- Shortened time for taking measures against accidents and for recovering services
- Rapid adjustment of train operations

(2) Enhancement of freight service efficiency
- Improved control telephone
- Improved and coordinated telephone exchange network
- Efficient information exchange by facsimile

(3) Rapidness of recovery from accidents
- Communication lines available for field work
- Accurate information on accidents
- Accurate information on track conditions

(4) Prevention of train accidents
- Improved block lines
- Smooth communication between level crossing attendants and stationmasters
- Accurate communication on work execution

(5) Smoothness of communication on services
- Adjusted and coordinated telephone exchange network
- Increased lines for various use

(6) Enhancement of passenger service
- Train information service at major stations

7-4 Signalling

7-4-1 Outline

The facility improvement plan of signalling will basically cover the installation of interlocking devices and color light signals, and improvement of block system and railway level crossings. On the Mandalay line, a CTC system will be installed in the third stage to realize effective traffic control. The detailed plans for each line are described in Table 7.4.1.

Table 7.4.1 Installations in the Improvement Plan

Item \ Plan		A	B
Mandalay line	1st stage	o Colour light signals (outer, distance and start) o Interlocking device (relay or electronic type) at Pegu, Myohaung, and Pyuntaza. o Electric lock devices for points o Level crossing alarm devices for main road o Block system (token, tokenless or electronic type)	Same as plan A
	2nd stage	o Interlocking devices (relay or electronic type) at all stations excluding three stations	
	3rd stage	o CTC (Centralized Traffic Control)	

Item \ Plan		A	B
Martaban line	2nd stage	o Colour light signals (outer, distance and start) o Electric lock devices for point o Level crossing alarm devices for main road o Block system (token or electronic type)	Same as plan A
	3rd stage	o Relay interlocking device at major stations	
Prome line	2nd or 3rd stage	o Same as the Martaban line at the 2nd and 3rd stages (plan A) o Relay interlocking devices at Letepadan station at the 2nd stage	o Same as the Martaban line at the 2nd stage o Relay interlocking interlocking devices at Letepadan station at the 2nd stage
Myitkyina line	3rd stage	o Same as the Martaban line at the 2nd and 3rd stages (plan A)	o Same as the Martaban line at the 2nd stage

The recent development of microelectronics was remarkable, and in the safety facilities of the Japan National Railways, interlocking device and block system introducing microelectronic technology have already been in practical use with high reliability. In this context, electronic interlocking and electronic block devices will be an alternative for the signalling improvement.

7-4-2 Improvement Plan

(1) Improvement at the four major stations

The result of investigation revealed the necessity for immediate replacement of deteriorated mechanical devices. Improvement will be carried out at the three stations of Pegu, Myohaung, and Pyuntaza on the Mandalay line and Letpadan station on the Prome line.

Relay interlocking or electronic interlocking devices will be installed at the aforementioned stations in the following way:

1) Unification of two control cabins

2) Construction of control machine, power supply, and maintenance rooms

3) Installation of water-proof electric switch machines, or raising ordinary machines.

4) Installation of outer and distant signals with visibility of 1500 m

5) Installation of start signals with visibility of 600 m

6) Laying of power cables for signals in a trough or underground

7) No inspection stand nor ladder for signals will be fixed as they may be stolen.

8) Low current will flow in the signal lamps to detect burnt filaments and cut signal cables.

9) At stations of the sections to be electrified, track circuits will use direct current.

Outline of such electronic interlocking device and block system are shown in Fig. 7.4.1.

Fig. 7.4.1 Signalling Facilities Improvement

Item	Relay interlocking, token, tokenless device Fig. 7.4.2, Fig. 7.4.3	Electronic interlocking, electronic block device Fig. 7.4.4
Mechanical interlocking device (Key lock)	. To install electric locking devices . To install relay interlocking devices at 3 main stations	. To install electric locking devices . To install electronic interlocking devices at 3 main stations
Mechanical signal (Distant & Outer Signals)	. To install color light signals at stations that can be seen from a farther distance (visible from 1.5 km) . To install new starting signals	. To replace signals with cab signals
Block system (line clear ticket system)	. To install tokenless system on double track line sections and tablets on single track line sections. . The new tokenless systems will use the wheel axle counter system	. To replace tokenless and token systems with an electronic token system by wireless.
Facility improvement work	. To install new electric locking devices at points on the main track . To install new starting signals and outer signals (with indicator) at stations, main tracks, and auxiliary main tracks . To use removed tablets . To improve power supply by installing overhead power lines . To remove mechanical signals . To make arrangements with BRC to prepare signals pole and troughs	. An electronic token system incorporating relay interlocking device . Centralized operation display for each division (Centralized divisional data supervisory) . Train separation detection . Less electric power consumption as no signal is installed (in the case of manual point operation) . ATS functions on locomotives . Train cab display to be indicated by radio transmission.

Item	Relay interlocking, token, tokenless device	Electronic interlocking, electronic block device
Advantages	. No need for key locking . Improved visibility lifts train speed on night operations . Wheel axle counter, a checking-in/out or tail check system for train arrivals and departures, detects train separation (on double track lines)	. Centralized tracking operation for maximum 15 stations . To remove distant and outer signals so that stealing of equipment can be prevented . Energy-saving machine operation is possible as no signal is installed . ATS function can be added . Small space required for this system
Disadvantages	. An engine generator is required for signals in case of power failure . Train can not be stopped in case of a signal check failure by driver (can be stopped if ATS is installed)	

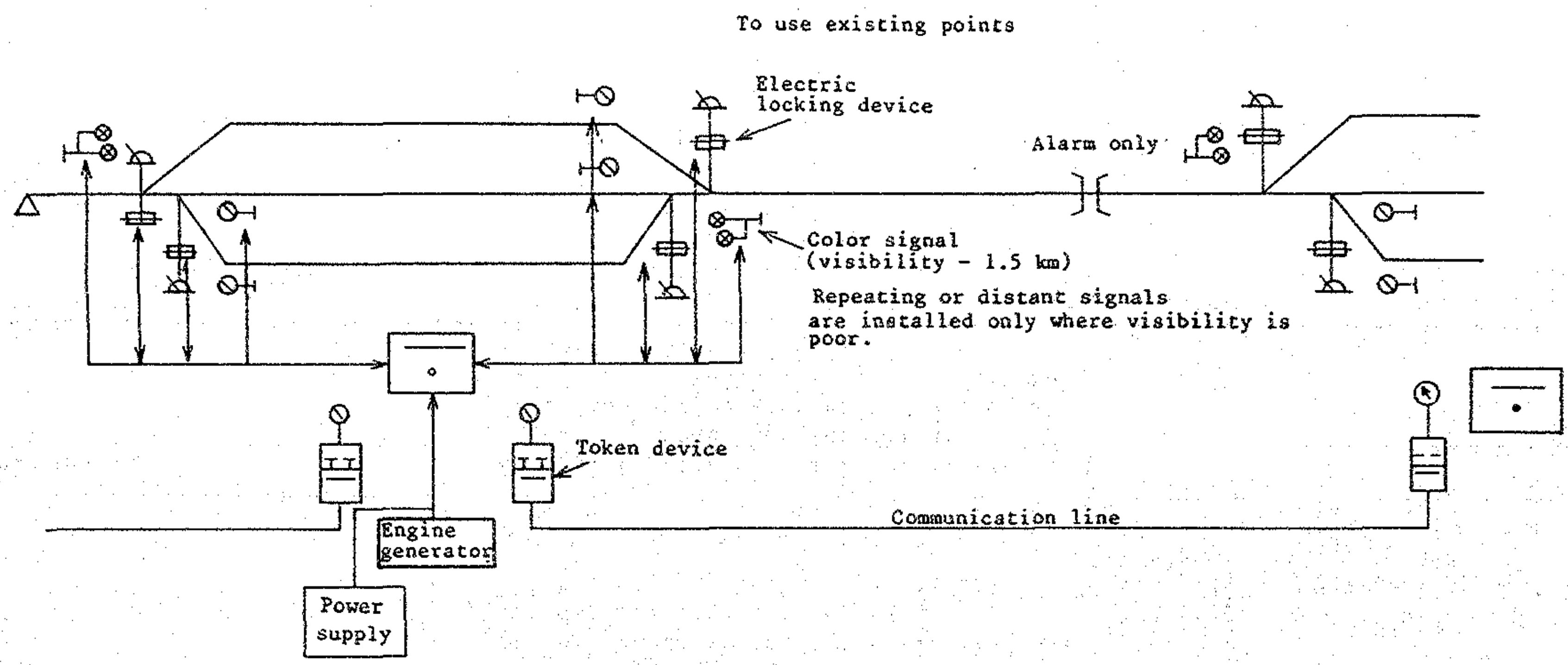
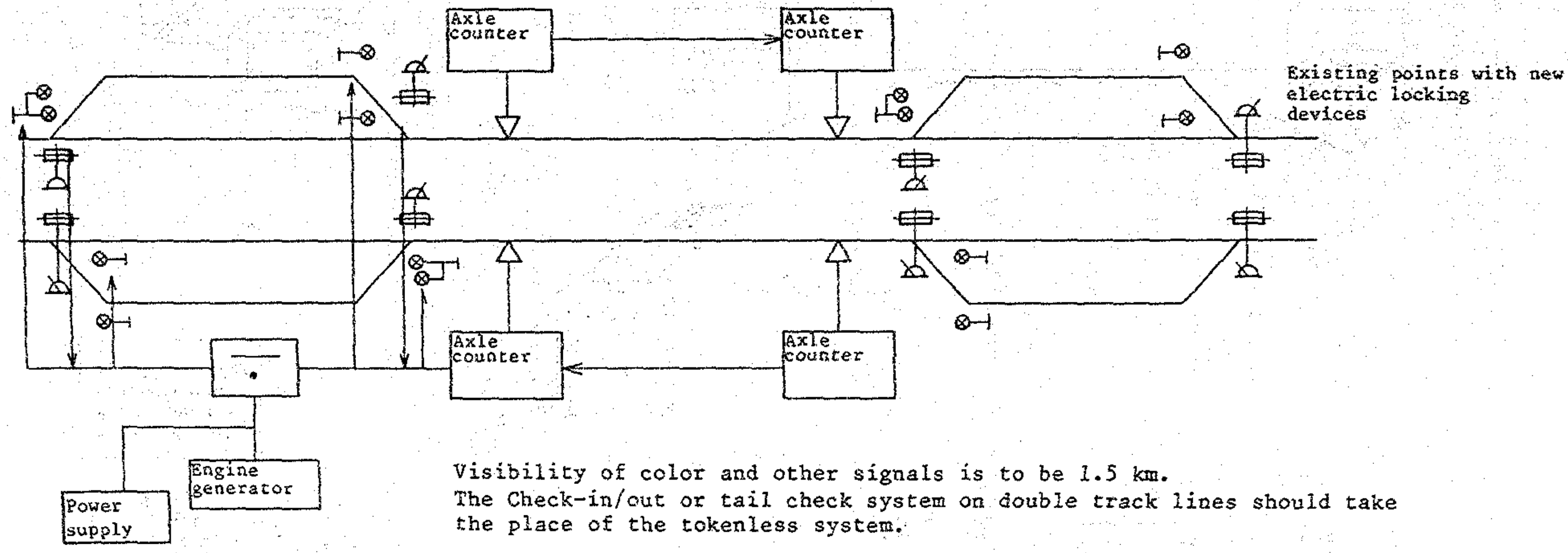


Fig. 7.4.2 General Drawing (Single track line) (Plan A, B)



Visibility of color and other signals is to be 1.5 km.
The Check-in/out or tail check system on double track lines should take the place of the tokenless system.

Fig. 7.4.3 General Drawing (Double track line) (Plan A. B)

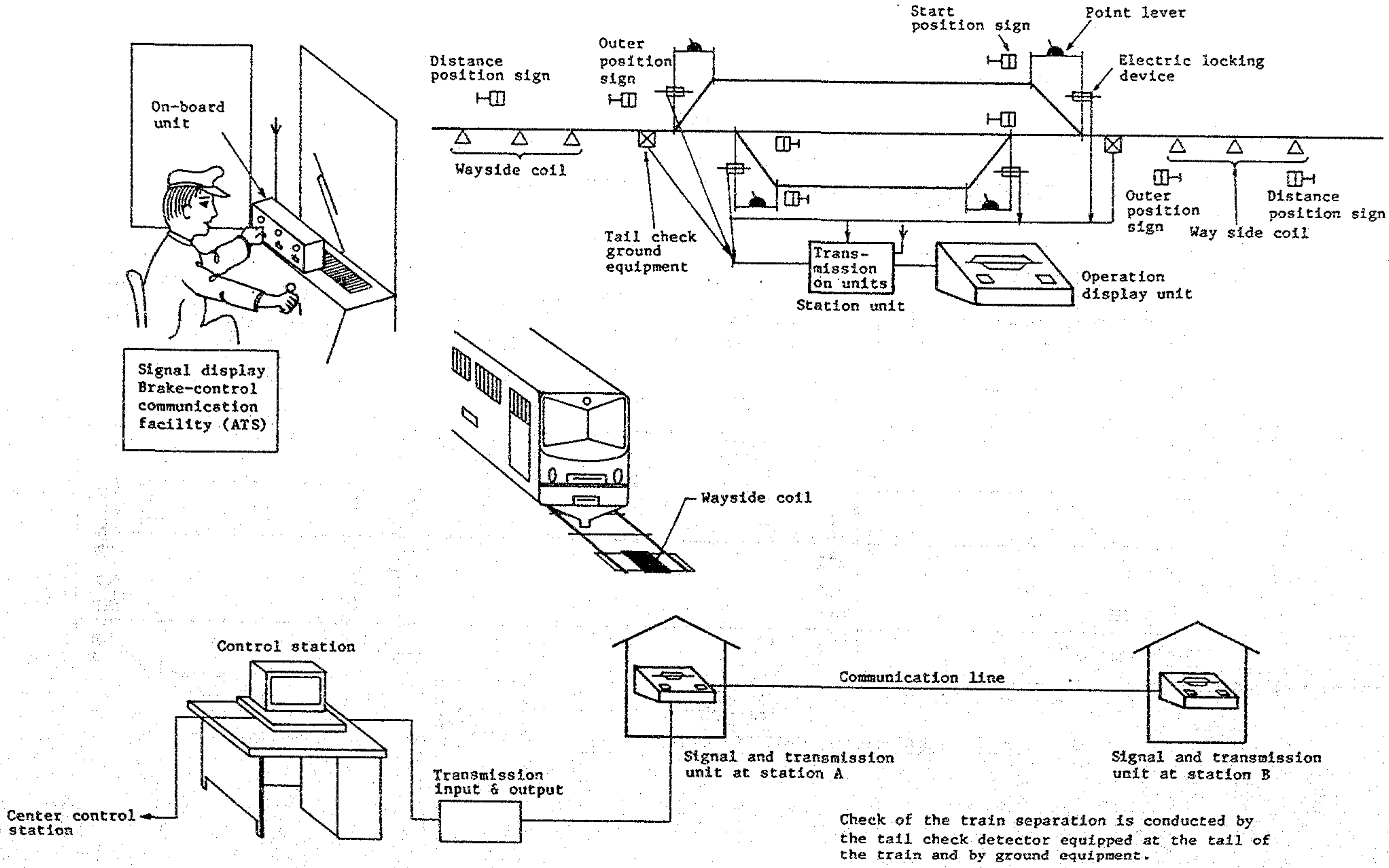


Fig. 7.4.4 General Drawing Alternative Plan of Electronic Tokenless Device (Plan A, B)

(2) Improvement at other stations

Signalling facilities of other stations will be improved in the following manner:

1) Electric point lock devices will be added to the existing points after partial improvement.

2) No track circuit will be installed.

3) Two outer signals on one pole or one outer signal with an indicator, as well as start and distant signals, will be installed.

4) Electric point lock devices and color light signals will be interlocked.

5) Isolation points will be installed on the loops at stations, when necessary.

6) Design of the visibility of signals, cable laying, and detection of burnt signal lamps are same as that at major stations.

(3) Block system

1) A check-in/check-out or tail check system will be used on the double line. A wheel axle counter will be installed at both the entering and departing ends of each station in order to block the section and check train separation. Fig. 7.4.3 shows the checking method by means of a wheel axle counter. Between the entering and departing wheel axle counters or tail check devices, there will be a block section. While a train is within the section, blocking the section is not released.

2) Existing tablet devices will be utilized on the single line, using newly installed telecommunication cable or improved PTC bare line

(4) Level crossing

Each level crossing at main road will have approach alarm devices with track circuit or wheel axle detecters which detect the train approach. The approach alarm will indicate when the gate is to be manually closed. Electric power for level crossings will be supplied from the nearest station.

(5) Power Supply Facility Improvement

For the color light signals at the stations without power supply, overhead power lines will be intalled from nearby power substations.

7-4-3 Effects from Improvement

The following effects are expected by the improvement.

(1) Increase in train speed, and reduction in train delays by:

- More signal visibility
- Timely level crossing closing
- Installation of the electric-point lock devices at points
- Shorter handling time of train operation at station
- Installation of isolation points on the loops

(2) Decrease in train accidents by:

- Decrease in signal failures
- Prevention of forced opening of trailing switch
- Decrease in level crossing accidents
- Prevention of accidents such as train separation

CHAPTER 8 CONCRETE SLEEPER AND RAIL WELDING

CHAPTER 8 CONCRETE SLEEPER AND RAIL WELDING

8-1 Prestressed Concrete Sleeper Manufacturing

8-1-1 General

The Mandalay Line, with a route length of 620 kilometers (385 1/2 miles), is a main line of the BRC network. On this line, the section between Rangoon and Pyinmana, having a route length of 362 kilometers (225 1/4 miles), is a double-track section, with the remainder being a single track section.

It is planned to replace wooden sleepers with prestressed concrete sleepers (hereinafter called PC sleepers) in order to strengthen the tracks, which is included in the facility improvement plan as described in Chapter 7.

The advantages and disadvantages of a PC sleeper compared with a wooden sleeper are as follows:

- Advantages of PC sleeper

1) No corrosion and/or rot, and longer durable life.

2) Suitable to construct a long-rail track, since it has adequate weight to maintain stability and has stronger resistance against the buckling of rails.

3) Use of a double elastic fastening, which brings less increase of track irregularity. Consequently, the maintenance cost will be less.

- Disadvantages of PC sleeper

1) Higher cost.

2) More difficulty in design of fastening.

3) Difficulty in manual handling of a PC sleeper because of its heavy weight.

4) Less insulation capacity.

A PC sleeper has both the advantages and disadvantages mentioned above. However, a PC sleeper is more advantageous in the country, because of the shortage of wooden resources for sleepers and the availability of the extension of an interval of track maintenance work due to the employment of long welded rails with PC sleepers. Furthermore, the disadvantages of PC sleepers are being reduced with the progress of technology.

Based on the background mentioned above, replacement of wooden sleepers with PC sleepers on the Mandalay Line is planned.

The estimated number of sleepers to be replaced are 1,410,000. Therefore, these PC sleepers will be manufactured to meet the progress of improvement work of the track. The period of the improvement work is estimated to be nine years, and the work is planned to be executed step by step at every section. The productivity of the Mahlwagon PC sleeper factory is too insufficient to supply the number of sleepers required for the work, and the factory is located near Rangoon at the southern end of the project area. Accordingly, some additional factories will be constructed to manufacture the 1,410,000 sleepers.

There are the following two methods to manufacture PC sleepers.

1) Pretension method

This method is being applied to manufacturing at the Mahlwagon factory. It is the traditional method to manufacture concrete sleepers.

2) Post-tension method

This method was developed after the pretension method was developed. Nowadays, it is used as much as the pretension method.

8-1-2 Pretension Method

The manufacturing process of the pretension method is as follows:

1) PC wires in mold are tensed up.

2) Embedded plugs for rail fastenings and election bars are fixed.

3) Concrete is placed and cured.

4) PC wires are cut at both ends after concrete becomes stiff and gains strength required.

5) Prestress is brought in the concrete by bond stress between PC wires and concrete.

The pretension method is classified into the following methods.

Long-line method ——┬—— Fixed bench
　　　　　　　　　└—— Transfer bench

Individual mold system

(1) Long-line method

This method is being applied to manufacturing at the Mahlwagon factory. The output of the factory is small at this time. Accordingly, PC wires are tensed up one by one, because only 25 forms of molds are lined up in a longitudinal row. Furthermore, curing of concrete is set up not by using steam. In this project, the facility of the new factory will be planned to have enough capacity to manufacture more than 200 sleepers per day. The outline of the manufacturing process is as follows (refer to Fig. 8.1.1).

PC wires are stretched through the molds for PC sleepers arranged in a distance of 15 to 20 cm from each other. The number of molds in a series is 37 vertically and 3 horizontally. The both ends of the wires are attached at abutments fixed on the earth. The tension of the wires is given with two jacks located at an abutment. The fixing type of abutments mentioned above is called "the fixed bench". Another type is called "the transfer bench". In this type, the fixing apparatuses of the PC wires are attached to movable structures like a bridge girder. The distance between the two abutments can be long (up to about 100 meters) in the case of the fixed bench, which is impossible in the case of the transfer bench. However, the transfer bench type has the advantage that it can carry on many kinds of manufacturing processes at a site.

(2) Individual mold system

In this system, PC wires are tensed and fixed at an individual mold before concrete is poured into the mold. Accordingly, molds need not be arranged vertically. However, the high rigidity of molds is necessary since the tensile force of PC wires is supported by an individual mold. The desired diameter of the wire should be big, because the fixing and the tension of the wires are complicated in cases where diameter is smaller.

8-1-3 Post-tension Method

The process of the post-tension method is as follows.

1) PC bars are used instead of PC wires to be tensed.

2) Concrete is poured into molds under the condition that adhesive force between PC bars and concrete is not generated.

3) Prestress is generated in concrete by tensile force applied to PC bars, after concrete is hardened to have the strength required.

One of the methods to prevent contact between the PC bars and concrete is as follows:

1) Forming bars are arranged when concrete is poured.

2) The bars are removed during the hardening of the concrete, and PC bars are inserted instead of the forming bars.

3) The PC bars are tensed up.

4) Gaps between the PC bars and concrete are filled with grout.

Nowadays, the unbonded system is applied commonly. In the PC system the bars are coated with special paint, which prevents contact force generating between the PC bars and concrete, then arranged in molds before the concrete is poured.

The scale of the manufacturing factory using the post-tension method is smaller than that of the pretension method one, because the manufacturing process of the former is simpler than the latter, and an assembly line system can be employed in the post-tension method. The arrangement of a factory for manufacturing 200 post-tension type concrete sleepers per day is shown in Fig. 8.1.2.

The manufacturing process of the post-tension method is classified into the following three systems.

- After hardening form-remove system
- Semi-spot form-remove system
- Spot form-remove system

(1) After hardening form-remove system and semi spot form-remove system

The after hardening form-remove system has concrete poured into molds after the PC bars are arranged in molds, and fastenings and embedded plugs are fixed, then prestress is generated after molds are removed when the concrete is hardened so as to generate prestress.

The semi spot form-remove system has molds removed when concrete is semi-hardened, then prestress is generated after concrete is hardened to gain the strength required.

These systems have the advantages of using considerably soft concrete and employing an assembly line system.

(2) Spot form-remove system

The spot form-remove system has molds removed immediately after concrete is poured. The system requires only a small number of molds because the turnover rate of molds is high. However, the manufacturing process requires much manpower because hard concrete is treated by vibrations of high intensity.

8-1-4 Selection of Manufacturing Method

(1) Comparison of manufacturing method

There are two methods of the pretension and post-tension manufacturing of PC sleepers, several of the processes are mentioned above. In this project, the following two methods will be studied taking into account the condition of the location, the output of the factory, and the condition of supply of materials.

1) Pretension: Long-line method with fixed-bench method
2) Post-tension: After hardening form-remove method

These two methods are now generally adopted in the world. The comparison of the two methods follows.

1) Pretension/fixed-bench method

This is a typical method that has been adopted for a long time in many factories. The manufacturing cost is cheaper than that of the post-tension method, since PC wires (2.9 mm x 3 twist wire) are used for tensioning. However, the number of manufacturing machines required is more. The required number of steel forms are twice as the number of output. Also, more labour is required. Accordingly, this method is suitable to adopt for a permanent facility at a fixed location, since the investment for the facilities is more than that of the post-tension method.

2) Post-tension/after hardening form-remove method

In the case that this method is adopted, the manufacturing cost of a sleeper is higher than that of the pretension method, since PC bars (diameter of 10 mm) are used instead of PC wires for steel material to be tensed up.

On the other hand, the scale of the factory is smaller and the facilities simpler (it uses a fewer number of molds), since the manufacturing work is carried out on an assembly line. Therefore, relocation of this factory is easier than a factory adopted for the pretension method.

(2) Selection of manufacturing method

There are two different methods for PC sleepers manufacturing as described above. The difference in the methods is basically due to the types of reinforcing steel used in the manufacturing, and make very little difference in the basic quality of the PC sleepers. Therefore, taking into account the following factors, adoption of the pretension method is recommended.

1) The total cost for the pretension method is slightly higher than the post-tension method. However, the pretension method will require less foreign currency for reinforcing steel.

2) The BRC presently has a PC sleeper factory in operation at Mahlwagon adopting the pretension method, therefore, it will be easy to expand the present plant facilities, and to train engineers and technicians on the pretension method.

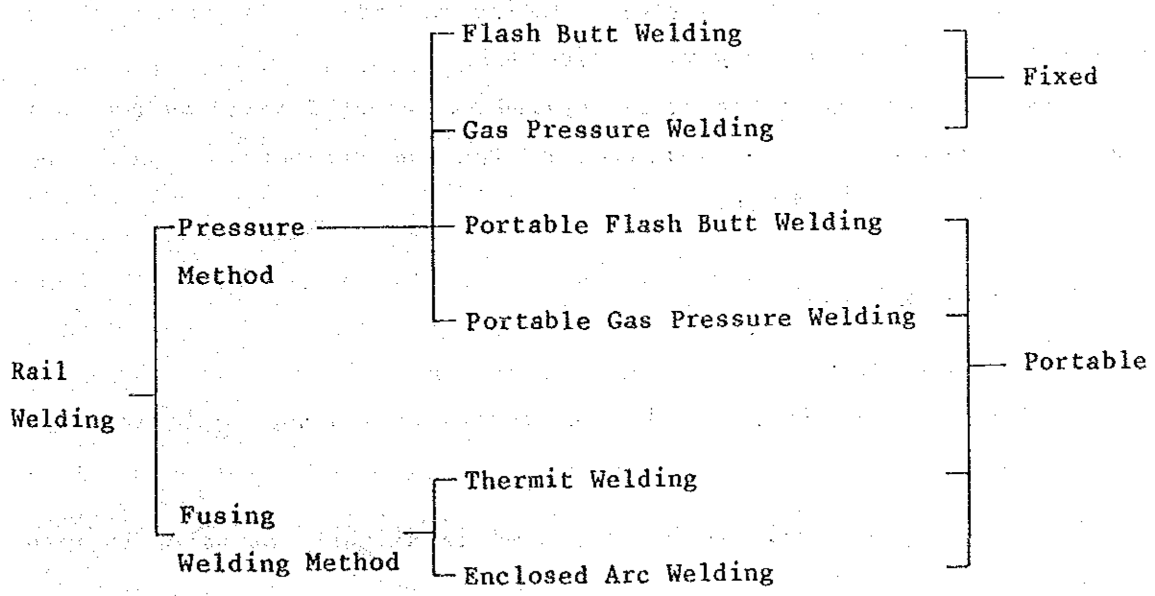
In constructing new PC sleeper plant facilities or to relocate existing plant facilities, an analysis should be made to reuse existing plant facilities.

8-2 Rail Welding

8-2-1 General

The length of a rail should be longer in order to reduce the number of joints. However, the length of a rail manufactured in a factory is limited owing to the condition of a manufacturing facility. Standard rail lengths are 25 meters, 18.29 meters (60 feet), and 11.887 meters (39 feet) for the Japanese National Railways, the British railway, and the U.S.A. railways respectively. Rails of standard length are welded to form a long rail of several hundred meters to reduce the number of joints, which are the weak points of rails. The impact caused at joints results in damage to fishplates and other materials and accelerates the destruction of tracks, which increases the maintenance cost and interferes with the riding comfort of passengers.

There are several kinds of welding methods. They are classified by principles of welding, sources of heat, and manufacturing sites as follows.



The pressure method heats up the ends of the rails to be welded and mechanical pressure is applied on the axial direction of rails. No welding bars or welding agents are used.

The fusing welding method uses welding metals such as welding bars and welding agents to fuse and congeal the ends of the rails without using pressure.

8-2-2 Long-Rail Welding

There are four kinds of long-rail welding methods. They are classified into welding at factories and welding at construction sites. The former is carried out at the factory where welding devices and transportation equipment for rails are installed. The length of a rail welded at the factory is determined based on the condition of transportation, the loading facilities, and etc. The rails welded at the factory are transported to the construction sites and welded again to form the long rails required. The latter is carried out at the site where the welding devices are provided. Rails are welded one after another being moved in a vertical direction by a moving apparatus. The rails are laid after the required length is welded.

Besides the two methods mentioned above, there is a method in which a welding depot is constructed temporarily at the construction site to weld rails, and is moved to the next site following the completion the construction work. Furthermore, there is another method in which existing laid rails are welded by the thermit welding method or the enclosed arc welding method to form the long rails required.

The type of welding method to be applied is selected based on the rail replacement method, the condition of the construction site, the construction schedule, and etc.

8-2-3 Rail Welding Methods

(1) Flash butt welding

The flash butt welding method uses electric resistance welding. The process is as follows.

1) Each end of two rails to be connected is slightly attached to each other.

2) Electric current (up to some ten thousand amperes in a moment) is sent through the attached ends.

3) The temperature at the ends of rails raises gradually by electric flash so that the ends of the rails are melted.

4) The pressure (20 to 30 tons) is applied on the axial direction when the surface of the attached rails is melted.

There are two kinds of devices for this process. One is the fixed type (big size) used in factories, and another is the portable type (small size) used at construction sites.

The flash butt welding method has the merit that the quality of the welded material is stable and reliable since the welding device is well automated and the accuracy of its parts is high. However, appropriate maintenance of the device, and skilled engineers who are capable of taking measures in unusual conditions concerning it are indispensable.

(2) Gas pressure welding

The process of gas pressure welding is as follows.

1) Compressed force is applied in the axial direction to attach two rail ends to each other.

2) Under the condition mentioned above, the attached ends are heated over with a neutral flame of oxygen and acetylene.

3) The rails are compressed up to the length stipulated by the heating mentioned above. Then, the welding process is finished.

There are two types of gas pressure welding devices. One is the fixed type used at factories, and another is the portable type used at construction sites. The advantage of this method is that the welded surface is not melted, since welding is carried out under temperatures of 1,200°C and 3 kg/mm^2 of cylindrical pressure. Its reliability is estimated to be high according to past experiences, and recently miniaturizing of the device is being developed. Therefore, the application of the gas pressure welding method will be considered depending on the conditions of the construction of the long rails.

(3) Enclosed arc welding

Enclosed arc welding is applied at construction sites. The process of the method is as follows.

1) Two rails to be welded are set in an axial direction with a gap between them.

2) The gap is adjusted to the size required.

3) The part to be welded is covered with enclosed metals of a water-cooled copper block.

4) The arc is generated with 120 to 260 amperes of high electric current between the rails and electrodes.

5) The gap is filled step by step with the material of the welding bars melted by the arc mentioned above.

The method consists of complicated processes, and requires great skill from the workers. Therefore, the application of the method shall be studied carefully.

(4) Thermit welding

The thermit welding method was developed early and is used in many countries. The principle of the method is to apply a heating effect caused by the deoxydizing of oxide of iron with aluminum. The temperature of deoxydized iron reaches 3,000°C so that the iron is melted with slag floating over the melted iron. The melted iron is poured into the mold fixed between the rails to be welded. It is formed after the iron is hardened and the mold removed. The method is suitable to welding carried out at construction sites since large scale devices such as electric generators, and pressing apparatus are not required. However, it has the disadvantage that the strength of the welded point is lower than that of the other methods, since the welded point is essentially cast iron and defects such as blowholes can occur.

(5) Golden summit welding

Thermit welding has the necessary and important advantages such as high mobility and easy construction required for welding at construction sites. The Golden summit welding method was recently developed in order to reduce the disadvantages in thermit welding. Its process is not essentially different from that of thermit welding, except for the improvement in solvents and the like, which results in obtaining highly reliable welding.

8-2-4 Selection of Rail Welding Method

The advantages and disadvantages of the welding methods mentioned above are summarized as follows.

Flash butt welding:

The quality of the welded part is stable.

The initial investment is big and maintenance work is difficult, because of the device's large scale and precision.

Gas pressure welding:

The quality of the welded part is stable.

The initial investment is small because of the device's small scale.

Enclosed arc welding:

The device's small scale and its light weight is suitable for welding carried out at sites.

The quality of the welded part depends on the capabilities of the workers.

Thermit welding:

The device's small scale is suitable for welding carried out at sites.

The quality of the welded part is not reliable.

Golden summit welding:

The device is almost the same as that of the thermit welding.

The quality of the welded part is considered to be highly reliable.

The purpose of rail welding in this project is to manufacture long rails by welding unit rails and to replace the existing rails with long rails. BRC has experience in welding rails by the thermit welding method and plans welding rails by gas pressure welding in 1986.

Therefore, the following methods are recommended for carrying out the rail welding in the project.

At factory (fixed or moved): Gas pressure welding

The facilities required for welding are different owing to the construction methods of changing the existing rails with new rails. An example of the facilities is shown in Fig. 8.2.1.

8-3 Railway Ballast

At the existing situation, the quantity of railway ballast is generally insufficient. As a result, ballast depth beneath of the sleeper does not meet the required thickness, and sides of the sleeper are exposed with own shoulders. Specially, the amount of ballast at backsides of abutment, both sides of level-crossing, and turnouts are particularly insufficient. For the track with long-welded rails, the quantity of ballast is necessary more than that of jointed rails.

The quantity of ballast required to strengthen the track between Rangoon and Mandalay was estimated approximate 630,000m^3 (22,200,000ft^3). According to the basic plan, more than 50,000m^3 (1,400,000ft^3) ballast should be supplied in a year. On the contrary the quantity of existing supply of ballast is only 11,400m^3 (399,000ft^3) for the line.

For the Mandalay Line the quarry sites exist along the Martaban Line and near Mandalay. The ballast is produced by manual at this moment, and the facilities is not adequate for mass product.

To meet the estimated volume of ballast the new mechanized facilities should be required. At least crushers and loading equipment should be provided.

Based on the plan, two locations of quarry site with productive capacity of 300m^3 (10,000ft^3) per day should be developed along the Martaban Line and near Mandalay.

The quantity of ballast for the project is very large, the transport system for ballast and the locations of stockyard should be studied more in detail in the next phase.

8-4 Technology Transfer

The following technology transfer is indispensable for BRC to carry out the strengthening of track structures between Rangoon and Mandalay.

1) Manufacturing of PC sleeper

2) Rail welding (gas pressure welding method)

The detailed items of technology transfer are as follows:

1) Manufacturing of PC sleeper

- Design of new type sleepers
- Planning of concrete sleeper factory
- Manufacturing program of PC sleeper
- Preparation of regulations and standards on design and manufacturing of PC sleepers

2) Rail welding (gas pressure welding method)

- Planning of welding facilities
- Technique for welding
- Preparation of regulations and standards on welding
- Rail replacement program
- Other related items

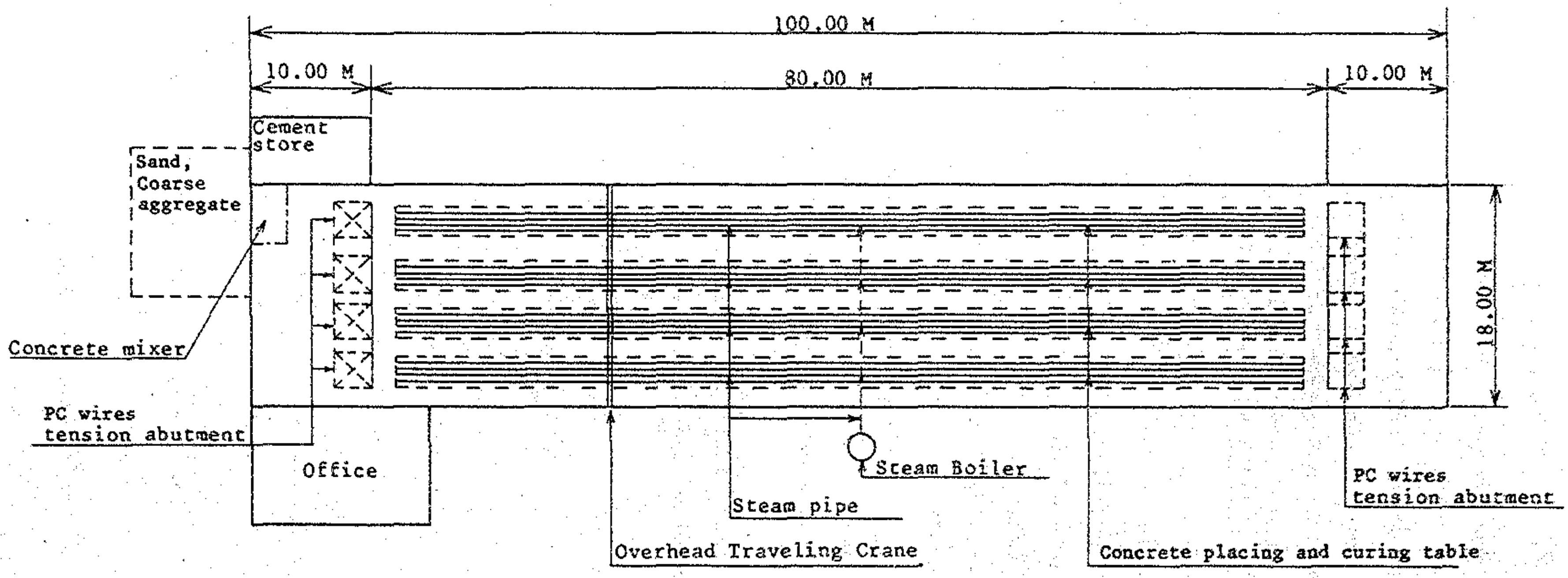


Fig. 8.1.1 PC Sleeper Factory (Pretension) Layout

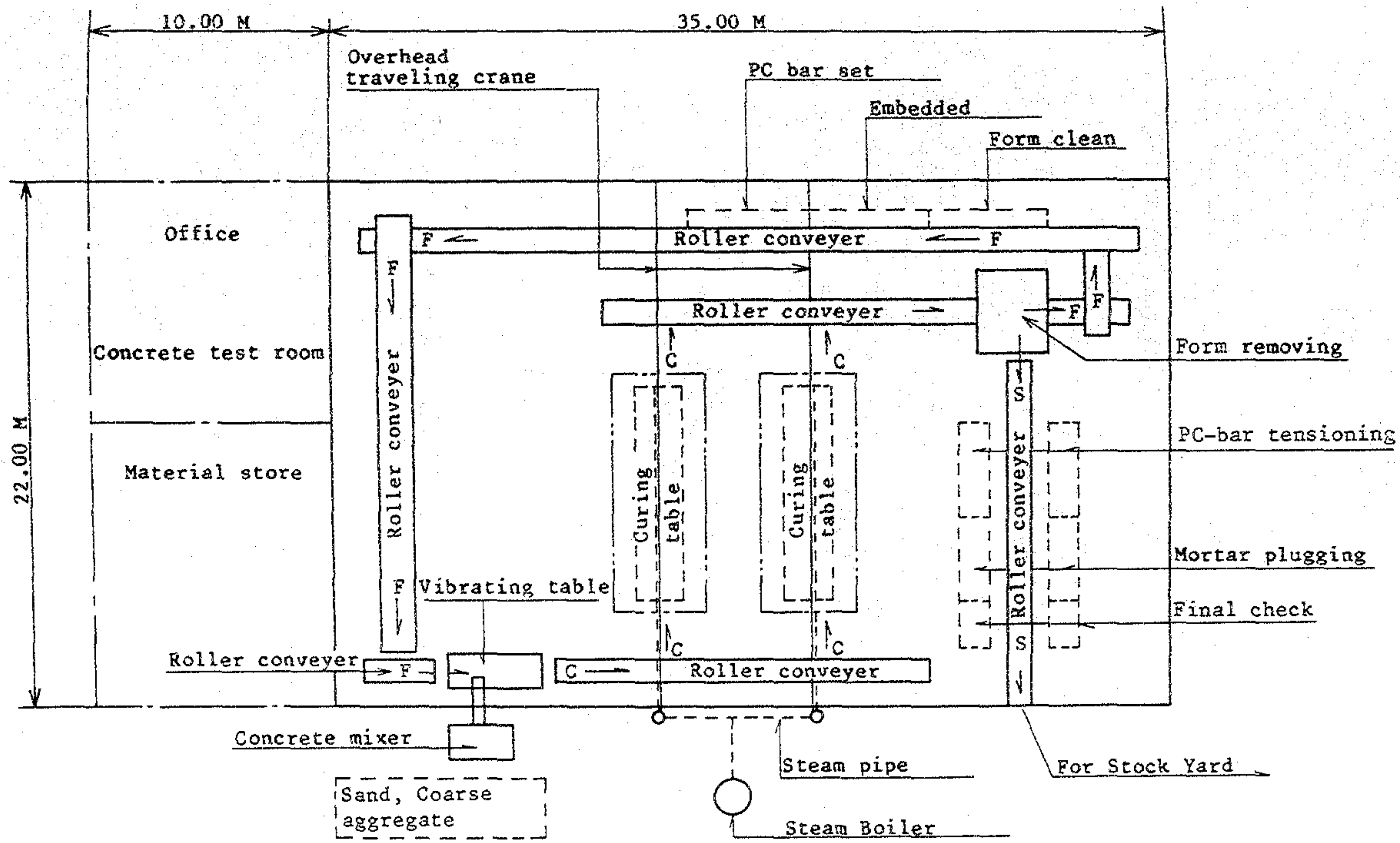


Fig. 8.1.2 PC Sleeper Factory (Post-tension) Layout

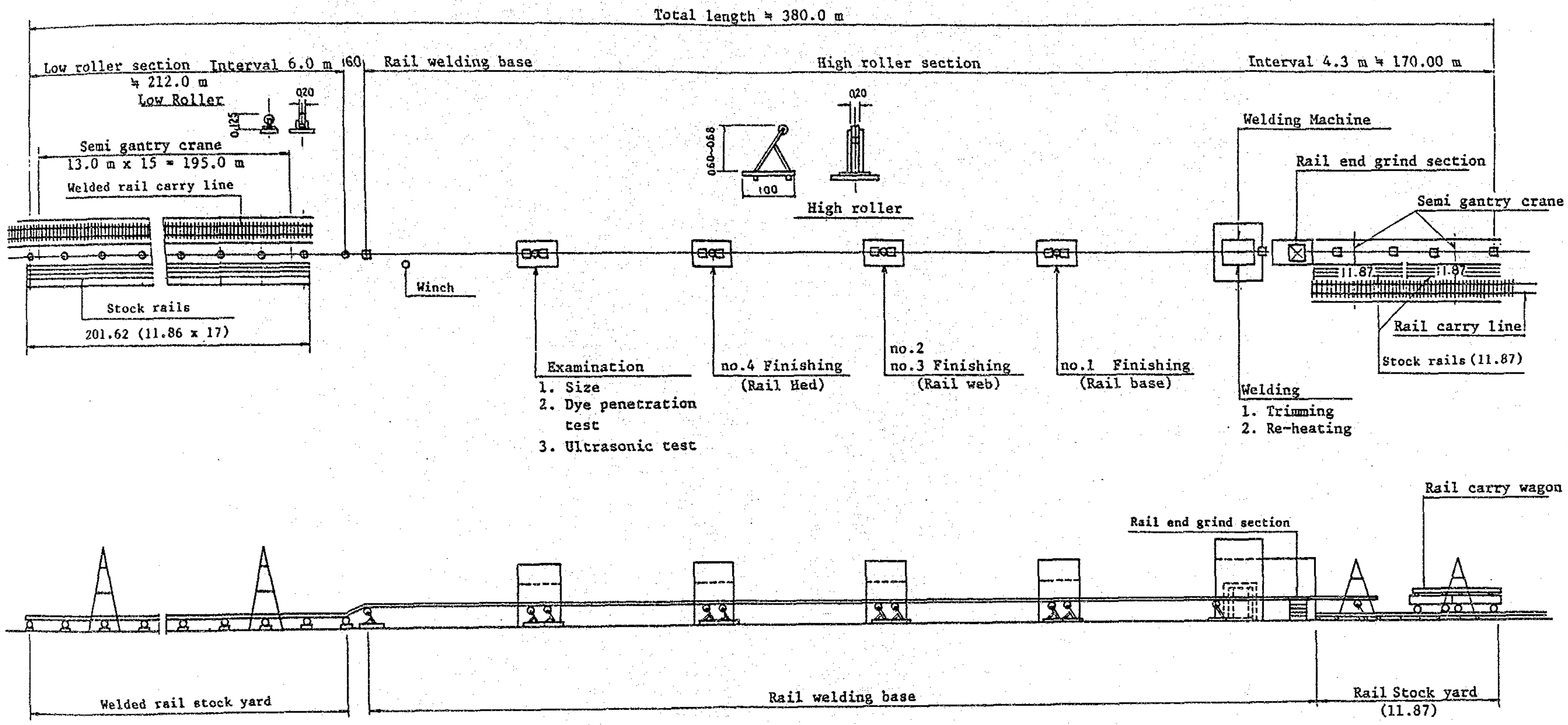


Fig. 8.2.1 Typical Rail Welding Workshop

CHAPTER 9 ESTIMATED PROJECT COST

CHAPTER 9 ESTIMATED PROJECT COST

9-1 General

Based on the basic planning of the project, improvement cost was estimated and converted to economic cost for the economic evaluation. Similarly, cost of maintenance was estimated.

The estimation was conducted in accordance with the following criteria:

1) The estimates are made on the assumption that all improvement work will be implemented by BRC.

2) The unit costs were computed under the economic conditions prevailing in January 1986. The exchange rates are set up as follows: 7.826 Ks/US$, 25.565 ¥/Ks.

3) The cost was estimated for all alternatives and was classified into foreign currency (indicated in Kyat) and local currency (indicated in Kyat) portions.

Foreign currency and local currency components of each unit price were computed based on the following classification of basic cost elements.

The foreign currency component consists of the costs of:

- Imported equipment, materials and supplies
- Domestic materials of which the country is a net importer
- Wages of expatriate personnel
- Overhead and profit of foreign firms.

The local currency component includes the costs of:

- Domestic materials and supplies of which the country is a net exporter
- Wages of local personnel
- Overhead and profit of local firms
- Taxes.

4) The unit cost of each improvement work item is obtained by accumulating the labour cost, equipment cost, material cost, etc. for the item, and the result is checked against the recent actual figures for construction work in Burma.

5) The engineering cost for the project preparation and technical training programme was assumed to be 4.0 percent of the entire project cost.

9-2 Unit Cost by Improvement Work Items

The unit cost by improvement work items is calculated from the material cost, labour cost, equipment cost, and etc., analyzing the data on the project cost of recent similar kinds of projects and taking into consideration the local conditions in Burma.

The material, labour and the resulting unit costs by items are as listed in Tables 9.2.1, 9.2.2, and 9.2.3.

Detailed unit price analysis was carried out for the selected work items to maintain the required accuracy of the cost estimates as well as to determine the components of foreign currency, local currency and tax.

Imported materials are considered to be the following duty and taxes.

1) Customs duty

Customs duty is levied on imported goods, with the assessable value (100.5 percent of CIF value) multiplied by the following rates of customs duty.

Rates of Major Commodities

(Unit: %)

Item	Rate
Electric facilites	20
Rolling stock	10
Track materials	10
Signalling facilities	15
Telecommunication facilities	15
Inspection and repair equipment	15

Source: Customs Tariff

2) Commodities and services tax (C & S Tax)

C & S tax is levied on imported goods at 30 percent of their assessable values.

Table 9.2.1 Unit Prices of Typical Materials (in 1986)

Material	Unit	Price	
Rail B.S 75R (Ordinary rail)	Kyats/ton	4,650.00	(CIF)1/
Fish plate (incl. Bolt)	Kyats/set	193.00	(CIF)
Spike (Screw)	Kyats/each	5.00	(CIF)
(Dog)	Kyats/each	3.50	
Point & Crossing 1 in 12 BS 75R	Kyats/set	143,325.00	(CIF)
Wood sleeper (Hard Wood)	Kyats/each	32.00	
Concrete sleeper (PC)	Kyats/each	146.71	
Fish plate for BS 75R	Kyats/pair	3,440.00	(CIF)
Signal lamp 80V/40W	Kyats/each	22.00	(CIF)
Dry cells AD 1.4V/250 AH	Kyats/each	74.00	(CIF)
Dry cells AD 1.4V/85 AH	Kyats/each	21.00	(CIF)
Ni-Cad Battery 12V/450 AH	Kyats/each	1,165.00	(CIF)
Cement	Kyats/ton	560.00	
Sand	Kyats/100ft^3	100.00	
Aggregate (2" - 4")	Kyats/100ft3	46.00	
Aggregate (1/2" - 3/4")	Kyats/100ft3	78.00	
Crushed stone (Ballast)	Kyats/100ft3	97.00	
Reinforcing bar	Kyats/ton	5,140.00	
PC wire	Kyats/ton	6,630.00	
Gasoline	Kyats/gallon	3.50	
H.S.D	Kyats/gallon	3.05	
Engine oil	Kyats/gallon	20.20	

1/ including local taxes

Table 9.2.2 Average Labour Costs (in 1986)

Category of Labours	Wage per Month* (Kyats/m)	Basic Salary + Allowance
Track work		
Leader of group	195	(125 + 70)
Patrol men	195	(125 + 70)
Common workers	180	(110 + 70)
Drivers of motor cars	195	(125 + 70)
Drivers of motor cars (with crane)	290	(220 + 70)
Drivers of Trucks	195	(125 + 70)
Electric Work		
Leader of group	400	(330 + 70)
Skilled workers (Electric)	290	(220 + 70)
Mechanics	290	(220 + 70)
Welding workers	220	(150 + 70)
Common workers	180	(110 + 70)

* including allowance

Working conditions

Working hours : 8 hr/day, 5 day/week

(Office worker : 6.5 hr/day)

Rate of overtime :

(Weekday) : $150\% \times \frac{\text{Present monthly salary} \times 12}{52 \times 44}$

(Holiday) : $200\% \times \frac{\text{Present monthly salary} \times 12}{52 \times 44}$

3) Income tax

Personal income tax is levied on the income which is more than 10,000 Kyats in a year.

Table 9.2.3 Unit Costs by Improvement Work Items

Thousand Kyats

Work Item		Unit	Cost			
			F/C	L/C	Tax	Total
Renewal of Rail 1/		Kyats/km 2/	244.20	0	99.90	344.10
Renewal of Sleeper (PC Sleeper)		Kyats/km 3/	95.48	92.35	45.19	233.02
Addition of Ballast		Kyats/km 4/	0.56	33.95	0.23	34.74
Telecom. (Mandalay L.)	A	L.S.	241.67	20.38	97.40	359.45
	B	"	191.13	16.62	77.55	285.30
Telecom. (Martaban L.)	A	L.S.	75.20	7.44	29.31	111.95
	B	"	19.62	1.94	1.82	23.38
Telecom. (Prome L.)	A	L.S.	72.64	6.77	29.31	108.72
	B	"	15.51	6.82	6.06	28.39
Telecom. (Myitkyina L.)	A	L.S.	131.70	12.70	53.40	197.80
	B	"	40.57	13.56	16.99	71.12
Signal (Mandalay L.)	A	L.S.	243.57	17.64	97.89	359.10
	B	"	120.79	9.09	48.09	177.97
Signal (Martaban L.)	A	L.S.	34.17	2.40	8.92	45.49
	B	"	28.91	2.11	8.73	39.75
Signal (Prome L.)	A	L.S.	40.35	2.66	12.69	55.70
	B	"	33.87	2.28	12.44	48.59
Signal (Myitkyina L.)	A	L.S.	108.18	7.40	34.89	150.47
	B	"	52.51	3.23	17.03	72.77

1/: long welded rail
2/: single track length (km)
3/: 1,514 sleepers per 1 km track length
4/: approximate 670 m^3/km single track length

9-3 Construction Cost

The construction cost estimated for the plan has been based on the quantities calculated in the basic planning and on the unit costs for each improvement work item.

The whole programme was divided into three stages to meet the stage construction programme, which is as described in Chapter 6 "BASIC PLANNING".

The summary of the calculation for each stage is presented in Tables 9.3.1 thru 9.3.4.

9-4 Maintenance Cost

Maintenance has been defined as "the preserving and keeping of each type of facility as nearly as possible in its original condition as constructed or as subsequently improved, and the operation of facilities and services to provide satisfactory and safe transportation."

Although the maintenance costs and the operation costs for the improvement facilities should be considered separately, the estimates include both costs. However the operation costs in this project are very small compared to the maintenance costs.

9-5 Investment Cost for Rolling Stock

Based on the future traffic demand and the new train operation plan which is described in Section 6-2, the additional investment cost for rolling stock is shown below.

Investment Cost for Rolling Stock

(Total Cost for 4 Lines) (Million Kyats)

Rolling Stock	Plan	Investment Period			Total	
		by 1993/94	by 1997/98	by 2005/06	(A)	(B)
Loco	A	0	207.64	564.70	772.34	-
	B	0	173.03	596.07	-	769.10
PC	A	16.80	36.96	299.01	352.77	-
	B	11.20	36.96	320.51	-	368.67
FC	A	590.24	198.22	1,299.84	2,088.30	-
	B	540.94	175.78	1,270.98	-	1,987.70
Total		-	-	-	3,213.41	3,125.47

Table 9.3.1 Summary of Economic Costs (Plan-A) in 1986 Prices

(Million Kyat)

Line			1st stage	2nd stage	3rd stage	Total
Mandalay	Track	F/C	215.00	151.23	-	366.23
		L/C	67.52	40.66	-	108.18
		Sub-total	282.52	191.89	-	474.41
	Telecom	F/C	179.69	51.19	10.79	241.67
		L/C	15.63	4.15	0.60	20.38
		Sub-total	195.32	55.34	11.39	262.05
	Signal	F/C	124.34	78.88	40.34	243.57
		L/C	9.36	5.85	2.44	17.64
		Sub-total	133.70	84.73	42.78	261.21
	Total	F/C	519.04	281.30	51.13	851.47
		L/C	92.50	50.66	3.04	146.20
		Sub-total	611.54	331.96	54.17	997.67
Martaban	Telecom	F/C	-	75.20	-	75.20
		L/C	-	7.44	-	7.44
		Sub-total	-	82.64	-	82.64
	Signal	F/C	-	28.91	5.26	34.17
		L/C	-	2.11	0.29	2.40
		Sub-total	-	31.02	5.55	36.57
	Total	F/C	-	104.11	5.26	109.37
		L/C	-	9.55	0.29	9.84
		Sub-total	-	113.66	5.55	119.21
Prome	Telecom	F/C	-	72.64	-	72.64
		L/C	-	6.77	-	6.77
		Sub-total	-	79.41	-	79.41
	Signal	F/C	-	33.87	6.48	40.35
		L/C	-	2.28	0.38	2.66
		Sub-total	-	36.15	6.86	43.01
	Total	F/C	-	106.51	6.48	112.99
		L/C	-	9.05	0.38	9.43
		Sub-total	-	115.56	6.86	122.42
Myitkyina	Telecom	F/C	-	-	131.70	131.70
		L/C	-	-	12.70	12.70
		Sub-total	-	-	144.40	144.40
	Signal	F/C	-	-	108.18	108.18
		L/C	-	-	7.40	7.40
		Sub-total	-	-	115.58	115.58
	Total	F/C	-	-	239.88	239.88
		L/C	-	-	20.10	20.10
		Sub-total	-	-	259.98	259.98
Ground total		F/C	519.04	491.93	302.75	1,313.71
		L/C	92.50	69.25	23.81	185.57
		Sub-total	611.54	561.18	326.56	1,499.28

Note: F/C: Foreign Currency Component
L/C: Local Currency Component

Table 9.3.2 Summary of Economic Costs (Plan-B) in 1986 Prices

(Million Kyat)

Line			1st stage	2nd stage	3rd stage	Total
Mandalay	Track	F/C	205.11	144.44	-	349.55
		L/C	67.47	40.63	-	108.10
		Sub-total	272.58	185.07	-	457.65
	Telecom	F/C	191.13	-	-	191.13
		L/C	16.62	-	-	16.62
		Sub-total	207.75	-	-	207.75
	Signal	F/C	120.79	-	-	120.79
		L/C	9.09	-	-	9.09
		Sub-total	129.88	-	-	129.88
	Total	F/C	517.03	144.44	-	661.47
		L/C	93.18	40.63	-	133.81
		Sub-total	610.21	185.07	-	795.28
Martaban	Telecom	F/C	-	19.62	-	19.62
		L/C	-	1.94	-	1.94
		Sub-total	-	21.56	-	21.56
	Signal	F/C	-	28.91	-	28.91
		L/C	-	2.11	-	2.11
		Sub-total	-	31.02	-	31.02
	Total	F/C	-	48.53	-	48.53
		L/C	-	4.05	-	4.05
		Sub-total	-	52.58	-	52.58
Prome	Telecom	F/C	-	15.51	-	15.51
		L/C	-	6.82	-	6.82
		Sub-total	-	22.33	-	22.33
	Signal	F/C	-	33.87	-	33.87
		L/C	-	2.28	-	2.28
		Sub-total	-	36.15	-	36.15
	Total	F/C	-	49.38	-	49.38
		L/C	-	9.10	-	9.10
		Sub-total	-	58.48	-	58.48
Myitkyina	Telecom	F/C	-	-	40.57	40.57
		L/C	-	-	13.56	13.56
		Sub-total	-	-	54.13	54.13
	Signal	F/C	-	-	52.51	52.51
		L/C	-	-	3.23	3.23
		Sub-total	-	-	55.74	55.74
	Total	F/C	-	-	93.08	93.08
		L/C	-	-	16.79	16.79
		Sub-total	-	-	109.87	109.87
Ground total		F/C	517.03	242.35	93.08	852.46
		L/C	93.18	53.78	16.79	163.75
		Sub-total	610.21	296.13	109.87	1,016.21

Note: F/C: Foreign Currency Component

L/C: Local Currency Component

Table 9.3.3 Summary of Project Costs (Plan-A) in 1986 Prices

(Million Kyat)

Line			1st stage	2nd stage	3rd stage	Total
Mandalay	Track	F/C	215.00	151.23	-	366.23
		L/C	159.68	96.16	-	255.85
		Sub-total	374.68	247.39	-	622.08
	Telecom	F/C	179.69	51.19	10.79	241.67
		L/C	90.33	23.98	3.47	117.78
		Sub-total	270.02	75.17	14.26	359.45
	Signal	F/C	124.34	78.88	40.34	243.56
		L/C	61.27	38.29	15.97	115.54
		Sub-total	185.61	117.17	56.31	359.10
	Total	F/C	519.03	281.30	51.13	851.46
		L/C	311.28	158.44	19.44	489.16
		Sub-total	830.31	439.74	70.57	1,340.62
Martaban	Telecom	F/C	-	75.20	-	75.20
		L/C	-	36.75	-	36.75
		Sub-total	-	111.95	-	111.95
	Signal	F/C	-	28.91	5.26	34.17
		L/C	-	11.03	0.29	11.32
		Sub-total	-	39.94	5.55	45.49
	Total	F/C	-	104.11	5.26	109.37
		L/C	-	47.78	0.29	48.07
		Sub-total	-	151.89	5.55	157.44
Prome	Telecom	F/C	-	72.64	-	72.64
		L/C	-	36.08	-	36.08
		Sub-total	-	108.72	-	108.72
	Signal	F/C	-	33.87	6.48	40.35
		L/C	-	13.16	2.19	15.35
		Sub-total	-	47.03	8.67	55.70
	Total	F/C	-	106.51	6.48	112.99
		L/C	-	49.23	2.19	51.43
		Sub-total	-	155.74	8.67	164.42
Myitkyina	Telecom	F/C	-	-	131.70	131.70
		L/C	-	-	66.10	66.10
		Sub-total	-	-	197.80	197.80
	Signal	F/C	-	-	108.18	108.18
		L/C	-	-	42.29	42.29
		Sub-total	-	-	150.47	150.47
	Total	F/C	-	-	239.88	239.88
		L/C	-	-	108.39	108.39
		Sub-total	-	-	348.27	348.27
Ground total		F/C	519.03	491.92	302.75	1,313.70
		L/C	311.28	255.45	130.32	697.05
		Sub-total	830.31	747.37	433.07	2,010.75

Note: F/C: Foreign Currency Component
L/C: Local Currenacy Component

Table 9.3.4 Summary of Project Costs (Plan-B) in 1986 Prices

(Million Kyat)

Line			1st stage	2nd stage	3rd stage	Total
Mandalay	Track	F/C	205.11	144.44	-	349.55
		L/C	157.74	94.99	-	252.74
		Sub-total	362.85	239.43	-	602.29
	Telecom	F/C	191.13	-	-	191.13
		L/C	94.17	-	-	94.17
		Sub-total	285.30	-	-	285.30
	Signal	F/C	120.79	-	-	120.79
		L/C	57.18	-	-	57.18
		Sub-total	177.97	-	-	177.97
	Total	F/C	517.03	144.44	-	661.47
		L/C	309.09	94.99	-	404.08
		Sub-total	826.12	239.43	-	1,065.55
Martaban	Telecom	F/C	-	19.62	-	19.62
		L/C	-	3.76	-	3.76
		Sub-total	-	23.38	-	23.38
	Signal	F/C	-	28.91	-	28.91
		L/C	-	10.84	-	10.84
		Sub-total	-	39.75	-	39.75
	Total	F/C	-	48.53	-	48.53
		L/C	-	14.60	-	14.60
		Sub-total	-	63.13	-	63.13
Prome	Telecom	F/C	-	15.51	-	15.51
		L/C	-	12.88	-	12.88
		Sub-total	-	28.39	-	28.39
	Signal	F/C	-	33.87	-	33.87
		L/C	-	14.72	-	14.72
		Sub-total	-	48.59	-	48.59
	Total	F/C	-	49.38	-	49.38
		L/C	-	27.61	-	27.61
		Sub-total	-	76.99	-	76.99
Myitkyina	Telecom	F/C	-	-	40.57	40.57
		L/C	-	-	30.55	30.55
		Sub-total	-	-	71.12	71.12
	Signal	F/C	-	-	52.51	52.51
		L/C	-	-	20.26	20.26
		Sub-total	-	-	72.77	72.77
	Total	F/C	-	-	93.08	93.08
		L/C	-	-	50.81	50.81
		Sub-total	-	-	143.89	143.89
Ground total		F/C	517.03	242.35	93.08	852.46
		L/C	309.09	137.20	50.81	497.10
		Sub-total	826.12	379.55	143.89	1,349.56

Note: F/C: Foreign Currency Component

L/C: Local Currenacy Component

CHAPTER 10 ECONOMIC APPRAISAL AND EXECUTION PLAN

CHAPTER 10 ECONOMIC APPRAISAL AND EXECUTION PLAN

10-1 General Considerations

The economic analysis is based on the results of the transport demand forecast and investment alternatives that were mentioned before.

The objective of this analysis is to set priorities among the aforementioned improvement plans of the four main lines from a national economic point of view.

10-2 Methodology

In this analysis the cost of investment and the benefits resulting from the investment are compared.

10-2-1 The Projects

In order to establish the long-term modernization programme for track, telecommunication, and signalling on BRC's main lines, the following four improvement plans are studied.

Mandalay Line: Track, telecommunication and signalling
Martaban Line: Telecommunication and signalling
Prome Line: - ditto -
Myitkyina Line: - ditto -

Each of these four lines has two types of investment plans. One requires large investment that produces many benefits, while the other requires small investment that produces a moderate amount of returns. In this study, the eight investment alternatives of the four lines are compared and prioritized.

10-2-2 Demand Type

Transport demand due to the improvement of the railways will have the following three components.

(1) Normal demand

Some portion of railway demand is expected to exist and increase naturally through preference for railways even if this project is not implemented.

(2) Diverted demand

Railway demand of this type is expected to arise as passengers who formerly used long-distance buses and vessels begin to prefer railway transportation and switch to it after implementation of the project. In the same way, some kinds of freight will be diverted from trucks and vessels to the railway due to the convenience of railway service after implementation of the project.

(3) Induced demand

Induced demand that takes place from the improvement of the railway will certainly arise. But this demand is not taken into consideration in this study, because the induced traffic volume will not be so great as compared with the volume of other demand types.

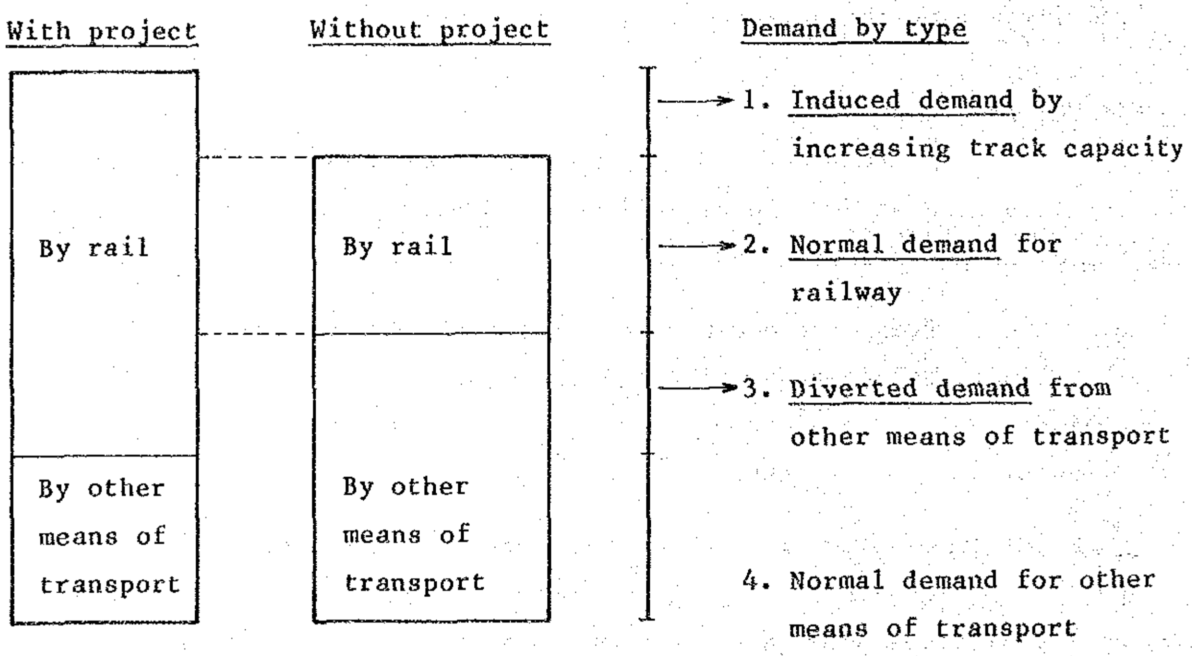


Fig. 10.2.1 Demand Type

10-2-3 With Project/Without Project

The costs and the benefits are calculated as the difference between with project and without project.

(1) With project

Investment in the railway sector will provide the facilities and rolling stock required for traffic demand with the railway transportation service as it is (normal demand), and the traffic diverted from bus, truck and vessel to the railway, as a result of the improved railway transportation service, is brought about by implementing this project (diverted demand).

(2) Without project

The railway investment plan for without project is based on a railway demand that will be forecast on the assumption that the present modal split will not change.

The cost for buses, trucks, and vessels are estimated to be based on the demand forecast for each means of transport.

10-2-4 Benefit Structure

The benefits as the result of the projects are shown in Fig. 10.2.2.

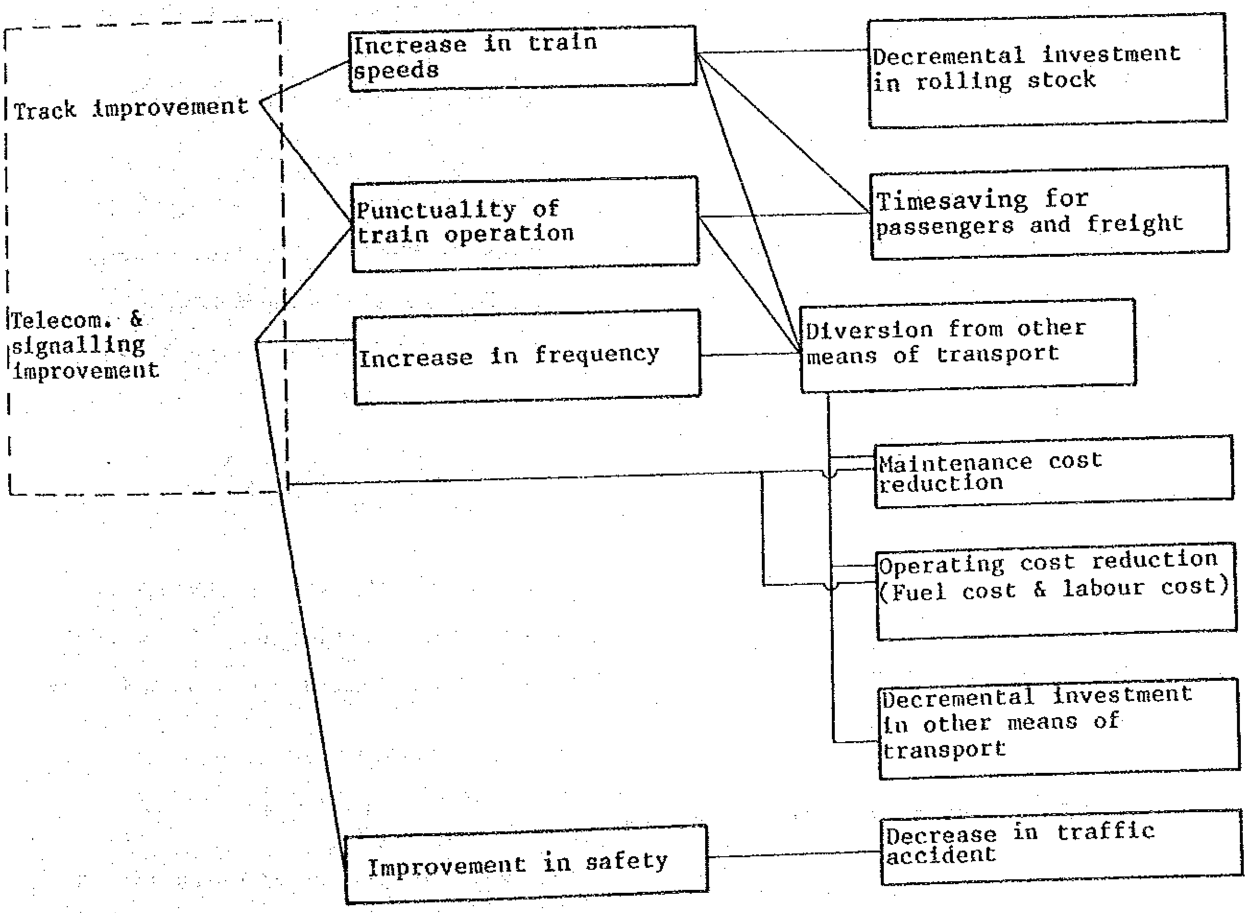


Fig. 10.2.2 Effects of the Project

10-2-5 Criteria

In this study, EIRR (Economic Internal Rate of Return), NPV (Net Present Value), and Total Amount of Investment are adopted as the criteria for the economic appraisal.

(1) EIRR

EIRR, which is usually used in many other economic evaluation studies, is a discount rate calculated by equalizing the sum of the present value of the benefits to that of the costs, as shown in the following formula.

$$\sum_{n=1}^{20} \frac{Bn}{(1+r)^n} = \sum_{n=1}^{20} \frac{Cn}{(1+r)^n}$$

Where

Bn: benefits in n^{th} year

Cn: costs in n^{th} year

r: discount rate

(2) NPV

NPV is calculated as the difference between the net present value of the benefits and costs that have been discounted by the same rate.

$$NPV = \sum_{n=1}^{20} \frac{Bn}{(1+r)^n} - \sum_{n=1}^{20} \frac{Cn}{(1+r)^n}$$

(3) Total amount of investment

In the case of the large scale project, the effects on the national economy and financial situation of BRC should be considered. So in this study, the total amount of investment for each improvement plan is adopted as one of the criteria.

10-2-6 Adjustment to be made in Economic Analysis

In carrying out the economic analysis, the following adjustments are made.

(1) Shadow price

If the prices of tradable goods are biased due to differences between the official exchange rate and the actual exchange rate, the prices should be adjusted. However it is very hard to define the actual exchange rate, and since no other project evaluations in Burma have used the shadow exchange rate, this study also adopts the official exchange rate.

Exchange Rate

Kyats - Japanese Yen 25.565 ¥/Ks

Kyats - U.S. Dollar 7.826 Ks/US$

(Average rate in Jan. '86)

Source: International Financial Statistics (IMF)

As for the cost of the unskilled labour force, minimum wage for the workers of the public and cooperative sectors is 170 Kyats per month.

However, per capita net value added in the agriculture sector is approximately 120 Kyats per month, which is less than minimum wage. In this study wage for unskilled labour is adjusted.

Conversion Factor for Unskilled Labour

Value of production	①	13.654 1/	Kyats in Million
Labour force (agriculture)	②	9.392	Thousand
Per capita net value	③	1.454	Kyats
Minimum wage	④	2.040	
Conversion factor for unskilled labour	(③/④)	0.713	

1/ $23,935.4 \times \frac{54,042.1}{94,733.5}$

Source: Report to Pyithu Hluttaw

Fuel price (diesel oil) is adjusted to be 1.67 kyats per litre. That is the international price by which Burma would get it on the assumption it exports the diesel oil.

The diesel prices except tax in Japan, Thailand and Singapore are shown in Table 10.2.1. The differences of these three is likely to depend on the methods of crude oil procurement. In this study, price in Thailand, which is the median among three figures, is adopted.

Table 10.2.1 Fuel Price

(Ks/ℓ)

	Burma	Japan 1/	Thailand 2/	Singapore 3/
Diesel oil	0.263	2.025	1.674	1.433
	(1.195 Ks/gallon)	(51.8 ¥/ℓ)	(5.7 B/ℓ)	(29.1 $/bbl)

1/ Resale price among wholesalers - Tax

2/ Ex-factory price + marketing cost (excl. tax and subsidy)

3/ FOB

4/ These all prices are at 21 Jan. '86.

Source: Nikkei Shinbun (Economic Newspaper in Japan), THAI RATH

(2) Tax, customs duties

These costs are excluded from the calculation of the cost benefit analysis. These are costs for those who pay the tax and the customs duties, but they are not economic costs for the country because they are only transferred from a purchaser to the Government.

10-3 Benefit Estimation

10-3-1 Decremental Investment in Rolling Stock

The improvement investment will result in train speed going up. For example, it will take nine or ten hours from Rangoon to Mandalay after the completion of investment and is equivalent to a four-hours savings. One train can make a round-trip in one day. In the case of without project, a train could only make a one-way trip in a day. So, the availability of rolling stock will increase and the investment for rolling stock will be saved.

Also the building up of an information system by facsimile between the relative stations will include such information as freight train formation and will save on shunting time and increase the availability of rolling stock.

10-3-2 Timesaving

(1) Timesaving for passenger

For normal demand, improvement of the railway will save passenger travel time, enabling this time to be used more productively. For diverted demand, improvement of the railway will also save time for passengers due to the increase in train speeds as compared with the other means of transport. Timesaving for passengers is calculated by the following formula.

[Travel timesaving] x [Passenger time value] x [Growth rate of time value]

where

Travel timesaving: For normal demand

$$\sum_{i}\sum_{j} Nij \times (tij - Tij)$$

"Nij" is the number of passengers going from i area to j area.

"Tij" is the travel time from i area to j area by train in the case of with project.

"tij" is the travel time from i area to j area by train in the case of without project.

These travel times include delaying times which are calculated as multiplying scheduled times by the delaying rate.

Table 10.3.1 Delaying Rate

(%)

<table>
<tr><th></th><th>Mandalay line</th><th>Others</th></tr>
<tr><td>With project</td><td>2.4</td><td>2.6</td></tr>
<tr><td>Without project</td><td colspan="2">7.6</td></tr>
</table>

Source: Study team

These rates are also used in the calculation of hauling timesavings for freight.

For diverted demand

$$\sum_{i}\sum_{j} Nij \times (tij - Tij)$$

"Nij" is the number of passengers from i area to j area.

"Tij" is the travel time from i area to j area by train in the case of with project.

"tij" is the travel time from i area to j area by bus or vessel.

Passenger time value: Per Capita GDP is adapted to the passenger time value, because the time saved due to the investment will be appropriated for productive activity and as a result the GDP will increase.

Table 10.3.2 Per Capita GDP

	1985/1986(provisional)
GDP	57,732.6 Ks in million
Population	37,115 thousand
Per capita GDP	1,555.5 Ks

Source: Report to the Pyithu Hluttaw

(2) Timesaving for freight

As same as the timesaving for passengers, improvement of the railway will save freight hauling time, and the efficiency of capital will increase as a result of the shortening of the period of capital. Timesaving for freight is calculated by the following formula.

Hauling timesavings	x	Freight value per ton	x	The rate of opportunity cost of capital

where

Hauling timesavings: For normal demand

$$\sum_{i}\sum_{j} Nij \times (tij - Tij)$$

"Nij" is the tonnage hauled from i area to j area.

"Tij" is the hauling time from i area to j area by train in the case of with project.

"tij" is the hauling time from i area to j area by train in the case of without project.

For diverted demand

$$\sum_{i}\sum_{j} Nij \times (tij - Tij)$$

"Nij" is the tonnage hauled from i area to j area.

"Tij" is the hauling time from i area to j area by train in the case of with project.

"tij" is the hauling time from i area to j area by truck or vessel.

Freight value per ton: Freight value is determined to be 693.5 Kyats per ton as a weighted mean of major freight items as shown in Table 10.3.3. According to the BRC, major commodities transported by the railway are as follows:

Rice and rice products, sugar cane, forest products, beans and pulses, other agricultural products, coal and coke, petroleum and oil products, base metal and ores, stone, salt, and all other industrial.

The producers' prices (in other words shipment value) are adopted as freight value by major commodities.

The rate of opportunity cost of capital: If the capital that was invested in the abovementioned goods is saved, it would be invested in producing other goods. In other words, the timesaving for freight results in using capital efficiently.

Usually capital has its own cost, and to use capital efficiently means to avoid the opportunity cost of capital.

In this country, the interest rate of industrial loans for state economic enterprises and cooperatives from the Myanma Economic Bank is eight percent.

The figure is adopted for the rate of opportunity cost of capital.

Table 10.3.3 Freight Value

(Kyats/Ton)

	Particular	Value/Ton	% in Weight	Weighted Value
1.	Rice & rice product	431.2	34.3	147.9
2.	Sugar cane	100.0	15.9	15.9
3.	Forest product	436.4	16.3	71.1
4.	Beans & pulses	4,634.0	0.7	32.4
5.	Other agricultural product	2,795.2	2.7	75.5
6.	Coal & coke	207.0	1.3	2.7
7.	Petroleum & oil product	759.9	5.0	38.0
8.	Base metal & ores	960.2	5.1	49.0
9.	Stone	215.8	6.1	13.2
10.	All other industrial	2,207.5	10.6	234.0
	Total		98.0	679.6
			100.0	693.5

Source: BRC, Concerning Ministry and Corporation

10-3-3 Maintenance Cost Reduction

The maintenance costs for track, telecommunication, and signalling facilities will exceed those of the existing level after the improvement investment. On the other hand, as a result of the investment, the availability of rolling stock will increase and the number of rolling stock required will decrease as compared with that in the case of without project. So the difference in maintenance costs for rolling stock between with project and without project should be counted as a benefit of the investment.

In addition to this benefit, lesser vehicles and vessels are required in with project as compared with without project because of the increase in the transport capacity of the railways. As a result, the difference in maintenance cost for vehicles and vessels between with project and without project should be counted as the benefit.

The maintenance costs in terms of economic cost are computed at 19,200 Kyats for bus, 13,200 Kyats for truck, and 20,000 Kyats for vessel based on the following assumptions.

Market price

	Kyats in thousand/unit
Bus	35.0
Truck	24.2
Vessel	36.5

Source: RTC, IWTC

Composition structure of cost

Parts	80%
Personnel	10%
Supplies	10%

Source: Study Team

Tax

Customs duties for parts	50%
Sales tax	15%

Labour cost

Almost all personnel are skilled labour.

Table 10.3.4 Maintenance Cost

(Ks in thousand per unit)

	Market price ①	Cost			Sales tax ②	Customs duties ③	Economic cost ①-②-③
		Parts (80%)	Personnel (10%)	Supplies (10%)			
Bus	35.0	28.0	3.5	3.5	3.6	12.2	19.2
Truck	24.2	19.4	2.4	2.4	2.5	8.5	13.2
Vessel	36.5	29.2	3.7	3.6	3.8	12.7	20.0

Source: Study Team

The benefit of maintenance cost reduction is calculated by the following formula.

[Maintenance cost of without project] - [Maintenance cost of with project]

+ [Maintenance cost of vehicles and vessels of without project]

- [Maintenance cost of vehicles and vessels of with project]

10-3-4 Operating Cost Reduction

For BRC, 95 percent of its operating costs are fuel and labour costs. Therefore, in this study, fuel cost reduction and labour cost reduction are referred to.

(1) Fuel cost reduction

Due to the investment for improvement, the transport volume will go up and the fuel cost of the railway will also increase.

However, owing to the diverting of traffic from the other means of transport to the railway, the total amount of fuel consumption will decrease in with project as compared to without project. This is due to the difference in the fuel consumption ratio per passenger or unit of freight between the railway and road transport. But, as for diverted traffic from vessels to railways, the benefit of fuel cost reduction will be minus, because the vessels are more fuel efficient than the railways.

The benefit of fuel cost reduction is calculated by the following formula.

$$\boxed{\sum_i F_i} \times \boxed{(\ell_i - L_i)} \times \boxed{\text{Diesel oil price}}$$

where

Fi: Fuel consumption ratio of "i" means transport such as a train, bus, truck, and vessel.

Fuel Consumption Ratio

Loco.	3.36 ℓ/km
Vehicle	0.38 ℓ/km
Vessel	72.7 ℓ/Steaming hour

Source: BRC, RTC, Study Team

The improvement of fuel consumption ratio owing to the track improvement in with project of the Mandalay line is set at six percent against 3.36 ℓ/km.

Li: Kilometers of "i" means transport in case of with project.

ℓi: Kilometers of "i" means transport in case of without project.

(2) Labour cost reduction

In accordance with the increase in train operation efficiency after the improvement investment, the number of operating personnel per train kilometer decreases.

As for diverted demand, it is said that normally railways and waterways are more efficient than road transport in terms of the number of operating crew per passenger or per freight ton. So if demand is diverted from road transportation to railways, labour cost will be saved from the viewpoint of national economy.

The average wages by occupation is calculated as follows.

Table 10.3.5 Wage by Occupation

(Ks/Month)

Occupation	Average Wage
1. Rail	
Driver	391
Guard	440
Unskilled	125
2. Road	
Driver	275
Conductor	200
Unskilled	125
3. Inland Water	
Captain	610
Sailor	278
Unskilled	125

Source: BRC, RTC, IWTC

(Further more details, refer to Long-term Modernization Programme, Appendix 10-3 (1))

10-3-5 Decremental Investment in Other Means of Transport

If rail capacity and railway service increase after the improvement investment, a certain part of demand diverts from the other means of transport to railways. In this context, if the investment is not implemented, it will be necessary to purchase buses and trucks to transport the passengers and freight that would have been diverted to the railway had the investment been implemented. So the improvement will save investment in other means of transport.

The economic cost of bus, truck, and vessel are estimated as follows.

Bus	200 Thousand Kyats/Unit	(BM Bus)
Truck	146 Thousand Kyats/Unit	(6.5 Ton Truck)
Vessel	5,478 Thousand Kyats/Unit	(Pass. cum Cargo)

(Further more details, refer to Long-term Modernization Programme, Appendix 10-3 (2))

10-3-6 Decrease of Traffic Accidents

Traffic accidents such as train collisions and derailments have often occurred in Burma railways. And, it is expected that these accidents will decrease enormously if the improvement of track, telecom. and signalling is implemented.

As for loss of life, it should be one of the most important reasons for the improvement investment. But, it is very hard to estimate the value of human life. So in this study, only restoration expenditure that would be prevented by the improvement is calculated as a tangible benefit.

As a result of the improvement, the number of accidents will decrease at the following rates.

	Mandalay line	Others
Plan A	70%	58%
Plan B	63%	52%

Source: Study Team

10-4 Project Priorities

According as the aforementioned cost-benefit analysis method, the results are as follows.

10-4-1 Benefits of each plan

The benefits that were discounted to represent their present value are shown in Table 10.4.1. According to the table, the Mandalay Line Plan A has the highest marks in terms of total benefits. Then Plan B of the same line comes next.

The percentage of shares of the benefits from the decrease of traffic accidents are relatively high on three lines, except for the Mandalay Line, because the frequencies of traffic accidents will be reduced by the improvement of signalling facilities.

Table 10.4.1 Benefit Composition

(Ks in Thousand)

	PLAN A				PLAN B			
	MANDALAY	MARTABAN	PROME	MYITKYINA	MANDALAY	MARTABAN	PROME	MYITKYINA
1. Dec. investment in rolling Stock	50881	-155	-1573	-5889	49783	4934	5878	13457
2. Dec. investment in other means of transport	40854	1345	878	6051	40854	1345	878	6051
3. Timesaving	57813	3674	3241	7972	51331	3592	3134	7647
4. Maintenance cost reduction	62691	-4163	-4779	-11900	67486	342	2643	-1546
5. Operating cost reduction	103944	5562	3592	6482	103944	5562	3592	6482
6. Decrease in traffic accidents	8699	2076	2260	10126	7576	1839	2006	9007
7. Total	324882	8339	3619	12842	320974	17614	18131	41098

Note: All these benefits were discounted at a 10 percent annual rate.

Source: Study Team

The benefits from the maintenance cost reduction were estimated for the Mandalay Line, Martaban Line Plan B, and the Prome Line Plan B, while the other plans had minus benefits.

10-4-2 Results

The results of the economic analysis are as follows.

(1) EIRR

As shown in Table 10.4.2, the Mandalay Line Plan B is 8.5 percent, while the Mandalay Plan A next in line.

Table 10.4.2 EIRR (%)

LINES	PLAN A	PLAN B
Mandalay Line	7.2	8.5
Martaban Line	(minus)	6.4
Prome Line	(minus)	4.1
Myitkyina Line	(minus)	6.0

Source: Study Team

(2) NPV

Net Present Value discounted at 6, 8, 10 per cent each is shown in Table 10.4.3 below. If the opportunity cost of capital, which is equivalent to the discount rate in this analysis, exceeds 10 percent, the NPV of all the plans are minus. In the case of 8 percent and 6 percent, the Mandalay Line Plan B has the highest priority.

Fig. 10.4.1 shows the change in NPV at discount rates from zero to 20 percent. The NPV curve of the Mandalay Line Plan A and B drops keenly according to the increase of the discount rate, while the curve of the Martaban Line Plan B is not affected by the change of the rate.

Table 10.4.3 Net Present Value

(Ks in Thousand)

Discount Rate		6%		8%		10%	
		Cardinal No.	Ordinal No.	Cardinal No.	Ordinal No.	Cardinal No.	Ordinal No.
Mandalay	A	55794	2	-29316	5	-83299	7
	B	106407	1	15739	1	-43885	5
Martaban	A	-46992	6	-44835	6	-41830	4
	B	882	3	-2421	2	-4412	1
Prome	A	-58416	7	-54881	7	-50762	6
	B	-4506	5	-7253	4	-8734	2
Myitkyina	A	-120602	8	-115274	8	-108086	8
	B	156	4	-5999	3	-9781	3

Source: Study Team

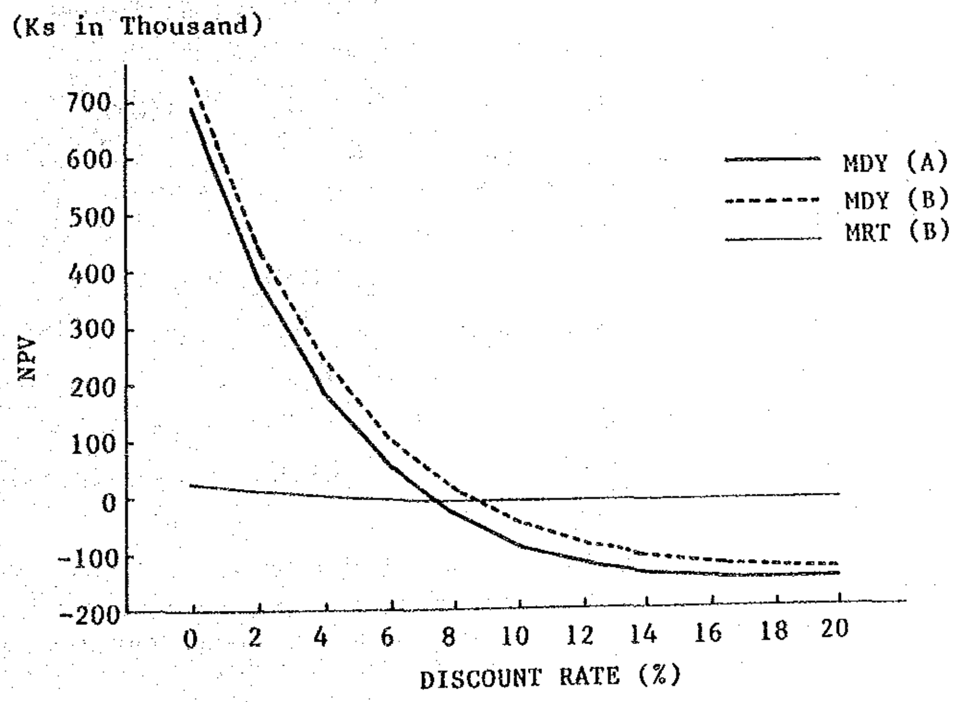


Fig. 10.4.1 Net Present Value

(3) Total Amount of Investment

Total amount of investment, which is the investment cost in terms of economic cost, is shown in Table 10.4.4.

To compare these four lines, investment of each plan is assumed to begin from stage one. Therefore, the investment costs for rolling stock in this study are slightly different from those in the implementation plan.

And, the investment costs for telecommunication and signalling between Rangoon and Pegu are divided into investment costs for the Mandalay Line and Martaban Line in adequate percentage shares.

The total amount of investment on the Mandalay Line exceeds those of the other three lines together. The second is Myitkyina Line with investment costs of only 26 percent in Plan A and 14 percent in Plan B.

Table 10.4.4 Total Amount of Investment
(Economic Cost)

(Ks in Million)

Line	Plan A		Plan B	
	Cardinal No.	Ordinal No.	Cardinal No.	Ordinal No.
Mandalay Line	998	8	795	7
	(900)		(916)	
Martaban Line	119	4	53	1
	(92)		(71)	
Prome Line	122	5	58	2
	(371)		(349)	
Myitkyina Line	260	6	110	3
	(803)		(757)	

Note: Figures in ( ) indicate those of investment for rolling stock.

Source: Study Team

(4) Conclusion

According to the above mentioned-results, the Mandalay Line should be ranked as the highest priority and the next as Martaban Line.

10-5 Execution Plan

The preparation of an execution plan was studied based on both facility improvement plans A and B. Both plans were compared with the viewpoints of various factors.

Although plan A is expected to have greater reductions in running time, train accidents, and train delays than plan B, the total investment project cost of 2,000 million Kyats including the local currency is approximately 50 percent more expensive than that of plan B's. (Project cost: refer to Tables 9-3-3 and 9-3-4. The benefits of plan A do not justify such an expense.

The total project cost of 2,000 million Kyats in Plan A is too high. It is necessary that the facility improvement be promoted without affecting the domestic finance as much as possible. In this respect, plan B is preferable from the point of "least cost investment".

Furthermore, plan B reduction in the scale of the improved facilities of telecommunication and signalling is preferable from the viewpoint of the power supply situation, which is one of the keys to facility improvement, though the improvement and continued use of bare wires as a basic communication line may become outdated and impractical in the future, with the rapid progress of telecommunication systems expected in Burma.

Therefore, the final decision on the order of priority of the implementation among the four lines, was made after an overall evaluation, referring to the various figures of the four lines' characteristics shown in Table 6.1.1 in section 6-1-1 (2).

The Mandalay line is first and the other three lines are scheduled to be implemented after its first stage.

The Mandalay line has the heaviest traffic volume and is expecting the highest growth in future traffic demand. The track facilities are considerably deteriorated, which is one of the main factors for reductions in train speed. Concerning telecommunication lines, 31 percent of the Mandalay line has none, while another 57 percent is in bad condition (the longest among the four lines). Also, signalling troubles have occurred most frequently on the Mandalay line. In addition, the IRR values of the Mandalay line in both plans are the highest.

The Martaban and Prome lines are second. The facility improvement first done in the Rangoon-Pegu section should essentially help the Martaban line to improve transport on its entire line, which is desirable from the viewpoint of investment efficiency. Regarding the Prome line, an extension of the line is planned with the expected growth in traffic volume, and its power supply situation is the best though the economic appraisal indicates considerably low investment benefit.

On the other hand, the implementation schedule for the Myitkyina line is made in the final stage, because its power supply situation is the worst, with only 35 percent of its stations receiving power at the moment and also, road construction is planned in that area.

From on the concepts above, the execution plan of the facility improvement for the long-term modernization programme is established, based on facility improvement plan B.

A feasibility study on the Mandalay line in the long-term modernization programme will be conducted as the first step of a short-term improvement project. The execution plan is shown in Table 10.5.1.

Table 10.5.1 Execution Plan

Unit: million Kyats

Line	Items	1st (86 87 88 89 90 91 92 93)	2nd (94 95 96 97)	3rd (98 99 00 01 02 03 04 05)	1st stage Total	1st stage F/C	1st stage L/C	2nd stage Total	2nd stage F/C	2nd stage L/C	3rd stage Total	3rd stage F/C	3rd stage L/C	Ground total Total	Ground total F/C	Ground total L/C
Mandalay																
Track	Replacement of rails				363	205	158	240	145	95				603	349	253
	Installation of long welded rails															
	Rail welding manufacture															
	Replacement of sleepers															
	PC sleeper manufacture															
	Increase in balast															
	balast manufacture															
	Replacement of turnouts															
Telecommunication	Installation of U.H.F microwave network				285	191	92							285	191	94
	Installation of underground cables															
	Installation of exchanges, control tele.															
Signalling	Installation of colour light signals				178	121	57							178	121	57
	Installation of Interlocking devices at three stations															
	Installation of electric lock devices															
	Improvement of block system															
	Installation of level crossing alarm devices													(1066)	(662)	(404)
Martaban																
Telecommunication	Installation of bare wire carrier system							23	19	4				23	19	4
	Installation of exchanges, control tele.															
Signalling	Installation of colour light signals							40	29	11				40	29	11
	Installation of electric lock devices															
	Improvement of block system													(63)	(48)	(15))
Prome																
Telecommunication	Installation of bare wire carrier system							28	15	13				28	15	13
	Installation of exchanges, control tele.															
Signalling	Installation of colour light signals							49	34	15				49	34	15
	Installation of electric lock devices															
	Improvement of block system													(77)	(49)	(28)
Myitkyina																
Telecommunication	Installation of bare wire carrier system										71	40	31	71	40	31
	Installation of exchanges, control tele.															
Signalling	Installation of colour light signals										73	53	20	73	53	20
	Installation of electric lock devices															
	Improvement of block system													(144)	(93)	(51)
Ground Total					826	517	309	380	242	138	144	93	51	1350	852	498

Note F/C: Foreign currency component
L/C: Local currency component including tax
( ): Total of each line

CHAPTER 11 CONCLUSION AND RECOMMENDATIONS

CHAPTER 11 CONCLUSION AND RECOMMENDATIONS

11-1 Conclusion

The study on establishing the long-term modernization programme for tracks on the Mandalay line, and for telecommunications and signalling on the Mandalay, Martaban, Prome, and Myitkyina lines, has been carried out for achieving the following objectives.

One is to prepare the execution plan of the facility improvement to upgrade and modernize the considerably deteriorated ground facilities to build up a foundation for BRC to ensure reliable transport services and efficient traffic control on a long-term basis.

Another is, to select line(s) or section(s) for a feasibility study from the viewpoints of an overall evaluation that takes into consideration the present transport volume, growth in future traffic demand, the present situation of train operation, the present operability of the ground facilities, and the economic appraisal.

The following are the conclusions on the study.

(1) BRC can be said not to be making full use of its advantages as a railway transport system, judging from the present situation of train operation, which has been caused mainly by the deterioration of the ground facilities due to aging.

This suggests that the ground facilities will become worse and that BRC might lose business to other competing modes of transportation, if the facilities are left as they are.

Therefore, though the calculated IRR of each line does not indicate a high value, the facility improvement on the four lines should be done with an eye on the future role of railway transport.

(2) The Mandalay line ranks first as the line requiring facility improvement, since it has the heaviest transport volume, the highest growth in future traffic demand, badly deteriorated ground facilities, and the highest IRR value.

Concerning the other three lines, the facility improvement should be made relying basically on the execution plan, with the modernization progress carried out step by step.

Based on the concepts mentioned above, the Mandalay line should have top priority in being selected for a feasibility study, which will be conducted to further develop the short-term improvement project for carrying out a preliminary design and establishing a detailed execution plan together with an overall evaluation.

11-2 Recommendations

The following supporting measures are recommended to be taken to assure the smooth progress of the execution plan established and an effective train operation after commissioning.

(1) Safety

1) Train accidents are expected to become fewer and fewer as the facility improvement progresses step by step; yet, some accidents caused by human error might still occur. Further cultivation of discipline of employees concerned is desired to eliminate such human errors.

2) Countermeasures necessary to ensure safety along with increases in train speed are to be fully taken, especially measures for preventing the free access of people to station yards and tracks.

(2) Maintenance control

The following items are recommended for maintaining the proper functions of the facilities to be provided.

1) To establish a new maintenance system to fit the improved facilities including the bare telecommunication lines.

2) To prepare standards, tolerances and manuals for safety, construction, and maintenance.

3) To arrange a sort of Rail Gang Car to go quickly to troubled areas.

4) To supply consistently necessary spare parts to maintain high operability of the improved facilities.

(3) Technology transfer

Since this is BRC's first big scale project with facility improvement and its modernization, the technical cooperation of other countries will be required for promoting this project smoothly.

Therefore, modern engineering technology on tracks, telecommunications, and signalling should be transferred though study, design, and implementation stages.

(4) Training

A new system is required to train maintenance staff about the new technology on the improved facilities through established programmes and actual training facilities.

(5) Repair work on bridges

Some bridges on the Mandalay line have deteriorated considerably due to aging. Repair work for those bridges is required for increasing train speed.

(6) Rolling stock

Rolling stock modernization is being carried out for the improvement of railway transport. Further improvement in rolling stock availability is advised along with its modernization.

SHORT-TERM IMPROVEMENT PROJECT

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SHORT-TERM IMPROVEMENT PROJECT

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