In mining, processing and manufacturing, Magwe, Mandalay, and some surrounding Divisions will increase their shares substantially, but Rangoon and Irrawaddy will show only modest increases. (See Appendix Table 2.3.3.2)

(3) DIA Share Relative to the National Output

Shares of GRP in agriculture will rise in Sagaing, Mandalay, Irrawaddy and Magwe, and will decline in Rangoon, Pegu and many surrounding divisions. In other primary industries, shares of GRP in Magwe, Mandalay and Pegu will rise, while those for Irrawaddy, and Rangoon will decline.

In mining, processing and manufacturing, Mandalay, Sagaing and Magwe will raise their shares relative to the whole country, while Rangoon, Pegu and Irrawaddy will reduce their share. In trade and services, shares of Rangoon will continue to rise. (See Appendix Table 2.3.3.3)

(4) Per Capita Gross Regional Product

The per capita GRP differential will be reduced only marginally. Sagaing and Magwe will raise their relative levels, while Rangoon and Pegu will see their relative positions decline.

However, Rangoon will remain at 1.5 times the per capita GRP, followed by Irrawaddy and Pegu, several points above the nationwide average in 2010/11. Surrounding Divisions will range between 3/5 and 3/4 of the per capita GRP in 2010/11. (See Table 2.3.7)

2.3.4 Estimated Gross Regional Product and Population by Zone, DIA

Forecast GRP by State/Division has been divided into the zones of the DIA. Economic statistical data were provided by Department of Planning (MOFP). The method of dividing is stated in Appendix 2.6 and the result is summarized in Table 2.3.10.

In the Direct Influence Area, the GRP is forecast to grow at 4.55% per annum from 1985/86 to 2010/11. And population is estimated to grow at 1.85% per annum in the same period.

Table 2.3.8 ESTIMATED GRP AND POPULATION BY ZONE, DIA

(In million Kyat, 1985/86 prices)

	Tharrawaddy 2	Prome 3	Padaung 4	Myede 5	Thayet 6	Magwe 7	Minbu 8	Pakokku 11	Kyangin 1	Salingyi 20	Nyaung U 10	Total
Gross Divisional Domestic Product												
1985/86	1,257.9	1,677.5	267.7	338.7	510.5	2,125.4	998.3	1,438.1	1,068.5	1,000.4	1,352.6	12,046.6
1990/91	1,509.9	2,093.4	343.4	451.6	658.1	2,722.1	1,277.4	1,834.4	1,310.7	1,290.1	1,723.5	15,214.5
2000/01	2,143.5	3,175.6	545.8	716.8	992.5	4,237.7	2,006.4	2,873.5	1,974.8	2,052.8	2,692.3	23,407.7
2010/11	3,235.0	5,061.6	900.2	1,189.9	1,556.8	6,821.1	3,293.1	4,700.1	3,125.7	3,352.0	4,310.1	37,545.6
1985/86 - 2000/01[1]	3.6%	4.3%	4.9%	5.1%	4.5%	4.7%	4.8%	4.7%	4.2%	4.9%	4.7%	4.5%
2000/01 - 2010/11[1]	4.2%	4.8%	5.1%	4.2%	4.6%	4.9%	5.1%	5.0%	4.6%	5.0%	4.8%	4.8%
Population in Persons												
1985/86	822,300	815,300	138,900	276,743	321,359	1,124,549	631,844	1,045,505	634,371	630,463	948,503	7,390,197
1990/91	883,430	885,386	156,734	314,781	355,842	1,245,834	695,888	1,148,656	693,172	699,116	1,044,027	8,122,866
2000/01	1,005,792	1,042,483	199,244	405,646	434,579	1,523,003	840,767	1,381,005	824,505	858,013	1,262,226	9,777,263
2010/11	1,149,012	1,226,689	253,126	520,454	528,415	1,853,689	1,011,363	1,653,080	978,759	1,049,994	1,518,393	11,742,974
1985/86 - 2000/01[1]	1.39%	1.66%	2.44%	2.59%	2.04%	2.05%	1.93%	1.88%	1.77%	2.08%	1.93%	1.88%
2000/01 - 2010/11[1]	1.33%	1.64%	2.43%	2.54%	1.99%	2.00%	1.88%	1.83%	1.74%	2.04%	1.89%	1.85%

From Appendix 2.6

Note: 1 The rate of increase is shown in average annual increase in percentage.

CHAPTER 3 REGIONAL DEVELOPMENT AND THE COMPLETION OF THE BRIDGE PROJECT

CHAPTER 3 REGIONAL DEVELOPMENT AND THE COMPLETION OF THE BRIDGE PROJECT

3.1 General

The direct influence area on both sides of the Irrawaddy River can achieve greater economic development if the bridge project is completed. An integrated economic development plan for the area by the Government of Burma is still in process. However, even in its rough conceptural form it suggests projects that can be used in this study to prepare a vision of development related to the completion of the bridge project.

The proposed development vision in this chapter is a forecast for the year 2010. Zones in the direct influence area are studied extensively, and Chin and Rakhine States were added in the forecast because of the development caused by the direct land transportation linkage to the east side of the River after the bridge completion.

An input-output table for the Burmese economy is not formulated yet. No inter-industrial relationship data using the matrix co-efficient are available. Important available data includes values for gross output and gross domestic product/expenditure for the whole country from the Report to The Pyithu Hluttaw. The development vision of DIA in this study is shown in the forecast of GRP in 2000 and 2010. From this increased GRP, development benefits attributable to the project bridge can be determined. The estimated development benefits are added into the benefit streams of the project as shown in Chapter 10, where B/C ratio, IRR and PW are analyzed.

3.2 Economic Activities

3.2.1 Existing Economy in the Divisions

The existing economic activities of the influence area have been studied in 2.3 Influence Area of the Project, Chapter 2, which discussed resources, population and sectoral characteristics for the Divisions of Rangoon, Irrawaddy, Pegu, Magwe, Mandalay, Sagaing, Rakhine and Chin.

The economy in the direct influence area is studied by breaking down the Divisional figures into zonal figures. Main characteristics of zones in the direct influence area are stated in the following paragraphs.

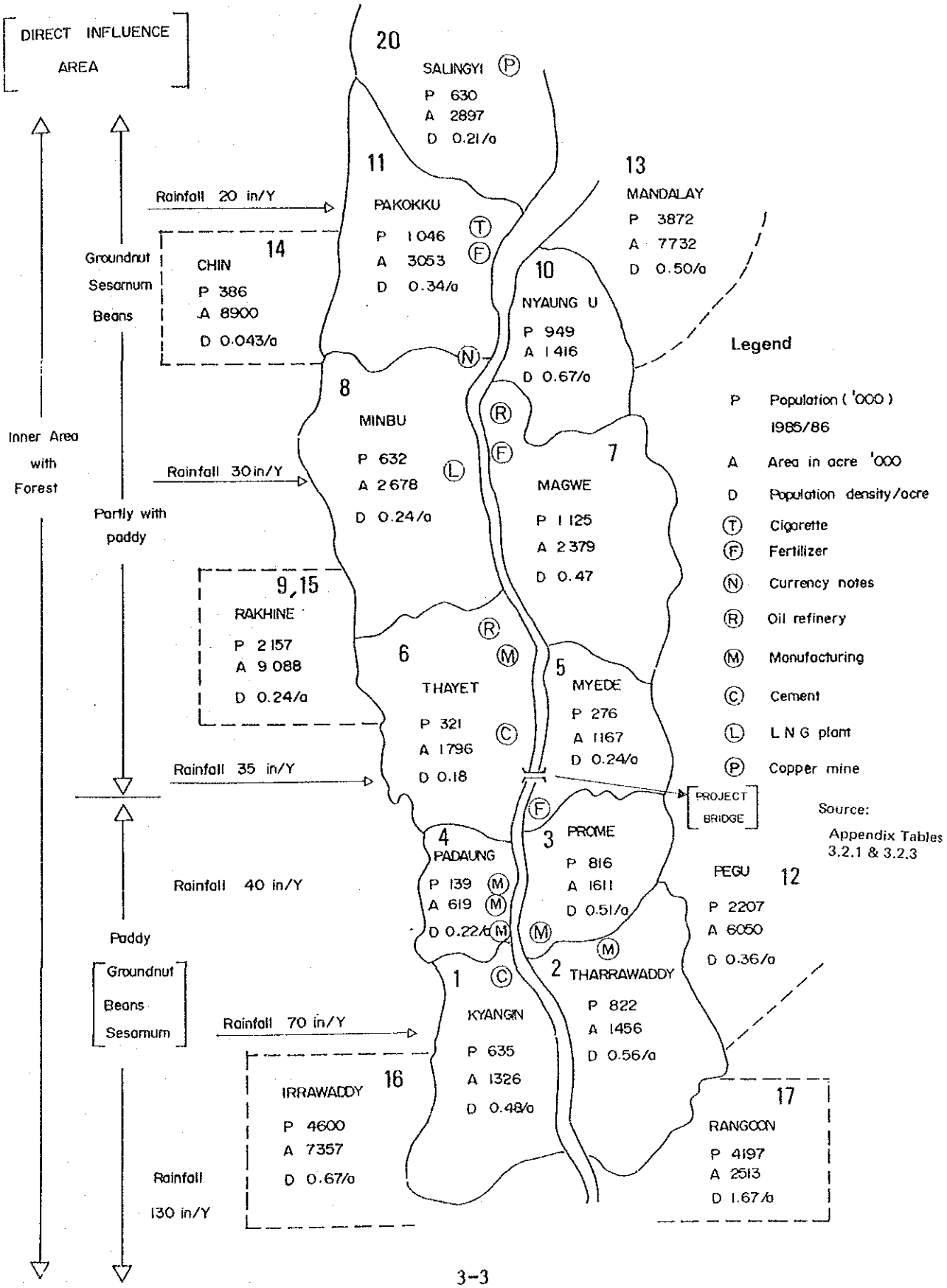
3.2.2 Direct Influence Area

Major characteristics of the economy of the DIA are schematically shown in Fig. 3.2.1. (Saw mills, power plants and rice mills are not shown.) Oil refineries, fertilizer plants are located near the oil and gas fields from which input resources are supplied. Cement factories are in Kyangin and Thayet where limestone quarries are located. Mechanical manufacturing plants are located in Padaung and Thayet. There is a textile mill in Shwedaung and a pottery factory in Tharrawaddy. In Salingyi (Zone 20), a copper mine and smelting complex has been under construction. However, the copper complex currently exports copper concentrate by river barge to Rangoon. Major government-owned plants are shown in Appendix Table 3.2.1.

Statistical data showing relative shares of DIA in various manufacturing activities are shown in Appendix Table 3.2.4. It shows that 50% of the country's total output by government enterprises is produced in this area.

In paddy production fields, off-season cropping of groundnuts, beans, sunflower, etc. are seen in approximately 20% of the paddy fields. Irrigation channels are not sufficiently developed to support a large scale double cropping. In dry zones north of Prome where the rainfall is 20-25 inches per year, main crops are groundnuts, sesamum,

Fig. 3.2.1 ECONOMICS OF THE DIRECT INFLUENCE AREA



sunflower seeds, beans, etc. Paddy fields are developed where irrigation channels have been constructed. In Kyangin and in Tharrawaddy, the cultivated fields usually produce paddy because of the larger rainfall, suitable flat terrain and irrigation network.

As shown in the Appendix Table 3.2.2 in Kyangin zone on the west bank, the sown area was 439,000 acres, 33% of the acreage in the whole zone. But the total of the zones from Padaung to Salingyi were 1,936,000 acres and 16%, in 1984/85 respectively.

On the east bank, the situation was quite similar; in Tharrawaddy zone, located close to the Kyangin zone, the sown area was 568,000 acre (39% of the total). The others from Prome to Nyaung U had a total of 2,093,000 acres (32%).

The fallow land and cultivable waste land of 1,212,000 acres (51% of the sown area) remain on the west bank zones and 1,134,000 acre (43% of the sown area) on the east bank zones.

Forest areas (reserved and non-reserved forests) represent 8,007,000 acre on the west side. On the east side, the area was 3,300,000 acres, 40% that of the west side. A large number of teak/hardwoods remain unexploited deep in the Rakhine mountains.

3.2.3 Relationship between the Distance to Rangoon and Zonal Population

Distribution of economic activities among the zones of direct influence of the bridge project was reviewed. The available statistical data by township, population and land acreage were used to identify a distribution pattern of population relative to the distance from Rangoon.

3.2.3.1 Zones

The direct influence area (DIA) is shown in Fig. 3.2.2. Rakhine (Zone 9, 15) and Chin (Zone 14) are discussed separately because their population data are not similar to the zones of DIA.

3.2.3.2 Population, Area and Distances

Population, area, population density and travel time in minutes on roads to Rangoon and Bassein are shown in Appendix Table 3.2.3.

As shown in Fig. 3.2.3 the zones are divided into high and low density groups. A regression line is estimated with the result as follows.

Formula

$Y = aX + b$

Y = P/A, population density per thousand acre.

x = trave time in minutes to Rangoon. Ferry waiting time and crossing time are included when necessary. (Refer to Chapter 5 and Appendix Tables in Chapter 10).

a,b = estimated parameters

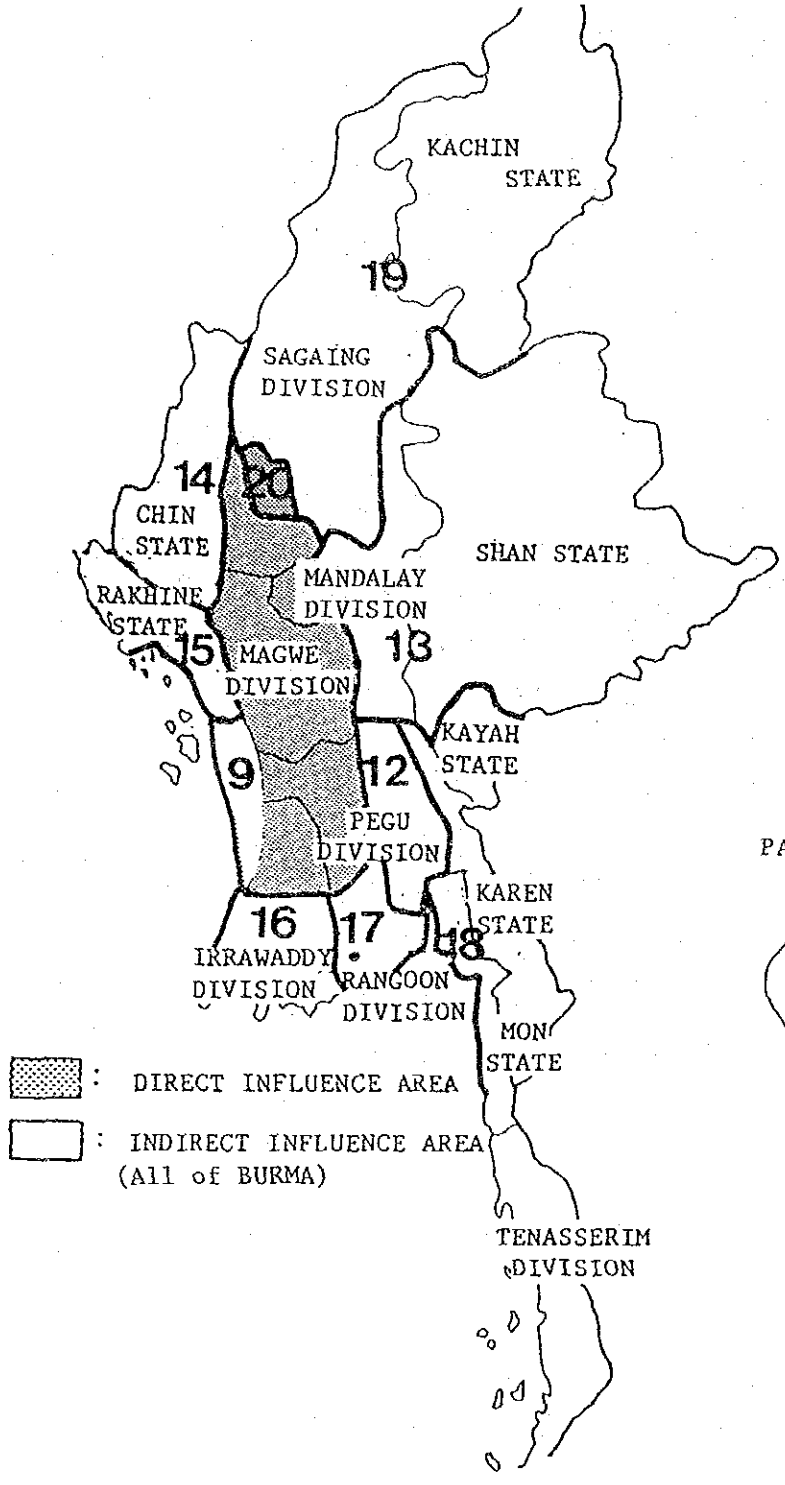
r = corelation coefficient

	Group	Parameters		r	Sample Nos
		a	b		
To Rangoon	High density	$-3.570/10^5$	0.518	0.78	6
	Low density	$-1.557/10^5$	0.374	0.47	5
To Bassein	High density	$-2.240/10^4$	0.471	0.34	6
	Low density	$-1.335/10^4$	0.389	0.42	5

Zones on the western side of the River generally register lower population densities, 0.18-0.34 persons per acre, than the zones in the eastern side, 0.24-0.67 persons per acre. In the southern part, the density becomes larger in Kyangin (Zone 1) and Tharrawaddy (Zone 2). The Irrawaddy Division (Zone 16), outside DIA, which covers the delta area of the Irrawaddy River, has the largest density among the divisions/states of the country.

A. Direct and Indirect Influence Area

Fig. 3.2.2 ZONING MAP



B. Zones in the Direct Influence Area

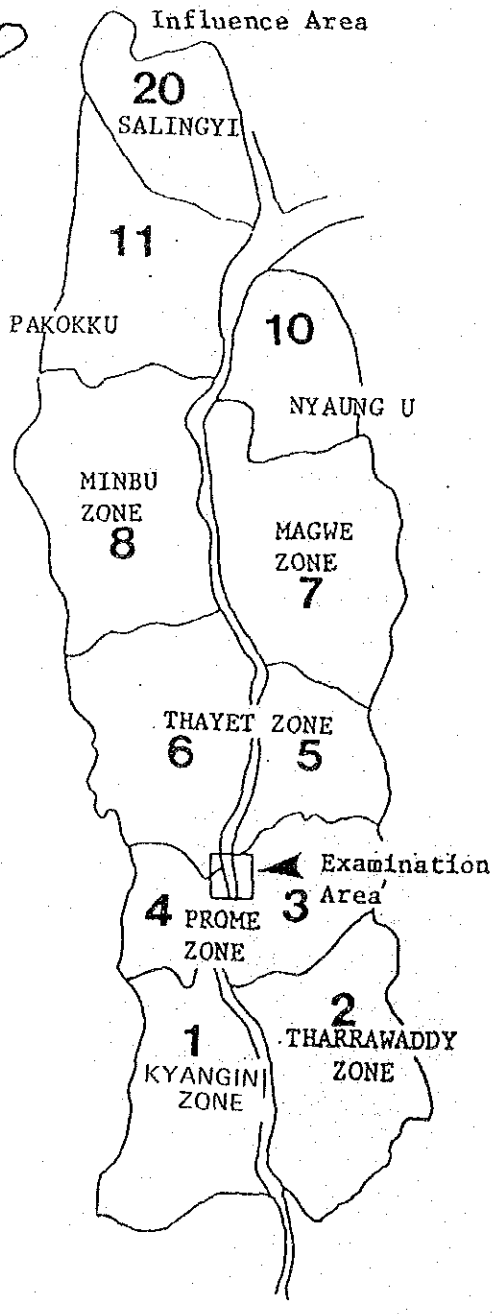


Fig. 3.3.2-A POPULATION DENSITY AND TRAVEL TIME

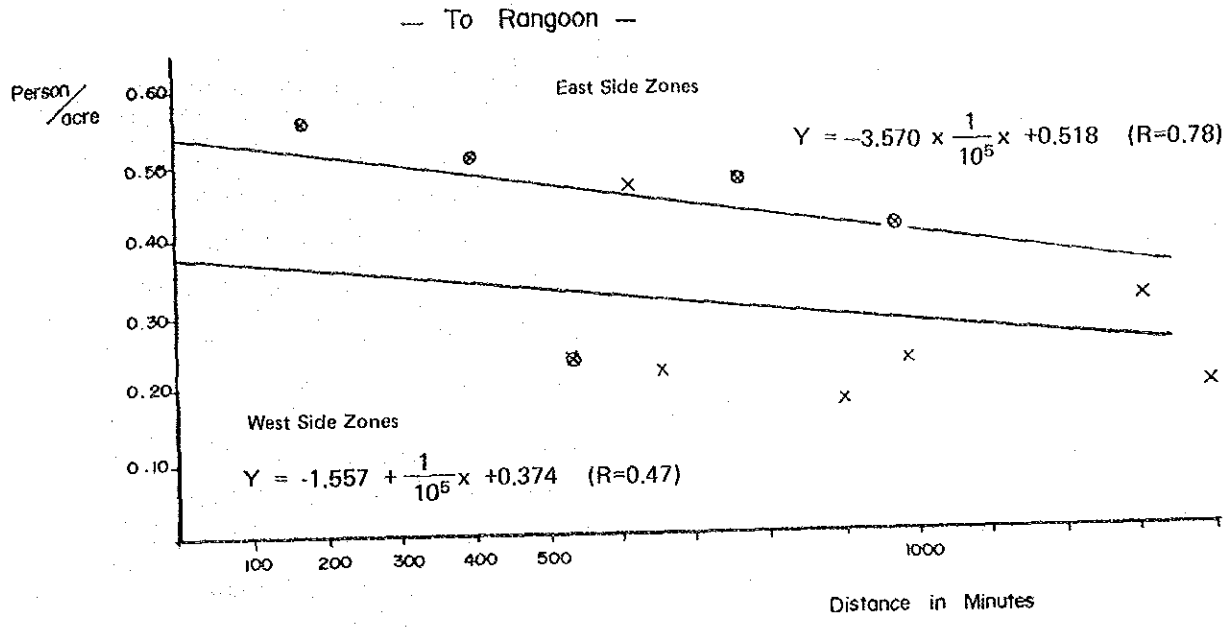
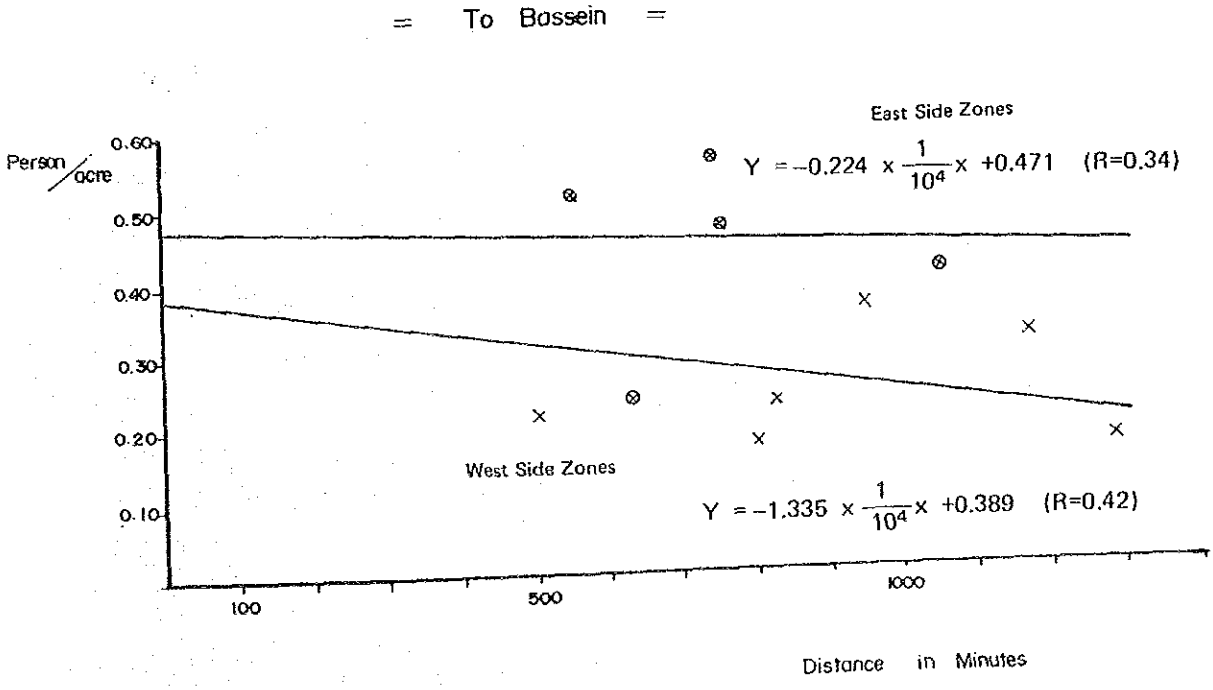


Fig. 3.2.3-B POPULATION DENSITY AND TRAVEL TIME



The following is noted:

- Zones on the east side are in the high density group, except Myede.
- Zones on the west side are in the low density group, except Pakokku.
- Travel time - population density relationship vis a vis Rangoon demonstrates a higher "r" value than that relative to Bassein. The influence of Bassein is not large at present. Traffic to/from Bassein is far smaller than that to Rangoon (origin/destination table of Table 5.2.2 in Chapter 5).
- On the east side of the river, where the land transport (road) network has had a direct link with Rangoon, population density has shown a trend indicating a linear decrease when the travel time increases, although the decline in modest.

3.3 Conceptual Plan of Development

3.3.1 Long Term Guideline

A long-term Twenty-Year Plan announced in December 1973 has been the instrument of development policy for the years from 1974/75 through 1993/94. The main objectives are as follows:[1]

(1) to double the standard of living of all nationalities of the Union and to fulfil to the maximum extent the food, clothing, shelter and social needs of all people.

(2) to transform Burma smoothly from an agricultural country to an agriculture-based industrial country in accordance with the laws of balanced planning in a national economy.

The Burmese Government has implemented policies to realize the objectives by subdividing the 20 years into five Four-Year periods. Currently the 5th Four-Year Plan has been implemented for 1986/87 through 1989/1990.

3.3.2 The 5th Four-Year Plan

The 5th Four-Year Plan for 1986/87 - 1989/90 is supposed to have the following objectives. However, no definite targets to be achieved by region or Division/State are shown. It is understood that each region should achieve mostly the same target figures of the whole country rather than separate growth targets.

During this period, the GDP at constant producers' prices is planned to increase at an average rate of 4.5% per annum. Per capita GDP is targeted to increase at an average rate of 2.5% per annum and labor productivity at a rate of 2.1%. To achieve those objectives, measures adopted to ensure successful implementation of the 5th Four-Year Plan are:

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1 Refer to 2.2.2 in Chapter 2.

(1) a strengthening of the active participation of the people in planning and implementation;

(2) a short-term special program for extensive cultivation of selected crops to achieve domestic self-sufficiency, fulfil domestic raw material requirements, facilitate diversification and expand exports and enhance farm income;

(3) specific programs to boost export earnings not only from the export of goods but also from exporting services;

(4) the maintenance of consistency among the existing economic activities and programs in accordance with prevailing economic conditions;

(5) effective utilization of existing productive resources;

(6) raising the efficiency of investment through efficient allocation and use of resources; and

(7) improvement in production efficiency and cost-effectiveness in every field of economic activity.

3.3.3 Development Potential of DIA

The area of Burma has tremendous potential, development of which is urgently necessary considering the current circumstances of the nation's economy. The influence area, particularly the west side of the river, has identified to contain large potentials for development in agriculture/forestry and manufacturing/mining.

3.3.3.1 Without the Bridge Project

Based on the forecast of the Burmese economy, GDP was divided first into Divisions and then into zones of DIA. The forecast was conducted assuming a scenario without the bridge project on the Irrawaddy River. The estimated GRP and population of zones in DIA are shown in Appendix Table 3.3.1 and summarized in Table 3.3.1.

The above forecast was made within a context of "balanced planning" for the country as a whole determined in the 20-year-plan, and specific features of the forecast include:

Table 3.3.1 GRP AND POPULATION IN DIA

(without the Bridge Project)

Sector	1985/86	1990/91	2000/01	2010/11	1985-2010 ratio, (% p.a.)
Agriculture	5,738.8	7,040.3	10,376.7	15,502.5	2.70 (4.1%)
Livestock, fishery	955.0	1,311.7	2,283.8	4,132.6	4.33 (6.0%)
Forestry	171.0	216.8	320.4	514.0	3.01 (4.5%)
Mining	273.0	385.0	632.9	1,089.2	3.99 (5.7%)
Manufacturing	1,194.9	1,602.4	2,707.0	4,891.0	4.09 (5.8%)
Other goods	259.1	313.9	533.4	1,089.0	4.20 (5.9%)
Transport	389.7	507.2	791.8	1,290.1	3.31 (4.9%)
Other service	1,077.2	1,325.9	1,964.5	2,996.5	2.78 (4.2%)
Trade	1,987.1	2,511.8	3,699.2	6,040.7	3.04 (4.5%)
Total	12,046.6	15,214.5	23,407.7	37,545.6	3.12 (4.6%)
(In million Kyat, 1985/86 prices)					
Population (in '000)					
DIA	7,390.2	8,122.9	9,777.3	11,743.0	1.59 (1.9%)
(In thousand)					

Source: Appendix Table 3.3.1

(1) The primary sector, including agriculture, livestock, fishery and forestry to develop at a growth rate of 4.4% per annum.

(2) Mining production depends on the development policy of the Government. In this forecast a growth rate of 5.7% per annum is assumed.

(3) Manufacturing sector will grow at a rate of 5.8% per annum.

(4) Population will increase at a rate of 1.9% per annum.

3.3.3.2 With the Bridge Project

1) Growth Potentials

Main development potentials in the DIA are as follows:

- There remain large areas of under utilized cultivable land. The areas can be brought under production by developing irrigation channels, fertilizing, using high-yield crop varieties and new agricultural technologies.

- Forestry resources, particularly teak and hardwood, have not been extracted sufficiently. Production can be increased by constructing feeder roads and improving transport.

- Mining resources can be developed, especially limestone, natural gas, crude oil, copper, gravel and sand.

- Large industrial plants and chemical factories have been built. Their number and capacity can be increased. Some use adjacent local natural resources and others imported material. Developing the manufacturing sector in the DIA is important because it represents the growth core of the regional economy.

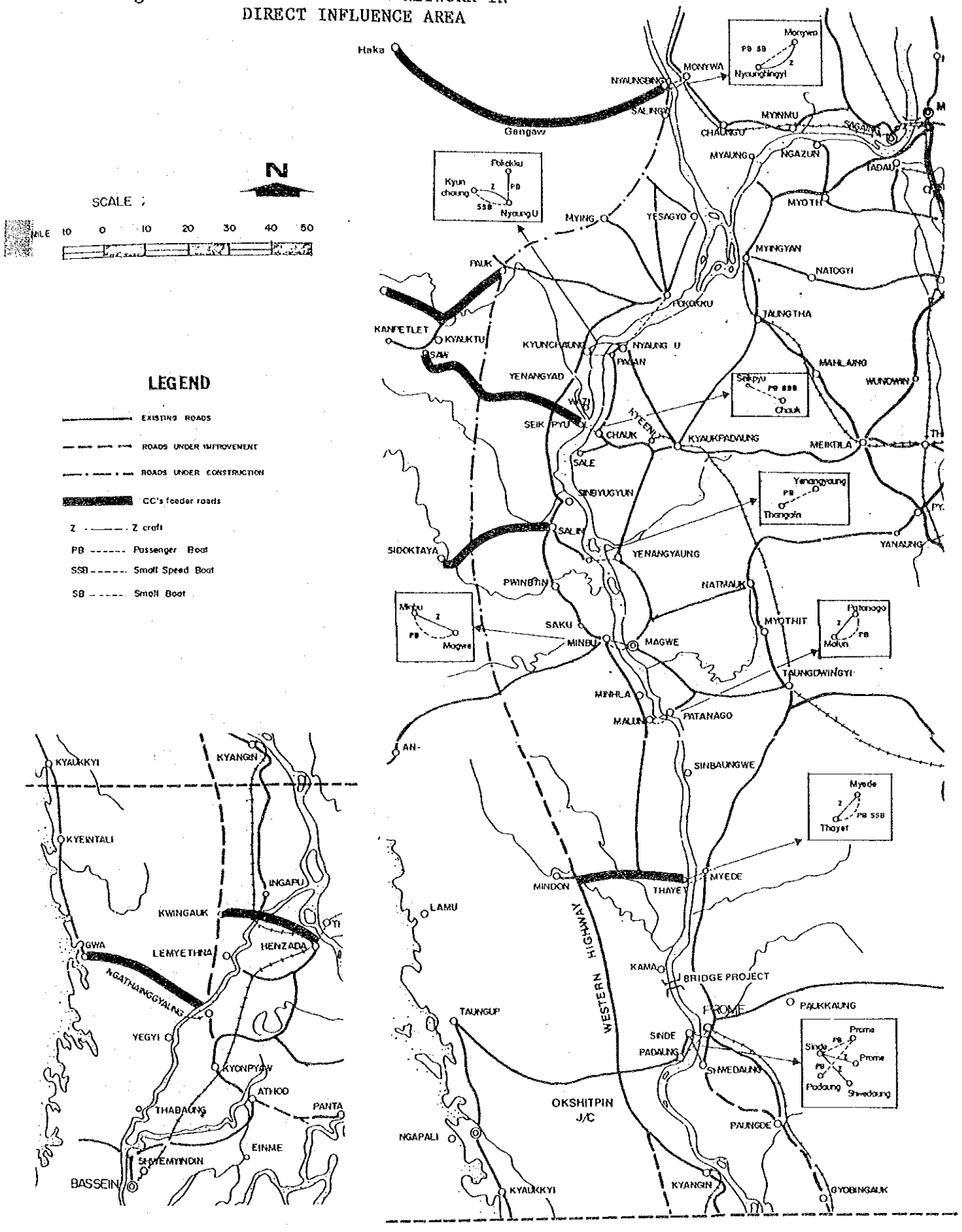
In order to support development of the major sectors, the Burmese Government has been improving the infrastructure of the DIA with such projects as

- the Western Highway from Bassin to Monywa (on-going)
- improvement of Minbu - Ann Road (on-going)
- improvement of Rangoon - Prome Road (on-going)
- improvement of Prome - Oktwin Road (completed in 1986)
- improvement of Padaung - Taungu Road (completed in 1975)
- improvement of Bassein and Akyab outports (on-going)

New projects to be implemented in near future (in 1980s) are shown in Appendix Table 3.3.2.

In addition there are plans for further construction/improvement of infrastructure. Proposed are:

Fig. 3.3.1 TRANSPORTATION NETWORK IN DIRECT INFLUENCE AREA



- Secondary/feeder road network project, linked to the Western Highway. A feasibility study is being prepared for negotiation with the World Bank. The project is expected to be implemented after the completion of Construction Industry Project. The road sections are shown in Fig. 3.3.1.

- Monywa - Nyaungbingyi Bridge Project over he Chindwin River. With the completion of this bridge, the Western Highway can serve as a direct link between Bassein and Mandalay via Monywa and Sagaing. A feasibility study will start in a few years.

- Second phase improvement plan of outer ports. This plan has been earmarked by ADB. Terms of reference have been drafted by Burma Ports Corporation, but are awaiting for approval from the Ministry of Transport and Cabinet. Bassein port is the most important outer port to be improved in the area west of the Irrawaddy River. There are plans to increase share of export/import from the current 2 - 3% to 5 - 6% and more in the future.

The Ports Corporation has studied the possibility of developing international ports somewhere on the coast along the Bay of Bengal. Although not an extensive feasibility study, studies in the past indicate that construction of a new port would entail large cost and that, under the circumstances, improving Basseins port facilities would be a realistic solution.

2) Forecast

Taking into account the growth potentials of DIA, forecasts are conducted for the years upto 2010 assuming the bridge project is ready for use in 1993. Details of the forecast are stated in Appendix 3.1. Main features of the forecast are as follows.

(1) The primary industry, including agriculture, livestock, fishery and forestry will have an output larger by 6.6% in 2010. The increase will be realized by expanding the net sown area and developing multiple cropping under other supporting policies.

(2) The manufacturing sector will develop firstly in proportion to the growth of the primary industry and secondarily under a policy to increase/expand the government-owned manufacturing plants. Increasing the number of plants would follow the Fourth Plan period rather than the plan in the current Fifth Plan period.

(3) Mining sector, particularly for crude oil and natural gas, is considered to increase their output rather by Government policy and other factors than the completion of the bridge. Their additional growth in relation to the bridge project is not considered.

(4) Other goods sector is assumed to increase in response to the development in (1) through (3) above.

(5) Transport, trade and other services will increase following the growth rate of the total of (1) through (4) above.

The resultant forecasts of GRP in DIA are shown in Tables 3.3.2 and 3.3.3, and summarized as follows:

	1985/86	2000/01	2010/11	'10/85
GRP				
1. Without bridge				
GRP, (mill.k)	12,046.6	23,407.7 (1.00)	37,545.6 (1.00)	3.12
Population, ('000)	7,390.2	9,777 (1.00)	11,743.0 (1.00)	1.59
2. With Rail-Road Bridge				
GRP, (in mill.k)	12,046.6	25,202.0 (1.08)	41,222.3 (1.11)	3.42
Population, ('000)	7,390.2	10,066.0 (1.03)	12,368.0 (1.05)	1.67
3. With Road Bridge				
GRP, (mill.k)	12,046.6	24,944.4 (1.06)	40,367.6 (1.09)	3.35
Population, ('000)	7,390.2	9,973.0 (1.02)	12,179.0 (1.04)	1.65
Increased GRP (mill.k)				
Rail-Road Bridge	-	1,794.3 (1.17)	3,676.7 (1.30)	
Road Bridge	-	1,536.7 (1.00)	2,822.0 (1.00)	

The above forecast were discussed between the study team and the Burmese agencies including C.C. and Department of Planning. Currently, the Burmese Government has been drafting the regional development plan. However, the study's forecast was considered reasonable as a course of growth by the Burmese side in light of the Burmese development policies.

Table 3.3.2 GRP and Population with Rail-cum-Road Bridge

(In million kyat, 1985/86 prices)

Sector	1985/86	1990/91	2000/01	2010/11	1985-2010 ratio, (% p.a.)
Agriculture	5,738.8	7,040.3	10,958.3	16,525.7	2.88 (4.3%)
Livestock, fishery	955.0	1,311.7	2,419.4	4,405.4	4.61 (6.3%)
Forestry	171.0	216.8	348.1	547.9	3.20 (4.8%)
Mining	273.0	385.0	626.2	1,089.2	3.99 (5.7%)
Manufacturing	1,194.9	1,602.4	3,117.5	5,908.3	4.94 (6.6%)
Other goods	259.1	313.9	686.8	1,315.5	5.08 (6.7%)
Transport	389.7	507.2	845.3	1,416.5	3.63 (5.3%)
Other services	1,077.2	1,325.9	2,105.0	3,290.2	3.05 (4.6%)
Trade	1,987.1	2,511.8	4,095.4	6,632.7	3.34 (4.9%)
Total	12,046.6	15,214.5	25,202.0	41,222.3	3.42 (5.0%)
Population ('000)					
DIA	7,390.2	8,122.9	10,065.6	12,368.0	1.67 (2.1%)

Source: from Appendix 3.1.

Table 3.3.3 GRP and Population with Road Bridge Project

(In million kyat, 1985/86 prices)

Sector	1985/86	1990/91	2000/01	2010/11	1985-2010 ratio, (% p.a.)
Agriculture	5,738.8	7,040.3	10,958.3	16,525.7	2.88 (4.3%)
Livestock, fishery	955.0	1,311.7	2,419.4	4,405.4	4.61 (6.3%)
Forestry	171.0	216.8	348.1	547.9	3.20 (4.8%)
Mining	273.0	385.0	626.2	1,089.2	3.99 (5.7%)
Manufacturing	1,194.9	1,602.4	2,979.2	5,477.9	4.58 (6.3%)
Other goods	259.1	313.9	656.4	1,219.7	4.71 (6.4%)
Transport	389.7	507.2	834.7	1,386.9	3.56 (5.2%)
Other services	1,077.2	1,325.9	2,078.4	3,221.2	2.99 (4.5%)
Trade	1,987.1	2,511.8	4,043.7	6,493.7	3.27 (4.9%)
Total	12,046.6	15,214.5	24,944.4	40,367.6	3.35 (4.9%)
Population (in '000)					
DIA	7,390.2	8,122.9	9,973.1	12,179.0	1.65 (2.0%)

Source: from Appendix 3.1.

3.4 Development Benefits related to the Project

Increased GRP is the result of the bridge construction, combined with investments and miscellaneous inputs. In order to identify the bridge's contribution to increased GRP, two factors are considered: the transport sector in GRP and the bridge's share in the transport sector.

3.4.1 Transport Sector in GRP

The percent share of the transport sector in GRP is estimated by using Tables 3.3.1 through 3.3.3. In Table 3.3.1, the percent is 1,290.1 ÷ 37,545.6 = 3.4% and in Table 3.3.3 the figure is also 1,386.9/40,367.6 = 3.4%. The percent, 3.4%, is used to determine the share of transport in GRP.

3.4.2 The bridge's share in the Transport Sector

The bridge project is an infrastructure project and its contribution in the GRP cannot be shown explicitly in national income accounts statements. Conventionally, the contribution of the bridge project is estimated by determining the asset value of the existing system and the bridge. The data are shown in Appendix Table 3.2. It is summarized as follows.

(1) Road Bridge

1) Road lengths under the administration of CC in DIA are studied by using data supplied by CC.

2) Average road construction cost in Magwe and Pegu division is studied. Data are supplied by CC.

3) The existing value of the road system is determined by using the above data 1) and 2).

4) If the project bridge is added with a cost of approximately 600 million kyat, its share in the system is estimated at 28%.

(2) Rail-cum-Road Bridge

1) The railway network is added to the road network by using the data supplied by BRC.

2) The value of the existing railway system is set at 50% of the cost for the new line between Kyangin and Prome.

3) The new line between Kyangin and Prome is added.

4) If the rail-cum-road bridge cost of 750 million Kyat is added to the existing road and railway asset, its share is approximated at 28%.

3.4.3 Impact on the Economy of Rakhine and Chin

Rakhine State and Chin State are on the west side of Rakhine and Chin mountains. They are favourably affected by the improvement of the river crossing. However, they are far from the bridge site and not considered to have the same impact as DIA. It is assumed the impact is half at the percent increase of DIA's GRP, regardless of the bridge types.

- GRP in Rakhine and Chin, without the bridge, 2000 ..... 4589 million Kyat
- Percent increase of GRP in DIA, 2000 ..... Rail-cum-Road bridge 8%
  Road bridge 6%
- Increased GRP in Rakhine and Chin, 2000 ..... 183.5 million kyat (8% x 1/2)
- Transport sector and the bridge contribution percent, 2000 ..... same as in DIA
- Development benefit of the bridge, 2000 ..... Rail-road bridge 1,747
  (In kyat '000) Road bridge 1,747

3.4.4 Development Benefits of the Bridge Project

If the bridge is opened in 1993, its influence on the development will be realized gradually, achieving full impact in 2000. Estimates for the year 2000 are summarized as follows:

Rail-cum-Road Bridge		
- Increased GRP, DIA		1,794 million kyat
- Increased GRP, Rakhine/Chine		183.5 million kyat
- Development Benefit	DIA	17,082,000 kyat
	Rakhine/Chin	1,747,000 kyat
	Total	18,829,000 kyat
Road Bridge		
- Increased GRP, DIA		1,536.7 million kyat
- Increased GRP, Rakhine/Chine		183.5 million kyat
- Development Benefit	DIA	14,629,000 kyat
	Rakhine/Chin	1,747,000 kyat
	Total	16,376,000 kyat

The development benefit will grow by 1/8 for years between 1993 and 2000 because of gradual realization of the Bridge impact. After that, the benefit will increase to 4.5% per annum, the same rate used in the stream of benefits for diverted traffic.

CHAPTER 4 TRANSPORTATION SYSTEM

CHAPTER 4 TRANSPORTATION SYSTEM

4.1 General

The transportation network system of the whole country and that of the direct influence area are studied in this chapter. Characteristics of the transportation system of the country are described first, followed by a review of roads, railways and waterways. Similarly, the waterways, roads and railways in the direct influence area (DIA) are studied.

On the Irrawaddy River, it is possible to cross the river at any point if landing banks are serviceable. However, in the study, eight crossing points between Prome and Monywa have been selected to represent these crossings and to link the road network on both sides of the river.

4.2 The Whole Country

4.2.1 Transportation Network

Burma's 167.2 million acres are classified into: sown and cultivable areas 28%; forests 47%; and others 25%. The population, 37.1 million in 1985/86, has registered an average growth of 1.93% per annum since 1973. The active labour force, 15.1 million in 1985/86, is divided into agriculture, livestock, fishery and forestry 66%, mining, manufacturing, power and construction 11%, transport and communication 3%, and service and trade 20%.[1]

A schematic map of the country is shown in Fig 4.1.1. The country has four main waterways (Irrawaddy, Salween, Sittang and Chindwin Rivers), which run through the mountain ranges of Chin, Kachin, Rakhine, and Pegu Yoma and through the Shan-Tenasserim highlands in the east and south.

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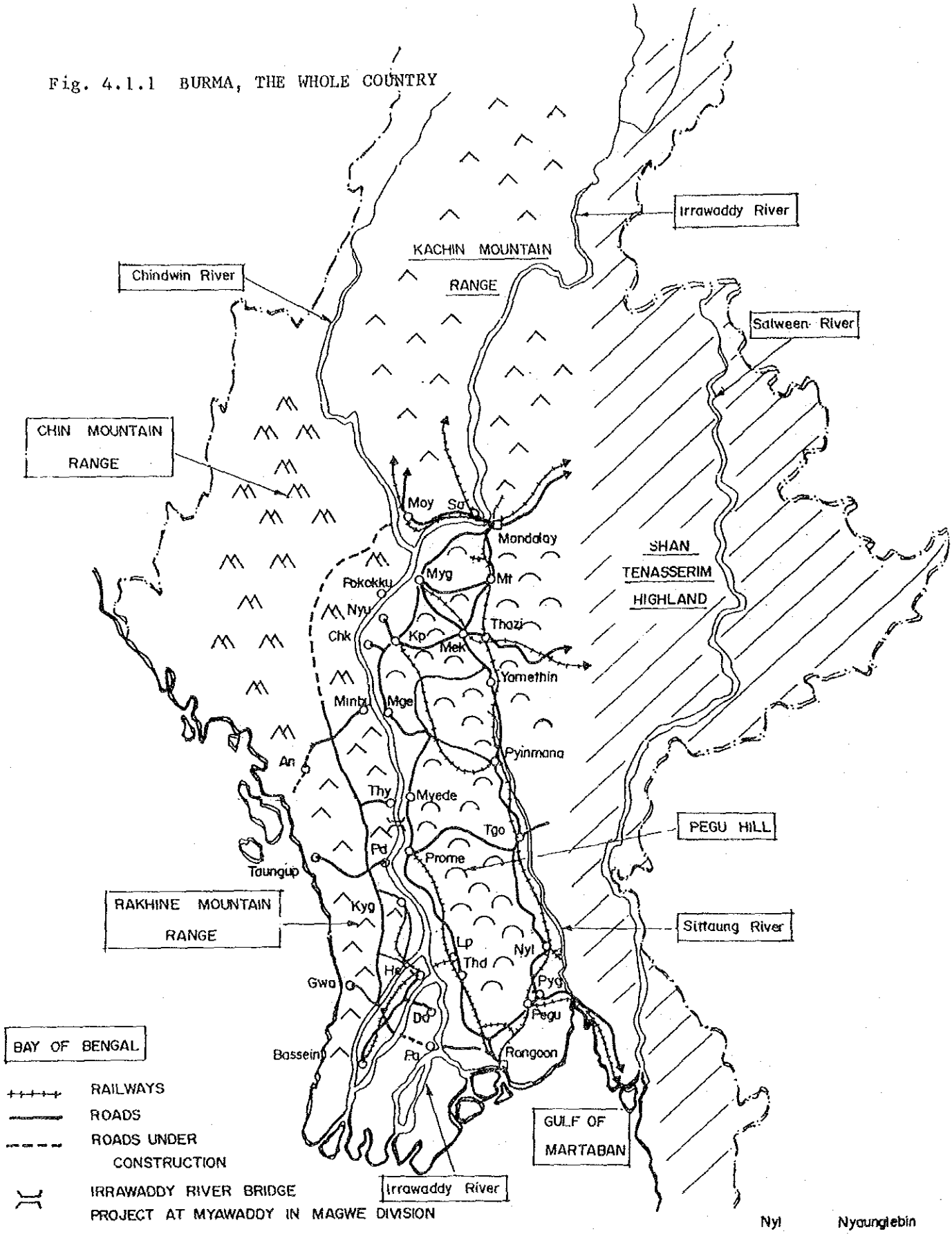
1. Report to Pyithu Hluttaw, 1986.

Fig. 4.1.1 BURMA, THE WHOLE COUNTRY



RAILWAYS

ROADS

ROADS UNDER CONSTRUCTION

IRRAWADDY RIVER BRIDGE

PROJECT AT MYAWADDY IN MAGWE DIVISION

Moy	Monywa
Sa	Sagaing
Myg	Myingyan
Mt	Myittha
Nyu	Nyaung U
Chk	Chauk
Kp	Kyaukpadaung
Mek	Meiktila
Nyl	Nyaunglebin
Mge	Magwe
Thy	Thayet
Tgo	Taungoo
Pd	Padaung
Pyg	Payagyi
Dd	Danubyu
Pa	Pataraw
Lp	Lerpadar

Waterways have been used as means of transportation in Burma, and the Irrawaddy River in particular has served to link Upper Burma to lower Burma.

The transportation networks, mainly waterways, roads, railways and airways, have developed to link together major populated regional centers. Trunk lines of waterways (river), roads and railways are also shown in Fig. 4.1.1. In addition to rivers, there are three land transport corridors:

- 1) Rangoon - Pyinmana - Mandalay: 400 miles
- 2) Rangoon - Prome: 150 miles
- 3) Bassein - Henzada - Kyangin: 150 miles

Corridors of 1) and 2) are located in the eastern regions of the Irrawaddy River. With the development of surfaced roads in the north, from Prome to Mandalay, and improvements on the existing roads and railways, these corridors seem to be consolidated into a ladder-like network of roads and railways.

In the region on the western side of the Irrawaddy River, the railways lie between Bassein and Kyangin via Henzada. The Western Highway, which starts from Bassein going up to Salingyi (the opposite side of Monywa over the Chindwin River), is still under construction and is scheduled to be completed in 1989. The transportation network in this region is less developed than the corridors on the east side.

The west side has no direct land-transport link to the east side of the Irrawaddy River. Ferries, boats and barges are used for crossing. Currently the Ava Bridge, serving both road and railway linkages, connects Mandalay and Sagaing over the Irrawaddy River. However, it does not link directly the western region in the DIA, including Irrawaddy, Rakhine, part of Magwe and part of Pegu, with the east side of the river.

States and Divisions located in peripheral areas are mostly composed of mountains, hills and plateaus. Transportation networks in these areas are fewer and less developed than those in the forementioned corridors. Additional investment is needed to improve and develop

networks along which people and products in the areas can move efficiently.

Improving the nationwide transport network is a long-standing objective of the Government, especially direct linking of land transport (roads and railwasy) between the west and east of the Irrawaddy River. If the bridge is constructed, the west side areas of the River can be linked directly to the east side, whereupon the transport system can assist the growth of the regional economy.

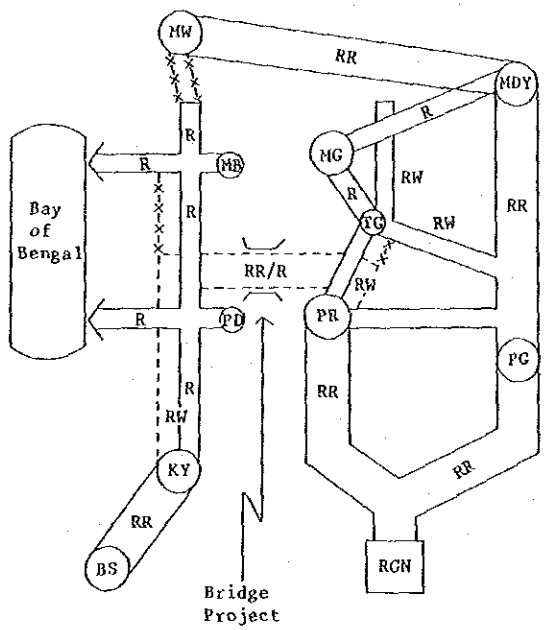
A schematic of transport trunk lines is shown in Fig. 4.1.2.

a) Railways and roads in the west side can be linked with the east side by the bridge.

b) There are three north-south corridors: Rangoon - Pegu - Mandalay, Rangoon - Prome - Mandalay and the Western Highway. The bridge can connect west to east at midepoint.

c) After the bridge is completed, the network can be extended further to Monywa and Taungdwingyi.

Fig. 4.1.2 TRUNK NETWORK



Legend:

RR	:	Road and Railway Corridor
R	:	Road corridor
RW	:	Railway corridor
RGN	:	Rangoon
PG	:	Pegu
PR	:	Prome
MG	:	Magwe
MDY	:	Mandalay
MW	:	Magwe
MB	:	Minbu
PD	:	Padaung
KY	:	Kyangin
BS	:	Bassein
TG	:	Taungdwingyi

---- to be constructed by 1993
-x-x programs after 1994.

4.2.2 Roads

4.2.2.1 Road Network

The major roads in the Burmese network are shown in Fig. 4.2.1. The types of surface that make up the almost 14,400 miles of national highways are shown in Table 4.2.1. Approximately 38% of the total have a bitumen surface varying in width from 12 ft. to 22 ft.; nearly 35% are surfaced with either macadam or gravel; the remainder are earth-surfaced and consequently not useful in all weather conditions. This road network is the responsibility of the Construction Corporation under the Ministry of Construction. There are an additional 2,800 miles of feeder roads maintained by Township Peoples' Councils with funds provided by the Ministry of Home and Religious Affairs with technical advice from the CC staff.

Most major surfaced roads are located in Rangoon, Pegu, Mandalay and Magwe Divisions. Mileage within these Divisions accounts for 91% of the national total of 18-22 ft. bitumen-surfaced roads, 36% of 12-18 ft. bitumen-surfaced roads and 23% of the overall total.

In these Divisions, road improvement projects on the eastern side of the Irrawaddy are in progress under the Construction Industry-Project and Rangoon-Prome Road Project, with IBRD and ADB as the funding agencies. While on the western side of the river a Western Highway Construction Project is underway partly with the assistance of GOA. These projects are briefly summarized below.

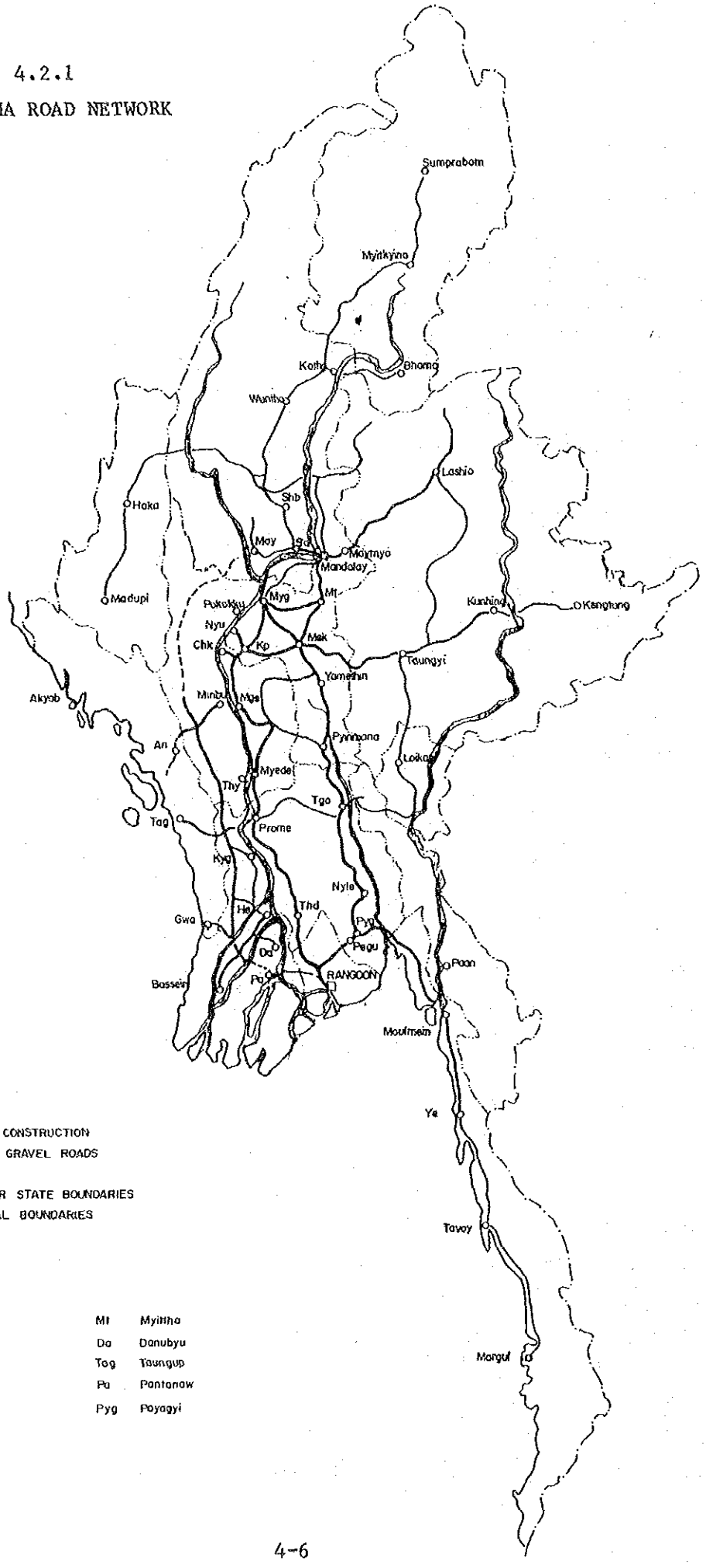
A. Construction Industry Project

With UNDP/IBRD assistance the Road Sector Improvement Study (RSIS) was carried out in 1977 and 1978 to determine priorities for road improvement and rehabilitation, to investigate road administration and planning, to establish road and bridge design standards and to assess the capabilities of design offices.

Based on this study GOB and IBRD agreed to improve and rehabilitate roads and to strengthen and enlarge the capacity of the Burmese construction industry. The project included two road rehabilitation routes and one road maintenance route, and the provision

Fig. 4.2.1

BURMA ROAD NETWORK



———	PAVED ROADS
- - - - -	ROAD UNDER CONSTRUCTION
———	UNPAVED OR GRAVEL ROADS
≈≈≈	RIVERS
—·—·—	DIVISIONAL OR STATE BOUNDARIES
—·—·—	INTERNATIONAL BOUNDARIES

Shb	Shwebo		
Moy	Monywa		
Sa	Sagaing		
Myg	Myingyan		
Nyu	Nyaung U	Mt	Myittha
Kp	Kyaukpadaung	Da	Danubyu
Mek	Meiktila	Tag	Tasngup
Chk	Chauk	Pa	Pantanaw
Mge	Magwe	Pyg	Payagyi
Thy	Thayet		
Tgo	Taungoo		
Kyg	Kyongin		
He	Henzada		
Thd	Tharrawaddy		
Nyle	Nyaunglebin		

Table 4.2.1 UNION OF BURMA HIGHWAYS BY STATE AND DIVISION

1984/85

Mile-furlong

STATE/DIVISION	ROAD CONDITION							REMARKS
	18'to 22' BITUMEN	OVER 10' BITUMEN	MACADAM METAL	LATERITE GRAVEL	MOTOR TRACK	CART TRACK	TOTAL	
KACHIN STATE	-	159-5	146-3	890-1	274-7	689-4	2160-4	
SAGAING DIV:	16-0	324-1	114-0	529-1	312-5	29-0	1324-7	
MANDALAY DIV:	156-0	698-1	59-5	76-4	38-7	-	1029-1	
MAGWE DIV:	82-5	411-2	90-0	501-1	188-0	-	1273-0	
CHIN STATE	-	38-1	1-0	29-5	625-0	124-3	818-1	
SHAN STATE	12-0	1439-5	776-1	700-0	1149-6	51-0	4128-4	
KAYAH STATE	-	122-6	29-5	144-3	99-0	18-0	413-6	
KAREN STATE	-	192-4	44-6	186-3	130-1	-	553-6	
MON STATE	8-2	338-4	0-3	35-4	25-5	15-7	424-1	
TENASSERIM DIV:	-	211-3	4-7	137-6	43-3	21-2	418-5	
IRRAWADDY DIV:	15-0	172-0	38-5	77-4	75-6	-	378-7	
RAKHINE STATE	-	162-3	135-1	111-7	26-2	-	435-5	
PEGU DIV:	204-5	501-3	23-1	71-4	14-1	-	814-6	
RANGOON DIV:	72-0	145-4	15-1	5-7	3-0	-	241-4	
TOTAL	566-4	4917-2	1478-6	3497-2	3006-3	949-0	14415-1	

Source: Construction Corporation (January 1986)

of technical assistance to the work planning and management abilities of the CC.

The two routes to be rehabilitated are the Payagyi-Taungoo Road (115 miles), a part of the main route connecting Rangoon and Mandalay, and the Payagyi-Sittang (26 miles), the connection between Karen and Mon States. The carriageways are 20 ft. with 3 in. penetration macadam and a single seal dressing surface. The width of shoulders is 8 ft. on either side. Estimated costs in 1981-prices were K 124 million (US$ 17.2 million) or K 1.1 million (US$ 150,000) per mile for the Payagyi-Taungoo Section, and K 16.4 million (US$ 2.3 million) or K 630,000 (US$ 88,000) per mile for the Payagyi-Sittang Section, excluding costs of equipment depreciation and technical assistance.

The road targeted for maintenance contains within an area bounded by Myingyan, Mandalay, Yewun, Meikhtila and Kyaukpadaung. The project aims to repair failed areas and surface dressing and to improve road shoulders.

The procurement costs of equipment were estimated to be US$ 15 million; workshop equipment was US$ 650,000; and cost of technical assistance was US$ 1.5 million.

B. Rangoon-Prome Road

RSIS economic and engineering data and analyses for the Rangoon - Prome Road were reviewed and updated in 1982. GOB decided to divide road improvement and reconstruction into several sections, to make it more economically and technically feasible.

The road begins at Htaukkyan, 21 miles north of Rangoon, at the junction between the Rangoon-Taungoo-Mandalay and Rangoon-Prome Roads. It runs 157.5 miles from this junction to Prome. For the reconstructed areas, the width of carriageway is 20 ft. with 6 in. base course and double bitumen surface dressing on the existing pavement. The shoulder width is 8 ft. in populated areas and 5 ft. in non-populated areas. 3 in. bitumen macadam overlay was adopted for improved sections.

Estimated construction cost is K 271 million (US$ 37.7 million), excluding costs of equipment depreciation and technical assistance. The cost of equipment and the technical assistance is K 407 million (US$ 56.5 million) and K 18 million (US$ 2.5 million) respectively in 1982 prices.

C. Western Highway (Bassein - Monywa)

Since 1972 Government of Australia (GOA) has been assisting Government of Burma (GOB) with the construction of North-South highway on the western bank of the Irrawaddy River.

The highway is categorized as D III with sub-base (19 in.), base (4 in.), a single seal of straight bitumen and 1/2-in chipping surface. The total length is 455 miles and the estimated cost is K 456 million (US$ 59 million) excluding equipment and technical assistance.

The Australian expenditure for equipment plant and some technical assistance, etc. provided since 1972 has reached K 100 million (A$ 13 million). The completion of the project to Salingyi is planned for 1989.

4.2.2.2 System of Road Construction and Maintenance

The Construction Corporation is an agency with authority to construct and maintain public work projects including roads, bridges, airfields, buildings, water supply, sewage and electrical supply systems.

All road construction and maintenance activity has been and is now conducted by force account methods. In the IBRD and ADB projects, the force account method is also being used in conjunction with the use of technical assistance of foreign consultants.

4.2.2.3 Funds for Road Construction and Maintenance

The total expenditure of CC for roads and bridges, building projects and others from FY 1981/82 to 1985/86 is shown in the following Table 4.2.2.

Table 4.2.2 C.C. EXPENDITURE FROM FY 1981/82 to 1984/85

(in thousand Kyat)

	81/82	82/83	83/84	84/85	85/86
Capital works					
Road & Bridges	141,421	195,160	259,130	278,623	330,230
(% share of sub-total)	17%	18%	20%	23%	28%
Housing	17,431	27,881	25,593	43,575	51,073
Others	658,944	843,000	992,681	919,752	815,457
Sub-total	817,796	1,066,041	1,277,404	1,241,950	1,196,760
Maintenance works					
Road & Bridges	159,700	183,630	201,960	222,156	244,372
(% share of sub-total)	77%	79%	77%	78%	78%
Housing	9,106	8,879	8,689	11,098	10,765
Others	38,234	41,001	50,030	50,898	58,435
Sub-total	207,040	233,510	260,679	284,152	313,572
Total	1,024,835	1,299,551	1,538,083	1,526,102	1,510,332

Source: Construction Corporation (October 1986)

As shown in the above table, the expenditure for the construction of roads and bridges increased a few per cent every year from FY 81/82 to 85/86 and was 28% of the total CC expenditure in 85/86 FY. The expenditure for the maintenance is constant, about 80% of the total.

4.2.2.4 Vehicles and Traffic

A. Vehicles

Vehicles registered with the Road Transport Administration are shown below in Table 4.2.3. Total registered vehicles increased by an average of 6.8% per annum in five years from 1980/81 to 1985/86. The largest increase was pickup trucks used mostly for passenger transportation, which increased from 8,300 in 1980/81 to 21,700 in 1985/86 (21.0% p.a.) Motorcycles increased less than pickups (17.6% p.a.), while large vehicles at 1.7% p.a. during the same period.

Table 4.2.3 REGISTERED VEHICLES

	1980/81	1982/83	1985/86	1980-1985 Average Growth p.a.
Small cars and vans	37,072	39,129	43,696	3.3%
Pickups	8,349	12,048	21,668	21.0%
Trucks and buses	38,979	40,146	42,483	1.7%
Motorcycles	12,159	17,887	27,401	17.6%
Threewheelers and others	4,726	4,891	5,767	4.1%
Total	101,285	114,101	141,015	6.8%

Note: See Appendix Table 4.2.2.1 for more detail.

B. Traffic Count

Construction Corporation has conducted periodic traffic counts on selected points of the national highways. However, the counting data are insufficient and have not been consolidated into a clear picture of national trends.

4.2.2.5 Road Transport Services

Public transport services are provided by the Road Transport Corporation (RTC), cooperatives and private operators. Their vehicles, shown in Table 4.2.4, indicate no vehicle increase in RTC. Increases in privately operated vehicles are found for both trucks and buses.

A. Road Transport Corporation

The Road Transport Corporation (RTC) is responsible for the following services:

(1) city bus in Rangoon and Moulmein
(2) long-distance highway bus

(3) road freight

(4) bus charter in cooperation with the Hotels and Tourist Corporation

(5) Taxi in Rangoon city

(6) Motor workshop to repair RTC vehicles and others.

The above activities, except (4) and (6), are summarized by the performance indicators of Appendix Table 4.2.2.2. It is found that freight service tonnage increased by 22% between 1980/81 to 1984/85 but decreased to the level of 1980/81 in 1985/86, while bus service decreased upto 1985/86 by 15% in passenger-miles.

The 1983/84 decrease in bus service is attributed to a flat bus fare that went into effect in Rangoon and encouraged private transport operators. Taxi operation was maintained at a level of 5.1 million passengers carried. Lack of growth may be due to an official policy not to increase RTC taxis in Rangoon city, but to increase private taxis gradually.

In fact, RTC vehicles have decreased slightly from 1981/82 to 1985/86. The change is shown in Table 4.2.4. With budgetary and foreign currency constraints it is difficult to purchase new vehicles. Most of new vehicles are bought from HIC factories assembling trucks, buses and taxis, whose production is also under the same constraints.

B. Other Agencies and Private Operators

Statistical data showing the distribution of services among RTC, other agencies and private operators are not available. Although the role of private operators seems to have increased in recent years, it is difficult to discuss the changes quantitatively in terms of passengers-miles, ton-miles, or vehicle-miles, etc.

Table 4.2.4 VEHICLES BY STATE, COOPERATIVE AND PRIVATE OPERATORS

	Road Transport Corporation			Cooperatives		Private	
	Pass. Buses	Taxis	Haul Trucks	Haul Trucks	Pass. Buses	Haul Trucks	Pass. Buses
1978/79	1,485	1,004	2,697	577	431	19,427	5,917
1980/81	1,595	673	2,835	627	401	21,761	5,818
1982/83	1,510	673	2,748	644	253	23,071	5,962
1984/85[1]	1,370	484	2,714	618	195	23,656	6,129
1985/86[2]	1,289	404	2,699	647	203	6,129	6,226

Source: Reports to the Pyithu Hluttaw (1982, 1985 and 1986).

Note: 1 Provisional actual
2 Provisional

4.2.3 Railways

4.2.3.1 Railway Network

All railway lines in Burma are operated by Burma Railways Corporation (BRC). The BRC network is shown in Fig. 4.2.2. Its total length is 1960 ml (approximately 3,137 km). The network is divided into three systems by the Irrawaddy River and the Salween River. The main railway network, including the Prome Line and the Mandalay Line, constitutes the major system serving Rangoon, Mandalay, Prome and other areas located between the Irrawaddy and the Salween Rivers.

The system located to the west of the Irrawaddy serves Bassein, Henzada and Kyangin area, which is connected with the major system only by ferry at Henzada. The system west of the Irrawaddy will be connected directly to the major system once a bridge over the Irrawaddy and the necessary approach railway are constructed. The other system located to the east of the Salween between Moulmein and Ye of 90 miles is also connected with the major system by ferry.

4.2.3.2 Train Operation

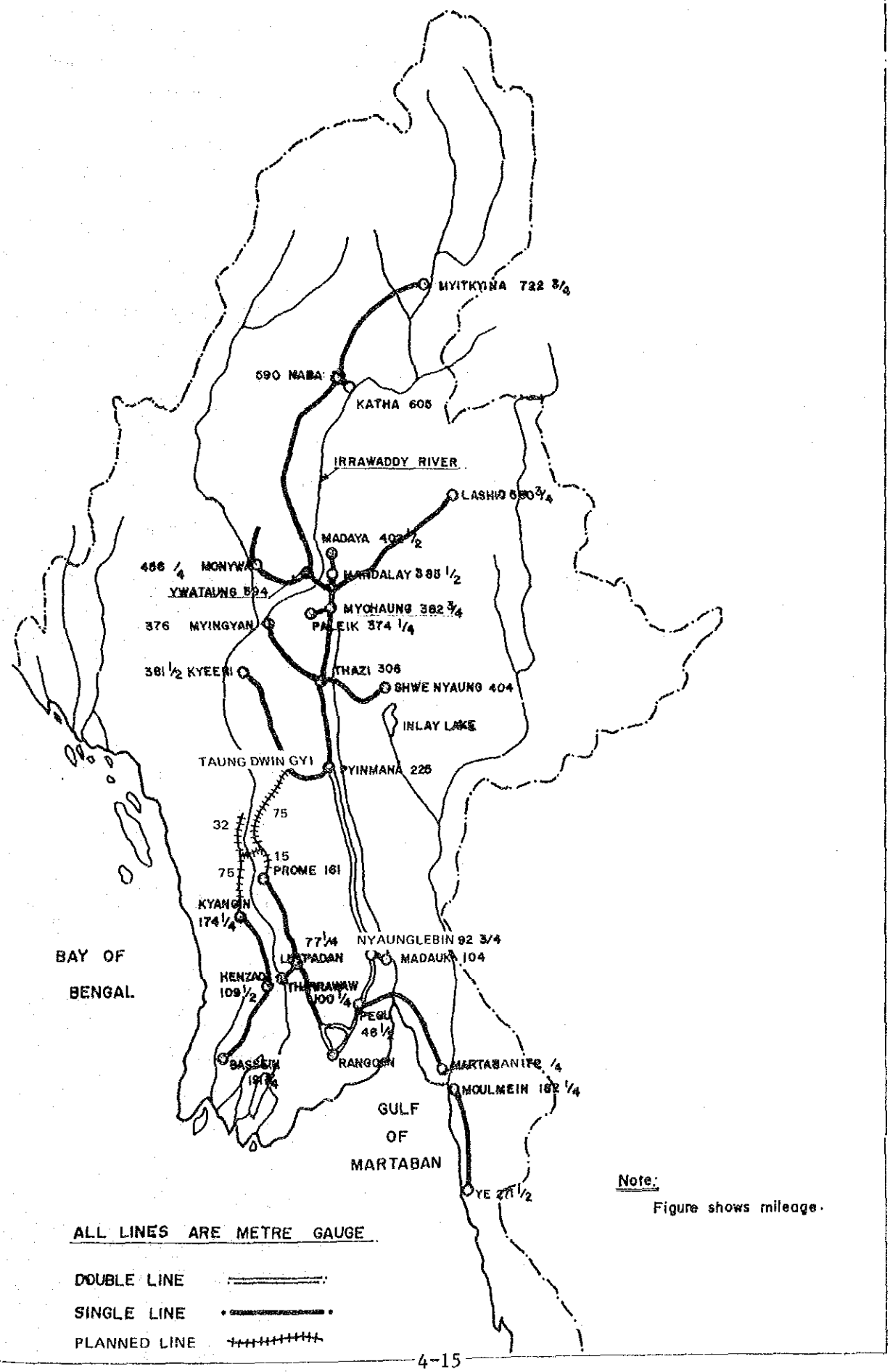
The main operating routes of BRC network and the number of trains on them are as follows.

Operation Route	Number of trains per day (each direction) Passengers	Goods
Rangoon - Mandalay (Malagon) (Myohaung)	6	2
Rangoon - Prome (Malagon) (Paungde)	2	2
Rangoon - Martaban	4	1
Mandalay - Myitkyina	2	1
Bassein - Kyangin	3	1

Notes: The name of stations in parentheses shows the goods stations.

Number of trains operating on other branch train operation routes are fewer than the above-mentioned numbers. Most trains on the

Fig. 4.2.2 BURMA RAILWAYS NETWORK



trunk lines and some on the branch lines are hauled by diesel locomotives, and the restings are hauled by steam locomotives. However, the number of steam locomotives is decreasing due to the BRC's dieselization programs.

4.2.3.3 Rolling Stock

A. Locomotives

BRC is promoting a dieselization program to replace the aging steam locomotive fleet. The existing motive power fleet consists of 227 diesel locomotives and 141 steam locomotives. The number of the diesel locomotives by type is shown in Table 4.2.5.

Table 4.2.5 DIESEL LOCOMOTIVE FLEET

as of 30th June, 1985

	Type	Horse Power	Q'ty	Remarks
Diesel electric	(Alsthom)	1,600	45	
"	"	1,200	60	
"	"	900	29	
Diesel hydraulic	(Krupp)	1,500	28	
"	"	900	22	
"	(KSK)	1,500	6	
"	"	1,200	10	
"	"	900	7	
"	"	500	10	Shunting
"	(KHI)	500	5	"
"	(Hitachi)	500	5	"
Total			227	

Source: BRC (December, 1985)

B. Coaching Stock

As of the June 30, 1985, BRC has coaching stock of 1,333 vehicles fitted with vacuum brakes. The coaches are classified as follows:

Upper class passenger coaches	149
Ordinary class passenger coaches	745
Mail van	37
Brake van	130
Other coaching stock	272
Total	1,333

Source: BRC (December, 1985)

C. Goods Stock

As of the June 30, 1985, BRC has goods wagon stock of 8,949 vehicles. The stock is classified as follows:

	Bogie	4-wheeled
Covered wagon	476	4,871
Low-sided wagon	36	1,290
High-sided wagon	546	82
Flat wagon	728	216
Tank wagon	158	34
Brake van	28	142
Other stock	145	197
Sub-total	2,117	6,832
Grand Total	8,949	

Source: BRC (December, 1985)

4.2.3.4 Permanent Way

The permanent way stndards of BRC are :-

Track Gauge: 1,000 mm

Number of Tracks

double line: Rangoon-Pyinmana, Rangoon circular line and Mandalay-Myohaung

single line: other sections

Maximum speed

passenger train: 45 mph (72 km/h)

goods train: 25 mph (40 km/h)

Maximum degree of curve

ordinary: 6° (radius 291 m)

mountainous area: 17° (radius 103 m)

Maximum gradient	
ordinary:	1 : 150
mountainous area:	1 : 25
Axle load:	12 tons
Effective length of track in station	
main track:	2,200 ft
loop track:	1,800 ft
Track	
rail:	75, 60 or 50 lbs/yard
sleeper:	wooden sleeper and concrete sleeper.

The construction clearance for fixed structure and the typical cross section of track are shown in Appendix Figs. 4.2.3.1 and 4.2.3.2.

4.2.3.5 Signalling and Telecommunications

A. Block System

Tyer's tablet instrument for single line sections are used on the following sections:

Dayingon - Prome
Pegu - Martaban
Myohaung - Hsumhsai
Myohaung - Ywatang

Tyer's lock and block instruments for double line section are used on the following sections:

Pegu - Malagon
Malagon - Mingaladon
Mandalay - Myohaung

On other sections where train density is low, only Morse telegraphs or magneto telephones are used for block working.

B. Signaling System

The signaling system of BRC is shown in Appendix Fig. 4.2.3.3. Interlocked signaling system is only applied to the main lines including Prome Line, while noninterlocked system is applied to the branch lines and local lines including the Western Line. Colour light signals are used only in Rangoon area and at other principal stations. Most of the stations, including stations on the Prome Line and the Western Line have semaphore signals. On the Prome Line working distant signals and working home signals are used, while on the Western Line fixed distant signals and working home signals are used.

C. Telecommunications

The line wire communication network of BRC is shown in Appendix 4.2.3.4. The Morse telegraph system and the magneto telephone system, which are an old type communication system, are still used on some sections. Also on the Western Line, the Morse telegraph system is used as the communication method for block working.

ETM wireless system network for message clearance and SSB radio telephone network for long distance communication have been installed in order to support the line wire communication network.

4.2.3.6 Development Plans

A. Extension of Railways

(1) Prome-Kyawzwa Line

Currently, plans exist to extend the Rangoon-Prome Line to Kyawzwa as part of a proposed Rangoon - Pyinmana-Taungdwingyi-Prome loop. The length of the new Prome-Kyawzwa line will be 23 miles, and it can also serve as an approach railway to the proposed Irrawaddy bridge. Construction cost and construction period are estimated at 47.5 million kyats and three years; survey work began in March 1986.

(2) Kyangin - Myawaddy Line

There are also plans to extend the Bassein-Kyangin line to Myawaddy as part of railway extension program on the west bank of the Irrawaddy River, which will facilitate transporting agricultural products, mine products, etc., on the west side of the Irrawaddy River. It can also serve as an approach railway to the proposed Irrawaddy bridge. The length of the new line will be 75 miles. Construction cost and the construction period are estimated at K 262.5 million and six years. Ground survey work has already been completed for a length of 40 miles from Kyangin to Natmauk (Padaung Township).

(3) Kangalay-Myede-Taungdwingyi Line

From Kangalay, 18 miles north from Prome along the planned extension railway line, an extension line of 75 ml is planned fowards north to join the existing railway at Taungdwingyi. The plan is still in the conceptual stage, no preparatory studies have been conducted yet. It is said this plan will be realized after the extension lines to the proposed bridge in completed.

(4) Myawaddy-Thayet Line

On the west side of the River, a plan of railway construction from Myawaddy to Thayet 32 ml is shown by BRC. No preparatory work has been conducted yet on this section. The construction will be realized after the extension lines upto the proposed bridge is completed.

B. Increase of Locomotives and Cars

Locomotives and cars are expected to increase as follows during the Fifth Four-Year Investment Plan, that is from FY 1986-87 to FY 1989-90.

Locomotive	
2,000 H.P.	15
1,200 H.P.	8
900 H.P.	11
500 H.P.	12
Total	46
Passenger coach	143
Freight wagon	676

C. Improvement of Signalling and Telecommunication Systems

BRC intends to improve signalling and telecommunication systems on the main line including the Prome Line, to secure safe operation and to increase train speed and traffic capacity. A feasibility study is underway.

4.2.3.7 Traffic Volume

A. Passenger

The number of passengers carried annually in the whole BRC network was about 62 million in 1985/86. Passenger-miles, were about 2.08 billion in 1980/81, increased to 2.34 billion in 1985/86. During these years, volume has not increased steadily, but fluctuated, decreasing after 1983/84 and increasing in 1985/86.

B. Freight

The number of tons carried annually in the whole BRC network was about 2.2 million and the ton-miles about 350 million in 1985/86. These statistics have also shown changes of increase and decrease. Either in 1981/82 and 1982/83, the volume increased. After a few years of decrease the volume showed an increase in 1985/86.

The figures are shown in Fig. 4.2.3 and Appendix Table 4.2.3.1.

C. Revenue and Expenses

The operation revenue of BRC was about 346 million Kyats (US$ 46 million) while the operating expenses are about 236 million Kyats (US$ 31 million) in the fiscal year 1985/86. Therefore, the operating ratio without interest is about 68%. However, the operating ratio with interest reaches about 100% of the revenue. The profit and loss statement, and the balance sheets for the fiscal year 1981/82 through 1985/86 are shown in Appendix Tables 4.2.3.2 and 4.2.3.3.

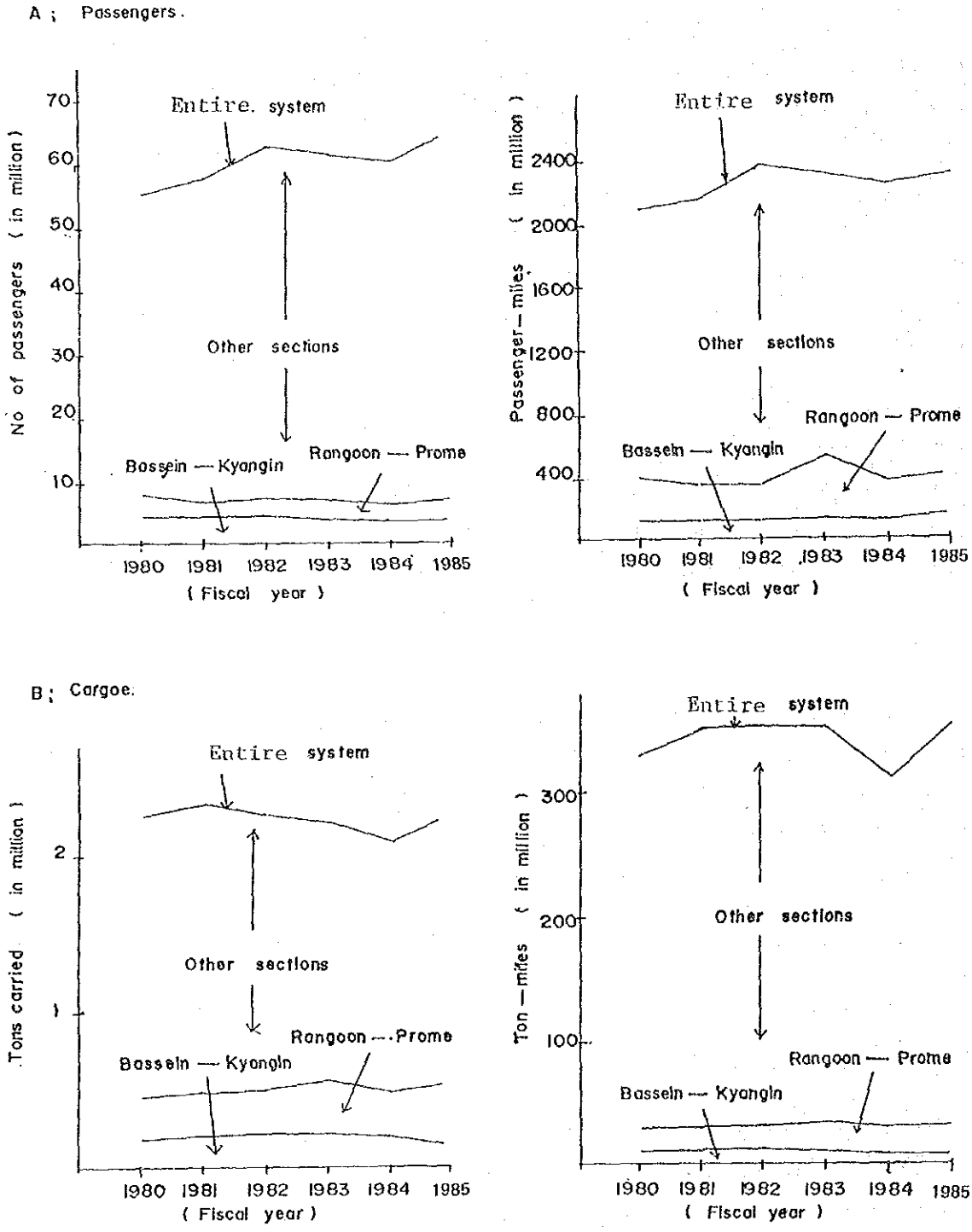


Fig. 4.2.3 Passenger and Freight Traffic on the Sections of Rangoon - Prome and Bassein - Kyangin, BRC

4.2.4 Rivers

The Burmese have used rivers as the principal mode of transportation for many years. Rivers provided not only short distance intraregional transport, but also long distance interregional haulages, although variations in water levels from rainy to dry seasons sometimes seriously limit navigation.

The Inland Water Transport Corporation (IWTC) provides particularly extensive service on the Irrawaddy River, particularly as a regular passenger-cum-cargo carrier between Rangoon and Prome and also between Prome and Mandalay, and for chartered haulages of fertilizer, cement, rice and so on.

Cooperatives organized by township councils also operate various types of waterway services of boats and barges. In addition, governmental organizations, such as HIC, Timber Corporation and Petrochemical Industry Corporation have their own barges and Z-crafts exclusively for their own use.

Table 4.2.6 shows how many vessels belong to IWTC, cooperatives and private owners, and identifies a large increases in private sector vessels over the past several years. The increase is strongest for low-powered passenger boats.

IWTC operates mainly on the Irrawaddy River and in Irrawaddy delta areas with service lines to and from Rangoon. Its service on the Chindwin, Sittang, and Salween is relatively modest. Statistical data indicate that in 1985/86, IWTC on the Irrawaddy River collected 79.8 million passenger-miles, 19% of the national total of 42.3 million, and freight ton-miles of 110.6, 36% of the national total. These data are filed in the Appendix Tables 4.2.4.1 and 4.2.4.2.

Table 4.2.6 WATERWAY VESSELS

	IWTC			Cooperatives		Private	Total	
	Passenger cum cargo	Barges	Tugs	Power barges	Non-power barges	Power vessels		
1978/79	169	240	37	214	852	760	2,272	(1.00)[3]
1980/81	173	266	37	245	804	703	2,228	(0.98)
1982/83	172	287	38	301	796	1,190	2,784	(1.23)
1984/85[1]	175	311	39	313	860	1,231	2,929	(1.28)
1985/86[2]	174	308	39	301	898	1,236	2,956	(1.30)

Source: Reports to the Pyithu Hluttaw (1982, 1985 and 1986).

1 Provisional actual
2 Provisional
3 The figures in ( ) mean the rate of change.

4.3 Direct Influence Area

4.3.1 Zoning of Direct Influence Area

The country is divided into direct influence area and indirect influence area. The direct influence area (DIA) is the area closely related to the bridge project in proximity and in traffic movement. The direct influence area and the indirect influence area are divided into zones for traffic study. The zones are also shown in Fig. 4.3.1 and Appendix Table 4.3.1.1.

4.3.2 Roads

4.3.2.1 Existing Roads

The transportation network including all-weather roads in the DIA is shown in Fig. 4.3.2. As shown roads in the east region of the Irrawaddy River are surfaced and have developed into a network that links major populated townships. They are under the jurisdiction of CC. In addition, gravel and earth roads, often unpassble in the rainy season, extend to less populated areas. Some are administered by CC and others by townships.

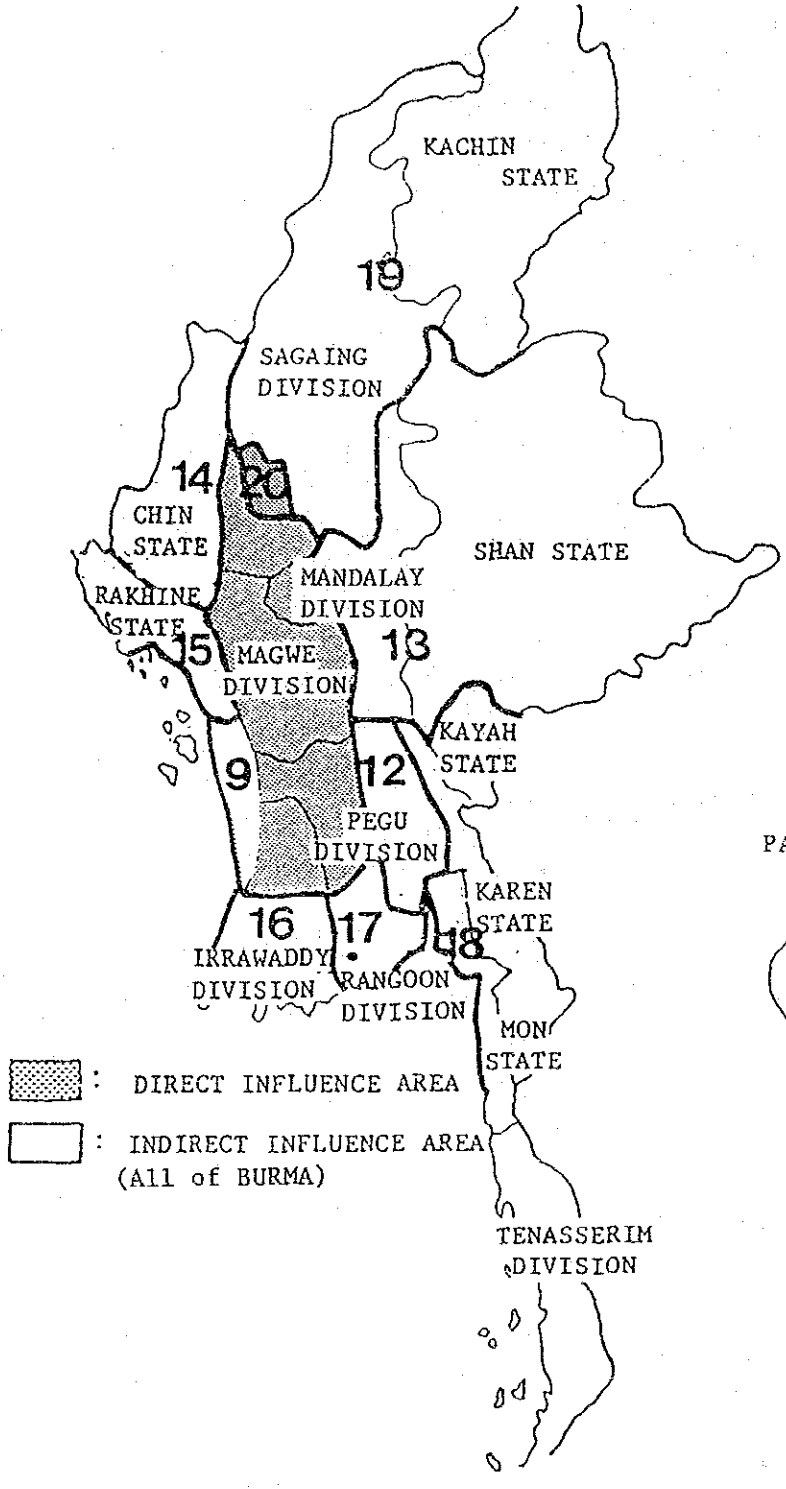
From Rangoon to Prome the road is surfaced to a width of 18 ft. to 20 ft. However, the surface needs much repair, strengthening and smoothing. Improvements have already begun.

From Prome north into Magwe Division, the roads are narrower and surface conditions poor, even compared with the Rangoon-Prome section. Road sections in Magwe Division and further north occasionaly flood during the rainy season, halting traffic for several hours. Unfortunately neither the frequency nor duration of the delays is recorded by the CC.

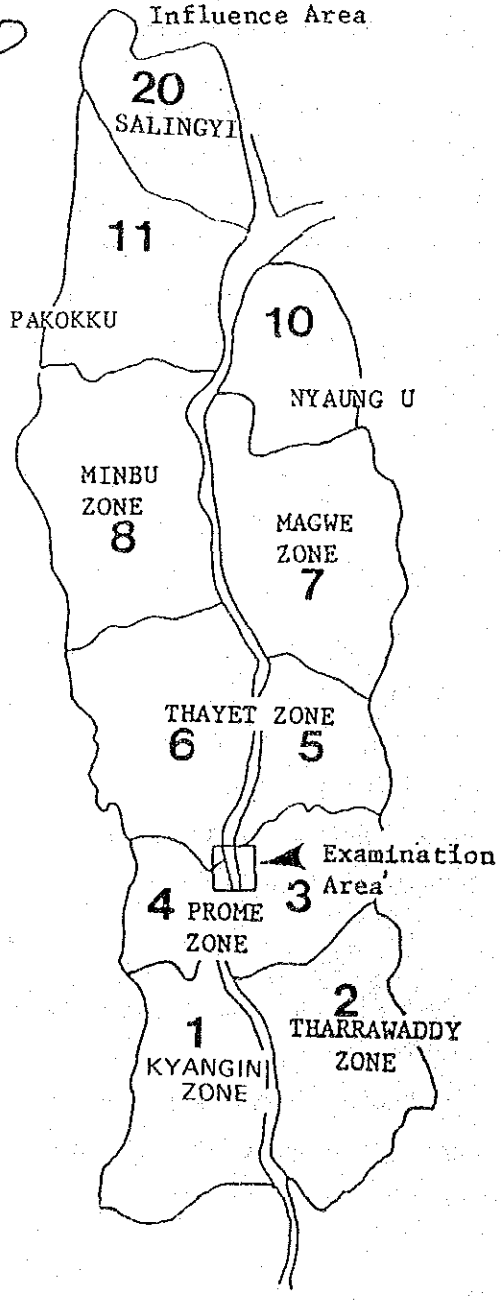
Roads crossing the Pegu Yoma (hills and mountains) from the river side to the Pegu-Taungoo-Meiktila-Mandalay road are rough and partly unsurfaced. Traffic is light. These sections are Prome-Oktwin, Taungdwingyi-Pyinmana and Natmauk-Yanaung. The only passable surfaced road is between Kyaukpadaung and Meiktila. The Prome-Oktwin section improvement was completed in mid-1986 to a surfaced/metal road.

Fig. 4.3.1 ZONING MAP

A. Direct and Indirect Influence Area



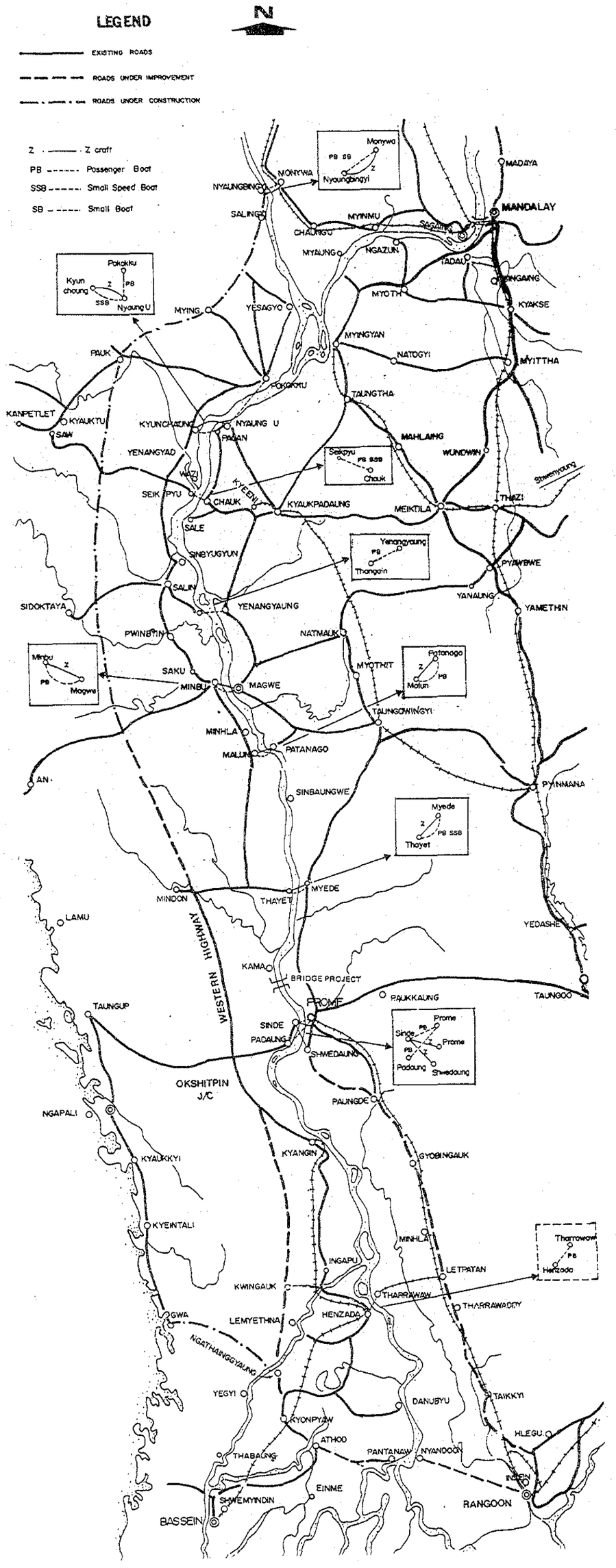
B. Zones in the Direct Influence Area



SCALE : 1 INCH = 20 MILES

MILE 10 0 10 20 30 40 50

Fig. 4.3.2 TRANSPORTATION NETWORK IN DIRECT INFLUENCE AREA



On the west side, surfaced roads extend mostly around Padaung township. They are from Sinde-Padaung-Taungup and include the western highway of Kyangin to Mindon. Another road from Minbu to Ann is surfaced on its eastern half. There are surfaced road sections in Minbu, Minhla, Pakokku, etc., but their lengths are mostly within the populated town centers. Road network in this region is less developed than in the east side.

4.3.2.2 Road Development Plans

There are two road projects now being implemented: the Rangoon-Prome Road and the Western Highway. They are already discussed in Sub-section 4.2.2. Besides these large scale national projects, the CC has mounted campaigns to repair surfaces and even to widen sections from Prome northward. There are no other specific road projects currently being implemented in the Direct Influence Area.

However, CC has prepared a feeder road development plans in the area around the Western Highway. The proposed feeder roads were described in 3.3 of Chapter 3.

4.3.2.3 Traffic Volumes on Roads

Traffic surveys in relation to the Irrawaddy River Bridge Project were conducted on the roads near Prome and the Western Highway junction at Okshitpin in Padaung township. The location and the traffic volumes are shown in the following Chapter 5, which also examines survey results of railway passengers and river-crossing traffic.

Construction Corporation has conducted traffic counts on trunk road sections twice a year in the past. Traffic volumes on selected points are shown in Fig. 4.3.3. Characteristics of the traffic data are noted as follows:

1) In the urbanized area of Prome-Shwedaung townships the daily motorized traffic is greater than 1,000 vehicles per day. However, in the suburban areas south of Shwedaung, traffic volume per day is about 800 vehicles per day.

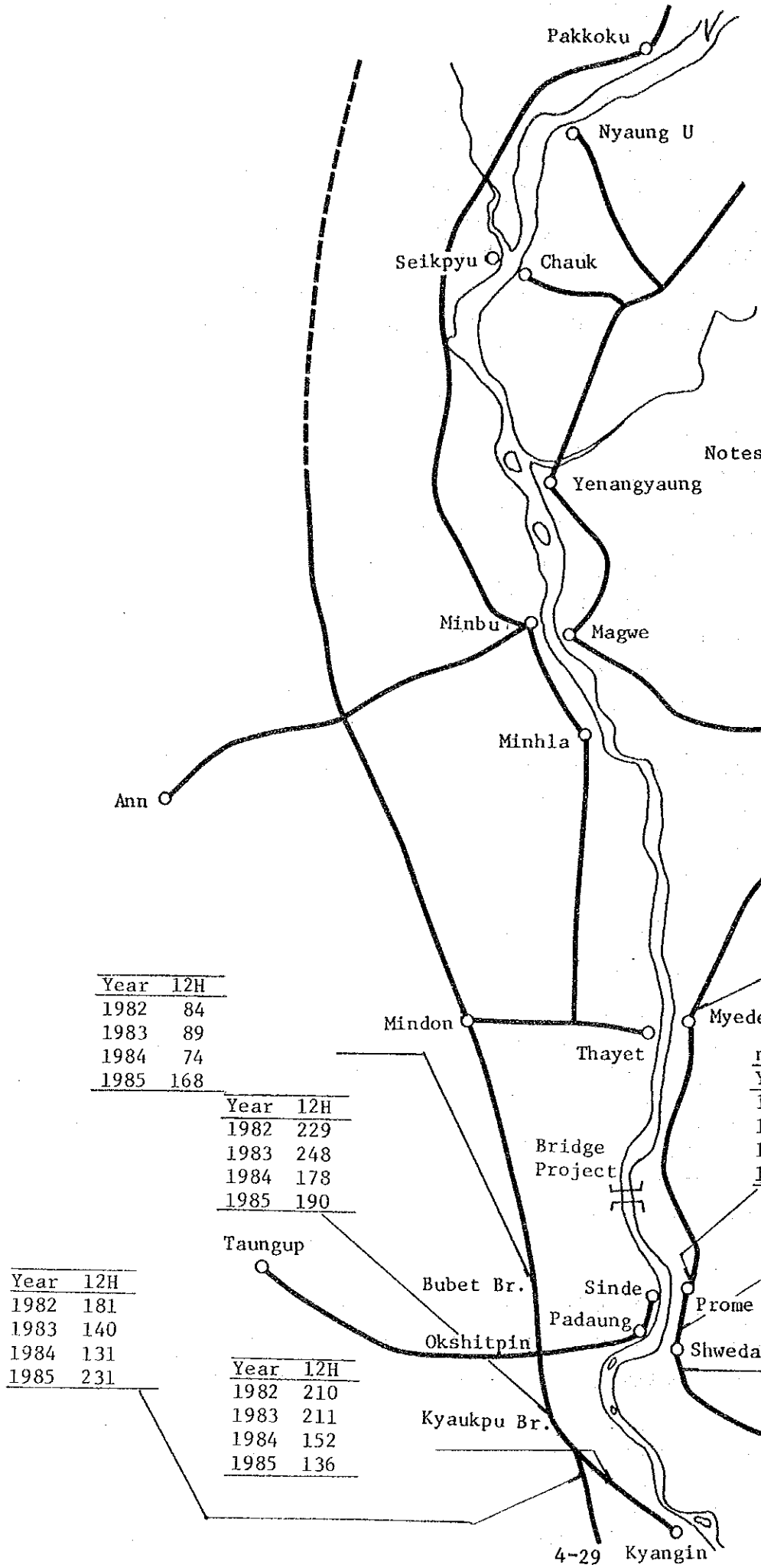


Fig. 4.3.3

TRAFFIC VOLUME ON SELECTED POINTS

Notes: On the roads beyond Myede, traffic data are few at present. (according to CC, Febuary, 1986)

1 12 H: traffic volume for twelve hours.

2 VPD : vehicles per day.

Year	12H
1982	84
1983	89
1984	74
1985	168

Year	12H
1982	229
1983	248
1984	178
1985	190

Year	12H
1982	181
1983	140
1984	131
1985	231

Year	12H
1982	210
1983	211
1984	152
1985	136

ml.220

Year	VPD
1985	440

ml.182

Year	VPD
1982	1,414
1983	1,024
1984	2,384
1985	1,766

ml.174 (101)

Year	VPD
1985	1,269

Note: Traffic Count was conducted by JICA Study Team.

ml.168

Year	VPD
1982	605
1983	763
1984	733
1985	754

2) On the roads northward from Prome, traffic counts are conducted only occasionally. Daily motorized traffic volume is far less than 1,000 per day, vehicles probably around several hundred.

3) On the western side, traffic data on Western Highway have been available for the past few years. Since the road is under construction from south to north, the volume includes construction works. Thus, no definite trend for normal traffic can be determined.

4) Daily traffic volume for a week-long period has been scarce and shows no definite pattern since the time of the Rangoon Prome Road Project Preparation Study (GITEC, 1982).

5) Vehicles are classified usually trucks, buses, small cars, motor cycles, bicycles/tricycles and animal carts. However, trucks, buses, and small pick-up trucks are all used for carrying passengers from time to time.

6) Animal carts, bicycles/tricycles and motor vehicles use the surfaced roadway. Particularly in populated areas, slow traffic movement often causes motor vehicles to change speed. Conflict between slow-moving traffic and faster motor vehicles is expected to increase since the latter will increase in coming years. Traffic safety problems will be serious and actions will be necessary to maintain the safety of all traffic movement.

4.3.2.4 Road Transport Corporation and Other Operators

A. RTC

The Road Transport Corporation (RTC) is organized by the government to engage in the services stated previously in 4.2.2.5. In the direct influence area, rice, stone, sand and fertilizer are the main cargo transported by RTC trucks, followed by industrial material, products and sawn timber and its products. Statistical data of transport by item-wise during 1980/81 - 1985/86 are shown in Appendix Table 4.3.2.1. But other state agencies, such as Timber Corporation, Petroleum Product Supply Corporation, etc., have their own vehicles. In addition, private operators transport some of these government goods,

though the majority are engaged in the transportation of goods of the private sector.

Passenger service by RTC in the direct influence area consists of the bus line service on the sections between Magwe and Rangoon. Private operators also have their regular routes not only for the above corridor but also in other areas.

Statistical data of passengers and freight transport carried by RTC in the direct influence area are shown in Appendix Table 4.3.2.2. Passengers carried by RTC vehicles decreased from 1980/81 to 1985/86. However, cargo increased in these years.

4.3.3 Railways

4.3.3.1 Railway Network

There are railway lines in the direct influence area: Rangoon-Prome, a single track line with two passenger trains up and down at Prome, and Bassein-Kyangin, a single track line with three passenger trains up and down at Kyangin daily. In addition, two branch lines from the Rangoon - Pegu - Mandalay line come in the DIA: Pynmana - Kyeeni and Thazi - Myngyan lines, each with one round trip passenger train service. Cargo trains move in response to cargo movements. The lines are shown in Figs. 4.2.2 and 4.3.2.

A. Train Operation on Prome Line and Western Line

There are two passenger and two freight trains for each direction on the existing Prome Line and three passenger and one freight train on the Western Line. The number of coaches per train is as follows:

	Express train	Mail train	Local train
Prome Line	14	15	-
Western Line	7	7	11

These trains are hauled by diesel locomotives, which are assigned to Rangoon shed and Malagon shed for Prome Line and to Henzada shed for Western Line.

The maximum speed is 35 miles per hour (56 km/h) for passenger trains and 25 miles per hour (40 km/h) for freight trains, while the actual scheduled speed for passenger trains is 23 miles per hour (37 km /h) on the section between Rangoon and Prome and 19 miles per hour (30 km/h) between Bassein and Kyangin.

B. Extension Plans

The railway extension plans are stated in 4.2.3.4 of this chapter. The plans will connect Kyangin and Prome through the project bridge.

4.3.3.2 Traffic Volumes

The total passengers and passenger-miles between Rangoon and Prome and between Bassein and Kyangin sections comprise 12% and 18% respectively of the whole BRC network. Therefore, only about 19,000 people travelled 1.0 million passenger-mile (1.6 million passenger-kilometers) per day in 1985/86.

Traffic movement on these two existing lines is shown in Fig. 4.2.3 and Appendix Table 4.3.3.1. Passengers carried by the entire BRC railway network showed a modest increase in number and in passenger-miles for 1980/81 - 1985/86. However, in the case of two sections, Rangoon-Prome and Bassein-Kyangin, a small decrease was evident for the same period.

The total tonnage and total ton-miles between Rangoon and Prome and between Bassein and Kyangin are about 20% and 9% respectively of the whole BRC network. Therefore, the tonnage and ton-miles per day on both sections are only 1.2 thousand tons and 76 thousand ton-miles (122 thousand ton-kilometers) in 1985/86.

Volumes of freight transported during these years decreased on the entire railway system in tons and ton-miles. On the sections of Rangoon-Prome and Bassein-Kyangin, freight transportation indicates of neither decrease nor increase. Both maintained a constant level of volume.

Cargo trains do not usually come to Prome station. Parcels and goods transported outward by attached wagons to the mail train were, according to the data at Prome Railway Station, 3,900 tons in 1983/84, but decreased to 892 tons in 1984/85. Cargo trains terminate at Paunde station, some 30 miles south of Prome. The situation is same at Kyangin Railway Station. Goods trains terminate at Myanaung Station, 10 miles south of Kyangin Station.

Appendix Table 4.3.3.2 shows volumes of passengers travelling outward from Prome and Kyangin Stations. Passengers from Prome Station increased 25% during the years from 1981 to 1985. At Kyangin Station passengers increased until 1982/83, and decreased the following year.

4.3.4 Rivers

4.3.4.1 Network

River transport on the Irrawaddy River was the dominant mode of transport until the mid 1970s in the direct influence area. Since then road transport has rapidly increased its share of the transportation market. However, those living along the river still depend on river service. Moreover, all vehicles, cargo and passengers traveling east-west must use river vessels since there is no bridge spanning the river in the direct influence area.

Currently, the river transport services are provided mostly by Inland Water Transport Corporation (IWTC), local cooperatives and private sectors. State factories along the Irrawaddy River and government agencies also have their own Z-crafts and barges for exclusive use in crossing and traveling up and downstream.

Crossing points in the direct influence area are many; some maintain regular schedules while others operate only as needed. There are eight regular crossing points between Prome and Monywa along the river. The eight crossing points are shown in Fig. 4.3.2 and Table 4.3.1.

4.3.4.2 Operation

Waterway service is operated by the agencies described below. However, statistical data of transport volumes and vessels on the river are limited. Minimum necessary data are gathered through the traffic studies described in the next chapter.

A. Inland Water Transport Corporation

Inland Water Transport Corporation (IWTC) has facilities on the Irrawaddy River, as shown below:

Vessels	Passengers	35
	Cargoes	98
	Non-powered barge	158

Landing facilities station flat	22
Dockyard Mandalay	1

Source: IWTC, January 1986.

At present, there is a regular service between Prome and Rangoon by IWTC. The service, for passengers and cargo, makes 208 round trips per year. It takes usually 2 days for the down-stream trip and 3 days for the up-stream trip. The vessel can carry 280 passengers and 60 tons of cargo. Another regular service runs between Mandalay and Prome and makes 365 round trips per year. It takes 4 days for upstream trip and 3 days for down-stream. This vessel also carries 280 passengers and 60 tons of cargo.

Each of these river services stops at about 30 towns and villages on both sides of the river. Transport statistics of the two lines are shown in Appendix Table 4.3.4.1. During the years from 1980/81 to 1985/86, passenger-miles increased 8.5% per annum for Rangoon-Prome Line but no increase for Mandalay-Prome Line. In ton-miles, increases of 4.2% per annum for Rangoon-Prome Line and 3.2% for Mandalay-Prome Line were registered for the same period.

The IWTC plies between Prome (Shwedaung) and Padaung (Sinde) using a Z-craft with a loading capacity of eight heavy vehicles and 100 passengers. It provides several round trips during the daytime. The service is shown in Table 4.3.1 together with the crossing services by cooperatives and private owners. There are no other regular services by IWTC in the direct influence area. Irregular vessel movements depend on the demand for transport service for cement, fertilizer, rice, etc.

B. Cooperative

There are cooperatives operating regular crossig service on the Irrawaddy River. The cooperative is formed in the township mostly on the west side of the river and authorized for the regular operation of Z-craft and/or passenger boats. The operation is not exclusive, but co-exists with other agencies and private operators.

Table 4.3.1 RIVER CROSSING SERVICE IN THE DIRECT INFLUENCE AREA: DECEMBER, 1985

A. Service for Passengers

No.	Location No.	Name of Location	Type of Boat	Operation	Number of Crossings
1.	301	Prome - Sinde	PB	Co-operative	13
	302	Prome - Padaung	PB	-"-	2
	303	Prome - Sinde	ZC	HIC	13
	304	Prome - Sinde	ZC	IWTC & Co-op	23
2.	305	Myede - Thayet	SSB	Co-operative	55
	305	Myede - Thayet	PB	-"-	10
	306	Myede - Thayet	ZC	Cement Factory	5
3.	307	Patanago - Malon	ZC	HIC	10
	307	Patanago - Malon	PB	Private	14
4.	308	Magwe - Minbu	PB	-"-	43
	308	Magwe - Minbu	ZC	Co-operative	15
5.	309	Chauk - Seikpyu	PB	-"-	15
	309	Chauk - Seikpyu	SSB	Private	73
	315	Chauk - Wazi	PB	Co-operative	4
6.	310	Yanangyaung - Thangain	PB	Co-operative	4
	310	Yanangyaung - Thangain	PB	Private	8
7.	312	Nyaung U - Kyun Chaung	SSB	Private	11
	312	Nyaung U - Kyun Chaung	ZC	Co-operative	4
	313	Nyaung U - Pakokku	PB	Private	6
8.	314	Monywa - Nyaung Bin Gyi	ZC	Co-operative	26
	314	Monywa - Nyaung Bin Gyi	PB	-"-	16
	314	Monywa - Nyaung Bin Gyi	SB	Private	316
		Grand Total			698

B. Service for Vehicles

No.	Location No.	Name of Location	Type of Boat	Operation	Crossings*
1.	303	Prome - Sinde	ZC	HIC	12
	304	Prome - Sinde	ZC	IWTC & Co-op	22
2.	306	Myede - Thayet	ZC	Cement Factory & Co-operative	4
3.	307	Patanago - Malon	ZC	HIC	10
4.	308	Magwe - Minbu	ZC	Co-operative	14
7.	312	Nyaung U - Kyun Chaung	ZC	Co-opertive	4
8.	314	Monywa - Nyaung Bin Gyi	ZC	Co-operative	26
		Grand Total			92

Note: Location number is for the classification of traffic survey point.

PB ····· Passenger boat
ZC ····· Z-craft carrying passengers and vehicles
SSB ···· small speed boat; a powered passenger boat
SB ····· small boat; manual and non-powered boat

* figured on the basis of one way trips per day.

The crossing services operated by cooperatives are specified in Table 4.3.1. Besides regular crossing routes, these cooperatives also provide unscheduled crossings in other directions, sometimes down to Rangoon port. Details of the size and number of vessels owned by these cooperatives and statistical data of goods and passengers carried are not available.

C. Private Operators

There are a number of powered vessels owned by private operators crossing the river. Generally, they provide one or two round trips per each vessel per day on the crossing route. A vessel leaves the jetty when it has a full passenger load. At the crossing points as shown in Table 4.3.1, private owners operate boats and small speed boats, but not vehicle-carrying Z-craft.

Besides the regular route, they serve any surrounding village as required to move passengers and cargo. Their movement is quite flexible and unscheduled serving both local demand and demand up and down stream. Particularly in Monywa, a large number of small manual boats are seen alongside Z-craft and large passenger boats. Statistical data for vessels and transportation run by private operators are also not available.

D. Government Agencies

There are several state agencies and factories, including those of the Heavy Industry Corporation (HIC), along the river. Each has its own exclusive water transport system. But some, such as in Thayet and Sinde, also serve the public. Those agencies with public service are included in Table 4.3.1.

4.3.4.3 Development Plans

IWTC, HIC, cooperatives and private owners wish to replace old vessels with new ones. However, it is hard to identify any definite replacement plans. Plans of new vessel purchases by IWTC and others for

the 5th Four-Year Plan seem to have beeen postponed because of problematic foreign currency finance. There are no river transport development studies in conjunction with other development plans in the direct influence area.

CHAPTER 5 TRAFFIC STUDIES

CHAPTER 5 TRAFFIC STUDIES

5.1 General

The traffic studies of this chapter consist of traffic surveys on roads, railways and river crossing and a forecast of the traffic that would traverse the project bridge.

Traffic surveys were conducted in the Direct Influence Area (DIA) in order to identify characteristic features of the traffic on the river, as well as on roads and railways. The results are compiled in a number of tables, including origin-destination (OD) matrices. After studying traffic survey results, a forecast of traffic passing through the projected bridge is made by combining estimation procedures of traffic growth, OD matrices for future years, and an estimate of traffic diverted to the project bridge.

5.2 Traffic Surveys

5.2.1 Types of Traffic Surveys

Traffic Surveys of ferry traffic, railroad passengers and roadside vehicles including OD interviews were conducted in December 1985 and January 1986. At jetties where ferries, including Z-craft arrive and depart, OD surveys were conducted of passengers and vehicles along with traffic counts. In addition, similar OD surveys were conducted for road vehicles and railway passengers on both sides of the river in the DIA.

Fig. 5.2.1 shows the locations of survey stations for the traffic surveys. Moreover, Appendix Table 5.2.1.1 and Appendix Tables 5.2.1.2 - 5.2.1.5 set out the schedule of traffic surveys and survey forms used.

Traffic survey stations are located throughout the DIA. Surveys had to be carried out in cooperation with the staff of CC and local agencies. The survey implementation system was organized in CC as shown in Appendix Fig. 5.2.1.1.

5.2.2 Ferry Survey

5.2.2.1 Survey

The study group conducted a traffic count on the ferry for passengers and vehicles to confirm total volumes, and interviewed for OD and other information of ferry passengers and vehicle drivers.

The traffic count was carried out on a weekday at jetties simultaneously with interviews conducted on ferries, Z-crafts, and passenger boats with details as follows:

Survey period:	December 23, 1985 - January 3, 1986. (excluding Saturday, Sunday and gazetted holidays).
Survey hours:	from 6:00 to 18:00 (Survey hours were almost the same as the operating hours of the ferries).
Survey locations:	Eight crossings which are classified into 14 jetties for traffic counting and 22 routes for OD interviews (Fig. 4.2.1.).
Direction:	Both directions
Interviews:	Passengers and vehicles using the river-crossing ferries.
Type of ferries:	Z-craft (including towed Z-craft), passenger boat, small speed passenger boat, small non-powered passenger boat.

5.2.2.2 Survey Results

A. Traffic Counting

The result of the counts of river crossing traffic on ferries for public service using the jetties at major crossing points are shown in Table 5.2.1.

Fig. 5.2.1 TRAFFIC SURVEY LOCATIONS

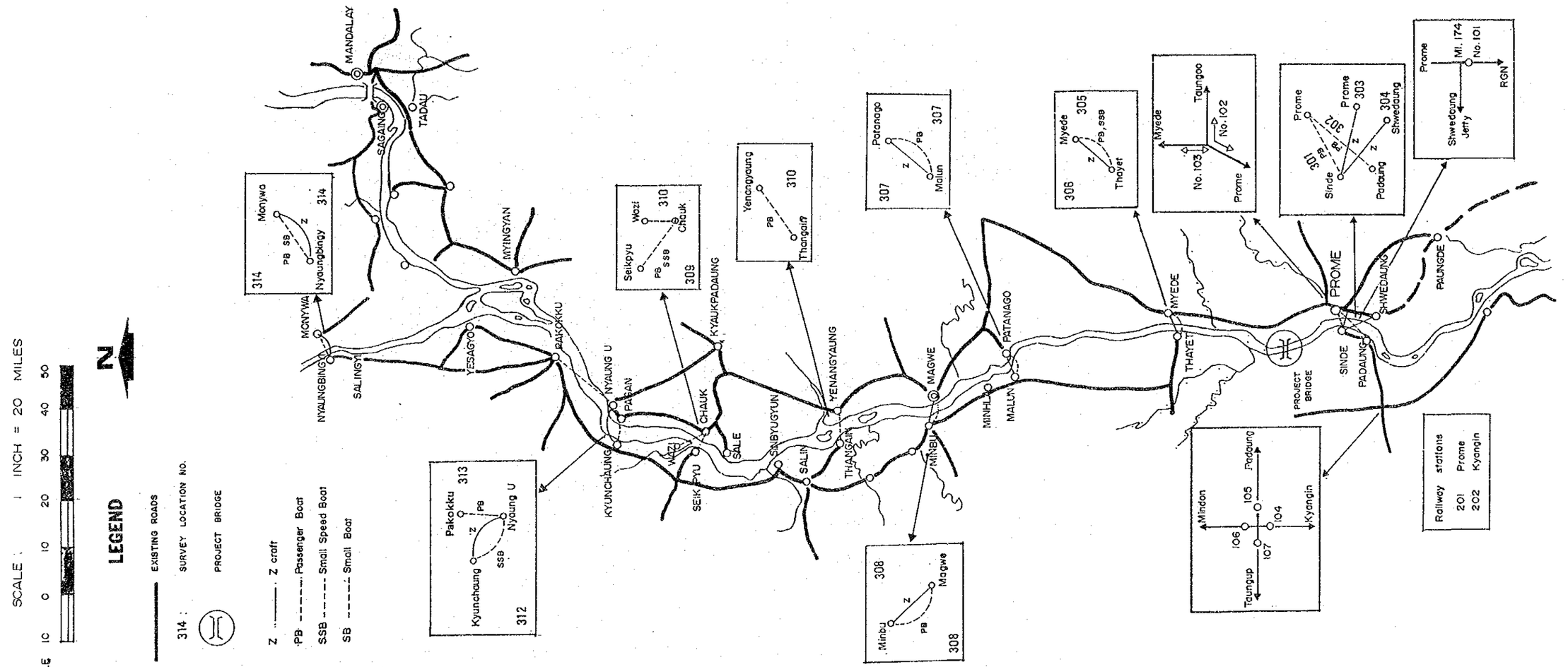


Table 5.2.1 RIVER CROSSING SERVICE IN THE DIRECT INFLUENCE AREA, DECEMBER, 1995

A. Service for Passengers

No.	Location	Name of Location	Type of Boat	Operation	Number of Crossing	Counted 12 hours	Interview 12 hours
1.	301	Prome - Sinde	PB	Co-operative	16	2,565	408
	302	Prome - Padaung	PB	Co-operative	2	120	32
	303	Prome - Sinde	ZC	H.I.C	12	695	62
	304	Prome - Sinde	ZC	I.W.T.C & co-op	22	390	162
2.	305	Myede - Thayet	SSB	Co-operative	55	646	-
	305	Myede - Thayet	PB	Co-operative	12	1,791	406
	306	Myede - Thayet	ZC	Cement Factory	5	69	-
3.	307	Patanago - Malon	ZC	H.I.C	10	284	100
	307	Patanago - Malon	PB	Private	14	162	75
4.	308	Magwe - Minbu	PB	Co-operative	52	1,305	214
	308	Magwe - Minbu	ZC	Co-operative	14	1,596	204
5.	309	Chauk - Seikpyu	PB	Co-operative	14	706	250
	309	Chauk - Seikpyu	SSB	Private	72	1,078	200
	315	Chauk - Wazi	PB	Co-operative	4	160	112
6.	310	Yenanchaung - Thangain	PB	Co-operative	4	250	-
	310	Yenanchaung - Thangain	PB	Private	8	200	-
7.	312	Nyaung U - Kyun Chaung	SSB	Private	12	101	44
	312	Nyaung U - Kyun Chaung	ZC	Co-operative	4	166	74
	313	Nyaung U - Pakokku	PB	Private	6	484	260
8.	314	Monywa - Nyaung Bin Gyi	ZC	Co-operative	26	3,248	781
	314	Monywa - Nyaung Bin Gyi	PB	Co-operative	16	1,926	324
	314	Monywa - Nyaung Bin Gyi	SB	Private	316	2,260	-
		Grand Total			698	20,202	3,708

B. Service for Vehicles

No.	Location	Name of Location	Type of Boat	Operation	Number of Crossing	Counted 12 hours	Interview 12 hours
1.	303	Prome - Side	ZC	H.I.C	12	54	27
	304	Prome - Sinde	ZC	I.W.T.C. & Co-op	22	74	58
2.	306	Myede - Thayet	ZC	Cement Factory	4	2	2
3.	307	Patanago - Malon	ZC	H.I.C	10	12	10
4.	308	Magwe - Minbu	ZC	Co-operative	14	31	26
7.	312	Nyaung U - Kyun Chaung	ZC	Co-operative	4	40	29
8.	314	Monywa - Nyaung Bin Gyi	ZC	Co-operative	26	73	45
		Grand Total			92	286	197

Note: Location number is for classification of the traffic survey point.

PB ..... Passenger boat
ZC ..... Z-craft carrying passengers and vehicles.
SSB .... Small speed boat: a powered passenger boat.
SB ..... Small boat: a non-powered boat.

Each oneway trip counts as a single crossing.

B. Interview

1) Origin and Destination

Table 5.2.2 shows the OD matrices in 1985 on a passenger-trip base and a vehicle-trip base (passenger cars, buses and trucks). The zoning used in OD matrices is in Fig. 5.2.2 and Appendix Table 4.3.1.1. OD matrices by vehicle type are shown in Appendix Table 5.2.2.1.

2) Access Time and Access Mode

Access time to the jetties and transportation modes are compiled in Appendix Table 5.2.2.2. Summarized figures are shown in Table 5.2.3.

3) Egress Time and Egress Mode

Egress time and egress mode of passengers from the jetties are also compiled in Appendix Table 5.2.2.3 from which the summarized figures are shown in Table 5.2.3.

Table 5.2.3 ACCESS AND EGRESS (FERRY PASSENGERS)

Mode	Access			Egress		
	Persons	(%)	Average Time	Persons	(%)	Average Time
			(min.)			(min.)
Walking	8,295	(42)	19	7,628	(39)	18
Bicycle, trishaw	3,551	(18)	26	3,416	(17)	20
Motorcycle	26	(-)	7	11	(-)	27
Cars, Jeeps	1,464	(7)	127	1,572	(8)	340
Buses, Pickups	3,849	(20)	123	4,156	(21)	169
Trucks	352	(2)	216	332	(2)	175
Railways	56	(-)	467	126	(1)	263
Ferries	44	(-)	54	109	(-)	553
Others	1,950	(10)	37	2,180	(11)	27
Total	19,587	(100)	56	19,550	(100)	85

A. Direct and Indirect Influence Area

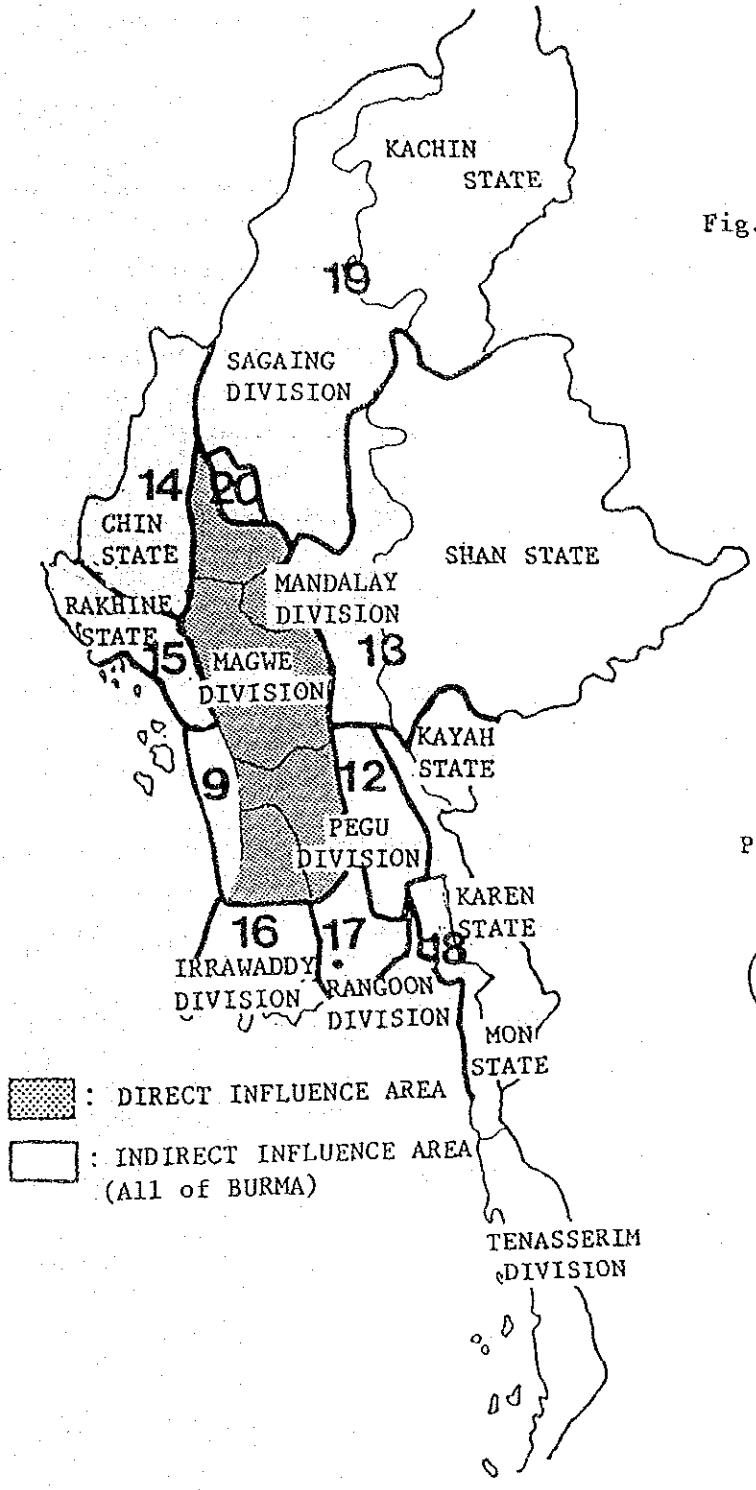


Fig. 5.2.2 ZONING MAP

B. Zones in the Direct Influence Area

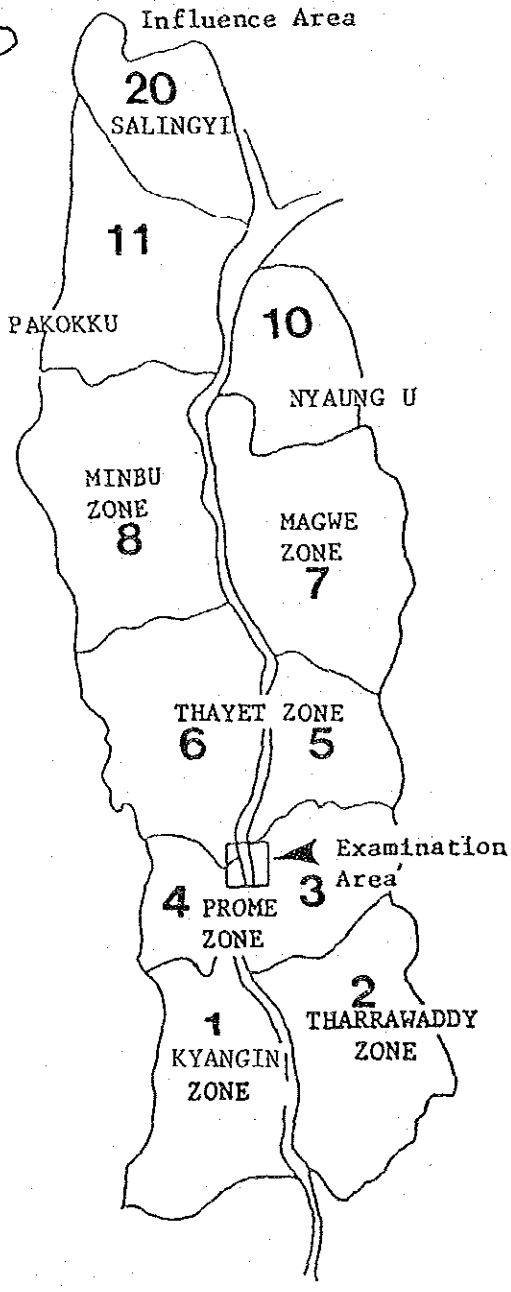


Table 5.2.2 OD MATRICES IN 1985 (FERRY PASSENGERS AND VEHICLES)

(Unit=persons/day)

PASSENGER TOTAL

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	Total
01 Kyangin	0	0	139	0	8	0	0	0	0	0	0	0	0	0	0	0	31	0	0	0	178
02 Tharrawaddy	0	0	0	14	0	0	0	10	0	0	0	0	0	0	0	3	0	0	0	0	27
03 Prome	76	0	0	1362	0	205	0	4	86	0	9	0	0	0	0	13	0	0	8	0	1763
04 Padaung	0	37	1320	0	64	0	14	0	0	0	0	0	0	0	0	0	73	0	0	0	1508
05 Myede	0	0	0	28	0	983	5	4	0	0	3	0	5	0	0	0	0	0	0	0	1028
06 Thayet	0	0	204	9	1108	18	353	0	0	0	30	10	39	0	0	0	35	12	0	0	1818
07 Magwe	0	0	0	4	0	290	0	1944	0	0	170	0	0	0	17	0	0	0	0	0	2425
08 Minbu	0	0	99	0	12	0	2039	0	0	32	5	5	40	0	0	0	97	0	9	0	2338
09 Sandoway	0	0	43	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	53
10 Nyaung U	0	0	0	0	0	0	5	91	0	4	217	1	0	0	0	0	0	0	0	0	318
11 Pakokku	0	0	11	0	3	3	200	11	0	154	15	7	19	0	0	3	45	0	31	0	502
12 Pegu	4	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11
13 Mandalay	0	0	0	0	0	11	0	52	0	0	38	0	0	0	0	0	0	0	0	179	280
14 Chin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 Rakhine	0	0	0	0	0	0	24	0	0	0	0	1	0	0	0	0	7	0	0	0	32
16 Irrawaddy	0	0	12	0	0	0	9	3	0	0	4	0	0	0	0	0	4	0	0	0	32
17 Rangoon	11	0	0	19	0	66	0	28	31	0	25	0	0	0	36	0	0	0	0	23	259
18 Karen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	17
19 Sagaing	0	0	0	0	0	0	3	0	0	3	62	0	6	0	0	0	0	0	9	3340	3423
20 Salingyi	0	0	0	0	0	0	0	0	0	0	7	0	110	0	0	0	162	0	3426	14	3719
Total	91	37	1828	1436	1195	1583	2652	2147	117	193	585	24	219	0	53	19	464	12	3483	3573	19711

All Vehicles

(Unit=Vehicles/day)

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	Total
01 Kyangin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	4
02 Tharrawaddy	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
03 Prome	2	0	0	23	0	1	4	1	12	0	3	2	0	0	0	0	0	0	0	0	48
04 Padaung	0	0	20	2	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	30
05 Myede	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
06 Thayet	0	0	0	2	0	0	7	0	0	1	1	0	1	0	0	0	0	0	0	0	12
07 Magwe	2	0	0	1	0	5	0	5	0	0	8	0	0	0	0	0	0	0	0	0	21
08 Minbu	2	0	2	0	1	0	12	0	0	2	0	0	0	0	0	0	1	0	0	0	20
09 Sandoway	0	0	11	3	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	17
10 Nyaung U	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
11 Pakokku	0	0	1	0	0	0	7	3	0	1	0	0	2	0	0	0	8	0	4	0	26
12 Pegu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 Mandalay	0	0	0	0	0	1	0	0	0	0	5	0	0	0	0	0	0	0	0	8	14
14 Chin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 Rakhine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 Irrawaddy	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
17 Rangoon	3	0	0	5	0	0	0	0	8	0	4	0	2	0	0	0	0	0	0	0	22
18 Karen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 Sagaing	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	22	24
20 Salingyi	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0	26	0	30
Total	9	0	37	38	1	7	30	10	20	4	23	2	7	0	0	0	26	0	31	30	275

Table 5.2.4 TRIP PURPOSES

(Percent in ( ))

	Passengers		Vehicles	
	(#)	(%)	(#)	(%)
To home	7,247	(37.0)	25	(9.2)
To work	3,033	(15.5)	79	(29.2)
To school	513	(2.6)	3	(1.1)
Working	1,357	(6.9)	66	(24.4)
Shopping	3,3,52	(17.1)	21	(7.7)
Farming	122	(0.6)	4	(1.5)
Others	3,988	(20.3)	73	(26.9)
Total	19,612	(100.0)	271	(100.0)

From: Appendix Table 5.2.2.4.

Table 5.2.5 WAITING TIME

(Percent in ( ))

Time (min) / Location	1-15	15-30	30-60	60-120	120-240	240-	Total
Passengers	8,432	6,109	3,863	435	131	2	18,972
(%)	(44.4)	(32.2)	(20.4)	(2.3)	(0.7)	(0.0)	(100)
Vehicles	37	57	79	37	40	17	267
(%)	(13.9)	(21.3)	(29.6)	(13.9)	(15.0)	(6.4)	(100)

From: Appendix Tables 5.2.2.5 and 5.2.2.6.

4) Trip Purpose

Trip purpose compositions of passengers and vehicles are shown in Appendix Table 5.2.2.4. The percent composition of the total are shown in Table 5.2.4.

5) Waiting Time

Waiting time for ferry departure by passengers and vehicles is compiled in Appendix Tables 5.2.2.5 and 5.2.2.6. From these tables the waiting time distribution is summarized in Table 5.2.5.

6) Commodities Carried

Goods carried by trucks are classified into commodity types as shown in Table 5.2.6.

7) Occupancy

The average number of passengers per vehicle type is shown in Table 5.2.7.

Table 5.2.6 COMMODITIES CARRIED BY TRUCKS ON FERRIES

Commodities	Westbound Vehicles		Eastbound Vehicles		Total Vehicles	
	(#)	(%)	(#)	(%)	(#)	(%)
Food grains	9	(14.0)	3	(6.0)	12	(11.0)
Fruit and vegetables	0	(0.0)	3	(6.0)	3	(3.0)
Fuels	11	(18.0)	10	(21.0)	21	(19.0)
Timber, bamboo	6	(10.0)	6	(13.0)	12	(11.0)
Machinery, manufactures	12	(19.0)	6	(13.0)	18	(17.0)
Stones, earth, cement	0	(0.0)	0	(0.0)	0	(0.0)
Cotton, tabacco	3	(5.0)	5	(11.0)	8	(7.0)
Textile, clothes	0	(0.0)	0	(0.0)	0	(0.0)
Others	21	(34.0)	14	(30.0)	35	(32.0)
Total	62	(100.0)	47	(100.0)	109	(100.0)

Table 5.2.7 PASSENGER OCCUPANCY (VEHICLES ON FERRIES)

Type of Vehicle	Vehicles	Passengers	Average Passengers/ vehicle	No answer
Motorcycles	9	10	1.0	0
Passenger cars	51	290	5.7	2
1- Buses	9	203	22.6	0
2- Pick-ups	53	303	5.7	0
Buses	62	506	8.2	0
Trucks	153	640	4.2	7
Total	275	1,446	5.3	9

5.2.3 Railway Passenger Survey and Road Vehicle Survey

Railway passenger interview surveys were carried out at Prome Station on December 23, 1985 and Kyangin Station on December 26, 1985. Passengers departing the station were selected for interview. Surveys and results are presented in Appendix 5.2.3.A.

A road vehicle interview survey was carried out at mile 174, Rangoon-Prome Road in Shwedaung Township on December 23, 1985 and at Okshitpin Junction of the Western Highway in Padaung Township on December 26, 1985. Surveys and results are presented in Appendix 5.2.3.B.

5.3 Characteristics of River Crossing Traffic

5.3.1 Crossings

A. Crossings and Landings

As shown in Fig. 5.2.1 and Table 5.2.1, eight public crossing points were identified along the river between Prome and Monywa. Each point has a various kinds of ferries. Some have Z-craft services. However, some Z-craft services not open to the public are not included in this survey.

Of these crossings, Monywa had the largest passenger traffic (7,430 persons), followed by Prome (3,770) and Magwe (2,910). Z-crafts carried 130 vehicles at Prome, 30 at Minbu and 73 at Monywa. Ferry service was available for 12 hours during daytime hours. Night service was quite rare at these crossings.

Jetties constructed on the river bank are mostly earthen approach roadways to the water line, and sometimes change their location because of water level variations. In most cases, the township office repairs and maintains the roadway. Z-crafts use the edge of the approach roadway for landing, while other boats are free to land at any point on the bank. Only passenger boats serving regular crossing routes have common landing points, and some of these points have ticket booths.

Chartered and irregular service boats are able to land at any point from which passengers can climb the bank or cargoes can be loaded/unloaded by labours. In Prome, Pakokku, etc., the landing area for passenger and cargo boats extends up to 1.5 km or more, parallel to the riverside urban area.

B. Traffic not Covered by Surveys

1) Passengers on other routes

Although the majority of the public traffic movement pass through the above-mentioned eight crossing points, there are numerous crossing routes with small volume. It was not possible to include all these minor and/or irregular crossings in the traffic survey of this bridge project.

According to information provided by those working at jetties and ferries, passenger traffic on these minor crossings was estimated to be approximately 25-35%. They were mostly local movement and in short distance. Accordingly, they are not included in the traffic forecast subject to the Bridge crossing.

2) Cargo on Ferries

The various types of ferry boats that use this river move cargo over an even wider area than they carry passengers. While the majority of passengers are carried by ferries on the eight crossing, there are no such regular routes or services for cargo. Ferry boats carrying cargoes vary from small nonpowered boats to Z-craft and powered barges. Landing points of cargo-carrying boats concentrate around the passenger jetties because of the availability of the approach roadway, where transfer to trucks and animal carts is easier and efficient. However, many ferry boats land at points along the bank where cargoes enroute to/from market are loaded or unloaded by laborers to/from waiting vehicles.

Cargo ferries are administered by designated townships or cooperatives. Tonnage data gathered during the traffic surveys are not sufficient because it was difficult to cover all landing points. Available data are shown in Appendix Table 5.3.1.1. The average daily movement in both directs was computed to be 790 tons. The volume shows only cargo crossing the river. Commodities moving in bulk up or down river are not included.

Categories of cargoes were the same as those carried by vehicles on Z-crafts, which are reported in Table 5.2.6. Items were food/grains, machinery products, sawn timber/wood products, fuels of diesel/gasoline, tobacco, cotton, etc. By using the data on Appendix Table 5.3.1.1 the total volume of cargoes carried by boats was estimated at 790 tons per day. It was determined that half of the volume has the origin-destination pattern same with the passengers on boats and the remaining half has the pattern same with the cargoes carried by trucks on Z-crafts.

C. Total Volume of the Crossing Traffic in DIA

Interviews with vehicle drivers on Z-craft ferries indicated that a total of 275 vehicles carried a total of 1,474 passengers and 529 tons of cargo in both directions every day. The total volume of crossing traffic is summarized in Table 5.3.1. In 1985/86 passengers of 22,000, 1,300 tons of cargo and 280 vehicles crossed the river every day.

Table 5.3.1 TRAFFIC VOLUMES CROSSING THE IRRAWADDY RIVER, 1985/86

(per day)

	Passengers	Cargoes	Vehicles
Ferry boat, barge, Z-craft	20,202	790.0	-
Vehicles on Z-craft	1,474 (in vehicles)	529 (in vehicles)	275
Total	21,676	1,319	275

5.3.2 Trip Distributions - Passengers and Vehicles

The passenger trip distribution in Table 5.2.2. shows that 80% or 15,900 trips in the total of approximately 20,000 trips covered short distances between a township on one side and one on the other. The trips between the west side of the DIA (Zones 1, 4, 6, 8, 9 and 11) and Rangoon (Zone 17) were 1.5% or 300 trips of the total. Those between the west side of the DIA and Mandalay-Shan (Zone 13) were only 0.5% or 100 trips of the total.

Of the vehicles carried by Z-craft ferries shown in Table 5.2.2, 110 vehicles travelled between townships located on both sides of the river. Vehicles between Rangoon (Zone 17) and the west side zones (Zone 1, 4, 6, 8, 9 and 11) constituted only 3% or 9 vehicles.

It is concluded that passenger trips were rather short in distance, mostly between townships located on both sides of the river.

Road vehicles crossing the river, however, showed a range of trip distances not only between river-spanning townships, but also to other Divisions and States such as Rangoon and Mandalay.

5.3.3 Up/down Stream Traffic Movements

Traffic movements up and down stream on the Irrawaddy River were studied with interviews at manufacturing plants along the river and by comparing the fare charges with those for trucks on roads and railways.

There are 16 state plants in manufacturing/processing plants in the DIA along the Irrawaddy River, excluding sawmills, to which questionaires of transportation input and output were sent. The ten responses received are shown in Appendix Table 5.3.3.1.

Answers concerning river vessels -- cost of maintenance, purchase price, use mileage, etc. -- were few. The questionaires revealed that those, who had their own jetty directly loaded/unloaded materials, used trucks to transport nearly 15% of the total freight. Other factories used trucks for short distances between the river jetty and the factory compound. Approximately 20% of the respondents used trucks to and from Rangoon; the rest used ferries upstream and down. One respondent indicated that his plant output was transported exclusively by truck. In this case, the volume of transport is rather small, favoring the efficiency of truck haulage over that of a large river vessel. Transportation to/from these state plants was administered by the state corporation, using its own vessels in most cases. Some suggested that they would use more trucks if the project bridge were constructed. However, considering the location of plants and the project bridge, cost of transport by vessels and trucks, origin and destination of materials, and the nature of cargoes and other constraints, a general tendency toward heavy dependance on river transport is likely to continue.

Trucks carrying materials to and from these plants and river crossings were the subject of interviews conducted on Z-craft in December 1985 - January 1986. they are included in the estimate of traffic which will be diverted onto the project bridge.

5.3.4 Comparison of Fare Charges

Comparing fares charged by trucks, railways, barges and raft indicated an advantage of transporting bulk commodity by river vessels. For example, between Rangoon and Prome, bulk cargoes of rice, cement, and fertilizer are carried by trucks at K 107 - K 109 per ton, by railway wagons at K 30 per ton and by IWTC barge at K 21 - K 24 per ton, not including transfer cost. Travel time is inversely proportionate to cost. It takes 3 days by barge but only 7 hours by truck.

The distribution of rice, fertilizer and cement are under the control of Commodity Movement Committee (CMC). It has been the policy of the CMC to use the most economical means of transport: long distance by river, short distance by truck. This policy is reasonable from the viewpoint of the transport fares shown in Appendix Table 5.3.3.2.

Considering the policy of the CMC and the fare differentials among the various modes of transportation, it is unlikely that most bulk commodities now carried by long distance barge would be diverted to trucks even if the project bridge is constructed.

5.4 Traffic Forecast

5.4.1 Approach

In order to estimate the traffic on the project bridge, the following work steps were considered:

- Traffic growth factor
- Estimated river crossing traffic in terms of OD matrices in 1993
- Diversion models
- Diverted bridge traffic
- Estimated induced traffic via the bridge.

Inter-relationship between work steps is shown in Fig. 5.4.1.

The results of the forecast simulation are shown as diverted traffic volume on a road bridge and on a rail-cum-road bridge in 1993/94. In addition, the induced traffic volume to be realized by reduced transport cost/time via the project bridge is also estimated for each bridge type.

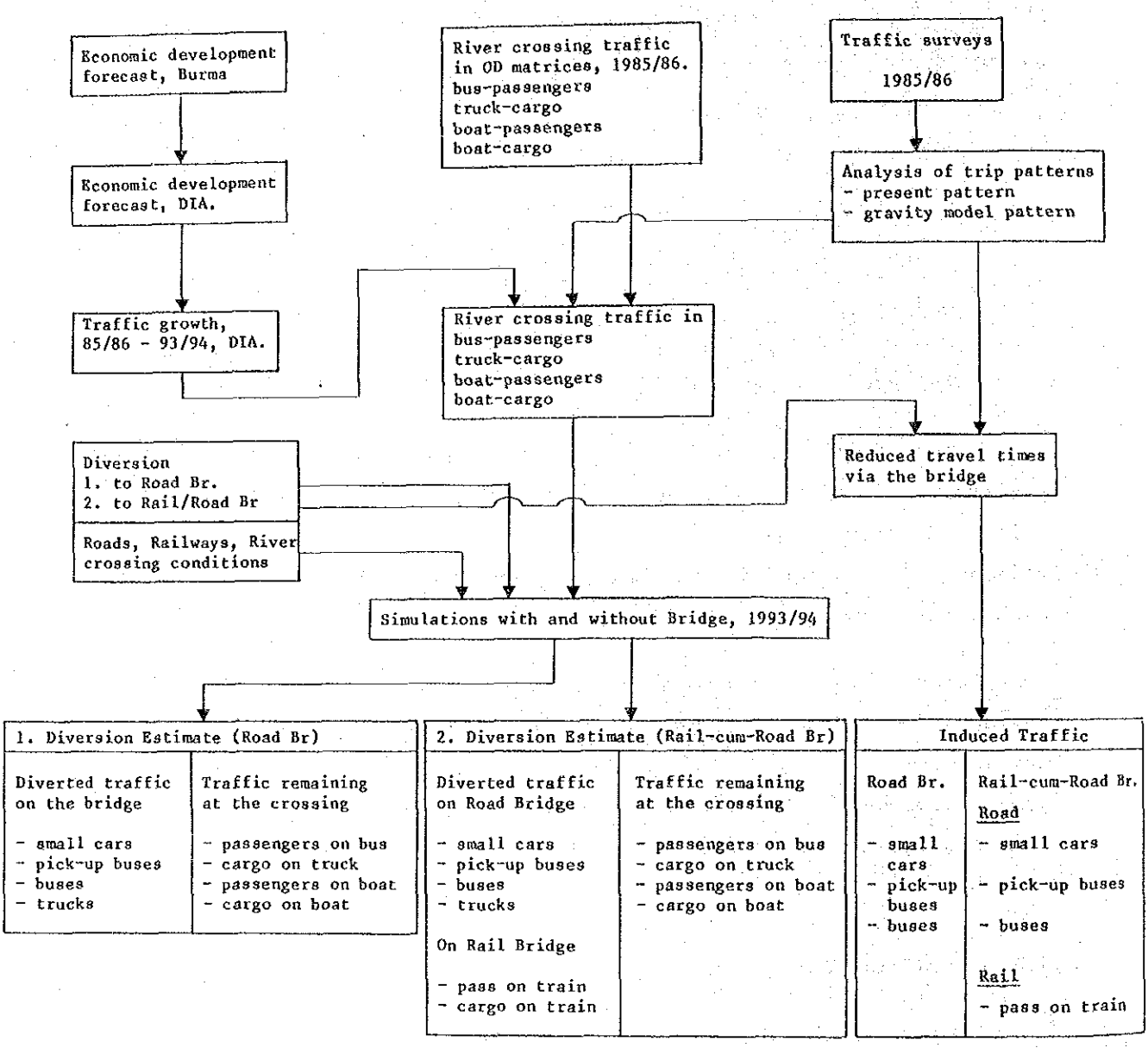
The following analysis is conducted by assuming no special regional development plan in association with the project bridge. The development is based on a balanced plan among the regions claimed for 20 year period by the Government. Economic development caused by the bridge project was considered separately as discussed in Chapter 3.

5.4.2 Traffic Growth Factors

Economic development of the DIA and surrounding areas was discussed in Chapters 2 and 3. Gross Regional Product (GRP) and population divided into zones are shown in Table 2.3.10. No specific regional development plan concerned with the bridge is shown in the table. The GRP will grow at 4.6% per annum and population at 1.86% per annum between 1985/86 and 2010/11.

Besides the development of the DIA, development factors and constraints of the national economy were considered. The main factors are listed below:

Fig. 5.4.1 FORECAST OF TRAFFIC ON THE PROJECT BRIDGE



- A modest growth forecast of GDP in the 5th Four-Year Plan period (4.5% p.a. from 1986/87 - 1990/91).
- Shortages in foreign exchange reserves and import restrictions which would reduce the import of complete/assembled transport equipments.

The historical development of traffic on roads, railways and waterways was studied in Chapter 4. Although registered vehicles showed an increase of more than 6% per year in the 1980/81 -1984/85 period, data on road traffic counts conducted by CC showed no definite trend of increase. It was difficult to find an average rate of growth for road traffic. (See Appendix Table 5.4.2.1.)

As studied in Fig. 4.2.3 of Chapter 4, traffic volumes on the railway lines of Bassein-Kyangin and Rangoon-Prome had modest growth in the early 1980s. Traffic volumes for the regular waterway service of Prome-Mandalay by IWTC, studied in Chapter 4, registered a growth of 3.2% per year in ton-miles and no growth in passenger miles between 1980/81and 1985/86.

In national income accounts, the development of the transport sector and the GDP are summarized in Appendix Table 5.4.2.2. It indicates that during the 4th Four-Year Plan period (1982/83 - 1985/86) the growth of the transport sector was 5.0% per year while that of GDP was slightly higher at 5.4% per year.

The forecasts of GDP and the DIA's GRP described in Chapter 2, estimated transport sector development as follows:

	1985/86	2000/01	2010/11	1985-2000
Burma				
Transport sector (Kyat, mil.)	3,423	6,722	10,863	
Average growth (%)		(4.6)	(4.9)	(4.7)
GDP (Kyat, mil.)	57,733	111,199	178,528	
Average growth (%)		(4.5)	(4.8)	(4.6)
DIA				
Transport sector (Kyat, mil.)	375.4	784.5	1,223.3	
Average growth (%)		(5.0)	(4.5)	(4.8)
GRP (Kyat, mil.)	11,449	22,151	34,820	
Average growth (%)		(4.5)	(4.6)	(4.6)

1 In million kyat, 1985/86 prices
2 Figures in parenthesis are the average annual percentage growth rate.

The forecasts indicate that the transport sector in the DIA would develop at a rate close to that of GRP within the DIA.

Accordingly, the increase in the transport sector of the DIA can be used to determine the increase in the overall traffic volume of roads, rivers and railways of the area. An average annual growth of 5% is used for the years of 1985/86 - 2000/01 and 4.5% for subsequent years.

The traffic volume growth factor of each zone within the DIA is assumed at the same ratio as the above because there would be no specialized zones of development in DIA. The total volumes of traffic crossing the river are shown in Table 5.4.2.

Table 5.4.2 TOTAL RIVER CROSSING TRAFFIC[1]

(per day)

	1985/86	1993/94	2000/01
Passengers on boats and Z-crafts	20,254	28,944[2]	63,248
Passengers on vehicles	1,474	2,172	4,746
Total	21,728	31,116	67,994
Cargo on boats	790	1,167	2,550
Cargo on vehicles	529	781	1,707
Total in tons	1,319	1,948	4,257

1 Passengers in persons and cargo in tons.
2 River crossing zone pair trips only.

5.4.3 OD Matrices for 1993/94

Traffic distribution for 1985/86 was surveyed and the results reported in sections 5.2. and 5.3. After Study of origin-destination distribution patterns, the following gravity model parameters are calculated:

$$T_{ij} = \frac{\alpha . P_i \times P_j}{d_{ij}^{\beta}}$$

where;

T_{ij} = Zone pair trips between i and j.

P_i = Population in Zone i, 1985/86.

P_j = Population in Zone j, 1985/86.

d_{ij} = Travelling time in minutes between i and j. Average speeds of 25 mph on paved roads and 10 mph on gravel-earth roads were used. Waiting time and river crossing time were also taken into account referring to Appendix Tables 10.2.1.1 and 10.2.1.3.

n = Number of zone pairs used in the regression.

Parameters estimated by regression analysis are shown below.

	n	α	β	γ
Road vehicles Pass.	23	4.62426×10^{-4}	2.557	0.848
Cargo	18	1.10552×10^{-4}	1.6123	0.812
Boats Passengers	56	5.32676×10^{-2}	3.3592	0.894
Cargo	47	2.45176×10^{-3}	3.2966	0.900

The total volume for 1993/94 was calculated by using the 5.0% per annum growth rate from which the total volume in 1985/86 was deducted, resulting in the total of net increased trips.

Zone pair trips were estimated by using the gravity model formula shown above, adjusted to the total of the net increased trips. The estimated future zone pair trips are thus composed of those observed in 1985/86 plus the net increased trips calculated by the above model.

5.4.4 Diversion Model

5.4.4.1 Road Bridge

To estimate traffic on the proposed road bridge, a diversion model was developed to indicate the percentage in the river crossing trips from Zone i to j that might be diverted to the bridge. Unfortunately, there are no data in Burma which indicate changes in use demand when a new bridge is constructed. This study used a model which would propose the following scenarios for trips between Zone i and j:-

1) If travel time via the river-crossing boat equals that of the proposed bridge, the traffic will be divided equally 50% between the two modes.

2) If travelling time via the bridge is 1.5 times longer than the existing river-crossing route or vice versa, there will be no traffic to the route with longer travel time.

To determine a travel route between Zone i and j, the minimum time route is selected by computer simulation for the case with the bridge and for the case without it, assuming average speeds, which were used in the case of gravity model analysis in 5.4.3, on each road link of the network. Waiting time at the jetty side and the time spent for river crossing are also included. Fare charges by ferry boat and vehicle are converted into time by using the time value. The model's formula is shown as follow:

$$P = 150 - 100\ (T\ell/Ts)$$

P: a percent share of the traffic on the longer time route with a condition, $1.0 \leq (T\ell/Ts) \leq 1.5$.

$T\ell$ and/or Ts: the travel time spent on the time minimum route between Zone i and j on the network without the bridge and with the bridge, respectively.

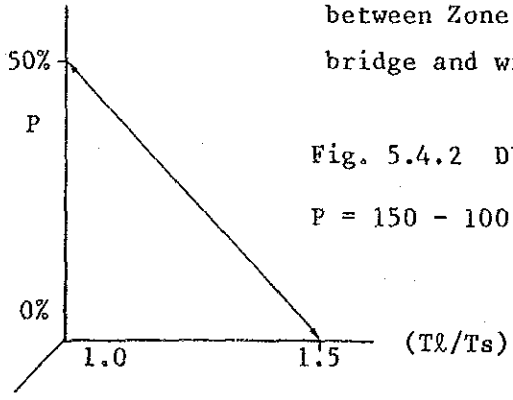


Fig. 5.4.2 DIVERSION MODEL

$P = 150 - 100\ (T\ell/Ts)$

The total travel time of the two routes, one through the bridge and the other through the ferries without the bridge, is compared between Zone i and j. Of these two routes, the longer travel time is shown by Tℓ and the shorter one by Ts. The route through the bridge comes to Tℓ or Ts depending on the network and the location of Zones. When a ratio of travel time on the two routes, Tℓ/Ts, is estimated in the range of 1.00 - 1.50, it indicates the percent share of the longer time route and the remaining percentage shows the share on the shorter time route by the formula.

A network of roads and railways, zone centers, river crossings and the proposed bridge is shown in Fig. 5.4.3 and conditions put in the network are stated in Appendix Table 5.4.4.1.

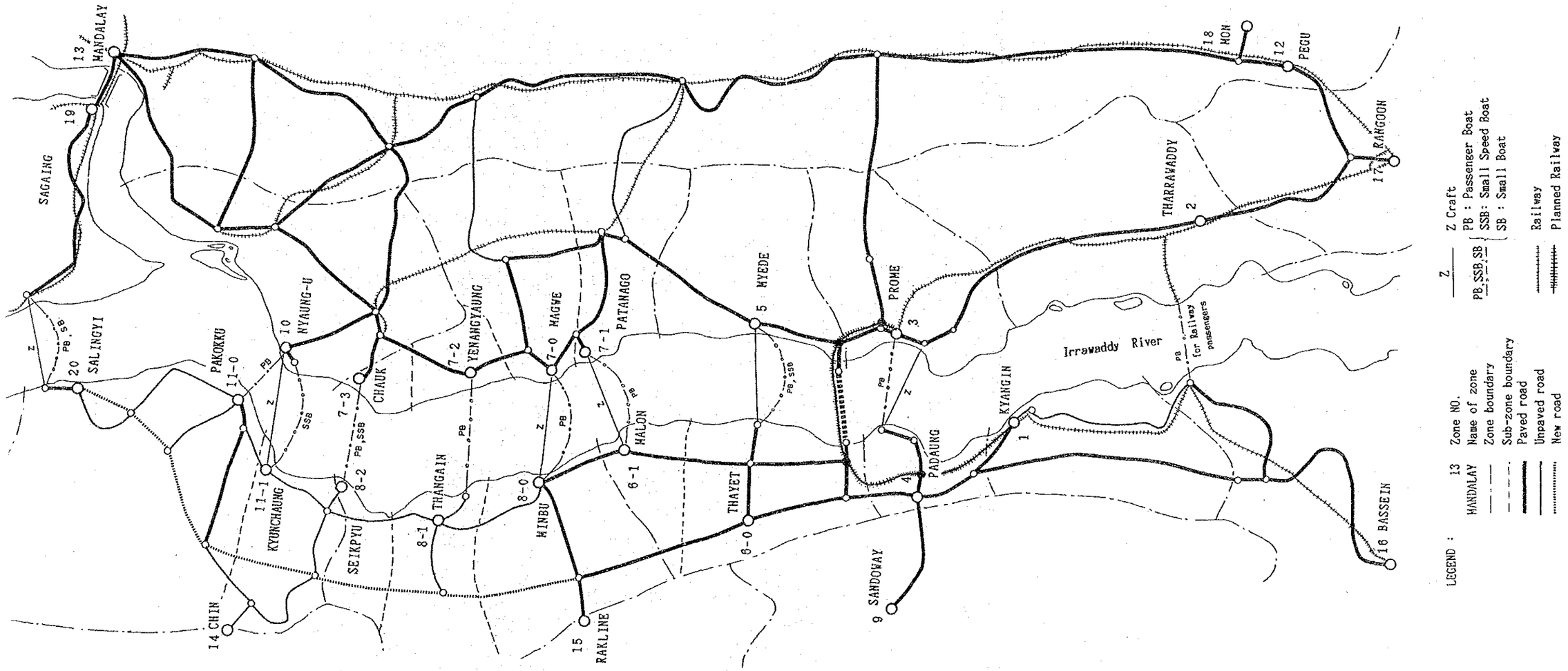
5.4.4.2 Rail-cum-Road Bridge

To estimate traffic diversion to railways from both road traffic and river crossing traffic, the model requires relevant data and a number of conditions. Such data are not available at this time; provisional assumptions for the estimate of railway users are put forward as follows:-

1) Extension lines from Kyangin (75 miles) and from Prome (23 miles) will be completed by the Government of Burma before the bridge is completed.
2) The train operation would make 2 round trips per day between Kyangin and Prome: one in the morning and the other in the afternoon. Average speed is 20 miles per hour.
3) A train consists of 8 passenger coaches of ordinary class with 60 seats each and 2 cargo wagons each with 30 ton capacity.
4) Fares are the same as those on existing lines.
5) Other input data are shown in Appendix Table 5.4.4.1.

The diversion model used in the case of road bridge is also used for this rail-cum-road bridge in the following way:

Fig. 5.4.3 TRANSPORTATION NETWORK



- First, diversion traffic is estimated from ferry boats to the road vehicle traffic on the proposed bridge (The diverted volume is basically same as that on the road bridge. However, the volume is modified in the second step under certain conditions).
- Second, diversion traffic is estimated from ferry boats to the use of railways, only if travel time through the railway is shorter than the route through the road bridge. In this zone pair trips, diverted traffic on the railways is estimated larger than that on the road bridge.
- Third, modal split between the use of vehicles on the road bridge and the use of the railway bridge is estimated, using the same diversion model.

5.4.4.3 Diverted Traffic

Estimated diverted traffic volume on the road bridge and railway-cum-road bridge in 1993/94 are shown in Appendix Tables 5.4.4.2 and 5.4.4.3 and the summary is shown in the following Table 5.4.3.

Table 5.4.3 DIVERTED TRAFFIC, 1993/94

(per day)

			Passengers (persons)		Cargo in tons
I	Total river crossing (without the project)	on boats	28,944	on boats	1,167.1
		on vehicles on Z-craft	2,172	on vehicles on Z-craft	781.4
		Total	31,116	Total	1,948.5
II	Road bridge		persons		tons
	from boats		3,396		358.5
	from Veh. on Z-craft		408		233.8
		Total	3,804	Total	592.3
		(II/I	12.2%)	(II/I	30.4%)
	Small vehicles		58		
	Pick-up buses		90		
	Buses		111		
	Trucks		180		
	Total		439	vehicles	
III	Rail-cum-road bridge				
	Railways		persons		tons
	from boats		2,119		175.7
	Roads				tons
	from boats		1,700		210.0
	from Veh. on Z-craft		408		233.8
	Sub-total		2,108		443.8
		Total	4,227		619.5
		(III/I	13.6%)	(III/I	31.8%)
	Roads Small-Veh.		58		
	Pick-up buses		45		
	Buses		56		
	Trucks		135		
	Total		294	vehicles	

5.4.5 Induced Traffic

It is expectable that traffic will be encouraged by a reduction in travel time as a result of the project bridge. To estimate the possible traffic increases, the gravity model formula was used, with road network and travel time conditions the same as that used in the diversion estimate:

1) $$T_{ij} = \frac{\alpha \times P_i \times P_j}{D_{ij}^{\beta}}$$

2) If the travel time via the project bridge is shorter than that using the ferry boat crossing, traffic volume would increase as follows:

$$T_{ij} = \alpha \times \frac{P_i \times P_j}{D_{ij}^{\beta}} \quad \cdots\cdots\cdots \text{ through the ferries}$$

$$t_{ij} = \alpha \times \frac{Pi \times Pj}{d_{ij}^{\beta}} \quad \cdots\cdots\cdots \text{ through the bridge}$$

A ratio of increase by the followings:

$$\frac{\Delta t}{T_{ij}} = \frac{t_{ij} - T_{ij}}{T_{ij}} = \left(\frac{D_{ij}}{d_{ij}}\right)^{\beta} - 1$$

where,
- D_{ij}: Travel time between Zone i and j using the ferry boat crossing
- d_{ij}: Travel time between Zone i and j using the project bridge
- Pi: Population in Zone i
- Pj: Population in Zone j
- T_{ij}: Trips between Zone i and j through the ferry crossing
- t_{ij}: Trips between Zone i and j through the project bridge
- Δt: Increased (induced) traffic encouraged by a reduction of travel time from D_{ij} to d_{ij}
- α, β: Parameters determined for the gravity model formula (See 5.4.3 of this chapter)

3) Increased traffic is considered to be in increased passengers, since the reduced travel time would stimulate people to move more frequently and/or over longer distances. Accordingly, increased passenger traffic is quantified in terms of buses, pick-ups and small vehicles.

4) Impact on production would not be negligible. However, expansion of production is usually accompanied by additional investment and manpower/technology input in economic sectors of the region, and would require a long development period. This can be defined as a development benefit in the DIA. The development benefit was studied in Chapter 3.

The ratio of induced additional traffic on the diverted traffic is 23.2% for both bridge types. Induced traffic was estimated for passengers. Passengers were converted to vehicles by assuming an average occupants per vehicles, the same occupancy as indicated by Z-craft survey in 1985/86. For the railway passengers, induced passengers are figured out, but it is not large enough to indicate necessity of additional trains.

The induced traffic in 1993/94 is shown in the following Table 5.4.4.

Table 5.4.4. INDUCED TRAFFIC, 1993/94

(Per day)

	Road bridge	Rail-cum-road bridge	
Passengers	Total 1,794	Rail	985 persons
		Road	1,006
		Total	1,991
Converted into vehicles on roadway			
Small veh.	31		31
Pick-up bus	42		21
Bus	52		26
Total in vehicles	125		78

5.4.6 Total Traffic on the Bridge

The total traffic volume on the bridge in 1993/94 is summarized in Table 5.4.5.

Table 5.4.5 TRAFFIC ON THE BRIDGE 1993/94

(per day)

	Road Bridge [1]		Rail-cum-road bridge [1]	
Railways				
in persons	-		3,104	passengers
in tons	-		175.7	tons of cargo
Road ways	Vehs.		Vehs.	
Small Veh.	89	Passengers	89	Passengers
Pick-up buses	132	5598	66	3114
Buses	163	Cargo	82	Cargo
Trucks	180	592 tons	135	443.8 tons
Total	564		372	

Note: 1 Diverted and induced traffic.

As discussed in Chapter 3, regional development caused by the bridge project will generate traffic in addition to the above estimate. However, economic growth related to the bridge will be materialized gradually after the completion of the bridge. The net addition of traffic in the years from 1993/94 - 2000/01 is estimated by using the average of the percent share of the increased GRP and the percent share of the development benefit over the traffic benefit. Increases of development traffic after 2000/01 are assumed to be equal to that of normal traffic. The total per day in 1993/94 and 2010/11 are shown below:

	1993/94		2010/11	
1. Road bridge				
Diverted, etc.	564		1,232	
Development-related	36		431	
Total	600	vehicles	1,663	vehicles
2. Rail-cum-road bridge				
Railway passengers:				
Diverted, etc.	3,104		6,782	
Development-related	205		2,543	
Total	3,309	passengers	9,325	passengers
Railway cargo:				
Diverted, etc.	175.7		384.0	
Development-related	11.6		144.0	
Total	187.3	tons	528.0	tons
Roadway vehicles:				
Diverted, etc.	372		813	
Development-related	25		305	
Total	397	vehicles	1,118	vehicles

CHAPTER 6 SURVEY AND INVESTIGATION

CHAPTER 6 SURVEY AND INVESTIGATION

6.1 General

Prior to beginning preliminary design and during phase 1 stage, studies were carried out on topography and geology, soils and materials, hydrology, etc. and surveys were conducted on the examination area. The findings and their analysis were used to select the route and determine the type of bridge, and used to undertake the preliminary design of the project. In this chapter the results and findings on the items taken into consideration are given in detail.

6.2 Topography and Land Use

6.2.1 Topography

The examination area for the Irrawaddy River Bridge is Approximately 4.5 square kilometers and centered at Longitude 95°08'E and Latitude 18°59'N. The topography of the examination area can be classified into three types:

(a) Hilly and undulating
(b) Rolling
(c) Alluvial flat plain

A. Hilly and Undulating Topography

This type of topography is found on the western side of the Irrawaddy River. The slopes of the hills in this area vary between 20° and 30°.

The valleys are narrow and in case of heavy rainfall, sudden flooding could occur. Gullies that have been shaped by river erosion are interspersed through the terrain between hilly areas.

The general shape and steepness of the slope indicate that the exposed bedrock has been weathered, but absence of slope failures further indicates good stability.

B. Rolling Topography

Rolling topography characterizes the wide area on the eastern side of the Irrawaddy River. The hill slopes in these areas are gentle as compared to the slopes found in hilly and undulating topography areas. Based on the nature of this topography, these areas consist of common soil and weathered bedrock.

C. Alluvial Flat Plain Topography

Alluvial flat plains are found in Myawaddy village on the western bank of Irrawaddy River and in Kyawza village and north of Thayetaw village on the eastern bank. The alluvial plains are covered by fine soil. Gravel beds are also observed below the surface.

6.2.2 Land Use

The examination area is located in Magwe Division. Generally most of the area is covered by bush. In the areas of flat alluvial plain and along existing rivers, cultivated areas are scattered. On the eastern bank, the flat areas close to Kyawzwa village are occupied by an industrial complex with fertilizer plants and relevant facilities. These areas belong to the Ministry of Energy.

6.2.3 Field Survey

The topographical maps of scale 1/5000 prepared by Burma Survey Department were used for the selection of the proposed route of the bridge site. Based on the proposed route selected the two-stage topographical survey work was started on February 10, 1986. The first stage was completed on March 10 1986 and the second stage was also completed on July 7, 1986. Major objective of the survey was to conduct field surveys to make a base map for the study.

The followings are the surveys conducted in these stages.

6.2.4 Levelling

The temporary bench mark set up besides the proposed Route I bridge site by MOE was confirmed from the bench mark located at the 196 km point of the Rangoon-Mandalay road.

6.2.5 Cross-sectioning

Cross-sectioning survey of the riverbed was conducted along the proposed center line of proposed Route I and II by using an echo sounder. The survey was carried out also along the lines 50 meters away from the center line.

6.2.6 Traversing

Horizontal control surveying was conducted from the established triangular point to the temporary bench mark in order to set up coordinate through traverse survey.

6.2.7 Results

Under the cooperation of CC, all of the survey necessary for this study have been completed as scheduled. The list of the survey results are shown in Appendix Table 6.2.1.

6.3 Soil Investigation

6.3.1 General

The field work for the soil investigation started in November 1985 and was completed at the end of June 1986, and laboratory tests on samples obtained from boreholes were completed at the end of August, 1986.

The drilling work was carried out by the staff of the Road Research and Soil Testing Laboratory, CC, in cooperation with the Study Team. For laboratory works, tests on the soil and rocks collected from the boreholes are made at the Soil Testing Laboratory, CC, Rangoon. The borehole locations are shown in Fig. 6.3.1.

Except BH7 and BH8 the 10 boreholes were allocated along the proposed Route 1. The drilling work of 12 boreholes (total drilling depth 308.33 m) took about six months.

All field investigation and the laboratory test results on samples obtained from the boreholes are summarized in this report.

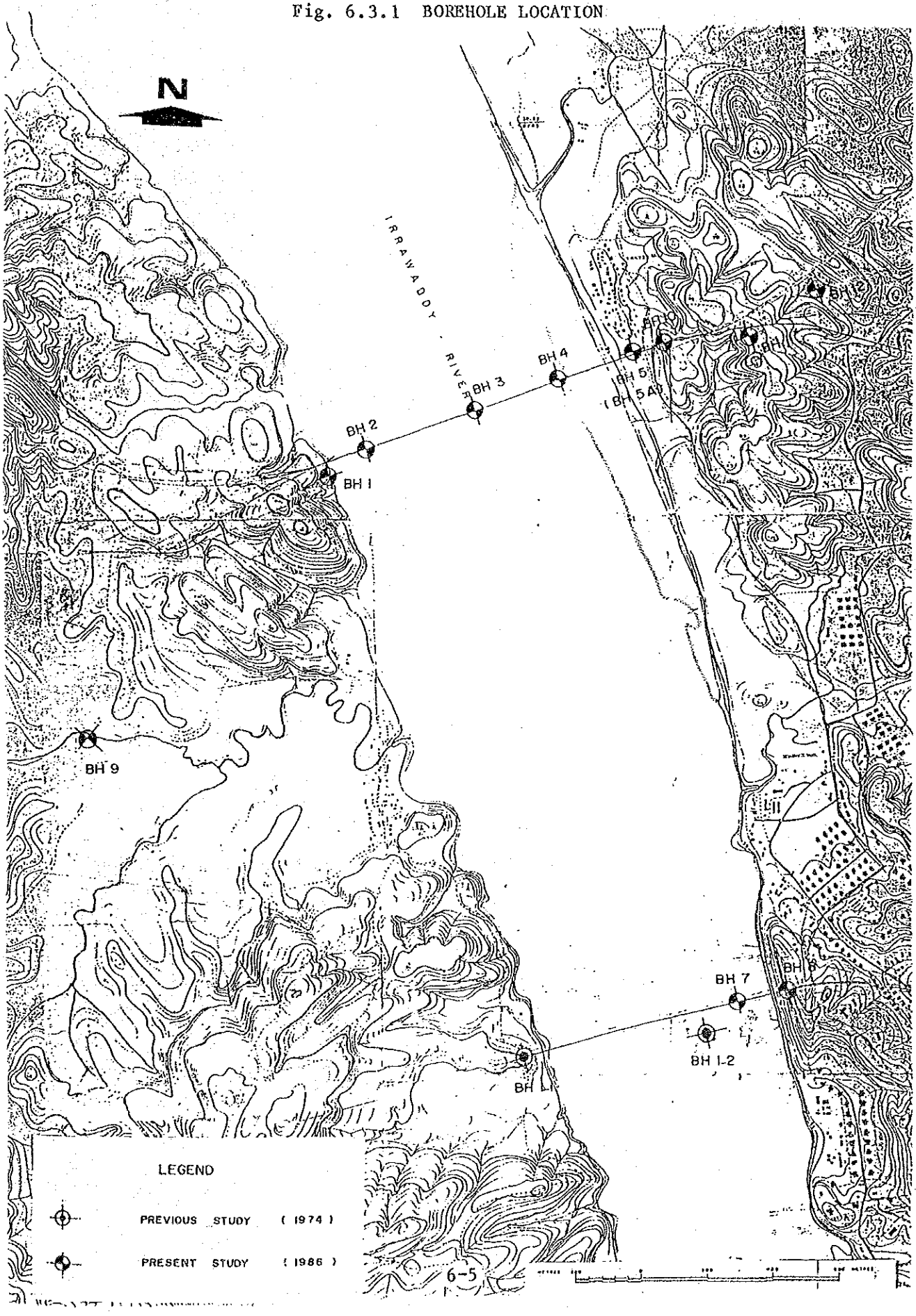
6.3.2 Method

A. Machine Boring

Machine boring was conducted to confirm the bearing strata of the bridge foundations. The diameters of boring are 66 mm or more for the bridge foundations and 55 mm or more for the cutting sections.

For the bridge foundations, the depth of borehole is drilled as far as the continuous 7 number of SPT with N-value of 50 blows or more in soil stratum and/or 10 meters below from the top rock stratum.

Fig. 6.3.1 BOREHOLE LOCATION



B. Standard Penetration Test (SPT)

SPT conforming to JIS A 1219 performed at intervals of 5 ft. (1.52 m) and at any depth where the soil stratum changes.

C. Undisturbed Sample and Rock Core

For collecting undisturbed cohesive soil samples, the thin walled tube open drive sampler (3 in. inner diameter) is used. At least two undisturbed cohesive soil samples are collected from each stratum of borehole.

For collecting rock core, the single core barrel with tungsten carbide bit crown (inner diameter 2 in.) is used.

D. Laboratory Tests

The test items and their specifications are mentioned in Appendix 6.3.2. In principle, the following tests are performed on each sample;

Sample	Tests
o Disturbed Soil (obtained by SPT)	Physical property
o Undisturbed cohesive soil	Physical property, mechanical property
o Rock core	Physical property, & unconfined compression
o Embankment materials	Physical property, compaction/CBR

As a result of checking the laboratory facilities, the following test items and numbers of tests are planned for Phase 1.

Test Item	Specification
Physical Property Test	
Natural Moisture Content	ASTM D2216
Unit Weight	ASTM
Specific Gravity	ASTM D854-58
Crain-size Distribution	ASTM D422-63
Atterberg Limits	ASTM D422-66

Test Item	Specification
Mechanical Property Test	
Unconfined Compression	D2166-66
Consolidation	D2435-70
Direct Shear	D3080-72
Compaction/CBR	D1883-73

6.3.3 Findings

"The Geological Map of Burma" published by Earth Science Research Division, Research Policy Direction Board in March 1977 was collected. A booklet attached to the map describes the general view and details of geological condition in Burma.

According to the map, bed rocks of the Irrawaddy River Bridge site consist of alternating layers of sandstone, siltstone and claystone of Miocene and Pleistocene eras.

A. Proposed Route I

In the east bank, over the lower flat portion, brown cohesive sedentary soils predominates, and at the upper hilly portion, semi-cemented fine-to-medium grained buff sandstones predominates with a thin layer of sandy shale.

The geological composition at the upper hilly portion is heterogeneous with approximately N 45° W strike and 31°-32° dipping away from the river.

In the west bank, the bank slope is composed of grayish brown fine-to-medium grained stone alternating with gray silty shale. The sandstone remains in saw-like steep river bank.

The geological composition is heterogeneous with N 40°-45° W strike and about 41° dipping upstream.

Fig. 6.3.2 GENERAL GEOLOGICAL MAP

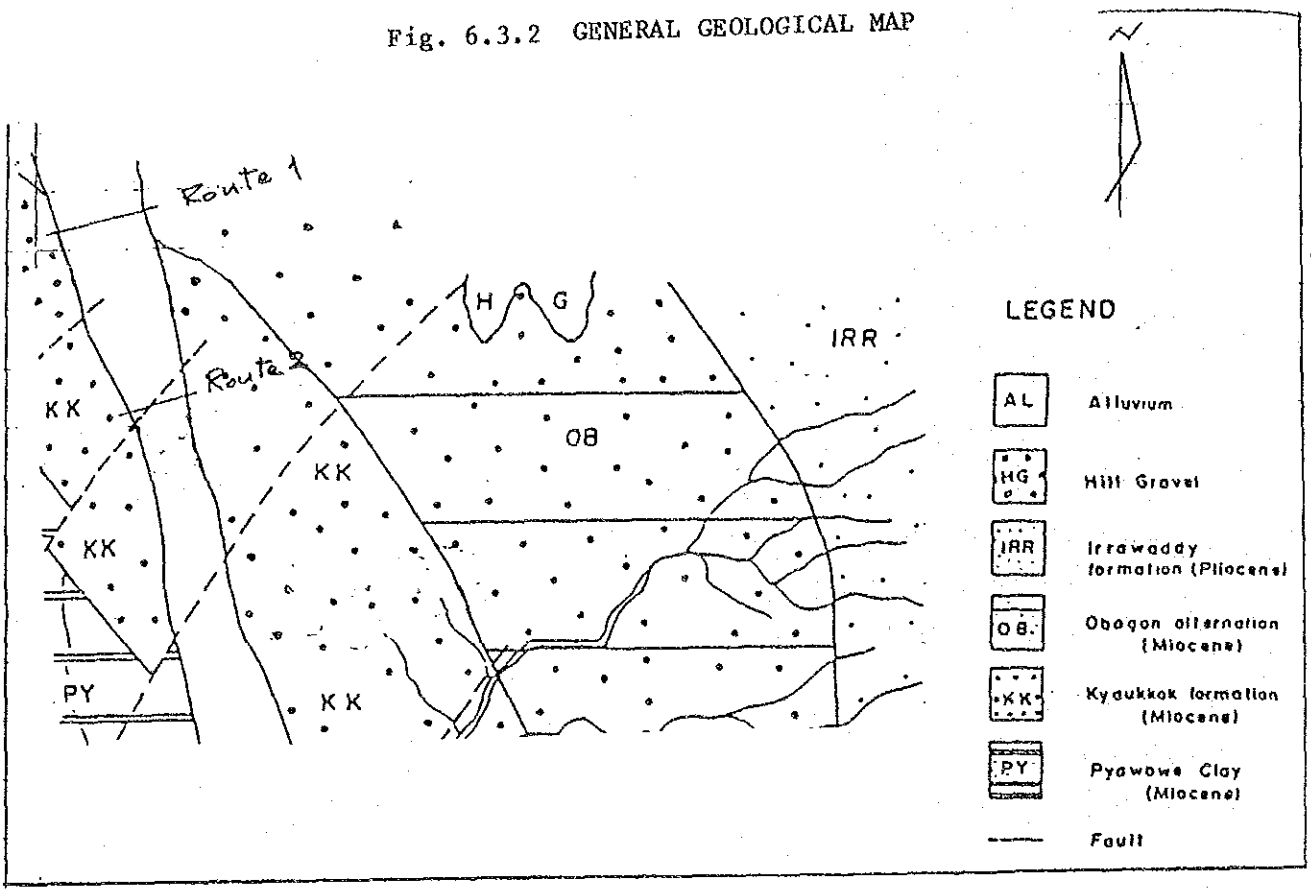


Fig. 6.3.2 is taken from "Progress Report of Field Investigation Team for Irrawaddy Bridge Construction Project (Supplementary Report of Soil Group), OTCA, April 25, 1975. According to the Fig. 6.3.2, the geology of the east bank and the west bank of the route is the Obagon alternation (Miocene) and the Kyaukkok formation (Miocene), respectively . In contrast, the geology of the east and west bank of the route 2 is specified as the Kyaukkok formation.

B. Proposed Route II

In the east bank, massive but friable and semi-cemented light buff coloured medium-to-fine grained sandstone exist on the upper most portion of the cliff. At the lower portion, there is then alternating sections of thin bedded sandstone and soil-like silty shale with a seam of hard fine grained yellowish brown sandstone.

The geological composition is homogeneous with N 40°-45° W strike and about 23° dipping away from the river.

In the west bank, the strata of the Kyaukkok formation are composed of alternating layers of yellowish brown sandstone, gray to bluish gray sandy shale and buff siltstone.

The geological composition is heterogeneous with N 65°-90° W strike and 10°-27° dipping upstream.

6.3.4 Results of the Borehole

The quantities of standard penetration test (SPT) bore sampling are summarized in the Table 6.3.1. Also the drilling logs are shown in the Appendix Figs. 6.3.1 - 6.3.15.

SPTs of all boreholes except BH5 (and BH1-1, BH1-2) were carried out with a automatic drop hammer device. But, the rope-cone-pulley method was adopted to the SPTs of BH5 (and BH1-1, BH1-2). Therefore, BH5A was drilled near the location of BH5 to check the difference of N-value between the automatic drop hammer method and the rope-cone-pulley method. The difference of N-value are shown below in Appendix Table 6.3.1.

According to the N-values of BH5 and BH5A, the N-value of rope-cone-pulley method shows a tendency to be larger than the N-value of automatic drop hammer method.

The rock formations were cored with a single-tube tungsten bit (ϕ2").

Based on the field investigation, the Fig. 6.3.3 and the Fig. 6.3.4 are drawn as the soil profile of the route 1 and route 2, respectively.

According to these soil profiles, the following layer-classification is categorized.

Geological Age	Type of Soil	Symbol
Quaternary	(Loose) Sandy Soil	Sd_1
"	(Medium) "	Sd_2
"	(Dense) "	Sd_3

Table 6.3.1 QUANTITIES OF BORING, S.P.T, SAMPLING

B.H No.	Co-ordinates N	Co-ordinates E	G.L. (m)	Drilling Depth (m)	ϕ2" Core Boring (m)	S.P.T. (No.)	Sampling (No.)	Remarks
1.	920,600.410	2,230,198.690	27.90	14.14	12.19	3		1. Automatic drop hammer device was used for all S.P.T. except S.P.T of B.H 5, B.H 1-1 and B.H 1-2.
2. *	920,704.792	2,230,342.837	4.52	37.24	4.58	23		2. The rope cone pulley method was adopted to the S.P.T of B.H 5, B.H 1-1 and B.H 1-2.
3. *	920,795.760	2,230,639.976	13.52	50.50	6.00	30		
4. *	920,881.210	2,230,895.875	17.90	40.16	4.96	24		3. B.H 5.A and B.H 9.A are 1.5 m away from B.H 5 and B.H 9, respectively.
5.	920,966.659	2,231,151.774	32.00	24.38	9.01	11		
5.A	920,966.223	2,231,150.339	31.90	10.92	0	7	1	4. Open drive sampling method (ϕ=3") was adopted to the sampling.
7. *	918,918.728	2,231,513.582	10.17	35.76	9.70	18		
8.	918,939.858	2,231,664.918	78.53	24.38	22.86	0		
9.	919,801.839	2,229,393.961	32.74	15.54	0	10	1	
(9.A)	" " "	" " "	32.74	(9.59)	0	0	2	* = River bed boring
10.	921,002.158	2,231,271.435	59.88	24.38	24.38	0		
11.	921,026.819	2,231,536.406	74.64	22.86	19.76	4		
12.	921,117.341	2,231,705.529	42.12	8.07	0	4	2	
Total 12. (13)				308.33 (317.92)	113.44	134	6	

B.H 1-1	(918,813.000)	(2,230,780.000)	50.79	50.90	19.62	3		Estimated Co-ordinates in ( ) Borings of the previous study in 1974.
B.H 1-2	(918,888.000)	(2,231,385.000)	9.20	21.30	0	34		