3-3 Estimated Scale of the Fleet

3-3-1 Estimation method

The number of rolling stock required for each Network is estimated on the basis of traffic volume and train operation plan for the years indicated below:

Network A: 1991 and 2005
Network B: 1996 and 2005
Network C: 2001 and 2005

(1) Electric locomotive for main line

To ensure efficient and economical use of locomotive and to facilitate their maintenance, one type of locomotive will be used for both passenger and goods trains.

As the first step, locomotive-kilometers per day is estimated based on the tentative train diagrams. The required number of electric locmotives is estimated on the basis of train-kilometers (or locomotive-kilometers) divided by the estimated locomotive-kilometers per day.

The locomotive-kilometers per day is observed to range between 450 and 700 km for the inter-city train, and between 300 and 400 km for KL urban train, depending on Networks and years.

(2) Diesel locomotives for shunting

Large-size diesel locomotives are assigned to large goods stations and rolling stock depots. Small-size diesel locomotives are assigned to goods stations with smaller goods handling volume. (See 4-5-1.)

(3) Coach

The required number of coaches is estimated using the same method as for electric locomotives; first, coach-kilometers per day are estimated from tentative train diagrams, and the required number of coaches is estimated for super express and express trains, ordinary trains and KL urban trains on the basis of estimated train-kilometers and train formation.

The coach-kilometers per day is observed to range between 550 and 750 km for super-express and express trains, and around 400 km for ordinary trains and KL urban trains, depending on Networks and years.

(4) Wagon

First, the average turn round time, in terms of days, for each type of wagons (i.e. container wagon, including high speed and ordinary container wagon, low side wagon, tank wagon, hopper wagon and brake van) is estimated. Then, the required number of wagons is estimated on the basis of the daily traffic demand and average actual load per wagon.

Covered wagons will not be used since containers and container wagons are available. At stations without container handling facilities, loading and unloading from lorry to container or vice versa will be performed by means conventionally used for covered wagons.

(5) Container

It is assumed that 50% of goods for railway container transport would be carried in domestic containers owned by the railway (the remaining 50% in customer-owned or provided containers). The railway-owned containers will be 20 feet ISO containers. The required number of them is estimated using the same method as that for wagons.

3-3-2 Scale of fleet

The required number of rolling stock thus estimated is summarized in Table 3-3-1. (See 4-5-1.)

Table 3-3-1 Scale of Fleet

Rolling Stock \ Network and year	Network A		Network B		Network C	
	1991	2005	1996	2005	2001	2005
Electric locomotive	24	38	59	73	97	111
Diesel locomotive						
(Large size)	7	7	19	19	31	31
(Small size)	1	1	5	5	14	14
Coach						
(for super-express and express train)	80	143	252	364	539	617
(for ordinary train)	-	-	64	64	158	158
(for KL urban train)	36	100	55	100	81	100
Total	116	243	371	528	778	875
Wagon						
Container wagon	655	1,110	1,445	1,909	1,946	2,293
Low side wagon	42	57	156	188	767	795
Tank wagon	163	197	481	566	669	741
Hopper wagon	26	50	92	139	399	465
Brake van	33	54	87	114	180	201
Service wagon	6	6	12	12	20	20
Total	925	1,474	2,273	2,928	3,981	4,515
* Container (in terms of 20 feet type)	935	1,561	2,366	3,025	3,515	4,150

* The number of containers denotes those to be owned by the railway, which is assumed as a half of the required number.

3-4 Train Operation System and Facilities

An outline of the facilities and systems related to train operation is described below.

3-4-1 Train operation control system

The CTC system is introduced for efficient train operations.

The CTC center will be located in Kuala Lumpur, and it will control mainly the turnouts and signals concerning the train operation at stations.

3-4-2 Signalling system

An automatic block signalling system is provided, in consideration of the maximum speed (160 km/h), the number of trains to be operated and the safety requirements. This adoption is supported by the experiences in other countries.

The signalling system will be provided with the following functions;

(1) Color light and wayside signalling system

(2) Four aspects indicating the following maximum permissible train speeds.

Green ...... 160 km/h	Green and yellow .... 120 km/h
Yellow ..... 70 km/h	Red .... 0 km/h (stop)

(3) For stop signal, partial overlapping method is adopted.

(4) ATS devices to check the train speed at every signal point are installed. If a train speed exceeds the speed restriction indicated by a signal, the alarm is activated and emergency brake is automatically actuated a few seconds after alarming unless the driver applies the brake. (Emergency brake is automatically actuated immediately if the train proceeds beyond a stop signal.)

3-4-3 Station facilities

The scale and track layout of stations are standardized on the basis of their estimated requirements (the number of trains and traffic volumes dealt with there). (See 4-3-2.)

(1) Passenger station

Passenger stations are largely classified into two categories: (a) stations where super express and express trains stop, and (b) stations where ordinary trains stop.

The former stations (a) are further classified into two types, according to whether or not they are provided with train switching back function. The latter stations (b) are also classified into two types, according to whether or not they are provided with train refuge function. Most of the KL urban stations will be type (b) without train refuge function.
The Kuala Lumpur Station will not be any of the above mentioned types because of its large-scale and special functions.

(2) Goods stations

Under the goods transport policies described in 3-1-2 main goods stations are designed to be capable of handling the largest category of cargo volume, while other stations are designed to handle a smaller volume of goods.

Limited number of large goods stations are provided with container handling facilities.

Goods stations are standardized according to the capability of annual handling volume of goods:

(a) Stations handling 2,000 thousands tons (including 1,000 thousands tons of container handling)

(b) Stations handling 1,000 thousands tons (including 500 thousands tons of container handling)

(c) Stations handling 500 thousands tons (including 300 thousands tons of container handling)

(d) Stations handling 100 thousands tons (no container handling)

In stations where express containers are handled, container loading/unloading facilities will be provided beside the departure/arrival tracks.

(3) Signal station

Signal stations are placed at an interval of about 20 km on single track sections, where necessary, to ensure possible train crossing.

(4) Effective track length

In consideration of train formation, trailing load and locomotive size, the adequate effective track length is estimated to be;

For inter-city passenger trains (14 coaches) .... 370 m
For KL urban passenger trains (8 coaches) .... 220 m
For goods trains (1,200 tons) .... 500 m

3-4-4 Rolling stock depot

Rolling stock depots are located as shown in Table 3-4-1.

Table 3-4-1 Locations of Rolling Stock Depots

Rolling Stock / Location	Electric Locomotive	Diesel Locomotive	Coach	Wagon
Kuala Lumpur	◎ (Segambut)	◎ (Rawan-Kuang)	◎ (Segambut)	◎ (Rawang-Kuang)
Kuantan	o	o	o	◎
Kota Bharu	◎	◎	◎	◎
Gemas	-	-	-	◎
Johor Bahru	◎	◎	◎	◎
Singapore	o	-	o	-
Ipoh	-	-	-	◎
Perai	◎	◎	◎	◎

Note : 1. Marks in the Table denote the type of inspections carried out; (See 5-2-4.)

◎ : Type A (daily) and Type B (regular) inspections
o : Type A (daily) inspection
- : No inspection

2. Kuala Lumpur depot is the sole depot where Type C inspection for electric and diesel locomotives is carried out.

Incidentally, the present meter gauge rolling stock depot at Brickfields will be relocated to Segambut even for Network A.

CHAPTER 4 CONSTRUCTION PLAN

CHAPTER 4 CONSTRUCTION PLAN

4-1 Construction Standard

The construction standards are as follows in this Study.

Gauge	1435 mm
Maximum speed	160 km/h
Standard radius of curvature	
4000 m (New East-West Railway)	
2000 m (West Coast Railway)	
Maximum gradient	15 ‰
Track effective length in stations	
Passenger train	370 m (KL urban transport station 220 m)
Goods train	500 m (Trailing load 1,200 t)
Rolling stock gauge	Fig. 4-1-1
Construction gauge	Fig. 4-1-1
Roadway dimension	Fig. 4-1-2
Live load diagram	Fig. 4-1-3

Of the above construction standards, the track gauge, the curve radius and the steepest gradient are the most important factors in determining the functions of a railway, and they are hard to modify, once constructed.

The reasons for assuming a high level of construction standards are as follows.

(1) Maximum speed - competitiveness with other passenger transport modes.

(a) An automobile passenger, travelling a middle/long distance, is observed to move at a speed 80 to 100 km/h on ordinary expressway.

A railway passenger, travelling the same distance, is obliged to lose time at the departure stations where the traveller buys ticket and waits the available train, and at the intermediate stations where the train stops to let other passengers get on and off.

First, therefore, in order for him to reach the destination at the same time as the automobile passenger, the train must run at a speed higher than automobile. The maximum speed will have to be more than 100 km/h.

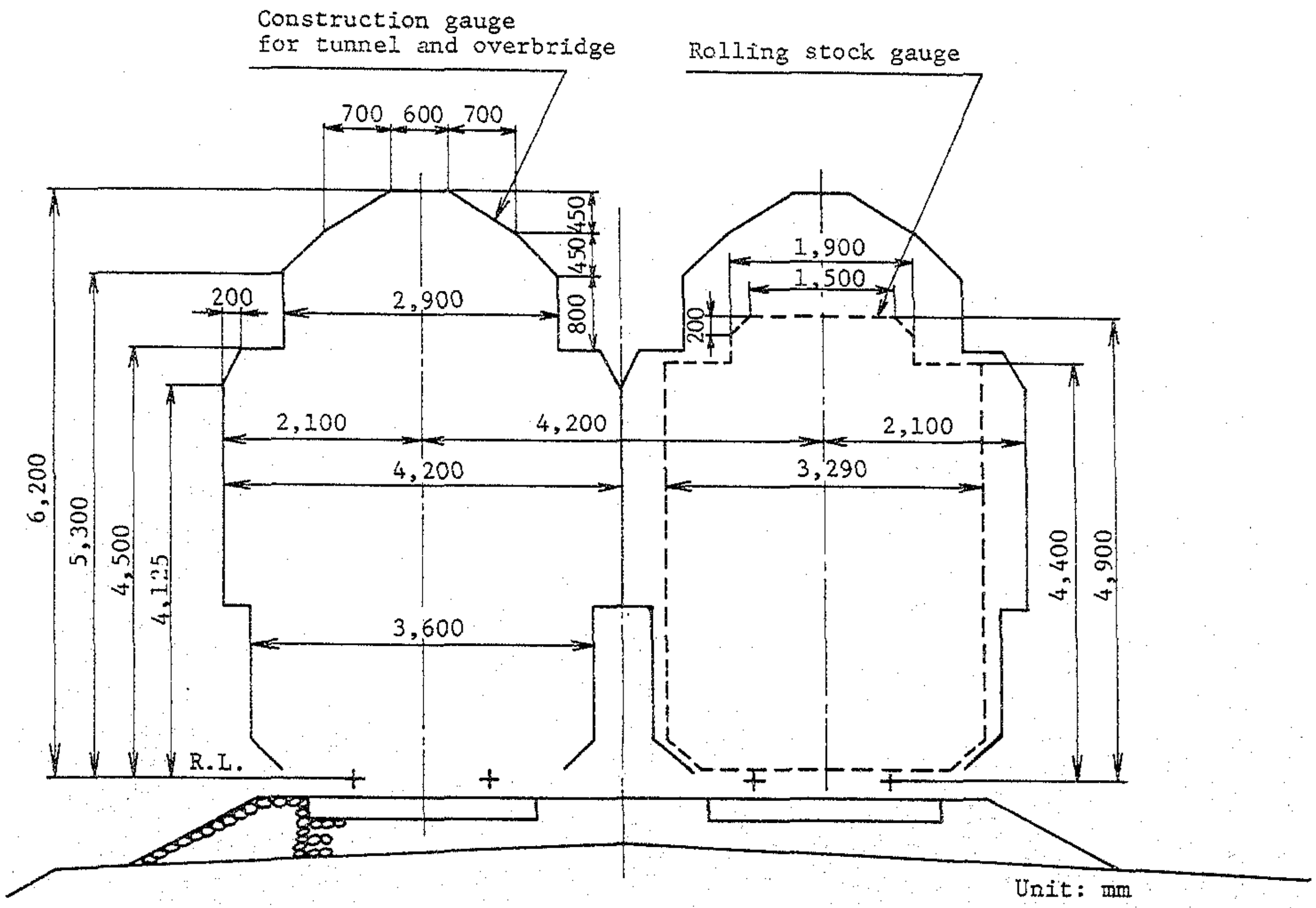


Fig. 4-1-1 Rolling Stock Gauge and Construction Gauge

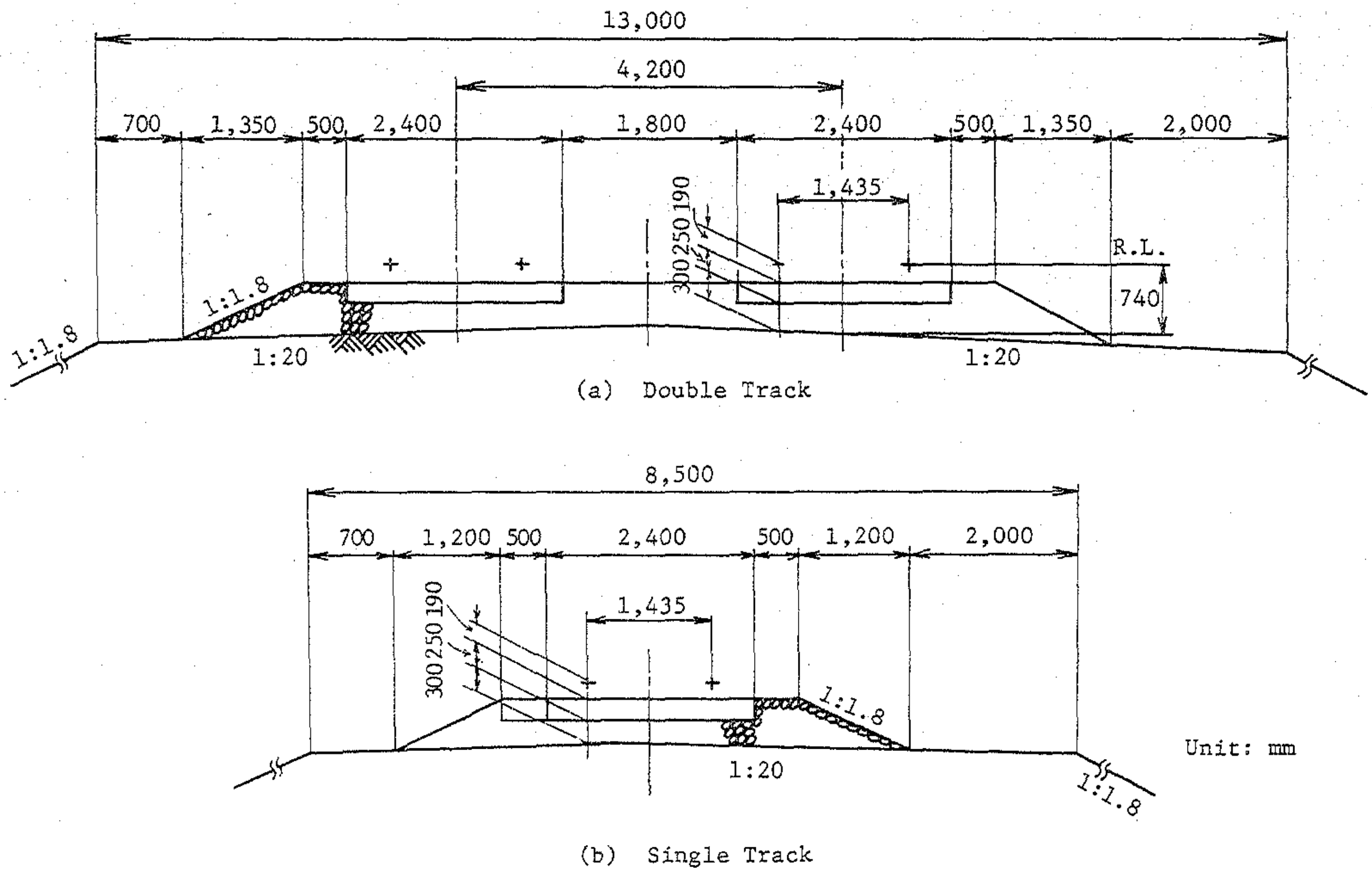


Fig. 4-1-2 Roadway Dimension

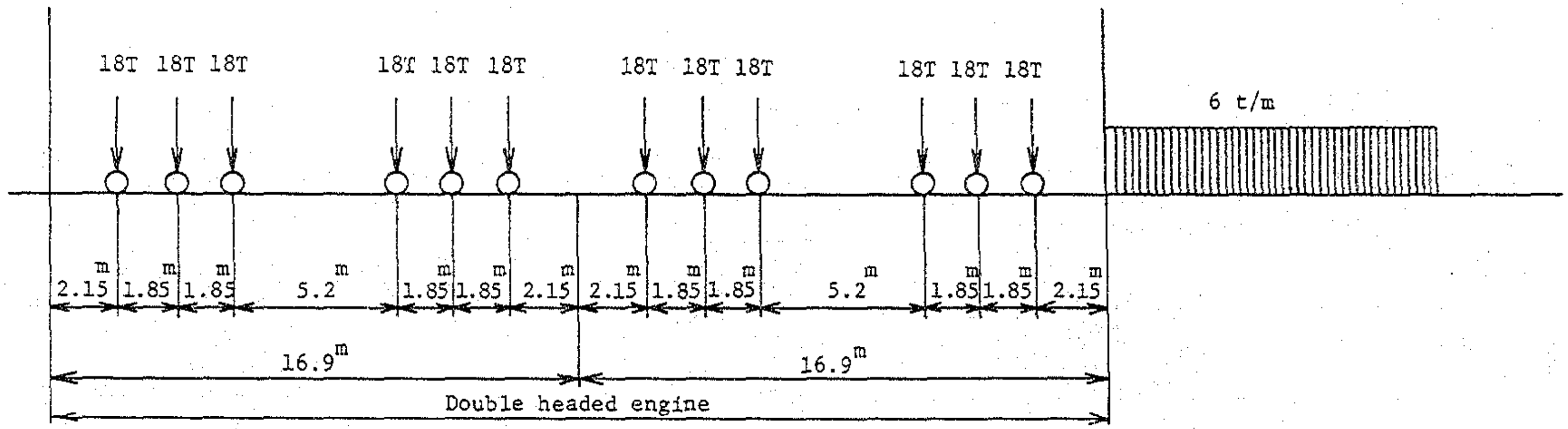


Fig. 4-1-3 Live Load Diagram

(b) With the same travelling time, however, the railway's supremacy over other modes is not ensured. Here, the factors other than travelling time, such as cost, comfort, access/egress time, door-to-door convenience, etc., also matter. Hence, the railway superiority will be ensured by offering the passenger a short enough travelling time so that a comparison of those other factors would not be of significance. This can be met by providing a high enough competitive scheduled-speed. And in order to ensure this scheduled-speed, the maximum speed will have to be 160 km/h or more.

(c) The competitive travel distance between the modes in Malaysia, will be mostly in a range not exceeding 350 km; considering the principal city locations (their population, their distance from adjacent principal cities), and also considering the passenger flows mainly centering on Kuala Lumpur.

(d) The projected railway must be proven to be "felt" (superior to other modes) within this rather short competitive distance of 350 km. Otherwise it would be ineffective. Even if a high-speed railway runs faster than automobile, the saving of actual travel time between the two modes is relatively small when the travel distance is short. This saving will not be "felt" by the users' subjective judgement.

To illustrate this point, a hypothetical case is shown below;

Table 4-1-1 Time-Saving "Felt" (Superior to other modes)

	Scheduled speed (Considering Time for Stops)	Travelling Time	
		For 100 km Distance	For 500 km Distance
Railway	160 km/h (200)	38 min.	3 hrs 8 min.
Automobile	100 km/h (*)	60 min.	5 hrs
Difference		22 min.	1 hr 52 min.

Note: Figure in parenthesis is approximate maximum speed required for attaining the scheduled speed of 160 km/h.

*; The maximum speed will be much more than 100 km/h.

In this case, time-saving ratio is the same, for 100 km and for 500 km distances. However, the saving of some 22 minutes for 100 km travel may not be considered as significant, if, for example, the passenger has to wait 15 minutes at the origin station for the train to come. While the difference of approximately 2 hours (1 hr 52 min.) for 500 km travel would be attractive enough to him to make this actually "felt."

Summarily, when the inter-city passengers' average travel distance is near 350 kilometers, as in Malaysia, the remarkable difference in speed between rail and auto becomes meaningful.

(e) An upgraded expressway, a super-expressway will allow an automobile to drive continuously at a speed exceeding 100 km/h. In order to be competitive with it, the projected railway must be prepared to attain in future the maximum train speed of even more than 200 km/h.

(f) The present "Hikari" of Tokaido Shinkansen in JNR, with the maximum speed of 210 km/h runs at the scheduled speed of 163 km/h (Distance between Tokyo and Shin-Osaka, 515 km, divided by travel time, 3 hrs. 10 min.), with only two stops between the origin and destination. This can be viables because the Tokaido Shinkansen covers a chain of megalopolises with a population of 2 to 12 million. 140 per day Hikari type of service with only two stops among the ten stations between Tokyo and Shin-Osaka, is justifiable, because the traffic demand on the line is so large that 250 trains are operated on it, including "Kodama" type of service. This is not applicable to Malaysia at present and in near future.

(g) Therefore, the projected railway design must provide room for the future operation at the maximum speed of 200 to 260 km/h.

In this Study, therefore, room was left in the design to prepare;

- the New East-West Railway for the 260 km/h operation, the highest commercial speed attainable by railway today.

  Because, this Railway covers the distant cities in the east coast, e.g., Kota Bharu, Kuala Tregganu, etc. and because, the standard curvature of 4,000 m for the 260 km/h and 2,000 m for 200 km/h would not differ much for practical purposes in avoiding obstacles in selecting routes.

- the West Coast Railway for the 200 km/h operation.

Because, compared with the 200 km/h operation, time-saving by the 260 km/h operation does not seem to be so valuable for the travellers within 350 km, who are expected to constitute most of the passenger traffic generated in the area served by the West Coast Railway, and because the existing right of way is required to be utilized to the fullest extent, from financial reasons.

- Such high scheduled speeds would be unnecessary for the projected railway at the present moment.

  Because, the average time value of Malaysian customers is not high enough to justify a high speed service involving the investment and maintenance resulting in a high fare.

(h) The difference will be remarkable in railway traffic volume, between the cases; with the scheduled speed of 130 km/h and with 90 km/h (corresponding to the maximum speeds of 160 km/h and 120 km/h, respectively).

In this regard, reference is found in the passenger demand forecast made in the M/P study;

Table 4-1-2 Railway Operating Speed and Passenger Demand for Various Modes

Source: The M/P study

Maximum speed	Scheduled speed	Unit	Rail	Car/Bus	Air	Total
160 km/h (Case A-A)	130 km/h	thousand passengers/ year	31,794	145,873	5,825	183,492
		Share	(17.3)	(79.5)	(3.2)	(100)
120 km/h (Case D-C)	90 km/h	thousand passengers/ year	20,690	156,106	6,696	183,492
		Share	(11.3)	(85.1)	(3.6)	(100)

For further reference, the competitive relationship between JNR's high-speed railways and expressways is commented in Appendix 4-1-1.

(i) Technical possibility for higher service-speed should be ensured by all means.

It is the speed that assures the railway a certain level of traffic. And it is when assured of a certain level of traffic that the railway, as a mass transport system, has economic advantages in its relatively low fare and low energy consumption per unit traffic. It would lose this advantage if the traffic volume is small.

(j) In addition, since air transport serving the above range is relatively costly for the general public, a high-speed railway providing a level of service similar in travel time to air is expected to make a significant contribution to the national economy.

(2) Track gauge

(a) Theoretically speaking, standard gauge track is better suited for a high-speed railway than narrow gauge track, because of its i) better running stability, ii) lower rate of degrading in terms of track irregularity, iii) larger tolerance for track irregularity and iv) availability of locomotives with larger output.

As a matter of fact, the railways of the world which experienced high-speed operation over 200 km/h are, all of them, standard-gauged.

(b) In the projected railway network, standard gauge track is recommended in consideration of the difficulties in track maintenance, particularly in respect of i) heavy annual rainfall exceeding 2,000 mm, ii) presence of soft ground areas, and iii) shortage of suitable fill materials. Although the construction cost for standard gauge track is higher, it will be more than compensated by saving in maintenance cost.

(c) The coexistence of different gauge railways in one country is problematic. The obstacles related to the goods transfer between the projected railway and the existing one, is expected to be surmounted by use of containers to the fullest extent. In this regard, it is encouraging that the containerization in the existing network is already going on.

(3) Curve radius

To allow high-speed trains to pass a curve safely, and spare the passengers from a sense of uncomfortable swerve, the track should be provided with a "superelevation" (a raise of the outer rail of the curved track compared with the inner rail). The theoretical value of the superelevation is determined in accordance with the centrifugal force acting on the passing train. At the same time, however, the value must be within the practical limit to keep the train stopped at the curve from toppling down by wind blast.

Practically, therefore, the permissible operating speed over a particular curve is limited by its radius.

In this Study, based on the JNR experiences and performance, a maximum deficiency of 60 mm is accepted against the theoretical value of superelevation (at which the direction of the combined force of gravity and centrifugal force points to center of the track at the rail level). On the other hand, the maximum superelevation is set at 180 mm, taking into account the aspect of track maintenance. The permissible passing speed is thus obtained for a given curve.

Conversely appropriate curve radii against required maximum operating speeds are thus obtained;

Maximum speed (km/h)	Curve radius (m)
200	1970
260	3330

Note: Permissible passing speed on an 800 m curve in urban areas and in branch lines is 120 km/h.

Based on the above results, the standrad curve radii for the projected railways are determined as follows;

New East-West Railway	4,000 m
West Coast Railway	2,000 m

In addition, it should be noted that, if the high-speed tilting type rolling stock now being developed can be used in the West Coast Railway in future, the maximum operating speed of the New East-West Railway would be also attainable in the West Coast Railway.

When the new standard gauge track with a standard curve radius of 2,000 m is laid within the existing right of way of the West Coast Railway, many times it crosses the existing track which has steep curves with a radii of 500 m or so. If the existing railway is to continue the operation after the new railway is built, many sections of it would have to be moved to give way to the new railway. This displacement would require in-advance or temporary relocation of the existing facilities, tracks, etc., and need considerably large expense. It is assumed in this Study therefore, that the operation of the existing railway will be terminated some time (two months or less) before the new railway enters commercial operation. The length of "some time" depends on the incremental expense for the relocation. During the period where there is no railway service, new or old, substitute transport using bus and other modes needs to be considered in the section Kuala Lumpur to Singapore for Network A and the section Kuala Lumpur to Butterworth for Network C. Containerization of goods will facilitate this shift.

(4) Gradient and design load

The steepest gradient is 15‰ through the whole route selected.

Track gradient together with the train speed and the trailing load of trains, is closely related to the locomotive's required tractive force. It is an important factor in determining output of the traction motors and total weight of the driving axles. In this Study, the one type of locomotives (used for both passenger and goods train) which can haul passenger trains at the maximum speed of 160 km/h, and goods trains trailing 1,200 ton load is considered.

However, the load of six driving axles in the design load is determined at 18 tons each, taking into account the locomotive which can haul 1,300 ton trains in singles.

Design live load of bridges and other structures whose reconstruction are not easy, are determined at a weight of two engines coupled. In the future when passenger trains of higher speeds are operated, the difference of speeds between passenger trains and goods trains would become too large to allow one type of locomotives to be used for both. Thus, the future locomotive will be for mono-use by train types. And power dispersal system such as TGV and Shinkansen, might be employed in super high-speed train.

4-2 Route Selection

In this Study, the route for the New East-West Railway proposed in the E/S (See 1-1.) and the route for the West Coast Railway proposed in the M/P are reviewed.

For this review, using the data and information listed below, the routes have been modified, in part, to reduce the construction cost and to avoid disturbing the existing or planned facilities.

4-2-1 Data and information used for route selection

(1) Maps used in the M/P

- (a) 1 : 63,360 scale topographical maps
- (b) 1 : 500,000 scale maps
- (c) 1 : 500,000 scale geological maps

(2) Data and information used in this Study in addition to (1) above

- (a) 1 : 25,000 scale topographical maps or compilation sheets and 1 : 10,000 scale topographical maps of the areas along the New East-West Railway prepared by JICA
- (b) 1 : 25,000 or 1 : 40,000 scale aerial photos
- (c) Litho sheets
- (d) Results of geological survey conducted in this Study
- (e) Route alignment of the Port Dickson Line and Pasir Gudang Line
- (f) Other data and information furnished by related organizations

4-2-2 Station

Station locations originally proposed in the M/P have been changed in this Study as follows;

(1) Stations added to or excluded from the original plan, after the M/P study having been made at the request of the Malaysian side:

Stations added	Janda Baik (Kg. Bukit Tinggi), Bentong
Station excluded	Karak

(2) Stations where goods handling is eliminated from the original plan, due to the proximity of adjacent goods stations:

Bukit Tengah, Bagan Serai, Trolak, Sungei Buloh

(3) Stations added or excluded due to major route changes:

Stations added	Batu Gajah, Malim Nawar, Kampar, Tapah Road
Stations excluded	Gopeng, Tapah

(4) Stations added for KL urban transport (Design consideration on alignment and gradient, is given to allow for additional KL urban transport stations which might be planned in the future):

KL urban transport stations added	Batu Caves, Petaling Jaya, Subang Jaya, Shah Alam, Kelang, Sungei Besi

(5) Stations added or excluded because the main line is extended, Pasir Gudang line is added and Port Kerteh line is eliminated from the original plan:

Stations added	Singapore, Pasir Gudang
Stations excluded	Port Kerteh

(6) Stations where passenger handling is eliminated from the original plan:

Telok Intan, Port Dickson, Bangi

A list of all proposed stations is shown in Appendix 4-2-1. The location of almost half the stations on the West Coast Railway are 0.5 to 1.5 km away from the present location, because of the route realignment.

4-2-3 Policy in route selection

(1) Major premises

(a) To select the route projected in this report within the existing right of way as much as possible.

(b) To minimize the total route length.

(c) To avoid the developed or developing areas.

(d) To minimize the length of tunnels and bridges.

(e) To detour the soft soil ground wherever possible.

(f) To grade-separate the intersections with the Federal Roads and major Rural Roads.

(2) Route modified

The following sections are modified compared with the plans in the M/P and E/S.

(a) The section between the Johor Bahru station and Singapore station is added. This section is planned to be single track.

(b) The construction of Port Kerteh branch line is not planned.

(c) The Pasir Gudang line is added.

(d) The turning track (Batu Caves to Kg. Kepong) is not planned, although it should be considered in the future.

(e) The Port Kelang line is changed to a part of the main line. (The line was planned as a branch line in the M/P).

(f) A branch line between Rawang and Kuala Lumpur is planned. It must be constructed in the phase of Network A, and will become the main line in Network C and D.

(g) All branch lines will handle goods transport only.

4-2-4 Natural feature

(1) Topographic feature

The topography of the areas along the two routes selected for the New East-West Railway and the West Coast Railway is characterized by four different features.

(a) Mountain zones

Mountain ranges, each 25 to 50 km in width, cut across the New East-West Railway and the West Coast Railway at the following places:

New East-West Railway, between Kuala Lumpur and Karak, by Banjaran Tittwangsa.
West Coast Railway, between Ipoh and Kuala Kangsar, by Banjaran Keledang.
West Coast Railway, between Kuala Kangsar and Taiping, by Banjaran Bintang.

The peak in the topography along the routes is about 1200 m above sea on the New East-West Railway and 300 m on the West Coast Railway.

(b) Hilly zone

The hilly zone is seen mainly in the Pahang peneplain, at the west foot of Banjaran Tittwangsa and around the cities of Kuantan, Segamat and Johor Bahru. The zone is dissected by rivers, including the Pahang and the Perak rivers. The lowland areas along the rivers include areas featuring soft, alluvial types of sediment. The zone in Perak and Selangor is dotted with a number of large tin mines.

(c) Inland lowland zone

The inland lowland zone is found in the States of Johor and Negri Sembilan. The zone is dissected by rivers, e.g., the Muar and the Endau, and it is flooded whenever heavy rain falls.

(d) Coastal plain

Along the east coast, an alluvial plain 10 km in width stretches between Kuantan and Kota Bharu. Along the west coast, a plain is found between Taiping and Butterworth, and around Telok Intan, Port Kelang and Johor Bahru. It contains natural levees with swamps, sand bars and tombolos with lagoons behind them.

(2) Geology

The geology along the two routes has the following four features.

(a) Mountain zone

This zone is mainly granite. Paleozoic limestone is observed at the foot of the mountain zones. Although the nature of the rocks are good for tunneling, they have been weathered into laterite to a considerable depth in the ground or have been partially fractured by faults.

(b) Hilly zone

This zone consists mainly of Paleozoic and Mesozoic sediment and forms a hilly area with a gentle slope and plain. The whole area is laterized to a considerable depth. Alluvial sandy soil covers a wide section of the Kinta Velley and contains abundant tin ore.

(c) Inland lowland zone

This zone consists mainly of Mesozoic sediment and forms a lowland area with knolls. The hilly area is laterized to a considerable depth. A shallow (some 10 m) alluvial clayey layer covers a wide extent of the flat lowland area.

(d) Coastal plain zone

Natural levees feature sandy or silty materials, which were brought by rivers and streams, while the swampy areas feature mostly clayey or silty materials. Furthermore, sand bars are formed with earth washed away by river streams and deposited alongside the coastal line under the influence of the long-shore current. The lagoons enclosed by such sand bars are characterized by soft ground with silty or clayey soil.

Generally speaking, the scale of sand bars on the west coast is smaller, and the depth of the soft layer in the west coast is more developed (50 m or so), compared with the east coast.

(3) Factors to be considered in structure design

(a) Tunnel

A few long tunnels are required through the mountain zone which consists wholly of granite. The zone is deemed favorable for tunneling except for weathered or fractured parts.

The existing Bt. Aman Tunnel near Kuala Lumpur Station runs through weathered Paleozoic sediment. The new tunnel is parallel to it. The construction work of it requires greatest attention to the existing tunnel and buildings adjacent to the site.

(b) Embankment on soft ground

In general, the coastal plain is covered by deep soil. Furthermore, alluvial soft soil is dispersed along the river to a relatively wide extent. When the route goes over soft ground, appropriate measures should be taken against subsidence, base failure and flood water level.

(c) Cutting

Large scale cutting is necessary in the mountain and hilly zones. These areas are mostly laterite. These cuttings require careful design and execution against the erosion by rainfall.

4-2-5 Selected routes

The selected routes are outlined as follows;

(1) Route length

As shown in the table below.

(a) Main line

Unit : km

New East-West Railway			West Coast Railway		
Major stations	Route length: Distance	Route length: Cumulative distance	Major stations	Route length: Distance	Route length: Cumulative distance
Port Kelang		0	Butterworth		0
	42.4			156.6	
Kuala Lumpur		42.4	Ipoh		156.6
	35.6			200.6	
Janda Baik (Kg. Bukit Tinggi)		78.0	Kuala Lumpur		357.2
	191.4			65.6	
Kuantan		269.4	Seremban		422.8
	72.0			43.8	
Paka (Kerteh)		341.4	Tampin		466.6
	105.5			50.8	
Kuala Trengganu		446.9	Gemas		517.4
	153.4			191.7	
Kota Bharu		600.3	Johor Bahru		709.1
				26.5	
			Singapore		735.6

(b) Branch line

Unit: km

Branch line	Route length	Junction with main line
Port Kuantan	5.2	Kuantan
Port Chukai	9.0	Chukai
Telok Intan	28.5	Tapah Road
Port Dickson	36.1	Seremban
Pasir Gudang	31.6	Kempas Baru

(c) Branch lines not included in this Study

Unit: km

Branch line	Route length	Junction with main line
Turning track	8.7	Batu Caves Kg. Kepong

(2) Features of the New East-West Railway

(a) As this route crosses the mountain range of the Peninsula, a number of tunnels must be constructed, totaling approximately 50 km, the longest of which being 10 km.

A maximum gradient of 15 ‰ is used in this section.

(b) A 960 m long bridge will be constructed to cross the Pahang river (the largest river in the Peninsula).

(c) The route cannot detour all of the soft ground scattered along the east coast because of the requirements of the minimum curve radius. Particularly near Chukai, the route has to pass through the soft ground zone for a total length of 7 km.

(d) Embankments more than 3 m high will be constructed in the areas apt to be inundated. The height is determined on the basis of the data obtained from the "National Water Resource Study, Malaysia" (JICA, 1982).

(e) In the Kelang Valley, the route will run parallel to the Port Kelang Line and Batu Caves Line in order to use the existing right of way as much as possible. As a result, the standard curve radius is 800 m.

(f) Stations at Kuantan, Chukai, Dungun, Kuala Trengganu, and Kota Bharu will be located at the margin of the urbanized areas. This route will require less land acquisition cost and it will leave room for development around the stations. However, access transport to the already urbanized areas should be provided.

(3) Features of the West Coast Railway

(a) The route is selected with due regard to the policy 4-2-3 (1) (a), using a curve radius of 2,000 m as a rule. As the result, 49% of the route length is within the existing right of way. It should be noted, however, that the land to be acquired should be determined in the detailed design stage, after having carefully studied the new and existing structures and the relevant construction methods.

(b) The route around Kuala Lumpur is selected on the existing right of way wherever possible using a minimum curve radius of 800 m, as the area is extremely urbanized and land acquisition is considered difficult.

In Singapore, the route alignment is as the present one, since it must be within the existing right of way.

(c) The route between Ipoh and Kuala Kangsar is selected along the existing railway. A short-cut route is conceivable but it requires construction of a 12 km long tunnel. To economize the cost, the short-cut route is avoided.

(d) In contrast, between Bagan Selai and Taiping, a short-cut route is selected rather than the existing route, because i) the route length is shorter, ii) a reservoir can be detoured, and iii) no major towns exist along the existing line.

(e) The remains of tin mine where the route passes should be thoroughly investigated of its geological conditions, when civil structures are designed and constructed.

(f) The route is superposed on the existing railway bridge (movable) over the Perai river between the Butterworth and Perai stations. The double-gauged track will be designed to accommodate both the meter and standard gauge.

(g) The new track will be constructed on the Causeway after removing the existing railway.

4-3 Railway Facilities and Station

4-3-1 Structure

(1) Earthwork

(a) The diagram of earthwork is shown in Fig. 4-3-1.

(b) Slope

The Peninsula is covered by laterite. The laterite, when cut, or used as embankment fill, will be eroded by heavy rain and will collapse on slopes in the long run. To prevent this, slopes of 1 : 1.8 or more and 1 : 1.5 or more (frequently used in this country) will be provided for embankment and cuttings, respectively.

(c) Slope protection

Slope protection will be done by vegetation, in principle, with concrete frame protection at lower parts of high embankments.

Thus, grasses suitable for laterite should be selected through further study. In addition, when the slope is covered by the organic soil obtained from swamps, it will be effective for plant growing. Slope protection will not be needed for embankments which consists of rock waste produced from tunneling.

(d) Soft ground

According to the geological surveys, soft ground areas are often found along the routes. The soft soil reaches a considerable depth in coastal areas (particularly around Chukai and near Taiping), but it is relatively shallow in inland areas (for instance, between Karak and Gambang).

Among the methods to construct track on soft ground are the preloading method which requires a considerably long time but relatively low cost, the piling method to sustain the track on solid rocks underneath the soft soil by pile which is relatively expensive, but faster in construction and highly reliable, the sand pile or other methods to accelerate water drainage of soil and the friction pile method to sustain the track by friction pile. The soil survey conducted in this Study indicates that the preloading method could be applied in most of the soft ground areas. An accelerated drainage method and bridge construction method will also be used in some sections. The construction of embankments employing the preloading method should be started in the early stages.

Additional soil surveys and tests on trial embankments should be carried out before the final design, to determine the optimum construction method. On the east coast, the route should be adjusted slightly to make the greatest use of the sand bars which have usually developed in strips.

(e) Cutting trees near the track

Overhead high tension (66 kV) wire will be installed along the railways. To avoid accidents caused by trees falling nearby, trees near the lines should be cleared in advance.

(2) Bridge and culvert

It is most economical to construct bridges according to the following standards; steel trusses for 60 m span bridges, PC girders for 30 m span, RC girders for 10 m span. The typical elevations of 30 m span bridge is shown in Fig. 4-3-2. Abutments will be supported by batter piles to bear the earth pressure of the backfill, the longitudinal force applied by long rails, and the brake force. All bridges will be equipped with a duct for laying signalling communication cables.

RC box culvert (standard section of 3 x 3 m) and corrugated pipe culvert (standard diameter of 0.9 m) will be used for water channels intersecting the roadway.

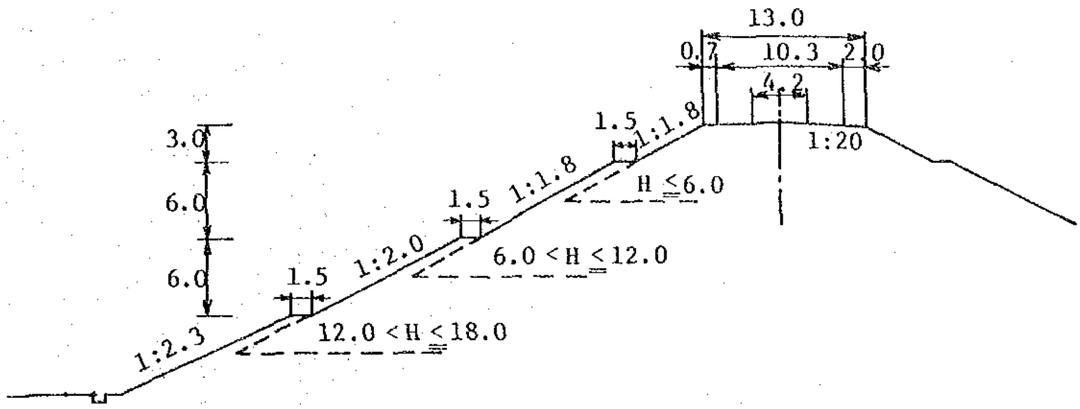
To ensure sufficient drainage near the tracks and thereby prevent embankment materials from being washed away by heavy rain, trenches beside the roadway and bridges or culverts perpendicular to track should be planned in the final design with reference to local topography (1 : 10,000 or similar large-scale maps should be used for this purpose).

(3) Tunnel

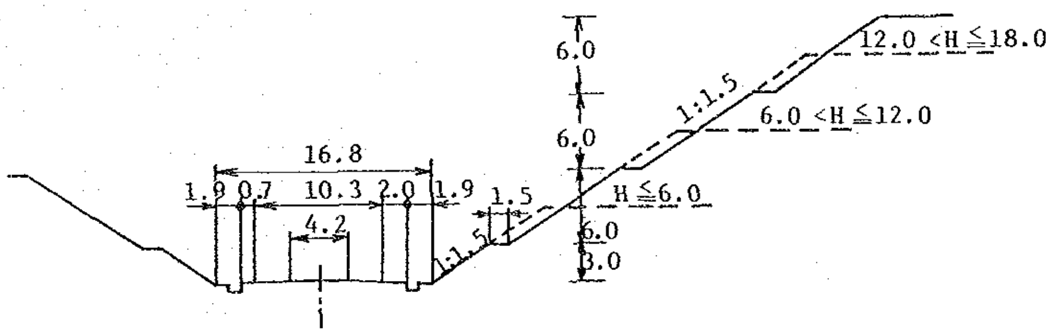
Standard sections of tunnel, both for single and double tracks, are shown in Fig. 4-3-3.

To meet the construction period of 5 years, long tunnels should be divided into sub-sections (3 km each) for construction. In this case, several horizontal or inclined shafts need to be pierced.

For Bukit Aman near the present Kuala Lumpur Station, it is planned in this Study to reconstruct the existing tunnel and construct a new double track tunnel beside the existing one. This construction work must be carried out by high level engineering in design and execution, so as not to seriously affect normal train operation and damage the buildings close to the tunneling site.



(a) Embankment



(b) Cutting

Unit: m

Fig. 4-3-1 Diagram of Earthwork

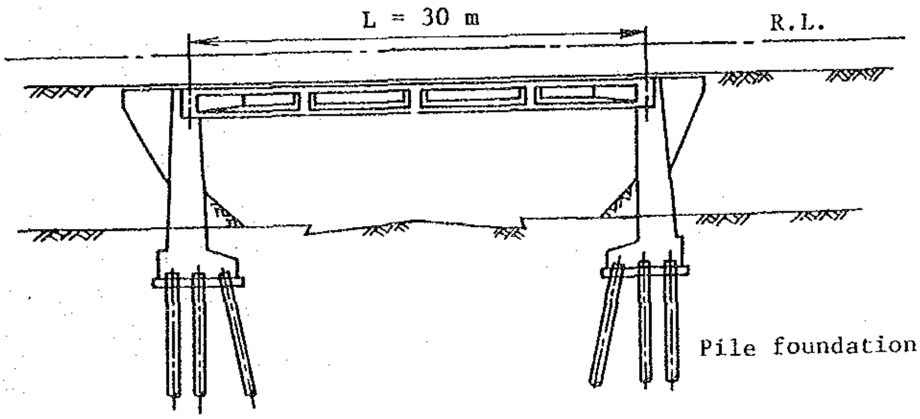
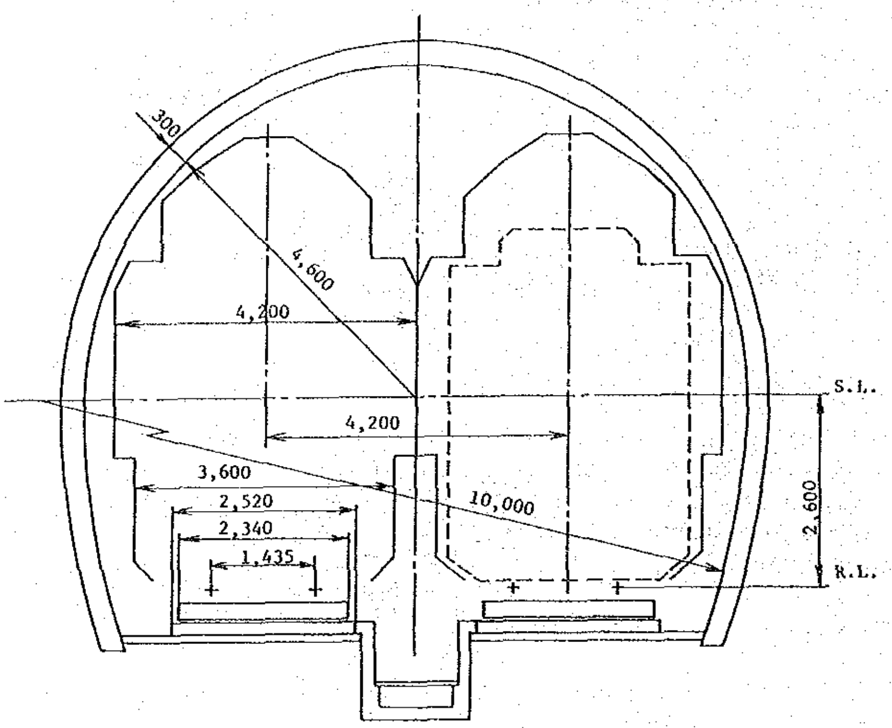
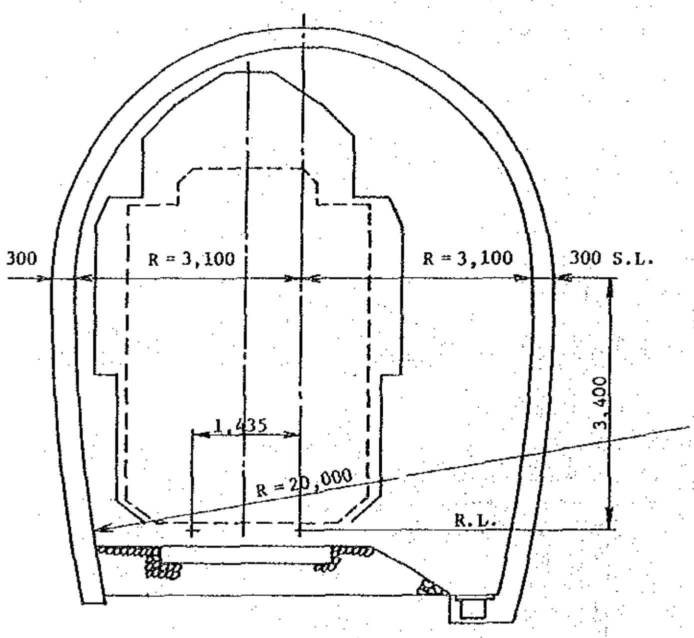


Fig. 4-3-2 Prestressed Concrete Bridge



(a) Double Track



(b) Single Track

Fig. 4-3-3 Tunnel

4-3-2 Station

(1) Eight station track layout models (4 types for passenger station and 4 types for goods station) are designed in accordance with the classification in 3-4-3.

(a) Passenger stations

Four station track layout models are designed, each for single track section and double track section.

They are illustrated in Fig. 4-3-4. Those for the single track sections are designed so as to allow for double-tracking in future. The platform width for super express and express train stop stations is 10 m, 5 m and 7 m for ordinary trains stop stations and for KL urban transport stations, respectively. The area of station building is 1,000 m^2 for the super express and express train stop stations. 500 m^2 is for other stations.

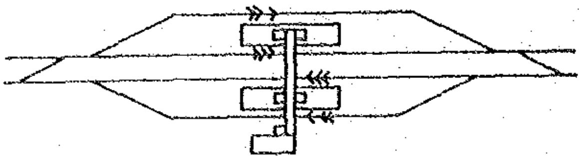
An overhead pedestrian bridge with 4 m width is provided between platforms at each station for passenger transit.

KL urban transport stations will be equipped with automatic ticketing machines for short distance travel.

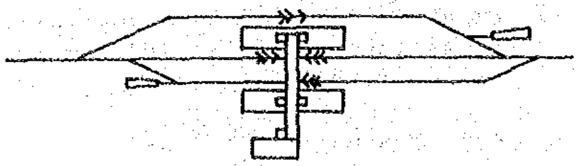
(b) Goods stations

The layouts of goods stations are illustrated in Fig. 4-3-5. They are designed for Network C. Thus, part of the facilities shown in the figure is not constructed during the Network A and B, to meet their goods handling capacity at the level of actual demand. Goods stations with a handling capacity of 100 thousand tons or 500 thousand tons are attached to passenger stations. In contrast, goods stations with a handling capacity of 1,000 thousand tons or 2,000 thousand tons are designed separately from passenger stations.

Containers are handled by forklifts. In addition, horizontal type container transfer machines will be provided for loading/unloading of express container underneath the live catenary, on arrival/departure tracks of the station.

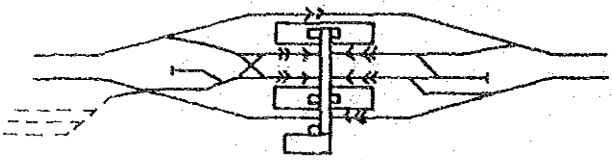


(i) Double track

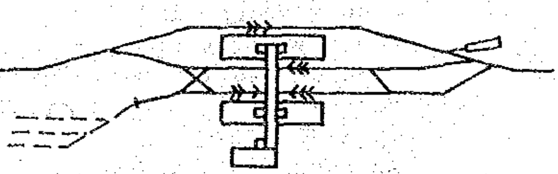


(ii) Single track

Type 1 Super express and express trains stop station

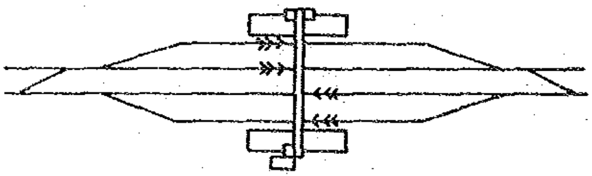


(i) Double track

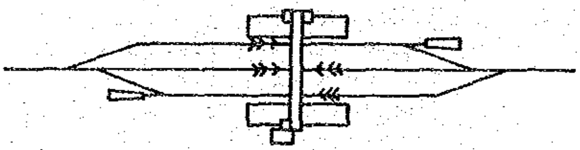


(ii) Single track

Type 2 Super express and express trains stop station with train switching back facilities

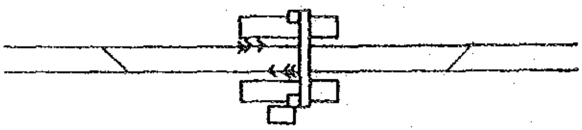


(i) Double track

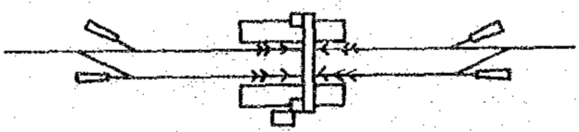


(ii) Single track

Type 3 Ordinary trains stop station with train refuge facilities



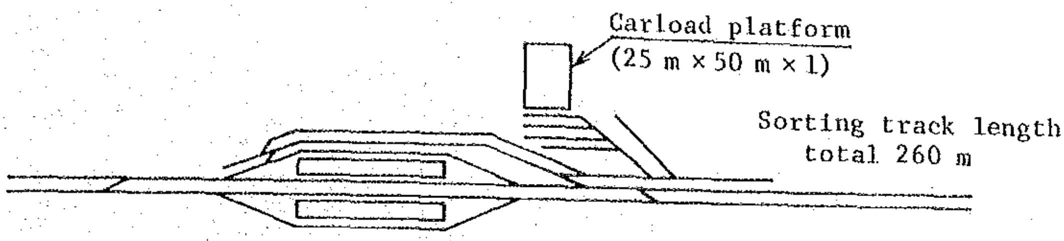
(i) Double track



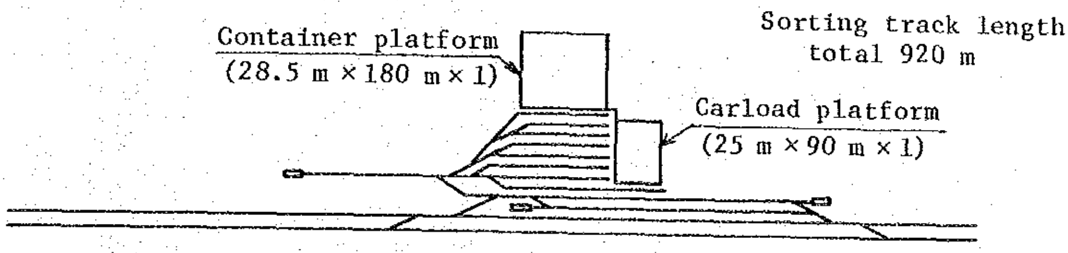
(ii) Single track

Type 4 Ordinary trains stop station

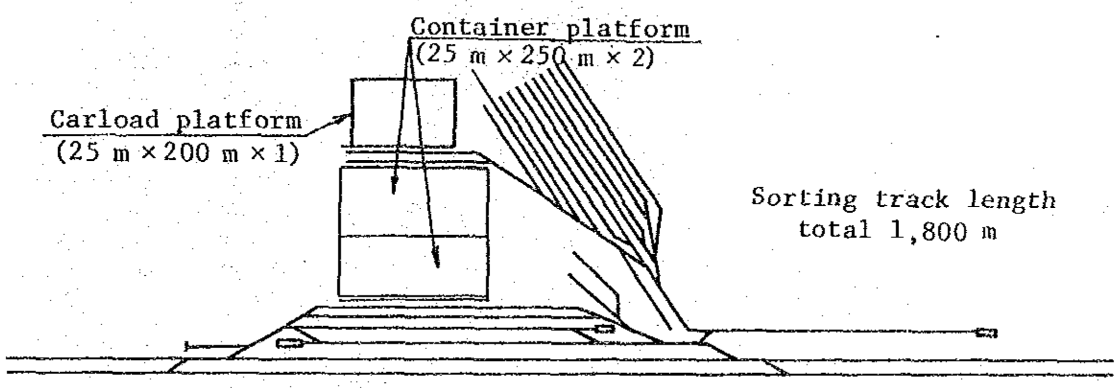
Fig. 4-3-4 Passenger Station Layouts



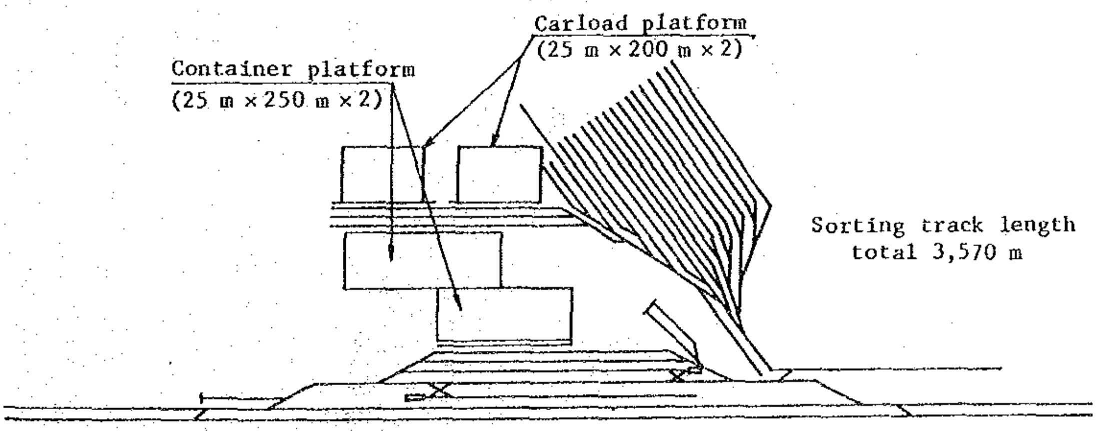
Type A Handling capacity 100,000 tons



Type B Handling capacity 500,000 tons incl. 300,000 tons of containers

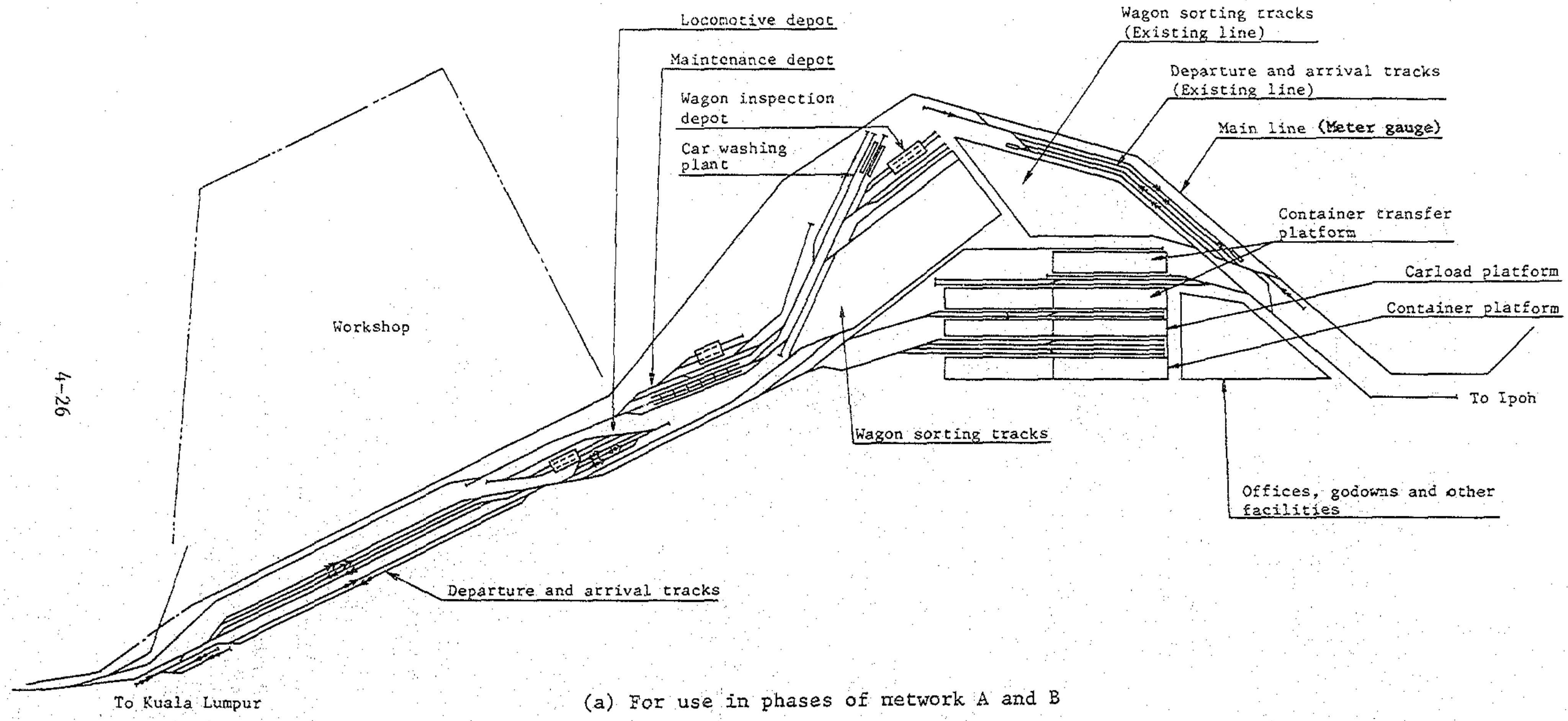


Type C Handling capacity 1 million tons incl. 500,000 tons of containers



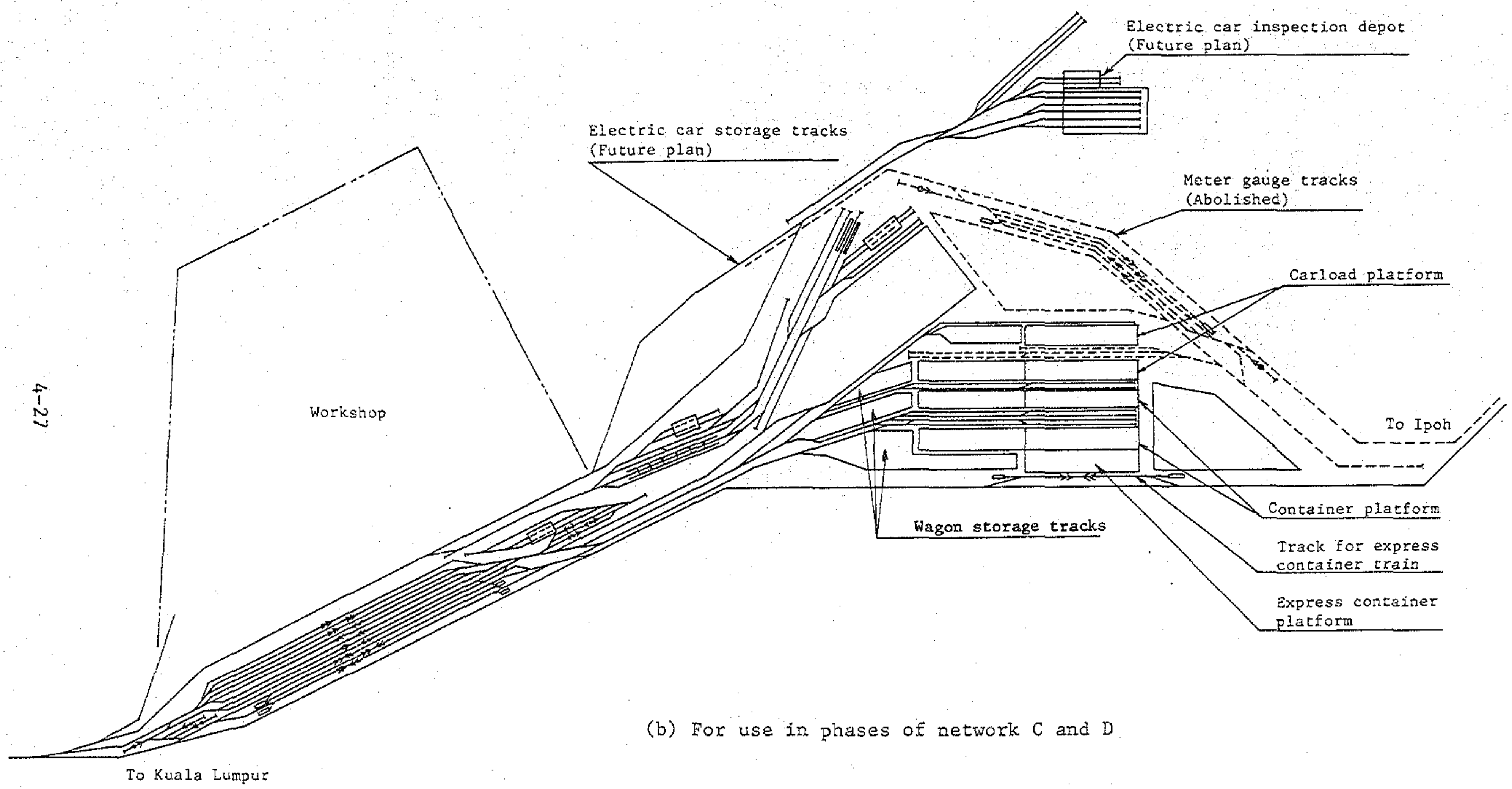
Type D Handling capacity 2 million tons incl. 1 million tons of containers

Fig. 4-3-5 Goods Station Layouts



(a) For use in phases of network A and B

Fig. 4-3-6 Container Terminal and Other Facilities in Rawang-Kuang



(b) For use in phases of network C and D

Fig. 4-3-6 Container Terminal and Other Facilities in Rawang-Kuang

(2) Rawang-Kuang goods station

A conceptional layout of the Rawang-Kuang goods station is shown in Fig. 4-3-6.

Platforms for transferring of containers between meter gauge and standard gauge line will be diverted to standard gauge line use after the meter gauge line is removed from service.

Room for future railcar storage is included in this Figure. Electric railcar (emu) trains could be operated for KL urban transport.

(3) Signal station

The track layout of signal stations is shown in Fig. 4-3-7.

(4) Rolling stock depot

A conceptional layout of the Segambut rolling stock depot for the standard gauge railway is shown in Fig. 4-3-8.

(5) Kuala Lumpur station and the surrounding area

The existing Kuala Lumpur station, with its space limitations, is not suitable for a capital station of the projected railway. A new station is planned in Brickfields located about 1 km away from the existing station. The handling of the meter gauge trains is transferred to the new station from the old one, during the period when two gauges are coexistent.

The existing Kuala Lumpur station is used as a KL urban transport station.

The existing rolling stock depot, engine depot and goods station in Brickfields must be relocated to Segambut.

Fig. 4-3-9 shows a conceptional track layout of the new station.

The New East-West Railway and the West Coast Railway are grade-separated to ensure smooth train operation.

A refuge track for switching back of goods train must be constructed near the junction of the New East-West Railway and the West Coast Railway (near Segambut). Such switching back can be done in the new station too.

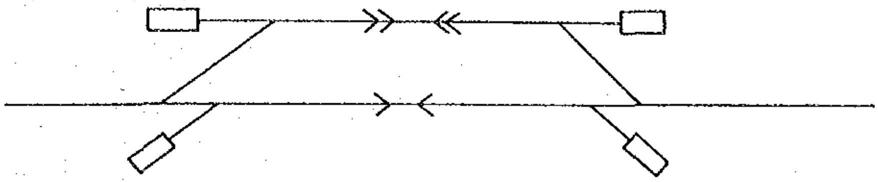


Fig. 4-3-7 Signal Station Layout

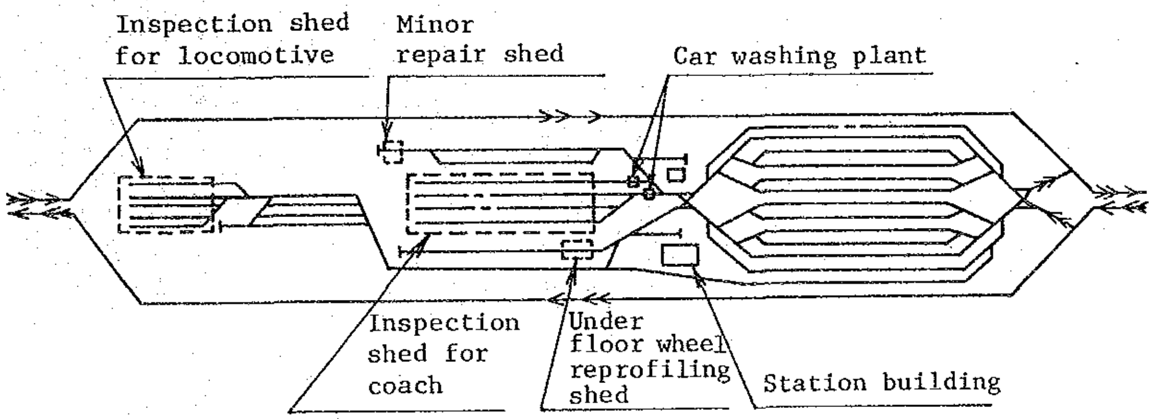


Fig. 4-3-8 Segambut Rolling Stock Depot (for the standard gauge railway)

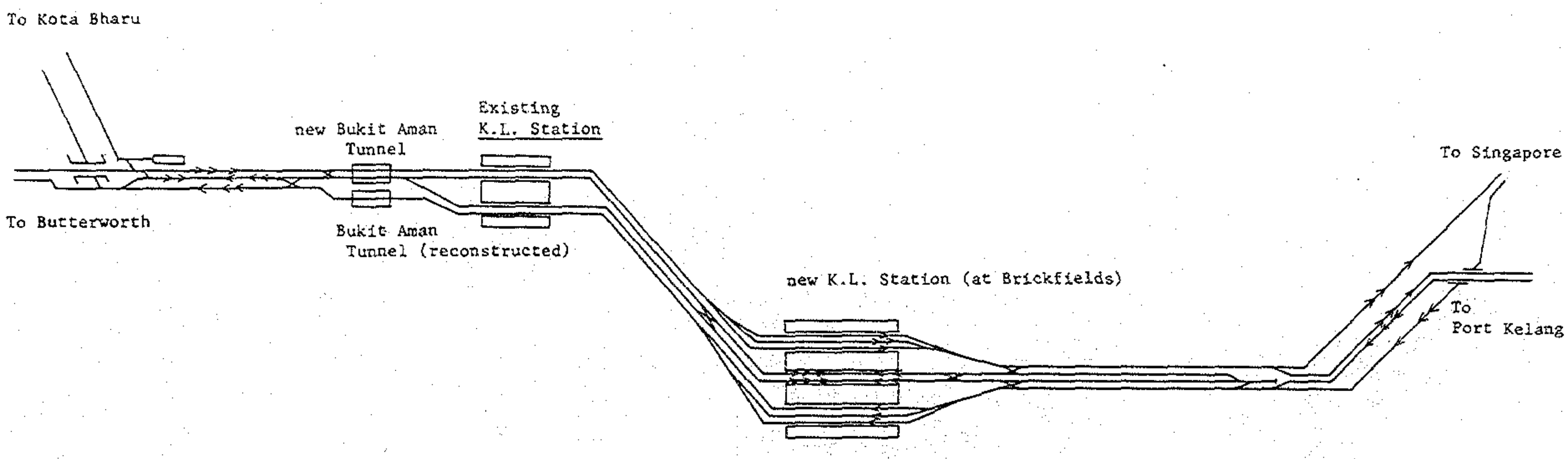


Fig. 4-3-9 Track Layout in Kuala Lumpur Station and its Vicinity

4-3-3 Track

Ballast track is used in all sections, except in the long tunnels between Batu Caves and Janda Baik, with slab structure.

Major features of the track structure assumed in this Study are as follows;

(1) Ballast structure

Rail	Main track	60 kg/m	
	Side track	50 kg/m	
Sleeper	Main track	Prestressed concrete	43 units/25 m
	Side track	Wooden	39 units/25 m
Fastening device	Double elastic fastening device		
Ballast depth	Main track	300 mm	
	Side track	200 mm	

(2) Slab structure

Rail	Main track	60 kg/m
Fastening device	Double elastic fastening device	
Track slab	Reinforced concrete	200 mm in thickness

(3) Turn out

Main track	No. 18 with movable crossing
Secondary track	No. 14
Side track	No. 9

Sleepers and fastening devices are selected from among those used by JNR.

Long welded rail is used for the main line track with expansion joints.

4-3-4 Level crossing

The route is selected according to the policy described in 4-2-3, (1)(f), and the crossings with roads indicated in the topographic map and the main planned roads are as follow.

Section		* Grade-separated crossing	Level crossing	Average distance between crossings (km)	
				Grade-separated crossing	Level crossing
New East-West Railway	Port Kelang to Paka	99	28	3.0	1.9
	Paka to Kota Bharu	28	40	9.2	2.4
West Coast Railway	Kuala Lumpur to Singapore	40	68	9.5	3.5
	Butterworth to Kuala Lumpur	60	43	5.9	3.4

Note: The average distance is calculated from the route length excluding tunnels.

Level crossings should be equipped with the safety facilities mentioned in 4-4-2, (6), and the track, paved at the level crossing.

The number of level crossings is obtained by counting all the present roads and paths crossing the railway routes, as indicated in the topographic maps used for the Study, less the crossings to be grade-separated. All roads and paths have been included considering the convenience of the nearby residents.

The distances between grade-separated crossings seem to be sufficiently short for automotive vehicles, and a matter-of-fact negotiations should be conducted with the parties and residents concerned during the implementation design stage to reduce level crossings through merging or abolishing relevant roads/paths. If the users of level crossings should be limited to pedestrians as a result of the negotiations, the level crrosings can be replaced with overhead pedestrian bridges for safety. The required cost could be covered with the investment for level crossings.

4-4 Electrical System

4-4-1 Electrification system

To minimize the voltage fluctuation and imbalance caused by the large load of train operation, and to ensure stable power supply, the projected railway network receives electric power from the extra high voltage (132 kV) system.

Single phase AC 50 Hz AT feeding system is used except the branch lines for Port Chukai and Port Kuantan. (Simple feeding system is applied to the branch lines.)

The feeding voltage is 25 kV which is the worldwide standard voltage.

(1) Substation

(a) General

(i) The receiving voltage is 132 kV 50 Hz by one line (two lines for the Kuala Lumpur substation).

(ii) Substations are of an outdoor installation type.

(iii) Countermeasures for flood and lightning are provided.

(b) Facilities

Scott-connected transformers are installed to reduce the incidence of voltage fluctuation and imbalance caused by single-phase load of electric locomotives. (Capacity of 20 MVA - 25 MVA)

(c) Sectioning post

(i) Sectioning posts are provided between substations supplied with different phase power/source.

(ii) Sectioning posts are equipped with ground changeover facilities. In case of a failure with one feeding circuit, its facilities function to feed power to the other side.

This extension of feeding requires the imposition of some restriction on train operation.

(iii) Sectioning posts are designed to keep each direction feeding circuit ordinarily closed for both tracks in double track section. In case of a failure, the feeding circuit can be separated to two circuits, for each track, by the circuit breaker equipped there.

(d) Remote control system

A substation control center is provided in Kuala Lumpur, from where all substations are controlled remotely.

(2) Overhead contact system

(a) Contact wire

(i)	Type:	Heavy simple catenary system is used for all the main lines. Pulley type tensioning device is applied to anchor messenger and contact wires together.
(ii)	Wire:	Galvanized stranded steel wire (ST 135 mm^2) is used for the messenger wire, and hard drawn grooved copper wire (GT 110 m^2) for contact wire.
(iii)	System height:	Vertical spacing between the messenger and contact wire at supporting points is ordinarily 1,500 mm, but 1,000 mm in tunnel.
(iv)	Contact wire height:	4,900 mm above the rail surface, in principle.

(b) Support

(i)	Support Span:	60 m, except curved track with radius not more than 2,000 m.
(ii)	Pole:	Catenary supporting poles are of a concrete type or a steel latticed mast, depending on magnitude of the load.
(iii)	Structure:	Catenary for main track is suspended by hinged cantilever type brackets.

(c) Flash-over protection system

Protector wire is of an aluminum cable steel-reinforced type (ACSR), with a section of 150 mm^2 and a double insulator system.

(d) Others

(i) Mechanized catenary wiring work is considered.

(ii) Salt corrosion is not considered because of frequent squalls.

(iii) Overhead ground wire is installed against lightning.

(3) Power supply system other than for electrification

(a) Distribution station

Power distribution stations are generally set up, associated with the substations.

An independent distribution station is set up, where the load is heavy, for instance, the Kuala Lumpur Station and the workshop.

(b) Power distribution line

(i) Power distribution line is stretched on the poles along the track at the voltage of 6.6 kV.

(ii) ACSR with a section of 95 mm^2 is used.

(c) Facilities concerned with the power

(i) Signalling system

(ii) Telecommunication system

(iii) Lighting in/at stations, yards, tunnels, etc.

(iv) Power for the machinery at stations

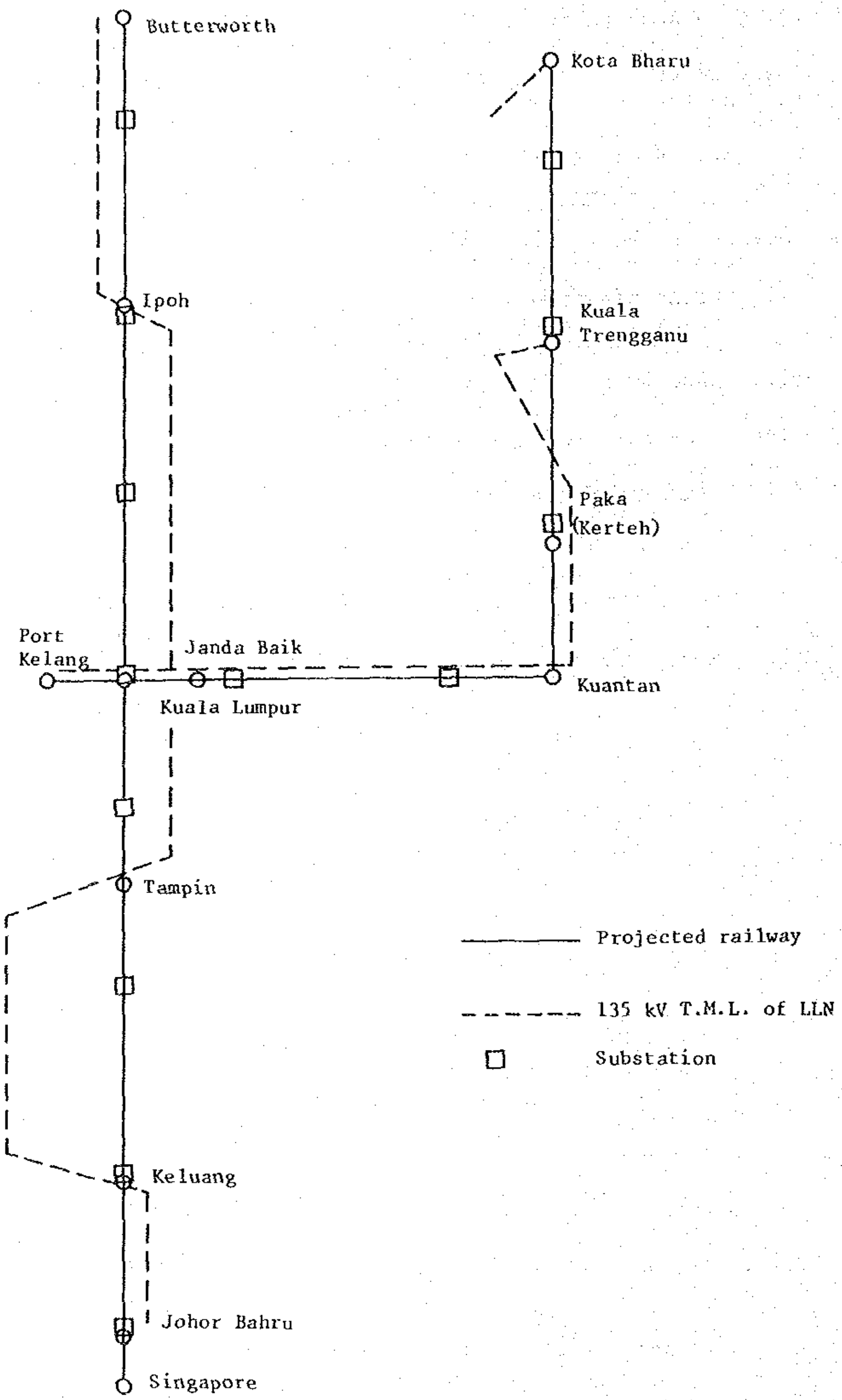
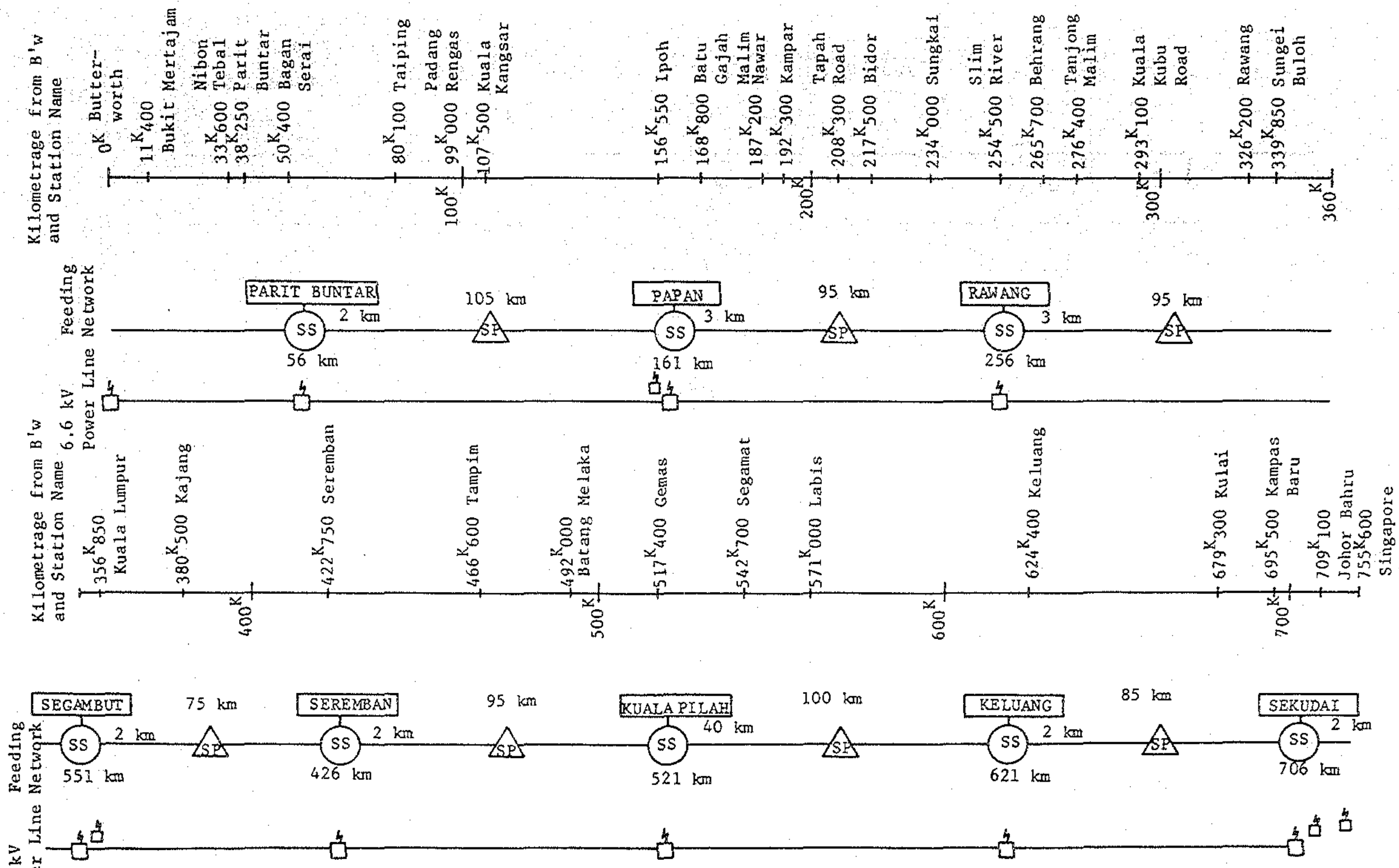


Fig. 4-4-1 Transmission Line and the Substation



Note:

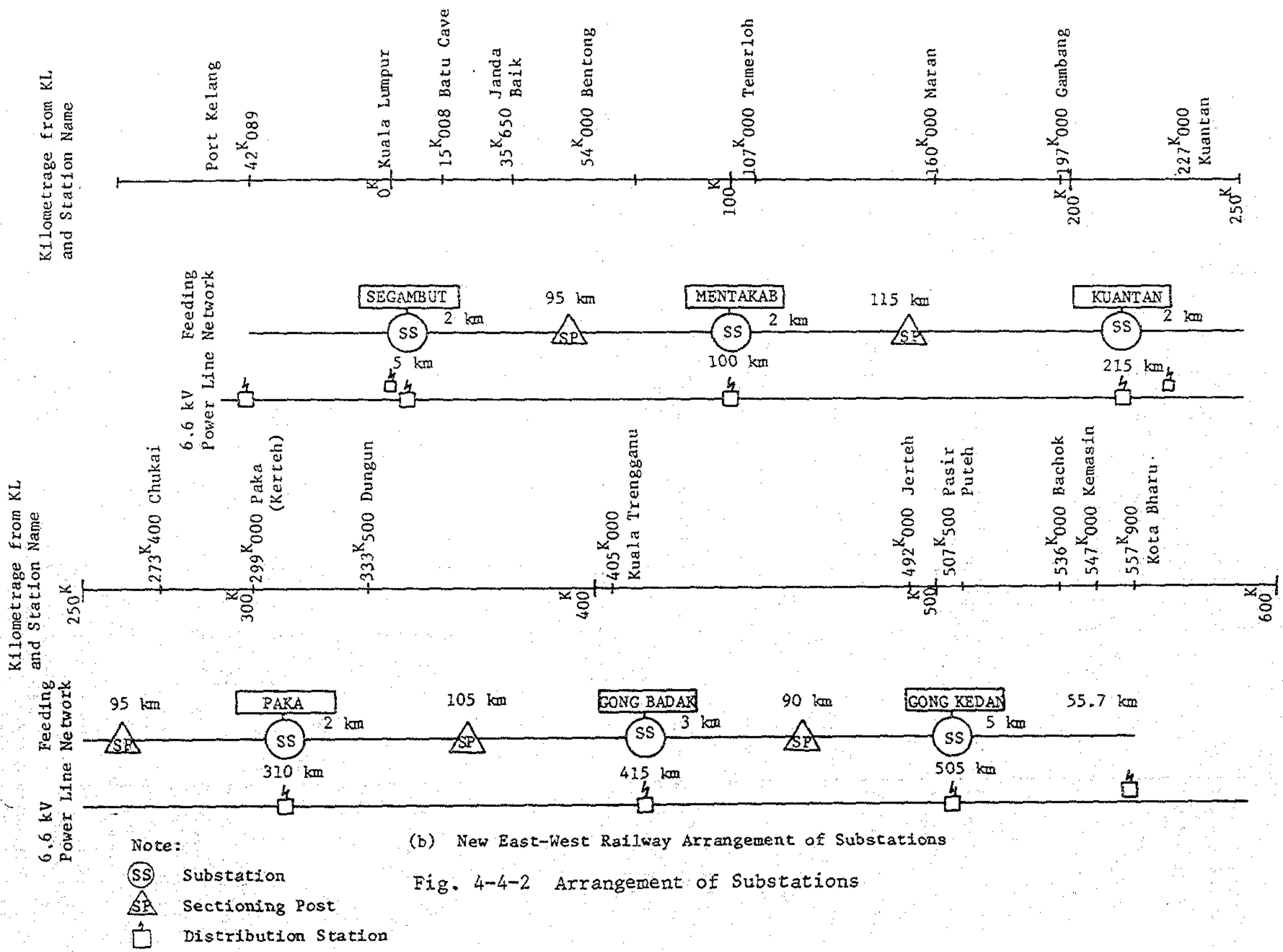
SS Substation

SP Sectioning Post

□ Distribution Station

(a) West Coast Railway Arrangement of Substations

Fig. 4-4-2 Arrangement of Substations



(b) New East-West Railway Arrangement of Substations

Fig. 4-4-2 Arrangement of Substations

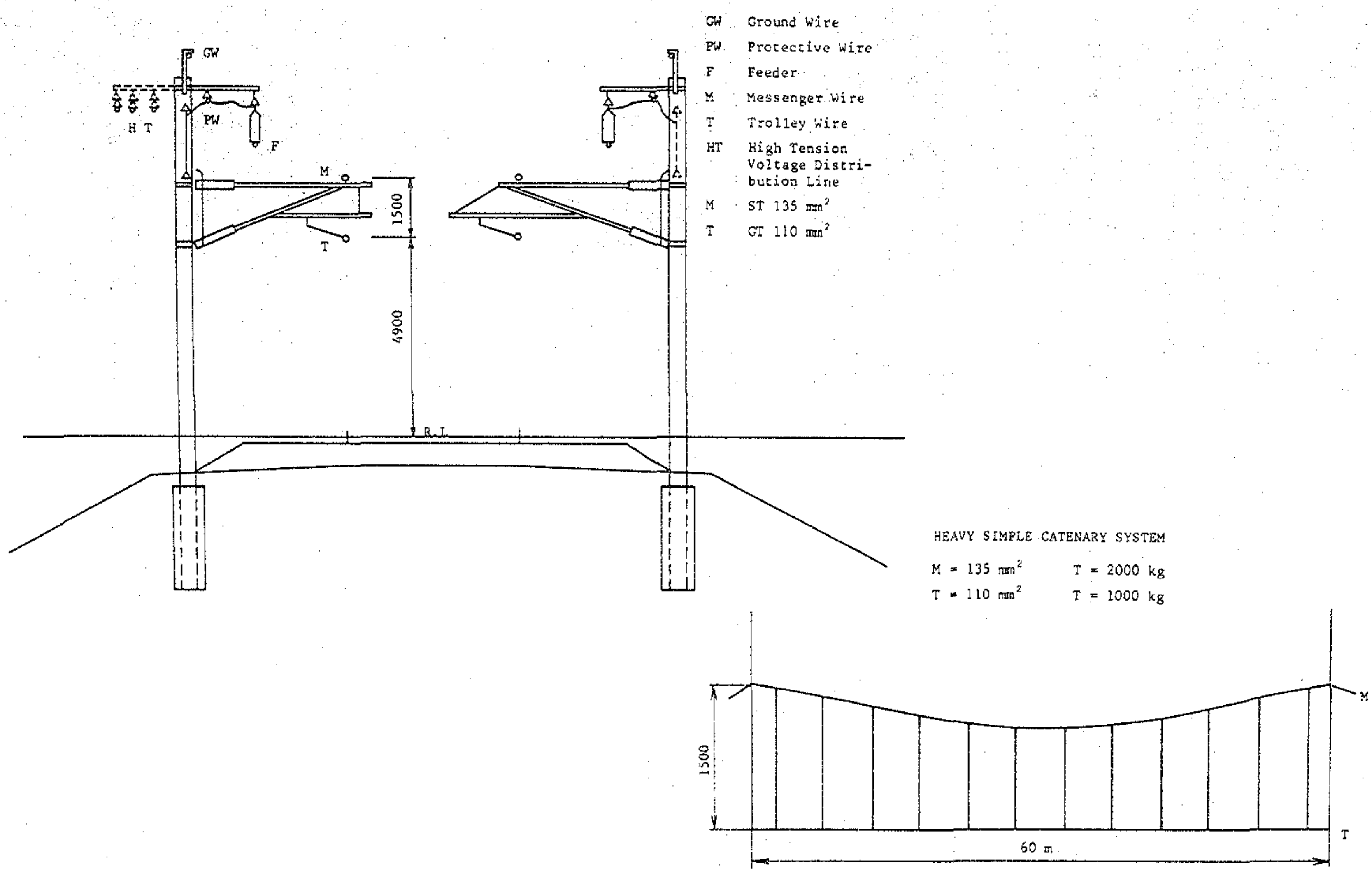


Fig. 4-4-3 Standard Supporting

4-4-2 Signalling facilities

(1) Signalling system

The signalling system for the projected railway is based on an automatic block system. It consists mainly of color light signals, electric switch machines, track circuits, relay interlocking devices, and centralized traffic control devices (CTC). In addition, intermittent controlled automatic train stop devices (ATS) are provided for increasing safety.

At level crossings, crossing alarms and gates are installed and they are controlled automatically. The general arrangement of the signalling facilities is illustrated in Fig. 4-4-4.

(2) Relay interlocking device

Electric relay interlocking devices are installed at each station to ensure efficiency and safety in traffic control. Route-setting for train operation is remotely controlled through CTC. When CTC malfunctions, the traffic control is switched over to each station for local control. Shunting works are also locally controlled.

(3) CTC device

CTC device is provided to monitor train positions and route conditions in a prompt and effective manner for efficient traffic control. The control center is located at Kuala Lumpur, through which the turnouts and signals concerning train operation at all stations are controlled. Train operation is also controlled from the center, since all dispatchers are situated there. In addition, control panel is provided at each station to allow for local control of turnouts and signals.

(4) Block system

An automatic block system is used. The track circuit to detect train position is of 80 Hz code type which is least affected by inductive disturbance.

In consideration of the train speed and the number of trains operated, block length is planned at about 4 km for double-tracked sections. For single track sections, 3 block signals are installed between adjacent stations. Minimum block length is planned at 1 km in consideration of braking distance.

(5) ATS device

ATS system is classified into the continuous control system and the intermittent control system. The appropriate system is selected in consideration of the type of trains, maximum speeds and frequency of operation. A type of intermittent control system, with checking devices on both cab and ground, is employed for the projected railway.

(6) Safety facilities at level crossing

Crossing alarms and gates are installed at level crossings and are automatically controlled by means of crossing controllers.

When the gate can not be closed, or some obstacle is detected after the gate was closed, the related block signals are switched to "red" automatically.

When replacing the level crossings with the over-head pedestrian bridges recommended in 4-3-4, the construction costs of the said safety facilities should be diverted for construction of those bridges.

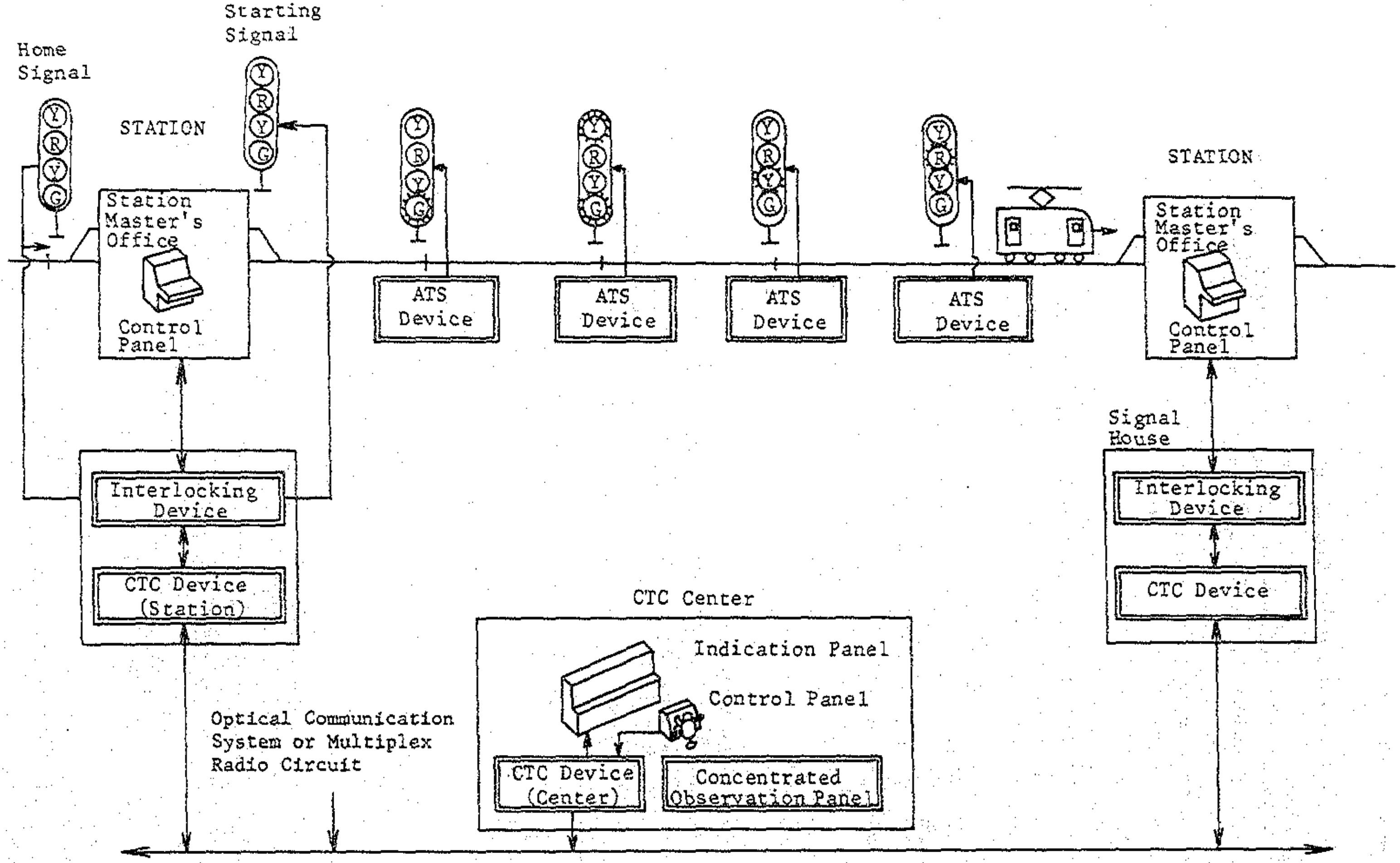


Fig. 4-4-4 Signal Equipment Composition

4-4-3 Telecommunication facilities

A general arrangement of telecommunication facilities is illustrated in Fig. 4-4-5.

(1) Optical fiber cable transmission system

The optical fiber cable transmission system is employed as the trunk line for important communication such as CTC, substation control, train dispatch, etc., because it ensures superior quality long distance transmission, free from electromagnetic induction caused by AC electrification. Future expansion of the network is easier in this system.

(2) Multiplex radio circuit

A multiplex radio circuit is installed as the back-up circuit for the aforementioned important communication line.

Antenna towers are built within the right of way and in station yards whenever possible, to ensure easy maintenance and to minimize the land acquisition.

(3) Cable

The cables are buried along the tracks:

- Optical cables for the trunk line of long distance communication.
- Copper cables for short distance communication station-to-station and approach lines to terminal equipments between stations.

Optical cable shielded for reinforcement, and copper cable sheathed for reinforcement and prevention against inductive disturbance are used.

(4) Automatic telephone exchange

To provide efficient communication among service units, automatic telephone exchanges are installed where necessary, to form a railway telephone system of a toll dialing type.

(5) Train radio

Train radio is provided to facilitate communication between trains and CTC center or stations.

Radio stations are installed at railway stations and/or at required places. In addition, leakage coaxial cables are installed on tunnel walls.

(6) Telephone

(a) Dispatcher telephone

Exclusive dispatcher telephones are provided between dispatchers and related units. Master telephones are installed at the centers, and secondary telephones, at related units.

(b) Wayside telephone

Wayside telephones are installed beside track between stations, to facilitate the communication between railway personnel in the field and related units.

(7) Other devices

(a) Talk-back system and yard radio system are provided for shunting yards in goods stations and rolling stock depots.

(b) Teletypewriters are installed at stations and related units to facilitate communications for dispatching and other tasks.

(c) Paging system is installed at major stations to call workers assigned between stations.

(8) Measures against inductive disturbances

Anti-inductive disturbance measures are provided for all public communication lines along the projected railway.

However, the worn-out lines of them are assumed to be improved by the owner himself.

(9) Computer system

(a) Seat reservation system

Seat reservation terminals are installed at stations and central processing unit, at the Reservation Center.

(b) Other computer system

Computer system is provided to ensure prompt and efficient work. Further study is required to determine appropriate subsystems, for instance, data processing of commercial/operation performance, accounting, personnel and material supplies/inventory.

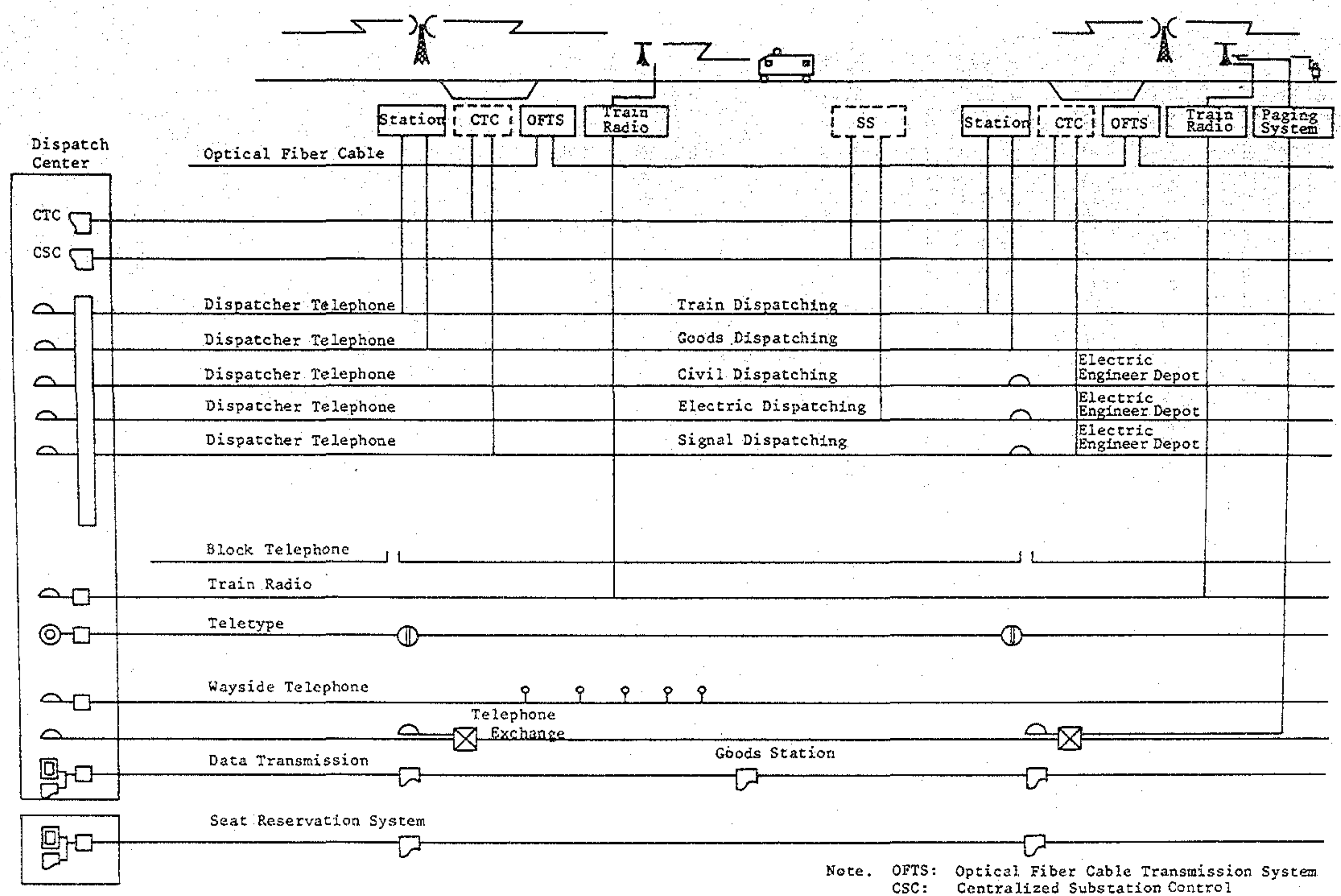


Fig. 4-4-5 Telecommunication System Plan

4-5 Rolling Stock and Workshop

4-5-1 Rolling stock

(1) Electric locomotive

Electric locomotives used in the projected railway are planned on the basis of the following criteria;

(a) One same type of electric locomotive is used for both passenger and goods trains. If otherwise, idle time would be considerable as most passenger trains are operated during the day and most goods trains at night, and operational/maintenance reserve and spare parts can not be minimized.

(b) The electric locomotives must be capable of high-speed and high hauling power; passenger trains must be operated at a maximum speed of 160 km/h, while goods trains must be operated on long continuous upward gradient section (15%) with trailing load of 1,200 tons.

(c) The electric locomotives employ the thyrister continuous phase control system, which is used worldwide and allows continuous speed control to optimize the use of friction.

(d) The electric locomotives employ an air brake system, which maintains braking power, even when brake pipes are damaged or car separation occurs during operation. This will also permit the brakes to be applied or released with smaller notches. The locomotives are equipped with an additional electric brake system which prevents the brake shoes from wearing out or the wheels from overheating, when applying air brake in long continuous downward grade sections.

Table 4-5-1 Main Features of Electric Locomotive

Gauge	1,435 mm
Electric system	Single phase AC 25 kV, 50 Hz
Axle arrangement	C_0 - C_0
Weight in working order	106 t
Maximum service speed	160 km/h
Performance (continuous rating)	
Output	4,200 kW
Tractive effort	18,540 kg
Operating speed	80.9 km/h
Maximum length	18,300 mm
Maximum width	3,200 mm
Maximum height	4,400 mm
Control system	Thyrister continuous phase control
Brake system	Air and electric brakes

(2) Diesel locomotive

Diesel locomotives for shunting are planned on the basis of the following criteria;

(a) Two types of shunting locomotive are planned; small-size locomotives for small goods stations and large-size locomotives for medium and large goods stations. The reason is that the goods stations on the projected railway network range in handling capacity from 0.1 to 3 million tons per year and the shunting locomotive at small stations shunt only a small number of goods wagons at a time, and their operating rate is poor. It is not economical to use the same type of shunting locomotive in all the goods stations.

(b) The speed of the shunting locomotives for small stations is good enough at the shunting speed (15 km/h) in station yards. They need not run on the main tracks as they can be inspected and repaired within their assigned station yards because of their output equivalent to a large lorry.

(c) In contrast, the shunting locomotives for medium and large stations must be operable at a speed equivalent to goods trains (90 km/h). Because they need inspection and repairs in rolling stock depot or workshop, they must be coupled with goods trains with their engines cut. Also, in station yards, they must have a hauling capacity of 1,200 tons with the speed of 25 km/h on 3‰ gradient track, and break away a 2,000 ton train on level track.

Table 4-5-2 Main Features of Diesel Locomotive

	Small-size	Large-size
Gauge	1,435 mm	1,435 mm
Transmission system	Hydraulic system	Electric system
Axle arrangement	Two axles	B_0 - B_0
Weight in working order	20 t	60 t
Maximum service speed	15 km/h	90 km/h
Output	210 HP	850 HP
Maximum length	7,500 mm	12,500 mm
Maximum width	2,560 mm	3,000 mm
Maximum height	3,130 mm	3,800 mm
Number of driver cabin	1	1

(3) Coach

Coaches are planned on the basis of the following criteria;

(a) Both coaches for inter-city express trains and ordinary trains are operated at a maximum speed of 160 km/h, the distance between stations being relatively long.

(b) However, coaches to be used for KL urban trains served in urban Kuala Lumpur are operated at a maximum speed of 120 km/h, the section having relatively sharp curves and the distance between stations being relatively short.

(c) Passenger service facilities in these coaches must be competitive with those of other modes.

Table 4-5-3 Main Features of Coach

	Inter-city				KL urban train coach
	1st class coach	2nd class coach	Dining coach	Ordinary train coach	
Capacity (persons)	48	64	40	88	122
Tare weight (t)	30.0	30.5	31.5	30.0	30.0
Maximum service speed (km/h)	160	160	160	160	120
Maximum length (mm)	21,300	21,300	21,300	21,300	21,300
Maximum width (mm)	3,000	3,000	3,000	3,000	3,000
Maximum height (mm)	4,060	4,060	4,060	4,060	4,060
Seat type	Reclining	Reclining		Fixed	Fixed
Air-conditioning	Equipped	Equipped	Equipped	Equipped	Equipped
Baggage room	Equipped	Equipped	None	None	None
Lavatory	1	2	1	2	2

Note: The capacity of a KL urban train coach includes space for approximately 34 standing passengers.

(4) Wagon and container

Wagons and containers are planned on the basis of the following criteria;

(a) Wagon types are: container wagons, low side wagons, tank wagons, hopper wagons and brake vans, all of which have bogies.

(b) The container wagons are: those for express container trains and those for ordinary container trains. The former will be able to be operated at a maximum speed of 120 km/h. The latter, 90 km/h. The former, operated during the day, should not interfere with high-speed passenger trains. While, the latter, mostly operated at night.

(c) As the loading/unloading work of express container trains are carried out underneath the overhead electrification wire, the containers must be limited in size to ISO standard 1C (usually called "20 ft container"). On the other hand, the containers loaded on ordinary container trains are permitted to be larger in size up to ISO standard 1A (usually called "40 ft container").

(d) 20 ft containers of two types, dry and flat rack containers will be provided.

Table 4-5-4 Main Features of Wagon and Container

	Load (t)	Tare weight (t)	Maximum service speed (km/h)	Maximum length (mm)	Remarks
Express container wagon	41.0	20.5	120	16,300	1C × 2 or 1D × 4
Ordinary container wagon	41.0	20.5	90	16,300	1A×1, 1C×2, 1D×4
Low side wagon	40.0	18.5	90	14,200	
Tank wagon	43.0	18.0	90	12,000	
Hopper wagon	40.0	15.5	90	10,800	
Dry container	18.0	2.32	-	6,058	19 ft 10 1/2 in
Flat rack container	18.0	2.32	-	6,058	19 ft 10 1/2 in

(5) Electric and track inspection car

These cars are equipped with instruments to test tracks and electric facilities while running at the commercial train speed on main line.

4-5-2 Rolling stock inspection and repair facilities

(1) Workshop

(a) The workshop is planned in line with the following policies;

(i) A new workshop will be constructed in Rawang-Kuang.

(ii) At the workshop, the rolling stock of standard gauge as well as of meter gauge will be inspected and repaired.

In this connection, double-gauged track will be laid out in the workshop.

(iii) Inspection/repair work in the workshop will be mechanized as far as economically viable.

(iv) Tables 3-3-1 and 5-2-1 show the number of cars of standard gauge and their inspection cycle, respectively.

(v) Table 4-5-6 shows a standard work schedule for the repair of the rolling stock of standard gauge and of meter gauge. As to the latter, the number of rolling stock is based on the MRA plan available at present.

(vi) When the southern portion of the West Coast Railway is constructed, a workshop for the cars operated on the existing East Coast Line will be constructed in Mentakab.

(vii) When the northern portion of the West Coast Railway is constructed, cars operated on the existing Kedah Line will be sent to Mentakab via Thailand.

(b) Scale of the workshop

The scale of the Rawang-Kuang workshop needs to be planned in consideration of the construction timing of the Mentakab workshop, to avoid excessive/premature investment.

(i) Construction timing of the Mentakab workshop

The Mentakab workshop will be constructed in time for the completion of the southern portion of the West Coast Railway for the following reasons;

- Initial investment for the Rawang-Kuang workshop can be economized,

- Rolling stock used in the existing East Coast Line can be sent to the Rawang-Kuang workshop via the existing West Coast Line for inspection/repair until the railway between Gemas and Kuala Lumpur is converted to standard gauge.

(ii) Scale of the Rawang-Kuang workshop

Based on the scale of fleet (of standard gauge and of meter gauge), on inspection/repair cycle and on standard repair work schedule, the optimum scale of the new workshop in the year 2005 is as shown in Table 4-5-5.

Table 4-5-5 Scale of Workshop (In the year 2005 when the West Coast Railway is opened)

	EL, DL	C	W	
Annual capacity for regular inspection	179	431	1,750	unit: cars
Maximum accommodating capacity at car body shop	9	14	18	
Building area	Approx. 55,500			unit: m2
Total area	Approx. 250,000			

Table 4-5-6 Standard Inspection Schedule for Rolling Stock

		Inspection	Number of days required
Standard gauge	EL	"D" (Main Components) "E" (Overhaul)	14 21
	Shunting DL	"D" (Main Components) "E" (Overhaul)	14 21
	C	"E" (Overhaul)	14
	W	"E" (Overhaul)	5
Meter gauge	Main line DL	Stage VI (Light Top Overhaul) " VIII (Heavy Top Overhaul) " IX (Complete Overhaul)	18 25 25
	Shunting DL	Stage VI (Light Top Overhaul) " VII (Heavy Top Overhaul) " VIII (Complete Overhaul)	18 25 25
	C	Complete Overhaul	14
	W	Complete Overhaul	5

Note: In the above 2 tables,
EL: Electric locomotive
DL: Diesel locomotive
C : Coach
W : Wagon

(c) Workshop layout

Major requirements

(i) Turn-in, turn-out of the cars will be done by switch-back operation.

(ii) Car inspection/repair will be carried out with a fixed system for electric locomotive, diesel locomotive and wagons, and with a temporary bogie system for coaches.

(iii) Design consideration will be given to the diesel engine shop so that it can be partially used for other purposes after the existing West Coast Line is abandoned.

(iv) Shops for heavy parts will be arranged side by side to minimize the distance of their transfer. Same precaution will be taken for other parts.

(v) Inspection/repair works for air brake valves, couplers and other parts common to all types of cars will be conducted in specialized shops.

(vi) The car body painting shop and the diesel engine testing shop will be separated from other shops to maintain a good working environment.

(vii) A waste-water treatment facilities will be provided.

(viii) The inside of the buildings will be well ventilated for worker comfort in hot weather.

A layout of Rawang-Kuang workshop is shown in Appendix 4-5-1.

(2) Rolling stock depot

The main facilities in the rolling stock depots will be as follows:

(i) Locomotive depot;

In depots where Inspections, Type A, B and C are conducted, overhead travelling cranes and bogie exchanging devices will be installed. In the Kuala Lumpur depot (at Segambut), in addition, an underfloor wheel reprofiling lathe will be installed. In depots where Inspection Type A alone is performed, circuit breakers for catenary and ventilator for exhaust gas will be installed.

(ii) Coach depot;

Overhead travelling cranes and bogie exchanging devices for minor repairs will be installed. Car-washing plant and water-supplying installations to coaches will also be installed in the depot.

(iii) Wagon depot;

Overhead travelling cranes and bogie exchanging devices for minor repair will be installed. Container repair facilities will be also built in the depot.

4-6 Construction Cost

4-6-1 Basis of cost estimation

The construction cost is estimated on the basis of the following assumptions.

(1) Social and economic factors

(a) Price

1984 prices are used for the cost estimation. Local prices are used where available, where not available, determined using prices in Japan as a reference.

(b) Foreign exchange rate

An exchange rate of 1 M$ = ¥105 is used.

(c) Procurement of equipment/material

Equipment and materials will be procured locally where available, and otherwise will be imported.

Major equipment and materials to be imported include;

(i) for Costruction work

Special construction equipment/machine
(e.g., for tunneling)
Steel bar/wire for prestressed concrete

(ii) for Track

Rail
Fastening
Turn out/expansion joint

(iii) for Electrification

Transformer
Trolley wire

(iv) for Signalling

Centralized traffic control device
Automatic train stopping device

(v) for Telecommunication

Optical cable
Optical communication device
Computer system

(vi) for Rolling stock

Locomotive
Electric/track inspection car
Bogie

(vii) for Workshop

Machine tool
Inspection facilities

(viii) Others

Container handling facilities

(d) Labor cost

The labor force required for the project, excluding personnel involved in education/training, design, technical assistance, construction supervision and hardware system examination, will be employed locally.

The following wage rates for major job types are used for the cost estimation.

General labor	20 M$/day
Carpenter	40 M$/day
Electrical worker	50 M$/day
Machine worker	40 M$/day

(2) Land acquisition cost

(i) Primary forests and swamp areas owned by the State is assumed to be available free of charge.

(ii) The right of way for double track is assumed to be acquired even at the time of the construction of single track, where it will be necessary in future.

(iii) Land purchase for intersections with roads and rivers as well as tunnels is assumed unnecessary.

(iv) Land for relocated stations on the West Coast Railway is assumed to be acquired through trading with existing station sites on an equivalent basis.

(v) One million m^2 of land is assumed to be necessary for the Rawang-Kuang goods station and workshop.

(vi) Compensation for houses to be demolished to clear the site is considered as being included in the land purchasing cost because houses involved are too few to constitute an independent item.

(3) Others

(i) The structures including embankments and cuts are assumed to be constructed for single track, regardless of future plans for double track. However, embankments on soft ground are assumed to be constructed for double track where applicable.

(ii) Private sidings are assumed to be constructed at the expense of users.

(iii) Construction cost for power receiving and transmission facilities from NEB is included in the estimate.

(iv) All the relocation and modification costs for the existing power transmission lines crossing over the projected railway are included in the estimate.

4-6-2 Construction cost

The construction cost estimated on the basis of the above assumptions is summarized in Table 4-6-1.

Table 4-6-1 Summary of Construction Cost

Unit: mil. M$

Category	Case I			Case II			Case III			Case IV			Remarks
	Foreign currency	Local currency	Total	Foreign currency	Local currency	Total	Foreign currency	Local currency	Total	Foreign currency	Local currency	Total	
1. Land	0	345	345	0	249	249	0	166	166	0	166	166	
2.1 Civil works	993	2,048	3,041	494	1,096	1,590	414	782	1,196	414	782	1,196	
2.2 Track	729	1,049	1,778	316	401	717	168	208	376	168	208	376	
2. Sub-total	1,722	3,097	4,819	810	1,497	2,307	582	990	1,572	582	990	1,572	2.1+2.2
3.1 Electrification facilities	647	117	764	259	47	306	121	22	143	121	22	143	
3.2 Signalling	120	24	144	60	12	72	30	6	36	30	6	36	
3.3 Telecommunication	258	31	289	122	15	137	61	7	68	61	7	68	
3. Sub total	1,025	172	1,197	441	74	515	212	35	247	212	35	247	3.1+3.2+3.3
4. Rolling stock	1,359	733	2,092	739	376	1,115	369	174	543	369	174	543	
5. Workshop,etc.	228	103	331	169	90	259	102	61	163	102	61	163	
6. Total	4,334	4,450	8,784	2,159	2,286	4,445	1,265	1,426	2,691	1,265	1,426	2,691	Sum of 1 to 5
7. Eng. Fee	145	185	330	69	95	164	44	63	107	44	63	107	
8. Sub total	4,479	4,635	9,114	2,228	2,381	4,609	1,309	1,489	2,798	1,309	1,489	2,798	6 + 7
9. Contingency	448	463	911	223	238	461	131	149	280	131	149	280	
10. Grand total	4,927	5,098	10,025	2,451	2,619	5,070	1,440	1,638	3,078	1,440	1,638	3,078	8 + 9

Note: 1. Figures are indicated in 1984 prices.
2. Case I corresponds to the traffic volume in the year 2010, and other cases to the traffic volume in the year 2005.
3. Costs of rolling stock corresponding to 1991 traffic demand are as follows:
- 329 mil. M$ for Case I, II and III.
- 46 mil. M$ for Case IV.
4. The engineering fee is 5% of the total cost excluding rolling stock and container handling equipment, and the contingency is 10% of "8. Sub total".

4-7 Construction Schedule

Based on JNR experience and performance each phase of the project is assumed to be able to be completed in five years, i.e. five years for constructing Network A, five years for expanding Network A to Network B, and another five years for expanding Network B to Network C. Construction of Network A is assumed, in cost estimation to start in 1986, completed in the year 1990, and open to traffic in the year 1991. (See Table 4-7-1.)

As to Network D, that is, track-doubling of Network C, a construction schedule is shown in Table 4-7-2. It is scheduled to be completed in four years.

Land acquisition is assumed to require two years. Priority in land acquisition should be given to the sections where construction work needs to be started earlier. Such sections include tunnels, portions of the existing railway requiring relocation, soft ground areas and bridges over major rivers.

Preparation should be started early enough for placing orders for domestic products which are large in quantity, lest their prices could soar, lest their delivery could exceed the time limit (where partial importation should be considered).

Each construction phase should be managed to be completed in the first half of the final (fifth) year, to minimize the volume of the work in this year. This is for training of the staff and for test runs.

Table 4-7-1 Construction Schedule in Each Phase

Work category	Year					Remarks
	1st year	2nd year	3rd year	4th year	5th year	
Land acquisition	←	→				
Civil work	←	—	—	—	→	
Track		←	—	—	→	
Electrification		←	—	—	→	
Signalling		←	—	—	→	
Telecommunication		←	—	—	→	
Rolling stock				←	→	
Workshop			←	—	→	
				← - - -	- → *	* Mentakab workshop
Survey/design/ system examination	←	→			←→	

Table 4-7-2 Track-Doubling Schedule

Work category	Year				Remarks
	1st year	2nd year	3rd year	4th year	
Civil work	←	—	—	→	
Track		←	—	→	
Electrification		←	—	→	
Signalling		←	—	→	
Telecommunication		←	—	→	

Note: Rolling stock are procured as required.

4-8 Construction of the West Coast Railway

Regarding the existing West Coast Line (referred to in this chapter as "the existing railway") in connection with the construction of the new West Coast Railway with standard gauge ("the new railway"), three alternatives are conceivable:

(a) To abandon the existing railway when the new railway starts construction.

(b) To continue the operation of the existing railway while constructing the new railway with the exception of parts where the existing railway operation would be disturbed by the works, and then to abandon the operation at a time to give way to constructing such remaining parts of the new railway.

(c) To continue the operation of the existing railway while constructing the new railway as in (b), and then to further continue its operation mainly providing goods service, even after the new railway starts operating.

With the alternative (a), the new railway can be constructed easily. But the alternative brings forth the lack of railway service, neither new nor old, for a period of four or five years during which the new railway is constructed. This will alienate the customers from railway service. The alternative (a) is impossible. As to the alternative (c) three sub-alternatives are conceivable, (i) grade separation of the new and existing railways, (ii) level-crossing of the two railways, (iii) separation of the two railways mostly on the same level. As to the sub-alternative (i), the construction cost will be almost prohibitive.

In such-alternative (ii), there will exist more than a hundred level crossings between Butterworth and Singapore (i.e. every 2 $\sim$ 3 km). This will totally deprive both railways of their operational capability. This sub-alternative is impossible.

As to the sub-alternative (iii), it is considered that when both the railways are operated in parallel, the profit of the new railway will be approximately the same with the case where the new railway alone is operated, while the profit/deficit of the existing railway will be extremely exacerbated (as most of the existing railway is in deficit, the deficit will increase a great deal) compared with the case where the existing railway alone is operated. And in total, it is considered that when both the railways are operated in parallel, the total railway profitability will be greatly degraded compared with the case where the new railway alone is operated. The reasons are as follows:

- Regarding the revenue:
  First, as to the new railway, its revenues in passenger and goods services will not change, whether both the railways are operated or the new railway alone is operated.
  Secondly, as to the existing railway, greater part of its revenue in passenger service will be taken away to the new railway due to the latter's higher quality of service, while in goods service, that traffic which is not covered by the new railway's service network will remain in the existing railway, but larger portion of goods traffic will transfer to the new railway. This bit of the goods traffic which will remain in the existing railway will be, for example, in case of Network B, the carload traffic between the southern portion of the West Coast Line and other portions of the existing railway network. This can be considered equivalent in 1982 to approximately 20% of the total goods traffic of MRA, or the revenue of 15 million M$ at best.

  Accordingly, when both the railways are operated, compared with the case where the new railway alone is operated, the total passenger revenue will be approximately the same, while the total goods revenue will be larger, by the amount of the revenue arising from the traffic which the new railway's goods service network will not cover.

- Regarding the operating cost, however, when both the railways are operated, compared with the case where the new railway alone is operated:
  First, as to the new railway, the operating costs will be nearly the same.
  Secondly, as to the existing railway, its operating cost will not decrease in proportion to the decrease in revenue. *This is due to the* high fixed portion of the railway operational cost.

  Accordingly, the total operational costs of both the railways will be by far larger than the case where the new railway alone is operated. This incremental operational cost is presumably several times as large as the total incremental revenue arising from the above mentioned carload goods revenue.

Furthermore pertaining to the sub-alternative (iii), in order to continue the existing railway operation, it will be necessary to relocate the existing facilities as required for constructing the new railway. This relocation is more extensive and costly than the relocation required in the alternative (b), because it is purposed to restore the existing railway's whole capability after the relocation. (See 4-8-1,(2).) Thus, the alternative (c) is not recommendable.

Therefore, in this Study the construction of the new railway is considered based upon the alternative (b), that is, to continue up until a certain time the existing railway operation while constructing the new railway, minimizing the disturbance on the existing railway, and then to abandon it with the shortest possible construction time prior to the new railway's opening to traffic. This time is assumed two months or less in this Study.

4-8-1 Basic concept

(1) Minimize disturbing the existing railway

Because the new railway route is selected to utilize the existing right of way as much as possible, the construction of the new railway will definitely disturb the commercial operation of the existing railway. Thus, the construction schedule should be carefully coordinated to minimize such disturbance.

To achieve this, all work that does not disturb the existing railway operation will be carried out at an early stage of the new railway construction. The remaining portion will be done, on and after abolishing the existing railway operation. The construction period of the remaining portion should be shortest, in order to minimize the period without railway service new or old.

(2) Relocation of the existing railway facilities

Abolishing the existing railway operation without justifiable reasons should be avoided, because the relevant areas are deprived of railway services, both new and old, for a certain period of time until the new railway is built. In this regard, it is important issue either to minimize the time required to complete the construction after the abolition of the existing railway, or to relocate the existing railway facilities affected by the construction work temporarily to let it continue operation (until, however, it will be finally abolished). Generally, the more facilities are relocated in advance, the shorter will be the period but the more expenses will be necessary.

As to whether or not this relocation is to be made, or, when affirmative, when and to what extent, the decision will be subject to the evaluation of following factors:

(i) Length of period required for constructing the "remaining portion". (See the preceding (1).) This length of period should be minimized in consideration of (iii) below.

(ii) Revenue and operating cost entailed if the existing railway operation would be continued during the period.

(iii) Evaluated loss of users concerned, or the substituting service expenses.

(iv) Cost required for the relocation.

(v) The new railway construction cost required additionally due to the continuation of the existing railway operation.

Further investigations will be necessary, case by case for each "remaining portion".

4-8-2 "Remaining Portions" and their treatment

The basic treatment of the existing railway facilities affected by the new railway construction will be as follows:

(1) Near Kuala Lumpur

The new passenger terminal in the Capital will be constructed in Brickfields, about one kilometer south of the existing Kuala Lumpur Station. Because a goods station, a marshalling yard, a rolling stock depot and other field units are located on the site for the new passenger terminal, they will be relocated to Segambut (about eight kilometers north of the present Kuala Lumpur Station).

The relocation work will be completed during an early stage of the new railway construction. The new passenger terminal will be constructed after the above facilities are relocated to Segambut.

A marshalling yard and a workshop for the new railway are planned to be constructed at Rawang-Kuang, about 30 kilometers north of the existing Kuala Lumpur Station (the new workshop will incorporate the existing Sentul workshop). Accordingly, a standard gauge branch line will be constructed beside the existing West Coast Line for connecting Rawang and the New East-West Railway's trunk line, at the stages of Network A and B.

(2) At sections between stations

At a site where the new railway comes across the existing railway, the construction is put off and the other portions are built first. Then, the existing railway operation is abolished, the existing track is removed and the new track is laid. In order to minimize the period of time from the removal of the existing track up to the completion of the new track, part of the existing track may be relocated or the new railway may even cross over the existing railway, depending on cases. (See 4-8-1,(2).)

(3) At stations

The new railway's stations may be built either in the existing station yards or in areas outside the station yards. The latter case need not be treated in this subsection. In addition, most of the new railway's goods handling stations and facilities will be built at locations away from the existing stations. This will be also out of consideration.

Therefore, model cases are studied in this subsection where the construction of the new railway's passenger stations affect the existing facilities.

(a) Model 1 - when side tracks are affected

The affected side tracks will be either relocated/replaced or removed. They will be relocated to nearby location or replaced by other tracks within the same station yard, as far as it is essential, possible and economical in consideration of the frequency and purpose of their use. Otherwise they will be removed or relocated to adjacent stations.

(b) Model 2 - when station-buildings are affected.

Most of the existing station buildings to be relocated will not be used after the new railway starts operation. They will be replaced by temporary buildings that serve the minimum requirements, to be finally removed for the new construction.

(c) Model 3 - when passenger platforms are affected.

Minimizing the disturbance to the existing railway train operations and minimizing the inconvenience of the users, following steps will be repeated until finally the existing platforms are replaced by those for the new railway track. Removing existing platform sectioned to several pieces → Laying of new track where platform existed → Building temporary platform for existing railway, piece by piece.

(d) Model 4 - when departure/arrival tracks are affected.

Departure/arrival tracks are hard to relocate because of their many auxiliary facilities such as signals and turnouts. Furthermore, these tracks will not be used for the new railway. For these reasons, the construction should be carefully planned so as not to affect these tracks. When they are affected after all, they will be removed at the outset of the period (see 4-8-1,(2).) for the new railway construction. They should be relocated only when the said construction cannot be performed within a certain period, (see 4-8-1(2).), only to the minimum extent.

(e) Model 5 - when tracks for sorting wagons or for goods-handling are affected.

They will be relocated within the same station yard, as far as it is possible and economical to do so without much degrading the yard's work efficiency. When the new railway construction cannot be performed within a certain period, they will be relocated to adjacent goods stations or yards. In this case, the minimum improvement works required will have to be performed in those stations and yards to accommodate the goods handling thus turned over there.

(f) In practice, any combination of the above facilities may be affected within a station yard. Therefore, the construction should be planned in such a way as to minimize the required relocations.

(4) Along Port Kelang Line

Along the Port Kelang Line, there are a number of private sidings owned by manufacturing plants. Some may remain even after the new railway is completed as far as they will be serviceable. During the coexistent period of two different gauge tracks, meter gauge sidings will cross the standard gauge tracks and vice versa.

Because such an intersection requires a complicated structure especially in signalling system, their number should be minimized. In this connection, consideration is required, in case of an industrial complex with some sidings bifurcating from the trunk lines. In such a case, these bifurcations are to be eliminated but one, main siding from which each plant of the industrial complex will provide its own siding. Thus, complicated bifurcations of sidings from the trunk lines will be minimized.

In addition, the use of run-over type turnout and double-gauged track is conceivable, when new sidings are built or existing sidings are improved.

CHAPTER 5 OPERATION AND MAINTENANCE

CHAPTER 5 OPERATION AND MAINTENANCE

5-1 Basic Concept

In order to function as a modern, high-speed transport system, the projected railway needs to be operated under an efficient, rational management.

Supported by reliable, modern facilities and rolling stock, and by CTC and other sophisticated information processing systems, the modernized railway operation and maintenance system is summarized as follows;

(a) Operation and management divisions at the head office will be simplified and staffed by competent personnel.

(b) District offices placed at strategic points, will maintain close communication with the head office and give instructions to the chiefs of the field units, advising them in planning works.

(c) Field work will be contracted out wherever possible. Particularly, aided by CTC system, station staff should be minimized.

More specifically;

(a) Traffic control:

The CTC center at Kuala Lumpur will control the traffic of the whole network. (District offices will not have dispatchers.)

(b) Operation and maintenance of rolling stock

The head office and workshop will make whole plans for rolling stock operation and maintenance, and rolling stock depots will make their day-to-day implementation plans. Maintenance work will be contracted out wherever possible. The railway staff will be assigned to inspections and major parts repair work of the rolling stock.

(c) Maintenance of ground facilities

The maintenance of ground facilities (i.e. tracks, structures and electrical facilities) are divided into inspection work and repair work. The former will be dealt with by the railway staff, and the latter, contracted out wherever possible.

Inspections will be performed at regular intervals. Electric and track inspection car will be utilized to save manpower and to enhance work efficiency.

5-2 Operation and Maintenance System

5-2-1 Traffic

(1) Station staff

CTC is introduced to handle work at stations minimizing the railway staff assigned to them.

Station staff should be trained to handle as many types of jobs as possible. Most of ticketing and ticket checking work will be contracted out.

(2) Crew assignment

Driver : One driver for one train (also for shunting)

Guards : Two guards for one super express or express passenger train, and one guard for one train of other types

5-2-2 Maintenance of track and structure

The railway staff will be responsible for planning and management of inspection and repair. Repair works will be contracted out wherever possible.

(1) Organization

The organization for maintenance will consist of the head office, district engineer offices and platoons, echeloned in a hierarchical order shown in Fig. 5-2-1.

```
Head office ─┬─District engineer office ───┬── Platoon
             ├─          "                 ├──   "
             ├─          "                 └──   "
             ┆
```

Fig. 5-2-1 Organization for Maintenance of Track and Structures

The head office will be responsible for planning, coordinating and administrating the maintenance work, including budget allocation and control, and will perform track inspections jointly with the district engineers using the high-speed electric and track inspection cars.

The district engineer will be responsible for analysing the inspection results, and planning, ordering and supervising repair work.

The platoons will be responsible for carrying out inspections and for supervising repair works contracted out.

(2) Inspection

- The track inspection will be performed using the high-speed electric and track inspection cars. It will be performed also by platoons' regular patrols (once every three days).

- Turnout and roadway inspections will be performed at regular intervals.

- The civil structures will be inspected by the platoons' regular patrols, along with regular deformation measurements.

(3) Installations for maintenance works

Track maintenance will be mechanized to the greatest extent, with incidental work done manually.

Maintenance depots will be constructed near the district engineer offices, and extra tracks for maintenance purposes will be provided at all stations including signal stations (some of them, provided with some maintenance equipments).

5-2-3 Maintenance of electrical facilities

(1) On the premise that electrical facilities for the projected railway will be designed to be highly reliable and maintenance free, the maintenance of the electrical facilities can be divided into: i) "preventive maintenance", meaning to take failure preventive measures regularly before breakdown occurs, and ii) "afterfailure maintenance", meaning to perform repair after breakdown.

(2) Preventive maintenance will be performed on feeder lines, catenary, signalling installations and other important facilities whose breakdown would seriously affect railway operation and security, and after-failure maintenance will be applied to lighting and other less important facilities.

Inspection will be carried out aided by mechanized inspecting devices at regular intervals.* The intervals are determined considering frequency of use and the operating conditions of the facilities.

(* In JNR, catenary is inspected by patrol team at four days' cycle, and power transformation and signal communication facilities, at 3 months' to 1 year's intervals.)

(3) The electric and track inspection car is planned to run at regular intervals to ensure efficient and smooth inspection works. They will collect the following data;

Catenary : Wear, height and displacement of trolley wire
Track circuit: ATS level (frequency and quality of grand coil), crossing control device level (control range), track circuit current

In addition, a central monitoring system will be installed in Kuala Lumpur to monitor the operating status of substations and other major facilities and will facilitate quick restoration in case of their failures.

(4) The railway staff will mainly be responsible for inspections, with most repair work being contracted out.

5-2-4 Maintenance of rolling stock

(1) Basic concept

Cars and locomotives must be kept in good operating condition at all times. This is particularly true for high-speed trains in operation. Failures in wheels or other driving equipment may cause serious accidents. The maintenance works of rolling stock are divided into regular inspections/repairs and daily inspections/supply of expendables.

Containers will be subject to afterfailure maintenance.

(2) Inspection type

Rolling stock inspection in the projected railway will be of the following six types: Type A to E inspections are made at regular intervals (see (4).), and Type F, as may be required.

Type A inspection: - Supply and replacement of expendables

- Visual inspection on conditions and performance

Type B inspection: - Inspection on conditions and performance of major components without disassembling

Type C inspection: - Replacement and removal of certain major components

- Disassembling of certain major parts for detailed inspection

Type D inspection: - Removal and disassembling of certain major components for detailed inspection

Type E inspection: - Disassembling of every part for detailed inspection

Type F inspection: - Inspection (major and minor) conducted as may be required when breakdowns take place.

(3) Place of inspection

The most economical location will be determined in cosideration of facilities, manpower, deadhead operation, and idle-time required for inspection.

Type A, B, C and F (minor) inspections do not require large scaled facilities, but must be done frequently. They are performed at rolling stock depots.

Type D, E and F (major) inspections require large facilities. They are performed at workshop.

(4) Inspection cycle

Some parts wear and deteriorate with use, other parts deteriorate with time, regardless of use. During the relatively long usable life of the rolling stock, the same type of car or locomotive will show a different degree of deterioration depending on the number of years elapsed since it was manufactured. Thus, regular inspection cycles for rolling stock should be determined in consideration of these conditions. An inspection cycle for each type of car and locomotive, based on JNR's experience and on the operating conditions of the projected railway, is proposed as shown in the Table 5-2-1.

Table 5-2-1 Inspection Cycle and Place of Inspection

		Type A Inspection	Type B Inspection	Type C Inspection	Type D Inspection	Type E Inspection	Type F Inspection
Electric locomotive		2 days	2 months	9 months	18 months	36 months	As required
Diesel locomotive		2	2	15	30	60	
Coach	Super express, express	2	2	12	-	24	
	Ordinary, KL urban	2	2	18	-	36	
Wagon	Express container	2	2	15	-	30	
	Except the above	2	2	18	-	36	
Place of inspection		Rolling stock depot			Workshop		Rolling stock depot or workshop

5-2-5 Maintenance of rolling stock inspection/repair facilities

From the maintenance viewpoint, machines installed at workshops and rolling stock depots are classified into the following three types;

(a) "Specially controlled machines"

Boilers, cranes and other machines, the breakdown of which relates directly to injury of workers and property loss/damage, as well as water treatment facilities and other equipment, the breakdown of which would cause environmental pollution.

(b) "Important machines"

Car wheel lathes, automatic car body painting equipment, and other machines, the breakdown of which would seriously affect the quality and schedule of car inspection/repair work.

(c) "Other machines"

Machines other than the above two types.

The first two types of machine will be subject to preventive maintenance and the last one to afterfailure maintenance.

5-3 Operation and Maintenance Cost

5-3-1 Track maintenance cost

(1) Tamping

Track irregularity in alignment, surface evenness, cross level and longitudinal level, is corrected by tamping work, using multiple tie tamper jointly with track liner.

These irregularities grow as train passage increases. Their growth rates depend on accumulated passing tonnage, train axle weight, train speed, technical characteristics of track structure and roadbed, precipitation, etc.

And the limit values of these irregularities are determined in view of operational safety and riding quality.

Tamping work must be carried out before each irregularity reaches the limit value. Accordingly, maintenance target values and cycle of tamping work can be determined based upon the irregularity growth rates. However, to determine these criteria, maximizing the effectiveness of maintenance capability consisting of equipment, depot facilities, amount and skill of worker, workable hours, budget, etc. should also be taken into account besides the irregularity growth rates. Usually, two maintenance target values are set below the above limit value. One is for preventive and periodical maintenance by using multiple tie tamper, and the other is for spot maintenance as occasion arises by using portable hand tampers. In practice, however, the determination of these criteria depends very much on empirical judgment. Also for the projected railway, further study will be necessary prior to the actual operation as well as in feedback from the performance after opening.

In this Study, the amount of tamping work is estimated based on JNR's performance and its analysis regarding the conventional line (1,067 mm gauge, 120 km/h maximum speed) and Tokaido Shinkansen (1,435 mm gauge, 210 km/h maximum speed), both of which have ballasted track. Tamping cost is estimated in consideration of labor wage, equipment cost and efficiency of similar work in Malaysia. Most of this tamping work is contracted out.

(2) Material replacement

Replacement cycle for major track components is estimated with reference to JNR's experience.

Rail replacement : 40 years
Sleeper replacement: 50 years
Ballast replacement: 20 years

Annual replacement cost is estimated by dividing the construction cost by durable years.

(3) Other maintenance cost

30% of the above costs is taken as other maintenance cost, such as for turnout replacement.

(4) Track maintenance equipment

As to track maintenance equipments, their purchasing and running costs are estimated.

Their usable life is determined on the basis of JNR's performance.

5-3-2 Structure maintenance cost

The maintenance cost for railway civil structures is estimated with reference to their annual maintenance costs in JNR.

5-3-3 Electrical facilities maintenance cost

Electrical facilities (power supply, signal and telecommunication facilities) are classified into replaceable and depreciable assets for cost estimation.

Replaceable assets:

Catenary, feeder lines, power distribution lines, lighting and other load facilities, signal/communication cables (including auxiliary equipments)

Depreciable assets:

Power transformation facilities, power source facilities, catenary supports, signal/telecommunication facilities (excluding cables).

Maintenance cost of replaceable assets is estimated from their construction costs and their length of service life with reference to JNR's performance.

Maintenance cost of depreciable assets is estimated based on a fixed percentage of construction cost, with reference to JNR's performance.

5-3-4 Maintenance cost of rolling stock

Maintenance cost of the rolling stock is estimated on the basis of JNR's performance which is adjusted as follows;

(a) All types of rolling stock are planned to be operated at larger car-kilometerage per day than on JNR conventional lines. The maintenance cost is adjusted proportionally.

(b) As to material cost, electrical and engine parts, wheels, axles and bearings are assumed to be imported, other parts being procured locally.

(c) Labor and service costs are adjusted according to local conditions.

5-3-5 Power cost

The power cost consists of the electric power cost required for electric locomotive and the fuel cost required by diesel locomotive and container handling equipment.

(a) Power and fuel consumption

The electric power consumption for train operation is estimated on the basis of the "power consumption rate" (in terms of kwh per ton-km of train's weight) of each type of train, according to operating performance characteristics of each. The power consumption rate is estimated on the basis of JNR performance which is adjusted in consideration of train running resistance ratio and other factors. The amount of fuel consumed by diesel locomotives and container handling equipment is estimated on the basis of consumption per locomotive/equipment per day with reference to JNR's performance.

(b) Unit cost

Unit costs prevailing in Malaysia are adopted.

5-3-6 Operation and maintenance cost

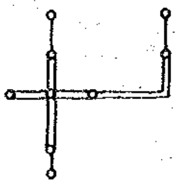
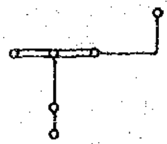
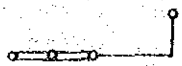
In accordance with the above concepts, operation and maintenance cost is estimated for each case and for years indicated below. The results are as shown in Table 5-3-1.

For the year

Case I 2010 (Network D)
Case II 2005 (Network B)
Case III
Case IV 2005 (Network A)

Table 5-3-1 Summary of Operation and Maintenance Costs

Unit: mil. M$
In 1984 price

Case (Year) / Item	Case I (2010) 	Case II (2005) 	Case III, IV (2005) 
Structure	5	2	2
Track	62	25	13
Electrification facilities	21	8	4
Signalling	4	3	1
Telecommunication	8	3	2
Rolling stock	78	41	20
Traffic and commerce	27	14	8
Power cost	88	39	16
Administration	3	2	2
Total	296	137	68
(Estimated personnel cost) *	(62)	(33)	(18)

* The estimated personnel costs are included in the rows "Total".

(Reference)

The estimated number of railway staff for Case I in the year 2010, Network D, is shown below.

Administration	400 persons	(Head office staff)
Traffic and commerce	1,800 persons	(Drivers, guards and station staff)
Civil	700 persons	(Track/structure maintenance staff)
Electrical	400 persons	(Electrical facilities maintenance staff)
Mechanical	1,800 persons	(Rolling stock maintenance staff)
Total	5,100 persons	

CHAPTER 6 ECONOMIC AND FINANCIAL ANALYSIS

6-1 Objectives

6-2 Economic Analysis

6-3 Financial Analysis

6-4 Sensitivity Analysis

6-5 Observation

CHAPTER 6 ECONOMIC AND FINANCIAL ANALYSIS

6-1 Objectives

The demand for transport service generated by economic and other activities in any country should generally be satisfied by a safe, sufficient, economical and efficient transportation system. Investment in transportation facilities is characterized by huge construction costs due to the indivisibility of facilities, the long range of the depreciation period and the prolonged period of construction.

Thus, any project to construct transportation facilities should be evaluated considering the efficient allocation of relatively scarce resources (optimum resource allocation), i.e., economic and social benefits to be produced by the project and the costs required to implement the project are compared to determine whether the project or any other alternative is chosen or the project is rejected in favor of investment projects other than transportation facilities. For this reason, benefits and costs measured in a transportation project differ from those in private projects in the sense that benefits and costs which are generated outside the particular project should be included in the project to be evaluated.

Furthermore, many transportation projects require a large investment in excess of their own financial capability, so that government subsidy and equity need to be introduced. For this reason, the profitability of such projects should be accurately assessed in advance to determine the financial requirements to be borne by the government.

Based on the above standpoints, this chapter examines both economic analysis and financial analysis of the railway network projects.