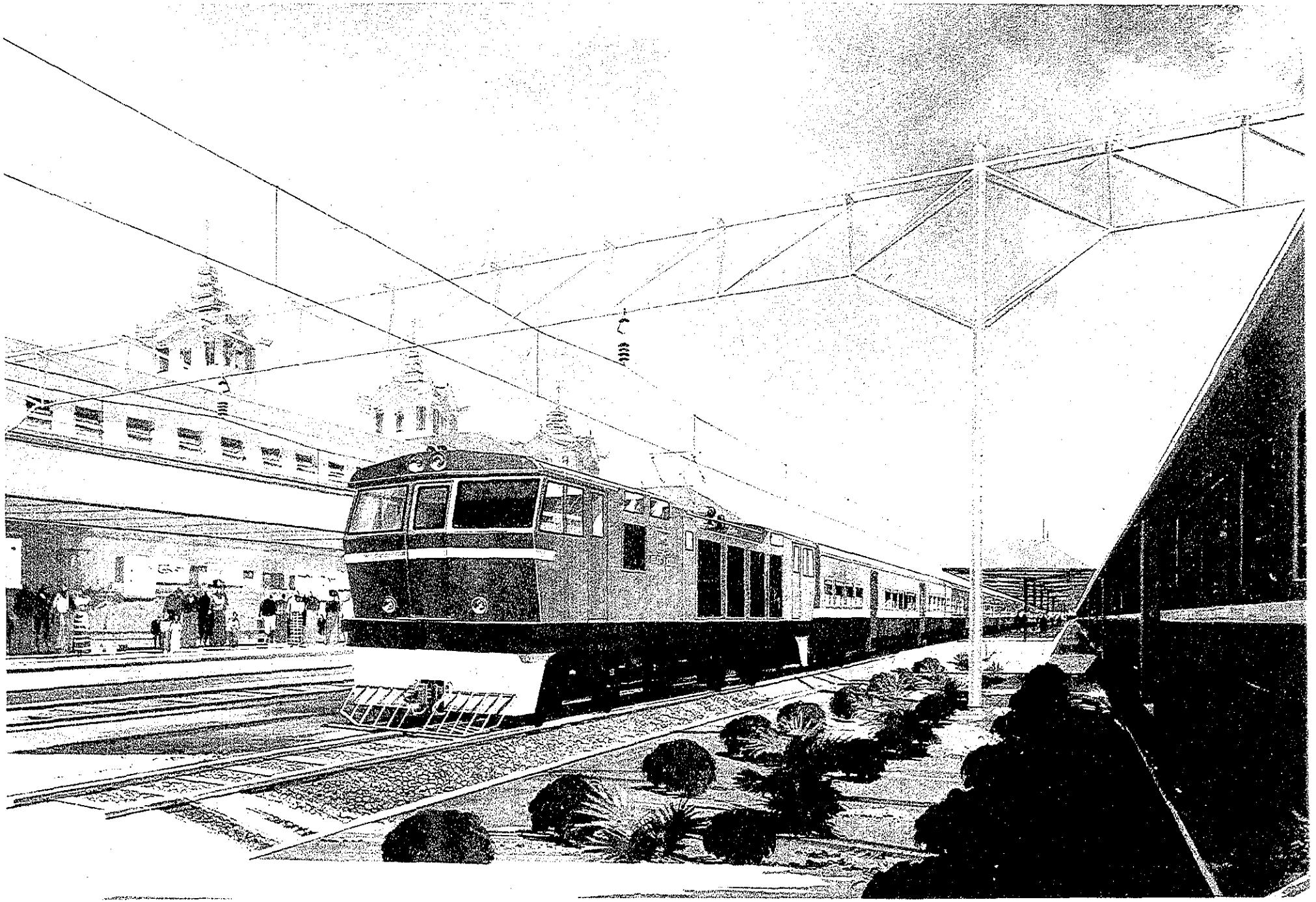
社会開発協力部報告書

SUMMARY OF REPORT
OF
THE FEASIBILITY STUDY
ON
THE ELECTRIFICATION OF RANGOON CIRCULAR RAILWAY LINE
IN
THE SOCIALIST REPUBLIC OF THE UNION OF BURMA

MARCH, 1985

JAPAN INTERNATIONAL COOPERATION AGENCY

(JICA)



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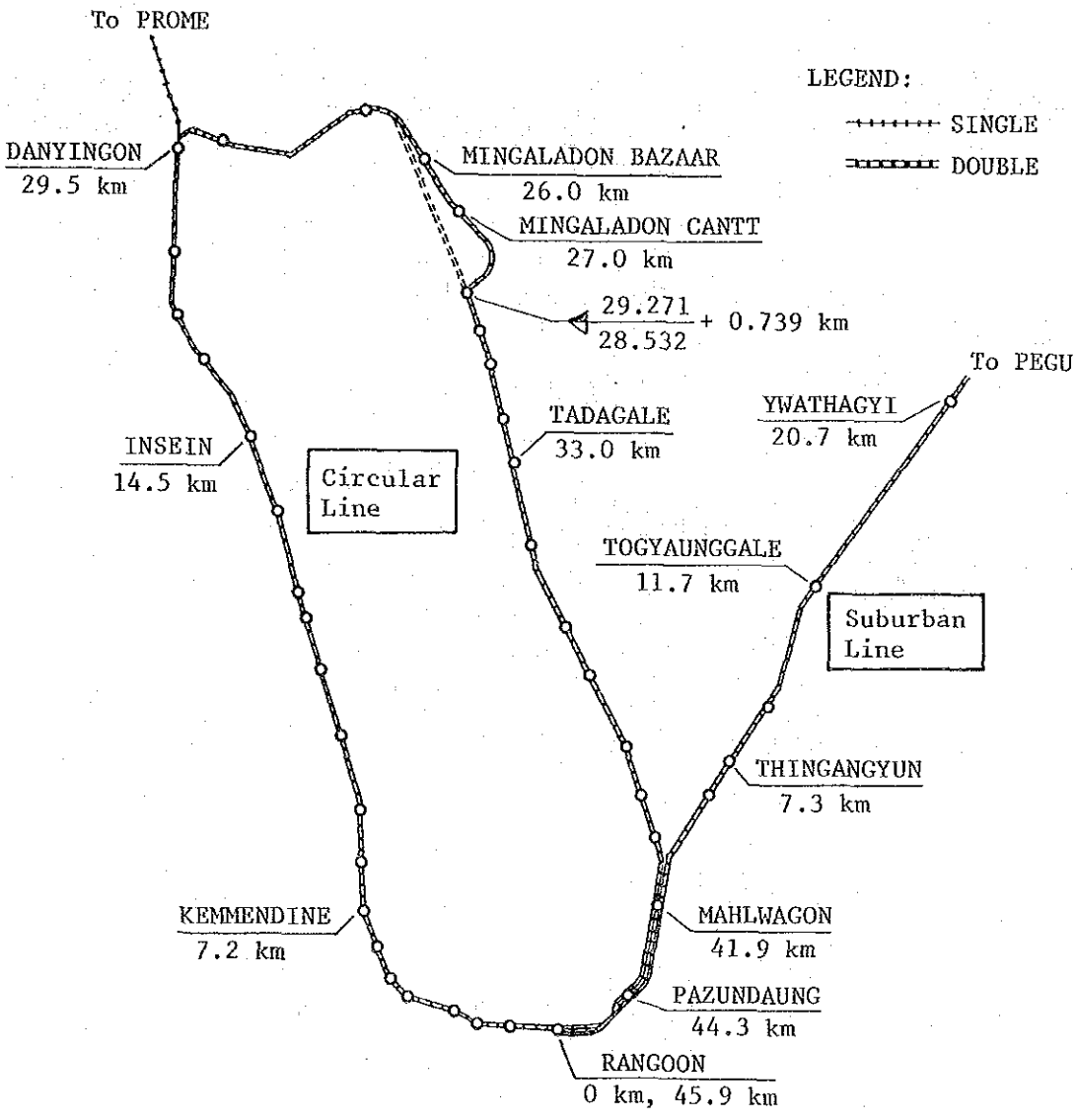
SUMMARY

1. Scope of the Study

(1) Objective

The study objective is to investigate the feasibility of the electrification project for the Circular and Suburban Lines.

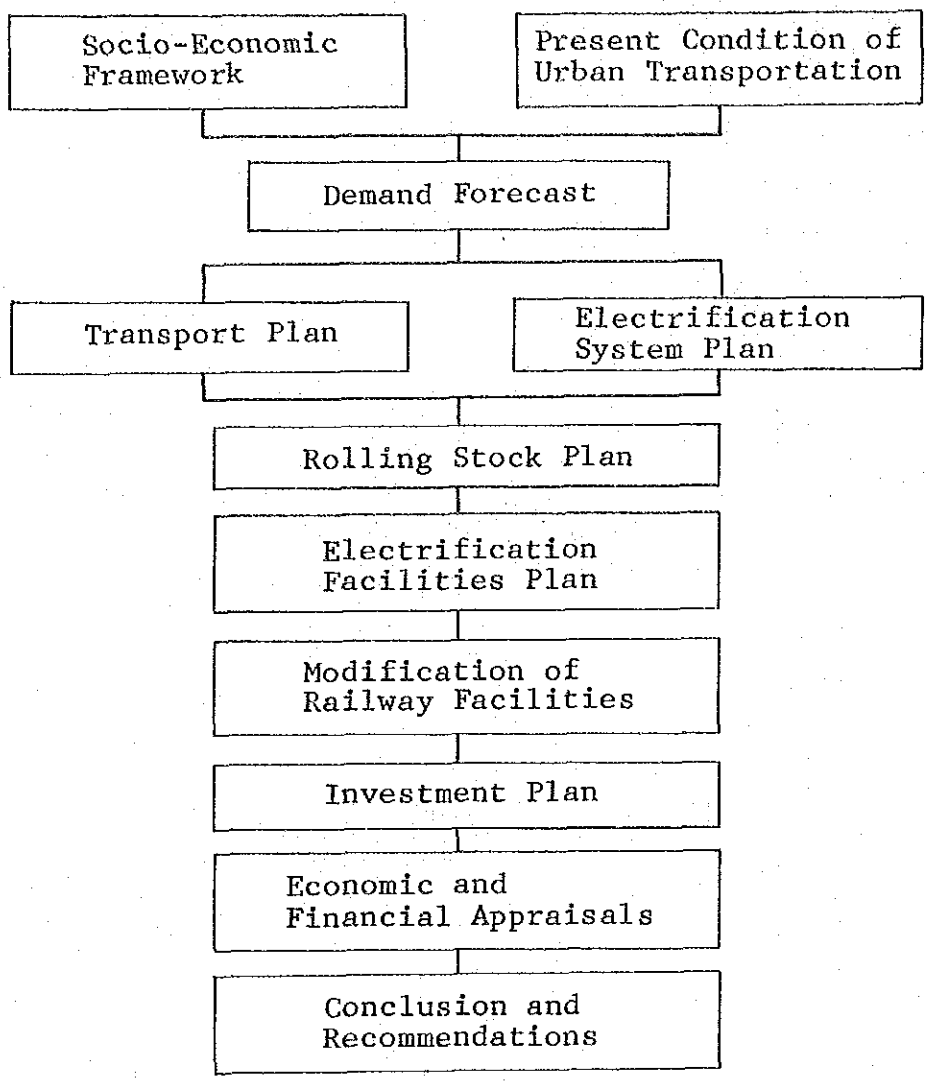
The study covers the following lines.



Circular and Suburban Lines

(2) Method

The study was conducted in the following manner. Each work element will be explained in later sections.



Study Flow

2. Socio-Economic Framework

(1) National economy

Burma has a population of 36 million (1982/83), and has had an annual growth rate of 2.2% for the past 20 years. The 1982/83 GDP was 46,945 million Kyats (equivalent to US$5,868 million) and the per capita GDP was 1,316 Kyats (equivalent to US$165) in nominal terms. The economy is greatly dependent upon agriculture, and rice cultivation in particular.

Burma has improved its economic performance through steady growth in the agricultural sector and by the rapid expansion of investment, and so the GDP growth rate has been averaging 6.4% in real terms since 1976/77. Stable prices have also encouraged this improvement.

(2) Economic plan

Burma has drawn up a Twenty-Year Plan (for 1974/75 to 1993/94) and five consecutive Four-Year Plans for which the major objectives are to double the standard of living through changes in the economic structure from an agricultural base to an agricultural-industrial one. The Plans have been successfully implemented on the whole. In addition, Burma has high potential for economic growth, and so, in accordance with the Plans, the estimation of future growth for the purpose of the study is set as follows.

Future Growth Estimation

	1983-1985	1986-1989	1990-2019
GDP Growth Rate	6.2%	7.0%	7.6%
Per Capita GDP Growth Rate	3.5%	4.6%	5.2%

(3) Energy situation

Burma is presently self-sufficient in energy, with the major energy sources being crude oil, natural gas, and hydro-electric power. Crude oil production has been constant between 10 and 11 million U.S. barrels, while the utilization of natural gas and electric power generation has rapidly increased.

The programmed consumption of oil and the utilization of natural gas and electric power are becoming important parts of the policy to maintain energy self-sufficiency.

(4) Development in Rangoon

Rangoon City belongs to the Rangoon Division and is composed of 27 townships. Its population of 2.5 million in an area of 209 square kilometres results in a population density of 11.9 thousand persons per square kilometre (1983/84).

The CBD and its adjacent townships also have high population densities as well as large numbers of employed. However, their growth rate has slowed or declined. The development policy also incorporates the dispersal of population and employment from the CBD to the suburban areas of Rangoon, with Insein, Mingaladon, Mayangon and Thingangyun being planned as areas for development.

3. Present Condition of Urban Transportation

Land transportation in Rangoon is mainly provided by railways, buses and express buses called "pick-ups".

Railway passenger services are provided by the Rangoon Circular Line (45.9 km) covering almost all of Rangoon City, and the suburban section (20.7 km) of the Mandalay Line extending north-east from Rangoon. Trains consist of one diesel electric locomotive and six carriages.

There is a large number of passengers between Insein and Rangoon, between Mingaladon Cantt and Rangoon, and between Thingangyun and Rangoon. In peak hours, trains have a capacity of over 200% in the most congested sections.

Bus and express services are provided by the Road Transport Corporation (R.T.C.) and also by the private sector controlled by the Rangoon Division Buses Control Committee (R.D.B.C.C.). R.T.C. has 11 normal bus lines and 7 special bus lines, while R.D.B.C.C. controls 16 bus lines and 12 express lines (by giving permission for service routes to private owners).

On some bus lines, passengers have to cling to the outside of the vehicle, with many passengers being left at stops in peak hours. Nearly all R.T.C. and R.D.B.C.C. vehicles are old, and some are well past their service life. Old buses are uncomfortable and have maintenance troubles.

Present Condition of Railways, Buses and Expresses

(1982/83)

	Railway	Bus	Express
Transport Volume			
Person (Thousand/day)	86	1,161	348
Share (%)	5.4	72.8	21.8
Headway of Peak Time (minutes)	15-20	1-3	1-3
Average Speed (km/hour)	21	19	23

4. Demand Forecast

(1) Method

Should the project be adopted ("With the Project"), the relative competitiveness of railways will increase due to improvements in the operational conditions, and so divert some passengers from the bus and express services.

Should the electrification project not be implemented ("Without the Project"), the railway will maintain its present share.

According to the above concept, the railway demand was forecast in the following manner.

Step 1: Estimation of the present origin and destination (OD)

Based on the OD survey, field observations and interviews with the concerned persons, the OD for the present status is estimated.

Step 2: Forecast of production-attraction

The future production and attraction volume for each township is estimated using a regression formula with the passenger volume and economic indices.

Step 3: Forecast of total OD

The OD for the total future demand can then be estimated by using the results of steps 1 and 2.

Step 4: Forecast of modal split

The future demand for each mode is forecast by using the modal split model which explains the preference for transport mode in terms of time and fare. In this model, the travelling time consists of access time, waiting time, the time on board and the transfer time and is calculated using the following competitive factors.

Competitive Factor Improvements

	Present	Electrification
Scheduled Speed (km/hour)		
Circular Line	19.7	23.0
Suburban Line	23.3	30.8
Average	20.8	25.3
Dependability (%)	92	95
Headway Ratio		
1990	100	70
2000	100	60
2010	100	50

(2) Results

The demand is forecast to be 233 thousand per day (equivalent to 2.7 times that for 1982) with an increase in share from 5.4% to 10.7% by 1990. This forecast is rather conservative, considering the dramatic diversion accompanying similar electrification projects in Japan and the much higher share held by railways in Tokyo and Osaka.

Demand Forecast

	1982	1990	2000	2010	2020
Passengers (Thousand/day)	1,597	2,179	2,860	3,691	4,705
Railway:					
Demand Forecast (Thousand/day)	86	233	323	436	555
		(118)	(154)	(199)	(254)
Share (%)	5.4	10.7	11.3	11.8	11.8
		(5.4)	(5.4)	(5.4)	(5.4)
Index Number (1982=1)	1	2.7	3.8	5.1	6.5
		(1.4)	(1.8)	(2.3)	(3.0)
Bus and Express:					
Demand Forecast (Thousand/day)	1,511	1,946	2,537	3,255	4,150
		(2,061)	(2,706)	(3,492)	(4,451)
Share (%)	94.6	89.3	88.6	88.2	88.2
		(94.6)	(94.6)	(94.6)	(94.6)
Index Number (1982=1)	1	1.3	1.7	2.2	2.7
		(1.4)	(1.8)	(2.3)	(2.9)

Remark: ( ) Without the Project

5. Transport Plan

(1) Basis for transport plan

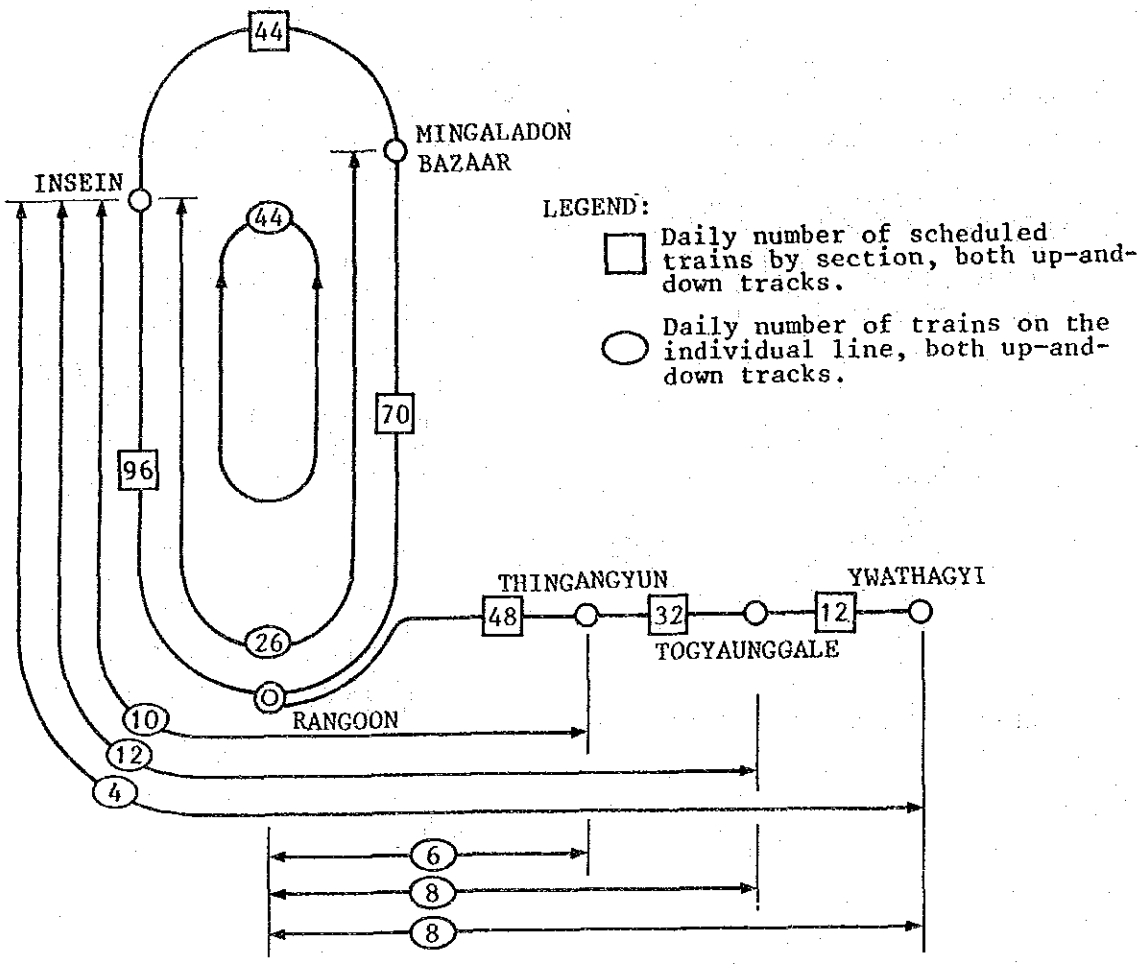
The transport plan is based on the railway demand forecast. For diversion it is necessary to increase the train frequency, with minimal switching of locomotives in stations and with an increase in the scheduled speed.

Major Items for Transport Plan

Unit Train Formation	1 Electric Locomotive and 6 Carriages
Riding Efficiency	
Peak Time	150% (900 persons)
Other Time	125% (750 persons)
Maximum Speed	
Circular Line	48 km/hour
Suburban Line	56 km/hour
Scheduled Time	
Circular Line	120 minutes for a round trip
Suburban Line	40 minutes between Rangoon and Ywathagyi
Minimum Possible Headway	7.5 minutes

(2) Transport network

Terminal stations are proposed for Insein, Mingaladon Bazaar, Thingangyun, Togyaunggale, Ywathagyi and Rangoon, with the following network and the number of scheduled trains adjusted to conform to the passenger flow.



Number of Scheduled Trains (1990)

(3) Number of rolling stock

The rolling stock fleet will consist of 19 locomotives and 105 carriages, based on train diagram for 1990. Modifications of the train diagram are planned for 2000 and 2010, accompanying the additional procurement of rolling stock.

Rolling Stock Procurement

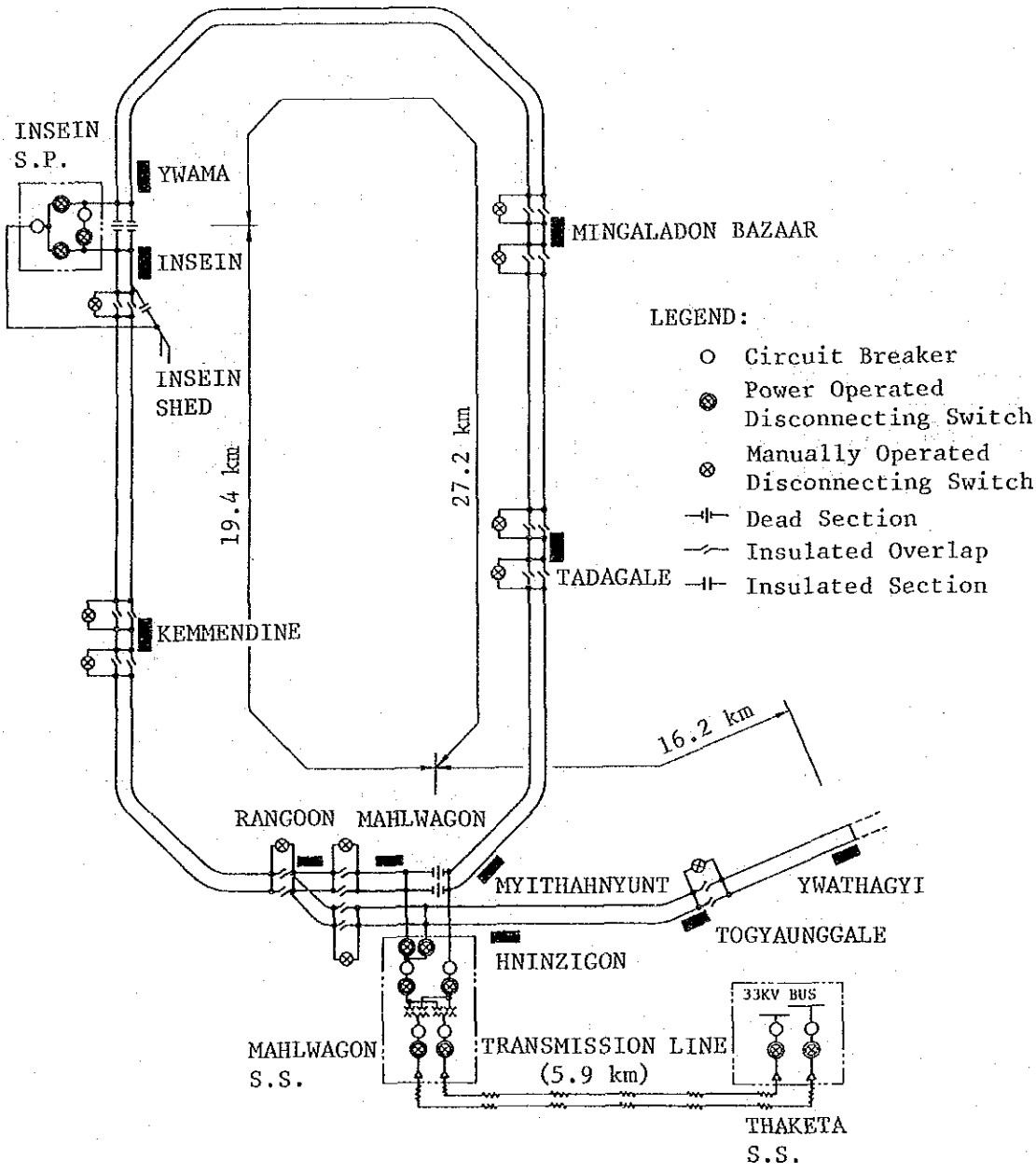
Fiscal Year	Train-km (km/day)	Total Number of Scheduled Trains	Locomotives	Carriages
1990	3,939.2	302	19(3)	105 (9)
2000	4,952.6	368	24(3)	136(10)
2010	6,358.4	458	31(5)	173(17)

Remark: Numbers in parentheses are the maintenance and stand-by rolling stock.

6. Electrification System Plan

The commercial frequency single-phase AC 25 kV simple feeding system is selected for this project.

The diagram for this feeding system is shown below.



Feeding System Diagram

7. Rolling Stock Plan

High performance electric locomotives are planned for increasing the scheduled speed. The height, with the pantograph folded down, is set on the basis of the present diesel electric locomotives.

Major Features of Rolling Stock

Electric locomotives	
Weight	
Working Order	48.0 ton
Axle Load	12.0 ton
Maximum Height	3,505 mm
Performance	
Continuous Rated:	
Output	1,000 kw
Tractive Effort	12,000 kg
Speed	30 km/hour
Maximum Service Speed	80 km/hour
Control System	Thyristor controlled with silicon rectifier
Brake System	Air brake system
Carriages	
Tare Weight	25 ton
Nominal Passenger Capacity	100 persons (seating 64, standing 36)
Maximum Height	3,405 mm
Side Entrance	2 on 1 side
Brake System	Air brake system

8. Electrification Facilities Plan

(1) Power source

The site selected for the railway substation is near Mahlwagon Junction. It is planned that the railway substation receives power from Thaketa substation of the Electric Power Corporation.

The maximum hourly demand for the electric traction power in the first year of electrification, is equivalent to 0.22% of the 1982/83 Burmese electric power capacity, while the annual consumption is equivalent to 0.67% of the 1982/83 Burmese power consumption results.

Furthermore, the single-phase electric traction power gives no adverse effect upon the general three-phase power network.

(2) Transmission line

Transmission lines between the Mahlwagon railway substation and Thaketa substation are underground cables having two circuits.

(3) Substation

The substation is of the outdoor type.

Two 10 MVA Scott-connected transformers are installed with the power receiving equipment. One is for normal use and the other kept as reserve.

Feeding circuit breakers are provided for each of the single-phases.

(4) Overhead contact system

The overhead contact wire has a minimum height of 3,800 mm, a standard height of 4,500 mm and a maximum height of 5,200 mm above rail level.

The simple catenary system is used, but overhead contact wires beneath road overbridges use two parallel contact wires only.

Equipment for Overhead Contact System

Overhead Contact Line Equipment		
Messenger Wire	Galvanized zinc steel	90 mm^2
Contact Wire	Grooved hard-drawn copper	110 mm^2
Support Equipment		
Poles	Prestressed concrete	
Beams	Rigid	
Protective Equipment		
Negative Feeder	Aluminum cable steel reinforced	58 mm^2

9. Modification of Railway Facilities

Major modifications to the railway facilities for electrification are as follows.

(1) Track

The number of intersections of the Circular and Suburban Lines between Rangoon and Pazundaung is reduced.

New shuttle operation facilities are installed at Mingaladon Bazaar and Togyaunggale.

Since the clearance beneath road overbridges is set at 4,100 mm above rail level, the roadbeds are lowered to secure the necessary clearance.

(2) Structures

Since the clearance beneath passenger overbridges is set at 4,550 mm above rail level, passenger overbridges are raised to secure the necessary clearance.

A passenger overbridge is to be newly constructed at Rangoon because of changes in the train arrival-departure platforms.

Concrete rainwater drains are constructed along track in cut regions and other regions susceptible to flooding.

Buildings required for the electrificaton will be constructed.

(3) Rolling stock shed

Insein shed is equipped with facilities for the daily inspection and light repair of electric locomotives.

Electric locomotives are stored in Insein shed, and carriages in Insein shed and Rangoon carriage shed. Storage track need not be newly installed at the initial stage, but in the future it is necessary with the increase of carriages.

(4) Workshop

Insein workshop is used for the inspection and repair of electric locomotives. The workshop is modified with an equipment and supply room, and a test running track for electric locomotives.

Myitnge workshop will still be used for the inspection and repair of carriages.

(5) Power distribution

Power distribution lines crossing the track are removed to meet safety requirements.

New line transformers connected to the overhead contact wires for signalling facilities are installed at each point where power supply is required.

(6) Signalling facilities

The present track circuits are upgraded to single-rail track circuits within stations, and to audio frequency non-insulated track circuits between stations, as measures to prevent inductive interference caused by AC electrification.

The present block system is changed to an automatic check-in check-out block system to secure a minimum train headway of 7.5 minutes.

Interlocking systems are installed at Insein, Mingaladon Bazaar and Togyaunggale stations to enable smooth shuttle operation.

Level crossing signals are installed at the main crossings.

(7) Telecommunication facilities

The overhead bare wires of the Posts and Telecommunications Corporation are replaced by underground cables to immunize inductive interference.

The present manual telephone exchanges are replaced with automatic ones at two stations. New telephones are installed for the dispatch and maintenance of the electrification facilities.

10. Investment Plan

(1) Investment costs

Initial investment costs are estimated on the basis of April 1984 economic conditions. An escalation factor is not considered.

Initial Investment Costs

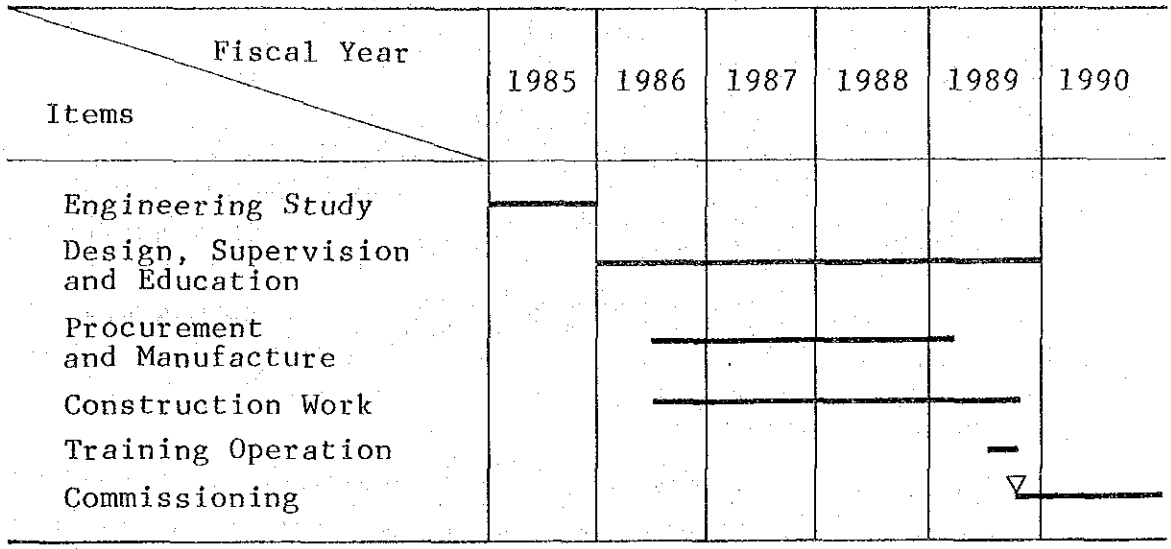
(Unit: Thousand Kyats)

Items	1986 - 1990		
	Local	Foreign	Total
Rolling Stock	-	216,775	216,775
Electric Facilities	2,974	86,544	89,518
Civil Engineering	32,087	15,176	47,263
Inspection and Repair Equipments	105	8,552	8,657
Signalling Facilities	814	29,772	30,586
Telecommunication Facilities	202	24,015	24,217
(Subtotal)	36,182	380,834	417,016
Engineering and Education	351	33,338	33,689
Tariffs and Taxes	164,926	-	164,926
Contingencies	1,827	18,374	20,201
(Subtotal)	167,104	51,712	218,816
Grand Total	203,286	432,546	635,832

(2) Construction schedule

Construction is scheduled so as to commence the electric traction in January 1990.

Construction Schedule



11. Economic and Financial Appraisals

Major premises are set as follows for the economic and financial appraisals.

Major Premises

Exchange Rate	¥100 = 3.5 Kyats US$1 = 8 Kyats	
Prices	The April 1984 prices, no escalation	
Oil Prices	Domestic Price for Financial Appraisal:	2.95 Kyats/gallon
	International Price for Economic Appraisal:	6.28 Kyats/gallon

(1) Economic appraisal

The purpose of the economic appraisal is to evaluate the economic significance of the project from the point of view of the Burmese economy. The economic significance is appraised by the EIRR based on a cost-benefit analysis and other benefits.

a. Cost-benefit analysis

The cost-benefit analysis is conducted on the incremental costs and benefits between the "With the Project" and the "Without the Project" cases which are composed of railway investments, passenger time savings, railway maintenance and operation costs, bus and express costs and road investments.

(a) Results

EIRR: 15.4%

(b) Sensitivity test

The results of the sensitivity test for the following cases show that all exceed the criteria of the Government of Burma, that the EIRR be greater than 10 - 12%.

Results of EIRR Calculations

Case	EIRR
Base Case	15.4%
10% Investment Cost Overrun	14.6%
20% Investment Cost Overrun	13.8%
10% Demand Decrease	14.4%
5% Inflation	21.3%

b. Evaluation

The project is judged as being highly significant since it has an acceptable EIRR as well as the following benefits which will contribute to Burmese development.

(a) Fuel savings: 69 million gallons

(b) Traffic congestion relief:

- Traffic accident reduction
- Alleviation of air pollution

(c) Employment creation for construction work: 331 thousand man·days

(d) Technology advances

(e) Hinterland development

(2) Financial appraisal

The purpose of the financial appraisal is to provide a reference for financial management of B.R.C. on this project, with the feasibility being appraised from both the profitability and the stability. The profitability is measured by the FIRR for the incremental cash flow between the "With the Project" and the "Without the Project" cases, while the stability is measured by the future financial indicators for the Circular and Suburban Lines.

a. Project profitability

The FIRR is calculated on the incremental cash flow which is composed of investments, revenues, expenses and turn over taxes.

(a) Results

FIRR: 5.1%

(b) Sensitivity test

The results of the sensitivity test for the following cases show that all exceed the B.R.C. average cost of funds of 3.8% and the weighted average interest rate of the project of 3.5%.

Results of FIRR Calculations

Case	FIRR
Base Case	5.1%
10% Investment Cost Overrun	4.5%
20% Investment Cost Overrun	3.9%
10% Demand Decrease	4.6%
5% Escalation	5.8%

b. Project stability

The future financial statements are projected on the basis of the following funding scheme.

° Investments

Concessional Loans: Foreign currency portion

° Maturity/Grace Period - 30 years including 10-year grace period

° Repayment - Equal annual instalments

° Interest Rates - 2.75% annually

Myanma Economic Bank (M.E.B.) Loans:

Local currency portion

° Maturity/Grace period - 10 years including 5-year grace period

° Repayment - Equal annual instalments

° Interest Rates - 5% annually

° Working Capital

M.E.B. Financial and Revenue Loans

° Interest Rates - 8% annually

(a) Results

Year of First Profit: 2007/08 (18 years)

Year of First Retained Profit: 2019/20 (30 years)

Year of Debt Service Cover Ratio > 1: 2009/10 (20 years)

Working Capital Shortfall: 7 years incurred

(b) Sensitivity test

The results of the sensitivity test for the following measures and funding options show that all cases will show a profit and exceed the debt service cover ratio of 1.0 within the project life.

Results of Financial Projections

Case	Year of First Profit	Year of First Retained Profit	Year of DSCR > 1	Working Capital Shortfall
Base case	2007	2019	2009	7 years
Measures;				
10% traffic demand increase	1995	2006	1999	3 years
10% fare rises by 10 years	1995	2008	1999	4 years
50% exemption of tariffs and taxes	1995	2005	1997	Nil
Funding options;				
50% debt equity ratio for local portion	1997	2009	2000	Nil
Two extensions of M.E.B. repayments	2004	2014	2008	3 years
Suspending M.E.B. repayments	2005	-	2003	Nil
3.5% interest rate for foreign loans	2019	-	2018	12 years

c. Evaluation

The project is judged as being financially feasible since it has both a reasonable profitability and an acceptable stability.

12. Conclusion and Recommendations

(1) Conclusion

The technical study was conducted on the basis of the demand forecast and in order to formulate an electrification plan. It was concluded that the electrification is technically feasible at the minimum cost.

The economic and financial appraisals were conducted on the basis of the investment plan provided by the technical study. The project is evaluated as being capable of making a great contribution to the development of Rangoon and to Burmese economic development in general, and as being feasible from the financial points of view.

The implementation of the project is therefore highly recommended.

(2) Recommendations

The following several supporting steps are recommended to be taken for the smooth implementation of construction and for sound operation after commissioning.

a. Maintenance of the electrified railway

The Circular and Suburban Lines should be maintained as a reliable transport system, and it is advisable to make a continuous effort to maintain the condition of the lines through the proper allocation of funds, materials and personnel.

b. Safety assurance

To secure safety assurance, safety facilities and measures are to be fully instituted. The installation of track fencing will also be recommended.

c. Electrification standards

The standard is to be established for the electrification prior to the implementation of the project.

d. Passenger information

Clear indications and easy-to-read signs will be necessary to minimize confusion accompanying changes in train operation, track layout and platform allocation.

e. Education system

On-the-job-training by foreign engineers and a programme of overseas study are essential in the education programme for smooth introduction of technology.

f. Fare adjustment

In order to improve the financial position of the lines, fare adjustment will be made in the long-term.

g. Funding scheme

The electrification is a large project for B.R.C. and is closely linked to the B.R.C. financial position. As regards the local currency portion it is advisable that government equity be increased to lower the debt equity ratio and that the M.E.B. loan conditions be relaxed to improve the financial position. As regards the foreign currency portion it is also advisable that concessional loans with low interest rates be raised.

h. Coordination with other transportation

The electrified Circular and Suburban Lines can play a major role in mass transportation between the CBD and the suburban areas, while buses and expresses will provide feeder services.