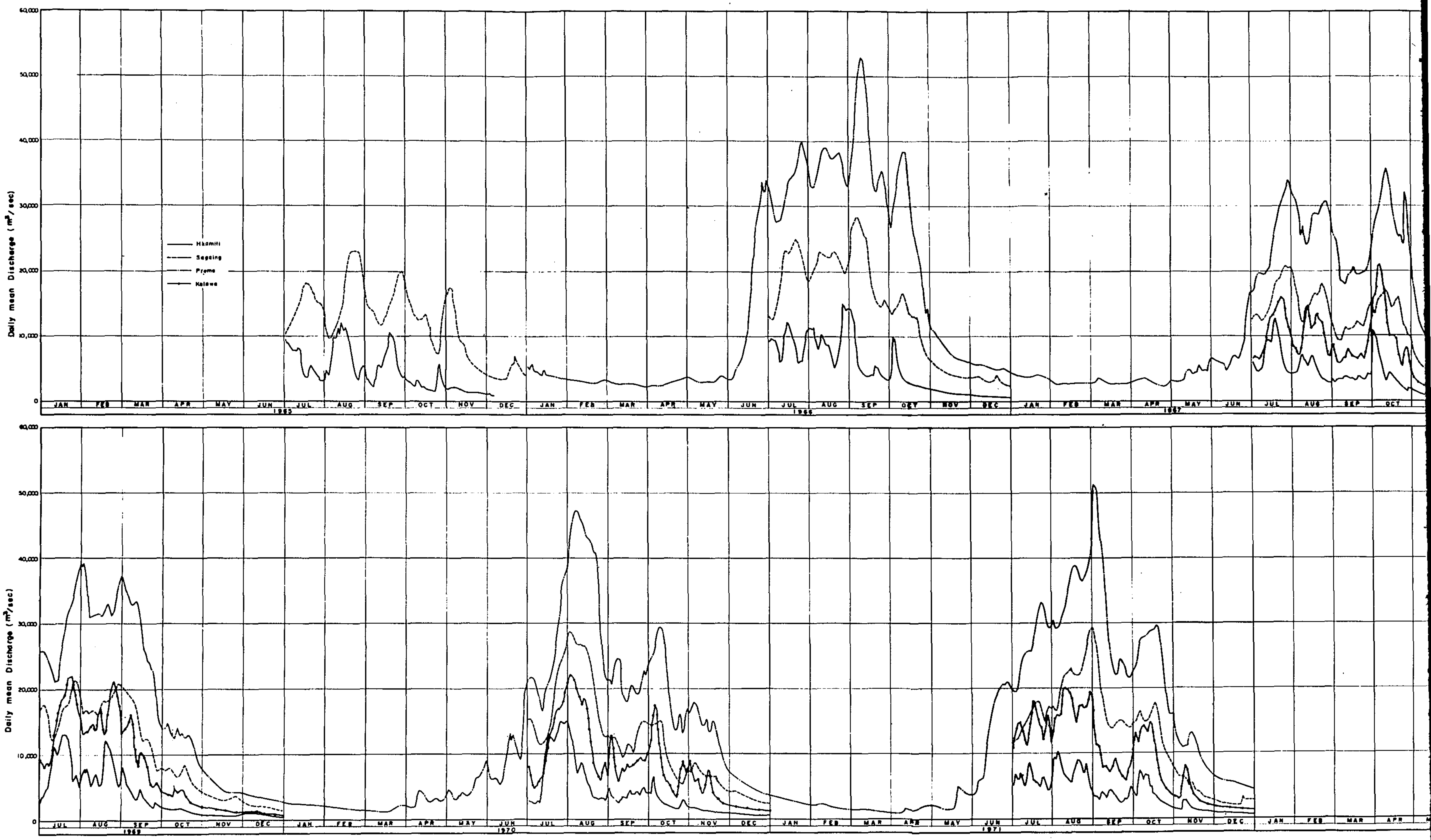
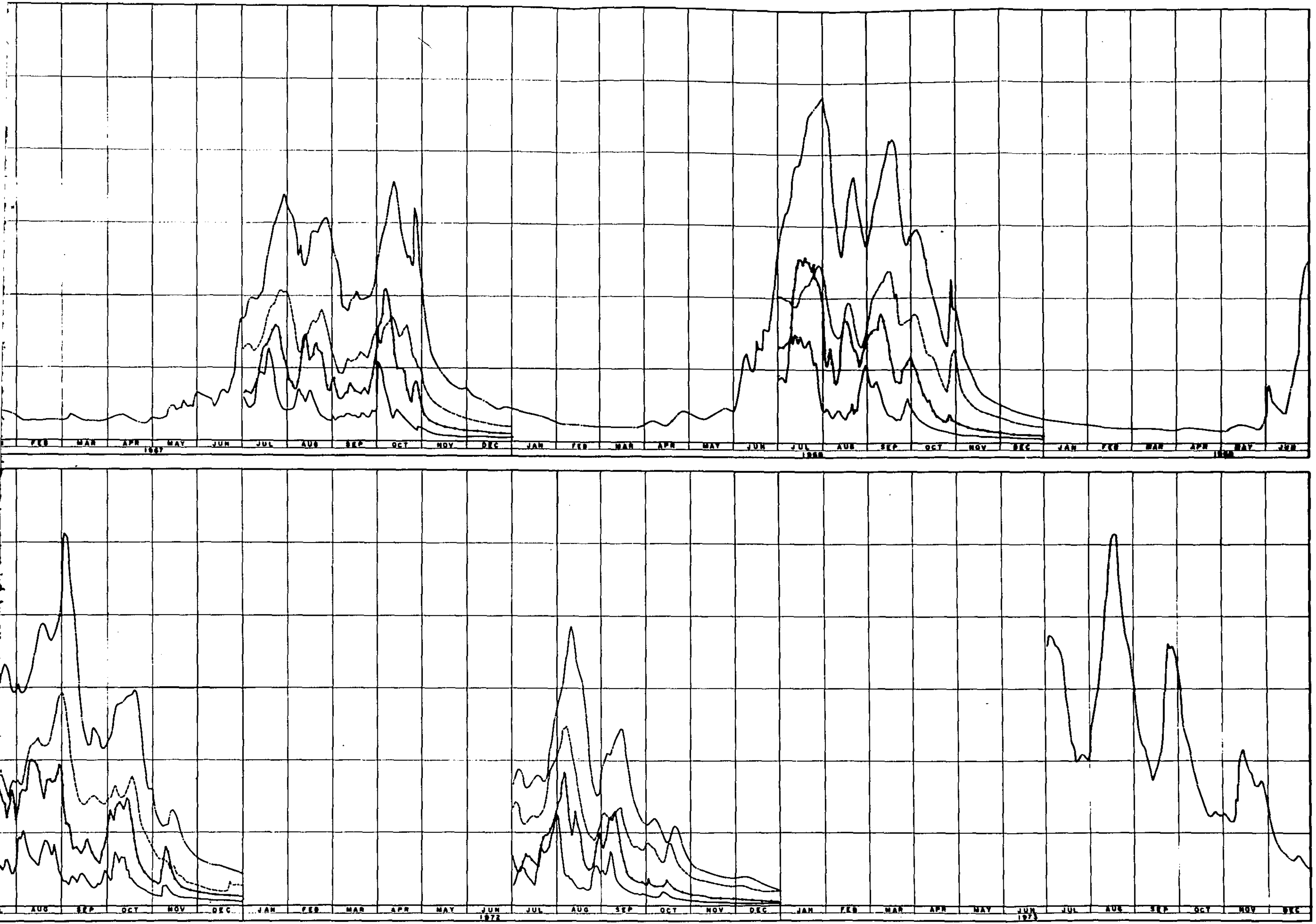


Fig 5 – 3 Discharge Hydrograph at Hkamti, Kalewa, Sagaing and Prome



at Hkamti, Kalewa, Sagaing and Prome

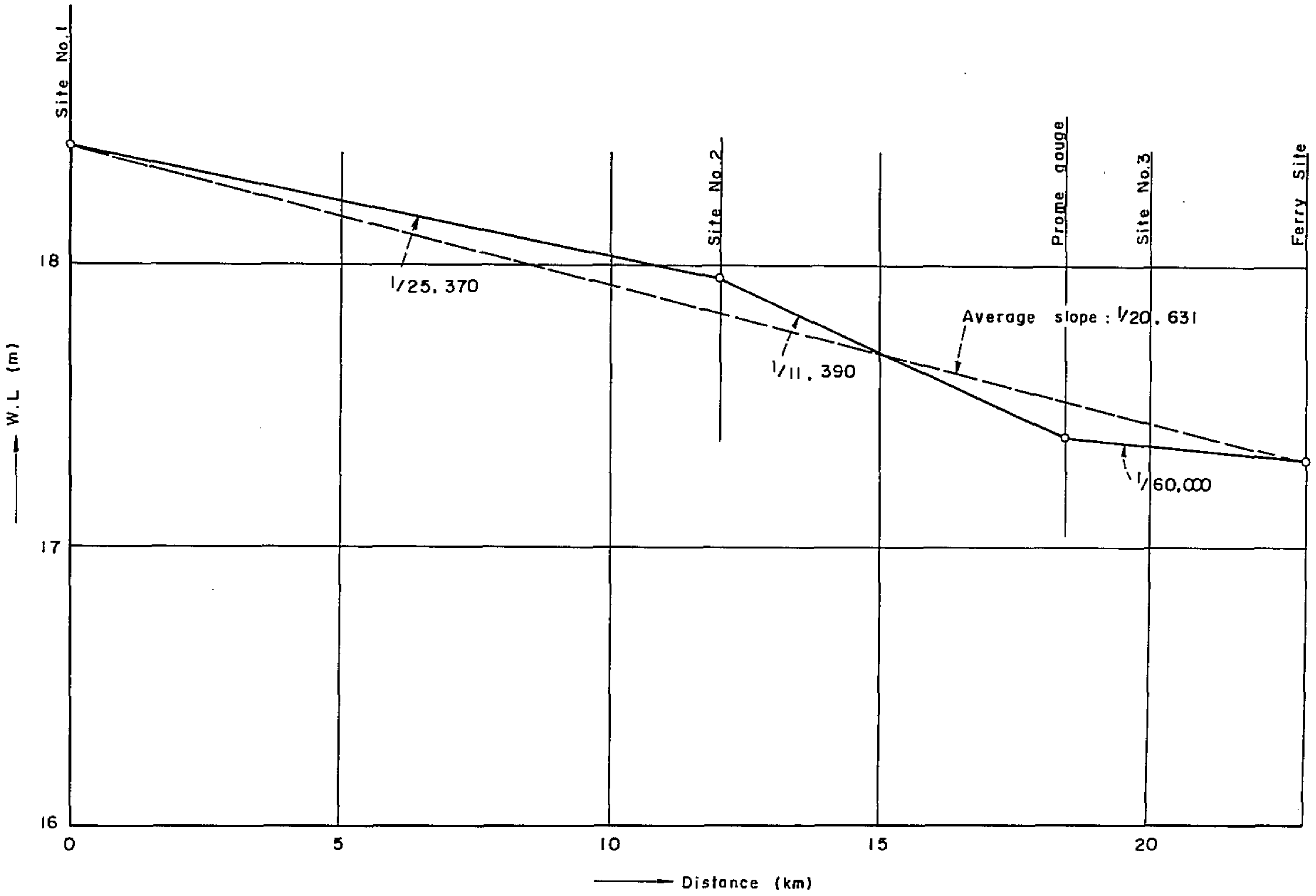
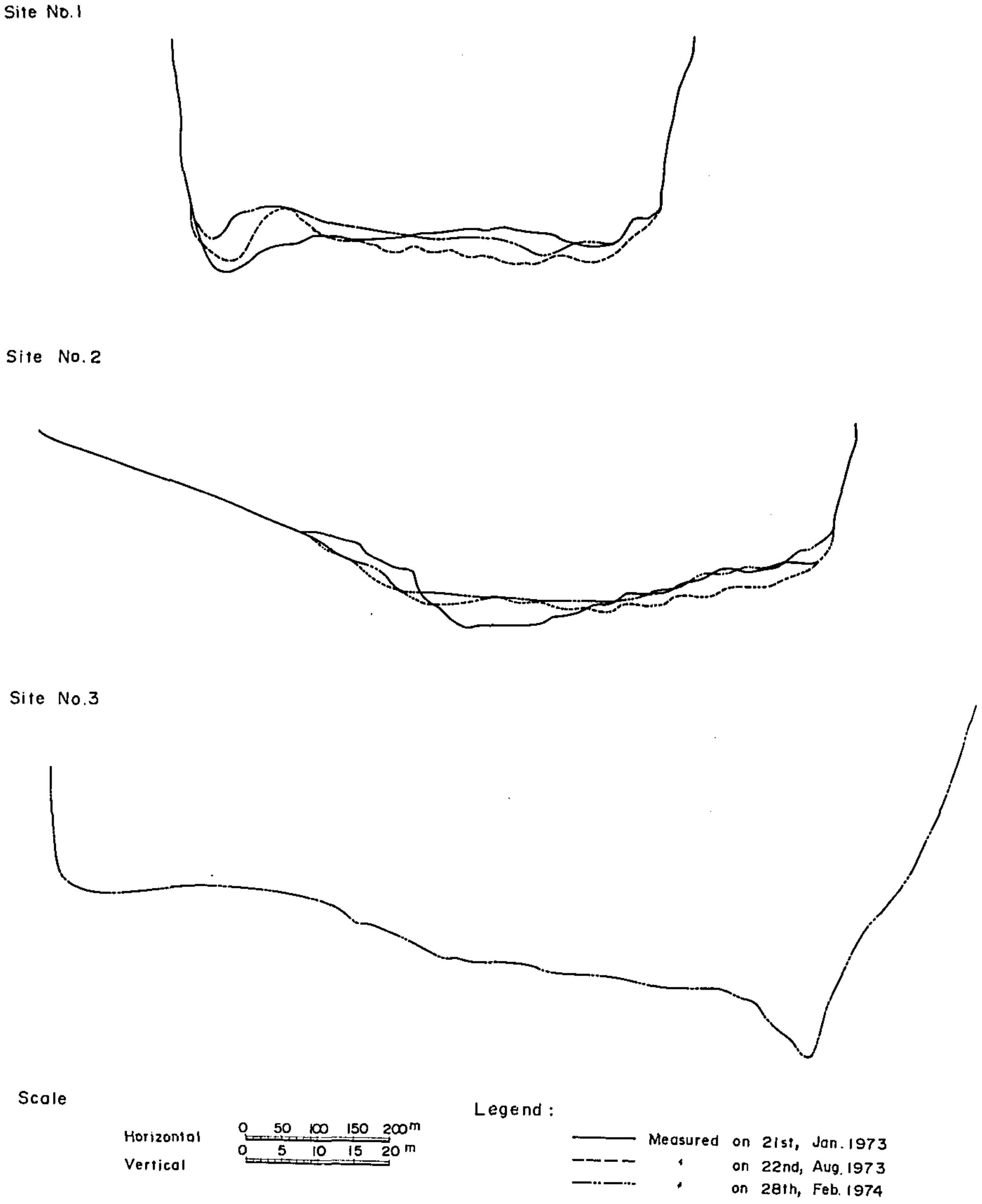


Fig 5-4 Water Surface Profile

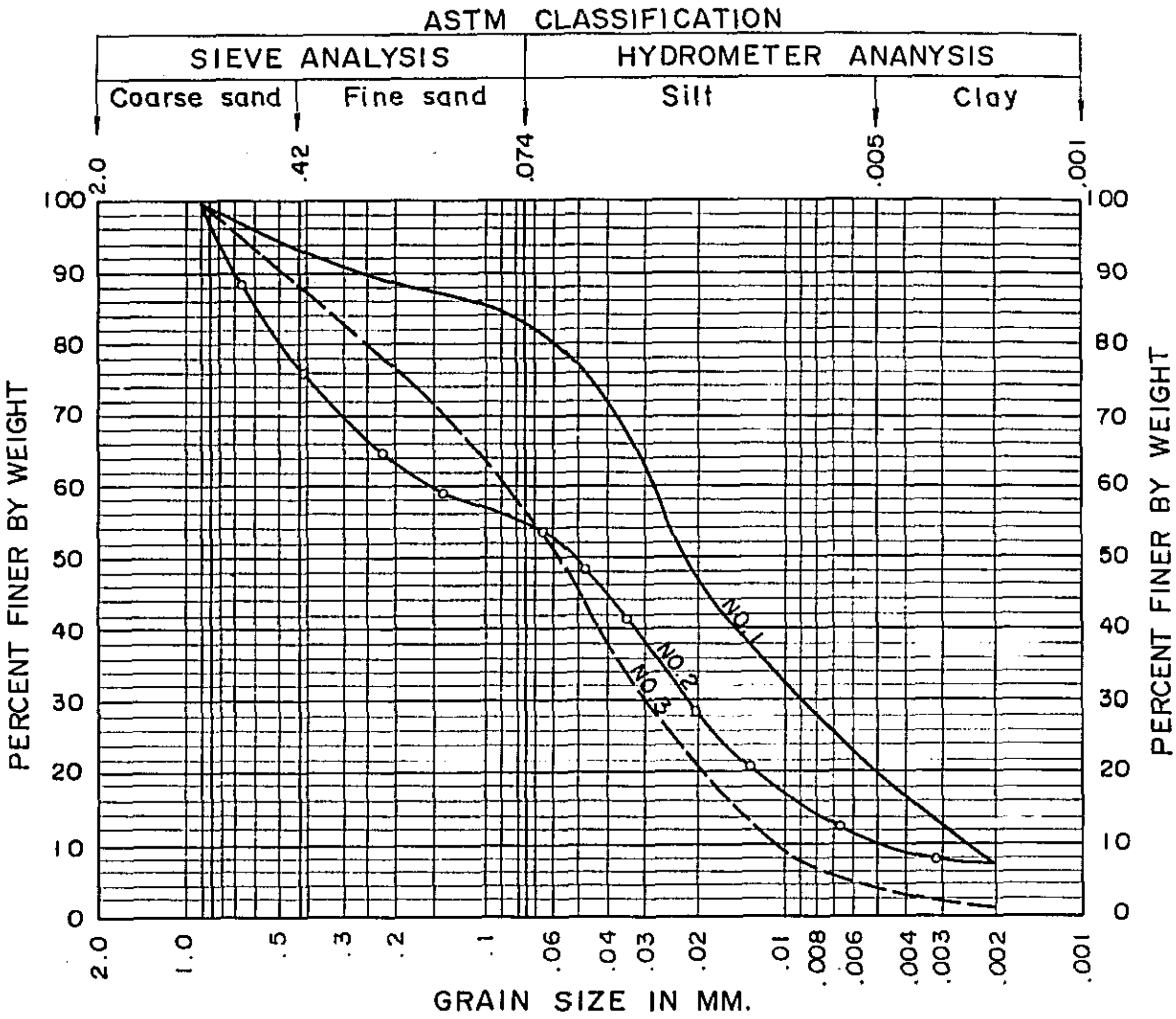


Site No.1

Site No.2

Site No.3

Fig. 5–5 River Cross Section at Alternative Bridge Site



| DATE | LEGEND | | DEPTH (ft) | D 65 (mm.) | D 50 (mm.) | D 35 (mm.) |
|---|---|---|---|---|---|---|
| 7 3 1974 | ——— | | 30 | 0. 03 | 0. 021 | 0. 011 |
| 〃 | — — — | | 25 | 0. 10 | 0.054 | 0. 033 |
| 〃 | —o— | | 15 | 0. 26 | 0. 054 | 0. 026 |

Fig 5 – 6 Result of Grading Analysis

Fig. 5-7 PROBABLE SCOURING DEPTH DUE TO PIER STRUCTURE

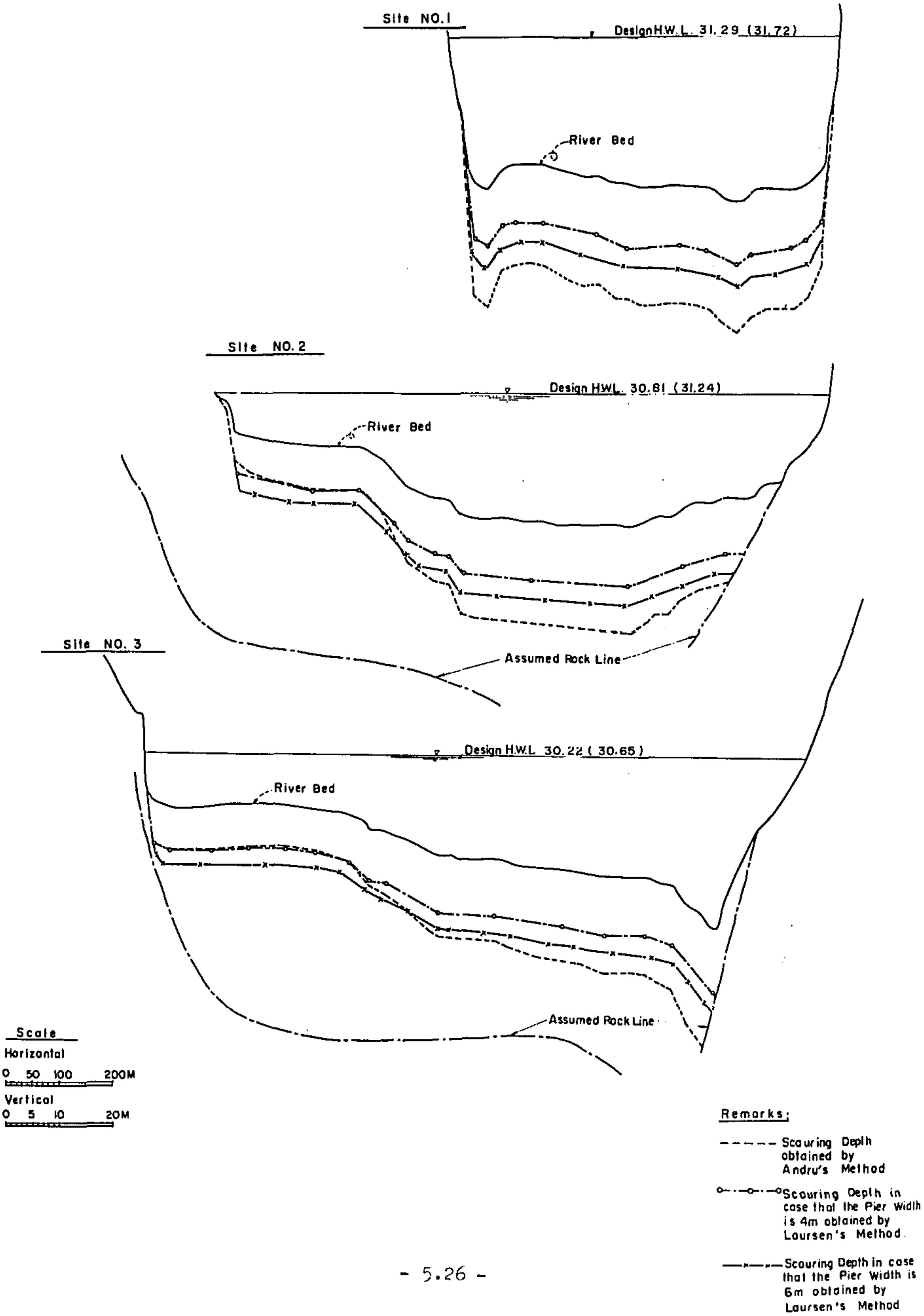
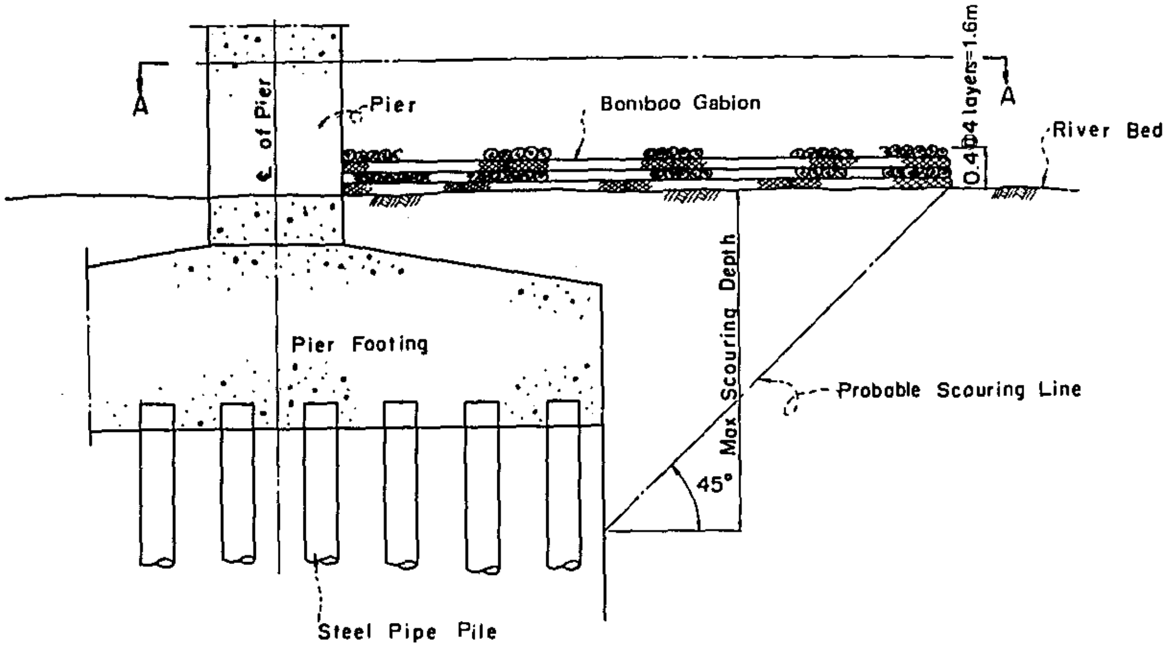
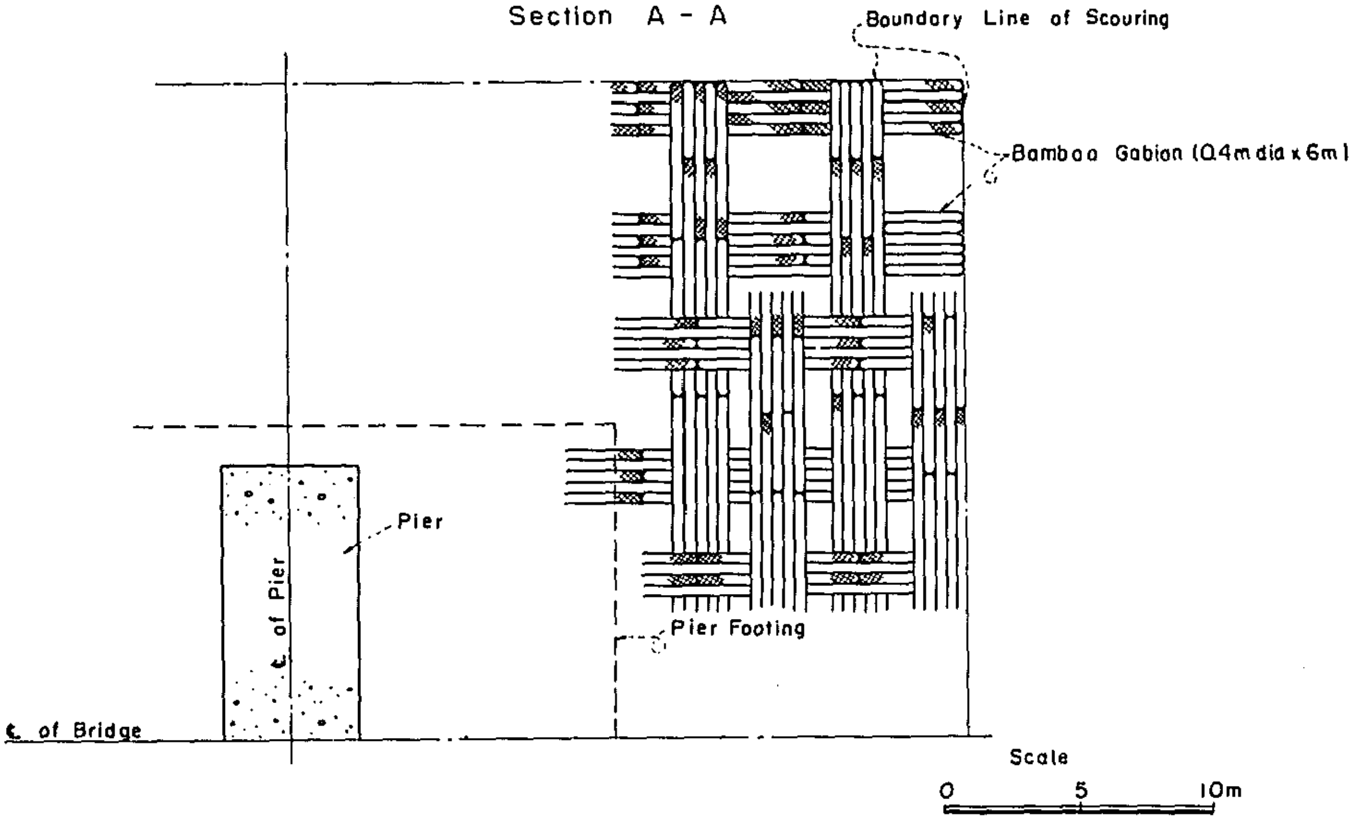


Fig. 5 — 8 TYPICAL STRUCTURE OF MATTRESS WORK

Profile

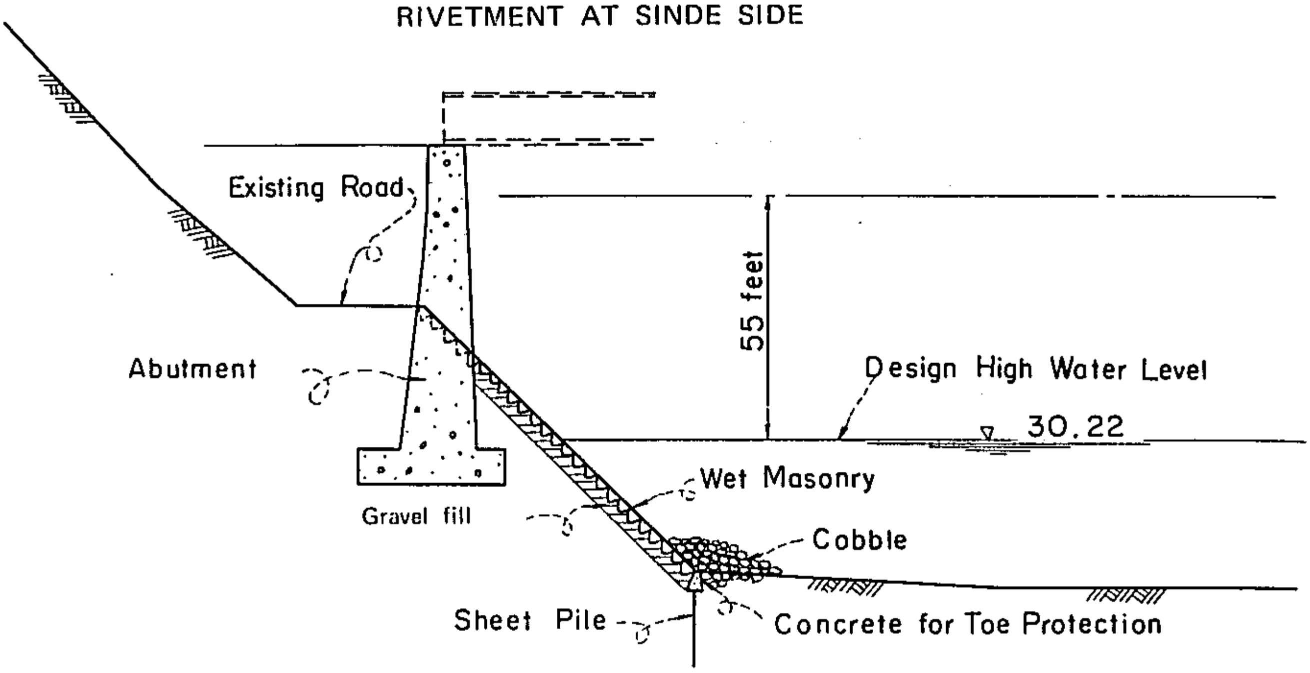


Section A - A

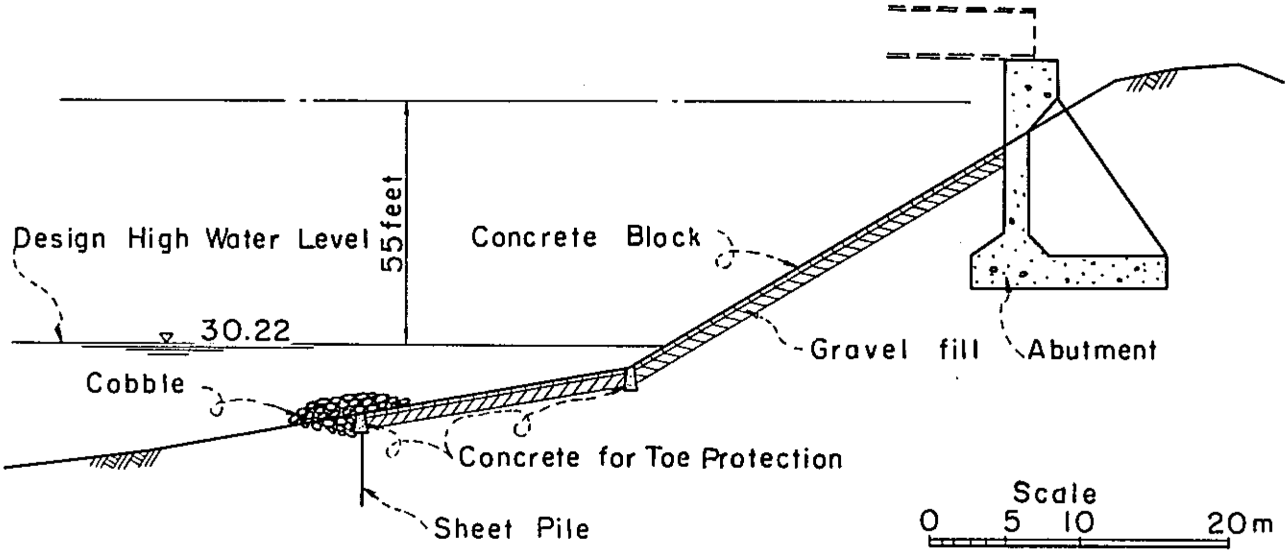


## Fig. 5-9 RIVETMENT AT SITE NO. 3

RIVETMENT AT SINDE SIDE



RIVETMENT AT PROME SIDE



## 6. ACCESS ROAD

# 6 ACCESS ROAD

## 6.1 General Description of Influence area

The Government has the future plan of construction and improvement of highway in the influence area of this project (Fig. 6.1). These are as follows:

(1) Four years plan

| | |
|---|---|
| Prome - Toungoo | (construction) |
| Myanaung - Okshitpim | ( " ) |
| Shandaw - Irrawaddy River Side | ( " ) |
| Bassein - Monywa | ( " ) |
| Nyaungdon - Rangoon | ( " ) |
| Maputi - Ranpetlet | ( " ) |
| Maputi - Hara | ( " ) |
| Gangaw - Monywa | ( " ) |
| Prome - Rangoon | (improvement) |
| Myanaung - Henzada | ( " ) |

(2) Twenty years plan

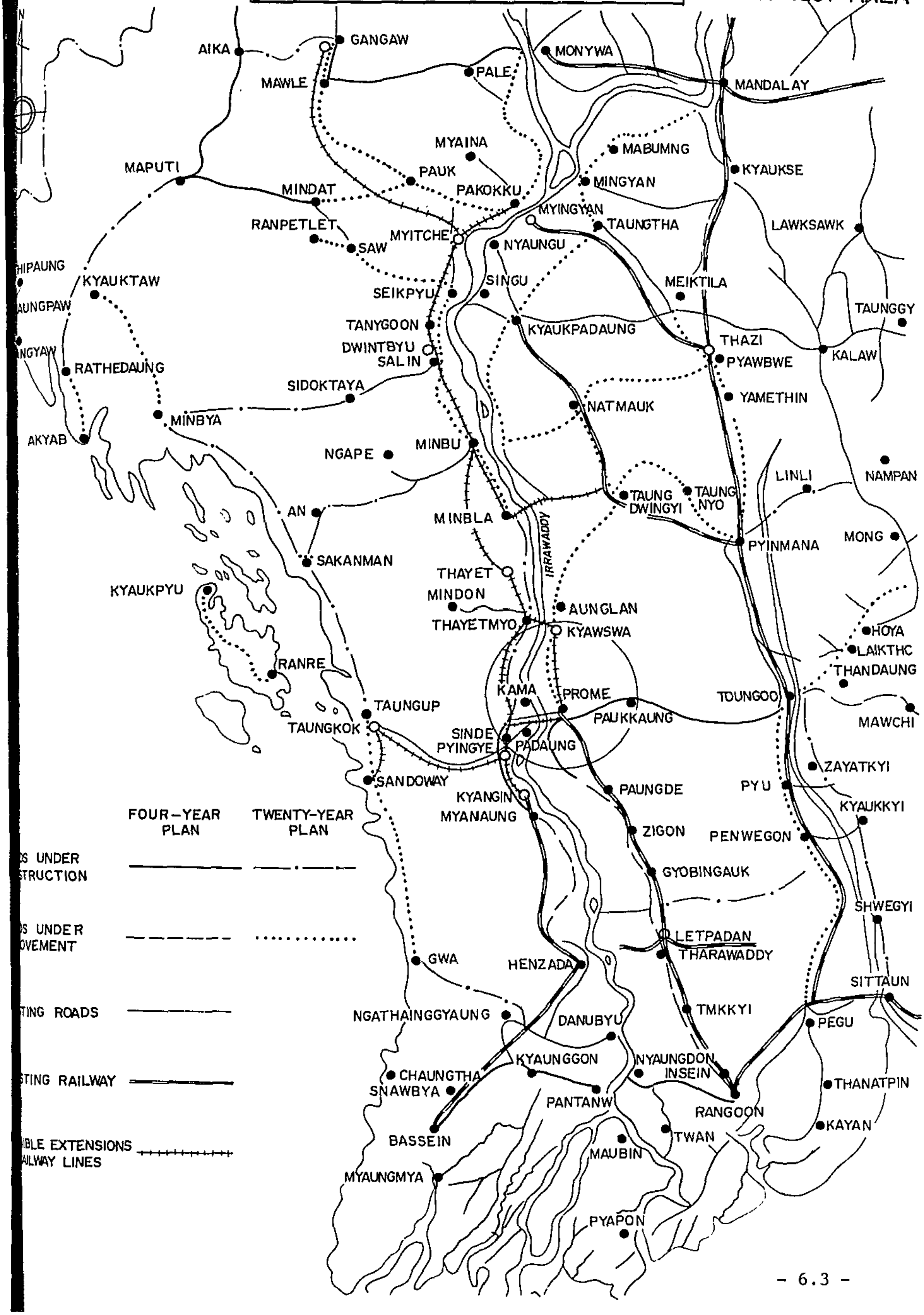
| | |
|---|---|
| Okshitpim - Minbla | (construction) |
| Taungup - Sakanman - Minbya | ( " ) |
| Sakanman - Ngape | ( " ) |
| Minbya - Sidoktaya | ( " ) |
| Rathedaung - Mapute | ( " ) |
| Aika - Gangaw | ( " ) |
| Toungoo - Sittaung | ( " ) |
| Shandaw - Penwegon | ( " ) |
| Prome - Taungdwingyi - Meiktila | (improvement) |

| | |
|---|---|
| Taungdwingyi - Myingyan | (improvement) |
| Toungoo - Pegu | ( " ) |
| Minkla - Ranpetlet | ( " ) |
| Taungup - Gwa | ( " ) |
| Minbya - Kyauktaw | ( " ) |
| Ranpetlet - Monywa | ( " ) |

6-1

# PROVEMENT PLAN OF ROADS AND POSSIBLE NETWORK PLAN OF RAILWAY AT THE PROJECT AREA

SCALE = 1 INCH TO 40 MILES



## 6.2 Design Standard

### 6.2.1 Terrain Condition

The project area consists of, for the most part, hilly and high land regions. Mountainous terrain is located in the west side of Site No. 2 and Site No. 3.

The following table presents terrain conditions encountered in each access road.

| | | | Length (Approx.) | Terrain |
|---|---|---|---|---|
| a) | Site No. 1 | | | |
| | Prome side (to the existing road) | | 9.8 km | Hilly |
| | Sinde side (to the future road) | | 4.4 km | Hilly |
| b) | Site No. 2 | | | |
| | Prome side (to the existing road) | | 9.2 km | High land |
| | Sinde side (to the future road) | | 17.2 km | Hilly and partly mountainous |
| c) | Site No. 3 | | | |
| | Prome side (to the existing road) | A | 8.7 km | High land |
| | (to the existing nearby road) | B | 1.5 km | |
| | Sinde side (to the future road) | A | 19.5 km | High land and partly mountainous |
| | (to the existing road) | B | 2.7 km | |

### 6.2.2 Design Criteria

The highway design standards of Burma were basically used in this study but some parts were revised taking into consideration engineering and economical points in this project.

a) Design Speed

A design speed of 80 Km/hr is adopted to minimise in the long range the sum of the highway construction cost plus the motor vehicle running cost for the access roads.

### b) Cross Section

Traffic lane of the access road is of 3.6 meters in width according to the highway design standards of Burma. This is considered to be the ideal width for the adopted design speed. The shoulder width of 24 meters is sufficient so that a stopped vehicle can clear the edge of the through traffic lane.

### c) Horizontal Alignment

In the design of horizontal curves, the minimum radius is 500 meters for a given design speed determined from the maximum rate of superelevation of 6 percent in this project.

### d) Vertical Alignment

In this study, the maximum grade is 4 percent taking into consideration the relationship between terrain conditions and design speed. The length of vertical curves as determined by stopping sight distance requirements is decided from the standpoint of safety, comfort and appearance. The minimum length of vertical curves is 400 meters for both crest vertical curves and sag vertical curves.

### e) Other Criteria

In addition to the criteria mentioned above, consideration into 25-year frequency is recommended for designing minor bridges, 10-year frequency for culvert and 5-years frequency for surface drainage systems. Guardrails are considered in the necessary locations. Traffic control devices such as markings, signs and channelizations are to be provided to maintain control of traffic on the access roads.

## 6.3 Access Road Location

Extensive field reconnaissance and review of available data were made to the most effective design and construction standards of the proposed access roads. And also on the basis of fact-finding, route location studies were carried out based on the topographic and photomaps. The alignments proposed in this report were set up in accordance with the considerations as indicated in the following figures.

As to the Site No. 3, A and B routes were considered in this study. A route has the purpose of direct connection with the future highway on Sinde side and of bypassing the built-up area on Prome Side. B route is the shortest cut to the existing roads.

On Prome side of the project area, a national highway from Rangoon to Mandalay via Prome was kept up under the comparatively good conditions. As to the connection between the projected bridge and the existing road, i.e. two kinds of access road, direct connection to the highway (B route) and a method of bypass (A route) avoiding the built-up area of Prome, were considered. When traffic volume on the access roads increase in the future, both connections might be necessary but at first one would be sufficient to handle the traffic.
According to the traffic studies of this project, the traffic volume in the Mandalay direction corresponds only a small proportion of the total traffic volume, being only 7 - 8% in terms of cargo vehicle traffic. The direct connection would be adequate from the point of traffic demand.
On Sinde side, the future highway is planned by Burmese Government. Connections of improved existing road (B route) and of the future highway directly (A route) were examined. According to the traffic studies, the direct connection would be effective for the vehicle traffic of long trip while improvement of the existing road would be necessary for that of short trip.

## 6.4 Structure Design of Access Road

### 6.4.1 Pavement

An asphaltic concrete pavement is recommended as the most practical and economical one for this Project, taking into consideration stage construction for reducting initial investment. Ultimate asphaltic concrete thickness may be increased to meet the future traffic volume requirement. Subgrade was evaluated by a visual investigation of the soil conditions encountered in the project sites. In the high land, the subgrade is mostly sandy and can be expected to have CBR value of more than 15. Some parts which consist of mudstone must meet the problem of swelling of subgrade soils during the construction period of this project. Saturation and swelling of the soils reduce the strength of subgrade. In this preliminary design, CBR value of 10 was used a little conservatively for the pavement design. Subbase course shall consist of a compact layer of granular material that is available near the project site. Crushed stone shall be used for the base course in this project.

### 6.4.2 Minor Bridges

In selecting the type of structure, the following are generally deemed preferable from economical and technical points of view:

- Minor bridges ranging approximately from 15 meters to 30 meters shall be of prestressed concrete type.
- Grade separation bridges on the future railway shall be of prestressed concrete type.
- Short span bridges ranging approximately from 7 meters to 15 meters shall be of reinforced concrete type.

Pile foundations shall be utilized for the substructure of bridges, if necessary.

### 6.4.3 Drainage and Erosion Control

Drainage requirements with reference to a 10-year return period discharge for culverts and a 5-year for road surface are given in the results of the hydrological considerations. The catchment areas have been determined on a scale of 1-inch/1-mile maps. For an equal discharge, pipe culverts are cheaper than box culverts and as a rule the formers have been preferred when thickness of the embankment cover is at least 0.5 meter. They are often used in groups. For maintenance reason, no pipe culvert less than 0.6 meter in diameter has been proposed. In cases where grouping of the above culvert types is unsuitable, either economically or technically, box culverts are therefore proposed in the minor rivers and channels.

Washouts and erosion are usually most severe in hilly areas subject to high rainfall where the energy in the rapid runoff is often capable of extensive damage if not properly channeled. Slope failures both in embankment and cuttings would be frequent in the mudstone area. While these failures are due to principally geological conditions and also to tectonic conditions, they usually occur after heavy rains. Therefore a suitable slope protection should be provided in the area required. The crest ditches shall be lined with turf in the case of soils not subject to erosion, and constructed in concrete masonry in the case of rock or highly erodable soils. Special care will be required at the outlet of the ditches to prevent regressive erosion. In cuttings at sags in the natural ground, the slope will be protected by water chutes either in concrete or in masonry which will lead water to the longitudinal ditches or directly to the culverts.

Longitudinal ditches will be used to collect and drain the surface water from the pavement, shoulders, cutting slopes and water chutes. Depending on the geological conditions, the ditches will be either lined with mortared riprap or left unlined where erosion is unlikely. Special care must be given to the construction of the outlets or spillways of longitudinal ditches. They should be located in natural undisturbed ground. They are kept well clear of erodable embankment slopes, and their ends are protected against regressive erosion as for the crest diches.

In order to prevent blocking of the ditches by isolated falls or slides from the upper slopes, berms will usually be provided between the ditch and bottom of the cutting slope. Berms may also be provided at version levels on the face of high cutting slopes in particularly erodable soils in which case they may also carry a supplementary longitudinal ditch or gutter.

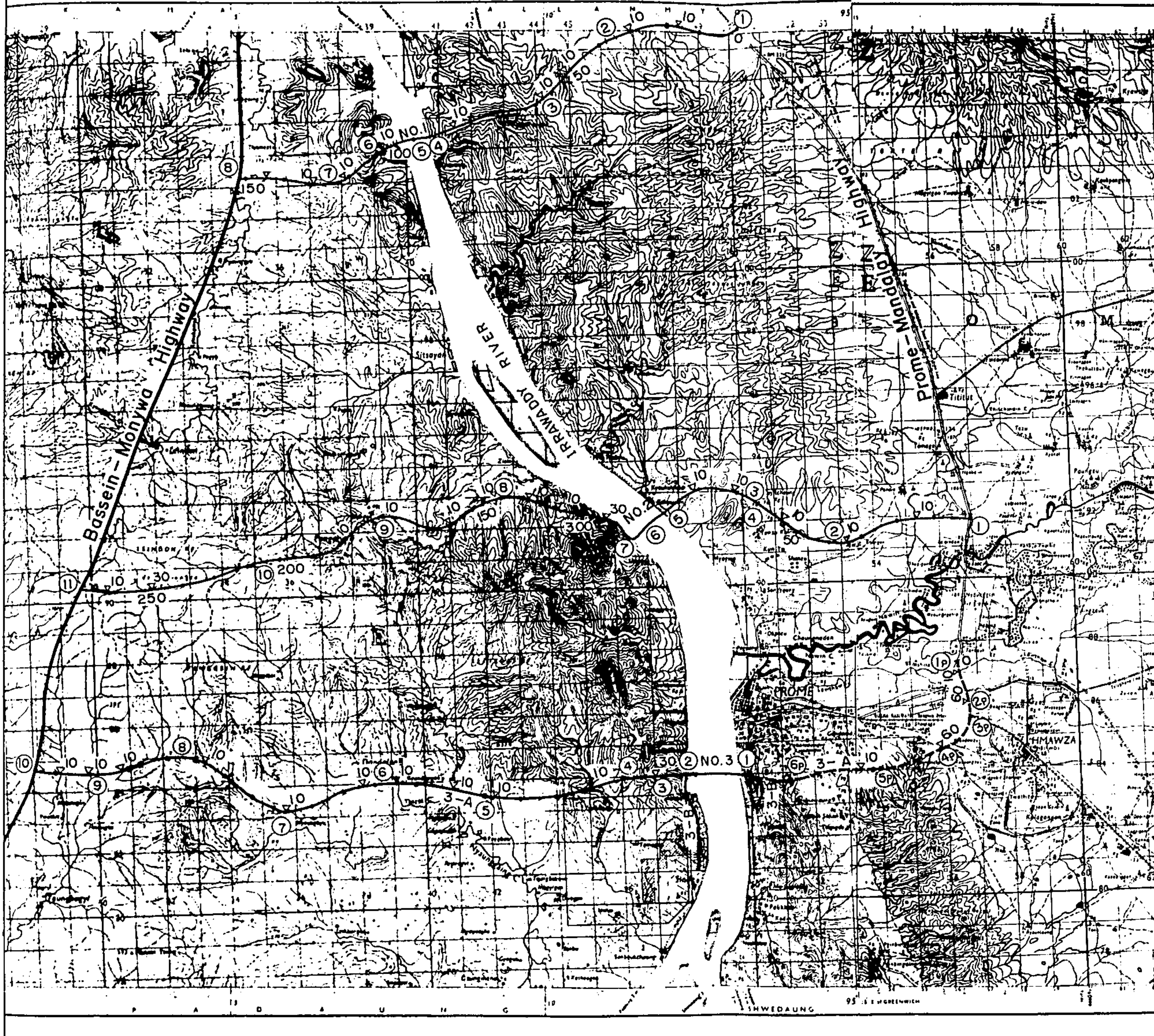
As the high embankments will be few and will almost always be in hilly areas where the cut-to-fill materials are likely to be rocky. Also, in most hilly areas, excavated material from cuttings will be in excess of fill requirements, and so spoil pits should be located so as to give added protection to embankment. While some erosion will have to be expected during and immediately after construction, this can be limited by ensuring adequate compacion of the earthworks. As to protection of culvert inlets and outlets, embankment are to be protected by concrete wing-walls, headwalls and apron slabs. In particularly erodable conditions, the inlet and outlet approaches are also to be pitched with masonry.

### 6.5 Construction Schedule

The following considerations have been used as guidelines when preparing the construction schedule of the access road. The construction schedule takes into account the climatic conditions prevailing at Prome area. Especially earthwork and pavement work are likely subject to the influence of the intense and frequent rainfall. About 200 days were decided for annual working days of the pavement. For the earthwork, scheduled duration was considered through a year, because rock excavation could be carried out even during the rainy season.

In this study, construction schedule was decided taking into account the term of redemption of construction equipment provided for the access roads. During the construction period, the equipment of earthwork would be depreciated perfectly but those of pavement work would be done partly because of small scale of this access road construction.

Fig. 6-2 LOCATION MAP

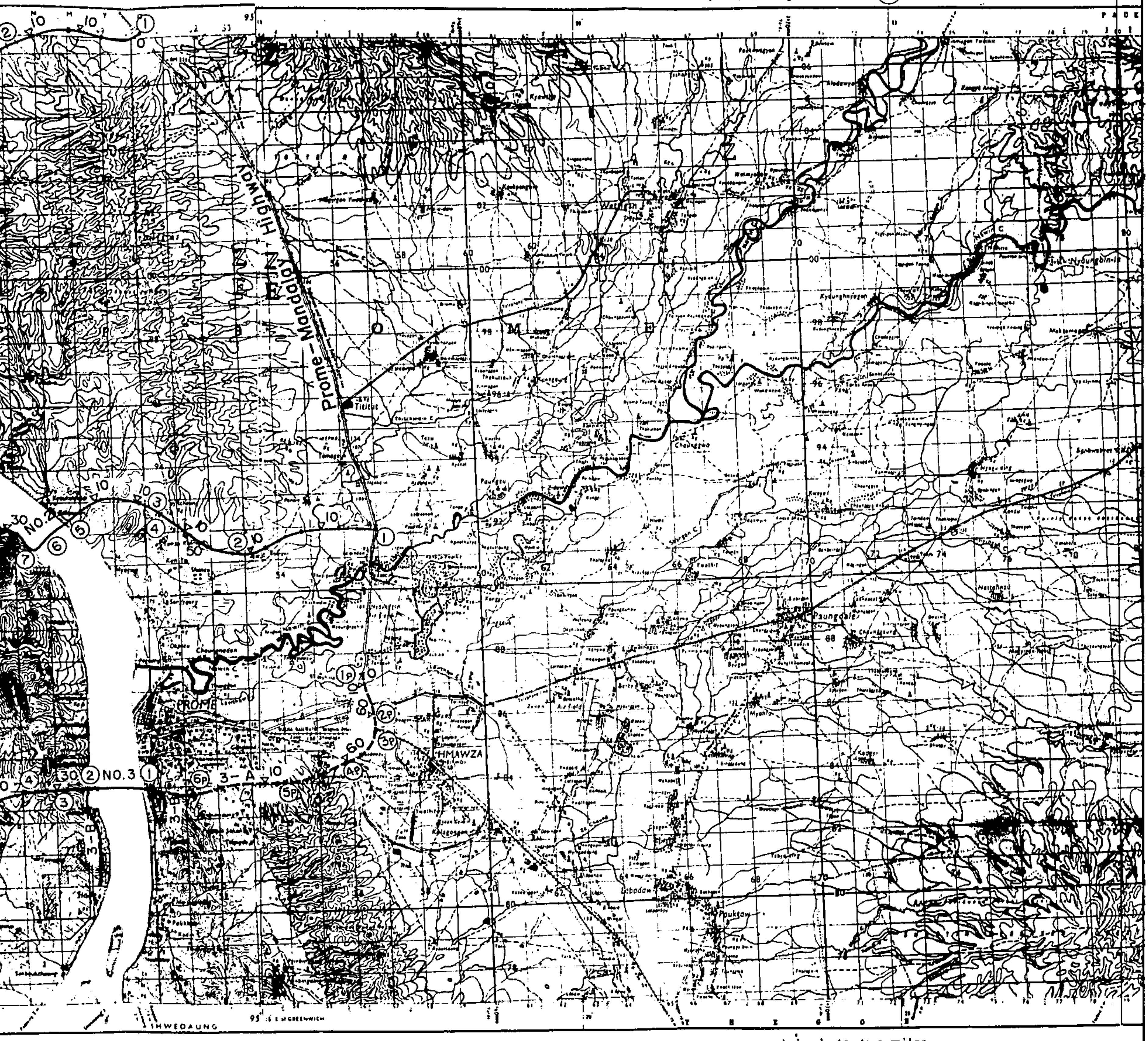


## -2 LOCATION MAP

SYMBOL

▽10 (Length) : Bridge

(NO) : Control Point



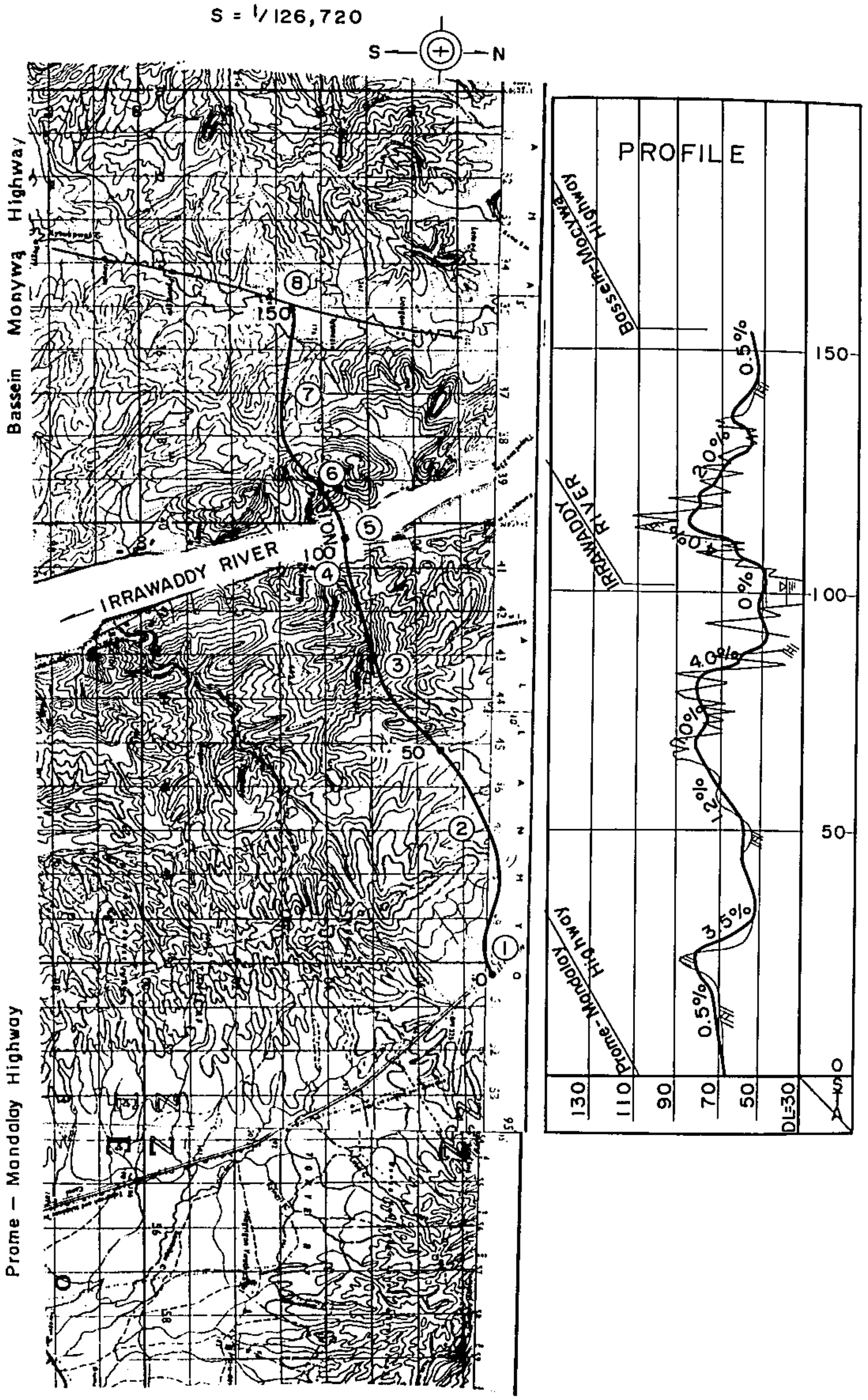
Scale

1 inch to two miles

0 1 2 3 Mile

0 1 2 3 4 5 KM

1/126,720



## SITE No. 1

### Outlines of Route

### Sinde Side

The route was selected to pass through the region of 60-80 meters above sea level in the south side of the mountain, taking into account terrain conditions and alignment as the first consideration.

8. To connect with the future highway in the midway between Dogo and Thjemezi.

7. To go through the region of 60-80 meters high above sea level in order to avoid tunnel.

6. To pass through the south portion on the hillside.

5. Vertical alignment continues up to 50 meters high at the proposed site.

### Prome Side

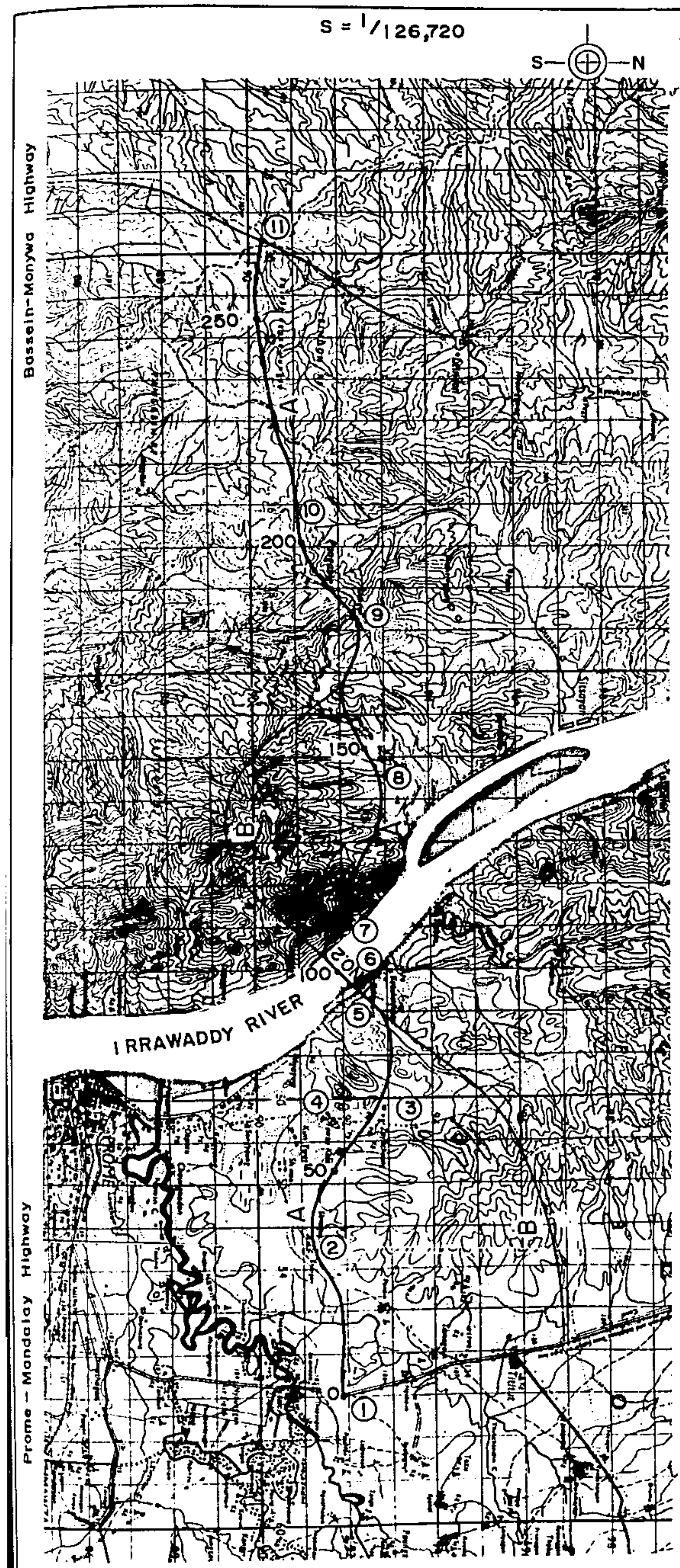
The route was planned to meet topography taking into consideration the connection of Kyawzwa and Kyaukogyi.

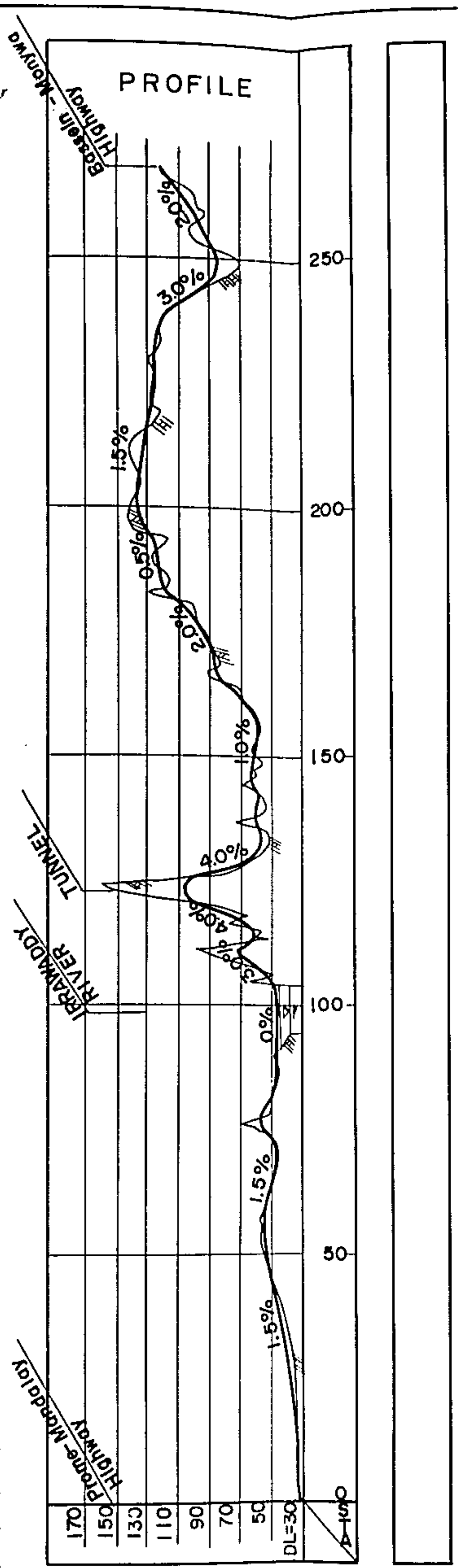
4. To pass the northern part of Kyawzwa and connect with Kyaukogyi by the existing road.

3. To pass the northern part of Kyaukogyi giving attention to the connection between the village and the paddy field.

2. To pass the northside of the hill.

1. To connect with the Prome-Mandalay highway.





## SITE No. 2

| Sinde Side | Prome Side |
|---|---|

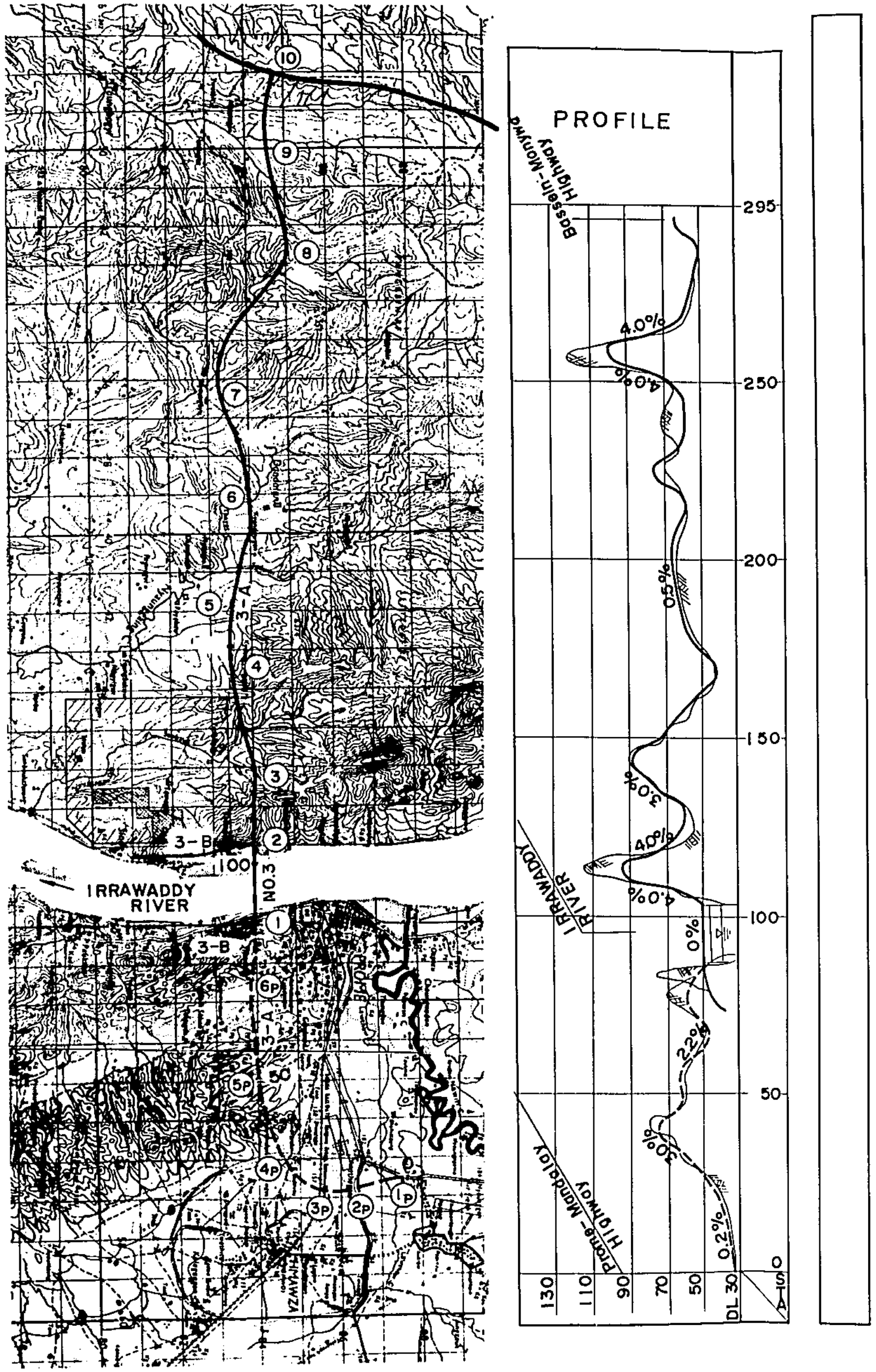
### Comparative study between A and B route

| Sinde Side | Prome Side |
|---|---|
| A route is possible to be constructed by cutting construction.<br>B route has a gentle horizontal alignment, but passes through mostly high land area as far as Pangabin with tunnel about one kilometer long.<br>In conclusion, B route is less advantageous than A from the points of land utilization and the connection with the existing villages. Also construction cost of B is higher than A because B passes through mostly mountainous area. | A route was passed through mostly paddy area via Zayitchang and Shangon taking into consideration the relation of the village.<br>B route was gone through the high land area, taking the shortest route. |

### Outlines of A Route

| Sinde Side | Prome Side |
|---|---|
| The route takes a little long way around the northern part of hillside taking into account connection with Yatnava and Pangabin, and conformation of the terrain conditions. | The route passes through between paddy and high land area via Zayitchaung and Shangon taking into account the connection with the villages. |
| 11. To connect with the future highway. | 6. Proposed hight is 50 meters at the bridge site. |
| 10. To be planned along the existing road. | 5. To pass the southern side of Konymain. |
| 9. To pass the southern side of Pangabin. | 4.,3. To connect with Kun Yuathit and Zayitchang by the existing road. |
| 8. To pass between mountainous and paddy area. | 2. To pass the north side of Shangon. |
| 7. Horizontal radius is 500 meters near the bridge site. | 1. To connect with the Prome-Mandalay highway. |

Bassein- Monywa Highway S = 1/126 720



## SITE No.3

### Sinde Side

Outlines of A Route

A route connects with the future highway along the west side of the river.

10. To connect with the future highway.

9.
8. To be planned in order to take account
7. of terrain conditions as the first
6. consideration.
5.

4. To avoid to pass the village and the pound as controls.

3. To be planned grade separation with the future railway.

2. To pass the north side of 100 meters from electric tower.

Outlines of B Route

B route is the connection to the existing road which passes along the west side of the river.

### Prome Side

Outlines of A Route

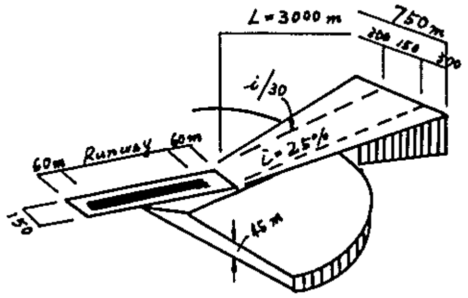
A route has the purpose of bypass of built-up area on Prome side.

6p. To connect with the existing road avoiding
5p. temple and pagoda.

4p. To hit at a right angle to the river.

3p. To cross the existing railroad. A grade separation would be planned in accordance with the future traffic requirements.

2p. To be satisfied with restriction of the airport. (refer to the following figure)



Obstruction & Restriction of Airport

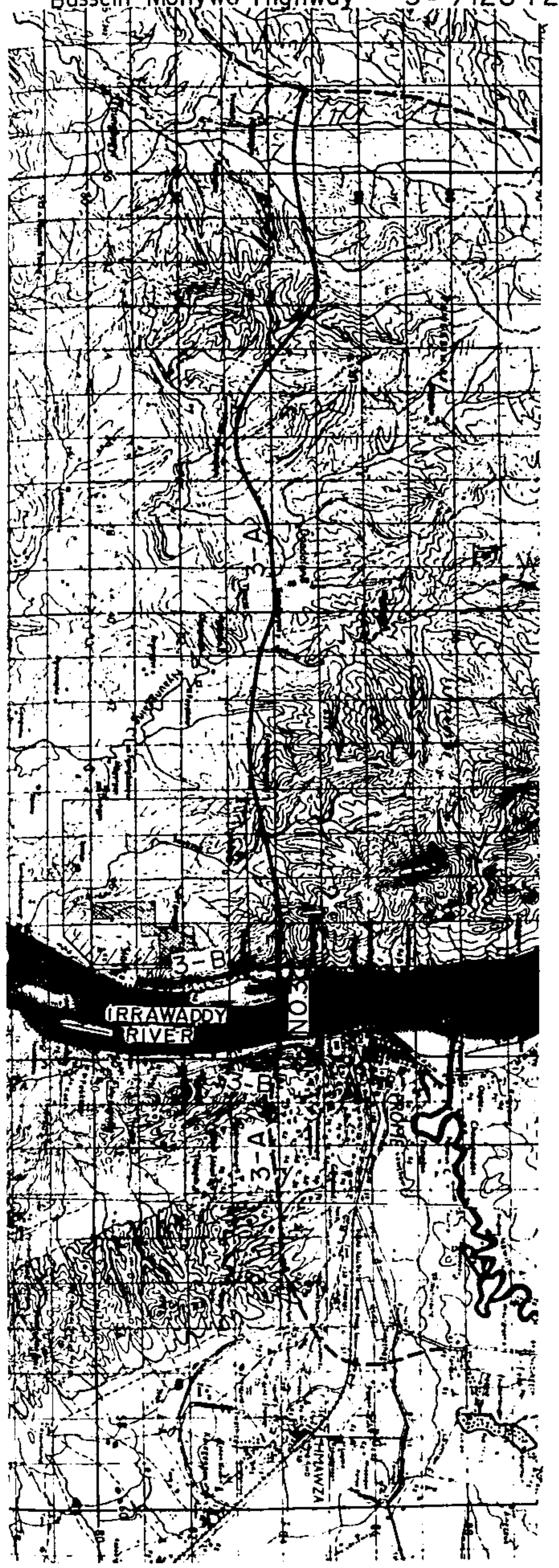
1p. To connect with the Prome-Mandalay highway.

Outlines of B Route

This route is the shortest connection to the existing national highway.

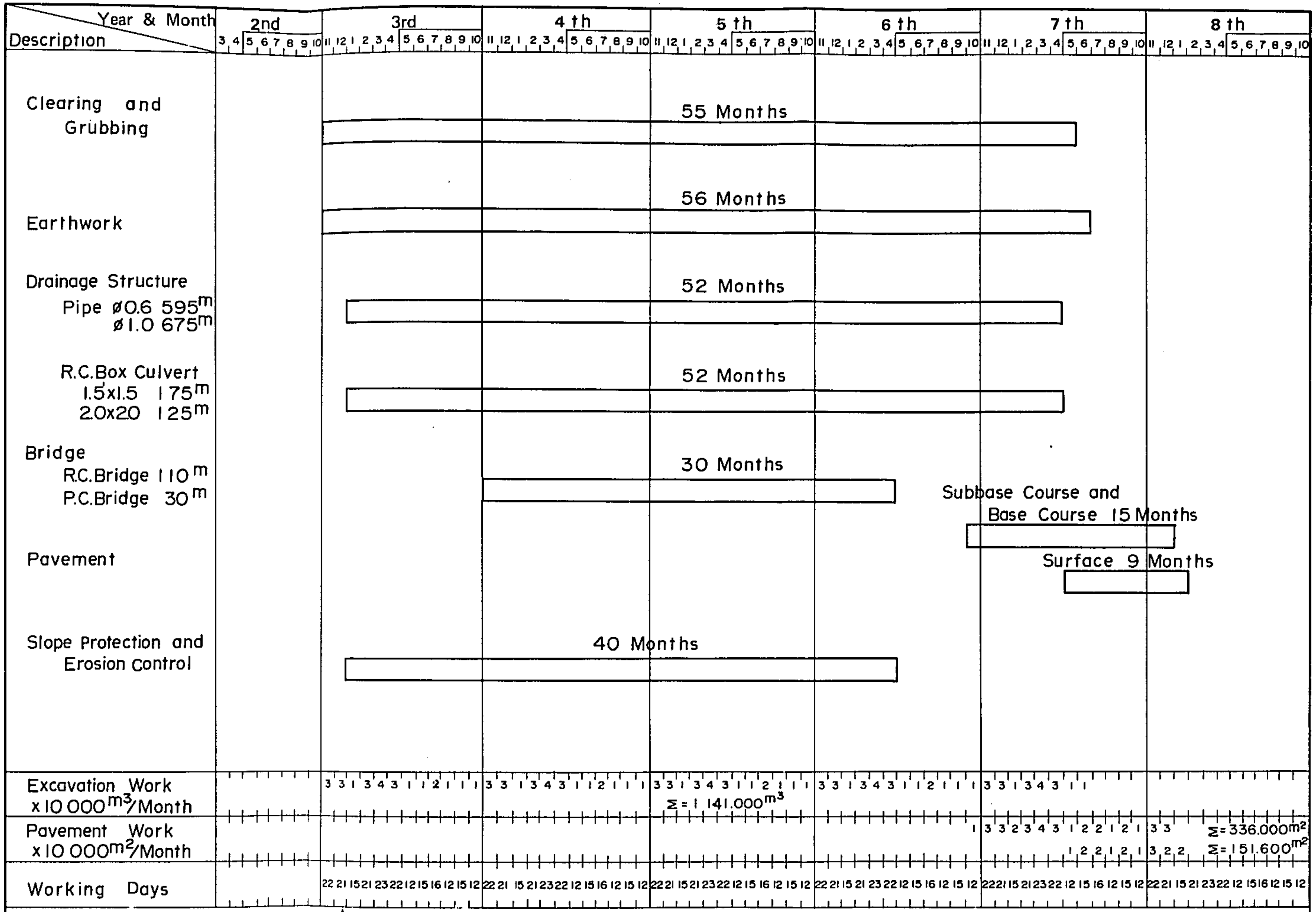
1. To pass no influence with the electric tower for cutting earth work.

Bassein-Monywo Highway S= 1/126 720



# SITE NO.3 PROME SIDE-B SINDE SIDE-A,B

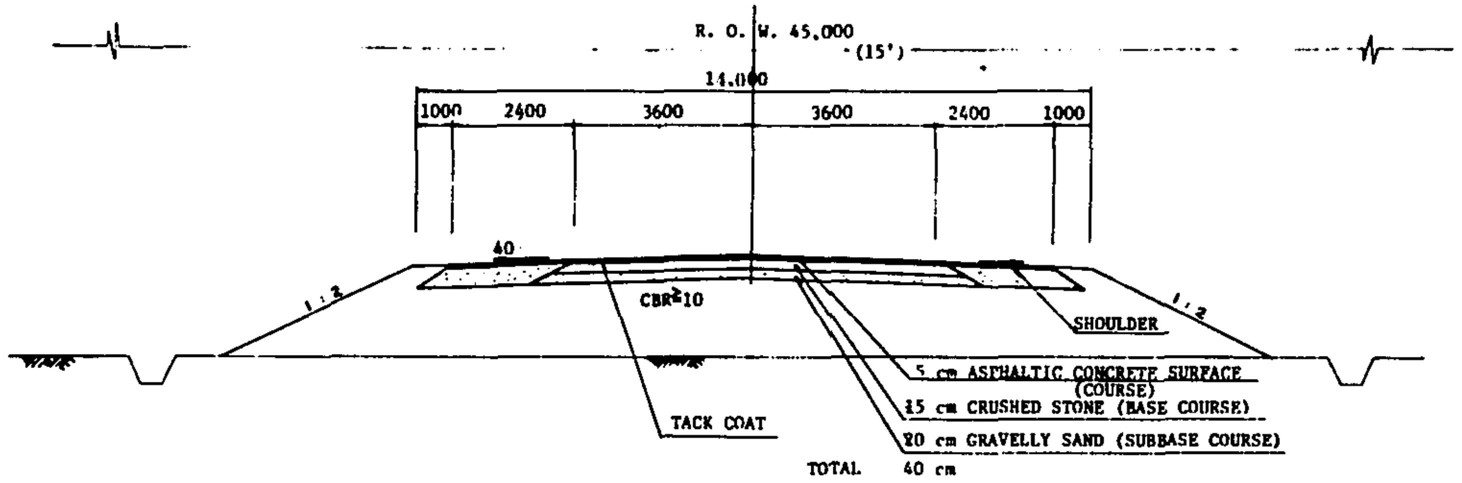
# CONSTRUCTION SCHEDULE



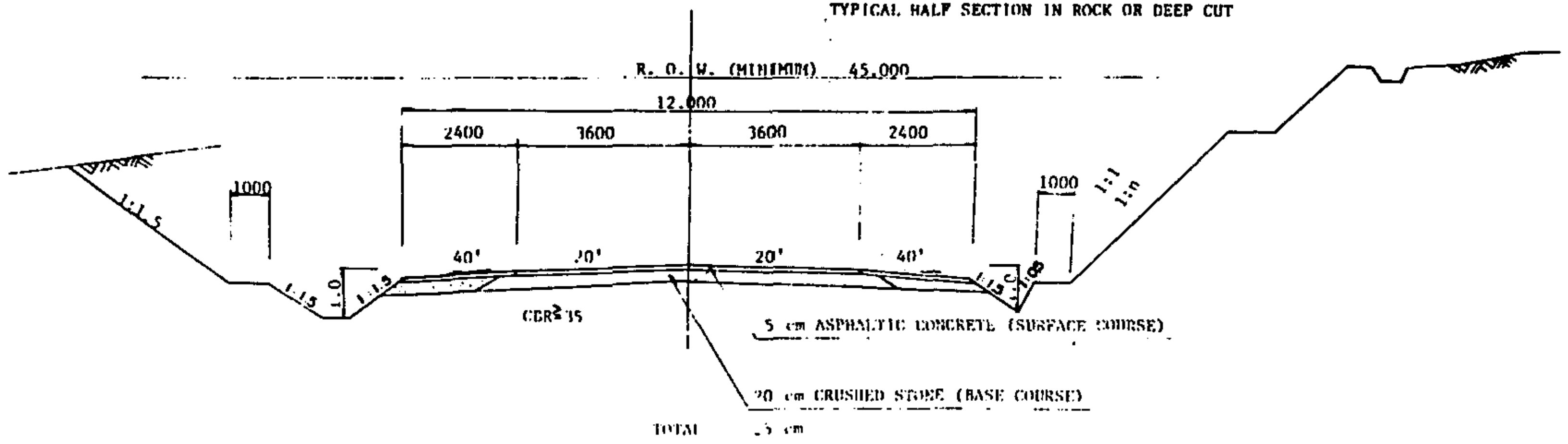
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Buldozer | $32^t$ | 2 | Tyre Roller | $15^t$ | 2 | Asphalt Plant | $30^t$ | 1 |
| Buldozer | $21^t$ | 3 | Motor Grader | $3.7^{m3}$ | 1 | Water Tank | $6\ 000^{\ell}$ | 1 |
| Buldozer | $11^t$ | 1 | Macadam Roller | $15^t$ | 2 | | | 0 |
| Tractor Shovel | $1.7^{m3}$ | 6 | Distributor | $5\ 000^{\ell}$ | 1 | | | |
| Dump Truck | $8^t$ | 21 | Finisher | $3\text{-}4.6^m$ | 1 | | | |

Fig. 6-3 TYPICAL CROSS SECTION

EMBANKMENT S : 1/100



CUTTING (GRANULAR SUBRADE) s : 1/100



# 7. ACCESS RALLWAY

# 7. ACCESS RAILWAY

## 7.1 General Description

The railway lines of the Burma Railways Corporation (BRC) are currently divided into three systems. The railways, including Prome Line, Mandalay Line, Moulmein Line, etc., constitute by far the major system which serves Rangoon and other areas located east of the Irrawaddy. A system located in the west of the Irrawaddy will join the major system by constructing a bridge over the Irrawaddy and constructing railways between Prome and Sinde as well as between Sinde and Kyangin. Currently as this system has no workshop, heavy repair of rolling stock is worked out at Insein and Myitnge workshops on the main system after ferrying across the Irrawaddy.

The other system located the opposite bank of the Salween will also be united with the main system by constructing a long bridge between Moulmein and Martaban in future.

The route length of the BRC is 1,949.25 miles, of which the main system is 1,776.0 miles. According to the BRC's statistics, route mileage of a system between Moulmein South and Ye is included in this figure. Whereas the system located west of the Irrawaddy is 173.25 miles in length.

The BRC has future plan of the railway lines, a part of which is indicated in Fig. 6-1. The line between Kyangin and Sinde as well as western portion of an alternative access railway via Site No. 1 constitutes a part of the North Link Line along west bank of the Irrawaddy.

## 7.2 Design Standard

### 7.2.1 Terrain Condition

The three proposed bridge sites are located in hilly area and the Irrawaddy flows through the confined river channel. Prome and Sinde are located on the low river terrace. The height of the existing Prome Station is about 30 meters from the sea level. As mentioned in 8.1.2, the rail level on the Irrawaddy Bridge is higher than 50 meters,for example, a case of steel bridge being 51.8 meters.

Each of three alternative lines passes through hilly area or alluvial lowland to the bridge sites after branching off from the existing Prome Line. Crossing the Irrawaddy, each linc again passes through the hilly terrain. The defense industry autholities have a programme to extend remarkably the industrial zone of Sinde. This planning affects the railway alignment and each alternative line shall make a detour course along the boundary of future extension zone. As the detour course is on the hilly area, a certain length of railway line is required to descend keeping the maximum allowable gradient of 5 in 1,000. The Sinde Station is accordingly located about 7 km southwest of the industrial area which is explained later in detail.

There are many pagodas, monasteries and other sacred buildings especially on the hill located south of Prome which affect considerably the decision of railway alignment.

### 7.2.2 Design Criteria

The railway standard applicable to the Prome Line is to be followed for the access railway between Prome and Sinde as well as the new railway between Kyangin and Sinde, as the trains will be operated through the three lines mentioned above and the Bassein-Kyangin Railway. Some modifications will, however, have to be made whenever the occasion arises.

#### 7.2.2.1 Track

The main standards of the track are as follows:

(a) Track gauge: 1.00 m

(b) Minimum curve radius: 300 m

The BRC uses the degree to define the grade of curve. The curve radius in meter is used for this project, instead. According to the BRC's regulation, the minimum radius of curve in the Prome Line is six degrees, which corresponds to 291.2 m. Even if the minimum radius of 300 m is allowed, less sharp curves are duly recommendable for maintaining operation safety and increasing train speed. In this respect, curve radius of 500 m.or more is actually used for the access railway and new railway between

Kyangin and Sinde. Only an exception has been made in the case of the first curve located nearer to the Kyangin Station where the curve with radius of 300 m is unavoidable.

(c) Maximum gradient: 5 in 1,000

The BRC expresses a gradient by fraction in such a way as 1/200, 1/300, 1/250, etc., where the numerator is 1 in every case. The permissible maximum gradient for the Prome Line is 1/200 which corresponds to 5 in 1,000. In this project, permillage method is to be applied. In profile along the alignment numerator only is shown.

Generally speaking, the gentler gradient is advantageous for train operation but requires more construction cost. As the stronger diesel locomotive might be introduced in these particular lines, an alternative planning will be recommendable to locate the line with the maximum grade of 10 in 1,000 by operation of 2,000 PS diesel locomotive in the detailed design stage.

The standard ballast section, track and typical earthwork section are shown in Figs. 7-1 and 7-2, respectively.

7.2.2.2 Station Yard

(a) Effective length of the main line and first loop line: 550 m

(b) Maximum gradient in station yard: 2.5 in 1,000. Flat as far as possible.

(c) Minimum distance, centre to centre of track between a passenger line and a line adjacent thereto: 4.20 m

For lines which are not passenger lines: 4.00 m

(d) Platform: As a general rule, only one track is equipped with passenger platform.

(e) Industrial siding: The industrial siding shall be installed by factories at their own expenses.

(f) The layout of track in each station including marshalling yard shall be sufficient and proper scale to handle traffic volume for succeeding years from the inauguration of the transport services over the line.

(g) The station buildings including main building, storage, staff quarters, etc. are of the wooden standard of the BRC.

### 7.2.2.3 Construction and Loading Gauges

Indian Railway's "Recommended Dimensions for Tunnels, Overbridges, Through and Semi-Through Girder Bridges for Meter Gauge" is to be used which are shown in Fig. 7-3.

### 7.2.2.4 Train Operation and Signal System

(a) Locomotive: The 1,200 PS class diesel locomotives which are running on the Prome Line for the main trains currently, will be used on the new railway lines as well as the existing system as far as Bassein for important trains. Steam locomotives, which is in use on the Bassein-Kyangin Line and for some local trains of the Prome Line, will still be in use for the local trains over the succeeding years after opening the transport services of the new lines.

(b) Signal System: Simplex Signal and Tablet Block System now in use in the Prome Line will be installed for the new railways. Only turnouts branching off from the main line and the first loop are to be interlocked each other and with signal.

### 7.2.2.5 Provision for Gauge Widening

It was informed that the BRC intends the gauge widening into standard gauge over the entire system in the long term planning and the system located in the west of the Irrawaddy will be in the first step among others. It should be stressed that the whole lines of the railway system shall be of the same standard, especially for the track gauge, so that through traffic over the entire system can be smoothly performed without any transshipment. If a system located west of the Irrawaddy including existing Bassein-Henzada-Kyangin Line and proposed new railway between Kyangin and Sinde remains separated with the main system, without constructing the Irrawaddy Bridge, enlargement of the track gauge into the standard one would be one of the solutions for strengthening the track capacity. However, if the access railway is constructed and two systems are unified into a system, through traffic of passengers and goods across the Irrawaddy Bridge and the access railway would be a great merit not only from the standpoint of passenger and freight services but also from that of the nation's economic growth.

In this study, the construction standards are based on the Indian Railway's "Schedule of Maximum, Minimum and Recommended Dimensions, Meter Gauge, 1930" which is now in use as the BRC's Standard. Of these dimensions, the Recommended Dimensions, which are not still in practice in the BRC, will be introduced in the new lines. This dimensions are quite roomy and even the rolling stock of the standard gauge railway can pass through except for the gauge required for electrification. An example of tunnel profile in accordance with the Recommended Dimensions is shown in Fig. 7-4. General design of small span bridge is shown in Fig. 7-5.

Reconsideration for the gauge widening is recommended for the above reason. If the BRC still intends the gauge widening in future, proper construction gauge and loading gauge are to be designed. When electrification is realised, tunnel section can be modified to enlarge downward maintaining train operation. The axle load of 17 tons and gauges used for this project will be enough for widened tracks.

## 7.3 Railway Location via Each Bridge Site

### 7.3.1 Comparative Study of Railway Alignment via Each Bridge Site

The comparative study of the relevant routes was carried out on the maps of 1-inch/1-mile at the early stage of the planning. An alignment via Site No. 3 was selected as the most suitable one to connect Prome with Sinde after scrupulous analyses mentioned in Chapter 11. Then more elaborated planning was carried out on maps 1 in 2,500. At the same time, alignments via Sites No. 1 and No. 2 were also checked on the maps 1 in 2,500 or 1 in 5,000 as far as possible, especially for length of tunnels.

Figs. 7- 6 and 7- 7 show the alignment of three alternative lines schematically arranged and on 1-inch map, repsectively. The results of the study made on the larger scale maps are partially included therein. The length of tunnels, the location thereof and total length of the each alternative line, among others are based on the detailed maps. Therefore, their relation to the contour lines might not be correct. The height of the Irrawaddy Bridge is fixed at 51.80 meters at every site, which corresponds to the rail height of the steel bridge.

The following table shows some features of the results of the comparative study.

| Route | Via Site No. 1 | Via Site No. 2 | Via Site No. 3 |
|---|---|---|---|
| Route length (km) | 70.2 | 30.8 | 20.0 |
| Tunnel (Number) | 8 | 2 | 5 |
| (Total length, m) | 6,735 | 6,370 | 3,115 |
| (Length of longest tunnel, m) | 2,830 | 6,240 | 1,350 |
| Bridge (Number) | 47 | 19 | 12 |
| (Total length, m) | 855 | 645 | 179 |
| Culvert, etc. (Number) | 53 | 19 | 23 |
| (Total length, m) | 865 | 246 | 269 |
| Retaining wall ($m^2$) | 20,400 | 6,300 | 6,500 |
| Cut and embankment ($m^3$) | 4,764,000 | 1,034,000 | 556,000 |
| Station (Number) | 8 | 4 | 2 |

### 7.3.2 Access Railway Via Site No. 1

The alignment and the profile of the railway via Site No. 1 are shown in Fig. 7-7 already cited and in Fig. 7-8, respectively. The main condition to plan the alignment was to make the Irrawaddy Bridge shortest in length taking topography of the bridge site and hinterlands of both banks into consideration.

The branch-off station of this alignment is the existing Hmawza Station on the Prome Line. Then the line goes north along the existing highway as far as the distance post of 24 km where the line turns to west. According to the checking work on the maps of 1 in 5,000, after passing the five tunnels with length of 850, 300, 210, 825 and 200 meters, the line reaches the Site No. 1. Crossing the Irrawaddy Bridge, the railway passes through two other tunnels of 1,420 and 100 meters in length. Then the line goes in southern direction through still hilly terrain. The line again goes through a tunnel with length of 2,830 meters at around the distance post of 52 km. The railway descends the hill along the boundary of the Sinde Industrial Zone and reaches the Sinde Station.

The total length of this alignment is approximately 70 km, which is more than three times that of the case of via Site No. 3. The tunnels are eight in number with total length of 6,735 meters. In view of the

the necessity as the access railway between Prome and Sinde, this alignment is too far away from these towns. A part of this alignment located west of the Irrawaddy might be of some use to the North Link Railway which is included in the future network of the BRC, as indicated in Fig. 6-1.

A section of the existing line between Hmawza and Prome will be used as the branch line in this case. Hmawza is located about seven km from the existing Prome Station. When most of the trains are operated along this line, passengers from or to Prome will be put to inconvenience. To avoid this, operation of trains or buses connecting therewith will be a solution. As the Prome Airport is located just north of the existing Prome Line, it is impossible to relocate the branch-off station towards Prome. The only alternative is to branch off the line at the New Prome Station in cases of the lines via Sites No. 2 and No. 3, connecting with the line via Site No. 1 under discussion in S-shaped alignment. In this case there might be a problem to pass through inundation plain along the Nawin Chaung. As the railway via Site No. 1 is not recommendable, details of branch-off position are not to be dealt with any more.

### 7.3.3 Access Railway Via Site No.2

The alignment and profile are shown in Figs. 7-7 and 7-9, respectively. The main condition for location is the same as the one in case of the alignment via Site No. 1. The length of the Irrawaddy Bridge is accordingly the shortest in length around Site No. 2 when the topography is taken into consideration.

It is difficult to extend the existing railway from Prome Station to the bridge site, because of the terrain and the urban conditions. The New Prome Station shall, therefore, be installed on the existing line about five km east of the existing station towards Hmawza. As the Prome Airport is located close to the Prome Line, the ICAO regulations applicable to the airport shall also be taken into account to determine the location of the New Prome Station. The line once goes north or northwestward and traversing the low alluvial plain, passes through hilly lands. At around the distance post of 11 km, the line turns to the west and reaches the east bank of the Irrawaddy of the Site No. 2. Immediately after crossing the Irrawaddy, the line enters into a tunnel which is as long as 6,240 meters, as the line shall pass through the highest portion of the hilly lands. Then the line passes again a short tunnel of 130 meters in length. The last section, 7.5 km in length, is of the same alignment over the line via Site No. 1.

The total length of the alignment via Site No. 2 is about 30.8 km. Even though its total length is much shorter than the one via Site No. 1, it has still about 1.5 times the length of the line via Site No. 3. Moreover, this line passes through low plain of the Nawin Chaung where inundation occurs in the east bank and passes a very long tunnel calling for difficult construction and much cost in the west bank. Under these circumstances, this line cannot be assumed to be superior to the line via Site No. 3.

### 7.3.4 Access Railway Via Site No. 3

The alignment in 1-inch map and profile (vertical scale: 1 in 2,000, horizontal scale: 1 in 25,000) are shown in fig. 7-7 and Fig. 7-10, respectively. The alignment on maps of 1 in 2,500 with profiles (vertical: 1 in 1,000, horizontal: 1 in 2,500) is shown in Fig. 7-11 through Fig. 7-21. Layout of New Prome and Sinde Stations is shown in Fig. 7-22. Typical cross-sections are shown in Fig. 7 -23 through Fig. 7-27.

In this case again, it is very difficult to extend the railway from the existing Prome Station to the Site No. 3. The main reasons are: the line shall pass through populated urban areas; as the maximum gradient of 5 in 1,000 is to be kept up, the long and high elevated bridge is unavoidable not only for the extended portion but also for the existing line to some extent; therefore, relocation or elevation of the Prome Station becomes necessary even in this case, which would make the construction cost fairly expensive.

The New Prome Station would, therefore, be constructed about five km east of the existing station along the existing line towards Hmawza. The location is the same as in the case of the line via Site No. 2. For the convenience of the passengers and consignors, the New Prome Station shall be closely located to the urban centre of Prome. However, Prome Airport is very close to the existing line and there are regulations now in force for buildings and lighting installations. Hence,the location of the new station was decided at the nearest position to Prome in conformity with the ICAO regulations. In addition to the above, the urban area of Prome is growing towards east and the new residential area is developing just south of the proposed New Prome Station.

The access railway runs along the existing line for about two km, because of the reason mentioned above. The line passes through the hilly terrain with a tunnel, the length of which is 240 meters. There are many sacred buildings on the hill, which necessitate the alignment to go around these installations with curves. After crossing the Irrawaddy Bridge, the line keeps its westerly course with four tunnels, the length of which being 1,350, 290, 960 and 275 meters. It proceeds along the northernmost boundaries of the future extension of the industrial zone. The location of the bridge, which is recommended considerably towards north of the original site proposed by Burma, was decided mainly in relation to the future extension of the industrial zone.

Then the railway turns to the south along the westernmost boundary of the future extension of the industrial zone. As the hilly landforms prevail on the detour course along the boundaries, some distance is required to descend to Sinde keeping the maximum allowable gradient of 5 in 1,000. Therefore, the Sinde Station is actually located near the village of Natmuk, about seven km southwest of the Sinde Industrial Zone. Each factory shall, at its expense, be equipped with the industrial siding from Sinde Station Yard. The last 5.5 km of this alignment is of the same as the lines via Site No. 1 and Site No. 2

The route via Site No.3 is 20 km long and is the shortest among the alternatives. The bridges other than the Irrawaddy Bridge are 12 in number and are the minimum among the three alternative routes. Because of the hilly terrain, tunnels will be five in number but the total length along this line is 3,115 meters which is the shortest among three routes. The longest tunnel is 1,350 meters in length which is not so long and not so difficult to construct in view of the recent engineering technique.

The existing railway west of the New Prome Station including old Prome Station will still be used for the branch line over which some trains will be operated.

At the inauguration stage no crossing station will be provided between New Prome and Sinde. The future installation of a station to meet the increased traffic volume shall be considered. For this purpose a section located around the distance post of 10 km where the grade is 2.5 in 1,000 will be used with minor modifications. The construction cost for the future addition of a station is not included in the cost mentioned in Ch. 10 and Ch. 11.

### 7.3.5 Construction Planning of Access Railway via Site No. 3

The rough estimation of the construction volume for the access railway via Site No. 3 is as follows:

| Item | Unit | Quantity | Note |
|---|---|---|---|
| 1. Earthwork | | | |
| Cut and embankment | $m^3$ | 556,000 | Main line only |
| Retaining wall, etc. | $m^2$ | 6,500 | " |
| 2. Bridge | | | |
| Bridge, concrete | $m^3$ | 2,720 | 12 bridges, total 179 m |
| Culvert, concrete | $m^3$ | 1,200 | 23 sites |
| 3. Tunnel | | | |
| Excavation | $m^3$ | 96,600 | 5 tunnels, total 3,115 m |
| Lining, concrete | $m^3$ | 28,100 | |
| 4. Track | | | |
| Main track | m | 20,000 | Main track |
| Siding | m | 6,000 | incl. marshalling yard |
| 5. Station | | | |
| Cut and embankment | $m^3$ | 334,000 | 2 stations |
| Platform | m | 360 | " |
| Pavement | $m^2$ | 3,080 | " |
| Station building, etc. | unit | 2 | " |
| Roofing of platform, etc. | $m^2$ | 850 | |
| 6. Telecommunications line, etc. | km | 22 | |
| 7. Signal system | set | 2 | 2 stations |
| 8. Common facilities | | | |
| 9. Miscellaneous works | | | |

The tunnels,which constitute the main task to the great extent,are five in number and 3,115 meters in total length, in other words, being about 16 percent of the route length. Twelve bridges other than the Irrawaddy main bridge spread over the entire length but they are all short and the total length is approximately 180 meters constituting less than one percent of whole. Along with the tunnel and bridge works, earthwork including cut and embankment of the main line is about 556,000 $m^3$ in total and those for constructing New Prome and Sinde Stations will total 334,000 $m^3$. Around the stage when the earthwork is nearly or completely finished, track laying, construction of the station buildings, installation of signal system, safety devices and telecommunications system, and provision of station facilities, etc. will be carried out. However, retaining wall installation and the similar works will be executed along with the main line earthwork.

The earthwork will be performed with the mechanised method using bulldozers, power shovels, etc. The bridges and culverts are all of short spans and no special construction method will be required. They can be constructed at any time and in any order during the construction period of tunnels. Other works including track laying, signal and safety device, station buildings, etc. will be worked out in the duration of one year or so.

The longest tunnel is one with 1,350 meters long. As the grade of the track is mono-cline of 5 in 1,000, excavation will be worked out from the east portal only. The years required for tunnel excavation will vary according to the following conditions:

(1) In Burma, overtime work is allowed only for emergency. Therefore, if the work is to be expedited,two shifts each eight hours totalling 16 hours work a day or three shifts totalling full length of a day are to be introduced.

(2) There are five tunnels in the line via Site No. 3. Work execution for two tunnels simultaneously or only for one tunnel individually determines the construction schedule. The condition of (1) above doubly influences in the case of (2).

(3) The machinery cost can be curtailed to some extent by introducing labour-intensive method. A longer construction period will accordingly be necessitated.

Under these conditions with tunnel excavation methods, the following construction period plannings were worked out:

| | Plan A | Plan B | Plan C |
|---|---|---|---|
| Construction period of whole work (year) | 3.5 | 5.0 | 10.0 |
| Earthwork incl. tunnel (year) | 2.5 | 3.6 | 7.8 |
| Shift of tunnel work (shift) | 3 | 2 | 2 |
| Simultaneous execution of tunnel work (site) | 2 | 2 | 1 |
| Other works (year) | 1.0 | 1.4 | 1.8 |

The trial calculation of construction cost for each plan was performed. The absolute construction cost of Plan A is the highest, next is the Plan B and the Plan C is the lowerst. However the difference among them is not so great. According to the economic analysis, if the construction of railway is carried out in such a way that the work is finished concurrently with completion of the bridge, the economic cost of the Plan A in term of present value is the minimum, on the contrary. This relation is applicable to the cases 2 and 3 in Chapter 11, where the railway is opened after five or ten years of the completion of the bridge. Therefore, only Plan A is dealt with hereinafter. The construction schedule is shown in Fig. 7-28.

The excavation method of the tunnels shall be determined by the results of the geological survey which will be worked out later. The rough idea in this stage is: upper half excavation method will be most suitable for this area where alternate layers of sandstone, shale and slate with fissures and soft layers are underlaid; support is made of steel; excavation will be worked out by drilling machine and explosives; mucking will be done by trolleys hauled by diesel locomotive; concreting will be made by the agitator and concrete pump on the trolley track.

Electric power of tunnelling as well as for constructing the Irrawaddy Bridge might be supplied by Electric and Power Corporation. However, in this report, the diesel compressors and generator are planned to use.

## 7.4 Railway Planning between Kyangin and Sinde

No larger scale map is available so far to plan the railway between Kyangin and Sinde, so that only a preliminary study was performed on the 1-inch maps. It might be very important to construct this railway to connect it with the access railway at Sinde so that the isolated railway system west of the Irrawaddy may be united to the major rail system.

There are two possible alignment between Kyangin and Tonbo. One is the route along the Irrawaddy. This alignment is the shortest link but a long tunnel is required to the south of Tonbo which calls for expensive work. In view of the proper functions of railway for the future development of agriculture and manufacturing industries, the other route in the hilly land is more recommendable as the potential development can be pointed out, along the most part of the line. Moreover, the latter is along the proposed highway which will be completed within a few years and can be used for the railway construction. The latter railway alignment and its profile are shown in Figs. 7-29 and 7-30, respectively.

From Tonbo the railway will run along the foot of hills located in west of the Irrawaddy and reaches Sinde Station, terminal of the access railway. The total length of the route between Kyangin and Sinde will be approximately 74 km.

The very rough estimates of the construction volume are made out as follows:

| | | | |
|---|---|---|---|
| Tunnel | (Number) | 3 | |
| | (Total length, m) | 2,000 | |
| Bridge | (Number) | 44 | |
| | (Total length, m) | 1,160 | |
| Culverts, etc. | (Number) | 29 | |
| Retaining wall, etc. | ($m^2$) | 62,700 | |
| Cut and embankment | ($m^3$) | 2,120,000 | |
| Station | (Number) | 8 | (excl. Kyangin and Sinde) |

Layout of Kyangin Station and a typical way station is shown in Fig. 7-31.

## 7.5 Train Operation Planning

### 7.5.1 Train Schedule

#### 7.5.1.1 General Conditions

Though several cases,where the railway is opened concurrently with the completion,of the bridge, five or ten years after the highway bridge completion might be planned in economic analysis, only a case was taken up based on the assumption that the access railway between New Prome and Sinde via Site No. 3 as well as the railway between Kyangin and Sinde will be opened to traffic concurrently with the completion of the Irrawaddy Bridge in 1983. If the latter railway is not to be included in this project, it shall be constructed by the BRC by that time. Therefore, in this case, it would become possible to operate the through train between Rangoon and Bassein via New Prome, Sinde, Kyangin and Henzada.

#### 7.5.1.2 Route of Train Operation

As to the access railway, only a route via Site No. 3 was taken into consideration. The railway standards of the access railway and the new railway between Kayngin and Sinde are mentioned in 7.2.2 and some features of these lines are dealt with in 7.3.4. and 7.4, respectively. Whereas, the existing Prome Line and Bassein-Henzada-Kyangin Line are deemed to be not so different from the current conditions when the new railways are opened to traffic.

#### 7.5.1.3 Train Speed

At present, the allowable maximum speed on the Prome Line and the Bassein-Henzada-Kyangin Line is as follows:

| | |
|---|---|
| Express Train: | 65 km/hr (40 mile/hr) |
| Others: | 40 km/hr (25 mile/hr) |

When the track and rolling stock are properly maintained, the maximum train speed could be increased in future. Since no definite planning of the BRC in this regard is available so far, train operation is planned on the above-mentioned speed.

### 7.5.1.4 Operation Time and Track Capacity

Based on the maximum train speed and current schedule of the Prome Line, the average train speed for the access railway is calculated as follows:

| | |
|---|---|
| Express train: | 50 km/hr |
| Others: | 32 km/hr |

The operation time between New Prome and Sinde will, therefore, be as follows:

| | |
|---|---|
| Express train: | 24 minutes |
| Others: | 37.5 minutes |

As no station will be installed between these two stations at the opening stage, the possible maximum number of train operation per day will be seven or eight trains in each direction.

### 7.5.1.5 Traffic Demand in 1983

1) Passenger

If the access railway including the Irrawaddy Bridge as well as the railway between Kyangin and Sinde will be opened to traffic, the diverted and generated passenger traffic volume will be as shown in Table 7.1 based on the analysis in Chapter 3. From this table passing traffic volume of diverted and generated passengers between major stations was calculated as shown in Table 7-2.

To cope with the increased passenger traffic, an express train between Rangoon and Bassein passing through Prome Line, Access Railway, Kyangin-Sinde Railway and Bassein-Henzada-Kyangin Railway would be necessary, as these railway lines will constitute one of the trunk system, similar to the Moulmein and Mandalay Lines. The local trains shall be planned in accordance with the increased traffic demand of each section, besides the through express train. For the local trains, 100 passengers for each ordinary coach are assumed with 125 percent riding efficiency for 80 seats.

2) Goods

Table 7-3 shows estimated diverted and generated goods traffic volume

Table 7-1 Diverted and Generated Passenger Traffic (1983)

(1,000 persons)

| | Kyangin | Henzada | Bassein | Prome | Letpadan | Rangoon and beyond |
|---|---|---|---|---|---|---|
| Sinde | 40.8 | 381.5 | 143.3 | | 1.4 | 53.3 |
| Kyangin | | | | 726.8 | 530.2 | 178.9 |
| Henzada | | | | 72.3 | | |
| Bassein | | | | 18.7 | | |

Table 7-2 Diverted & Generated Passenger Traffic Demand In Each Section (1983)

| | Number of passengers per year in both directions (1,000 persons) | Number of passengers per year in each direction (1,000 persons) | Number of passengers per day in each direction (persons) |
|---|---|---|---|
| Bassein | | | |
| | 162.0 | 81.0 | 222 |
| Henzada | | | |
| | 615.8 | 307.9 | 844 |
| Kyangin | | | |
| | 2,092.5 | 1,046.3 | 2,867 |
| Sinde | | | |
| | 1,581.6 | 790.8 | 2,167 |
| Prome | | | |
| | 763.8 | 381.9 | 1,046 |
| Letpadan | | | |
| | 232.2 | 116.1 | 318 |
| Rangoon | | | |

Table 7-3 Diverted and Generated Goods Traffic (1983)

(tons)

| Destination<br>Origin | BASSEIN | HENZADA | SINDE | PROME | LETPADAN | RANGOON |
|---|---|---|---|---|---|---|
| BASSEIN | | - | - | 1,671 | 37 | 1,579 |
| HENZADA | - | | - | 1,167 | 1,943 | 1,079 |
| SINDE | - | - | | 223 | 8,721 | 9,316 |
| PROME | 167 | 477 | 278 | | - | - |
| LETPADAN | 4 | 99 | - | - | | - |
| RANGOON | 27,066 | 5,542 | 21,217 | - | - | |

## Table 7-4 Diverted & Generated Goods Traffic Demand in Each Section

| Traffic Demand (tons/year) | Traffic Demand (tons/day) | ↓ |  | ↑ | Traffic Demand (tons/year) | Traffic Demand (tons/day) |
|---|---|---|---|---|---|---|
|  |  |  | Bassein |  |  |  |
| 3,287 | 9 |  |  |  | 27,237 | 75 |
|  |  |  | Henzada |  |  |  |
| 7,476 | 20 |  |  |  | 33,355 | 91 |
|  |  |  | Sinde |  |  |  |
| 25,736 | 71 |  |  |  | 54,850 | 150 |
|  |  |  | Prome |  |  |  |
| 22,675 | 62 |  |  |  | 53,928 | 148 |
|  |  |  | Letpadan |  |  |  |
| 11,974 | 33 |  |  |  | 53,825 | 147 |
|  |  |  | Rangoon |  |  |  |

compiled as to major stations from the goods OD in 1983, based on the analysis in Chapter 3. From this table passing diverted and generated goods tonnage between sections is assumed to be as shown in Table 7-4.

When the goods traffic is planned, the permissible load including tare weight of goods vehicle per train and the seasonal fluctuation of goods are of some important factors. In this study, the total weight of the goods vehicle and the maximum fluctuation ratio were assumed to be 150 percent of the net weight of goods and 200 percent of the average traffic volume, respectively. The number of goods train was determined by the figures in Table 7-4.

As the diverted and generated traffic volume of both passengers and goods in the section between Henzada and Bassein was assumed to be small, addition of a mixed train was planned besides the through express passenger train. Therefore, the goods vehicles will be operated by attached to the mixed train.

### 7.5.1.6 Train Diagramme in 1983

Based on the passenger and goods traffic demand in 1983 mentioned in 7.5.1.5, the required number of trains which shall be added on the current diagramme will be as follows:

| | |
|---|---|
| Passenger train: | |
| Express train: | |
| Between Rangoon and Bassein | 1 round trip |
| Local train: | |
| Between Rangoon and Kyangin | 1 round trip |
| Between New Prome and Kyangin | 1 round trip |
| Mixed train: | |
| Between New Prome and Bassein | 1 round trip |
| Goods train: | |
| Between Rangoon and Sinde | 1 round trip |
| Between Sinde and Henzada | 1 round trip |

In addition to the above, two round trips of local goods train will be operated on the section between New Prome and existing Prome Stations and when the necessity arises, deadhead trains will be operated for the marshalling purpose of the mixed and the passenger trains over the same section.

An example of train diagram, which is made by a-ding required new trains on the current train schedule with minor modifications, is shown in Fig. 7-32. The average train speed, operating hours in other words, is based on the figures in 7.5.1.4. As to the sections between New Prome and Sinde as well as between Sinde and Kyangin, figures applicable to the existing Prome Line are to be used.

### 7.5.1.7 Train Consists

The permissible load is to be as follows:

| | | |
|---|---|---|
| Passenger train and mixed train: | 40 units | 40 vehicles |
| Goods train: | 85 units | 60 vehicles |

Based on these figures, the train consists of the passenger and the mixed trains mentioned in 7.5.1.5 will be as follows:

Passenger train:

Express train:

| | |
|---|---|
| Upper class coach | 1 |
| Ordinary class coach | 7 |
| Restaurant car | 1 |
| Brake van | 1 |

Local train:

| | |
|---|---|
| Ordinary class coach | 9 |
| Brake van | 1 |

Mixed train:

| | |
|---|---|
| Ordinary class coach | 6 |
| Brake van | 1 |

(And goods vehicles)

### 7.5.2 Rolling Stock

### 7.5.2.1 Locomotive

In relation to the BRC's dieselisation programme, the additional trains mentioned in 7.5.1.6 will be hauled by diesel locomotives as a rule. However, short hauls mainly on the railway lines located in the west of the Irrawaddy will be tracted by steam locomotives which are diverted from the surplus ones by dieselisation. Accordingly the type of locomotive by train is as follows:

Express tain, local passenger train between Rangoon and Kyangin, goods train between Rangoon and Sinde, and mixed train between New Prome and Bassein .......1,200 PS diesel locomotive

Local passenger train between New Prome and Kyangin, goods trains between Sinde and Henzada, and New Prome and Prome .......Steam locomotive, type YB, etc.

The required number of the locomotives will be as follow:

| | | |
|---|---|---|
| Diesel locos. ---- | Required number: | 8 |
| | Spare: | 1 |
| | Total: | 9 |
| Steam locos.---- | Required number: | 3 |
| | Spare: | 1 |
| | Total: | 4 |

### 7.5.2.2. Locomotive Shed

The locomotives and crew are to be assigned to the following sheds.

| | |
|---|---|
| Diesel locomotive: | Malagon Diesel Loco. Shed. |
| Steam locomotive : | Henzada Steam Loco. Shed. |

### 7.5.2.3 Inspection and Repair of Locomotive

Inspection and light repair will be carried out at locomotive sheds. Heavy repair is to be performed at the Ywataung Workship for diesel locomotives and at the Insein Workshop for steam locomotives.

### 7.5.2.4 Facilities for Train Operation

No refuelling facilities would be installed in the access railway, as the existing facilities in Prome could be used. New installation of the refuelling facilities at Bassein and Kyangin are required for the through trains between Rangoon and Bassein, and between Rangoon and Kyangin.

No new installation of watering facilities would be necessitated for steam locomotives. Those in Prome and Kyangin will still be used after the new lines are opened to traffic.

Turning facilities for steam locomotives are provided currently with a turntable at Prome and a Y-line at Kyangin. An additional Y-line will also be installed at Sinde.

### 7.5.2.5 Coach

Required coaches for each train are mentioned in 7.5.1.7 , from which the required number of coach by type can be calculated as follows:

| Type | Required Number | Spare | Total |
|---|---|---|---|
| Upper class coach | 2 | - | 2 |
| Ordinary class coach | 53 | 5 | 58 |
| Restaurant car | 2 | - | 2 |
| Brake van | 8 | 2 | 10 |

The coaches above-mentioned are additions to the existing fleet. Spares for the upper class coach and the restaurant car will not be required because spares for the existing fleet may be usable.

### 7.5.2.6 Goods Vehicle

The goods transportation in 1983, as mentioned in 7.5.1.5, is 4,185,000 ton-miles from the west area of the Irrawaddy to the east area and 15,145,000 ton-miles from the east to the west, totalling 19,330,000 ton-miles. The total figure corresponds to 4.98 percent of the actual result of the BRC's traffic in terms of the ton-miles in the Fiscal Year 1972/73. As the serviceable goods stock converted to four-wheelers were 10,462 wagons in September 30, 1973, required number of goods stock for 19,331,000 ton-miles will be 521 goods vehicles in terms of four wheelers.

Spares of ten percent being added, the required number of vehicles becomes 573.

The heavy repairs of wagon will be executed at Myitnge Workshop.

### 7.5.3 Signal and Safety Device

### 7.5.3.1 Block System

The existing lines adjacent to the new railways has been equipped with the following block system:

| | |
|---|---|
| Prome Line: | Tablet System (Tyer's Tablet Instrument) |
| Kyangin-Henzada-Bassein Line: | Ticket System (Line-Clear Ticket System where Mores Telegraph or Telephone Instrument only is in use.) |

Generally speaking, there are three typical block systems for single track which can be introduced in this project. They are automatic block system, tablet system and ticket system. Reviews of the applicability to this project are made hereunder.

Automatic Block System: This system has the highest degree of safety, but the adjacent existing lines have the tablet or ticket system. There would be no particular reason for raising the safety standard for this section only.

Ticket System: It is not recommendable from the safety standpoint to introduce this system except for the local lines where few trains only are operated per day.

Tablet System: The tablet system is being used over the Prome Line. It would be justified to adopt the same type for the access railway and over the section between Sinde and Kyangin in view of the standardization.

From the foregoing reasons, the tablet system is deemed to be the most suitable for the access railway between New Prome and Sinde as well as the railway between Kyangin and Sinde.

### 7.5.3.2 Signal Device

Signals in the section between New Prome and Sinde as well as the new line between Kyangin and Sinde are to be equipped with the following ones based on the conditions as mentioned hereunder:

(1) The block system over the said line is the tablet system.
(2) Kinds and location of signals are similar to those of the existing Prome Line.

Two kinds of signals, i.e., working outer and distant signals, are to be installed at the spots indicated in Fig. 7-33. The departure signal will not be provided in the same way as on the other lines of the BRC.

The semaphore type signal is installed. Working outer signals will be provided for each line in the station.

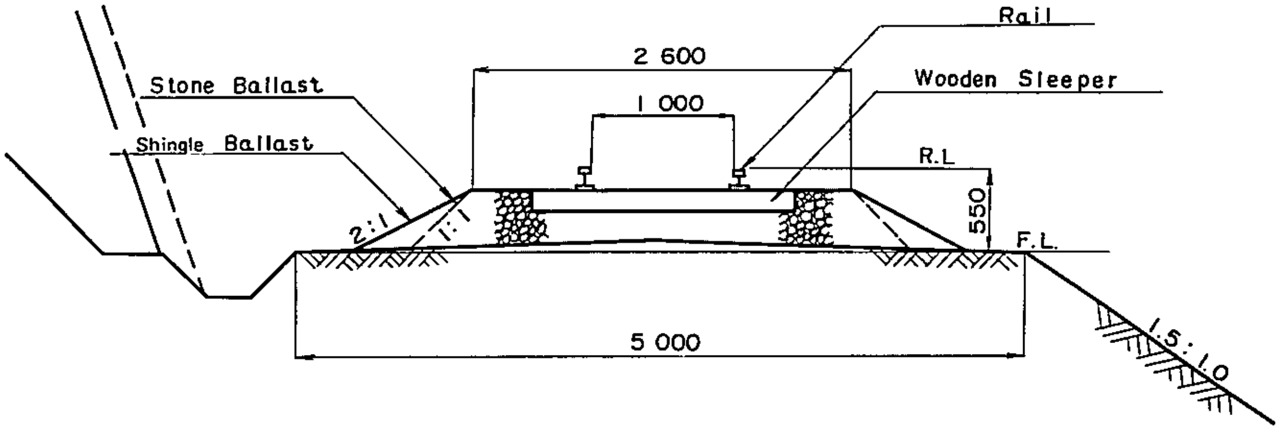
Indications are "Proceed" and "Stop" for the working outer signal and while "Proceed" and "Caution" for the working distant signal.

### 7.5.2.3 Interlocking

Turnout and working outer signal as well as working outer signal and working distant signal will be interlocked each other. The mechanical interlocking system will be introduced.

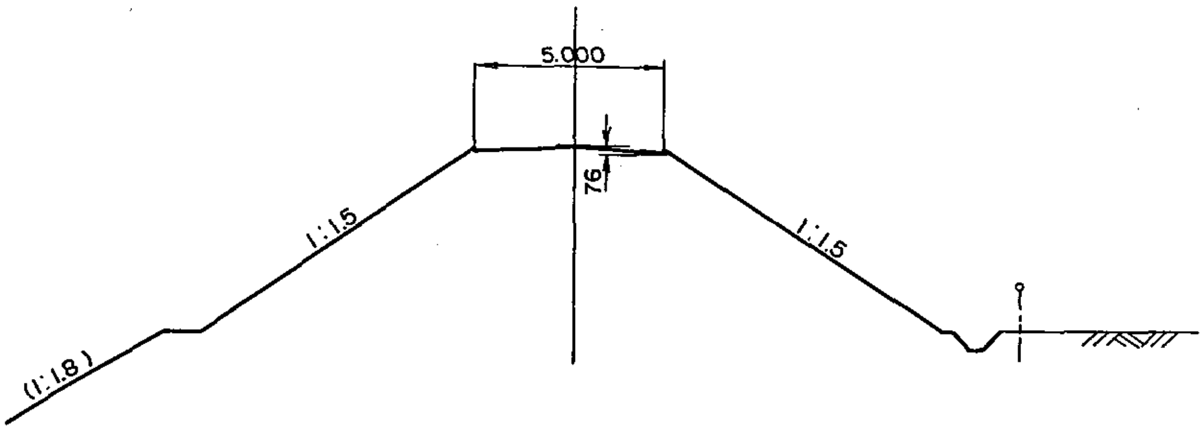
Fig. 7–1 STANDARD BALLAST SECTION & TRACK

S = $^1/_{50}$

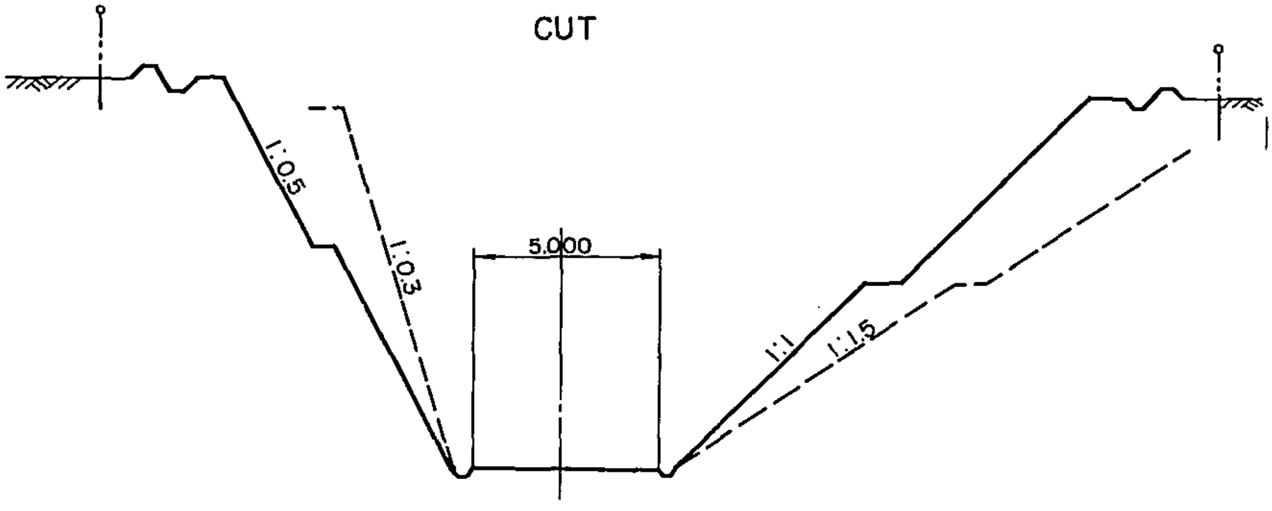


## Fig. 7-2 TYPICAL EARTHWORK SECTION

EMBANKMENT

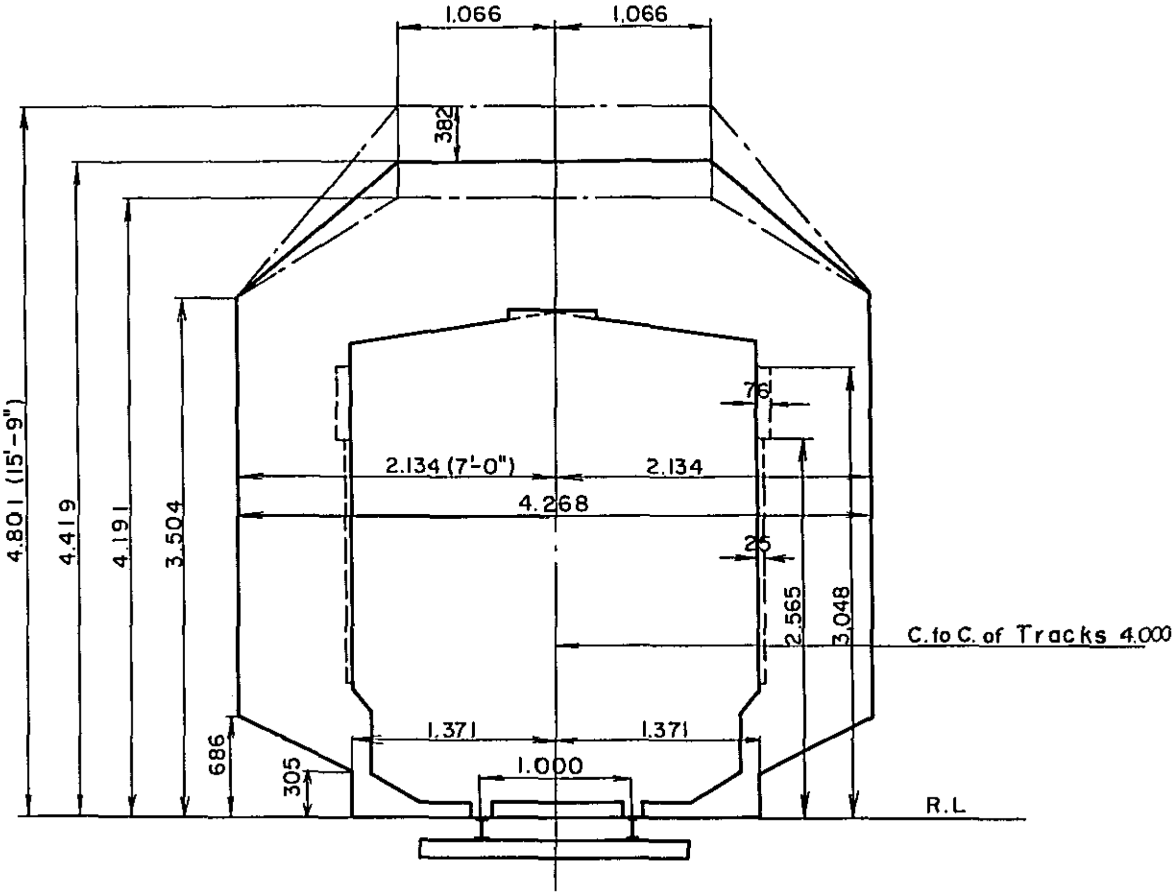


CUT



UNIT : MM

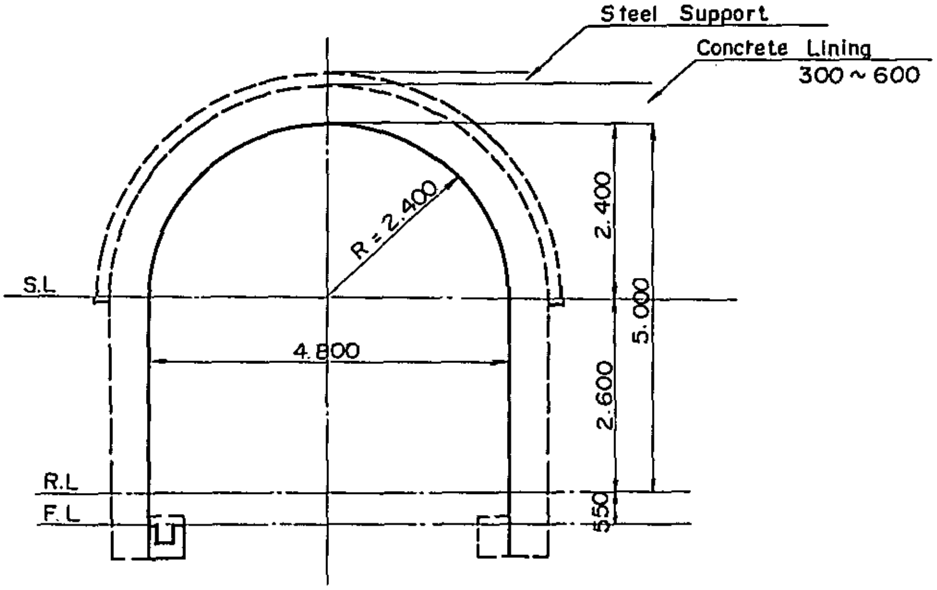
Fig.7-3 RECOMMENDED DIMENSION
FOR CONSTRUCTION GAUGE-METER GAUGE



Note: "RECOMMENDED" is a kind of gauge specified in the BRC. Therefore, it does not mean Japanese Team's recommended gauge.

UNIT : MM

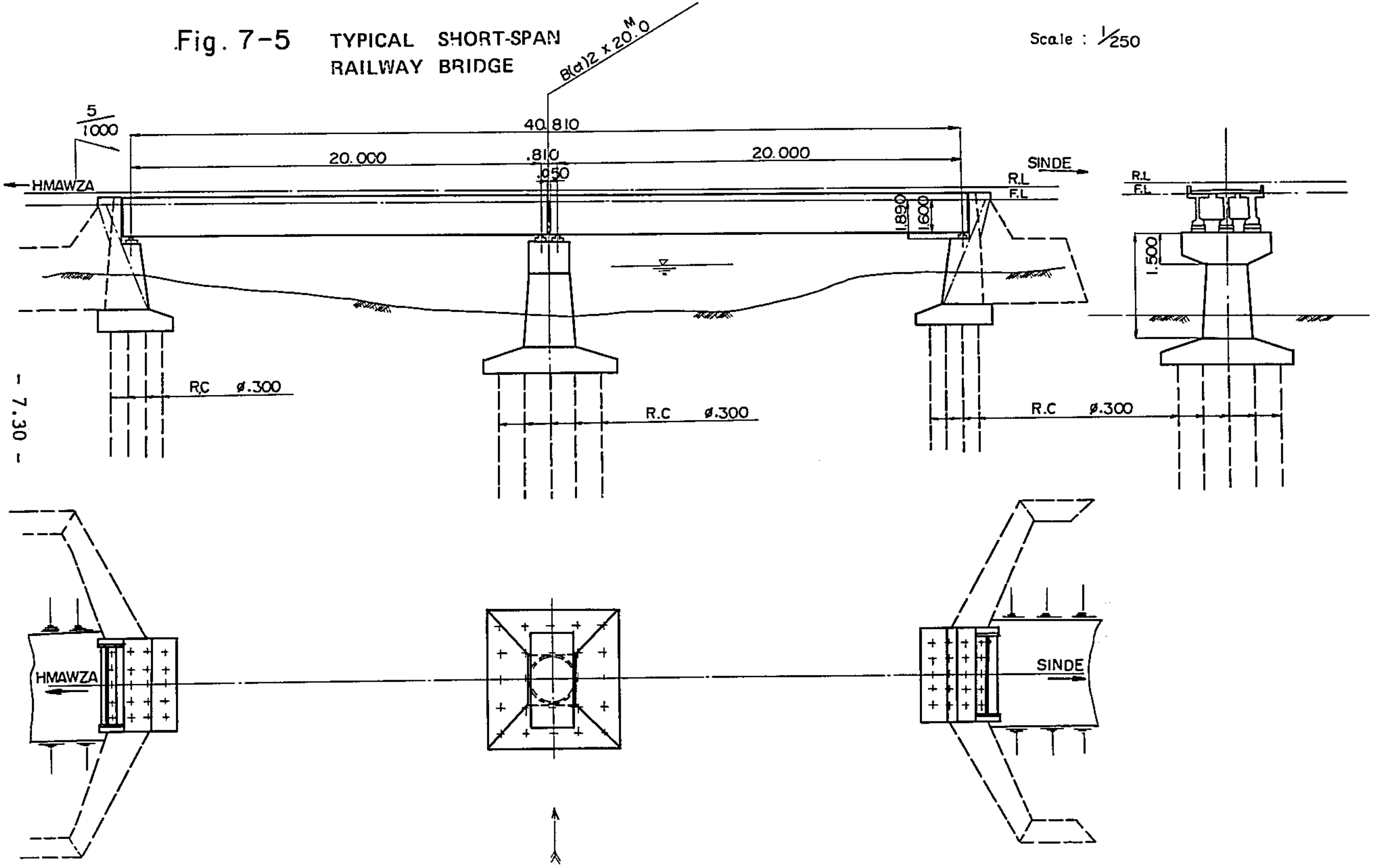
# Fig 7-4 TUNNEL SECTION



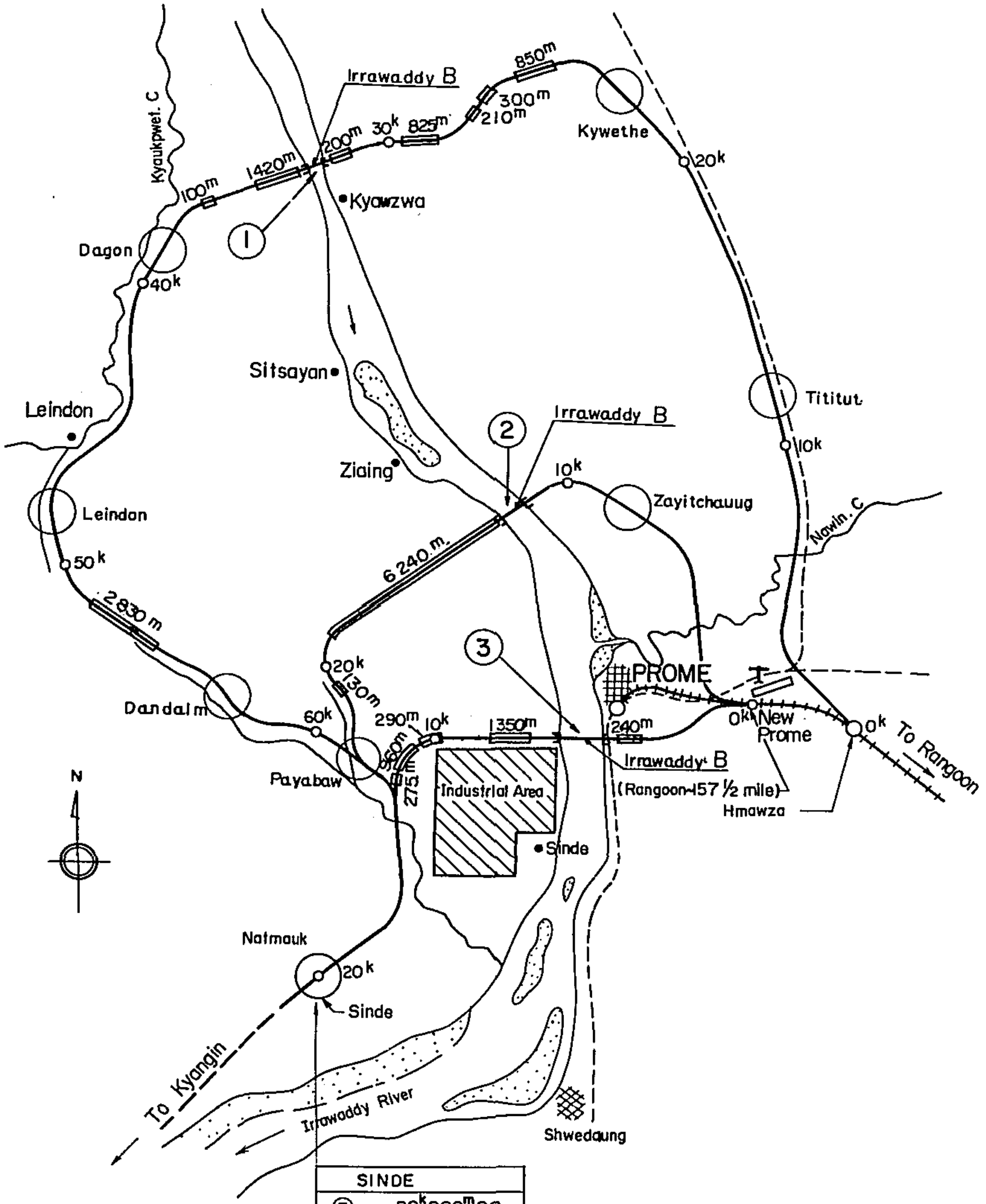
UNIT : mm

Fig. 7-5 TYPICAL SHORT-SPAN RAILWAY BRIDGE

Scale : 1/250



# Fig. 7-6 ILLUSTRATING MAP OF ALTERNATIVE LINES



| SINDE | |
|---|---|
| ③ | 20k000m00 |
| ② | 30.800.00 |
| ① | 70.200.00 |

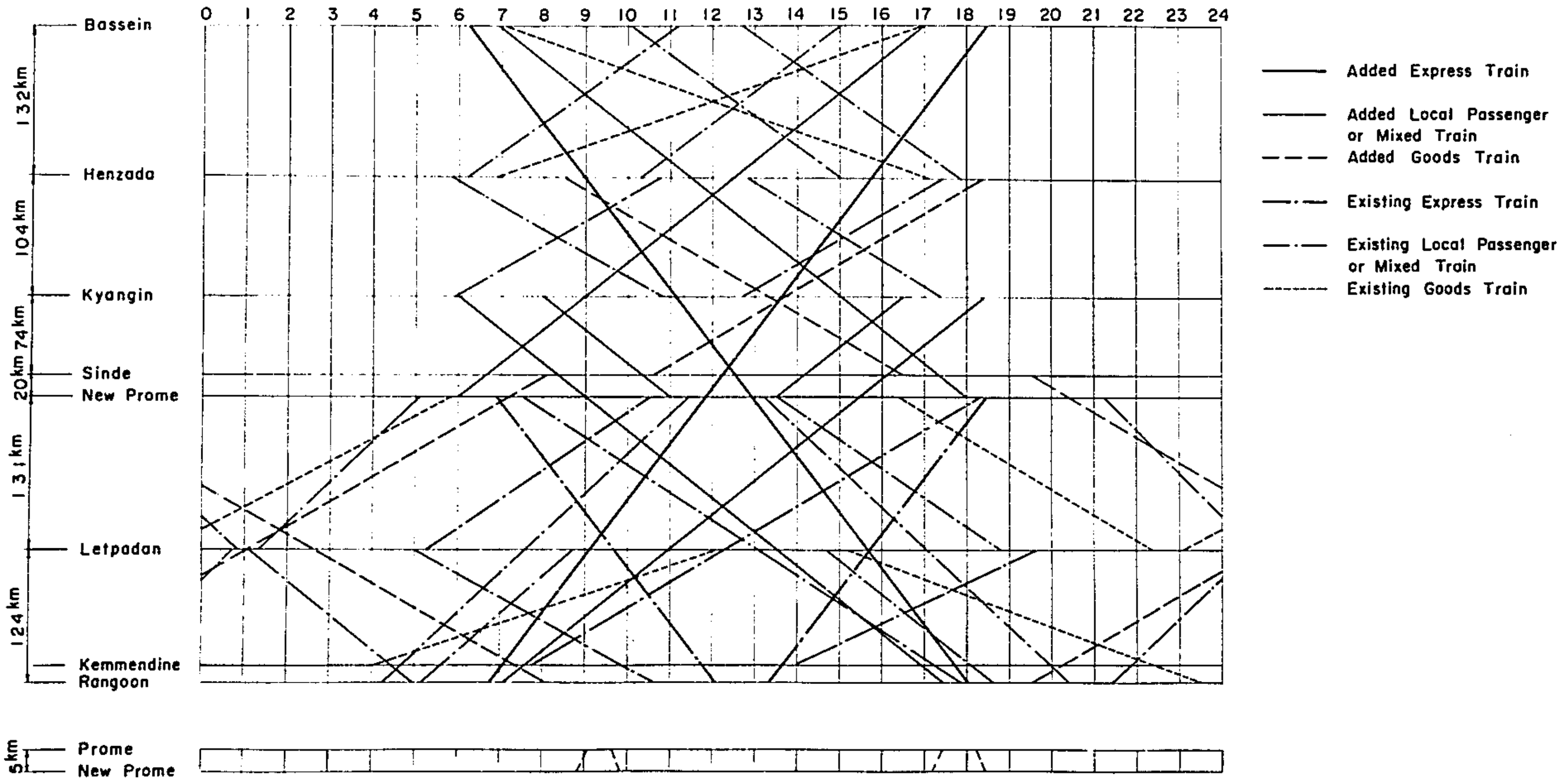
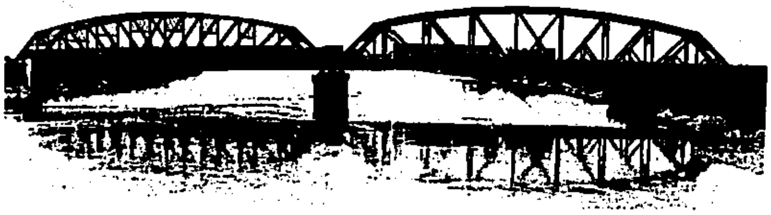


Fig 7-32 Proposed Train Diagramme Between Bassein and Rangoon (1983)

# 8. BRIDGE PLANNING



# 8. BRIDGE PLANNING

## 8.1 Design Standard

### 8.1.1 General Conditions and Considerations

#### 8.1.1.1 Superstructure

The type of bridge superstructure was designed taking account of the following factors among others:

- minimum clear distance of 350 ft should be maintained except for the both end approach spans,
- minimum clearance above design high water level should be 55 ft,
- optimum span length to minimise the total construction cost,
- technical advantages in the construction of substructures and the erection of superstructure,
- materials used should be determined considering the maintenance cost as well as the adaptability for the local conditions,
- esthetic points of view.

(1) Steel Bridge

There were many possibilities of employing various types of structure, such as continuous box girder, bow-string and truss. For a continuous box girder, necessary girder height at intermediate support was about 5.0m for 110m span length, even when the steel orthotropic deck was employed to reduce the dead weight of bridge. Whereas, bow-string or truss bridge needed about 1.8m high for floor system including lower chord for the same span length as that of the box girder. This height had a great influence on the determination of rail level which had in turn a determinative effect on the alignment of access railway. When the span length is over 100m, the continuous box girder bridge gives excessive deflection which is not allowed for railway bridge and if the span length is over 70m, the construction cost of box girder becomes higher than that of bow-string or truss. Therefore, the continuous girder bridge was omitted for further consideration except for a highway bridge.

Although a bow-string bridge is generally cheaper than a continuous truss bridge in the range of span length for this project, several temporary supports should be installed in the river during the construction, or cable erection method should be employed. It was not practical to place many temporary supports in the Irrawaddy, because of deep water, soft soil and limited available construction period through a year. The cable erection method was also not practical because of very wide river and its long construction time. Whereas, a continuous truss bridge would be easily built employing cantilever construction method or floating crane. From the above-mentioned considerations, it followed that a continuous truss bridge was the most suitable type of a highway-railway bridge. But considering the possibility of stage construction, the feasibility of the construction of railway bridge and highway bridge separately resting on the same substructure should be considered. For this case, a continuous truss was also applied to railway bridge in order to satisfy the deflection requirement, but a continuous truss and a continuous box girder should be considered for highway bridge in order to determine the most favourable type of bridge.

### (2) Prestressed Concrete Bridge

Because of difficulties of scaffolding in the Irrawaddy, only possible construction method applicable to prestressed concrete bridge would be segmental cantilever construction. When the segmental cantilever construction method was considered, two solutions would be possible; one was a classical free cantilever construction employing in situ concrete and the other was also a free cantilever construction employing precast segments stressed together with epoxy glued joints.

This relatively new construction technique was already widely used in order to reduce the construction period, but very strict site control and tolerance were required to obtain well matched joint faces and to be applied successfully to the site.

Therefore, a segmental cantilever construction method employing the movable wagons and in situ concrete was thought to be the most suitable construction procedure for this Project.

### 8.1.1.2 Substructure

The type of substructure should be selected considering the following important factors:

- During the rainy season, the water level of the river rises approximately by about 44ft above that of the dry season and the maximum velocity of current is about 3.3m/sec at that time. Therefore it is desirable to complete at least one whole substructure within one dry season so as to avoid any duplication of preparatory works for one substructure.
- The water depth is usually very deep even during the dry season, but at this season sand bank extends as far as about one-third of the river width at Sites No.2 and No.3.
- Reliable bearing bed only can be found about 30m or more below the river bed.
- Probable scouring depth shall be considered in the design of substructure and the maximum scouring depth is expected to be very deep.

After having carried out several preliminary designs of substructure and considering its construction method, steel pipe pile, pneumatic caisson, open caisson, and spread foundations were selected.

Steel pipe pile were applied to the foundations under the deep water using steel caissons as footings. Open caissons were adopted to the foundations in the area of sand bank. Pneumatic caisson was also used on west bank, and spread footings were placed for both abutments.

The idea that the foundation in the area of sand bank at site No.3 would be constructed using steel pipe piles could not be adopted because of higher cost of drainage for excavation necessary to setting the footings.

The steel caisson for the steel pile foundation would be prefabricated on abroad and transported to the site or be assembled at site using the members transported from abroad. The comparative study showed the preference for the former.

### 8.1.2 Design Criterion

(1) The AASHO Specifications are applied to the design of highway bridge as a general principle. The live load shall consist of HS20-44 and pedestrians.

(2) The live load for railway-highway bridge shall consist of the live load specified for the highway design and the applied moving load of trains specified by Indian Ministry of Railways (Standard Gauge M.L.).

(3) Loading of trailer-track carrying a heavy equipment (total weight 60t) is considered in the design of floor system and/or deck slab at 130 percentage of the basic unit stress.

(4) The amount of impact allowance shall be determined by the following formulae.

$$\text{Highway loading} \ldots\ldots\ldots \; I = \frac{50}{L+125} \leq 0.3$$

$$\text{Railway loading} \ldots\ldots\ldots \; I = \frac{65}{L+45}$$

In designing the main girder or main truss structure of highway-railway bridge, no impact allowance is considered for highway loading. In design of the floor system or deck slab, the impact allowances for each type of loadings are considred by using the respective impact formula.

(5) Clearance diagrams for railway-highway bridge, highway bridge and railway bridge were specified as shown in Fig. 8-1 (a) and (b), respectively.

(6) The effect of stream current on piers shall be considered in the design.

(7) The impact force due to river vessels colliding with piers shall be taken into consideration. The effect of colliding river vessel on piers can be calculated considering the weight and velocity of vessel, velocity of stream current and necessary distance until the vessel being stopped. But computed horizontal force due to colliding of vessel (3,100 ton) was resulted in lesser effect than that due to earthquake in design of substructure and hereafter the effect

was neglected.

(8) The fundamental seismic coefficient shall be assumed to be 0.12 according to Mr. E. Kuribayashi's Report on "Preliminary Survey on Seismology and Earthquake Engineering in the Union of Burma". Considering the unfavourable effect of the height of pier, the design seismic coefficient shall be increased by 25% at 150 percentage of the basic unit stress.

(9) The decrease in flow area due to the construction of piers in the river channel shall be less than six percent of the flow area of existing river channel.

(10) All the foundations are placed on the rock bed and the bottom face of footing shall be placed below the probable scouring surface, except some protections are provided for the scouring effect. Therefore steel sheet piles shall be attached to the circumference of footing of steel pile foundation, when the bottom face of the footing is placed above the probable scouring depth.

(11) The Japanese practice might be applied to some specific details, if the AASHO Specifications do not specify on these points.

## 8.2 Preliminay Design of Highway-Railway Bridge at Site No.3 (Fig. 8-2)

### 8.2.1 Prestressed Concrete Bridge

### 8.2.1.1 Structural System

The effect of earthquake on the bridge was very large, therefore the best structural system to be employed would be such one in which each pier should resist the earthquake effect due to only the dead weight of the part of superstructure supported by that pier and of that pier itself. Therefore, T-shaped structure was selected as a fundamental structural system. The leg of one T-shaped structure was fixed in a fundation structure and the whole effect of earthquake acting on the structure was directly transmitted to the foundation.

Two main alternative highway-railway bridges at Site No.3 were studied to determine the optimum span length.

### 8.2.1.2 Comparison between Two Alternatives

Taking account of the necessary quantities of materials and unit cost for various items, the total construction costs for both alternatives were roughly estimated and the results are given in Table 8-1. The figures of the estimated construction costs given in those Tables are not exact to figure out the final actual construction costs, but these figures could be used just to compare the relative construction costs of two alternatives in order to select one type of the bridge out of two alternatives.

Although it could be concluded from this Table that there was no remarkable difference between two alternatives in direct construction costing. After considering the structural characteristics and the practical construction method of two alternatives, the alternative I was selected as an appropriate prestressed concrete bridge to this Project.

### 8.2.2 Steel Bridge

### 8.2.2.1 Structural System

A continuous truss bridge was considered to be the most suitable type for a steel structure, especially to satisfy the deflection requirement. Two erection methods were considered in building a continuous truss bridge.

(A) Free cantilever construction with travelling crane

The first method was a free cantilever construction employing berges for transportation of truss members to the site, lifting cranes, trolleys with travelling crane running on the upper cord of the truss already constructed. All the members of truss will be transported from a stock yard to the site and lifted to the position, then connected to the truss already built.

(B) Large block erection with floating crane

An adequate length of the truss bridge would be assembled at a yard and transported to the site by a deck barge. One end of this pre-assembled part of the truss would be placed on the top of a pier and the other end of the truss would be connected to the over-hanging part of the truss already constructed by means of a floating crane ship.

Three main alternative railway-highway bridges were studied at Site No.3 to determine the optimum span length.

#### 8.2.2.2 Comparison among Three Alternatives

The quantities of materials and total construction costs for each alternative were estimated considering the unit cost for various items and given in Tables 8-1. This Table is prepared considering the differences in the erection method of truss. According to this Table, there are no remarkable differences in the direct construction costs among these three alternatives except for the alternative III. Considering the practical convenience in construction of the bridge, the alternative IV was thought to be the most safe and economical solution for the steel truss bridge. The differences in the erection method did not give any remarkable difference in the direct construciton costs of the bridge. However the total weight of a pressembled part of truss bridge to be handled in case of (B) by a floating crane becomes 700 tons and this weight will be too heavy to be managed safely and securely. Therefore the erection method (A) was adopted for the construciton of steel truss bridge.

## 8.3 Highway-Railway Bridge at Site No.3

After having selected the most optimum span length of the bridge, as stated in Paragraph 8.2, an elaborated design was carried out. For the prestressed concrete bridge of alternative I, it seemed more advisable to increase the span length of the second span from Sinde side up to 143 m long, avoiding any trouble in building a foundation under deep water. This span was covered by a combination of T-shaped structure and one suspended span. The final design for the prestressed concrete bridge is shown in Fig. 8-3, and the necessary quantities of construction materials are given in Table 8-2. So long as the alternative IV is adopted for steel bridge at Site No. 3, it was found that there was no necessity to change the position of foundations due to the reason stated above. The final design is shown in Fig. 8-4. The necessary quantities of construction materials are given in Table 8-3.

## 8.4 Highway Bridge and Railway Bridge Separately Constructed on the Same Substructure at Site No.3

Considering the possibility of stage construction,that is, the construction of railway bridge superstructure would be delayed for several years, because of economic and financial reasons, highway bridge and railway bridge constructed separately on the same substructure shall be designed.

The span length applied to the highway-railway bridge described in Paragraph 8.3 was adopted in designing these separate bridge. The clearance between two superstructures was determined to give necessary minimum space to the later construction of the railway bridge, adjacent to the highway bridge superstructure. Consequently, the top width of pier was determined by this consideration. Substructures should be proportioned for the both superstructures and also be checked for only the highway bridge superstructure considering the effect of its eccentricity.

For the separate prestressed concrete bridge, the structural system and construction method should be the same as for the highway-railway bridge described in Paragraph 8.3. The height of girder of the highway bridge at intermediate support could be reduced by about 1.0m as compared with that of highway-railway bridge. Fig. 8-5 shows the highway bridge and the railway bridge separately constructed on the same substructure and Table 8-2 gives the necessary quantities of construction materials.
For the steel highway bridge, two types of bridge were taken into consideration in the comparative designs, the one was three continuous box girder with orthotropic deck and the other was three continuous truss bridge with the same span length as that of the highway-railway bridge described in Paragraph 8.3. The results of the comparative designs were shown in the following Table.

Comparison between Two Types of Steel Highway Bridge

| | Total Steel Weight (t) | Max. Reaction (t) | Depth or Height (m) |
|---|---|---|---|
| Box Girder | 6960 | 1720 | 5 (Constant) |
| Truss | 4960 | 2100 | 14 (End Support)<br>21 (Intermediate Support) |

In spite of the reduced maximum reaction in the box girder bridge, the dimensions of substructure were little affected, because of the weight of sub-structure. Therefore, the total construction costs of the substructure for these two types of bridge could be assumed to be the same and the increased steel weight of 2000 tons in the box girder could not justify the advantage of easy maintenance over the truss bridge.
Only a highway steel truss bridge should be considered here.

For a railway bridge, steel truss was only taken into consideration in order to fulfil the deflection requirement. Fig. 8-6 shows the steel highway bridge and railway bridge separately constructed on the same substructure, and Table 8-3 gave the necessary quantities of construction materials.

## 8.5 Highway-Railway Bridge at Site No.1

The most suitable structural system and span length for the highway-railway bridge at Site No.3 could be adopted in the design of this bridge with a little modification considering the total length of bridge and the foundation conditions at this site.

Fig. 8-7 and 8-8 give the drawings of the prestressed concrete bridge and the steel truss bridge, respectively.

Rough estimation of required construction materials was carried out and the results were shown in Tables 8-2 and 8-3.

## 8.6 Highway-Railway Bridge at Site No.2

The same design principles were applied to the design of this bridge as those applied to the bridge at Site No. 1.
Fig. 8-9 and Fig. 8-10 give the drawings of the prestressed concrete and steel truss bridges, respectively. Rough estimation of required materials was carried out and the results are given in Tables 8-2 and 8-3.

## 8.7 Proposed Construction Method for Bridge at Site No.3

### 8.7.1 Superstructure

#### 8.7.1.1 Prestressed Concrete Bridge

As already stated in Paragraph 8.1, the segmental cantilever construction method employing in situ concrete is applied. The number of piers to be completed within one dry season is generally four, therefore the number of wagons to be used shall be eight in order to proceed the symmetrical construction works from each pier head.

The weight of a wagon is about 50 tons and the length of one segment to be concreted varies from 2.5m to 3.5m according to its weight. The standard construction cycle of one segment is determined under an assumption that the minimum curing time shall be 7 days in order to fulfill the compressive strength requirement at prestressing. In making construction schedule, it was assumed for safety that one segmental construction cycle would last 12 days and the segmental cantilever construction can be carried out during 9 months a year, with a decreased efficiency during rainy season.

#### 8.7.1.2 Steel Truss Bridge

The erection of steel truss bridge shall be carried out by the cantilever construction method. It was assumed that about 500 tons of steel weight a month could be erected. After the completion of any substructure, a post crane is installed on the top of pier, and two panels of the truss preassembled in the yard are carried to the construction site with a barge and lifted on the temporary supports fixed to the pier shaft with the post crane.

For the approach span, the cantilever erection from pier continued as far as end of the cantilever truss reaches to the middle of this span and then the remaining part of truss is assembled on the temporary support.

### 8.7.2 Substructure

(1) Abutments and the first pier near Prome Side

The ordinary open-cut construction method shall be applied up to the basement of the structures.

(2) Piers in the area of sand bank

The excavation and sinking of the open caissons shall be carried out using two big clamshell grabbing cranes and the height of one lift of open caisson is about 5m. After completion of caisson works, pier shaft will be concreted using slip-forms in the cases of prestressed concrete bridge, but shall be done using scaffold standing on the caisson for steel bridge.

(3) Piers under water (Fig. 8-11)

(i) The groin shall be installed in the upstream location of each foundation by driving steel piles.

(ii) At the same time, the excavation shall be carried out using the grab-dredger up to the depth of basement of footing.

(iii) A template consisted of steel pipes shall be installed and the steel skirt sheet piles shall be driven around the position of footing in order to prevent scouring.

(iv) Steel caisson to be used as the forms of footings and a lower part of pier shaft, is towed to the final position and sunk by pouring water or cement concrete into the caisson. The position of caisson will be adjusted by means of the guide frames. After the completion of caisson sinking, the remaining space of caisson is filled with concrete.

(v) The treatment of steel pile heads will be carried out in dry condition and the working chamber will be finally filled with concrete.

The connection between the steel caisson and the skirt sheet piles shall be carried out with cast in situ concrete under water. For safety, the first construction year is devoted to only the steel pile and skirt sheet pile driving works, in preparation of the final construction schedule. In order to protect the pile head already driven from any damages during rainy season, the top part of the steel pile, say about 5m will be filled with concrete. Next construction year will be confined to the clearing off the sedimentary materials, the caisson sinking and the construction of pier shaft. After having obtained the enough experiences for the construction of steel pile foundation carried out during the first and second construction years, one whole steel pile foundation, thereafter, could be completed within one dry season.

(4) Pier near Sinde Side (Fig. 8-11 Continued)

This pier would be directly built on inclined rock surface under water. Therefore the foundation shall be constructed by pneumatic caisson process.

In the case of prestressed concrete bridge, the position of this pier is near the west bank and depth of water is rather shallow. Therefore, after making a bank, the rock bed will be bored with revolving tools and bursted into fragments. The reinforced concrete caisoon shall be built on the bank and sunk using the ordinary pneumatic caisson technique.

In the stage of detailed design, more drilling tests should be carried out to clarify the shape of rock surface.

The foundation of this particular pier may be changed to those of the other piers accordingly.

In the case of steel truss bridge, the position of this pier is rather far from the west bank and the depth of water is not shallow. Therefore, the different construction method shall be adopted for this case. After the rock bed is bored and bursted into fragments, excavation is carried out by the grab dredger and prefabricated steel caisoon will be towed to the final position.

## 8.8 Construction

The total construction period of this Project would be mainly affected by the bridge construction period, therefore, the bridge construction period is desirable to be as short as possible from the importance of this Project and the social need.

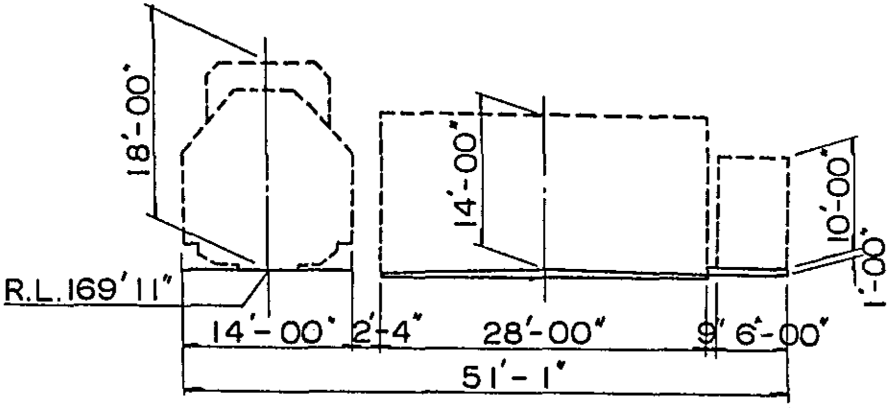
The construction schedule of the highway-railway bridge at Site No. 3 was prepared considering the above requirement, safety of construction and geographical and meteorological features of the district.

This construction schedule was determined only considering the technical possibilities. The results are given in Fig. 8-12 and Fig. 8-13 for the prestressed concrete bridge and the steel truss bridge, respectively.

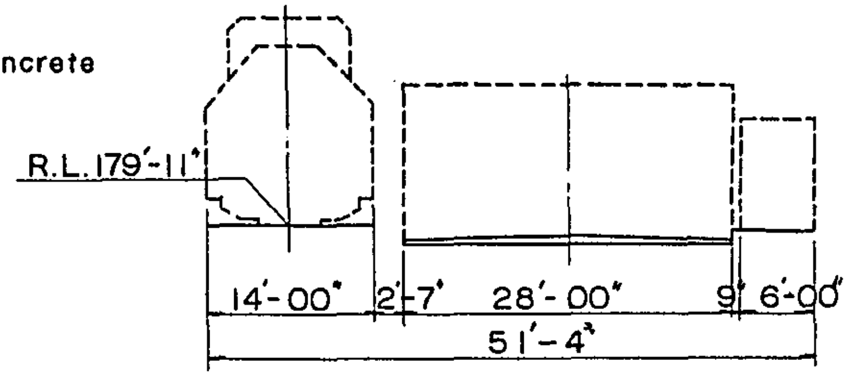
Fig 8-1 Clearance Diagram

a) Railway—Highway Bridge

Steel Bridge

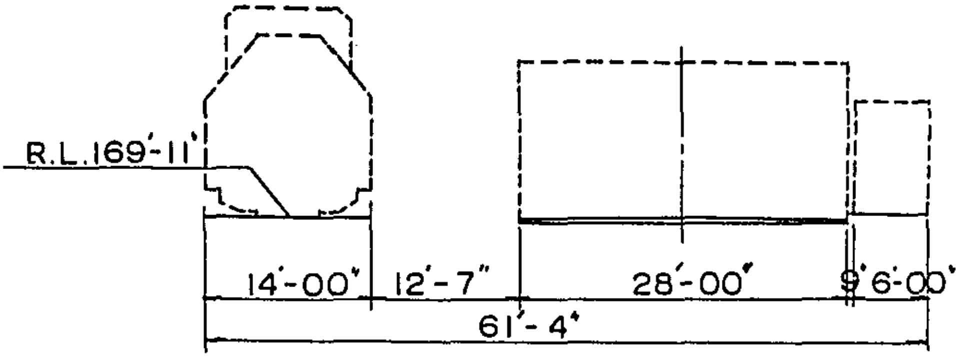


Prestressed Concrete Bridge



b) Highway and Railway Bridge separately Constructed on same Substructure

Steel Bridge



Prestressed Concrete Bridge

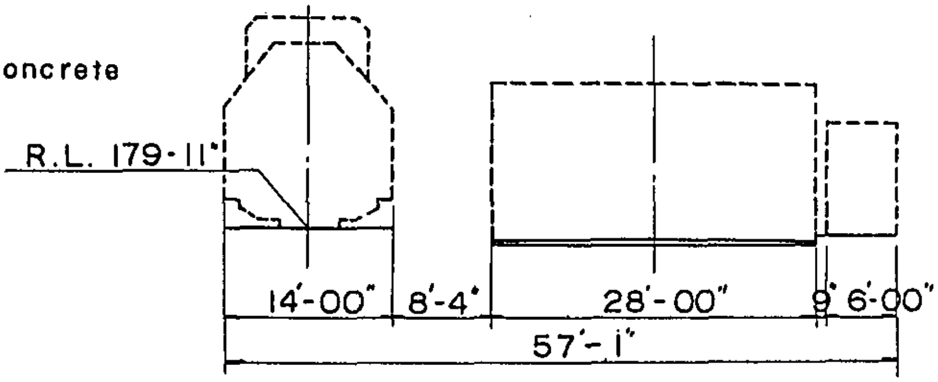


Fig. 8-2 Alternatives

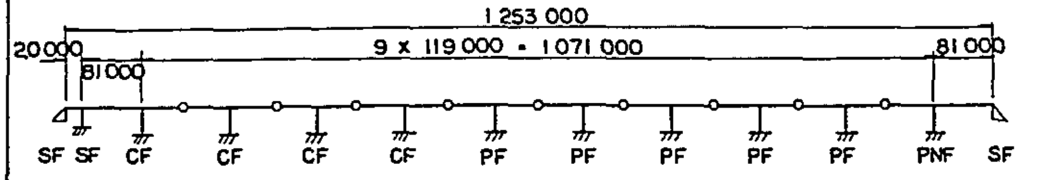
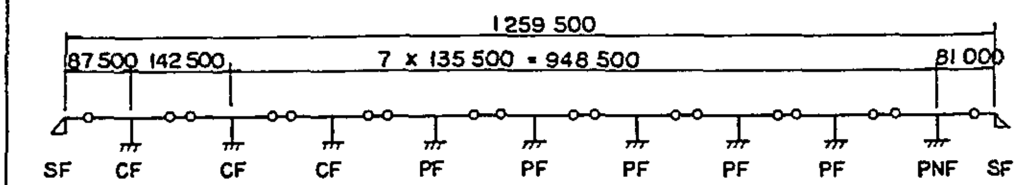
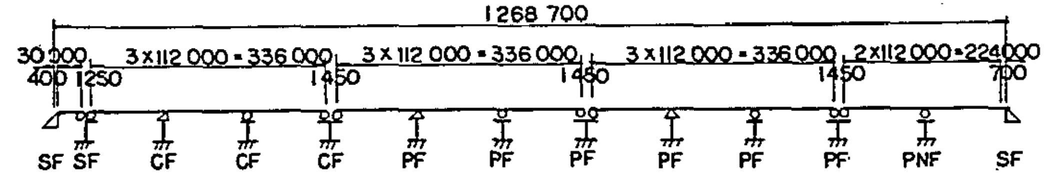
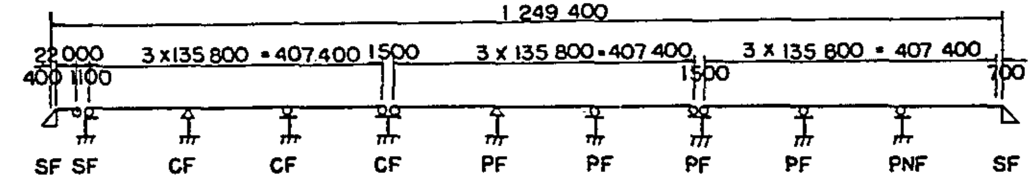
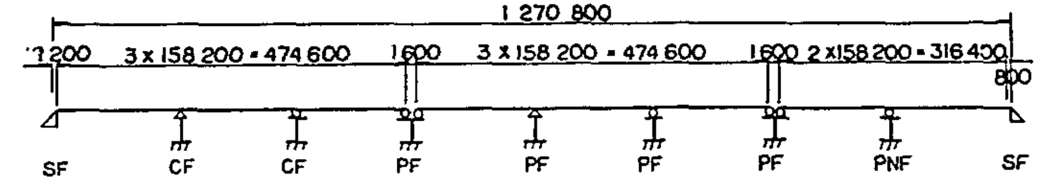
| | Alternative | Span Length (m) | Side View (mm) | Note |
|---|---|---|---|---|
| Prestressed Concrete Bridge | I | 119.0 |  | Type of Foundation<br>SF = Spread Foundation<br>CF = Caisson Foundation<br>PF = Pile Foundation<br>PNF = Pneumatic Caisson Foundation |
| | II | 135.5 |  | |
| Steel Truss Bridge | III | 112.0 |  | |
| | IV | 135.8 |  | |
| | V | 158.2 |  | |

Table 8-1 Comparison of Direct Construction Cost between Various Alternatives

| | Erection* Method | Alternative | Span Length (ft) | Super-structure (million Kyats) | Sub-structure (million Kyats) | Total (million Kyats) |
|---|---|---|---|---|---|---|
| Prestressed Conrete Bridge | | I | 390 | 53.7 | 251.3 | 305.0 |
| | | II | 442 | 56.6 | 260.2 | 316.8 |
| Steel Truss Bridge | A | III | 367 | 95.3 | 237.4 | 332.7 |
| | | IV | 446 | 110.4 | 188.1 | 298.5 |
| | | V | 519 | 131.6 | 180.0 | 311.6 |
| | B | III | 367 | 94.6 | 237.4 | 332.0 |
| | | IV | 446 | 108.2 | 188.1 | 296.3 |
| | | V | 519 | 128.5 | 180.0 | 308.5 |

Direct construction cost was calculated using the unit costs described in Chapter 10.

Note: * Erection Method

A = Cantilever Erection with Traveller Crane

B = Large Block Erection with Floating Crane

Table 8-2 Quantities of Construction Materials for Prestressed Concrete Bridge

| Site No. | Structure \ Item | | | Concrete (m$^3$) | | | Form Works (m$^2$) | | Rein force-ment (t) | Tendon | | | | Steel* (t) | Steel Pipe Pile (t) | Steel Sheet Pile (t) | Pavement (m$^3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | · 12T13 | | 1207 | | | | | |
| | | | | Class A | Class A | Class $C_1$ & $C_2$ | Metal | Timber | | Wire (t) | Anchorage (set) | Wire (t) | Anchorage (set) | | | | |
| 1 | Highway-Railway Bridge | Superstructure | | 11,613 | | 588 | 23,468 | 12,389 | 781 | 494 | 1,640 | 77 | 2,608 | 102 | | | 440 |
| | | Substructure | | | 8.608 | 48.656 | 19,190 | | 2,746 | | | | | 2,685 | 10,185 | 1,199 | |
| | | Total | | 11,613 | 8,608 | 49,244 | 42,658 | 12,389 | 3,527 | 494 | 1,640 | 77 | 2.608 | 2,787 | 10,185 | 1,199 | 440 |
| 2 | Highway-Railway Bridge | Superstructure | | 19.555 | | 974 | 41,017 | 18.708 | 1,315 | 877 | 3,200 | 128 | 4.320 | 30 | | | 729 |
| | | Substructure | | | 14,921 | 74,497 | 44,519 | | 5,023 | | | | | 4,436 | 8,279 | 1,062 | |
| | | Total | | 19,555 | 14,921 | 75,471 | 85,708 | 18,708 | 6,338 | 877 | 3,200 | 128 | 4,320 | 4,466 | 8,279 | 1,062 | 729 |
| 3 | Highway-Railway Bridge | Superstructure | | 22,253 | | 1,113 | 45,901 | 22,192 | 1.497 | 974 | 3,540 | 156 | 5,188 | 191 | | | 942 |
| | | Substructure | | | 22,893 | 71.665 | 50,029 | | 5,608 | | | | | 2,799 | 7,099 | 1,061 | |
| | | Total | | 22,253 | 22,893 | 72,778 | 95,930 | 22,192 | 7,105 | 974 | 3,540 | 156 | 5,188 | 2,990 | 7,099 | 1,061 | 942 |
| | Highway and Railway Bridge | Super-structure | Highway | 12,467 | | 550 | 31,273 | 16,294 | 849 | 734 | 2,444 | 104 | 5,056 | 182 | | | 942 |
| | | | Railway | 10,132 | | 694 | 26,568 | 18,453 | 701 | 655 | 2,400 | 65 | 5,056 | 134 | | | |
| | | Substructure | | | 30,776 | 80,313 | 61,156 | | 6,360 | | | | | 3,123 | 7,710 | 1,101 | |
| | | Total | | 22,599 | 30,776 | 81,557 | 118,997 | 34,747 | 7,910 | 1,389 | 4,844 | 169 | 10,112 | 3,439 | 7,710 | 1,101 | 942 |

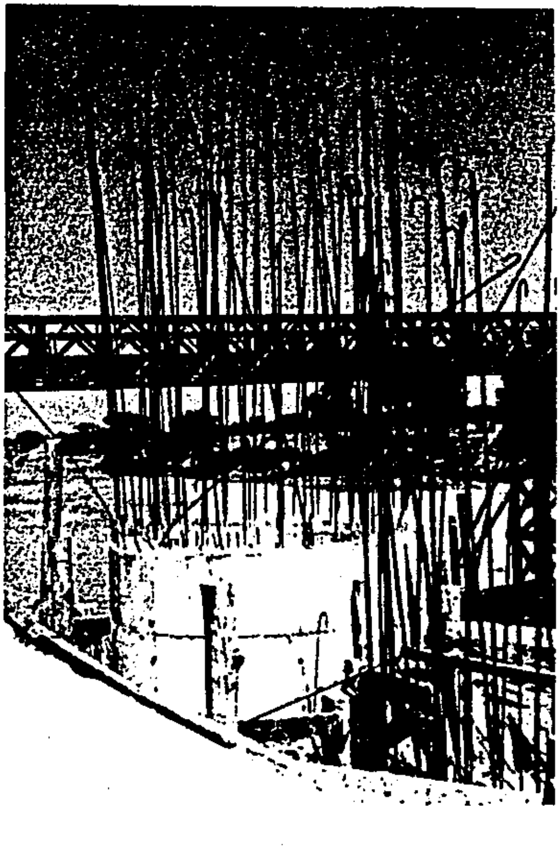
Note : * Shoes, Railing, Drainage, Expansion, etc. for Superstructure and Steel Caisson for Substructure

Table 8-3 Quantities of Construction Materials for Steel Bridge

| Site No. | Structure \ Item | | | Steel | | | Steel Pipe Pile (t) | Steel Sheet Pile (t) | Reinforce-ment (t) | Concrete Class $C_1$ & $C_2$ | Form Works | | Pavement (m$^3$) | Paint (m$^2$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Plate (t) | Shape (t) | Others* (t) | | | | | Metal (m$^2$) | Timber (m$^2$) | | |
| 1 | Highway-Railway Bridge | Superstructure | | 4,100 | 689 | 369 | | | 573 | 2,291 | | 8,857 | 371 | 103,160 |
| | | Substructure | | 579 | 2,401 | | 6,598 | 790 | 1,729 | 36,076 | 12,507 | | | |
| | | Total | | 4,679 | 3,090 | 369 | 6,598 | 790 | 2,302 | 38,367 | 12,507 | 8,857 | 371 | 103,160 |
| 2 | Highway-Railway Bridge | Superstructure | | 6,151 | 1,029 | 556 | | | 856 | 3,424 | | 13,250 | 555 | 154,720 |
| | | Substructure | | 682 | 2,864 | | 7,282 | 885 | 3,113 | 60,123 | 33,967 | | | |
| | | Total | | 6,833 | 3,893 | 556 | 7,282 | 885 | 3,969 | 63,547 | 33,967 | 13,250 | 555 | 154,720 |
| 3 | Highway-Railway Bridge | Superstructure | | 7,060 | 1,203 | 572 | | | 1,001 | 4,003 | | 15,480 | 648 | 176,700 |
| | | Substructure | | 726 | 3,297 | | 4.769 | 637 | 3,950 | 67,608 | 44,460 | | | |
| | | Total | | 7,786 | 4,500 | 572 | 4,769 | 637 | 4,951 | 71,611 | 44,460 | 15,480 | 648 | 176,700 |
| | Highway and Railway Bridge | Super-structure | Highway | 3,761 | 766 | 435 | | | 1,001 | 4,003 | | 15,480 | 648 | 99,240 |
| | | | Railway | 4,329 | 413 | 39 | | | | | | | | 95,620 |
| | | Substructure | | 727 | 3,332 | | 4,769 | 637 | 4,031 | 63,651 | 45,769 | | | |
| | | Total | | 8,817 | 4,511 | 474 | 4,769 | 637 | 5,032 | 67,654 | 45,769 | 15,480 | 648 | 194,860 |

Note: * Shoes, Railing, Drainage, Expansion, etc. for Superstructure

# 9. CONSTRUCTION MATERIAL



# 9. CONSTRUCTION MATERIAL

## 9.1 Quantity of Construction Material

### 9.1.1 General Description

The construction material survey was made to investigate the availability and quantity of such materials as cement, sand, gravel, stone, steel etc., which will be needed for the bridge construction project.

The survey for the availability of raw materials such as sand, gravel and stone was concentrated mostly areas within about 30 miles from Prome, taking their transportation distance into consideration. The quantities of these materials were calculated based on the result of field survey but not confirmed yet by boring or test pit. The availability of the cement and steel was studied taking into account the production capacity of existing factories and a cement factory under construction.

### 9.1.2 Total Construction Quantities

The construction quantities required for the construction of bridge, access road and railway at the proposed three sites were summarised in Table 9-1. The quantities of construction materials required at each site were estimated as shown in Table 9-2 based on the figures in Table 9-1.

Among the proposed three bridge sites, the elaborate studies on the construction materials have been carried out only for Site No.3. The construction quantities required annually for the bridge construction at Site No.3 were estimated as shown in Table 9-3 based on the construction schedule given in Figure 11-2. The quantities of the construction materials required annually for the bridge construction at Site No.3 were estimated as shown in Table 9-4 based on the figures in Table 9-3.

The quantities of normal portland cement, fine and coarse aggregates were estimated based on the concrete mix proportion given in Table 9-8. The details of the design of concrete mix proportion are explained in later paragraph.

### 9.1.3 Quantities of Materials Available in Burma

Among the construction materials shown in Table 9-2, the normal portland cement, coarse and fine aggregates, crushed stone, crusher run and rubble stone are available in Burma. The study on the quantity of the above materials is as follows:

1) Normal cement

The normal portland cement produced at the existing Thayetmyo factory and Kyangin factory which is under construction is available for this Project. The Thayetmyo cement factory is located at about 36 miles north of Prome. This factory is equipped with three wet type rotary kilns and its annual production capacity is about 300,000 tons. The Kyangin cement factory,which is scheduled to be constructed by 1975,is located at about 35 miles south of Prome and its annual production capacity is estimated at about 240,000 tons. The location of these factories is given in Fig. 9-1.

The total amount of the normal cement required for the bridge construction at Site No.3 was estimated at about 41,500 tons considering the possible 5% loss. The annual maximum quantity of cement requirement is about 17,500 tons as shown in Table 9-4. Comparing the above figures for annual maximum cement requirement with the annual production capacity at both cement factories, it may be said that the total amount of cement required for this Project can be fully supplied from these factories since the annual maximum quantity required for this Project is equivalent only to 6% of the production capacity at the Thayetmyo factory and its ratio will decrease to 3.2 % after the Kyangin cement factory is fully operated.

2) Coarse and fine aggregates

The river deposit around Kamagale situated in the east bank of the Irrawaddy, about 18 miles north of Prome and also the river deposit around Taungdi located along the Mindon, a small tributary of the Irrawaddy, have been proposed as the gravel pit for coarse aggregate. The coarse aggregate at the above two pits consists of quartz andesite and sandstone. The location of these gravel pits is given in Figs 9-1. The volume of deposit at Kamagale was estimated at about 200,000 $m^3$, of which about 80,000 $m^3$ was assumed to be available as coarse aggregate for bridge construction.

At Taungdi, river deposit with one to two meters in depth and 30 meters in width was found. The total volume was presumed to be about 360,000 $m^3$, of which about 300,000 $m^3$ was seemed to be available as the coarse aggregate.

The total quantity of coarse aggregate required for this project was estimated at about 108,500 $m^3$ considering 15 % loss. Of the proposed two gravel deposits, Taungdi site was considered to be most appropriate not only from the quantitative viewpoint but also from the qualitative standpoint as explained in later paragraph.

The fine aggregate to meet the quantity required for this Project is available at any place in the Irrawaddy around Prome. The fine aggregate at the river deposit in the Irrawaddy is of quartz andesite and sandstone.

3) Crushed stone, crusher run and rubble stone

The survey to select the quarry site for crushed stone, crusher run and rubble stone was made for three places, namely, Ngaung Chi Dauk, Akauk Taung and Kamyaing. The location of these sites is given in Fig. 9-1. Among the above three sites, Ngaung Chi Dauk site was considered to be the most appropriate for the quarry site from the viewpoints of location and the quality. The proposed quarry site at Ngaung Chi Dauk is located at favourable place along the existing road connecting Sinde and Taungup. The total quantity of the stones available at this site was roughly estimated at 300,000 $m^3$. Since the total required volume of the crushed stone, crusher run and rubble stone was estimated at 229,000 $m^3$ considering 25% loss. Sufficient supply will be expected from the quarry site at Ngaung Chi Dauk.

### 9.1.4 Quantities of Imported Material

Among the construction material estimated in Table 9-4, high-early strength cement and steel materials including reinforcement bar and steel shape shall be imported from abroad because of the following reasons:

1) The high-early strength cement is not produced in Burma at present. The total quantity of high-early strength cement required for this project was estimated at about 4,000 tons and the annual required quantity of such cement is about 2,000 tons at its maximum. It will be technically

possible to produce the high-early strength cement by utilising the existing cement factory. However, as a result, the producing capacity of the normal cement will be largely decreased and the price of high-early strength cement thus produced will become so costly due to the installation of additional equipment.

2) There is only one steel mill in Burma at present. Its annual production capacity is as small as about 30,000 ton and only two kinds of product, namely, round bar and small-type steel sheet are produced at this steel mill at present, while the steel materials required for this Project are the deformed reinforcement bar, prestressing steel, steel shape, etc. Thus, it is hardly expected to meet the requirement from the viewpoints of production capacity and the kind of product.

Taking into account the above situations, the kinds of construction materials to be imported and their quantities were estimated as shown in Table 9-5.

## 9.2 Quality of Construction Material

### 9.2.1 General Description

The test to examine the quality of the construction materials available in Burma was made at the laboratory at Rangoon.

The samples collected are the cement, sand, gravel, stone and water in the Irrawaddy. The results of quality test have clarified that the construction materials available in Burma are quite suitable for the bridge construction.

### 9.2.2 Quantity Test and Result

The kinds of test and the results are as follows:

1) Cement

The quality control test on .the normal cement at the existing cement factory is being made based on the British Standard BS-12 and the test results always satisfy the values specified in the British Standard BS-12. Judging from these results, it is considered that the normal cement produced at the existing cement factory is appropriate for the bridge construction.

2) Coarse and fine aggregates

The samples for coarse aggregate were collected from the gravel layer at Kamagale and the river deposit at Taungdi. The kinds of test for these samples and their results are given in Table 9-6. The result of test shows that the values of specific gravity, absorption, distribution of size and unit weight for the sample collected from Kamagale are almost the same as those for the sample at Taungdi, but the result of abraison test is quite different, namely, the abraison for the sample at Kamagale is quite larger than that at Taungdi. It means that the coarse aggregate at the Kamagale is fairly weathered and its quality is not suitable for construction use. In view of the above conditions, the gravel pit at Kamagale was eliminated in this project.

The sample for fine aggregate was collected at the river deposit of the Irrawaddy at Prome. Judging from the results of test shown in Table 9-6, it is considered that the river sand in the Irrawaddy is suitable as the fine aggregate for this Project.

3) Stone

The samples for stone to be used as crushed stone, crusher run and rubble stone were collected from the proposed quarry sites at Ngaung Chi Dauk, Akauk Taung and Kamyaing. The samples at Akauk Taung consist of sandstone and laterite and that at Ngaung Chi Dauk and Kamyaing comprises sandstone. The test results show that the specific gravity and absorption for the sample collected at Ngaung Chi Dauk are almost the same as those at other two sites, but, the results of abraison and compressive test for the sample at Ngaung Chi Dauk are superior to those at other sites.

Judging from these results, it is considered to be appropriate to apply the stone collected from the quarry site at Ngaung Chi Dauk to the construction.

4) Water

In order to examine whether water of the Irrawaddy can be used for concrete mixing or not, the chemical test of water was made. The result of the test is shown in Table 9-7. Since the organic matter and sulfuric magnesium which are harmful for concrete are not included in water, it can be used for concrete mixing.

### 9.3 Design Criteria for Concrete Mix Proportion

Prior to designing concrete mix proportion, the compressive strength of cement at an age of 28 days was estimated based on the result of quality control test of cement. The estimated compressive strength of cement was 320 $kg/cm^2$.

The compressive strength of concrete at 28 days ( $\sigma_{28}$) can be represented as a function of the compressive strength of cement at 28 days ($K_{28}$) and the cement-water ratio (C/W).

$$\sigma_{28} = K_{28} (0.61 \, C/W - 0.34) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Applying the estimated compressive strength of cement at 28 days to Eq.(1), the following relation was obtained:

$$\sigma_{28} = 195.2 \, C/W - 108.8 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Depending on the design compressive strength at an age of 28 days, four concrete mixtures were introduced as follows.

| Class | Design Comp. Strength(Kg/cm2) | Slump (cm) | Structure or Member |
|---|---|---|---|
| A | 400 | 5.0~8.0 | Prestressed Concrete Girder |
| B | 300 | 10.0 ~ 12.0 | Upper Part of Pier Shaft for P.C Bridge, Reinforced Concrete Bridge, etc. |
| C * | 240 | 15.0 ~ 18.0 | Pier Shaft for Steel Bridge ($C_2$) Tunnel Lining ($C_2$), Box Curvert ($C_2$), etc. Wall of Open Caisson ($C_1$) |
| D | 180 | 10.0 ~ 12.0 | Base-slab, Retaining Wall, Foundation for Minor Structure , etc. |

* Class C concrete was subdivided into Class $C_1$ and $C_2$ when normal cement and high early strength cement are used in each mixture.

In order to improve the workability of concrete, admixture shall be applied to the concrete mixture.

Applying Eq. (2), C/W for the target compressive strength of each class shall be determined and the concrete mixtures for each class are given in Table 9-8.

## Table 9-1 Total Construction Quantity

| Item | Unit | Site No. 1 | | Site No. 2 | | Site No. 3 | |
|---|---|---|---|---|---|---|---|
| | | Steel Bridge | P.C.Bridge | Steel Bridge | P.C.Bridge | Steel Bridge | P.C.Bridge |
| A) Bridge | | | | | | | |
| (1) Substructure | | | | | | | |
| Concrete class B | $m^3$ | 408 | 8,608 | 498 | 14,921 | 390 | 19,893 |
| " $C_1$ | " | 31,476 | 48,656 | 44,504 | 67,610 | 50,009 | 60,426 |
| " $C_2$ | " | | | 4,941 | 6,887 | 5,012 | 11,239 |
| Reinforcing Bar | t | 1,510 | 2,746 | 2,812 | 5,022 | 3,887 | 5,608 |
| Steel Pipe Pile | " | 5,815 | 10,184 | 6,205 | 8,279 | 4,062 | 7,099 |
| Steel Sheet Pile | " | 755 | 1,199 | 870 | 1,062 | 593 | 1,061 |
| Steel Shape & Plate | " | 2,446 | 2,685 | 2,947 | 4,536 | 2,609 | 2,799 |
| Steel Form | $m^2$ | 5,127 | 10,480 | 9,899 | 18,948 | 11,741 | 29,479 |
| Timber Form | " | 2,348 | 8,710 | 13,594 | 26,222 | 20,384 | 20,550 |
| Earthwork | $m^3$ | 85,336 | 167,272 | 126,129 | 203,318 | 124,816 | 222,086 |
| (2) Superstructure | | | | | | | |
| Concrete Class A | $m^3$ | | 11,613 | | 19,555 | | 22,253 |
| " $C_1$ | " | 2,291 | 588 | 3,424 | 974 | 4,008 | 1,113 |
| Reinforcing Bar | t | 573 | 781 | 856 | 1,315 | 1,001 | 1,497 |
| Prestressing Strand | " | | 494 | | 877 | | 974 |
| Prestressing Wire | " | | 77 | | 128 | | 156 |
| Steel Shape & Plate | " | 5,158 | 102 | 7,736 | 30 | 12,289 | 191 |
| Steel Form | $m^2$ | | 23,468 | | 41,017 | | 45,901 |
| Timber Form | " | 8,857 | 12,389 | 13,250 | 18,708 | 15,480 | 22,192 |
| Asphalt Concrete | " | 7,420 | 8,800 | 11,100 | 14,580 | 12,920 | 16,660 |
| B) Access Road | | | | | | | |
| Clearling & Grubbing | $m^2$ | 368,000 | | 802,000 | | 867,000 | |

| Item | Unit | Site No. 1 |  | Site No. 2 |  | Site No. 3 |  |
|---|---|---|---|---|---|---|---|
|  |  | Steel Bridge | P.C.Bridge | Steel Bridge | P.C.Bridge | Steel Bridge | P.C.Bridge |
| Earthwork | $m^3$ |  | 880,000 |  | 2,440,000 |  | 2,835,000 |
| Slope Protection | $m^2$ |  | 193,000 |  | 416,000 |  | 468,900 |
| Drainage Structure |  |  |  |  |  |  |  |
| R.C. Pipe ϕ 1,000 | m |  | 450 |  | 850 |  | 750 |
| R.C. Pipe ϕ 600 | " |  | 450 |  | 850 |  | 655 |
| Bridge & Box Culvert |  |  |  |  |  |  |  |
| Concrete Class B | $m^3$ |  | 3,686 |  | 7,852 |  | 8,513 |
| " $C_1$ | " |  | 888 |  | 1,107 |  | 1,107 |
| Reinforcing Bar | t |  | 124 |  | 213 |  | 252 |
| Pavement |  |  |  |  |  |  |  |
| Subbase | $m^2$ |  | 117,500 |  | 220,800 |  | 197,500 |
| Base | " |  | 109,400 |  | 205,600 |  | 184,400 |
| Shoulder | " |  | 68,000 |  | 128,200 |  | 114,600 |
| Asphalt Concrete | " |  | 102,300 |  | 192,200 |  | 172,400 |
| Seal Coat | " |  | 68,000 |  | 128,200 |  | 114,600 |
| C) Access Railway |  |  |  |  |  |  |  |
| Earthwork |  |  |  |  |  |  |  |
| Excavation | $m^3$ |  | 2,927,000 |  | 821,000 |  | 488,800 |
| Concrete Class D | $m^3$ |  | 11,220 |  | 3,465 |  | 3,575 |
| Tunnel Work |  |  |  |  |  |  |  |
| Excavation | $m^3$ |  | 163,700 |  | 144,500 |  | 104,800 |
| Concrete Class $C_1$ | " |  | 45,900 |  | 39,800 |  | 29,400 |
| Bridge & Box Culvert |  |  |  |  |  |  |  |
| Concrete Class A | $m^3$ |  | 1,334 |  | 1,576 |  | 56 |
| " B | " |  | 12,369 |  | 5,115 |  | 2,655 |

| Item | Unit | Site No. 1 | | Site No. 2 | | Site No. 3 | |
|---|---|---|---|---|---|---|---|
| | | Steel Bridge | P.C.Bridge | Steel Bridge | P.C.Bridge | Steel Bridge | P.C.Bridge |
| Concrete Class $C_1$ | $m^3$ | | 3,532 | | 1,106 | | 1,204 |
| Reinforcing Bar | t | | 1,202 | | 517 | | 341 |
| Prestressing Bar | " | | 4.5 | | 5.4 | | 0.2 |
| Prestressing Wire | " | | 71.5 | | 89.2 | | 3.2 |
| Track Structure | | | | | | | |
| Roadbed, Ballast | $m^3$ | | 111,200 | | 48,800 | | 32,000 |
| Railing | m | | 69,500 | | 30,500 | | 20,000 |
| D) River Work | | | | | | | |
| (1) Mattress Work | | | | | | | |
| Rubble Stone | $m^3$ | | 41,000 | | 41,000 | | 41,000 |
| (2) Rivetment Work | | | | | | | |
| Concrete Block | $m^2$ | | 1,500 | | 1,500 | | 1,500 |
| Wet Masonry | $m^2$ | | 1,000 | | 1,000 | | 1,000 |

Table 9-2 Total Quantity of Construction Material

(Including Bridge, Access Road, Access Railway and River Works)

| Item | Unit | Site No.1 | | Site No.2 | | Site No.3 | |
|---|---|---|---|---|---|---|---|
| | | Steel Bridge | P.C. Bridge | Steel Bridge | P.C. Bridge | Steel Bridge | P.C. Bridge |
| Normal Cement | t | 37,046 | 50,153 | 36,013 | 56,527 | 33,305 | 39,472 |
| High-early Strength Cement | " | | | 1,626 | 2,266 | 1,649 | 3,668 |
| Coarse Aggregate | $m^3$ | 78,862 | 93,736 | 78,897 | 118,822 | 73,660 | 94,212 |
| Fine Aggregate | " | 45,911 | 59,488 | 45,694 | 60,252 | 45,623 | 53,598 |
| Admixture | t | 112 | 151 | 112 | 177 | 104 | 129 |
| Crushed stone | $m^3$ | 153,067 | 153,105 | 122,251 | 122,347 | 102,192 | 102,299 |
| Crusher Run | " | 23,500 | 23,500 | 44,160 | 44,160 | 39,500 | 39,500 |
| Rubble Stone | " | 41,000 | 41,000 | 41,000 | 41,000 | 41,000 | 41,000 |
| Reinforcing Bar | t | 3,628 | 4,853 | 5,021 | 7,067 | 5,481 | 7,698 |
| Prestressing Bar | " | 4.5 | 4.5 | 5.4 | 5.4 | 0.2 | 0.2 |
| Prestressing Strand | " | | 494 | | 877 | | 974 |
| Prestressing Wire | " | 71.5 | 148.5 | 89.2 | 217.2 | 3.2 | 159.2 |
| Steel Pipe Pile | " | 6,598 | 10,184 | 7,383 | 9,035 | 4,062 | 7,099 |
| Steel Sheet Pile | " | 790 | 1,199 | 885 | 1,062 | 593 | 1,061 |
| Steel Shape & Plate | " | 8,156 | 2,787 | 11,330 | 4,566 | 11,444 | 2,990 |
| R.C. Pipe | m | 900 | 900 | 1,810 | 1,810 | 1,405 | 1,405 |
| Asphalt | t | 412 | 417 | 763 | 776 | 555 | 566 |
| Filler | " | 856 | 867 | 1,586 | 1,613 | 648 | 661 |
| Seal Coat | " | 102 | 102 | 192 | 192 | 191 | 197 |
| Rail | m | 139,000 | 139,000 | 61,000 | 61,000 | 40,000 | 40,000 |

Table 9-3 Construction Quantity of Highway-Railway Bridge at Site No.3

| Item | Unit | Construction Year | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 3rd | 4th | 5th | 6th | 7th | 8th | Total |
| In case of Prestressed Concrete Bridge | | | | | | | | |
| A) Bridge | | | | | | | | |
| (1) Substructure | | | | | | | | |
| Concrete Class B | $m^3$ | | 8,777 | 8,543 | 5,573 | | | 19,893 |
| " $C_1$ | " | 803 | 19,642 | 21,131 | | | | 60,426 |
| " $C_2$ | " | | 5,690 | 5,549 | | | | 11,239 |
| Reinforcing Bar | t | | 2,215 | 2,185 | 1,208 | | | 5,608 |
| Steel Pipe Pile | " | 2,970 | | 2,864 | 1,265 | | | 7,099 |
| Steel Sheet Pile | " | 437 | | 429 | 195 | | | 1,061 |
| Steel Shape & Plate | " | | 1,104 | 1,153 | 542 | | | 2,799 |
| Steel Form | $m^2$ | | 12,026 | 11,528 | 5,925 | | | 29,479 |
| Timber Form | " | | 7,776 | 7,647 | 5,127 | | | 20,550 |
| Earthwork | $m^3$ | 51,870 | 26,339 | 75,665 | 68,212 | | | 222,086 |
| (2) Superstructure | | | | | | | | |
| Concrete Class A | $m^3$ | | | 4,900 | 9,558 | 5,570 | 2,225 | 22,253 |
| " $C_1$ | " | | | 247 | 478 | 278 | 110 | 1,113 |
| Reinforcing Bar | t | | | 329 | 644 | 374 | 150 | 1,497 |
| Prestressing Strand | " | | | 214 | 420 | 243 | 97 | 974 |
| Prestressing Wire | " | | | 34 | 67 | 39 | 16 | 156 |
| Steel Shape & Plate | " | | | 47 | 86 | 44 | 14 | 191 |
| Asphalt Concrete | $m^2$ | | | | | | 16,660 | 16,660 |
| Steel Form | " | | | 10,100 | 19,761 | 11,450 | 4,590 | 45,901 |
| Timber Form | " | | | 4,880 | 9,542 | 5,550 | 2,220 | 22,192 |
| B) Access Road | | | | | | | | |

| Item | Unit | Construction Year | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 3rd | 4th | 5th | 6th | 7th | 8th | Total |
| Clearling & Grubbing | $m^2$ | 189,160 | 189,160 | 189,160 | 189,160 | 110,360 | | 867,000 |
| Earthwork | $m^3$ | 607,500 | 607,500 | 607,500 | 607,500 | 405,000 | | 2,835,000 |
| Slope Protection | $m^2$ | 90,170 | 108,200 | 108,200 | 108,200 | 54,130 | | 468,900 |
| Drainage Structure | | | | | | | | |
| R.C.Pipe ϕ 1,000 | m | 140 | 170 | 170 | 170 | 100 | | 750 |
| R.C.Pipe ϕ 600 | " | 125 | 150 | 150 | 150 | 80 | | 655 |
| Bridge & Box Culvert | | | | | | | | |
| Concrete Class B | $m^3$ | | 3,400 | 3,400 | 1,713 | | | 8,513 |
| " $C_1$ | " | 210 | 260 | 260 | 260 | 117 | | 1,107 |
| Reinforcing Bar | t | 30 | 70 | 70 | 70 | 12 | | 252 |
| Pavement | | | | | | | | |
| Subbase | $m^2$ | | | | 13,200 | 158,000 | 26,300 | 197,500 |
| Base | " | | | | 12,300 | 147,200 | 24,500 | 184,000 |
| Shoulder | " | | | | 7,660 | 91,900 | 15,290 | 114,850 |
| Asphalt Concrete | " | | | | | 114,700 | 57,400 | 172,100 |
| Seal Coat | " | | | | | 76,400 | 38,300 | 114,700 |
| C) Access Railway | | | | | | | | |
| Earthwork | | | | | | | | |
| Excavation | $m^3$ | | | 179,100 | 130,400 | 130,400 | 48,900 | 488,800 |
| Concrete Class D | " | | | 1,300 | 960 | 960 | 355 | 3,575 |
| Tunnel Work | | | | | | | | |
| Excavation | $m^3$ | | | 23,000 | 33,200 | 33,200 | 10,400 | 104,800 |
| Concrete Class $C_1$ | " | | | 7,800 | 9,350 | 9,350 | 2,900 | 29,400 |
| Bridge & Box Culvert | | | | | | | | |
| Concrete Class A | $m^3$ | | | | 56 | | | 56 |

| Item | Unit | Construction Year | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 3rd | 4th | 5th | 6th | 7th | 8th | Total |
| Concrete Class B | $m^3$ | | | 1,330 | 1,325 | | | 2,655 |
| " $C_1$ | " | | | 602 | 602 | | | 1,204 |
| Reinforcing Bar | t | | | 171 | 170 | | | 341 |
| Prestressing Bar | " | | | 0.2 | | | | 0.2 |
| Prestressing Wire | " | | | 3.2 | | | | 3.2 |
| Track Structure | | | | | | | | |
| Roadbed, Ballast | $m^3$ | | | | 10,000 | 22,000 | | 32,000 |
| Railing | m | | | | 15,000 | 25,000 | | 40,000 |
| D) River Work | | | | | | | | |
| (1) Mattress Work | | | | | | | | |
| Rubble Stone | $m^3$ | | | | | 20,000 | 21,000 | 41,000 |
| (2) Rivetment Work | | | | | | | | |
| Concrete Block | $m^2$ | | | | | | 1,500 | 1,500 |
| Wet Masonry | " | | | | | | 1,000 | 1,000 |
| In case of Steel Truss Bridge | | | | | | | | |
| A) Bridge | | | | | | | | |
| (1) Substructure | | | | | | | | |
| Concrete Class B | $m^3$ | | 96 | 198 | 96 | | | 390 |
| " $C_1$ | " | 7,868 | 23,011 | 12,886 | 6,244 | | | 50,009 |
| " $C_2$ | " | 3,420 | 1,592 | | | | | 5,012 |
| Reinforcing Bar | t | 1,060 | 1,777 | 679 | 371 | | | 3,887 |
| Steel Pipe Pile | " | 1,045 | | 2,202 | 815 | | | 4,062 |
| Steel Sheet Pile | " | 150 | | 293 | 150 | | | 593 |
| Steel Shape & Plate | " | 128 | 1,086 | 1,004 | 391 | | | 2,609 |
| Steel Form Work | $m^2$ | 3,399 | 4,755 | 2,482 | 1,105 | | | 11,741 |

| Item | Unit | Construction Year | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 3rd | 4th | 5th | 6th | 7th | 8th | Total |
| Wooden Formwork | $m^2$ | 9,220 | 10,386 | | 778 | | | 20,384 |
| Earthwork | $m^3$ | 16,434 | 52,011 | 37,052 | 19,319 | | | 124,816 |
| (2) Superstructure | | | | | | | | |
| Erection Work of Truss | t | | | 2,945 | 2,945 | 2,945 | | 8,835 |
| Deck Slab | | | | | | | | |
| Concrete Class $C_1$ | $m^3$ | | | | 2,004 | 2,004 | | 4,008 |
| Reinforcing Bar | t | | | | 501 | 500 | | 1,001 |
| Timber Form | $m^2$ | | | | 7,740 | 7,740 | | 15,480 |
| Asphalt Concrete | " | | | | | 12,920 | | 12,920 |
| B) Access Road<br>C) Access Railway<br>D) River Work | Same quantity as for prestressed concrete bridge | | | | | | | |

## Table 9-4 Construction Material Required

(In case of Highway-Railway Bridge at Site No. 3)

| Item | Unit | Construction Year | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 3rd | 4th | 5th | 6th | 7th | 8th | Total |
| In case of Prestressed Concrete Bridge | | | | | | | | |
| Normal Cement | t | 333 | 10,873 | 17,130 | 6,730 | 3,361 | 1,045 | 39,472 |
| High-early Strength Cement | " | | 1,842 | 1,826 | | | | 3,668 |
| Coarse Aggregate | $m^3$ | 702 | 26,196 | 38,521 | 13,911 | 10,510 | 4,372 | 94,212 |
| Fine Aggregate | " | 409 | 14,967 | 21,871 | 7,929 | 5,979 | 2,443 | 53,598 |
| Admixture | t | 1 | 38 | 57 | 20 | 10 | 3 | 129 |
| Crushed Stone | $m^3$ | | | | 14,373 | 78,995 | 8,931 | 102,299 |
| Crusher Run | " | | | | 2,640 | 31,600 | 5,260 | 39,500 |
| Rubble Stone | " | | | | | 20,000 | 21,000 | 41,000 |
| Reinforcing Bar | t | 30 | 2,285 | 2,755 | 2,092 | 386 | 150 | 7,698 |
| Prestressing Bar | " | | | | 0.2 | | | 0.2 |
| Prestressing Strand | " | | | 238 | 438 | 223 | 75 | 974 |
| Prestressing Wire | " | | | 38 | 73.2 | 36 | 12 | 159.2 |
| Steel Pipe Pile | " | 2,970 | | 2,864 | 1,265 | | | 7,099 |
| Steel Sheet Pile | " | 437 | | 429 | 195 | | | 1,061 |
| Steel Shape & Plate | " | | 1,104 | 1,200 | 628 | 44 | 14 | 2,990 |
| R.C. Pipe | m | 265 | 320 | 320 | 320 | 180 | | 1,405 |
| Asphalt | t | | | | | 344 | 222 | 566 |
| Filler | " | | | | | 402 | 259 | 661 |
| Seal Coat | " | | | | | 115 | 82 | 197 |
| Rail | m | | | | 4,500 | 14,500 | 21,000 | 40,000 |

| Item | Unit | Construction Year | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 3rd | 4th | 5th | 6th | 7th | 8th | Total |
| In case of Steel Truss Bridge | | | | | | | | |
| Normal Cement | t | 2,658 | 8,915 | 9,196 | 7,471 | 4,020 | 1,045 | 33,305 |
| High-early Strength Cement | " | 1,125 | 524 | | | | | 1,649 |
| Coarse Aggregate | $m^3$ | 7,968 | 19,712 | 19,352 | 15,738 | 8,629 | 2,261 | 73,660 |
| Fine Aggregate | " | 4,646 | 11,405 | 11,268 | 9,130 | 6,981 | 2,193 | 45,623 |
| Admixture | t | 11 | 28 | 28 | 22 | 12 | 3 | 104 |
| Crushed Stone | $m^3$ | | | | 14,373 | 79,363 | 8,456 | 102,192 |
| Crusher Run | " | | | | 2,640 | 31,600 | 5,260 | 39,500 |
| Rubble Stone | " | | | | | 20,000 | 21,000 | 41,000 |
| Reinforcing Bar | t | 1,090 | 1,847 | 920 | 1,112 | 512 | | 5,481 |
| Prestressing Bar | " | | | | 0.2 | | | 0.2 |
| Prestressing Wire | " | | | | 3.2 | | | 3.2 |
| Steel Pipe Pile | " | 1,045 | | 2,202 | 815 | | | 4,062 |
| Steel Sheet Pile | " | 150 | | 293 | 150 | | | 593 |
| Steel Shape & Plate | " | 128 | 1,086 | 3,949 | 3,336 | 2,945 | | 11,444 |
| R.C. Pipe | m | 265 | 320 | 320 | 320 | 180 | | 1,405 |
| Asphalt | t | | | | | 383 | 172 | 555 |
| Filler | " | | | | | 447 | 201 | 648 |
| Seal Coat | " | | | | | 134 | 57 | 191 |
| Rail | m | | | | 4,500 | 14,500 | 21,000 | 40,000 |

Table 9-5 Construction Materials to be Imported and their Quantities

| Item | Unit | Construction Year | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 3rd | 4th | 5th | 6th | 7th | 8th | Total |
| 1) In Case of Prestressed Concrete Bridge | | | | | | | | |
| High-early Strength Cement | t | | 1,842 | 1,826 | | | | 3,668 |
| Admixture | " | 1 | 38 | 57 | 20 | 10 | 3 | 129 |
| Reinforcing Bar | " | 30 | 2,285 | 2,755 | 2,092 | 386 | 150 | 7,698 |
| Prestressing Strand | " | | | 238 | 438 | 223 | 75 | 974 |
| Prestressing Wire | " | | | 38 | 73.2 | 36 | 12 | 159.2 |
| Steel Pipe Pile | " | 2,970 | | 2,864 | 1,265 | | | 7,099 |
| Steel Sheet Pile | " | 437 | | 429 | 195 | | | 1,061 |
| Steel Shape & Plate | " | | 1,104 | 1,200 | 628 | 44 | 14 | 2,990 |
| Rail | m | | | | 4,500 | 14,500 | 21,000 | 40,000 |
| Asphalt | t | | | | | 344 | 222 | 566 |
| Filler | " | | | | | 402 | 259 | 661 |
| Seal Coat | " | | | | | 115 | 82 | 197 |

| Item | Unit | Construction Year | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 3rd | 4th | 5th | 6th | 7th | 8th | Total |
| 2) In Case of Steel Truss Bridge | | | | | | | | |
| High-early Strength Cement | t | 1,125 | 524 | | | | | 1,649 |
| Admixture | " | 11 | 28 | 28 | 22 | 12 | 3 | 104 |
| Reinforcing Bar | " | 1,090 | 1,847 | 920 | 1,112 | 512 | | 5,481 |
| Prestressing Bar | " | | | | 0.2 | | | 0.2 |
| Prestressing Wire | " | | | | 3.2 | | | 3.2 |
| Steel Pipe Pile | " | 1,045 | | 2,202 | 815 | | | 4,062 |
| Steel Sheet Pile | " | 150 | | 293 | 150 | | | 593 |
| Steel Shape & Plate | " | 128 | 1,086 | 3,949 | 3,336 | 2,945 | | 11,444 |
| Rail | m | | | | 4,500 | 14,500 | 21,000 | 40,000 |
| Asphalt | t | | | | | 383 | 172 | 555 |
| Filler | " | | | | | 447 | 201 | 648 |
| Seal Coat | " | | | | | 134 | 57 | 191 |

### Table 9-6 Test Results on Raw Materials

| Kind of Raw Material | Coarse Aggregate | | Fine Aggregate | Crushed Stone | | | |
|---|---|---|---|---|---|---|---|
| Site / Kind of Test | Taungdi | Kamagale | Prome | Akauk Taung No. 1 | Akauk Taung No. 2 | Ngaung Chi Dauk | Kamyaing |
| Maximum Size (mm) | 40 | 40 | 1.2 | | | | |
| Finess Modulus (FM) | 6.66 | 6.64 | 1.76 | | | | |
| Specific Gravity | 2.67 | 2.66 | 2.65 | 2.62 | 2.63 | 2.64 | 2.63 |
| Absorption (%) | 0.21 | 0.26 | 4.00 | 0.25 | 0.15 | 0.20 | 0.20 |
| Unit Weight (kg/$m^3$) | 1,720 | 1,656 | 1,608 | | | | |
| Abrasion (%) (Los Angeles) | 33 | 46 | | 35 | 33 | 28 | 35 |
| Compressive Strength (kg/$cm^2$) | | | | 214 | 200 | 423 | 314 |
| Rock Type | | | | Laterite | Sandstone | Sandstone | Sand-stone |
| Quality | Good | Poor | Fair | Poor | Poor | Good | Fair |

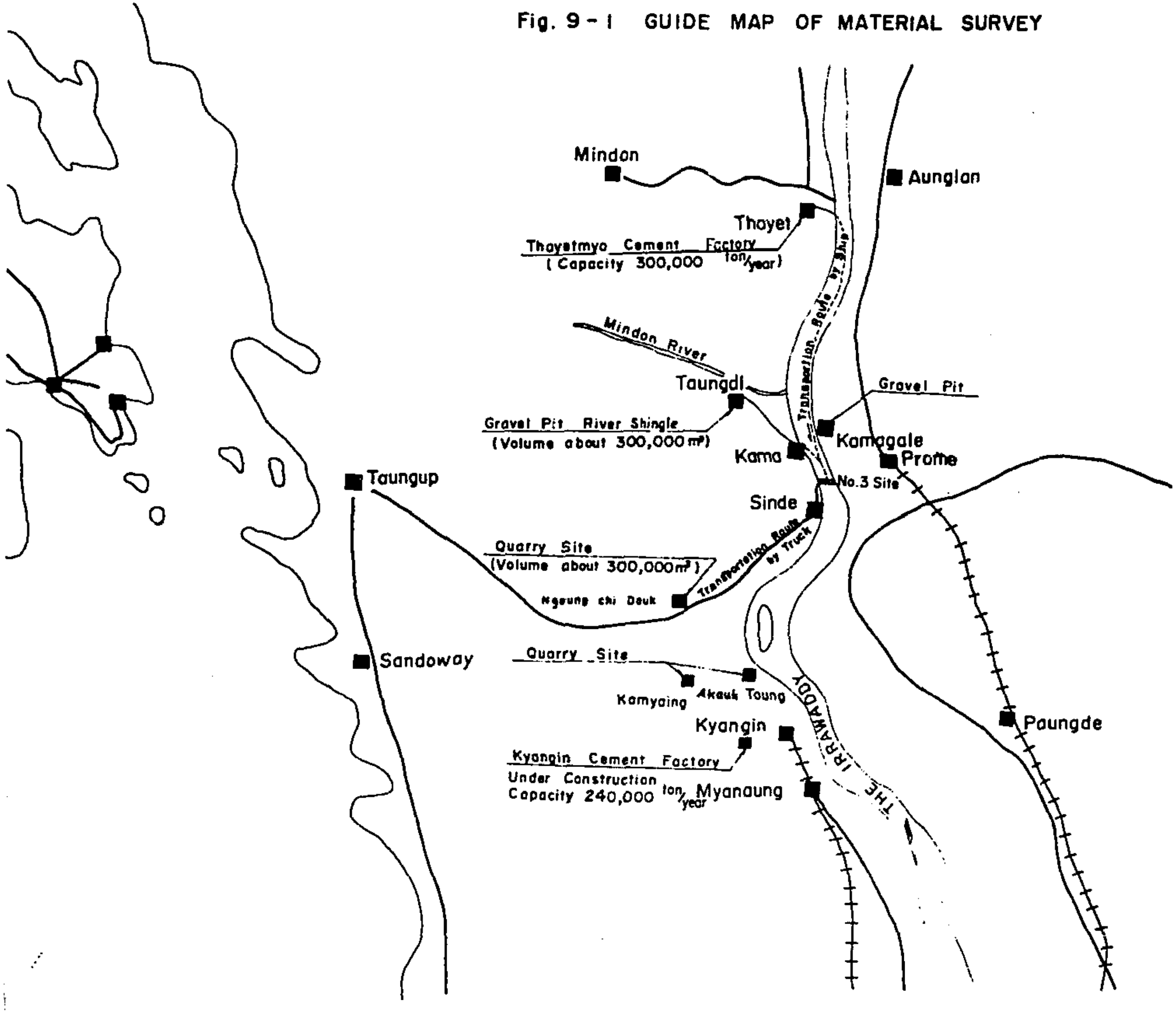
Table 9-7 Test Result on Water of the Irrawaddy

| Item | Water of the Irrawaddy at Prome | Average Value of River Water in Japan |
|---|---|---|
| Total Solids | 174.0 (mg/ℓ) | 88.1 (mg/ℓ) |
| Dissolved Solids | 44.0 " | |
| Total Hardness as $CaCO_3$ | 106.0 " | 22.4 " |
| Total Alkalinity as $CaCO_3$ | 108.0 " | |
| Calcium as $Ca^{2+}$ | 24.7 " | 10.3 " |
| Magnesium as $Mg^{2+}$ | 11.6 " | 2.5 " |
| Chlorides as $NaC\ell$ | 18.2 " | |
| Sulphates as $SO_4^{2-}$ | 6.0 " | 17.4 " |
| Sediment | 130.0 " | |
| Turbidity as $SiO_2$ | 26.0 " | 21.9 " |
| Organic Impurities | NIL | 0.1 " |
| PH | 8.6 | 6.9 " |

Table 9-8. Concrete Mix Proportion

| Description | | unit | Class A | Class B | Class $C_1$ | Class $C_2$ | Class D |
|---|---|---|---|---|---|---|---|
| Design Strength $\sigma ck$ | | $kg/cm^2$ | 400 | 300 | 240 | 240 | 180 |
| Target Strength $\sigma_c$ | | $kg/cm^2$ | 440 | 330 | 260 | 260 | 200 |
| Slump | | cm | 5.0-8.0 | 10.0-12.0 | 15.0-18.0 | 15.0-18.0 | 10.0-12.0 |
| Mix Proportion | Water-Cement Ratio | % | 35.5 | 44.5 | 52.0 | 52.0 | 62.5 |
| | Sand-Aggregate Ratio | % | 32.0 | 34.0 | 35.5 | 35.5 | 37.5 |
| | Cement | $kg/m^3$ | 436 | 360 | 329 | 329 | 256 |
| | Water | $kg/m^3$ | 150 | 160 | 171 | 171 | 160 |
| | Sand | $m^3/m^3$ | 0.356 | 0.389 | 0.404 | 0.404 | 0.451 |
| | Gravel | $m^3/m^3$ | 0.717 | 0.710 | 0.693 | 0.693 | 0.708 |
| | Admixture | $kg/m^3$ | 1.31 | 1.08 | 1.00 | 0.99 | 0.77 |

Fig. 9 - 1 GUIDE MAP OF MATERIAL SURVEY



# 10. CONSTRUCTION COST ESTIMATE

# 10. CONSTRUCTION COST ESTIMATE

## 10.1 General Description

For the purpose of this study, the cost estimate presented was calculated under the economic conditions in 1974. The exchange rates between Japanese Yen, Barmese Kyat and US Dollar were set at 308 and 4.81 in one, respectively.

Cost estimates undertaken hereafter aimed to carry out cost-benefit calculation for this Project as well as to establish the unit costs of the various construction work items and the total construction cost as accurately as possible.

The costs of construction equipment and imported materials including the freight and insurance charges, were determined referring the data obtained directly from the Japanese suppliers.

The unit construction costs of various items were studied with a detailed breakdown of the basic constituents, such as materials, equipment, labours, technical assistances, etc. under an assumed combination of necessary number of local and foreign labourers.

The breakdown into foreign and local components had been applied from the very basic prices and followed up through the whole of the cost study.

The total construction cost for any alternative route was given by a combination of the following items:

(a) Total direct construction cost obtained by adding the costs of various construction items which were given by multiplying the quantity of construction work by its unit cost with 15 percent surcharge for administration cost

(b) Engineering fee estimated at 10% of the item (a)

(c) Contingency estimated at 15% of the sum of items (a) and (b)

The total construction cost for each alternative route was studied on the basis of the possible construction period from the technical and/or economic point of view.

## 10.2 Unit Cost

### 10.2.1 Price of Basic Item

#### 10.2.1.1 Price of Raw Material

Because of a large amount of aggregate and crushed stone necessary for the construction of bridge, access road and railway, their production facilities shall be newly installed. The capacity of each equipment to be installed was determined on the basis of the annual amount to be supplied, the possibility of peak-shaving and storage, and the possible working day. The unit costs of aggregate and crushed stone, including the transportation cost, were estimated on the basis of equipment, labour and material.

The unit costs of concrete for the various classes were estimated on the basis of necessary amount of raw materials to fulfil the compressive strength requirement and the equipment cost as well as labour cost.

The costs of raw materials and concrete are given in Table 10-1.

#### 10.2.1.2 Labour Wages and Fees for Foreign Skilled Technician

The daily labour gross wages for nominal working hour and the monthly fees for various foreign skilled technicians are given in Table 10-2.

### 10.2.2 Machinery and Equipment

The various construction machinery and equipment to be applied to this Project is given in Table 10-3.

### 10.2.3 Estimation of Unit Construction Price

The unit construction cost for various items was studied with a detailed breakdown of the basic constituents and given in each Table of construction cost estimate.

## 10.3 Construction Cost Estimate of Each Alternative Route

### 10.3.1 General Description

The following construction cost estimates were carried out according to the necessary construction items, their unit costs and the construction schedule. Administration, cost engineering fee, contingency, etc. were also included.

### 10.3.2 Construction Cost for each Site in Case of Highway-Railway Bridge

The summary of construction cost for each Site is given in Tables 10-4, 10-5 and 10-6.

### 10.3.3 Construction Cost for Site No.3 in Case of separated Construction of Highway Bridge and Railway Bridge

The construction cost of highway bridge and access road is given in Table 10-7 and that of railway bridge and access railway is given in Table 10-8. The construction cost of the substructure is included in the construction cost of the highway bridge.

### 10.3.4 Construction Cost for Railway between Kyangin and Sinde

The construction cost of the railway between Kayngin and Sinde is given in Table 10-9.

## Table 10-1 Costs of Raw Materials and Concrete

(1974 Basis at Prome)

| Item | Unit | Unit Cost (Kyats) | | |
|---|---|---|---|---|
| | | Foreign Component | Local Component | Total |
| Concrete Class A | $m^3$ | 23 | 114 | 137 |
| " B | " | 22 | 96 | 118 |
| " $C_1$ | " | 22 | 89 | 111 |
| " $C_2$ | " | 99 | 17 | 116 |
| " D | " | 21 | 74 | 95 |
| Normal Portland Cement | t | | 220 | 220 |
| High-early Strength Cement | " | 235 | | 235 |
| Admixture (Retarder) | kg | 6 | | 6 |
| Fine Aggregate | $m^3$ | 7 | 2 | 9 |
| Coarse Aggregate | " | 4 | 22 | 26 |
| Rubble Stone | " | 10 | 3 | 13 |
| Crusher Run | " | 18 | 6 | 24 |
| Crushed Stone | " | 23 | 6 | 29 |
| Reinforcing Bar (Deformed) | t | 1,778 | | 1,778 |
| Prestressing Strand (ϕ12.7mm) | " | 3,810 | | 3,810 |
| Prestressing Wire (ϕ7mm) | " | 3,629 | | 3,629 |
| Prestressing Bar | " | 3,431 | | 3,431 |
| Steel Pipe Pile | " | 1,663 | | 1,663 |
| Steel Sheet Pile | " | 1,618 | | 1,618 |
| Steel Shape H-400x400x13/21 | " | 1,266 | | 1,266 |
| " " H-300x300x10/15 | " | 1,266 | | 1,266 |
| " " H-150x150x7/10 | " | 1,266 | | 1,266 |
| " " I-250x90x9 | " | 1,681 | | 1,681 |
| " " L-150x150x12 | " | 1,680 | | 1,680 |
| Steel Plate | " | 1,183 | | 1,183 |
| Rail 40 kg/m 10 meter long | pcs | 592 | | 592 |
| " 30 " | " | 655 | | 655 |
| *Reinforced Concrete Pipe ϕ1,000mm | m | | 190 | 190 |
| * " " ϕ 600mm | " | | 120 | 120 |

| Item | Unit | Unit Cost (Kyats) | | |
|---|---|---|---|---|
| | | Foreign Component | Local Component | Total |
| Timber $30^{cm}$ x $30^{cm}$ x $3^{m}$ | pcs | 217 | | 217 |
| * " Scantling (Hard Wood) | $m^3$ | | 530 | 530 |
| * " " (Jungle Wood) | " | | 283 | 283 |
| Sleeper $20^{cm}$ x $20^{cm}$ x $2^{m}$ | pcs | 45 | | 45 |
| Log $7^{m}$ | " | 33 | | 33 |
| *Plywood 3-Ply (Jungle Wood) | " | | 13 | 13 |
| * " 5-Ply ( " ) | " | | 25 | 25 |
| Asphalt (Foreign) | t | 370 | | 370 |
| * " (Local) | " | | 450 | 450 |
| Filler | " | 78 | | 78 |
| *Gasoline | gal | | 4 | 4 |
| *Kerosene | " | | 3 | 3 |
| *Lubricants | " | | 10 | 10 |
| *Grease | lb | | 3 | 3 |
| Diesel Oil | gal | 4 | | 4 |
| *Gelignite | lb | | 6 | 6 |
| *Detonator | pcs | | 0.5 | 0.5 |
| *Safety Fuse | Rft | | 30 | 30 |
| *Cordex Wire | " | | 1.5 | 1.5 |
| Seal Coat | t | 903 | | 903 |
| Guardrail | m | 119 | | 119 |

Note: High-early strength cement is only used for the mixture of concrete $C_2$.

* The unit cost is based on the information obtained in Burma.

Table 10-2 Wages of Local Labour and Monthly Fee for Japanese Skilled Technician

Unit:Kyats

| Classification | Labour Wages | Remarks |
|---|---|---|
| Local Labour | Daily | |
| 1. Foreman | 10 | |
| 2. Carpenter | 10 | Grade I |
| 3. Steel Worker | 10 | " |
| 4. Mason | 10 | " |
| 5. Blacksmith | 10 | " |
| 6. Labourer | 4 | |
| 7. Welder | 7 | Ordinary |
| 8. Certified Welder | 10 | Qualified |
| 9. Structural Steel Erector | 15 | Skilled |
| 10. Concrete Placer | 5 | |
| 11. Batching, Mixer Operator | 8 | |
| 12. Crushing, Screening Plant Operator | 8 | |
| 13. Heavy Equipment Operator | 12 | Bulldozer, etc. |
| 14. Light Equipment Operator | 6 | Pump Driver, etc. |
| 15. Driver | 8 | Truck |
| 16. Repairman (Machinery) | 10 | Grade I |
| 17. Electrician | 9 | |
| 18. Power Man | 8 | Drilling & Blasting |
| Japanese Skilled Technician | Monthly | |
| 1. Spider Man (Bridge) | 16,835 | Highly Skilled |
| 2. " " ( " ) | 14,430 | Skilled |
| 3. Electric Welder | 14,430 | Qualified |
| 4. Tunnel Foreman | 14,430 | Specialised |
| 5. Electrician | 14,430 | " |
| 6. Mechanic | 14,430 | " |
| 7. Operator | 16,835 | " |
| 8. Diver | 19,240 | " |
| 9. Caisson Worker | 19,240 | " |

Table. 10-3-1. Machine and Equipment (in case where steel truss bridge is adopted)

| Description | Capacity or Model No. | Q'ty | * | Description | Capacity or Model No. | Q'ty | * | Description | Capacity or Model No. | Q'ty | * |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Derrick Crane | 30 t | 2 | Bu | Compressor | 55 PS | 3 | R | Winch | 15-30 PS | 9 | .R |
| " | 200 tm | 4 | Bℓ | " | 50 PS | 4 | Bu | Diesel Locomotive | 89 PS | 6 | R |
| Traveller Crane (Truss) | 20 t | 4 | Bu | Pump Car | 90m$^3$/hr | 2 | Bℓ | Diesel Engine | 220 KW | 2 | R |
| " (Yard) | 20 t | 2 | Bu | Turbine Pump | ϕ40-80mm | 13 | R | Mucking Car | 30 t | 70 | R |
| Post Crane | 20 t | 4 | Bu | Concrete Pump (hydraulic) | 12m$^3$/hr | 3 | R | Batcher Plant | 60-90 m$^3$/hr | 1 | M |
| Crawler Crane | 100 t | 4 | Bℓ | Agitator Car | 4.5 m$^3$ | 12 | Bℓ | " | 21 m$^3$/hr | 3 | R |
| Bulldozer | 32 t | 6 | Bℓ2,R2<br>H2 | " | 3.0 m$^3$ | 3 | R | Portable Crushing Plant | 50 m$^3$/hr | 1 | M |
| " | 21 t | 9 | Bℓ2,R4<br>H3 | Diesel Generator | 500 KVA | 1 | C | Asphalt Plant | 30 t | 1 | H |
| " | 15 t | 2 | Bu | " | 220 KVA | 2 | Bℓ | Tractor Shovel | 1.7m$^3$ | 12 | R3,H9 |
| " | 11 t | 6 | R3,M2<br>H1 | " | 200 KVA | 1 | M | Tunnel Shovel (Air Type) | 0.2m$^3$ | 4 | R |
| Dump Truck | 15 t | 8 | Bℓ | " | 175 KVA | 2 | Bℓ | Rocket Shovel | RS<br>85,0.4m$^3$ | 4 | R |
| " | 8 t | 68 | R22,M20<br>H21 | O.D. Drilling Machine | 3½" | 3 | Bℓ | Crawler Shovel | 1.2m$^3$ | 3 | M |
| Truck | 12 t | 4 | Bℓ | Clamshell | 3 m$^3$ | 4 | Bℓ | Tyre Roller | 15 t | 3 | R1,H2 |
| " | 11 t | 2 | Bu | Deck Barge | 500 t | 4 | Bu | Macadam Roller | 15 t | 2 | H |
| " | 4 t | 2 | Bℓ | Tug Boot | 60 t | 1 | Bu | Leg Jumbo | 8.5 t | 4 | R |
| Trailer | 15 t | 2 | Bu | Anchor Boat | 20 t | 1 | Bu | Crawler Drill | ϕ65 mm | 2 | M |
| Jeep | 6 person | 2 | Bℓ | Hydraulic Jack | 200 t | 8 | Bu | Portable Dredger | 30 m$^3$/hr | 1 | M |
| Compressor | 200 PS | 1 | R | Pile Driver | M23,85PS | 1 | Bu | Moter Grader | 3.7 m$^3$ | 1 | H |
| " | 170 PS | 5 | Bℓ | Trolly | 30 t | 10 | Bu | Finisher | 3-4 m | 1 | H |
| " | 110 PS | 1 | M | Winch | 50 PS | 16 | Bu | Distributer | 5,000 L | 1 | H |
| " | 100 PS | 4 | R | " | 30 PS | 8 | Bu | Water Tank | 6,000 L | 1 | H |

Note. * Construction Item

C: Common Equipment
Bu: Bridge Superstructure
Bℓ: Bridge Substructure
H: Access Road
R : Access Railway
M : Production of Construction Material

Table. 10-3-2. Machine and Equipment (in case where prestressed concrete bridge is adopted)

| Description | Capacity or Model No. | Q'ty | * | Description | Capacity or Model No. | Q'ty | * | Description | Capacity or Model No. | Q'ty | * |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Derrick Crane | 200tm | 4 | Bℓ | Pump Car | 90 $m^3$/hr | 2 | Bℓ | Diesel Locomotive | 89 PS | 6 | R |
| Tower Crane | 4 t | 4 | Bu | Turbine Pump | ø50mm-2 | 7 | Bu | Diesel Engine | 220 KW | 2 | R |
| Crawler Crane | 100 t | 4 | Bℓ | " | ø40-80mm | 13 | R | Mucking Car | 30 t | 70 | R |
| " | 35 t | 1 | Bu | Concrete Pump(hydraulic) | 12$m^3$/hr | 3 | R | Batcher Plant | 60-90$m^3$/hr | 1 | M |
| Hydraulic Crane | 10 t | 2 | Bu | Agitator Car | 4.5 $m^3$ | 20 | Bℓ | " | 21 $m^3$/hr | 3 | R |
| Bulldozer | 32 t | 6 | Bℓ2,R2<br>H2 | " | 3.0 $m^3$ | 3 | R | Portable Crushing Plant | 50 m3/hr | 1 | M |
| " | 21 t | 9 | Bℓ2,R4<br>H3 | Diesel Generator | 500 KVA | 1 | C | Asphalt Plant | 30 t | 1 | H |
| " | 11 t | 6 | R3,H1<br>M2 | " | 200 KVA | 2 | Bℓ | Tractor Shovel | 1.7 $m^3$ | 12 | R3,H9 |
| Dump Truck | 15 t | 8 | BL | " | 200 KVA | 1 | M | Tunnel Shovel (Air Type) | 0.2 $m^3$ | 4 | R |
| " | 8 t | 68 | R27,H21<br>M20 | " | 175 KVA | 2 | Bℓ | Rocker Shovel | RS85,0.4$m^3$ | 4 | R |
| " | 4 t | 2 | Bu | Slip Form | Girth Length 70m | 4 | Bℓ | Tyre Roller | 15 t | 3 | R1,H2 |
| Truck | 12 t | 4 | Bℓ | O.D. Drilling Machine | 3½" | 3 | Bℓ | Macadam Roller | 15 t | 2 | H |
| " | 8 t | 1 | Bu | Clamshell | 3 $m^3$ | 4 | Bℓ | Leg Jumbo | 8.5 t | 4 | R |
| " | 6 t | 2 | Bℓ | Power Reach | 4 t | 4 | Bu | Crawler Drill | ø65 mm | 2 | M |
| " | 4 t | 3 | Bu1,Bℓ2 | Wagon | 200 tm | 8 | Bu | Portable Dredger | 30 $m^3$ hr | 1 | M |
| Jeep | 6 person | 2 | Bℓ | Deck Barge | 600 t | 1 | Bu | Motor Grader | 3.7 $m^3$ | 1 | M |
| Compressor | 200 PS | 1 | R | " | 100 t | 2 | Bu | Finisher | 3 - 4 m | 1 | H |
| " | 170 PS | 5 | Bℓ | " | 30 t | 2 | Bu | Distributer | 5,000 L | 1 | H |
| " | 110 PS | 1 | M | Tug Boat | 60 t | 1 | Bu | Water Tank | 6,000 L | 1 | H |
| " | 100 PS | 14 | Bu10,R4 | Z-Craft | 50 t | 2 | Bu | | | | |
| " | 55 PS | 3 | R | Winch | 15-30 PS | 9 | R | | | | |

Note. * Construction Item   C: Common Equipment   Bu: Bridge Superstructure   Bℓ: Bridge Substructure,
H: Access Road   R : Access Railway   M : Production of Construction Material

Table 10-4 Summary of Construction Cost for Site No. 1

Unit: 1,000 Kyats

| Item | Prestressed Concrete Bridge | Steel Bridge |
|---|---|---|
| I. Common Facilities | 3,357 | 3,357 |
| II. Bridge | 273,775 | 222,287 |
| III. Access Road | 24,837 | 24,837 |
| IV. Access Railway | 206,723 | 206,723 |
| V. River Works | 1,059 | 1,059 |
| Total Direct Constrction Cost | 509,751 | 458,263 |
| Engineering Fee | 50,975 | 45,826 |
| Contingency | 84,109 | 75,613 |
| Total Construction Cost | 644,835 | 579,702 |

Table 10-5 Summary of Construction Cost for Site No. 2

Unit: 1,000 Kyats

| Item | Prestressed Concrete Bridge | Steel Bridge |
|---|---|---|
| I. Common Facilities | 3,357 | 3,357 |
| II. Bridge | 352,829 | 278,042 |
| III. Access Road | 56,212 | 56,212 |
| IV. Access Railway | 108,259 | 108,259 |
| V. River Works | 1,059 | 1,059 |
| Total Direct Construction Cost | 521,716 | 446,929 |
| Engineering Fee | 52,172 | 44,693 |
| Contingency | 86,083 | 73,743 |
| Total Construction Cost | 659,971 | 565,365 |

Table 10-6 Summary of Construction Cost for Site No. 3

Unit: 1,000 Kyats

| Item | Prestressed Concrete Bridge | Steel Bridge |
|---|---|---|
| I. Common Facilities | 3,357 | 3,357 |
| II. Bridge | 332,337 | 284,161 |
| III. Access Road | 65,257 | 65,257 |
| IV. Access Railway | 71,974 | 71,974 |
| V. River Works | 1,059 | 1,059 |
| Total Direct Construction Cost | 473,984 | 425,808 |
| Engineering Fee | 47,398 | 42,581 |
| Contingency | 78,207 | 70,258 |
| Total Construction Cost | 599,589 | 538,647 |

Table 1-7 Summary of Construction Cost for Site No. 3 In the Case of Highway Bridge

Unit: 1,000 Kyats

| Item | | Prestressed Concrete Bridge | Steel Bridge |
|---|---|---|---|
| I. Common Facilities | | 3,357 | 3,357 |
| II. Bridge | Superstructure | 41,995 | 57,027 |
| | Substructure | 289,642 | 186,924 |
| III. Access Road Construction | | 65,257 | 65,257 |
| IV. River Works | | 1,059 | 1,059 |
| Total Direct Construction Cost | | 401,310 | 313,624 |
| Engineering Fee | | 40,131 | 31,362 |
| Contingency | | 66,216 | 51,748 |
| Total Construction Cost | | 507,657 | 396,734 |

Table 10-8 Summary of Construction Cost for Site No. 3 Railway Bridge and Access Railway

Unit: 1,000 Kyats

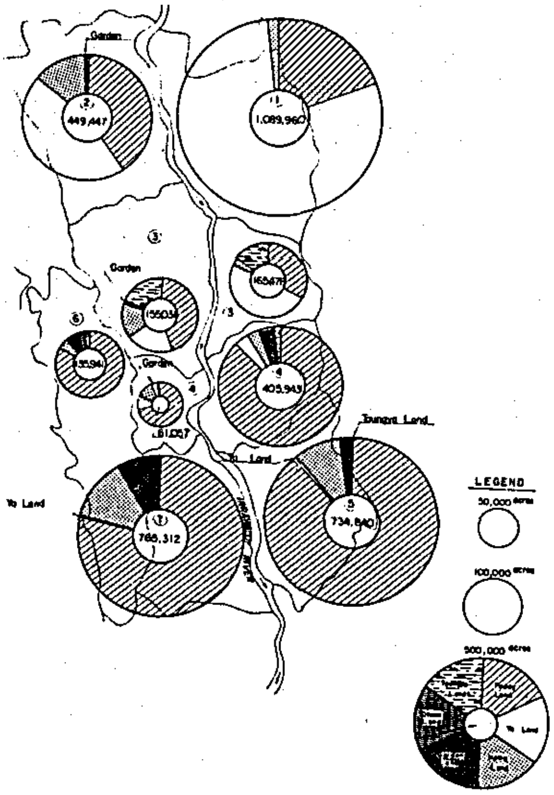
| Item | Prestressed Concrete Bridge | Steel Bridge |
|---|---|---|
| I. Common Facilities | 1,339 | 1,339 |
| II. Bridge Superstructure | 35,795 | 51,578 |
| III. Access Railway | 71,974 | 71,974 |
| Total Direct Construction Cost | 109,108 | 124,891 |
| Engineering Fee | 10,911 | 12,489 |
| Contingency | 18,003 | 20,607 |
| Total Construction Cost | 138,022 | 157,987 |

Table 10-9 Summary of Construction Cost for Railway between Kyangin and Sinde

Unit: 1,000 Kyats

| | |
|---|---|
| Total Direct Construction Cost | 167,380 |
| Engineering Fee | 16,738 |
| Contingency | 27,618 |
| Total Construction Cost | 211,736 |

# 11. ECONOMIC ANALYSIS



# 11. ECONOMIC ANALYSIS

## 11.1 General Description

### 11.1.1 Bridge Site

As mentioned in Chapter 10, it has been judged that Site No.3 would be preferable to the other two sites in relation to the bridge construction costs including those of the access road and access railway. On the other hand, in view of the benefit derived from the completion of the bridge, it was easily foreseen that Site No. 3 is the most beneficial followed by Site No. 2, while Site No. 1 is the least advantageous. This anticipation was clearly explained by the analyses of the interregional passenger and the goods flows passing over the bridge in the following three types of traffic.

Type 1: Transport between Prome and Sinde or via these two towns.
This kind of transport has a considerably large share in the traffic demand even at present and it must be again one of the major routes in future transport networks. Site No. 3 is the most advantageous to this kind of transport in cost and the time required because of the shortest transport distance among these three proposed sites.

Type 2: Transport between regions located upstream of Prome on the east side of the Irrawaddy and those located downstream of Sinde on the west bank, and transport between regions located downstream of Prome on the east side and regions upstream of Sinde on the west side.
The location of the bridge may not cause much difference in transport distance, whether the bridge is constructed at the site upstream or downstream. Therefore, differences in benefit among three sites could not be considered.

Type 3: Transport between regions located upstream of Prome on the east side of the Irrawaddy and regions upstream of Sinde in the west side, and transport between regions located downstream of Prome on the east side and regions downstream of Sinde on the west side.

The upstream site is more advantageous for the former traffic and the downstream site is better suited to the latter. The economic superiority of the bridge site for this kind of traffic shall be determined by the comparison of traffic volume between the former and the latter. Considering the facts that the population is denser and the industries are more developed in the southern than in the northern regions, more benefit as a whole for this kind of traffic will be expected, if the bridge is constructed at a downstream site.

From the above considerations, provided that the railway-highway bridge is constructed, Site No. 3 is deemed to be the most suitable. Therefore, economic analyses will hereafter be made only for Site No.3.

### 11.1.2 Bridge Type

As mentioned in Chapter 10, the construction cost of the prestressed concrete bridge at Site No. 3 from the financial standpoint is more expensive than that of the steel bridge by about 16 percent. The difference in the financial cost is not necessarily equal to difference in economic cost, because ratios between the foreign and the local currency components of the construction cost as well as the construction schedules for these two types will be different from each other. In addition, there are such problems for reference to selecting the proper bridge type as the technical level of workers to be assigned to this Project, effects of technical upgrading resulting from execution of this Project, etc. which cannot be evaluated in terms of currency and will be required for practical judgement in view of the situations in Burma.

Because of the above reasons, the results of analyses for each bridge type are mentioned for the purpose of providing reference materials to make selections without forming any conclusion.

### 11.1.3 Timing of Bridge Completion

In this analysis, the railway-highway bridge construction was the fundamental condition. The opening of the bridge to traffic was assumed to be in 1983,which is the possible earliest year from the technical point of view. However, the necessity of simultaneous opening of the highway and railway services should be discussed and the most economical date for opening the railway bridge and the highway bridge should be analised. Consequently, the following three cases were studied to seek for possibility of construction by stages with the most suitable time lag.

| | |
|---|---|
| Case 1 : | Railway-highway bridge is opened to traffic in 1983 |
| Case 2 : | Highway bridge is opened to traffic in 1983 and railway bridge in 1988 |
| Case 3 : | Highway bridge is opened to traffic in 1983 and railway bridge in 1993 |

Only the cases of construction by stages, where the highway bridge is opened first and the railway bridge comes next, were analised in Cases 2 and 3 above. The main reasons are that the construction costs of the railway bridge and the access railway are higher than those of the highway bridge and the access highway, and that the anticipated loss of benefit due to delay of the railway bridge construction will be less than that due to delay of the highway bridge.

### 11.1.4 Railway between Kyangin and Sinde

In order to estimate the effect of the construction of railway bridge, it is inevitably conditioned on the fact that the railway between Kyangin

this railway and the railway bridge was assumed for the analysis.

Though the construction of this railway is fundamentally a separated project,the analyses were performed for the cases where it is united with the Irrawaddy Bridge Project (aforementioned cases 1, 2 and 3) and for the cases, as completely separated project, where its completion is assumed in 1988 (case 2-2) and in 1993 (case 3-2).

### 11.1.5 Other Condition of Analysis

Other conditions adopted to the analysis were as follows:

(a) Calculation of benefit and cost in this analysis shall cover the construction period of bridge and the related facilities together with 30 years' duration after opening of the bridge to traffic.

(b) All prices of the estimation of cost and benefit shall be those in 1974 and future fluctuation of prices shall be ignored.

(c) The present value of this analysis shall be termed in the worth as of 1975.

## 11.2 Construction Schedule

The combined construction schedule of the Project was prepared from the schedules of construction items including the bridge superstructure and substructure, the access railways, the access highways and river works. The schedules of the bridge structures, which require the longest period, were taken as the basis of the whole planning. The other construction items were arranged to finish their works within the construction period of the bridge. The combined construction schedules of Case 1, which aim at the simultaneous completion of the railway bridge and the highway bridge,are shown in Fig. 11.1 for the steel bridge and Fig. 11.2 for the prestressed concrete bridge. The schedules for Case 1 could also be applied for Cases 2 and 3, if the construction schedule of the bridge superstructure for the railway and the access railway is to be postponed by 5 and 10 years, respectively.

## 11.3 Economic Evaluation of Project Cost

### 11.3.1 Economic Construction Cost

The construction cost mentioned in Chapter 10 is the financial cost and shall be modified to evaluate the economic cost due to the following reasons:

(a) Shadow rate for foreign component of construction cost

A fairly large part of the construction materials, machinery, equipment and facilities as well as skilled technicians will be supplied from overseas. The foreign component of the construction cost in Chapter 10 is based on the official exchange rate.

However, as is shown in other feasibility studies, it seems to be proper that the foreign component might be estimated at a higher shadow rate than at the official rate, in view of the possible benefits derived, if this amount is invested in the import of other necessary commodities.

In addition to the analysis based on the official rate, two cases in which the shadow rates with 1.5 and 1.75 times the official rate were analised.

(b) Indirect Cost

Besides the direct construction cost, such indirect costs as engineering fee and contingency are included in the construction cost in Chapter 10. Among these indirect costs, the contingency is excluded from the construction cost in this economic analysis due to its uncertainty.

The economic construction cost modified from the financial cost based on the procedures mentioned above is shown in Tables 11-1 through 11-3.

### 11.3.2 Present Value of Construction Cost

Based on the assumed year for opening of the bridge in 1983 and on the combined construction schedules in Figs. 11-1 and 11-2, annual outlay of the economic cost was estimated as shown in Tables 11-4 through 11-6.

Table 11-7 shows the present value of the construction cost as of 1975 in Cases 1, 2, 3, 2-2 and 3-2 for the steel bridge; Table 11-8 shows those for the prestressed concrete bridge. In these Tables, the foreign component of the construction cost is evaluated in three kinds of rates, i.e., the official rate, 1.5 times and 1.75 times the official rate. The discount rates used for calculating the present value are 0.03, 0.06, 0.09, 0.12 and 0.15 per annum.

### 11.3.3 Remaining Value of Assets

The bridge, the access highway and the railways can still be used after lapse of the period to be analised. The remaining value of the assets in 2013 shall be deducted from the construction cost calculated in Tables 11-7 and 11-8. The reason is that the remaining value of assets shall not be allocated as the cost during the predicted period.

Table 11-9 shows the remaining value of the assets in 2013 and Table 11-10 shows their present value as of 1975.

### 11.3.4 Maintenance Cost

The estimated maintenance costs of the bridge, highways, railways and river works to be constructed in this Project are shown in Table 11-11. The total of the maintenance costs during the period of the economic analysis was discounted to get the present value as of

1975 as shown in Table 11-12.

### 11.3.5 Net Economic Cost of Project

The net cost of the project expressed in the value as of 1975 which is calculated by summing up the construction cost, maintenance cost and the remaining value of assets (deduction) is shown in Table 11-13 for the steel bridge, and Table 11-14 for the prestressed concrete bridge.

## 11.4 Estimation of Direct Benefit

### 11.4.1 General Description

In this study, only direct benefits which could be evaluated in terms of the currency were estimated as shown in Fig. 11-3. The estimation of these benefits is based on the traffic demands estimated in Chapter 3.

### 11.4.2 Benefit Derived from Diverted Passenger Traffic

This kind of benefit consists of cost saving and time saving. The benefit of cost saving was calculated as the difference between the transport cost via the new route passing over the bridge and that via the route without the bridge for each OD. The estimated transport cost of each mode in Chapter 3 was used for the calculation. As to the time saving benefit, it was calculated in such a way that the total of the saving time for each OD was multiplied by the economic value of a passenger per hour. Table 11-15 shows the annual benefit derived from the cost and the time saving of passengers in 1983, 1988, 1993, 2003 and 2012. Table 11-16 shows the present discounted value, as of 1975, of the total benefit during the period of analysis. For calculating the total present value, the period was divided into four short periods, e.g., 1983-87, 1988-92, 1993-2002 and 2003-12. It was assumed that the yearly benefit would be changed on the fixed trend in each divided short period.

The method for calculating the present value of the discounted total benefit was also used for calculating the other benefits referred to hereunder. In this case, the trend of change in benefit was assumed in the fixed ratio or the constant annual increase within each short period in relation to the variation of the benefits in 1983, 1988, 1993, 2003 and 2012.

### 11.4.3 Benefit Derived from Generated Passenger Traffic

The benefit derived from the generated passenger traffic as a result of the completion of the bridge was estimated based on the assumption that the average benefit of a passenger in each OD is half of the benefit derived by totalling the cost and time savings of a diverted passenger in the same OD. Table 11-17 shows annual benefits derived from the generated passengers. Table 11-18 shows the discounted present value of total of this kind of benefits during the period 1983 through 2012.

### 11.4.4 Benefit Derived from Diverted Goods Traffic

The benefit derived from diverted goods traffic was estimated for the cost and the time savings, as in the case of passenger traffic. The transport cost of each transport mode and the evaluated time loss in Chapter 3 were used for the calculation. Table 11-19 shows the annual estimation of the benefit and Table 11-20 shows the present value of the discounted total benefit during the period 1983 through 2012.

### 11.4.5 Benefit Derived from Generated Goods Traffic

The new demand for goods traffic resulting from the bridge construction is due to the increase in production and consumption of goods in the related areas.

Benefits derived from the increased production and consumption themselves will be discussed separately in 11.5.1. As far as the increased goods traffic demand is concerned, the benefit will consist of the cost and the time savings as in the case of the diverted goods traffic.

Tables 11-21 and 11-22 show the estimated annual benefit and the total discounted present value of this kind of traffic, respectively.

### 11.4.6 Benefit Derived from Diverted Motor Vehicle Carried by Z-Craft

#### A. Cost Saving

When the bridge is completed, motor vehicles currently transported by the Z-craft will be converted fully to the self-driving mode passing over the bridge. As a result, operation cost of the Z-craft is saved, whereas the running cost of the motor vehicle is increased as the running distance is added by about one mile.

The curtailed amount of the operation cost of the Z-craft and increased cost of the motor vehicle operation were estimated as shown in Table 11-23. The benefit from the operation cost is the difference between the two items above. The discounted present values of the total benefit are indicated in Table 11-24.

Besides the cost saving mentioned above, other benefits will be derived from the reassignment of the Z-crafts to the other important locality and from elimination of additional investments to strengthen or to renew the Z-craft fleet to cope with the increased traffic demand in future without bridge.

The benefit in the former case was estimated as the remaining values of the Z-crafts in 1983. The crafts in use are of the 50-ton and the 100-ton class each, the year of launching being 1970 and 1972, respectively. The estimated values are as follows:

Unit: 1,000 kyats

| | 50-ton Class | 100-ton Class | Total |
|---|---|---|---|
| Purchase price at 1974 level (Official rate) | 2,561 | 3,826 | 6,387 |
| Remaining value in 1983 (Official rate) | 711 | 1,488 | 2,199 |
| Do (Shadow rate: 1.5 times official rate) | 1,067 | 2,232 | 3,299 |
| Do (Shadow rate: 1.75 times official rate) | 1,244 | 2,604 | 3,848 |

In these calculations, 18 years were taken as the service life of the Z-craft. The value of this benefit as of 1975 is indicated in Table 11-24.

The amount of savings derived from the cancellation of the renewal and strengthening of Z-crafts in future was estimated based on the renewal of the 50-ton class in 1988, renewal of the 100-ton class in 1990 and 2008, strengthening of the 50-ton class in 1995 and the 100-ton class in 2006. In the above estimations, strengthening of the 100-ton class in 2006 is actually to upgrade Z-craft to the bigger size instead of the simple renewal of the 50-ton class one.

The total investments required for renewing and strengthening the Z-crafts were discounted to estimate their present value as of 1975. Then the present value of the remaining value of the Z-craft fleet in 2013 was calculated and the result was subtracted from the present value of the investment. The final results are shown in Table 11-24.

B. Time saving

The time saving of a motor vehicle resulting from diversion of the transport route from the Z-craft to the self driving mode passing over the bridge will be about one hour.

According to the field survey made in March 1974, the average number of riders in a jeep were four persons. The lorries were sometimes used exclusively for either passengers or goods transport and in other cases for both passengers and goods. The estimated loading of a lorry was 9.3 passengers and approximately three tons of goods.

The total time saved for the passengers and goods in motor vehicle transport was estimated in the following table based on the estimated number of those diverted self-driving mode of the motor vehicles from those transported by the Z-craft mentioned in Chapter 3.

Unit: Passenger: 1,000 man-hr
Goods : 1,000 ton-hr

| Year | Jeep Passenger | Lorry | |
|---|---|---|---|
| | | Passenger | Goods |
| 1983 | 70.6 | 179.7 | 58.0 |
| 1988 | 76.1 | 220.2 | 71.0 |
| 1993 | 91.4 | 268.9 | 86.7 |
| 2003 | 163.8 | 442.1 | 142.6 |
| 2012 | 271.1 | 748.0 | 241.3 |

The estimated benefits of the time saving of passengers and goods are shown in Table 11-23 based on the same standard of the evaluated hourly time loss of passengers and goods in Chapter 3.

The total of the discounted present value is shown in Table 11-24. In this calculation, the average price of goods was assumed to be 5,000 kyats per ton.

### 11.4.7 Other Direct Benefits

The direct benefits mentioned hereto were those derived from the traffic passing over the bridge. In addition to the above, other benefits derived from other than traffic via the bridge were recognized as follows:

(a) Operation cost saving of existing railway between Bassein and Kyangin

After completion of the bridge, the access railway and the railway between Kyangin and Sinde, the steam locomotives now in use on the railway between Bassein and Kyangin can be replaced by diesel locomotives. The alternation of the traction mode may reduce the transport cost even for the traffic within the existing railway.

Furthermore, other benefits will be derived from the improved operation efficiency of the rolling stock caused by long-distance train operation, etc.

These benefits, however, were not estimated as it was difficult to assume practical plans.

It is apparent that only transport and loading-unloading costs for the ferry transport of the rolling stock to be repaired at workshops located to the east side of the Irrawaddy will be eliminated. This kind of cost is estimated currently to be about 91,000 Kyats per annum.

Table 11-25 shows the annual amount of cost saving estimated on assumption that this kind of cost will increase if the traffic demand increases in future. Table 11-26 shows the total of the discounted present value during the period of analysis.

(b) Benefit derived from railway between Kyangin and Sinde

The railway between Kyangin and Sinde will undoubtedly be used for passengers and goods traffic passing over the bridge, but it will also be utilized for interregional traffic on the west side of the Irrawaddy. The traffic demand and benefit of the latter case of traffic were estimated at the same time and in the same way as the former traffic. The results revealed that the traffic demand and benefit of goods transport would be negligible but those for passengers would be quite big.

The benefit of passenger traffic consists of cost and time savings for the diverted passengers and benefits of generated passengers. Table 11-27 shows the yearly amount of these benefits. The present value, as of 1975, of the total benefit is shown in Table 11-28.

### 11.4.8 Total of Present Value of Direct Benefit

The total amount of the present value of the direct benefit based on three kinds of exchange rates and five kinds of discount rates for each case is shown in Table 11-29.

## 11.5 Indirect Benefit

### 11.5.1 Benefit Derived from Industrial Development

The annual increase of the net output to be generated in the directly related areas by completion of the bridge was calculated in Chapter 2.

According to the estimation based on the result of this calculation, the total amount of its present value reaches considerably a large amount as shown below.

Price as of 1974
Unit : Million Kyats

| | 0.03 | 0.06 | 0.09 | 0.12 | 0.15 |
|---|---|---|---|---|---|
| Case 1 | 3,457 | 1,523 | 710 | 349 | 181 |
| Case 2 | 3,056 | 1,333 | 614 | 299 | 153 |
| Case 3 | 2,904 | 1,265 | 583 | 283 | 145 |

A study has been made to a great extent on how the above effect should be regarded as benefit.

However, a part of the increase of the net output in the directly related areas may consist of output simply transfered from other areas or other economic sectors where it would probably be generated unless the bridge is constructed. Furthermore, even if an increase in net output should be caused by the bridge construction, it would not necessarily be brought about only by the investment in the bridge. It will be required for a large amount of investment in other related production areas.

If the increase of the nation-wide net output which may not be generated without the bridge construction can be estimated and then divided into the part resulting from the investment in the bridge and the other part from other necessary investments, the former part would ought to be dealt with as benefit generated in this Project. However, no attempt has been made to calculate this benefit, because it is extremely difficult.

### 11.5.2 Other Indirect Benefit

The construction of the Irrawaddy Bridge will contribute to the benefit of Burma not only in the aspects of economics but also in those of military, security, education, culture, etc. However, these benefits cannot be evaluated in terms of currency and they are excluded from the analysis in this chapter.

## 11.6 Overall Cost and Benefit Analysis and Economic Appraisal of Project

The results of the overall analysis of the economic cost of the project as shown in 11.3 and the benefit derived from the Project as estimated in 11.4 are shown in Table 11-30 for the steel bridge and Table 11-31 for the prestressed concrete bridge.

In these Tables, ratio of cost and benefit and internal rate of return are calculated using discount rates of 3, 6, 9, 12 and 15% as the criteria of economic evaluation of the project.

A summary of the results of the analysis is as follows.

| Exchange Rate | | Case | Steel Bridge | | Prestressed Concrete Bridge | |
|---|---|---|---|---|---|---|
| | | Item | Ratio of cost and benefit (discount rate :9%) | Internal rate return (%) | Ratio of cost and benefit (discount rate :9%) | Internal rate of return (%) |
| Official rate | | 1 | 0.249 | 2.44 | 0.231 | 2.32 |
| | | 2 | 0.275 | 2.60 | 0.239 | 2.33 |
| | | 3 | 0.300 | 2.81 | 0.254 | 2.48 |
| | | 2-2 | 0.330 | 3.30 | 0.277 | 2.89 |
| | | 3-2 | 0.338 | 3.38 | 0.278 | 2.92 |
| Shadow rate | 1.50 | 1 | 0.189 | 1.63 | 0.176 | 1.56 |
| | | 2 | 0.208 | 1.75 | 0.181 | 1.56 |
| | | 3 | 0.227 | 1.91 | 0.191 | 1.67 |
| | | 2-2 | 0.249 | 2.41 | 0.200 | 2.09 |
| | | 3-2 | 0.254 | 2.49 | 0.209 | 2.12 |
| | 1.75 | 1 | 0.170 | 1.36 | 0.157 | 1.31 |
| | | 2 | 0.186 | 1.46 | 0.162 | 1.31 |
| | | 3 | 0.203 | 1.62 | 0.171 | 1.41 |
| | | 2-2 | 0.220 | 2.07 | 0.185 | 1.74 |
| | | 3-2 | 0.226 | 2.15 | 0.186 | 1.76 |

In order to draw conclusions on the economic effectiveness of this Project from the above results, the matters mentioned hereunder should be taken into account.

(a) The estimated direct benefits might have been under-estimated to some extent since future plans for the Burmese economy, particularly in industrial development and location plans for related areas, are unknown.

(b) The fact that such benefits immeasurable in terms of currency as mentioned in 11.5 cannot be neglected.

(c) Generally, in the developing countries, considerably high direct benefit can be anticipated in few cases from the investment in the infrastructure.

From the results of the aforementioned economic analyses, the following matters may be pointed out.

(1) On the whole, the economic effectiveness in terms of direct benefit is not so high, and consequently it calls for full studies to determine whether or not investment in this Project should be made in priority to other investments.

(2) In comparison between the steel bridge and the prestressed concrete bridge, the steel bridge is beneficial within the scope of this analysis.

(3) The determination of the shadow rate depends on judgement of the relative importance of foreign currency. However, for every 25 percent increase in the shadow rate over the official rate, the rate of cost and benefit decreases by a little over 10 percent.

(4) In the case in which the construction of the railway between Kyangin and Sinde is included in this Project, simultaneous construction of the railway bridge and the highway bridge, particularly in the case of the steel bridge, is not advantageous.

(5) On the assumption that the railway between Kyangin and Sinde is constructed separately from this Project, the economic effectiveness of this Project would be a little higher.

In this case, there is little difference in the economic effectiveness between the simultaneous construction of the railway and highway bridges and the construction by stages.

Remarks: The official conversion rate of Burmese Kyat to SDR was devaluated by 25 percent. However, as mentioned clearly in chapter 10, no correction in relation to this devaluation was made hereto.

Fig. 11-3 Benefit to be Measured

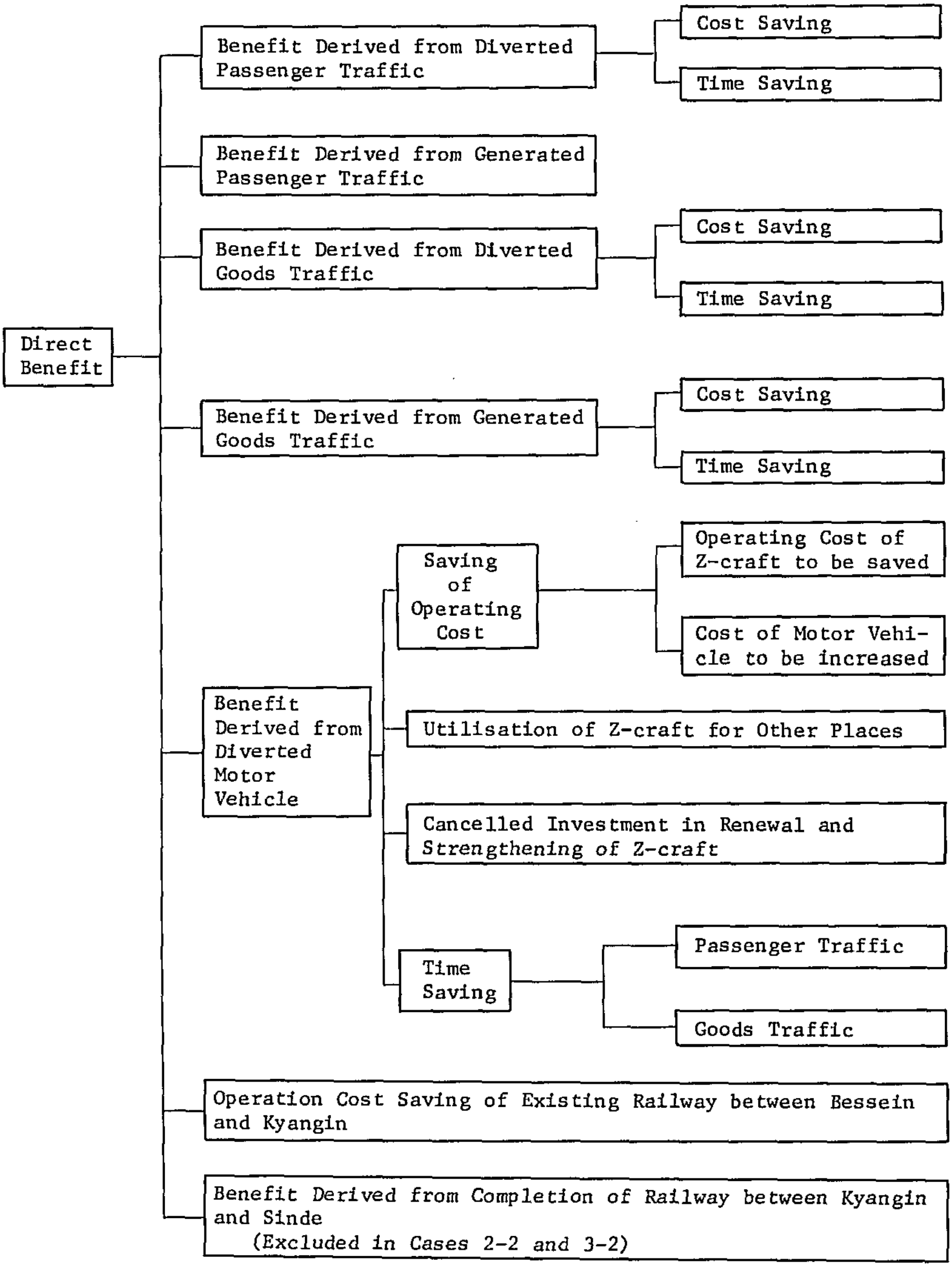


Table 11-1 Economic Construction Cost of Steel Bridge

Unit: 1,000 Kyats

| Case | Kind of Bridge | Item | Local Comp. | Foreign Comp. | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Official Rate | Shadow Rate | | Official Rate | Shadow Rate | |
| | | | | | 1.50 | 1.75 | | 1.50 | 1.75 |
| 1 | Railway - Highway Bridge | Common Facility | 1,895 | 1,798 | 2,697 | 3,147 | 3,693 | 4,592 | 5,042 |
| | | Bridge | 60,208 | 252,369 | 378,554 | 441,645 | 312,577 | 438,762 | 501,853 |
| | | Highway | 33,316 | 38,467 | 57,701 | 67,317 | 71,783 | 91,017 | 100,633 |
| | | Railway | 32,951 | 46,234 | 69,351 | 80,910 | 79,185 | 102,302 | 113,861 |
| | | River Works | 556 | 609 | 913 | 1,066 | 1,165 | 1,469 | 1,622 |
| | | Total | 128,926 | 339,477 | 509,216 | 594,085 | 468,403 | 638,142 | 723,011 |
| 2, 3 | Highway Bridge | Common Facility | 1,895 | 1,798 | 2,697 | 3,147 | 3,693 | 4,592 | 5,042 |
| | | Bridge | 54,647 | 213,698 | 320,548 | 373,971 | 268,345 | 375,195 | 428,618 |
| | | Highway | 33,316 | 38,467 | 57,701 | 67,317 | 71,783 | 91,017 | 100,633 |
| | | River Works | 556 | 609 | 913 | 1,066 | 1,165 | 1,469 | 1,622 |
| | | Total | 90,414 | 254,572 | 381,859 | 445,501 | 344,986 | 472,273 | 535,915 |
| | Railway Bridge | Common Facility | 705 | 768 | 1,152 | 1,344 | 1,473 | 1,857 | 2,049 |
| | | Bridge * | 7,450 | 49,286 | 73,929 | 86,251 | 56,736 | 81,379 | 93,701 |
| | | Railway | 32,951 | 46,234 | 69,351 | 80,910 | 79,185 | 102,302 | 113,861 |
| | | Total | 41,106 | 96,288 | 144,432 | 168,505 | 137,394 | 185,538 | 209,611 |

Note: * Cost for the substructure is not included.

Table 11-2 Economic Construction Cost of Prestressed Concrete Bridge

Unit: 1,000 Kyats

| Case | Kind of Bridge | Item | Local Comp. | Foreign Comp. | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Official Rate | Shadow Rate | | Official Rate | Shadow Rate | |
| | | | | | 1.50 | 1.75 | | 1.50 | 1.75 |
| 1 | Railway - Highway Bridge | Common Facility | 1,895 | 1,798 | 2,697 | 3,147 | 3,693 | 4,592 | 5,042 |
| | | Bridge | 80,812 | 284,758 | 427,137 | 498,326 | 365,570 | 507,949 | 579,138 |
| | | Highway | 33,316 | 38,467 | 57,701 | 67,317 | 71,783 | 91,017 | 100,633 |
| | | Railway | 32,951 | 46,234 | 69,351 | 80,910 | 79,185 | 102,302 | 113,861 |
| | | River Works | 556 | 609 | 913 | 1,066 | 1,165 | 1,469 | 1,622 |
| | | Total | 149,530 | 371,866 | 557,799 | 650,766 | 521,396 | 707,329 | 800,296 |
| 2, 3 | Highway Bridge | Common Facility | 1,895 | 1,798 | 2,697 | 3,147 | 3,693 | 4,592 | 5,042 |
| | | Bridge | 81,260 | 283,540 | 425,310 | 496,195 | 364,800 | 506,570 | 577,455 |
| | | Highway | 33,316 | 38,467 | 57,701 | 67,317 | 71,783 | 91,017 | 100,633 |
| | | River Works | 556 | 609 | 913 | 1,066 | 1,165 | 1,469 | 1,622 |
| | | Total | 117,027 | 324,414 | 486,621 | 567,725 | 441,441 | 603,648 | 684,752 |
| | Railway Bridge | Common Facility | 705 | 768 | 1,152 | 1,344 | 1,473 | 1,857 | 2,049 |
| | | Bridge * | 8,352 | 31,023 | 46,535 | 54,290 | 39,375 | 54,887 | 62,642 |
| | | Railway | 32,951 | 46,234 | 69,351 | 80,910 | 79,185 | 102,302 | 113,861 |
| | | Total | 42,008 | 78,025 | 117,038 | 136,544 | 120,033 | 159,046 | 178,552 |

Note: * Cost for the substructure is not included.

Table 11-3 Economic Construction Cost of Railway between Kyangin and Sinde

Unit: 1,000 Kyats

| Local Comp. | Foreign Comp. | | | Total | | |
|---|---|---|---|---|---|---|
| | Official Rate | Shadow Rate | | Official Rate | Shadow Rate | |
| | | 1.50 | 1.75 | | 1.50 | 1.75 |
| 77,894 | 106,254 | 159,381 | 185,945 | 184,148 | 237,275 | 263,839 |

## Table 11-4 Annual Outlay for Economic Construction Cost of Steel Bridge

Unit: 1,000 Kyats

| Case | Kind of Bridge | Item / Exchange Rate / Year | Common Facility | | | Bridge | | | Acess Road | | | Access Railway | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Official Rate | Shadow Rate | | Official Rate | Shadow Rate | | Official Rate | Shadow Rate | | Official Rate | Shadow Rate | | Official Rate | Shadow Rate | |
| | | | | 1.50 | 1.75 | | 1.50 | 1.75 | | 1.50 | 1.75 | | 1.50 | 1.75 | | 1.50 | 1.75 |
| 1 | Railway - Highway Bridge | 1976 | 3,693 | 4,592 | 5,042 | 5,602 | 8,016 | 9,222 | | | | | | | 9,295 | 12,608 | 14,264 |
| | | 1977 | | | | 18,476 | 25,597 | 29,158 | 4,944 | 6,398 | 7,125 | | | | 23,420 | 31,995 | 36,283 |
| | | 1978 | | | | 54,371 | 75,182 | 85,587 | 13,881 | 17,767 | 19,710 | | | | 68,252 | 92,949 | 105,297 |
| | | 1979 | | | | 93,268 | 130,631 | 149,313 | 15,645 | 19,856 | 21,961 | 14,741 | 19,101 | 21,281 | 123,654 | 169,588 | 192,555 |
| | | 1980 | | | | 80,859 | 114,012 | 130,588 | 15,646 | 19,858 | 21,963 | 31,825 | 41,222 | 45,921 | 128,330 | 175,092 | 198,472 |
| | | 1981 | | | | 53,571 | 76,200 | 87,515 | 13,253 | 16,934 | 18,775 | 25,116 | 32,293 | 35,881 | 91,940 | 125,427 | 142,171 |
| | | 1982 | | | | 7,595 | 10,593 | 12,092 | 8,414 | 10,204 | 11,099 | 7,503 | 9,686 | 10,778 | 23,512 | 30,483 | 33,969 |
| | | Total | 3,693 | 4,592 | 5,042 | 313,742 | 440,231 | 503,475 | 71,783 | 91,017 | 100,633 | 79,185 | 102,302 | 113,861 | 468,403 | 638,142 | 723,011 |
| 2, 3 | Highway Bridge | 1976 | 3,693 | 4,592 | 5,042 | 5,602 | 8,016 | 9,222 | | | | | | | 9,295 | 12,608 | 14,264 |
| | | 1977 | | | | 18,522 | 25,654 | 29,220 | 4,944 | 6,398 | 7,125 | | | | 23,466 | 32,052 | 36,345 |
| | | 1978 | | | | 51,204 | 70,546 | 80,218 | 13,881 | 17,767 | 19,710 | | | | 65,085 | 88,313 | 99,928 |
| | | 1979 | | | | 82,089 | 114,339 | 130,464 | 15,645 | 19,856 | 21,961 | | | | 97,734 | 134,195 | 152,425 |
| | | 1980 | | | | 68,246 | 96,068 | 109,979 | 15,646 | 19,858 | 21,963 | | | | 83,892 | 115,926 | 131,942 |
| | | 1981 | | | | 38,863 | 55,178 | 63,335 | 13,253 | 16,934 | 18,775 | | | | 52,116 | 72,112 | 82,110 |
| | | 1982 | | | | 4,984 | 6,863 | 7,802 | 8,414 | 10,204 | 11,099 | | | | 13,398 | 17,067 | 18,901 |
| | | Total | 3,693 | 4,592 | 5,042 | 269,510 | 376,664 | 430,240 | 71,783 | 91,017 | 100,633 | | | | 344,986 | 472,273 | 535,915 |
| | Railway Bridge | 1982 (1987) | 1,473 | 1,857 | 2,049 | | | | | | | | | | 1,473 | 1,857 | 2,049 |
| | | 1983 (1988) | | | | 5,564 | 7,958 | 9,154 | | | | | | | 5,564 | 7,958 | 9,154 |
| | | 1984 (1989) | | | | 15,874 | 22,793 | 26,253 | | | | 14,741 | 19,101 | 21,281 | 30,615 | 41,894 | 47,534 |
| | | 1985 (1990) | | | | 14,582 | 20,913 | 24,078 | | | | 31,825 | 41,222 | 45,921 | 46,407 | 62,135 | 69,999 |
| | | 1986 (1991) | | | | 17,537 | 25,158 | 28,969 | | | | 25,116 | 32,293 | 35,881 | 42,653 | 57,451 | 64,850 |
| | | 1987 (1992) | | | | 3,179 | 4,557 | 5,247 | | | | 7,503 | 9,686 | 10,778 | 10,682 | 14,243 | 16,025 |
| | | Total | 1,473 | 1,857 | 2,049 | 56,736 | 81,379 | 93,701 | | | | 79,185 | 102,302 | 113,861 | 137,394 | 185,538 | 209,611 |

Note: 1) Cost of "River Works" is included in Item "Bridge Construction".

2) Years in Parenthesis for Railway Bridge are for Case 3 and those without parethesis are for Case 2.

Table 11-5 Annual Outlay for Economic Construction Cost of Prestressed Concrete Bridge

Unit: 1,000 Kyats

| Case | Kind of Bridge | Item / Exchange Rate / Year | Common Facility | | | Bridge | | | Access Road | | | Access Railway | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Official Rate | Shadow Rate 1.50 | Shadow Rate 1.75 | Official Rate | Shadow Rate 1.50 | Shadow Rate 1.75 | Official Rate | Shadow Rate 1.50 | Shadow Rate 1.75 | Official Rate | Shadow Rate 1.50 | Shadow Rate 1.75 | Official Rate | Shadow Rate 1.50 | Shadow Rate 1.75 |
| 1 | Railway - Highway Bridge | 1976 | 3,693 | 4,592 | 5,042 | | | | | | | | | | 3,693 | 4,592 | 5,042 |
| | | 1977 | | | | 28,415 | 40,000 | 45,793 | 4,945 | 6,400 | 7,127 | | | | 33,360 | 46,400 | 52,920 |
| | | 1978 | | | | 70,369 | 97,602 | 111,218 | 13,881 | 17,767 | 19,710 | | | | 84,250 | 115,369 | 130,928 |
| | | 1979 | | | | 100,849 | 139,490 | 158,811 | 15,645 | 19,856 | 21,962 | 14,741 | 19,101 | 21,281 | 131,235 | 178,447 | 202,054 |
| | | 1980 | | | | 108,305 | 150,559 | 171,686 | 15,645 | 19,856 | 21,961 | 31,825 | 41,222 | 45,921 | 155,775 | 211,637 | 239,568 |
| | | 1981 | | | | 43,194 | 60,175 | 68,666 | 13,253 | 16,934 | 18,774 | 25,116 | 32,293 | 35,882 | 81,563 | 109,402 | 123,322 |
| | | 1982 | | | | 15,145 | 20,952 | 23,856 | 8,414 | 10,204 | 11,099 | 7,503 | 9,686 | 10,777 | 31,062 | 40,842 | 45,732 |
| | | 1983 | | | | 458 | 640 | 730 | | | | | | | 458 | 640 | 730 |
| | | Total | 3,693 | 4,592 | 5,042 | 366,735 | 509,418 | 580,760 | 71,783 | 91,017 | 100,633 | 79,185 | 102,302 | 113,861 | 521,396 | 707,329 | 800,296 |
| 2, 3 | Highway Bridge | 1976 | 3,693 | 4,592 | 5,042 | | | | | | | | | | 3,693 | 4,592 | 5,042 |
| | | 1977 | | | | 29,642 | 41,738 | 47,786 | 4,945 | 6,400 | 7,127 | | | | 34,587 | 48,138 | 54,913 |
| | | 1978 | | | | 74,736 | 103,612 | 118,050 | 13,881 | 17,767 | 19,710 | | | | 88,617 | 121,379 | 137,760 |
| | | 1979 | | | | 106,781 | 147,646 | 168,079 | 15,645 | 19,856 | 21,962 | | | | 122,426 | 167,502 | 190,041 |
| | | 1980 | | | | 107,051 | 148,768 | 169,627 | 15,645 | 19,856 | 21,961 | | | | 122,696 | 168,624 | 191,588 |
| | | 1981 | | | | 37,285 | 51,858 | 59,145 | 13,253 | 16,934 | 18,774 | | | | 50,538 | 68,792 | 77,919 |
| | | 1982 | | | | 10,175 | 14,005 | 15,920 | 8,414 | 10,204 | 11,099 | | | | 18,589 | 24,209 | 27,019 |
| | | 1983 | | | | 295 | 412 | 470 | | | | | | | 295 | 412 | 470 |
| | | Total | 3,693 | 4,592 | 5,042 | 365,965 | 508,039 | 579,077 | 71,783 | 91,017 | 100,633 | | | | 441,441 | 603,648 | 684,752 |
| | Railway Bridge | 1982 (1987) | 1,473 | 1,857 | 2,049 | | | | | | | | | | 1,473 | 1,857 | 2,049 |
| | | 1983 (1988) | | | | 1,263 | 1,761 | 2,009 | | | | 14,741 | 19,101 | 21,281 | 1,263 | 1,761 | 2,009 |
| | | 1984 (1989) | | | | 5,552 | 7,739 | 8,834 | | | | 31,825 | 41,222 | 45,921 | 20,293 | 26,840 | 30,115 |
| | | 1985 (1990) | | | | 14,386 | 20,053 | 22,886 | | | | 25,116 | 32,293 | 35,882 | 46,211 | 61,275 | 68,807 |
| | | 1986 (1991) | | | | 10,349 | 14,426 | 16,464 | | | | 7,503 | 9,686 | 10,777 | 35,465 | 46,719 | 52,346 |
| | | 1987 (1992) | | | | 7,573 | 10,557 | 12,048 | | | | | | | 15,076 | 20,243 | 22,825 |
| | | 1988 (1993) | | | | 252 | 351 | 401 | | | | | | | 252 | 351 | 401 |
| | | Total | 1,473 | 1,857 | 2,049 | 39,375 | 54,887 | 62,642 | | | | 79,185 | 102,302 | 113,861 | 120,033 | 159,046 | 178,552 |

Note: 1) Cost of "River Works" is included in Item "Bridge Construction".

2) Years in parenthesis for Railway Bridge are for Case 3 and those without parethesis are for Case 2.

Table 11-6 Annual Outlay for Economic Construction Cost of Railway between Kyangin and Sinde

Unit: 1,000 Kyats

| Exchange Rate / Year | | | Official Rate | Shadow Rate | |
|---|---|---|---|---|---|
| | | | | 1.50 | 1.75 |
| (Case 1) | (Case 2) | (Case 3) | | | |
| 1978 | 1983 | 1988 | 27,503 | 35,575 | 39,611 |
| 1979 | 1984 | 1989 | 41,501 | 53,633 | 59,699 |
| 1980 | 1985 | 1990 | 40,868 | 52,819 | 58,795 |
| 1981 | 1986 | 1991 | 52,309 | 67,060 | 74,435 |
| 1982 | 1987 | 1992 | 21,967 | 28,188 | 31,299 |
| Total | | | 184,148 | 237,275 | 263,839 |

Table 11-7 Present Value of Construction Cost of Steel Bridge

Unit: 1,000 Kyats

| Case | Exchange Rate / Discount Rate | | 0.03 | 0.06 | 0.09 | 0.12 | 0.15 |
|---|---|---|---|---|---|---|---|
| 1 | Official Rate | | 569,629 | 499,199 | 440,037 | 389,746 | 346,761 |
| | Shadow Rate | 1.50 | 764,279 | 670,116 | 590,872 | 523,489 | 465,876 |
| | | 1.75 | 861,604 | 755,574 | 666,288 | 590,359 | 525,433 |
| 2 | Official Rate | | 543,460 | 449,451 | 376,580 | 319,318 | 273,227 |
| | Shadow Rate | 1.50 | 731,104 | 605,638 | 508,225 | 431,553 | 369,912 |
| | | 1.75 | 824,924 | 683,731 | 574,045 | 487,668 | 418,254 |
| 3 | Official Rate | | 510,623 | 404,108 | 329,014 | 274,411 | 233,028 |
| | Shadow Rate | 1.50 | 687,919 | 545,998 | 445,654 | 372,474 | 317,022 |
| | | 1.75 | 776,566 | 616,943 | 503,973 | 421,505 | 359,017 |
| 2-2 | Official Rate | | 406,337 | 346,336 | 298,324 | 259,408 | 226,988 |
| | Shadow Rate | 1.50 | 554,399 | 472,741 | 407,355 | 354,322 | 310,298 |
| | | 1.75 | 628,428 | 535,944 | 461,869 | 401,777 | 351,952 |
| 3-2 | Official Rate | | 392,339 | 327,056 | 278,153 | 240,418 | 210,040 |
| | Shadow Rate | 1.50 | 535,491 | 446,692 | 380,096 | 328,653 | 287,384 |
| | | 1.75 | 607,066 | 506,510 | 431,066 | 372,770 | 326,055 |

Table 11-8 Present Value of Construction Cost of Prestressed Concrete Bridge

Unit: 1,000 Kyats

| Case | Exchange Rate / Discount Rate | | 0.03 | 0.06 | 0.09 | 0.12 | 0.15 |
|---|---|---|---|---|---|---|---|
| 1 | Official Rate | | 615,994 | 540,699 | 476,997 | 422,789 | 376,406 |
| | Shadow Rate | 1.50 | 825,069 | 724,519 | 639,415 | 566,966 | 504,950 |
| | | 1.75 | 929,606 | 816,427 | 720,622 | 639,053 | 569,221 |
| 2 | Official Rate | | 615,190 | 514,499 | 435,600 | 372,907 | 322,441 |
| | Shadow Rate | 1.50 | 826,770 | 692,798 | 587,612 | 503,868 | 436,327 |
| | | 1.75 | 932,559 | 781,946 | 663,616 | 569,347 | 493,271 |
| 3 | Official Rate | | 584,193 | 471,784 | 390,879 | 330,772 | 284,792 |
| | Shadow Rate | 1.50 | 786,385 | 637,146 | 529,349 | 448,976 | 387,282 |
| | | 1.75 | 887,481 | 719,827 | 598,585 | 508,077 | 438,525 |
| 2-2 | Official Rate | | 478,067 | 411,384 | 357,344 | 312,997 | 276,202 |
| | Shadow Rate | 1.50 | 650,065 | 559,901 | 486,742 | 426,637 | 376,713 |
| | | 1.75 | 736,063 | 634,159 | 551,440 | 483,456 | 426,969 |
| 3-2 | Official Rate | | 465,909 | 394,732 | 340,018 | 296,779 | 261,804 |
| | Shadow Rate | 1.50 | 633,957 | 537,840 | 463,791 | 405,155 | 357,644 |
| | | 1.75 | 717,981 | 609,394 | 525,678 | 459,342 | 405,563 |

Table 11-9 Estimated Value of Asset in 2013

Unit: 1,000 Kyats

| Kind of Bridge | Item | Case | Bridge Type | Steel Bridge | | | | | | | | Prestressed Concrete Bridge | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Average Durable Years<br>Comp | 100 | 90 | 60 | 50 | 35 | 30 | ∞ | Total | 100 | 90 | 60 | 50 | 35 | 30 | ∞ | Total |
| Railway-Highway Bridge | Value in year of completion | 1 | Local | 88,068 | 6,674 | 20,332 | 8,087 | 4,825 | 926 | 9 | 128,921 | 124,665 | 6,674 | 4,339 | 8,087 | 4,825 | 926 | 9 | 149,525 |
| | | | Foreign | 222,427 | 5,131 | 100,503 | 7,529 | 2,560 | 1,327 | | 339,477 | 348,797 | 5,131 | 6,522 | 7,529 | 2,560 | 1,327 | | 371,866 |
| | Value in 2013 | 1 | Local | 61,648 | 4,449 | 10,166 | 3,235 | 689 | 31 | 9 | 80,227 | 87,266 | 4,449 | 2,170 | 3,235 | 689 | | 9 | 97,818 |
| | | | Foreign | 155,699 | 3,421 | 50,252 | 3,012 | 366 | 44 | | 212,794 | 244,158 | 3,421 | 3,261 | 3,012 | 366 | | | 254,218 |
| Highway Bridge | Value in year of completion | 2,3<br>2-2<br>3-2 | Local | 65,621 | 5,148 | 9,743 | 5,077 | 4,825 | | | 90,414 | 101,977 | 5,148 | | 5,077 | 4,825 | | | 117,027 |
| | | | Foreign | 190,426 | 2,840 | 53,849 | 4,897 | 2,560 | | | 254,572 | 314,117 | 2,840 | | 4,897 | 2,560 | | | 324,414 |
| | Value in 2013 | 2,3<br>2-2<br>3-2 | Local | 45,935 | 3,432 | 4,872 | 2,031 | 689 | | | 56,959 | 71,384 | 3,432 | | 2,031 | 689 | | | 77,536 |
| | | | Foreign | 133,298 | 1,893 | 26,925 | 1,959 | 366 | | | 164,441 | 219,882 | 1,893 | | 1,959 | 366 | | | 224,100 |
| Railway Bridge | Value in year of completion | 2,3<br>2-2<br>3-2 | Local | 23,136 | 1,526 | 12,494 | 3,010 | | 926 | 9 | 41,101 | 32,193 | 1,526 | 4,339 | 3,010 | | 926 | 9 | 42,003 |
| | | | Foreign | 33,462 | 2,291 | 56,576 | 2,632 | | 1,327 | | 96,288 | 65,253 | 2,291 | 6,522 | 2,632 | | 1,327 | | 78,025 |
| | Value in 2013 | 2 | Local | 17,352 | 1,102 | 7,288 | 1,505 | | 154 | 9 | 27,410 | 24,145 | 1,102 | 2,531 | 1,505 | | 154 | 9 | 29,446 |
| | | 2-2 | Foreign | 25,097 | 1,655 | 33,003 | 1,316 | | 221 | | 61,292 | 48,940 | 1,655 | 3,804 | 1,316 | | 221 | | 55,936 |
| | | 3 | Local | 18,509 | 1,187 | 8,329 | 1,806 | | 309 | 9 | 30,149 | 25,754 | 1,187 | 2,893 | 1,806 | | 309 | 9 | 31,958 |
| | | 3-2 | Foreign | 26,770 | 1,782 | 37,717 | 1,579 | | 442 | | 68,290 | 52,202 | 1,782 | 4,348 | 1,579 | | 442 | | 60,353 |
| Railway between Kyangin and Sinde | Value in year of completion | 1,2,3 | Local | 43,692 | 9,161 | 15,167 | 6,905 | | 2,939 | 30 | 77,894 | 43,692 | 9,161 | 15,167 | 6,905 | | 2,939 | 30 | 77,894 |
| | | | Foreign | 59,821 | 14,753 | 21,293 | 6,482 | | 3,905 | | 106,254 | 59,821 | 14,753 | 21,293 | 6,482 | | 3,905 | | 106,254 |
| | Value in 2013 | 1 | Local | 30,584 | 6,107 | 7,584 | 2,762 | | 98 | 30 | 47,165 | 30,584 | 6,107 | 7,584 | 2,762 | | 98 | 30 | 47,165 |
| | | | Foreign | 41,875 | 9,835 | 10,647 | 2,593 | | 130 | | 65,080 | 41,875 | 9,835 | 10,647 | 2,593 | | 130 | | 65,080 |
| | | 2 | Local | 32,769 | 6,616 | 8,847 | 3,453 | | 490 | 30 | 52,206 | 32,769 | 6,616 | 8,847 | 3,453 | | 490 | 30 | 52,206 |
| | | | Foreign | 44,866 | 10,655 | 12,421 | 3,241 | | 651 | | 71,834 | 44,866 | 10,655 | 12,421 | 3,241 | | 651 | | 71,834 |
| | | 3 | Local | 34,954 | 7,125 | 10,111 | 4,143 | | 980 | 30 | 57,343 | 34,954 | 7,125 | 10,111 | 4,143 | | 980 | 30 | 57,343 |
| | | | Foreign | 47,857 | 11,475 | 14,195 | 3,889 | | 1,302 | | 78,718 | 47,857 | 11,475 | 14,195 | 3,889 | | 1,302 | | 78,718 |

Note: The value of the foreign component is based on the official exchange rate.

Table 11-10 Present Value of Asset in 2013

Unit: 1,000 Kyats

| Case | Exchange Rate \ Discount Rate \ Bridge Type | | Steel Bridge 0.03 | 0.06 | 0.09 | 0.12 | 0.15 | Prestressed Concrete Bridge 0.03 | 0.06 | 0.09 | 0.12 | 0.15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Official Rate | | 131,803 | 44,270 | 15,330 | 5,464 | 2,001 | 150,996 | 50,717 | 17,562 | 6,259 | 2,292 |
| | Shadow Rate | 1.50 | 176,989 | 59,448 | 20,586 | 7,338 | 2,688 | 202,918 | 68,157 | 23,601 | 8,412 | 3,081 |
| | | 1.75 | 199,583 | 67,036 | 23,214 | 8,274 | 3,030 | 228,880 | 76,877 | 26,621 | 9,487 | 3,474 |
| 2 | Official Rate | | 141,195 | 47,424 | 16,422 | 5,853 | 2,144 | 166,210 | 55,827 | 19,332 | 6,889 | 2,523 |
| | Shadow Rate | 1.50 | 189,584 | 63,678 | 22,050 | 7,859 | 2,880 | 223,429 | 75,046 | 25,988 | 9,261 | 3,392 |
| | | 1.75 | 213,779 | 71,802 | 24,864 | 8,862 | 3,246 | 252,038 | 84,655 | 29,315 | 10,446 | 3,826 |
| 3 | Official Rate | | 148,271 | 49,801 | 17,245 | 6,146 | 2,251 | 172,372 | 57,897 | 20,049 | 7,145 | 2,617 |
| | Shadow Rate | 1.50 | 198,918 | 66,823 | 23,136 | 8,247 | 3,021 | 231,429 | 77,734 | 26,918 | 9,594 | 3,514 |
| | | 1.75 | 224,241 | 75,317 | 26,081 | 9,296 | 3,405 | 260,956 | 87,651 | 30,353 | 10,817 | 3,962 |
| 2-2 | Official Rate | | 100,854 | 33,874 | 11,730 | 4,181 | 1,531 | 125,869 | 42,277 | 14,640 | 5,217 | 1,910 |
| | Shadow Rate | 1.50 | 137,562 | 46,204 | 15,999 | 5,703 | 2,089 | 171,407 | 57,572 | 19,937 | 7,105 | 2,601 |
| | | 1.75 | 155,916 | 52,367 | 18,134 | 6,464 | 2,367 | 194,175 | 65,220 | 22,585 | 8,048 | 2,947 |
| 3-2 | Official Rate | | 104,021 | 34,938 | 12,098 | 4,312 | 1,579 | 128,122 | 43,034 | 14,902 | 5,311 | 1,945 |
| | Shadow Rate | 1.50 | 141,867 | 47,660 | 16,500 | 5,882 | 2,154 | 174,378 | 58,571 | 20,282 | 7,229 | 2,647 |
| | | 1.75 | 160,790 | 54,005 | 18,700 | 6,666 | 2,441 | 197,505 | 66,339 | 22,972 | 8,187 | 2,998 |

Table 11-11 Annual Amount of Maintenance Cost

Unit: 1,000 Kyats

| Item \ Years after Completion \ Bridge Type | | Steel Bridge 1-3 | 4-10 | 11-13 | 14-23 | 24- | Prestressed Concrete Bridge 1-3 | 4-10 | 11-13 | 14-23 | 24- |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Superstructure of Bridge | Railway-Highway Bridge | - | 162 | | 312 | 462 | - | 12 | | 12 | 12 |
| | Highway Bridge | - | 98 | | 188 | 278 | - | 8 | | 8 | 8 |
| | Railway Bridge | - | 94 | | 184 | 274 | - | 4 | | 4 | 4 |
| Access Road | | 230 | | 345 | | | 230 | | 345 | | |
| Access Railway | | 150 | 100 | | | | 150 | 100 | | | |
| River Works | | - | 160 | | | | - | 160 | | | |
| Railway between Kyangin and Sinde | | 550 | 370 | | | | 150 | 370 | | | |

Table 11-12 Present Value of Maintenance Cost

Unit: 1,000 Kyats

| Case \ Discount Rate \ Bridge Type | Steel Bridge 0.03 | 0.06 | 0.09 | 0.12 | 0.15 | Prestressed Concrete Bridge 0.03 | 0.06 | 0.09 | 0.12 | 0.15 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 18,792 | 11,545 | 6,345 | 4,049 | 2,711 | 15,267 | 9,802 | 5,424 | 3,532 | 2,404 |
| 2 | 16,957 | 9,067 | 5,174 | 3,123 | 1,979 | 13,431 | 7,373 | 4,306 | 2,652 | 1,709 |
| 3 | 14,848 | 7,732 | 4,303 | 2,542 | 1,587 | 11,846 | 6,305 | 3,580 | 2,153 | 1,364 |
| 2-2 | 12,081 | 6,477 | 3,720 | 2,267 | 1,455 | 8,555 | 4,783 | 2,852 | 1,796 | 1,185 |
| 3-2 | 11,210 | 5,977 | 3,417 | 2,077 | 1,333 | 8,208 | 4,550 | 2,694 | 1,688 | 1,110 |

## Table 11-13 Present Value of Net Cost for Steel Bridge

Unit: 1,000 Kyats

| Exchange Rate | | Case | Discount Rate<br>Item | 0.03 | 0.06 | 0.09 | 0.12 | 0.15 |
|---|---|---|---|---|---|---|---|---|
| Official Rate | | 1 | Construction Cost | 569,629 | 499,199 | 440,037 | 389,746 | 346,761 |
| | | | Maintenance Cost | 18,792 | 11,545 | 6,345 | 4,049 | 2,711 |
| | | | (-) Asset Value in 2013 | 131,803 | 44,270 | 15,330 | 5,464 | 2,001 |
| | | | Net Cost | 456,618 | 466,474 | 431,052 | 388,331 | 347,471 |
| | | 2 | Construction Cost | 543,460 | 449,451 | 376,580 | 319,318 | 273,227 |
| | | | Maintenance Cost | 16,957 | 9,067 | 5,174 | 3,123 | 1,979 |
| | | | (-) Asset Value in 2013 | 141,195 | 47,424 | 16,422 | 5,853 | 2,144 |
| | | | Net Cost | 419,222 | 411,094 | 365,332 | 316,588 | 273,062 |
| | | 3 | Construction Cost | 510,623 | 404,108 | 329,014 | 274,411 | 233,028 |
| | | | Maintenance Cost | 14,848 | 7,732 | 4,303 | 2,542 | 1,587 |
| | | | (-) Asset Value in 2013 | 148,271 | 49,801 | 17,245 | 6,146 | 2,251 |
| | | | Net Cost | 377,200 | 362,039 | 316,072 | 270,807 | 232,364 |
| | | 2-2 | Construction Cost | 406,337 | 346,336 | 298,324 | 259,408 | 226,988 |
| | | | Maintenance Cost | 12,081 | 6,477 | 3,720 | 2,267 | 1,455 |
| | | | (-) Asset Value in 2013 | 100,854 | 33,874 | 11,730 | 4,181 | 1,531 |
| | | | Net Cost | 317,564 | 318,939 | 290,314 | 257,494 | 226,912 |
| | | 3-2 | Construction Cost | 392,339 | 327,056 | 278,153 | 240,418 | 210,040 |
| | | | Maintenance Cost | 11,210 | 5,977 | 3,417 | 2,077 | 1,333 |
| | | | (-) Asset Value in 2013 | 104,021 | 34,938 | 12,098 | 4,312 | 1,579 |
| | | | Net Cost | 299,528 | 298,095 | 269,472 | 238,183 | 209,794 |
| Shadow Rate | 1.50 | 1 | Construction Cost | 764,279 | 670,116 | 590,872 | 523,489 | 465,876 |
| | | | Maintenance Cost | 18,792 | 11,545 | 6,345 | 4,049 | 2,711 |
| | | | (-) Asset Value in 2013 | 176,989 | 59,448 | 20,586 | 7,338 | 2,688 |
| | | | Net Cost | 606,082 | 622,213 | 576,631 | 520,200 | 465,899 |
| | | 2 | Construction Cost | 731,104 | 605,638 | 508,225 | 431,553 | 369,912 |
| | | | Maintenance Cost | 16,957 | 9,067 | 5,174 | 3,123 | 1,979 |
| | | | (-) Asset Value in 2013 | 189,584 | 63,678 | 22,050 | 7,859 | 2,880 |
| | | | Net Cost | 558,477 | 551,027 | 491,349 | 426,817 | 369,011 |
| | | 3 | Construction Cost | 687,919 | 545,998 | 445,654 | 372,474 | 317,022 |
| | | | Maintenance Cost | 14,848 | 7,732 | 4,303 | 2,542 | 1,587 |
| | | | (-) Asset Value in 2013 | 198,918 | 66,823 | 23,136 | 8,247 | 3,021 |
| | | | Net Cost | 503,849 | 486,907 | 426,821 | 366,769 | 315,588 |
| | | 2-2 | Construction Cost | 554,399 | 472,741 | 407,355 | 354,322 | 310,298 |
| | | | Maintenance Cost | 12,081 | 6,477 | 3,720 | 2,267 | 1,455 |
| | | | (-) Asset Value in 2013 | 137,562 | 46,204 | 15,999 | 5,703 | 2,089 |
| | | | Net Cost | 428,918 | 433,014 | 395,076 | 350,886 | 309,664 |
| | | 3-2 | Construction Cost | 535,491 | 446,692 | 380,096 | 328,653 | 287,384 |
| | | | Maintenance Cost | 11,210 | 5,977 | 3,417 | 2,077 | 1,333 |
| | | | (-) Asset Value in 2013 | 141,867 | 47,660 | 16,500 | 5,882 | 2,154 |
| | | | Net Cost | 404,834 | 405,009 | 367,013 | 324,848 | 286,563 |
| | 1.75 | 1 | Construction Cost | 861,604 | 755,574 | 666,288 | 590,359 | 525,433 |
| | | | Maintenance Cost | 18,792 | 11,545 | 6,345 | 4,049 | 2,711 |
| | | | (-) Asset Value in 2013 | 199,583 | 67,036 | 23,214 | 8,274 | 3,030 |
| | | | Net Cost | 680,813 | 700,083 | 649,419 | 586,134 | 525,114 |
| | | 2 | Construction Cost | 824,924 | 683,731 | 574,045 | 487,668 | 418,254 |
| | | | Maintenance Cost | 16,957 | 9,067 | 5,174 | 3,123 | 1,979 |
| | | | (-) Asset Value in 2013 | 213,779 | 71,802 | 24,864 | 8,862 | 3,246 |
| | | | Net Cost | 628,102 | 620,996 | 554,355 | 481,929 | 416,987 |
| | | 3 | Construction Cost | 776,566 | 616,943 | 503,973 | 421,505 | 359,017 |
| | | | Maintenance Cost | 14,848 | 7,732 | 4,303 | 2,542 | 1,587 |
| | | | (-) Asset Value in 2013 | 224,241 | 75,317 | 26,081 | 9,296 | 3,405 |
| | | | Net Cost | 567,173 | 549,358 | 482,195 | 414,751 | 357,199 |
| | | 2-2 | Construction Cost | 628,428 | 535,944 | 461,869 | 401,777 | 351,952 |
| | | | Maintenance Cost | 12,081 | 6,477 | 3,720 | 2,267 | 1,455 |
| | | | (-) Asset Value in 2013 | 155,916 | 52,367 | 18,134 | 6,464 | 2,367 |
| | | | Net Cost | 484,593 | 490,054 | 447,455 | 397,580 | 351,040 |
| | | 3-2 | Construction Cost | 607,066 | 506,510 | 431,066 | 372,770 | 326,055 |
| | | | Maintenance Cost | 11,210 | 5,977 | 3,417 | 2,077 | 1,333 |
| | | | (-) Asset Value in 2013 | 160,790 | 54,005 | 18,700 | 6,666 | 2,441 |
| | | | Net Cost | 457,486 | 458,482 | 415,783 | 368,181 | 324,947 |

Table 11-14 Present Value of Net Cost for Prestressed Concrete Bridge

Unit: 1,000 Kyats

| Exchange Rate | | Case | Item \ Discount Rate | 0.03 | 0.06 | 0.09 | 0.12 | 0.15 |
|---|---|---|---|---|---|---|---|---|
| Official Rate | | 1 | Construction Cost | 615,994 | 540,699 | 476,997 | 422,789 | 376,406 |
| | | | Maintenance Cost | 15,267 | 9,802 | 5,424 | 3,532 | 2,404 |
| | | | (-) Asset Value in 2013 | 150,996 | 50,717 | 17,562 | 6,259 | 2,292 |
| | | | Net Cost | 480,265 | 499,784 | 464,859 | 420,062 | 376,518 |
| | | 2 | Construction Cost | 615,190 | 514,499 | 435,600 | 372,907 | 322,441 |
| | | | Maintenance Cost | 13,431 | 7,373 | 4,306 | 2,652 | 1,709 |
| | | | (-) Asset Value in 2013 | 166,210 | 55,827 | 19,332 | 6,889 | 2,523 |
| | | | Net Cost | 462,411 | 466,045 | 420,574 | 368,670 | 321,627 |
| | | 3 | Construction Cost | 584,193 | 471,784 | 390,879 | 330,772 | 284,792 |
| | | | Maintenance Cost | 11,846 | 6,305 | 3,580 | 2,153 | 1,364 |
| | | | (-) Asset Value in 2013 | 172,372 | 57,897 | 20,049 | 7,145 | 2,617 |
| | | | Net Cost | 423,667 | 420,192 | 374,410 | 325,780 | 283,539 |
| | | 2-2 | Construction Cost | 478,067 | 411,384 | 357,344 | 312,997 | 276,202 |
| | | | Maintenance Cost | 8,555 | 4,783 | 2,852 | 1,796 | 1,185 |
| | | | (-) Asset Value in 2013 | 125,869 | 42,277 | 14,640 | 5,217 | 1,910 |
| | | | Net Cost | 360,753 | 373,890 | 345,556 | 309,576 | 275,477 |
| | | 3-2 | Construction Cost | 465,909 | 394,732 | 340,018 | 296,779 | 261,804 |
| | | | Maintenance Cost | 8,208 | 4,550 | 2,694 | 1,688 | 1,110 |
| | | | (-) Asset Value in 2013 | 128,122 | 43,034 | 14,902 | 5,311 | 1,945 |
| | | | Net Cost | 345,995 | 356,248 | 327,810 | 293,156 | 260,969 |
| Shadow Rate | 1.50 | 1 | Construction Cost | 825,069 | 724,519 | 639,415 | 566,966 | 504,950 |
| | | | Maintenance Cost | 15,267 | 9,802 | 5,424 | 3,532 | 2,404 |
| | | | (-) Asset Value in 2013 | 202,918 | 68,157 | 23,601 | 8,412 | 3,081 |
| | | | Net Cost | 637,418 | 666,164 | 621,238 | 562,086 | 504,273 |
| | | 2 | Construction Cost | 826,770 | 692,798 | 587,612 | 503,868 | 436,327 |
| | | | Maintenance Cost | 13,431 | 7,373 | 4,306 | 2,652 | 1,709 |
| | | | (-) Asset Value in 2013 | 223,429 | 75,046 | 25,988 | 9,261 | 3,392 |
| | | | Net Cost | 616,772 | 625,125 | 565,930 | 497,259 | 434,644 |
| | | 3 | Construction Cost | 786,385 | 637,146 | 529,349 | 448,976 | 387,282 |
| | | | Maintenance Cost | 11,846 | 6,305 | 3,580 | 2,153 | 1,364 |
| | | | (-) Asset Value in 2013 | 231,429 | 77,734 | 26,918 | 9,594 | 3,514 |
| | | | Net Cost | 566,802 | 565,717 | 506,011 | 441,535 | 385,132 |
| | | 2-2 | Construction Cost | 650,065 | 559,901 | 486,742 | 426,637 | 376,713 |
| | | | Maintenance Cost | 8,555 | 4,783 | 2,852 | 1,796 | 1,185 |
| | | | (-) Asset Value in 2013 | 171,407 | 57,572 | 19,937 | 7,105 | 2,601 |
| | | | Net Cost | 487,213 | 507,112 | 469,657 | 421,328 | 375,297 |
| | | 3-2 | Construction Cost | 633,957 | 537,840 | 463,791 | 405,155 | 357,644 |
| | | | Maintenance Cost | 8,208 | 4,550 | 2,694 | 1,688 | 1,110 |
| | | | (-) Asset Value in 2013 | 174,378 | 58,571 | 20,282 | 7,229 | 2,647 |
| | | | Net Cost | 467,787 | 483,819 | 446,203 | 399,614 | 356,107 |
| | 1.75 | 1 | Construction Cost | 929,606 | 816,427 | 720,622 | 639,053 | 569,221 |
| | | | Maintenance Cost | 15,267 | 9,802 | 5,424 | 3,532 | 2,404 |
| | | | (-) Asset Value in 2013 | 228,880 | 76,877 | 26,621 | 9,487 | 3,474 |
| | | | Net Cost | 715,993 | 749,352 | 699,425 | 633,098 | 568,151 |
| | | 2 | Construction Cost | 932,559 | 781,946 | 663,616 | 569,347 | 493,271 |
| | | | Maintenance Cost | 13,431 | 7,373 | 4,306 | 2,652 | 1,709 |
| | | | (-) Asset Value in 2013 | 252,038 | 84,655 | 29,315 | 10,446 | 3,826 |
| | | | Net Cost | 693,952 | 704,664 | 638,607 | 561,553 | 491,154 |
| | | 3 | Construction Cost | 887,481 | 719,827 | 598,585 | 508,077 | 438,525 |
| | | | Maintenance Cost | 11,846 | 6,305 | 3,580 | 2,153 | 1,364 |
| | | | (-) Asset Value in 2013 | 260,956 | 87,651 | 30,353 | 10,817 | 3,962 |
| | | | Net Cost | 638,371 | 638,481 | 571,812 | 499,413 | 435,927 |
| | | 2-2 | Construction Cost | 736,063 | 634,159 | 551,440 | 483,456 | 426,969 |
| | | | Maintenance Cost | 8,555 | 4,783 | 2,852 | 1,796 | 1,185 |
| | | | (-) Asset Value in 2013 | 194,175 | 65,220 | 22,585 | 8,048 | 2,947 |
| | | | Net Cost | 550,443 | 573,722 | 531,707 | 477,204 | 425,207 |
| | | 3-2 | Construction Cost | 717,981 | 609,394 | 525,678 | 459,342 | 405,563 |
| | | | Maintenance Cost | 8,208 | 4,550 | 2,694 | 1,688 | 1,110 |
| | | | (-) Asset Value in 2013 | 197,505 | 66,339 | 22,972 | 8,187 | 2,998 |
| | | | Net Cost | 528,684 | 547,605 | 505,400 | 452,843 | 403,675 |

Table 11-15 Annual Benefit Derived from Diverted Passenger Traffic

Unit: 1,000 Kyats

| Item | | 1983 | 1988 | 1993 | 2003 | 2012 |
|---|---|---|---|---|---|---|
| Railway-Highway Bridge | Cost Saving | 946.7 | 1,127.9 | 1,443.9 | 2,032.0 | 2,929.2 |
| | Time Saving | 812.3 | 950.4 | 1,531.5 | 3,086.5 | 7,126.2 |
| | Total | 1,759.0 | 2,078.3 | 2,975.4 | 5,118.5 | 10,055.4 |
| Highway Bridge | Cost Saving | 896.3 | 1,068.7 | 1,383.0 | | |
| | Time Saving | 766.3 | 901.0 | 1,508.9 | | |
| | Total | 1,662.6 | 1,969.7 | 2,891.9 | | |

Table 11-16 Present Value of Benefit Derived from Diverted Passenger Traffic

Unit: 1,000 Kyats

| Discount Rate / Case | 0.03 | 0.06 | 0.09 | 0.12 | 0.15 |
|---|---|---|---|---|---|
| Case 1 | 61,975 | 31,307 | 17,124 | 10,065 | 6,295 |
| Case 2 | 61,599 | 31,024 | 16,910 | 9,901 | 6,158 |
| Case 3 | 61,273 | 30,812 | 16,769 | 9,806 | 6,104 |

Table 11-17 Annual Benefit Derived from Generated Passenger Traffic

Unit: 1,000 Kyats

| Item | 1983 | 1988 | 1993 | 2003 | 2012 |
|---|---|---|---|---|---|
| Railway-Highway Bridge | 4,606.9 | 6,075.7 | 8,597.4 | 18,112.2 | 37,492.4 |
| Highway Bridge | 4,540.2 | 5,988.3 | 8,450.3 | | |

Table 11-18 Present Value of Benefit Derived from Generated Passenger Traffic

Unit: 1,000 Kyats

| Discount Rate / Case | 0.03 | 0.06 | 0.09 | 0.12 | 0.15 |
|---|---|---|---|---|---|
| Case 1 | 204,737 | 100,678 | 53,605 | 30,729 | 18,802 |
| Case 2 | 204,460 | 100,470 | 53,448 | 30,609 | 18,709 |
| Case 3 | 204,112 | 100,245 | 53,300 | 30,510 | 18,643 |

Table 11-19 Annual Benefit Derived from Diverted Goods Traffic

Unit: 1,000 Kyats

| Item | | 1983 | 1988 | 1993 | 2003 | 2012 |
|---|---|---|---|---|---|---|
| Railway-Highway Bridge | Cost Saving | 1,925.3 | 2,126.5 | 2,479.6 | 3,256.8 | 4,154.8 |
| | Time Saving | 436.6 | 490.3 | 527.3 | 649.4 | 714.1 |
| | Total | 2,361.9 | 2,616.8 | 3,006.9 | 3,906.2 | 4,868.9 |
| Highway Bridge | Cost Saving | 339.0 | 390.7 | 490.8 | | |
| | Time Saving | 128.6 | 146.9 | 157.9 | | |
| | Total | 467.6 | 537.6 | 648.7 | | |

Table 11-20 Present Value of Benefit Derived from Diverted Goods Traffic

Unit: 1,000 Kyats

| Discount Rate / Case | 0.03 | 0.06 | 0.09 | 0.12 | 0.15 |
|---|---|---|---|---|---|
| Case 1 | 52,118 | 28,408 | 16,660 | 10,399 | 6,832 |
| Case 2 | 44,802 | 22,910 | 12,488 | 7,205 | 4,366 |
| Case 3 | 37,784 | 18,342 | 9,475 | 5,192 | 3,005 |

Table 11-21 Annual Direct Benefit Derived from Generated Goods Traffic

Unit: 1,000 Kyats

| Item | | 1983 | 1988 | 1993 | 2003 | 2012 |
|---|---|---|---|---|---|---|
| Railway-Highway Bridge | Cost Saving | - | 1,249.5 | 1,524.2 | 1,895.7 | 2,247.1 |
| | Time Saving | - | 288.1 | 324.1 | 378.0 | 386.2 |
| | Total | - | 1,537.6 | 1,848.3 | 2,273.7 | 2,633.3 |
| Highway Bridge | Cost Saving | - | 524.8 | 698.1 | | |
| | Time Saving | - | 197.3 | 224.6 | | |
| | Total | - | 722.1 | 922.7 | | |

Table 11-22 Present Value of Direct Benefit Derived from Generated Goods Traffic

Unit: 1,000 Kyats

| Discount Rate<br>Case | 0.03 | 0.06 | 0.09 | 0.12 | 0.15 |
|---|---|---|---|---|---|
| Case 1 | 28,494 | 15,208 | 8,702 | 5,291 | 3,387 |
| Case 2 | 26,691 | 13,840 | 7,655 | 4,484 | 2,859 |
| Case 3 | 23,934 | 12,086 | 6,472 | 3,693 | 2,325 |

Table 11-23 Annual Benefit Derived from Diverted Motor Vehicles Carried by Z-craft

Unit: 1,000 Kyats

| Item | 1983 | 1988 | 1993 | 2003 | 2012 |
|---|---|---|---|---|---|
| (A) Saving of Operating Cost of Z-Craft | 120.9 | 135.2 | 155.3 | 253.0 | 385.7 |
| (B) Increase of Driving Cost of Motor Vehicle | 32.9 | 38.8 | 47.2 | 79.6 | 133.8 |
| Cost Saving (A - B) | 88.0 | 96.4 | 108.1 | 173.4 | 251.9 |
| Time Saving | 36.1 | 46.4 · | 60.8 | 128.7 | 282.8 |

Table 11-24 Present Value of Benefit Derived from Diverted Motor Vehicles Carried by Z-craft

Unit: 1,000 Kyats

| Exchange Rate | | Discount Rate<br>Item | 0.03 | 0.06 | 0.09 | 0.12 | 0.15 |
|---|---|---|---|---|---|---|---|
| Official Rate | | (A) Utilisation of Existing Z-craft for Other Purposes | 1,736 | 1,380 | 1,104 | 888 | 719 |
| | | (B) Discontinued Investment in New Craft | 7,208 | 4,319 | 2,669 | 1,699 | 1,110 |
| | | (C) Cost Saving Shown in Table 11-23 | 2,152 | 1,142 | 654 | 401 | 260 |
| | | (D) Time Saving | 1,497 | 737 | 394 | 227 | 140 |
| | | Total | 12,593 | 7,578 | 4,821 | 3,215 | 2,229 |
| Shadow Rate | 1.50 | (A) Utilisation of Existing Z-craft for Other Purposes | 2,604 | 2,070 | 1,656 | 1,332 | 1,079 |
| | | (B) Discontinued Investment in New Craft | 10,812 | 6,478 | 4,004 | 2,549 | 1,665 |
| | | (C) Cost Saving Shown in Table 11-23 | 2,152 | 1,142 | 654 | 401 | 260 |
| | | (D) Time Saving | 1,497 | 737 | 394 | 227 | 140 |
| | | Total | 17,065 | 10,427 | 6,708 | 4,509 | 3,144 |
| | 1.75 | (A) Utilisation of Existing Z-craft for Other Purposes | 3,038 | 2,415 | 1,932 | 1,555 | 1,258 |
| | | (B) Discontinued Investment in New Craft | 12,615 | 7,558 | 4,671 | 2,973 | 1,943 |
| | | (C) Cost Saving Shown in Table 11-23 | 2,152 | 1,142 | 654 | 401 | 260 |
| | | (D) Time Saving | 1,497 | 737 | 394 | 227 | 140 |
| | | Total | 19,302 | 11,852 | 7,651 | 5,156 | 3,601 |

Table 11-25 Annual Cost Saving in Transport of Rolling Stock used on Bassein-Kyangin Railway

Unit: 1,000 Kyats

| | 1983 | 1988 | 1993 | 2003 | 2012 |
|---|---|---|---|---|---|
| Annual Amount | 91.0 | 98.8 | 112.9 | 177.5 | 244.2 |

Table 11-26 Present Value of Cost Saving in Transport of Rolling Stock used on Bassein-Kyangin Railway

Unit: 1,000 Kyats

| Discount Rate / Case | 0.03 | 0.06 | 0.09 | 0.12 | 0.15 |
|---|---|---|---|---|---|
| Case 1 | 2,194 | 1,168 | 672 | 413 | 268 |
| Case 2 | 1,844 | 905 | 472 | 260 | 150 |
| Case 3 | 1,509 | 687 | 329 | 164 | 85 |

Table 11-27 Annual Benefit Derived from Construction of Railway between Kyangin and Sinde (Passenger Traffic Only)

Unit: 1,000 Kyats

| Item | 1983 | 1988 | 1993 | 2003 | 2012 |
|---|---|---|---|---|---|
| Diverted Traffic | | | | | |
| Cost Saving | 92.6 | 110.4 | 125.7 | 181.8 | 259.2 |
| Time Saving | 168.8 | 200.2 | 346.4 | 720.2 | 1,402.2 |
| Generated Traffic | 190.0 | 222.9 | 457.2 | 1,176.3 | 2,753.3 |
| Total | 451.4 | 533.5 | 929.3 | 2,078.3 | 4,414.7 |

Note: Benefit of passenger traffic passing over the Bridge is excluded.

Table 11-28 Present Value of Benefit Derived from Construction of Railway between Kyangin and Sinde (Passenger Traffic Only)

Unit: 1,000 Kyats

| Discount Rate / Case | 0.03 | 0.06 | 0.09 | 0.12 | 0.15 |
|---|---|---|---|---|---|
| Case 1 | 22,617 | 10,918 | 5,698 | 3,202 | 1,923 |
| Case 2 | 20,821 | 9,570 | 4,676 | 2,420 | 1,320 |
| Case 3 | 18,669 | 8,177 | 3,761 | 1,812 | 910 |

Note: Benefit of passenger traffic passing over the Bridge is excluded.

Table 11-29 Total of Present Value of Direct Benefits

Unit: 1,000 Kyats

| Case | Item | | Discount Rate | No. | 0.03 | 0.06 | 0.09 | 0.12 | 0.15 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Traffic Passing Over the Bridge | Passenger | Diverted Traffic | 1 | 61,975 | 31,307 | 17,124 | 10,065 | 6,295 |
| | | | Generated Traffic | 2 | 204,737 | 100,678 | 53,605 | 30,729 | 18,802 |
| | | Goods | Diverted Traffic | 3 | 53,118 | 28,408 | 16,660 | 10,399 | 6,832 |
| | | | Generated Traffic | 4 | 28,494 | 15,208 | 8,702 | 5,291 | 3,387 |
| | | Motor Vehicle Diverted from Z-craft | Official Rate | 5-A | 12,593 | 7,578 | 4,821 | 3,215 | 2,229 |
| | | | Shadow Rate (1.5) | 5-B | 17,065 | 10,427 | 6,708 | 4,509 | 3,144 |
| | | | Shadow Rate (1.75) | 5-C | 19,302 | 11,852 | 7,651 | 5,156 | 3,601 |
| | Others | Cost Saving in Bassein-Kyangin Railway | | 6 | 2,194 | 1,168 | 672 | 413 | 268 |
| | | Benefit Derived from Construction of Kyangin-Sinde Railway | | 7 | 22,617 | 10,918 | 5,698 | 3,202 | 1,923 |
| | Total | | Official Rate | 8-A | 384,728 | 195,265 | 107,282 | 63,314 | 39,736 |
| | | | Shadow Rate (1.5) | 8-B | 389,200 | 198,114 | 109,169 | 64,608 | 40,651 |
| | | | Shadow Rate (1.75) | 8-C | 391,437 | 199,539 | 110,112 | 65,255 | 41,108 |
| 2 | Traffic Passing over the Bridge | Passenger | Diverted Traffic | 1 | 61,599 | 31,024 | 16,910 | 9,901 | 6,168 |
| | | | Generated Traffic | 2 | 204,460 | 100,470 | 53,448 | 30,609 | 18,709 |
| | | Goods | Diverted Traffic | 3 | 44,802 | 22,910 | 12,488 | 7,205 | 4,366 |
| | | | Generated Traffic | 4 | 26,691 | 13,840 | 7,655 | 4,484 | 2,859 |
| | | Motor Vehicle Diverted from Z-Craft | Official Rate | 5-A | 12,593 | 7,578 | 4,821 | 3,215 | 2,229 |
| | | | Shadow Rate (1.5) | 5-B | 17,065 | 10,427 | 6,708 | 4,509 | 3,144 |
| | | | Shadow Rate (1.75) | 5-C | 19,302 | 11,852 | 7,651 | 5,156 | 3,601 |
| | Others | Cost Saving in Bassein-Kyangin Railway | | 6 | 1,844 | 905 | 472 | 260 | 150 |
| | | Benefit Derived from Construction of Kyangin-Sinde Railway | | 7 | 20,821 | 9,570 | 4,676 | 2,420 | 1,320 |
| | Total I (No. 7 Included) | | Official Rate | 8-A | 372,810 | 186,297 | 100,470 | 58,094 | 35,801 |
| | | | Shadow Rate (1.5) | 8-B | 377,282 | 189,146 | 102,357 | 59,388 | 36,716 |
| | | | Shadow Rate (1.75) | 8-C | 379,519 | 197,571 | 103,300 | 60,035 | 37,173 |
| | Total II (No. 7 Excluded) | | Official Rate | 9-A | 351,989 | 176,727 | 95,794 | 55,674 | 34,481 |
| | | | Shadow Rate (1.5) | 9-B | 356,461 | 179,576 | 97,681 | 56,968 | 35,396 |
| | | | Shadow Rate (1.75) | 9-C | 358,698 | 181,001 | 98,624 | 57,615 | 35,853 |
| 3 | Traffic Passing Over the Bridge | Passenger | Diverted Traffic | 1 | 61,273 | 30,812 | 16,769 | 9,806 | 6,104 |
| | | | Generated Traffic | 2 | 204,112 | 100,245 | 53,300 | 30,510 | 18,643 |
| | | Goods | Diverted Traffic | 3 | 37,784 | 18,342 | 9,475 | 5,192 | 3,005 |
| | | | Generated Traffic | 4 | 23,934 | 12,086 | 6,472 | 3,693 | 2,325 |
| | | Motor Vehicle Diverted from Z-Craft | Official Rate | 5-A | 12,593 | 7,578 | 4,821 | 3,215 | 2,229 |
| | | | Shadow Rate (1.5) | 5-B | 17,065 | 10,427 | 6,708 | 4,509 | 3,144 |
| | | | Shadow Rate (1.75) | 5-C | 19,302 | 11,852 | 7,651 | 5,156 | 3,601 |
| | Others | Cost Saving in Bassein-Kyangin Railway | | 6 | 1,509 | 687 | 329 | 164 | 85 |
| | | Benefit Derived from Construction of Railway | | 7 | 18,669 | 8,177 | 3,761 | 1,812 | 910 |
| | Total I (No. 7 Included) | | Official Rate | 8-A | 359,874 | 177,927 | 94,927 | 54,392 | 33,301 |
| | | | Shadow Rate (1.5) | 8-B | 364,346 | 180,776 | 96,814 | 55,686 | 34,216 |
| | | | Shadow Rate (1.75) | 8-C | 366,583 | 182,201 | 97,757 | 56,333 | 34,673 |
| | Tatal II (No. 7 Excluded) | | Official Rate | 9-A | 341,205 | 169,750 | 91,166 | 52,580 | 32,391 |
| | | | Shadow Rate (1.5) | 9-B | 345,677 | 172,599 | 93,053 | 53,874 | 33,306 |
| | | | Shadow Rate (1.75) | 9-C | 347,914 | 174,024 | 93,996 | 54,521 | 33,763 |

Table 11-30 Overall Analysis of Cost and Benefit (Steel Bridge)

Unit: 1,000 Kyats

| Exchange Rate | | Case | Item \ Discount Rate | 0.03 | 0.06 | 0.09 | 0.12 | 0.15 |
|---|---|---|---|---|---|---|---|---|
| Official Rate | | 1 | Present Value of Net Cost | 456,618 | 466,474 | 431,052 | 388,331 | 347,471 |
| | | | Present Value of Direct Benefit | 384,728 | 195,265 | 107,282 | 63,314 | 39,736 |
| | | | Benefit Cost Ratio | 0.843 | 0.419 | 0.249 | 0.163 | 0.114 |
| | | | Internal Rate of Return (%) | 2.44 | | | | |
| | | 2 | Present Value of Net Cost | 419,222 | 411,094 | 365,332 | 316,588 | 273,062 |
| | | | Present Value of Direct Benefit | 372,810 | 186,297 | 100,470 | 58,094 | 35,801 |
| | | | Benefit Cost Ratio | 0.889 | 0.453 | 0.275 | 0.184 | 0.131 |
| | | | Internal Rate of Return (%) | 2.60 | | | | |
| | | 3 | Present Value of Net Cost | 377,200 | 362,039 | 316,072 | 270,807 | 232,364 |
| | | | Present Value of Direct Benefit | 359,874 | 177,927 | 94,927 | 54,392 | 33,301 |
| | | | Benefit Cost Ratio | 0.954 | 0.491 | 0.300 | 0.201 | 0.143 |
| | | | Internal Rate of Return (%) | 2.81 | | | | |
| | | 2-2 | Present Value of Net Cost | 317,564 | 318,939 | 290,314 | 257,494 | 226,912 |
| | | | Present Value of Direct Benefit | 351,989 | 176,727 | 95,794 | 55,674 | 34,481 |
| | | | Benefit Cost Ratio | 1.108 | 0.554 | 0.330 | 0.216 | 0.152 |
| | | | Internal Rate of Return (%) | 3.30 | | | | |
| | | 3-2 | Present Value of Net Cost | 299,528 | 298,095 | 269,472 | 238,183 | 209,794 |
| | | | Present Value of Direct Benefit | 341,205 | 169,750 | 91,166 | 52,580 | 32,391 |
| | | | Benefit Cost Ratio | 1.139 | 0.569 | 0.338 | 0.221 | 0.154 |
| | | | Internal Rate of Return (%) | 3.38 | | | | |
| Shadow Rate | 1.50 | 1 | Present Value of Net Cost | 606,082 | 622,213 | 576,631 | 520,200 | 465,899 |
| | | | Present Value of Direct Benefit | 389,200 | 198,114 | 109,169 | 64,608 | 40,651 |
| | | | Benefit Cost Ratio | 0.642 | 0.318 | 0.189 | 0.124 | 0.087 |
| | | | Internal Rate of Return (%) | 1.63 | | | | |
| | | 2 | Present Value of Net Cost | 558,477 | 551,027 | 491,349 | 426,817 | 369,011 |
| | | | Present Value of Direct Benefit | 377,282 | 189,146 | 102,357 | 59,388 | 36,716 |
| | | | Benefit Cost Ratio | 0.676 | 0.343 | 0.208 | 0.139 | 0.099 |
| | | | Internal Rate of Return (%) | 1.75 | | | | |
| | | 3 | Present Value of Net Cost | 503,849 | 486,907 | 426,821 | 366,769 | 315,588 |
| | | | Present Value of Direct Benefit | 364,346 | 180,776 | 96,814 | 55,686 | 34,216 |
| | | | Benefit Cost Ratio | 0.723 | 0.371 | 0.227 | 0.152 | 0.108 |
| | | | Internal Rate of Return (%) | 1.91 | | | | |
| | | 2-2 | Present Value of Net Cost | 428,918 | 433,014 | 395,076 | 350,886 | 309,664 |
| | | | Present Value of Direct Benefit | 356,461 | 179,576 | 97,681 | 56,968 | 35,396 |
| | | | Benefit Cost Ratio | 0.831 | 0.415 | 0.247 | 0.162 | 0.114 |
| | | | Internal Rate of Return (%) | 2.41 | | | | |
| | | 3-2 | Present Value of Net Cost | 404,834 | 405,009 | 367,013 | 324,848 | 286,563 |
| | | | Present Value of Direct Benefit | 345,677 | 172,599 | 93,053 | 53,874 | 33,306 |
| | | | Benefit Cost Ratio | 0.854 | 0.426 | 0.254 | 0.166 | 0.116 |
| | | | Internal Rate of Return (%) | 2.49 | | | | |
| | 1.75 | 1 | Present Value of Net Cost | 680,813 | 700,083 | 649,419 | 586,134 | 525,114 |
| | | | Present Value of Direct Benefit | 391,437 | 199,539 | 110,112 | 65,255 | 41,108 |
| | | | Benefit Cost Ratio | 0.575 | 0.285 | 0.170 | 0.111 | 0.078 |
| | | | Internal Rate of Return (%) | 1.36 | | | | |
| | | 2 | Present Value of Net Cost | 628,102 | 620,996 | 554,355 | 481,929 | 416,987 |
| | | | Present Value of Direct Benefit | 379,519 | 197,571 | 103,300 | 60,035 | 37,173 |
| | | | Benefit Cost Ratio | 0.604 | 0.318 | 0.186 | 0.125 | 0.089 |
| | | | Internal Rate of Return (%) | 1.46 | | | | |
| | | 3 | Present Value of Net Cost | 567,173 | 549,358 | 482,195 | 414,751 | 357,199 |
| | | | Present Value of Direct Benefit | 366,583 | 182,201 | 97,757 | 56,333 | 34,673 |
| | | | Benefit Cost Ratio | 0.646 | 0.332 | 0.203 | 0.136 | 0.097 |
| | | | Internal Rate of Return (%) | 1.62 | | | | |
| | | 2-2 | Present Value of Net Cost | 484,593 | 490,054 | 447,455 | 397,580 | 351,040 |
| | | | Present Value of Direct Benefit | 358,698 | 181,001 | 98,624 | 57,615 | 35,853 |
| | | | Benefit Cost Ratio | 0.740 | 0.369 | 0.220 | 0.145 | 0.102 |
| | | | Internal Rate of Return (%) | 2.07 | | | | |
| | | 3-2 | Present Value of Net Cost | 457,486 | 458,482 | 415,783 | 368,181 | 324,947 |
| | | | Present Value of Direct Benefit | 347,914 | 174,024 | 93,996 | 54,521 | 33,763 |
| | | | Benefit Cost Ratio | 0.760 | 0.380 | 0.226 | 0.148 | 0.104 |
| | | | Internal Rate of Return (%) | 2.15 | | | | |

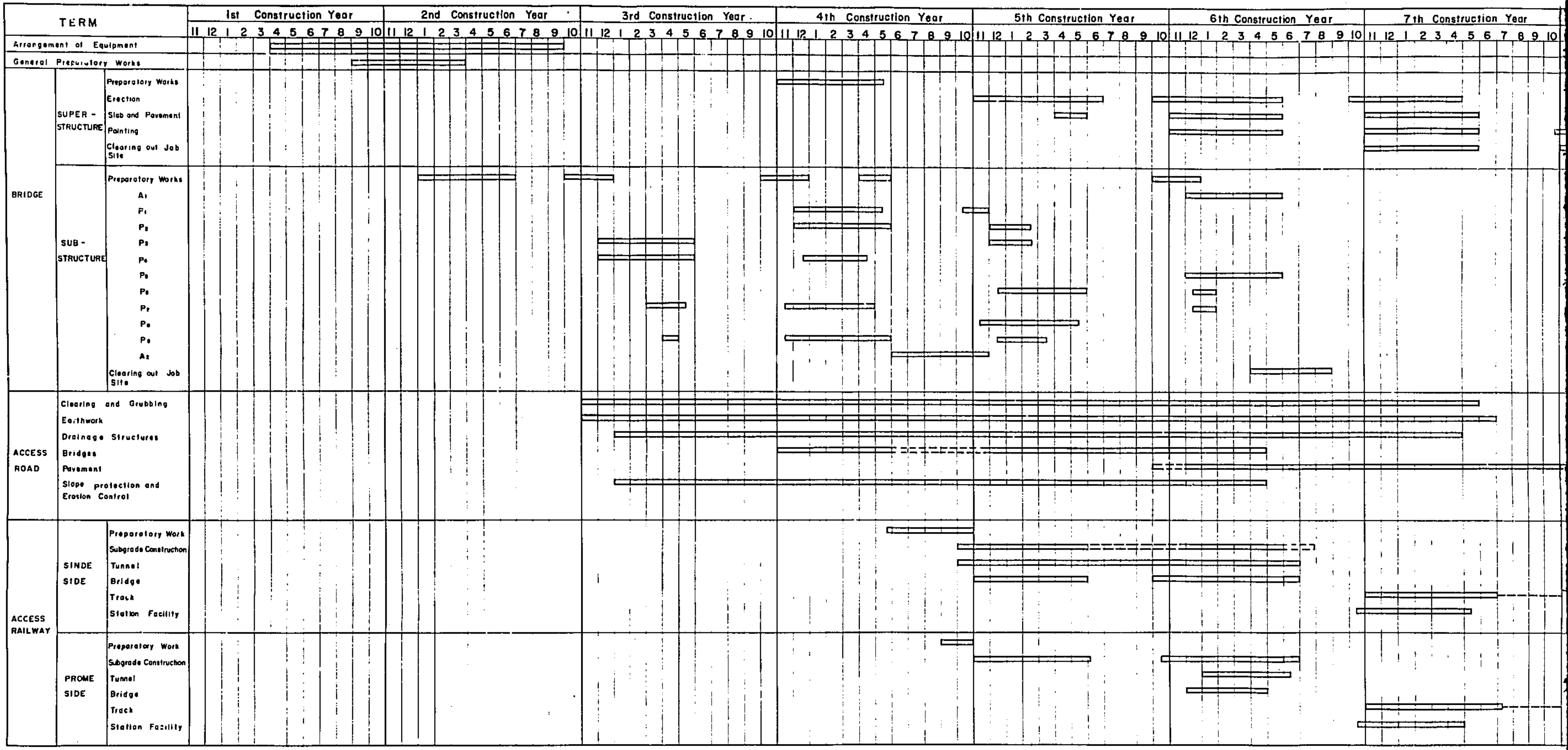
Table 11-31 Overall Analysis of Cost and Benefit (Prestressed Concrete Bridge)

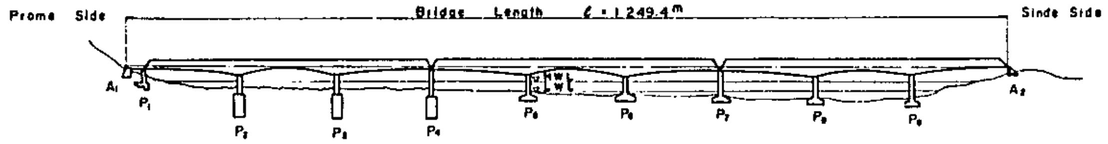
Unit: 1,000 Kyats

| Exchange Rate | | Case | Item \ Discount Rate | 0.03 | 0.06 | 0.09 | 0.12 | 0.15 |
|---|---|---|---|---|---|---|---|---|
| Official Rate | | 1 | Present Value of Net Cost | 480,265 | 499,784 | 464,859 | 420,062 | 376,518 |
| | | | Present Value of Direct Benefit | 384,728 | 195,265 | 107,282 | 63,314 | 39,736 |
| | | | Benefit Cost Ratio | 0.801 | 0.391 | 0.231 | 0.151 | 0.106 |
| | | | Internal Rate of Return (%) | 2.32 | | | | |
| | | 2 | Present Value of Net Cost | 462,411 | 466,045 | 420,574 | 368,670 | 321,627 |
| | | | Present Value of Direct Benefit | 372,810 | 186,297 | 100,470 | 58,094 | 35,801 |
| | | | Benefit Cost Ratio | 0.806 | 0.400 | 0.239 | 0.158 | 0.111 |
| | | | Internal Rate of Return (%) | 2.33 | | | | |
| | | 3 | Present Value of Net Cost | 423,667 | 420,192 | 374,410 | 325,780 | 283,539 |
| | | | Present Value of Direct Benefit | 359,874 | 177,927 | 94,927 | 54,392 | 33,301 |
| | | | Benefit Cost Ratio | 0.849 | 0.423 | 0.254 | 0.167 | 0.117 |
| | | | Internal Rate of Return (%) | 2.48 | | | | |
| | | 2-2 | Present Value of Net Cost | 360,753 | 373,890 | 345,556 | 309,576 | 275,477 |
| | | | Present Value of Direct Benefit | 351,989 | 176,727 | 95,794 | 55,674 | 34,481 |
| | | | Benefit Cost Ratio | 0.976 | 0.473 | 0.277 | 0.180 | 0.125 |
| | | | Internal Rate of Return (%) | 2.89 | | | | |
| | | 3-2 | Present Value of Net Cost | 345,995 | 356,248 | 327,810 | 293,156 | 260,969 |
| | | | Present Value of Direct Benefit | 341,205 | 169,750 | 91,166 | 52,580 | 32,391 |
| | | | Benefit Cost Ratio | 0.986 | 0.476 | 0.278 | 0.179 | 0.124 |
| | | | Internal Rate of Return (%) | 2.92 | | | | |
| Shadow Rate | 1.50 | 1 | Present Value of Net Cost | 637,418 | 666,164 | 621,238 | 562,086 | 504,273 |
| | | | Present Value of Direct Benefit | 389,200 | 198,114 | 109,169 | 64,608 | 40,651 |
| | | | Benefit Cost Ratio | 0.611 | 0.297 | 0.176 | 0.115 | 0.081 |
| | | | Internal Rate of Return (%) | 1.56 | | | | |
| | | 2 | Present Value of Net Cost | 616,772 | 625,125 | 565,930 | 497,259 | 434,644 |
| | | | Present Value of Direct Benefit | 377,282 | 189,146 | 102,357 | 59,388 | 36,716 |
| | | | Benefit Cost Ratio | 0.612 | 0.303 | 0.181 | 0.119 | 0.084 |
| | | | Internal Rate of Return (%) | 1.56 | | | | |
| | | 3 | Present Value of Net Cost | 566,802 | 565,717 | 506,011 | 441,535 | 385,132 |
| | | | Present Value of Direct Benefit | 364,346 | 180,776 | 96,814 | 55,686 | 34,216 |
| | | | Benefit Cost Ratio | 0.643 | 0.320 | 0.191 | 0.126 | 0.089 |
| | | | Internal Rate of Return (%) | 1.67 | | | | |
| | | 2-2 | Present Value of Net Cost | 487,213 | 507,112 | 469,657 | 421,328 | 375,297 |
| | | | Present Value of Direct Benefit | 356,461 | 179,576 | 97,681 | 56,968 | 35,396 |
| | | | Benefit Cost Ratio | 0.732 | 0.354 | 0.208 | 0.135 | 0.094 |
| | | | Internal Rate of Return (%) | 2.09 | | | | |
| | | 3-2 | Present Value of Net Cost | 467,787 | 483,819 | 446,203 | 399,614 | 356,107 |
| | | | Present Value of Direct Benefit | 345,677 | 172,599 | 93,053 | 53,874 | 33,306 |
| | | | Benefit Cost Ratio | 0.739 | 0.357 | 0.209 | 0.135 | 0.094 |
| | | | Internal Rate of Return (%) | 2.12 | | | | |
| | 1.75 | 1 | Present Value of Net Cost | 715,993 | 749,352 | 699,425 | 633,098 | 568,151 |
| | | | Present Value of Direct Benefit | 391,437 | 199,539 | 110,112 | 65,255 | 41,108 |
| | | | Benefit Cost Ratio | 0.547 | 0.266 | 0.157 | 0.103 | 0.072 |
| | | | Internal Rate of Return (%) | 1.31 | | | | |
| | | 2 | Present Value of Net Cost | 693,952 | 704,664 | 638,607 | 561,553 | 491,154 |
| | | | Present Value of Direct Benefit | 379,519 | 197,571 | 103,300 | 60,035 | 37,173 |
| | | | Benefit Cost Ratio | 0.547 | 0.280 | 0.162 | 0.107 | 0.076 |
| | | | Internal Rate of Return (%) | 1.31 | | | | |
| | | 3 | Present Value of Net Cost | 638,371 | 638,481 | 571,812 | 499,413 | 435,927 |
| | | | Present Value of Direct Benefit | 366,583 | 182,201 | 97,757 | 56,333 | 34,673 |
| | | | Benefit Cost Ratio | 0.574 | 0.285 | 0.171 | 0.113 | 0.080 |
| | | | Internal Rate of Return (%) | 1.41 | | | | |
| | | 2-2 | Present Value of Net Cost | 550,443 | 573,722 | 531,707 | 477,204 | 425,207 |
| | | | Present Value of Direct Benefit | 358,698 | 181,001 | 98,624 | 57,615 | 35,853 |
| | | | Benefit Cost Ratio | 0.652 | 0.315 | 0.185 | 0.121 | 0.084 |
| | | | Internal Rate of Return (%) | 1.74 | | | | |
| | | 3-2 | Present Value of Net Cost | 528,684 | 547,605 | 505,400 | 452,843 | 403,675 |
| | | | Present Value of Direct Benefit | 347,914 | 174,024 | 93,996 | 54,521 | 33,763 |
| | | | Benefit Cost Ratio | 0.658 | 0.318 | 0.186 | 0.120 | 0.084 |
| | | | Internal Rate of Return (%) | 1.76 | | | | |

# CONSTRUCTION SCHEDULE ( STEEL BRIDGE )

## IRRAWADDY RIVER BRIDGE PROJECT





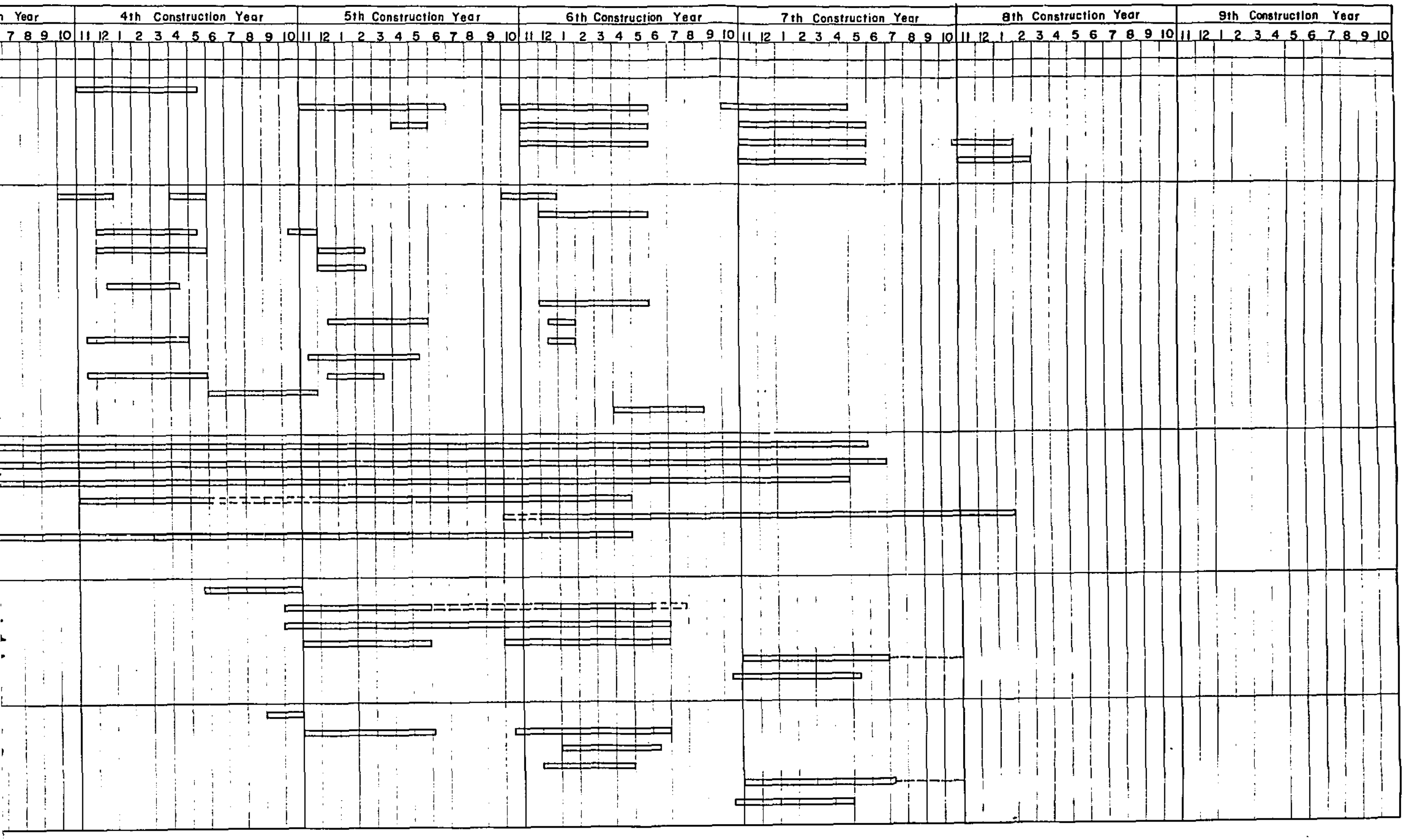
Legend

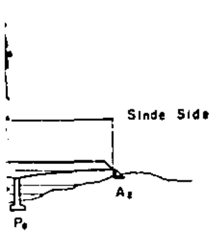
1 — January
2 — February
12 — December

Notes

1. Arrangement of Equipment includes Purchase, Shipment, etc.
2 General Preparatory Works includes Office, Residence, Water Suplly, Electricity, Repair Shop, Stock Yard, Roadway used by Wheeled Traffic, Installation of Quarry, etc
3 The dry season is from the middle of October to the middle of May of next year. Any other months are in wet season

## STRUCTION SCHEDULE ( STEEL BRIDGE )





Legend

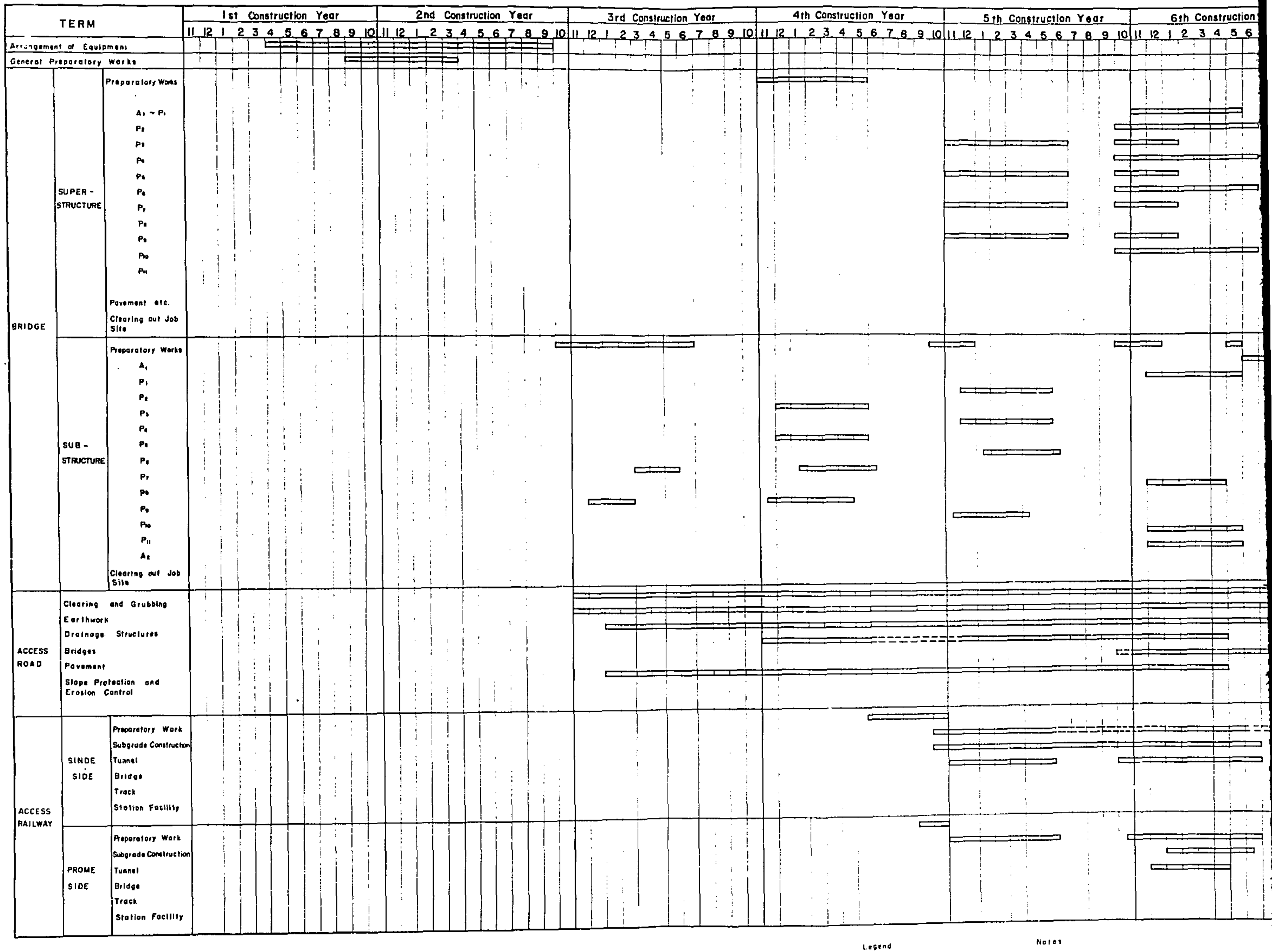
1 — January
2 — February
12 — December

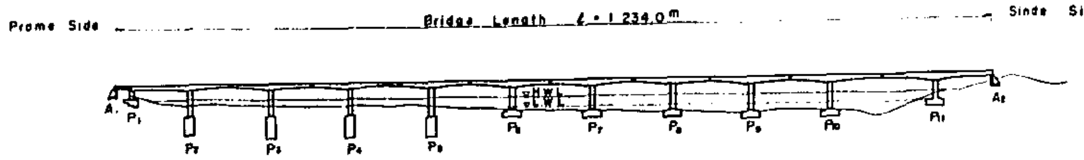
Notes

1. Arrangement of Equipment includes Purchase, Shipment, etc.
2 General Preparatory Works includes Office, Residence, Water Suplly, Electricity, Repair Shop, Stock Yard, Roadway used by Wheeled Traffic, Installation of Quarry, etc
3 The dry season is from the middle of October to the middle of May of next year. Any other months are in wet season

IRRAWADDY RIVER BRIDGE PROJECT

# CONSTRUCTION SCHEDULE ( PRESTRESSED CONCRETE BRIDGE )





Legend

1 —— January
2 —— February
12 —— December

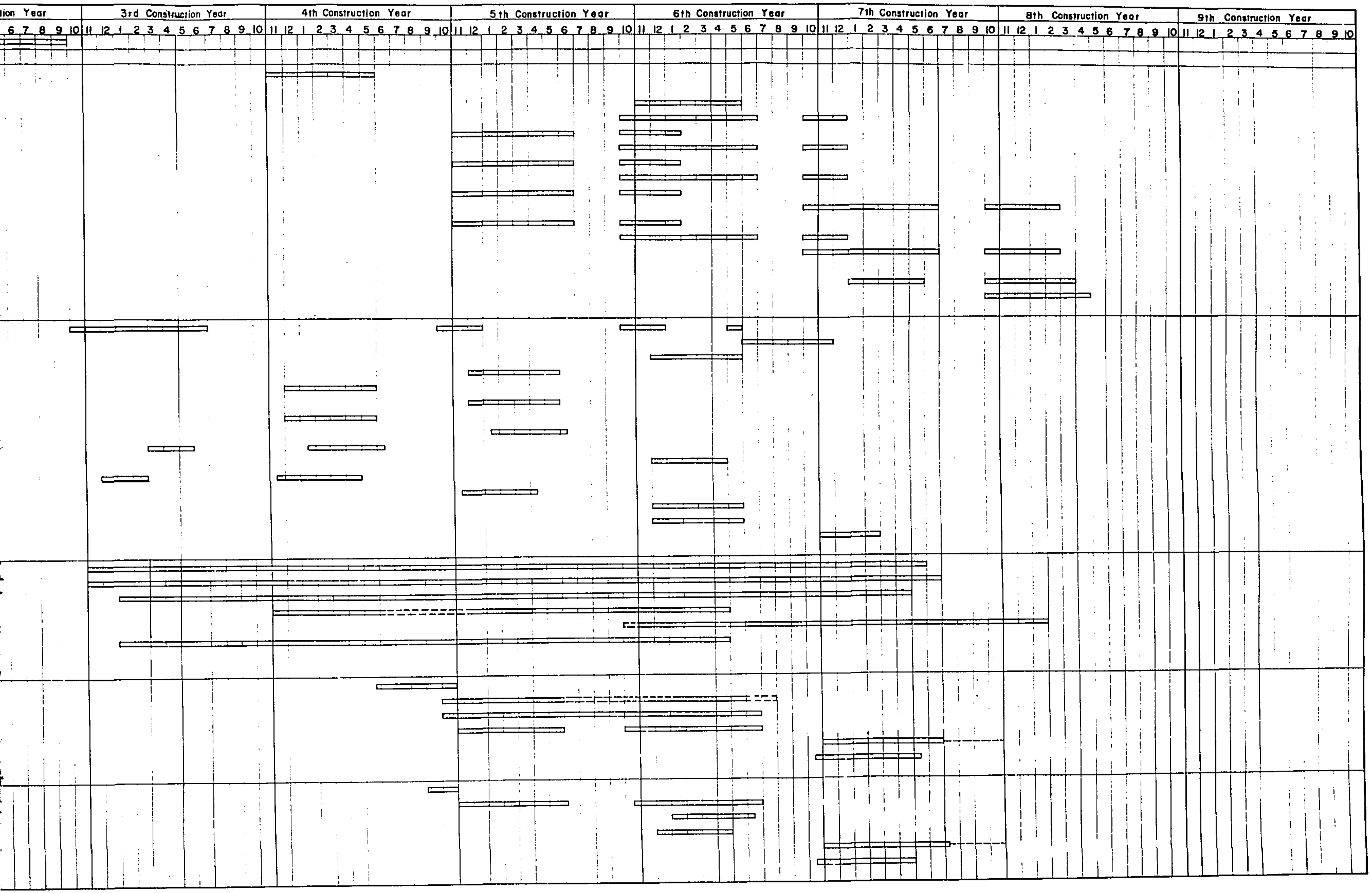
Notes

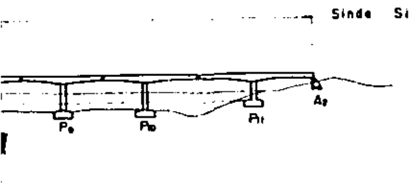
1 Arrangement of Equipment Includes Purchas

2 General Preparatory Works Includes Office, R
Stock Yard, Roadway used by Wheeled Traffi

3 The dry season is from the middle of Octo
other months are in wet season

## CONSTRUCTION SCHEDULE ( PRESTRESSED CONCRETE BRIDGE )





Legend

1 — January

2 — Februdry

12 — December

Notes

1 Arrangement of Equipment includes Purchase, Shipment, etc

2 General Preparatory Works includes Office, Residence, Water Suplly, Electricity, Repuir Shop, Stock Yard, Roadway used by Wheeled Traffic, Installation of Quarry. etc

3 The dry season is from the middle of October to the middle of May of next year. Any other months are in wet season