Chapter 6

DIESEL MULTIPLE UNIT (DMU)

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6-1 Current Situation

MRA operates 196 regular trains each day, (inbound and outbound) including 76 passenger trains and 120 freight trains.

Of these, 28 railbuses are operated between Port Klang - K.L. - Sentul, the service started in 1989 as the first phase of the commuter rail service around Klang Valley area.

Rolling stock owned by MRA is listed in Table 6-1-1.

Table 6-1-1 MRA's Rolling Stock

Type	Units
Diesel locomotive	128
Main line	89
Shunting	39
Diesel railcar (Rail bus)	40
Passenger coach	304
Freight wagon	5,012

Table 6-1-2 shows the maximum operating speeds of trains. Note that most of the rolling stock, excepting railbuses and some bogie tank wagons, are equipped with vacuum brakes with braking distance of around 1,000m.

Table 6-1-2 Maximum Operating Speeds of Trains

Kinds of Train	Max. Speed
Express trains	88 km/h
Ordinary trains	
. Rail buses	90 km/h
. Others	72 km/h
Freight trains	56 km/h
Others	40 km/h

40 diesel railcars (railbuses) were introduced from Hungary April 1989, to vitalized the urban rail services, and they are operated in 5 lines throughout the country.

A railbus-train is 3-car or 5-car consist. They are 2-axled non-bogie type and are subject to significant vibration and noise during high speed operation, partly due to irregular track maintenance.

The railbuses are not air-conditioned. In Malaysia, hot and humid throughout the year, this would cause problems in attracting the commuters to RBCS.

Furthermore, the carbody is manufactured based on bus body design. This offers an advantage in light weight, but it is questionable if they withstand long period of use for railway service.

6-2 Diesel Multiple Units (DMUs) for DTP

MRA plans to operate 16 to 20 trains in Port Klang - K.L. - Sentul section of Port Klan Line, and Rawang - Seremban section of North-South Line, from the end of 1992 when ground facilities of the DTP are scheduled to completed. (Each consists of 3 DMUs, hence 54 DMUs in total)

The DMU for DTP are characterized by the maximum speed of 120 km/h and good acceleration and deceleration. Seat arrangement is designed for medium and long distance passengers, rather than commuter service.

Major features of DMU indicated in tender specifications are as follows.

6-2-1 Major Features of DMU for DTP

Tender specifications provide the following design conditions which will determine the passenger carrying capacity of a DMU.

(1)	Body construction	: 2 doors on one side
(2)	Body length	: Less than 22m between couplers
(3)	Driver's cab	: Pass-through type
(4)	Train consist	: 3-car, fixed type
(5)	Passenger seat	: Non-reclining type
(6)	Seat arrangement	: Cross seat type on both sides of aisle
(7)	Number of seats	: 210/3 cars or more
(8)	Standing capacity	: 90 passengers/3 cars or more
(9)	Seat spacing	: 915mm or more
(10)	Number of toilets	: 1/DMU set (3 cars)
(11)	Car floor level	: 1,054mm (proposed)
(12)	Suitable platform level	: 3 types (1,045mm, 610mm, and 380mm)
(13)	Inside noise level	: Less than 65 dB (at 90km/h)

The passenger carrying capacity of each DMU car (assumed to be of deck-less type) was estimated on the basis of the layout shown in Fig.6-2-1.

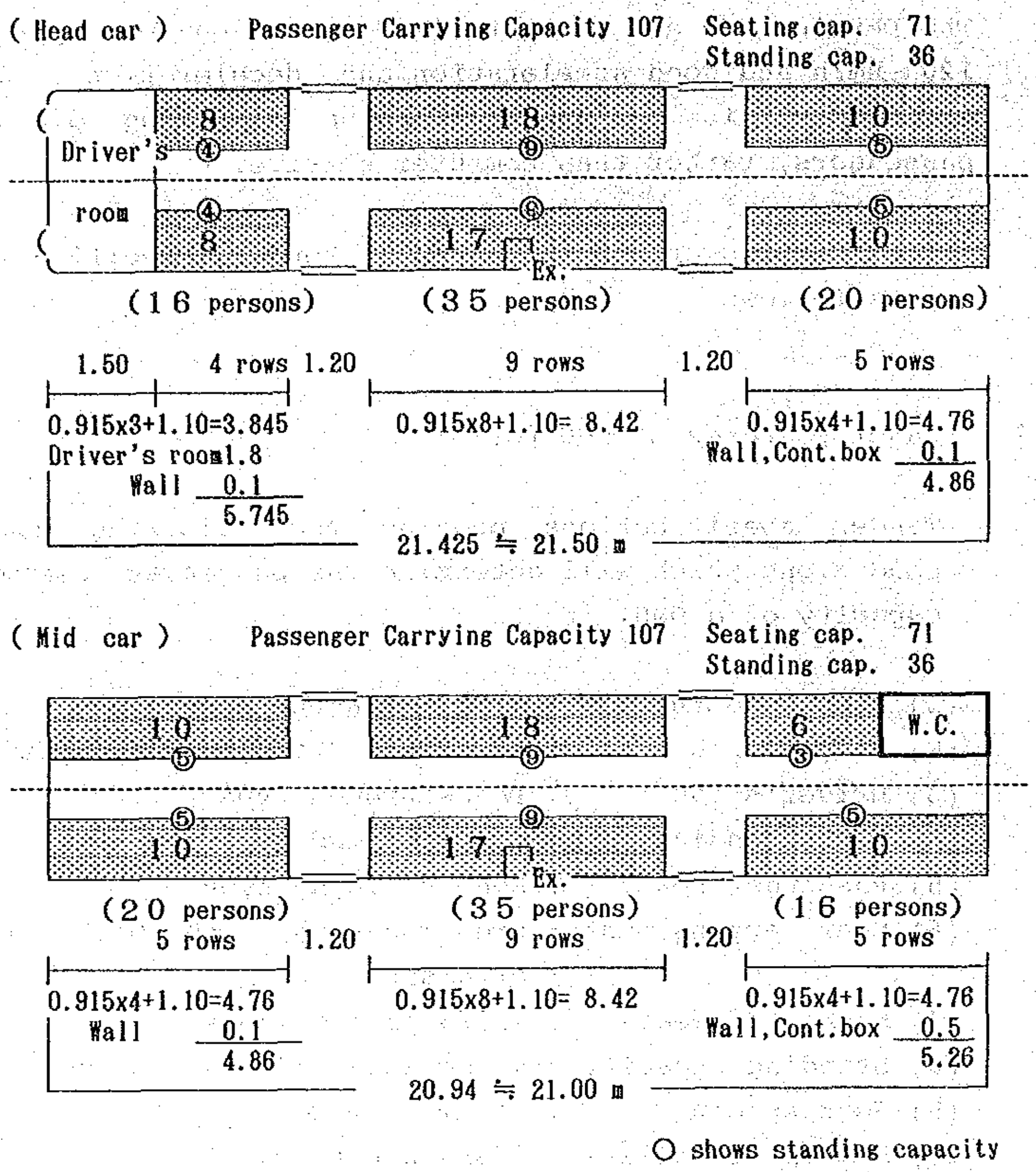


Fig.6-2-1 Estimation of Passenger Carrying Capacity of DMUs for DTP

As the result, the passenger carrying capacity of a DMU car is estimated at 107. (Seating 71, Standing 36)

The maximum allowable congestion rate

$\left(\frac{\text{Standing area}}{\text{Number of standing passengers aboard}}\right)$ (m^2) in Japanese

commuter railways is 0.14 m^2/passenger. Applying it to DMU for DTP, the maximum number of passengers carried by a 3-car DMU set is estimated at 565.
(load factor 177%, 565 ÷ 107 ÷ 3)
(Refer to Appendix 6-2-1)

6-2-2 Performance of DMU for DTP

Tender specifications provide the design conditions related to operating performance as follows:

(1) Maximum speed : 120 km/h on straight/flat track
(2) Acceleration : 0 - 100 km/h Within 165 seconds
(3) Braking distance from 120 km/h : 700 m on straight/flat track
(4) Power transmission system : Electric or hydraulic
(5) Maximum load : 27.0 tons/3 cars
(6) Maximum axle load : 15.0 ton or less
(7) Car body : Stainless steel or aluminum alloy
(8) Engine location : Suspended on underframe
(9) Running resistance:

Speed	20	40	60	80	100	120	km/h
Resistance	2.62	2.95	3.45	4.05	4.95	6.10	kg/ton

The running performance curves of a DMU train estimated on the basis of the above features are shown in Appendix 6-2-2.

Considering the 3-car consist, the engine layout of a DMU set will be 475 PS x 2 units or 320 PS x 3 units.

6-3 Diesel Multiple Units (DMUs) for RBCS

The DMU for RBCS should satisfy the requirements of mass transport service in 2005 envisaged by RBCS.

6-3-1 Planning Concept for RBCS DMU

A DMU for RBCS is planned under the following assumptions.

(1) The track alignment will remain as it is during RBCS project.
(2) Platform level is 1,054mm.
(3) Train length is 220m, or 10 cars at maximum.
(4) Car performance will emphasize high acceleration and deceleration.
(5) Car-body will emphasize quick boarding and alighting of commuters.
(6) Seating capacity will not be less than DMU for DTP.
(7) Dividing and adding the train consist will be flexible.

According to the Railway Commuter Transport in Chapter 5, trains on Rawang - Seremban of the North-South Line are operated with 10-minute headway in 2005. At around two junctions near K.L., 5-minute headway is anticipated, as trains on the Port Klang Line are operated on the same tracks.

To meet this demand of high density train operation, DMU should be designed to satisfy the requirements such as large standing space, shortest access to doorways for quick boarding and alighting, good riding comfort even when congested, high acceleration and deceleration and, nonetheless, suited for the service during off-peak hours.

It is to be noted that high speed performance is not essential for DMU trains. As shown in the run curves for DTP trains in Rawang - K.L. - Seremban section (Appendix 5-2-1) train operation at 120km/h is limited to 8km in length for rapid trains, and none for local trains. This is due to the speed restrictions arising from curves, turnouts, etc.

(1) Doorway

DMU for DTP is designed to have two doorways on one side, while, 3 double doors will be provided for DMU for RBCS, to further reduce boarding and alighting time. When 4 or more doorways are provided, the air-conditioning will lose effectiveness considering the hot weather in Malaysia.
DMU for DTP is equipped with steps adjustable to 3 types of platform levels. While, no step will be provided for DMU for RBCS.
Therefore, doors and seats can be freely arranged. This will minimize the boarding time.

(2) Seat arrangement

A RBCS diesel multiple-unit railcar is laid out in such a way that enables it to have an increased standing capacity with as many seats as a DTP car and be easier for passengers to get on and off.

A semi-cross seat type, shown on Fig. 6-3-1, is adopted for the arrangement of seats, taking three factors into account:

1) commuter trains will have to cover the K.L. - Seremban section in a relatively long traveling time of one hour to one hour and half;

2) the number of passengers will greatly vary by time zones and sections; and

3) commuter cars will be used as local trains in daytime hours.

The planned maximum carrying capacity is obtained in the following series of expressions:

1) the total seat area is substracted from the total passenger compartment area and the obtained figure is divided by the maximum allowable congestion rate of $0.14m^2$ per person used in Japanese commuter railways, whose quotient is the maximum standing capacity.

2) This figure and the seating capacity makes the planned maximum carrying capacity.

Figures on Table 6-3-1 refer to the average and maximum carrying capacity of a seven-car train, each car with the above-described seat arrangement.

(As for detailed calculation of the maximum carrying capacity, refer to Appendix 6-3-1.)

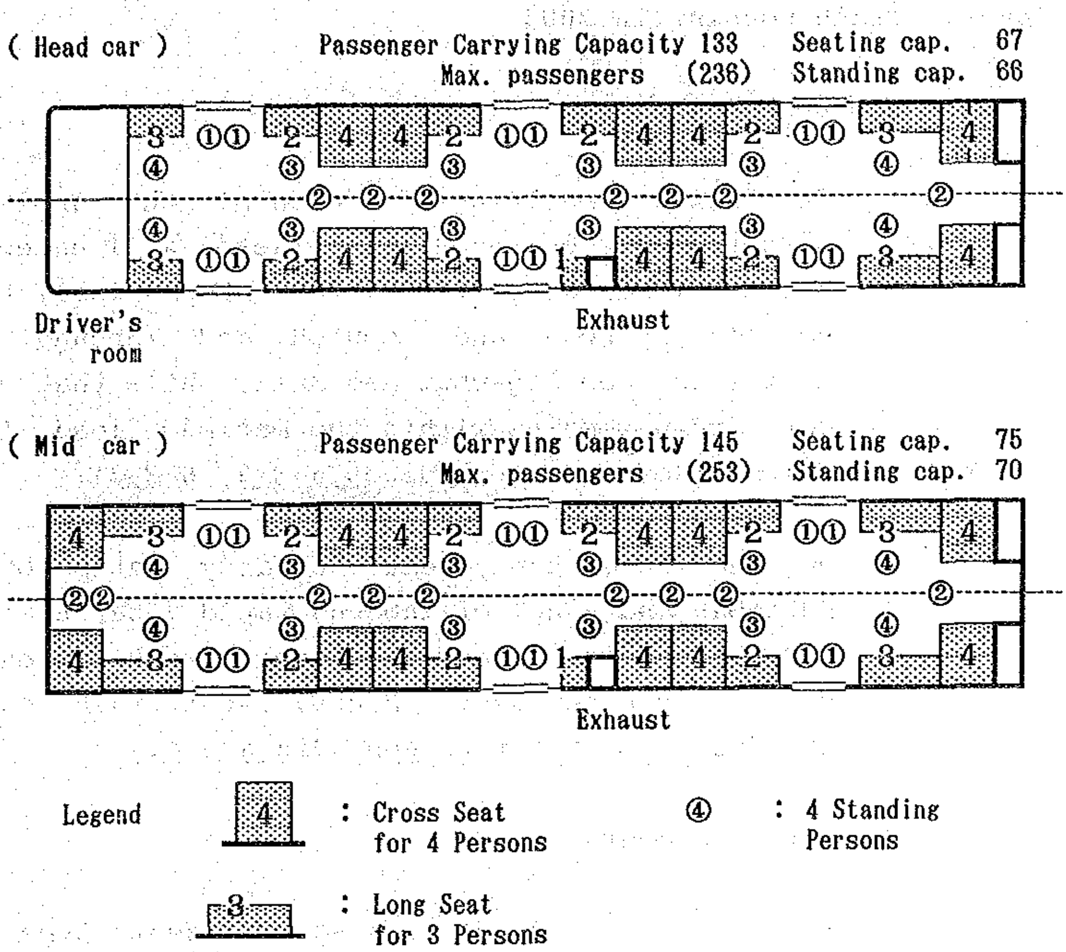


Fig. 6-3-1 Passenger Carrying Capacity of Semi-cross Seat Type

Table 6-3-1 Passenger Carrying Capacity and Maximum Number of Passengers by Semi-Cross Seat Layout

(per car)

Seat layout	Passenger carrying capacity			Maximum carrying capacity (in number of passengers)	Maximum load factor
	Seat-ing	Stand-ing	Total		
Semi-cross seat type	72	68	140	245	175.8%

6-3-2 Train Consist in 2005

(1) Peak hours

If trains consisting of 6 cars of the semi-cross seat type are operated, load factor will exceed the maximum load factor (1.73) for inbound local trains between Sg.Besi and Seputeh and inbound local trains between Segambut and Mall, while that of 7-car train remains within the maximum load factor value. (Refer to Appendices 6-3-2, 6-3-3)

On the other hand, seat occupancy ratio between Seremban and Bangi of inbound rapid 7-car train is 1.0, which mean every passengers traveling on that section can get seat. Hence, 7-car train consist is adopted. (Refer to Appendix 6-3-4.)

(2) Off-peak hours

If DMU trains of semi-cross seat type are operated at 80% load factor, in order to meet traffic demand during off-peak hours in 2005, train consist of 7.1 cars is required during daytime hours and 6.9 cars during nighttime hours in some sections, thus it is desirable to maintain 7-car train consist during off-peak hours.
(Refer to Appendix 6-3-5, Table 1 and Table 2)

6-3-3 Concept of Train Consist

To cope with the further increase in commuter traffic expected after 2005, train consist must be enlarged.

Hence, a flexible powering system to enable maintaining the same train performance must be adopted.

As DMUs of DTP are expected to have acceleration performance of less than 165 seconds for 0 - 100 km/h, the similar performance is expected for RBCS DMUs.

DMUs of RBCS employ light weight stainless steel body, i.e. 37.0 tons for power cars and 28.0 tons for trailer cars planned.
The total load for a 7-car train, assuming that each car carries 245 passengers, is estimated as follows:

Weight per train:

37.0 tons x 5 cars + 28.0 tons x 2 cars = 241.0 tons

Load per train:

0.07 tons x 245 persons x 1.1 x 7 cars = 132.1 tons

Total: 373.1 tons

Required horsepowers to accelerate from 0 to 100km/h within 165 seconds is estimated at 2,390 PS per train. (Refer to Appendix 6-3-6)

Here, it is difficult to mount a few large engines of 1,000 PS class in order to reduce the number of engines, because of space limitation and noise.

On the other hand, if a fixed 7-car consist is adopted, use of push/pull type DMUs having separate engine rooms may possible. However, the push/pull type is not suitable for flexible train consist required.

Thus the simplest power layout is to mount a 340 PS class engine on each car.

This allows easy separation and integration of cars according to change in the traffic volumes by line section and time zone.

However, the increase in the number of engines will cause investment and maintenance costs.

For reference, possible selection of engine layouts for average power of 340 PS per car is shown in Fig.6-3-2.

Number of Cars	PS × Number of Engines (Distribution of Engine Power)				
(1 unit)	340 X 1				
(2 units)	680 X 1	or 340 X 2			
(3 units)	1020 X 1	or 510 X 2	or 340 X 3		
(4 units)	1360 X 1	or 680 X 2	or 450 X 3	or 340 X 4	
(5 units)	1700 X 1	or 850 X 2	or 566 X 3	or 425 X 4	or 340 X 5

(shaded) : In case of all power car

Fig.6-3-2 Alternatvie Engine Layout Plans

Assuming that the basic unit of train consist is 3 or 4 cars, from Fig.6-3-2, 3 types of engines - 450 PS, 510 PS, and 680 PS - are selected. Among them, if engines with the same horsepower are to be used for all power cars, 510 PS engines will provide the smallest difference in output per car.

3-car consist:

510 PS x 2 engine ÷ 3 car = 340 PS

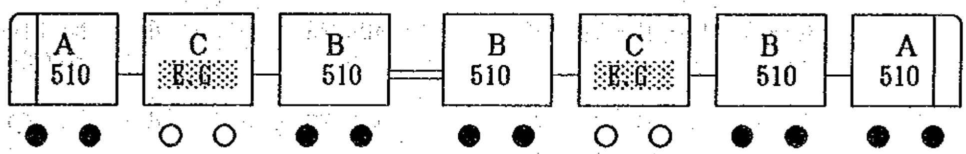
4-car consist:

510 PS x 3 engine ÷ 4 car = 382 PS

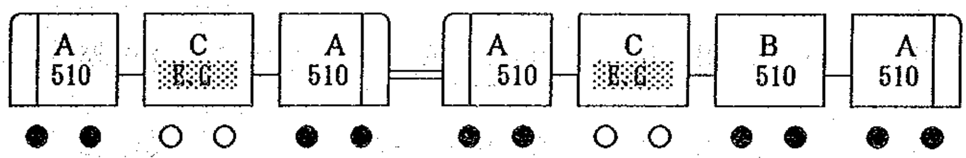
As more than 340 PS per car can be obtained with minimum difference in average power output per car, this plan appears to be most advantageous.

Power layout in the case of 510 PS engines is shown in Fig.6-3-3.
To ensure efficient maintenance work, DMUs are limited to three types (A, B, and C) as shown below.

(7-car consist)



(3 car + 4 car consist)



A: Head power car (with driver's cab)
B: Mid power car
C: Trailer (with diesel engine generator conditioning)

Fig.6-3-3 Power Layout for 510 PS Engines

Possible train consist by these cars types are shown in Table 6-3-2.

An engine generator mounted in the mid-trailer will feed electricity for 4 cars.

Table 6-3-2 Variation of Dispersed Power-Car Layout

No. of Cars	Operation Mode	Output per Car	No. of Engines	
1	Inadequate	510 PS		(One Cab Drive)
2	A－A ×	1020 PS (510)	2 or 1	(1 Engine) No Electricity for Cooler
3	A－C－A	340 PS	2	○
4	A－C－B－A	382 PS	3	○
5	A－C－C－B－A	306 PS	3	Poor Power
	A－C－B－B－A ×	408 PS	4	No Electricity for Cooler
6	A－C－B－B－C－A	340 PS	4	○
7	A－C－B • B－C－B－A	364 PS	5	○
8	A－C－B－B • B－B－C－A	382 PS	6	○
9	A－C－B • B－C－B • B－C－A	340 PS	6	○
10	A－C－B • B－C－B • B－C－B－A	357 PS	7	○
11	A－C－B • B－C－B－B • B－C－B－A	370 PS	8	○
12	A－C－B－B • B－C－B－B • B－C－B－A	340 PS	8	○

Under line ——— shows covering range of electricity for cooler

○ : Possible Operation

6-3-4 Required Number of DMU for RBCS

According to the train diagram shown in Fig.5-4-11 in Chapter 5, 21 seven-car trains and 2 one-car trains are operated during the morning peak hours (6:00 - 8:30) as shown in Fig.6-3-4.

The number of cars required for 21 seven-car trains are given as follows:

21 x 7 cars = 147 cars

In actual commercial operation, about 10% of the total number of cars in service are required as service reserve, and about 5% as inspection reserve. Hence, number of cars required for the commercial service are calculated as below;

147 cars x (1 + 0.1 + 0.05) ≒ 169 cars

Since passenger demand for the Seremban-Bangi section is less than what one car can carry, three cars will be necessary for shuttle service between the two stations:

2 trains x 1-car + 1 car (spare car) = 3 cars.

As a result, 172 DMU cars are required in 2005.

6-3-5 Number of DMUs to be Introduced by Year

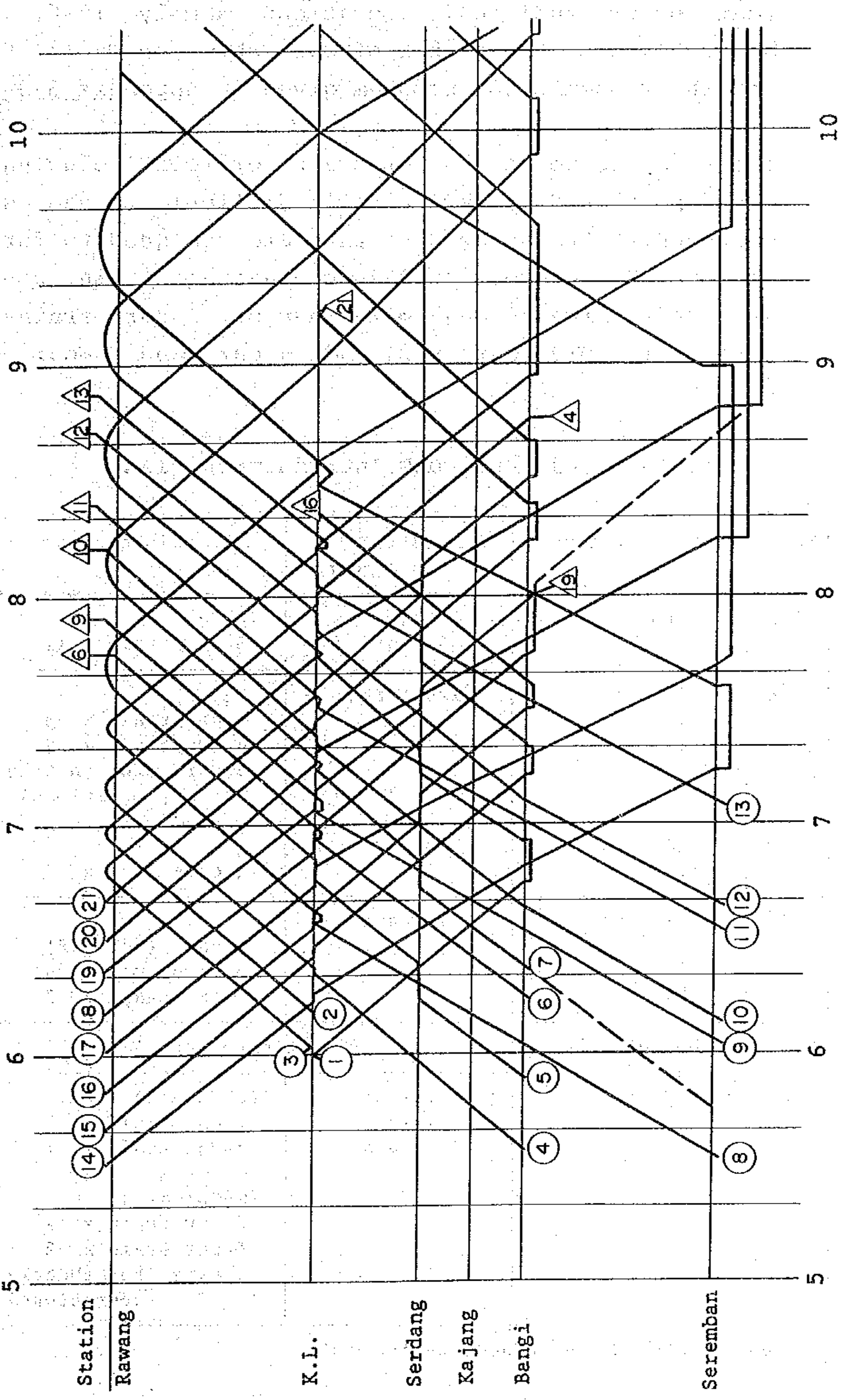
7-car-consist trains and 172 cars are required to meet commuter traffic demand in 2005, the target year of the RBCS Project.

In 1997, the commencement year of RBCS. A total of 19 train services are projected, except for shuttle cars between Seremban and Bangi; and if one car carry up to 245 persons, 5-car trains can serve the purposes most economically as illustrated in Appendix 6-3-7.

The year when 6-car trains becomes necessary to cope with transport demand is 2001. (Appendix 6-3-8)

In short, 5-car trains are to be put into service in 1997, 6-car trains in 2001 and 7-car trains in 2005.

Fig. 6-3-4 DMU Rostering Schedule



Consequently, trains are planned to be commissioned one year before full-scale operations, namely, 1996, 2000 and 2004, with the number of cars shown on Table 6-3-3 and their commitment program given in <u>Appendix 6-3-9</u>.

The RBCS Project calls for train services including 33 DMUs purchased by DTP which is difficult to use as 5-car-consist trains because they are designed to form 3-car trains. Hence, in 1997, the average train consist are made five through mixed use of 6-car trains (a three-unit DTP car x 2) and 4-car and 5-car RBCS trains.

Table 6-3-3 RBCS DMU Introduction Plan

Year	Number of cars	Cumulative number of cars	Train consist
1992	*(DTP) 33 cars	33 cars	(DTP) 3-car train x 11
1996	87 cars 48 36 3	120 cars	6-car train x 8 4-car train x 9 3 cars (for shuttle opeations)
2000	18 cars (18)	138 cars	2 cars x 9
2004	34 cars 5 15 14	172 cars	5 cars (for DTP) 15 cars (mid cars) 7-car train x 2
Total number of cars to be purchased under RBCS plan		(Cumulative total)	
		(Final train consist) 172 cars	(DTP cars) 7-car train x 5 3-car train x 1
			(RBCS cars) 7-car train x 17 6-car train x 2 3 cars (for shuttle operations)

*: Number of DMUs introduced by the DTP

6-4 Performance and Major Features of RBCS DMUs

On the basis of above consideration, performance and major features of the RBCS DMUs are proposed as follows.

(1) Major performance of RBCS DMUs

1) Maximum speed : 120 km/h
2) Acceleration performance
   0 to 100 km/h: 134 sec (7-car consist)
3) Deceleration performance
   120 km/h to 0: 700 m
   (100 km/h to 0: 486 m)

Fig.6-4-1 shows a tractive effort curve when five diesel engines of 550 PS are used as motive power, and Fig.6-4-2 and Table 6-4-1 shows a running performance curve and a distance-travel time table respectively.

Furthermore, Appendix 6-4-1 shows a running performance curve and a distance-travel time table for 6-car trains which show the worst running performance.

(2) Major features of RBCS DMUs

1) Car dimension

Length	:	21.00 m (distance between couplers 21.5 m)	
Width	:	2.75 m	
Floor level	:	1.10 m	
Weight	:	Head car (power car)	37.0 ton
		Mid car (power car)	37.0 ton
		Mid car (trailer)	28.0 ton

2) Body construction

Light weight stainless steel
Passenger doors: 3 double doors/single side,
1,300mm wide
Driver's cab : Pass-through type

Proposed below on the basis of the above consideration are major specifications for the RBCS diesel railcar:
The outer appearance of the car is illustrated on Fig. 6-4-3.

3) Engine/transmission

Water-cooling, series 6 cylinders, 19,000 cc,
4-cycle diesel engine, 550 PS, 2,100 r.p.m.
Turbo-charger/after cooler
Consist of power cars: 5 power cars + 2 trailers
(7-car consist)
1-engine and 2-axle drive system

4) Accommodation

Seat layout : Semi-cross type
Doorway step: None

5) Bogie

Type: Light weight bolsterless bogie
(with air suspension)

6) Operation safety devices

Automatic train protection (ATP)
(continuous-control)

7) Air-conditioning system

Ducted and centralized type air-conditioning system (roof mounted package type)

Power generating unit: A.C. 280 KVA (capable air-conditioning 4 cars)

8) Toilet

Not installed

9) Window

Double structure, tinted glass (partially openable)

Refer to Appendix 6-4-2 for detailed performance and major features of DMU.

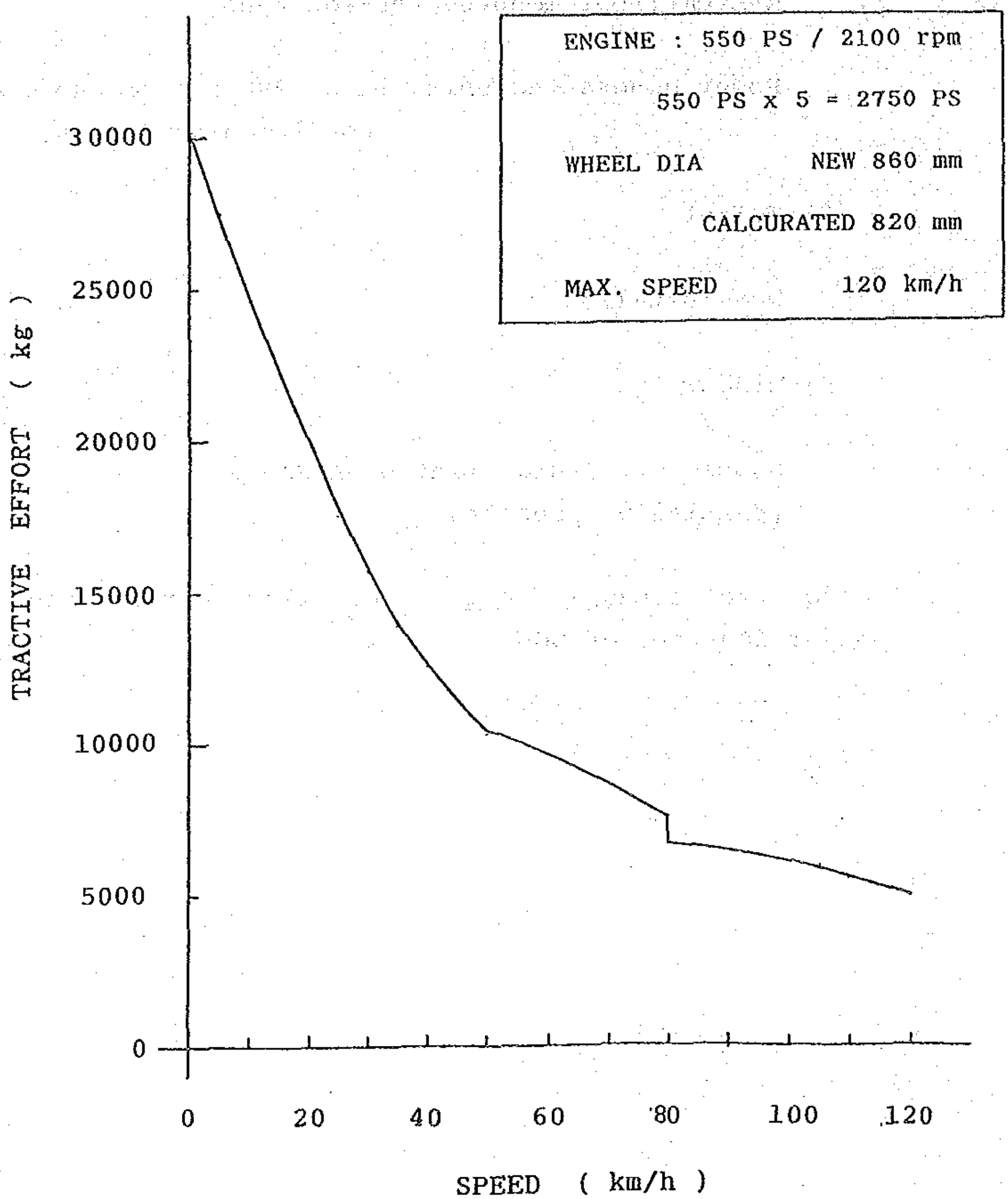


Fig.6-4-1 Tractive Effort Curve

Table 6-4-1 Distance-Travel Time Table
(7-Car Consist)

V km/h	F kg	Z kg	R kg	S m	T sec.	Akm/h/s
0	29186	30119	933	0.0	0.00	2.6076
5	26531	27500	969	1.4	1.99	2.3703
10	23610	24619	1010	6.0	4.20	2.1093
15	21208	22262	1054	14.7	6.67	1.8948
20	18804	19905	1101	28.2	9.44	1.6799
25	16526	17679	1153	47.8	12.57	1.4765
30	14507	15714	1208	75.1	16.14	1.2960
35	12614	13881	1267	112.0	20.21	1.1270
40	11242	12571	1329	160.5	24.86	1.0044
45	9997	11393	1395	222.1	30.07	0.8932
50	8749	10214	1465	300.1	35.97	0.7816
55	8282	9821	1539	395.6	42.51	0.7399
60	7943	9560	1617	505.4	49.38	0.7096
65	7469	9167	1698	630.9	56.60	0.6673
70	6860	8643	1783	776.4	64.35	0.6129
75	6510	8381	1871	944.4	72.68	0.5816
80	5632	7595	1963	1140.6	81.78	0.5032
85	4488	6548	2059	1389.9	92.64	0.4010
90	4127	6286	2159	1703.6	105.53	0.3687
95	4023	6286	2263	2055.9	119.23	0.3594
100	3654	6024	2370	2447.7	133.68	0.3265
105	3412	5893	2481	2896.3	149.42	0.3049
110	2905	5500	2595	3418.7	166.89	0.2595
115	2525	5238	2713	4055.8	187.25	0.2256
120	2141	4976	2835	4828.7	210.90	0.1913

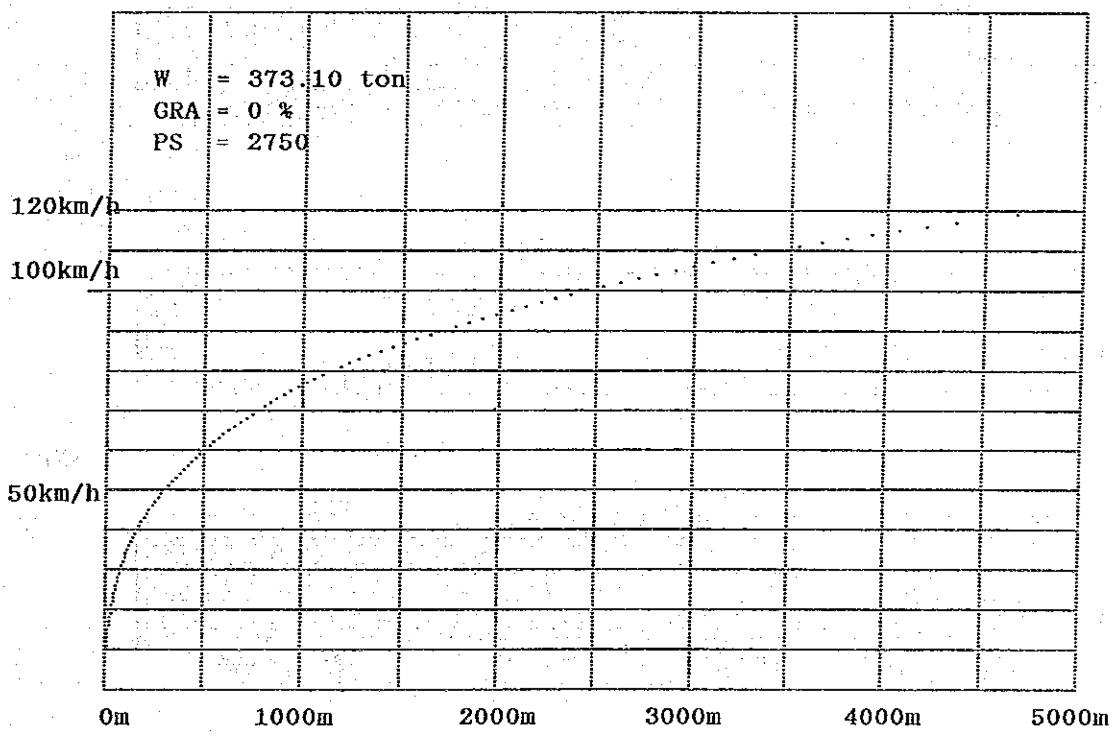
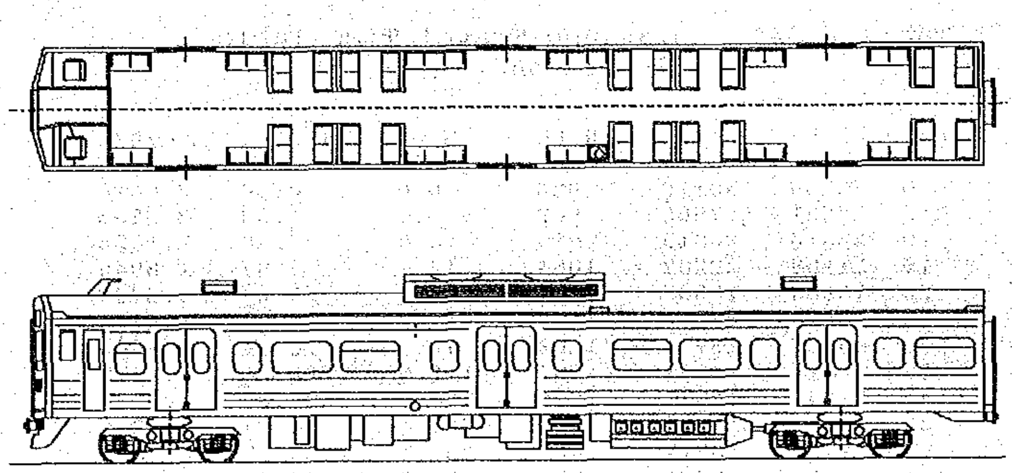
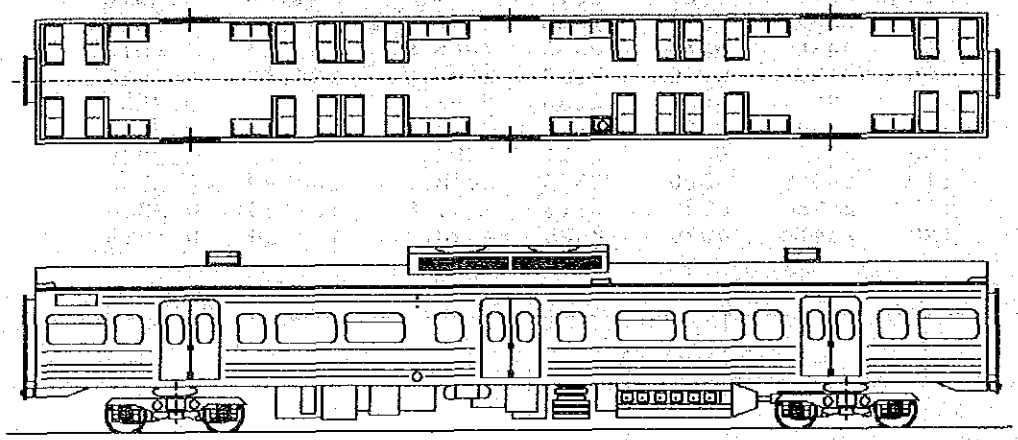


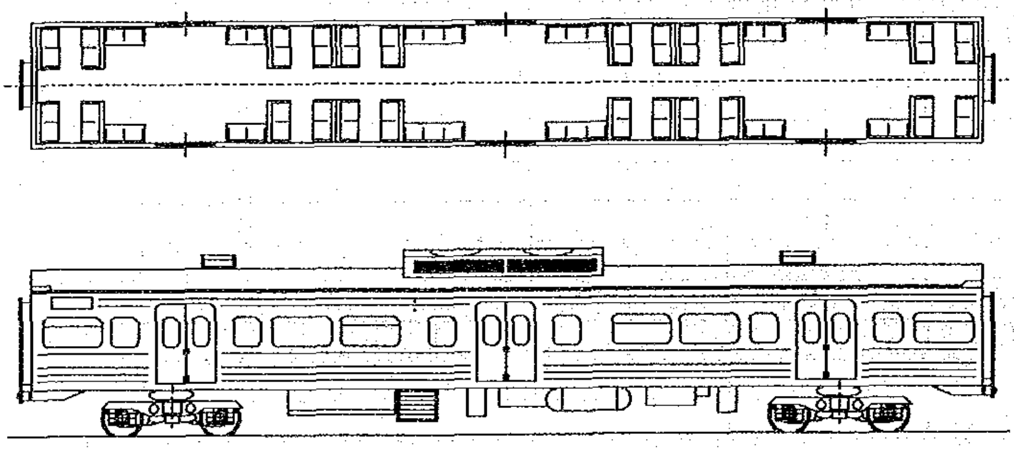
Fig.6-4-2 Running Performance Curve (7-Car Consist)



A type



B type



C type

Fig.6-4-3 External Appearance of RBCS DMUs

6-5 DMUs for Shuttling Operation

For the shuttling operation between Bangi and Seremban, one diesel railcar with double driver's cabs is used in consideration of relatively small traffic volume.

Use of the existing railbuses for this purpose is not feasible as they will becomes 8 years old in 1997.

Design concept and running performance of the railcar is almost the same as those of RBCS DMUs, except for car length which is shortened from 21 m to 15 m and engine power of 350 PS.

On the basis of above consideration, performance and major features of the DMU are proposed as follows.

(1) Major performance

1) Maximum speed : 120 km/h
2) Acceleration performance
(from 0 to 100 km/h): 131 sec
3) Deceleration performance
120 km/h to 0 : 700 m
(100 km/h to 0 : 486 m)

Running performance curve by use of diesel engine of 350 PS is shown in Fig.6-5-1, and a distance-travel time table in Table 6-5-1.

(2) Major features

1) Car dimensions

Length : 15.0 m
(distance between couplings: 15.50 m)
Width : 2.75 m
Floor level: 1.10 m
Weight : 29.5 tons

2) Construction

Light weight stainless steel
Passenger door: 2 double doors/single side
1,300mm wide
Driver's cab : Pass-through type on both ends

3) External appearance

Considerations should be given to car designs so that their appearance would impress the public with a image of modern commuter railway;

External appearance is shown in Fig.6-5-2.

4) Engine/transmission

Water-cooling, series 6 cylinders, 14,000 cc,
4-cycle diesel engine
350 PS, 2100 rpm
Turbo-supercharger/after-cooler

1-engine and 1-axle drive system

5) Accommodation

Seat layout : Semi-cross type
Doorway step : Not installed

6) Bogie

Bogie type
Bolsterless air-spring bogie

7) Operation safety devices

Automatic train protection (ATP)

8) Air-conditioning system

Ducted and centralized air-conditioning system
(roof mounted package type)
Compressor-directly-connected-to-engine type

9) Toilet

Not installed

10) Window

Double structure, tined glass (partially openable)

Table 6-5-1 Distance-Travel Time Table
(Shuttling Train)

V km/h	F kg	Z kg	R kg	S m	T sec.	Akm/h/s
0	3731	3833	103	0.0	0.00	3.0256
5	3393	3500	107	1.2	1.72	2.7516
10	3020	3133	113	5.2	3.62	2.4495
15	2713	2833	120	12.6	5.75	2.2004
20	2405	2533	129	24.3	8.13	1.9502
25	2111	2250	139	41.2	10.83	1.7124
30	1850	2000	150	64.7	13.91	1.5005
35	1604	1767	162	96.6	17.43	1.3011
40	1424	1600	176	138.7	21.46	1.1546
45	1258	1450	192	192.5	26.01	1.0206
50	1092	1300	208	261.0	31.19	0.8855
55	1024	1250	226	345.5	36.98	0.8304
60	971	1217	245	443.9	43.13	0.7877
65	901	1167	266	557.5	49.67	0.7304
70	812	1100	288	691.4	56.80	0.6585
75	755	1067	311	849.0	64.61	0.6125
80	631	967	336	1037.9	73.37	0.5114
85	471	833	362	1289.2	84.31	0.3822
90	411	800	389	1625.3	98.12	0.3330
95	382	800	418	2022.8	113.58	0.3097
100	318	767	448	2492.9	130.91	0.2583
105	270	750	480	3081.3	151.54	0.2193
110	188	700	512	3866.0	177.77	0.1522
115	120	667	546	5084.0	216.65	0.0975
120	51	633	582	7361.3	286.19	0.0418

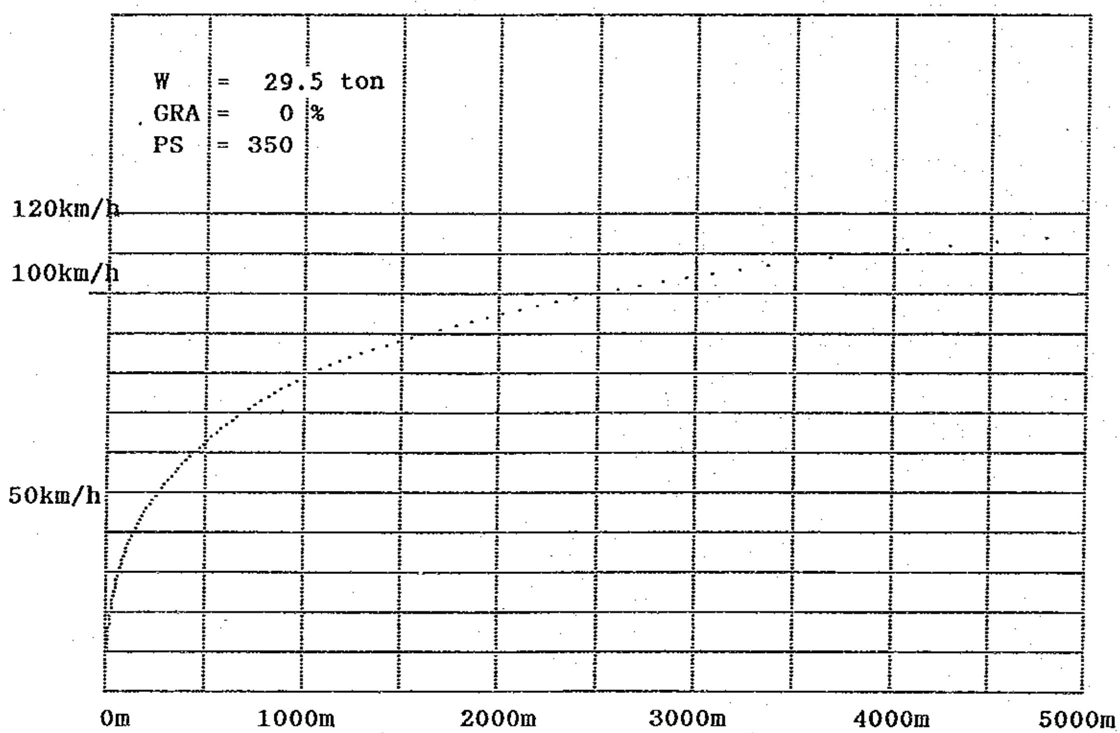
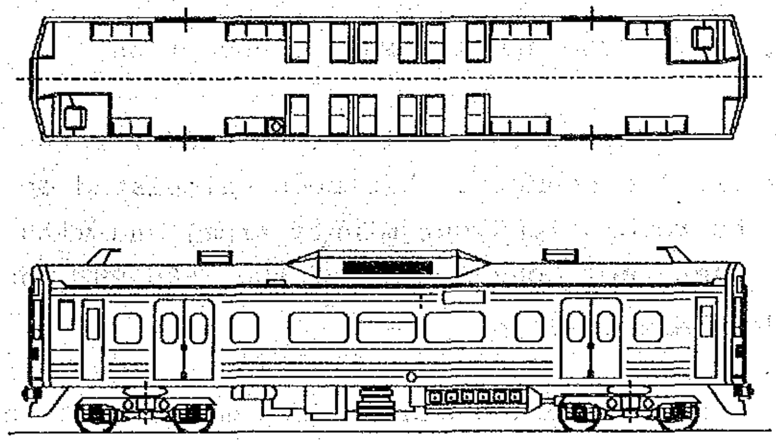


Fig.6-5-1 Running Performance Curve (Shuttling Train)



Width of the car body (inside) = 2.55 m	Width of Doorway	Seat Width	Pitch of Seat	Length	Space for Seat

Semi-cross seat type B	Front Wall	Driver's Room	Middle Wall	1.4 Door-1	Door-2	0.43 Long seat	1.5 Box seat	Rear Wall	Total Length	Impossible Space
Both Ends Head Car for Shuttle Service	0.15	1.5+1.0 2.5	0.1x2 0.2	2 2.8		11 4.73	3 4.5	0.15	15.03	1

Passenger Capacity					Load Factor
Seating Capacity	Standing Areas	Standing Capacity	Carrying Capacity	0.14 Max. Capacity	Maximum Ratio
(persons) 45	(Sq.m) 15.01	(persons) 46	(persons) 91	(persons) 152	167 %

Fig.6-5-2 External Appearance of Shuttling DMU

6-6 Yearly Fuel Consumption of DMU in RBCS Project

6-6-1 Engine for DMU and Its Fuel Consumption

A 550-PS diesel engine is to be used for the RBCS DMU. Its fuel consumption has been calculated on the basis of the revolutions per minute (rpm) and with reference to the fuel consumption of the 600-PS engine. (See Appendix 6-6-1)

The maximum torque and the maximum output occur when the number of revolutions per minute reaches 1,500 and 2,100. Fuel consumption and output generated at those moments are given on Table 6-6-1, in parallel with data at idling.

Table 6-6-1 Fuel Consumption of 600-PS Engine for DMU

Status of engine use	Output	Number of revolutions	Fuel consumption
Maximum output	600 PS	2100 rpm	124.555 l/hr
Maximum torque	470 PS	1500 rpm	92.178 l/hr
Idling	——	625 rpm	3.462 l/hr

Note: l/hr = Liter/hours

6-6-2 Fuel Consumption Depending on Running Pattern of Train

The actual running behavior is divided into two patterns, one power running and the other coasting, and fuel consumption is calculated for each.

(1) Fuel consumption at power running

The ratio of fuel consumption at the time of maximum torque to that at maximum output is put at one to one. Fuel consumption is computed as follows, considering that a 600-PS engine has a maximum output about 10% larger than that of the RBCS engine and that actual power running does not mean traveling at maximum torque and output:

(124.555 L/hr x 0.5 + 92.178 L/hr x 0.5) = 108.367 L/hr
108.367 L/hr x 0.8 = 1.445 L/min.

(2) Fuel consumption at coasting

The engine mostly remains idle while the car is coasting, inclusive of braking moments. Hence the fuel consumption is calculated presuming the ratio of power running to idling as 1 : 9.

(108.367 L/hr x 0.1 + 3.462 L/hr x 0.9) = 13.953 L/hr
= 0.232 L/min.

6-6-3 Fuel Consumption for Service Sections

In order to compute fuel consumption in the sectors of the Rawang-Seremban section, the power running time rate for local, rapid and shuttle services have been completed based on the train running curve in Chapter 5. The result are tabulated on Table 6-6-2.

Table 6-6-2 Power Running Rate by Sector and Train Service

Service section		Power running rate
Rawang - K.L.	(Local)	50.00 %
K.L. - Bangi	(Local)	47.35 %
K.L. - Seremban	(Rapid)	46.43 %
Bangi - Seremban	(Shuttle)	87.70 %

Fuel consumption per-engine for every section shown on Table 6-6-3 is derived from the power running rates on Table 6-6-2 and fuel consumption for each traveling pattern. (See Appendix 6-6-2)

Table 6-6-3 Fuel Consumption Per Engine by Section

(Liter/Engine)

Service sector	Fuel consumption
Rawang - K.L. (Local)	32.396
K.L. - Bangi (Local)	34.448
K.L. - Seremban (Rapid)	47.869
Bangi - Seremban (Shuttle)	23.907

Note 1: The engine idles for 1.0 minute at ordinary stopover stations and 2.5 minutes at K.L. Station (an actual stop for 5.0 minutes).

Note 2: Fuel consumption for entering and leaving the maintenance depots is estimated as 5% of the total fuel consumption.

Note 3: Fuel consumption of the shuttle DMU mounted with a small 350-PS engine is calculated with the discount rate of 0.536.

6-6-4 Total Yearly Fuel Consumption

Yearly fuel consumption is estimated to grow in a phased manner because 5-car trains are put into service in 1997, 6-car trains in 2001 and 7-car trains in 2005 and the daily number of services will slightly increase in the Rawang-K.L. section. (Refer to Appendix 6-6-4.)

Figures listed on Table 6-6-4 are calculated from fuel consumption per-engine by section given in Appendix 6-6-2, and considering the daily number of train services and the number of engines per train.

Table 6-6-4 Annual Fuel Consumption

(Liter/year)

Year	Annual fuel consumption
1997 - 2000	9.41×10^6
2001 - 2004	10.20×10^6
2005 and Beyond	13.72×10^6

Details of the calculation process are shown on Appendix 6-6-3.

Given below are figures indicating annual fuel consumption of the DTP DMU train for a period from 1993 to 1997. They are derived from the rate of kilometerage of the DTP and the RBCS Project (2005-) tabulated on Appendix 6-6-4.

$$Q_{DTP} = Q_{RBCS} \times \frac{TD_{DTP}}{TD_{RBCS}} = 13.72 \times 10^6 \times \frac{22,623}{61,225}$$

$$= \underline{5.07 \times 10^6} \text{ (Liter/year)}$$

Q_{DTP} : Total fuel consumption in 1993 under DTP

Q_{RBCS} : Total fuel consumption in 2005 under RBCS

TD_{DTP} : Total kilometerage in 1993 under DTP

TD_{RBCS} : Total kilometerage in 2005 under RBCS

6-7 Image Impact of RBCS Diesel Railcar

A public image of the RBCS Project is an important key decisive of its outcome.

Introduction of stainless steel railcars with a modern design sense will prelude to the arrival of a new era.

Possible alternatives for attractive RBCS diesel railcars may include double-deckers, high-deckers, and first-class cars as well as cars exclusively specified for ladies and children.

For example, adoption of double-deck cars or high-deck car for a limited number of mid cars will greatly improve image of railway with minor investment. (See Appendix 6-7-1)

Altrough MRA's rolling stock gauge does not allow employment of those cars, their operation limited between Rawang and Seremban may be possible, because there remains a lot of room between existing construction gauge and rolling stock clearance. (See Fig. 7-1-1 in Chapter 7 "Railway Ground Facilities")

Chapter 7

RAILWAY GROUND FACILITIES

Chapter 7 RAILWAY GROUND FACILITIES

Improvement of ground facilities of RBCS is planned to enable the DMU operation as planned in Chapters 5 and 6. The precondition of the improvement is that the DTP will have been completed by 1993, and other related projects including the Sixth Malaysia Plan will be implemented as scheduled.

7-1 Track and Structure

7-1-1 Track and Structure Conditions without the RBCS Project

(1) Right of way

Track addition is made utilizing the existing R/W of 40 m width at the minimum between stations and 50 m to 130 m width in the station yards. Acquisition of the R/W is considered necessary in the following cases;

1) Expansion of Rawang DMU depot and some station plazas

2) Construction of by-pass tracks at three junctions (Batu Jct., Port Klang Jct., and Salak South Jct.)

Squatters occupying the R/W are to be removed by the governmental measures.

(2) Alignment and structure

In the DTP, additional track is constructed mostly in the west side of the existing track. The track realignment to improve the train speed is not implemented.

New by-pass tracks for freight train operation are laid at three junctions mentioned above. Because of the topographical and economical restraints, the minimum radius of the curvatures will stay at 110 m at Port Klang Jct. and 160 m at others. All of the three junctions are constructed as at-grade crossing.

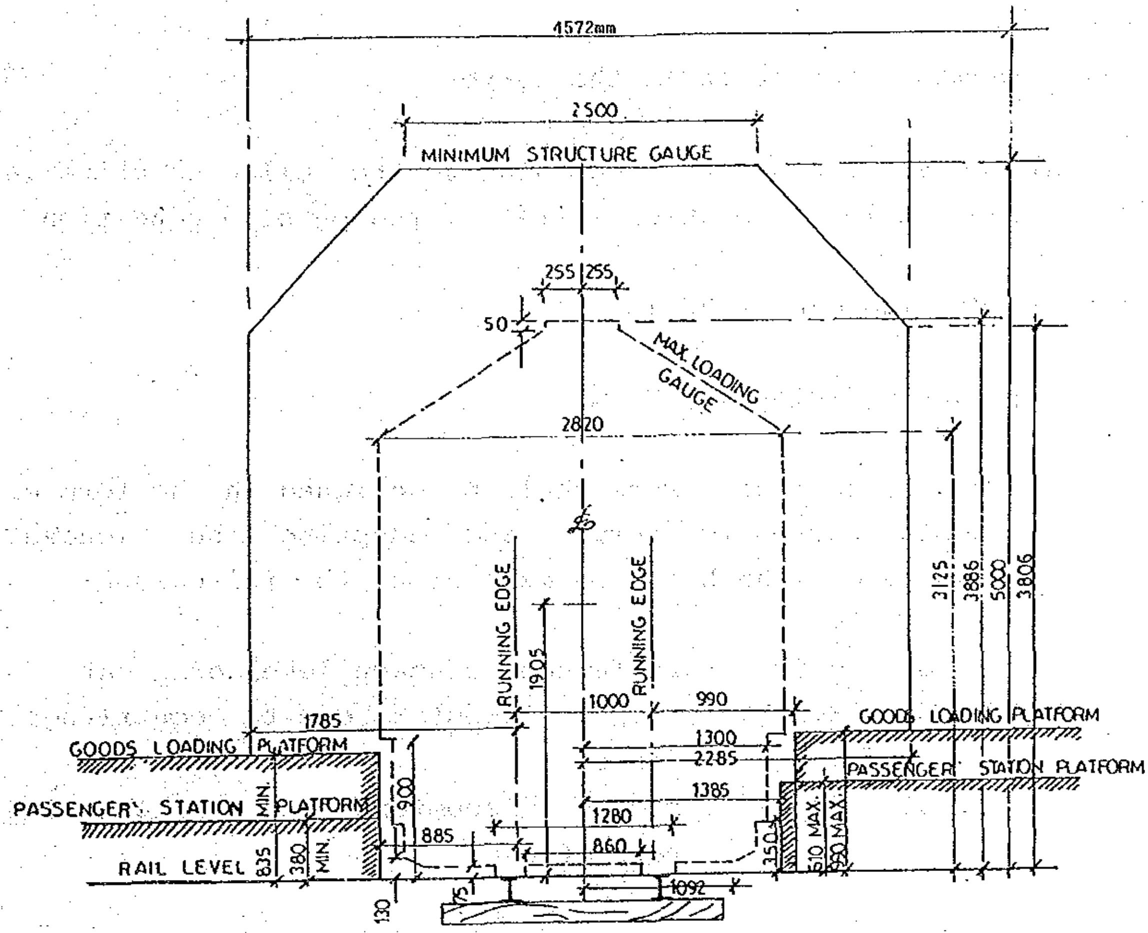
(3) Tracks

Rehabilitation of the existing track will be made in the framework of 6th Malaysia Plan and laying of new track, in the framework of DTP. The DTP is planned with the following standards.

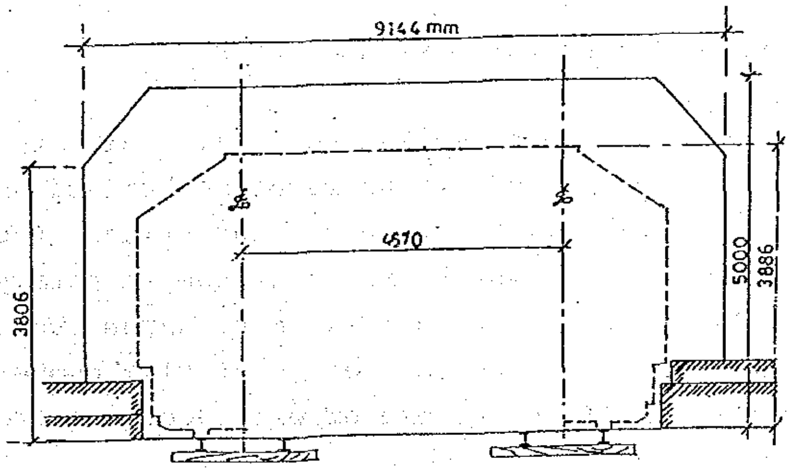
Rail : 40 kg/m (imported)
Sleeper : PC sleeper (prestressed concrete with 700 mm spacing. Only fastenings are imported).
Ballast depth : 250 mm (with drainage)
Long welded rail : one continuous span in the whole inter-station section, if the alignment allows.

(4) Structure and loading gauge

The distance between the center lines of the two tracks is 4.57 m both in the inter- and intra-station area. These gauges are shown in Fig. 7-1-1.



SINGLE TRACK



DOUBLE TRACK

Fig. 7-1-1 Structure and Loading Gauge at Present

(5) Alignment regulation in the curves

All curves are set out according to the following criteria except at location which is restricted by site condition.

1) Maximum Cant = 90 mm.

2) Cant deficiency = 50 mm.

3) The transition curves shall be designed in the form of cubic parabolic curves and adopting the longest indicator length (L in meters) of the followings:

a. L1 = 0.6E. : rail-wheel contact level of a car
b. L2 = EV/126 : riding discomfort due to centrifugal force
c. L3 = 0.46V : riding discomfort due to changing rate of cant.

Where E is the equilibrium cant in mm and V is the maximum speed in km/hr.

Where the Site conditions permit, L1 shall be equal to E.

(6) Maintenance system for permanent ways

Two hours of manual works(e.g. for rail replacement) during the daytime and 3-4 hours of mechanized works (e.g. tamping by multiple tie tampers, and bridge replacement) are secured at present by means of the temporary changes of freight train schedules. New maintenance system will be in practice after the completion of DTP. Number of MRA maintenance staff per kilometer will decrease from 1.0 at present to 0.5.

(7) Speed restrictions due to soil structure

From economic consideration, in general, alluvial soil is used for the subgrade materials.

The most serious speed restriction is now in force in the section between km 401.3 and km 402.1 near Sungai Besi. It is due to the soft ground, caused by the underground water flowing between the pond excavated in former mining holes. After reinforcement measures, of the roadbed to be implemented by the DTP, this speed restriction will be removed.

A few other speed restrictions due to track conditions are to be removed by the DTP.

(8) Track layout of station yard

Track layout at most of the stations is designed in the DTP, based on a principle that the long distance passenger / freight trains are given priority over the local trains. The local trains therefore wait at intermediate stations to let the long distance trains pass them over.

In this context, the stations of a standard type have two passing-through (main) tracks without platforms and two sidings with platforms. The effective length is 610 m, considering the length of the freight trains.
(Refer to Fig. 7-1-2)

Major particulars of a standard station for DMU trains in DTP are as follows:

1) Effective siding length : 610 m
2) Platform length : 130 m (21.5 m x 6 coaches)
   height : 1050 mm
   width : 6 m

3) Foot overtrack (passenger) bridge

width : 2.5 m

structure : concrete

4) Fence : install surrounding station compound

A standard halt has a foot overbridge, a high platform (1050 mm), but no staff is manned. The nearest private store is entrusted the ticket issuing.

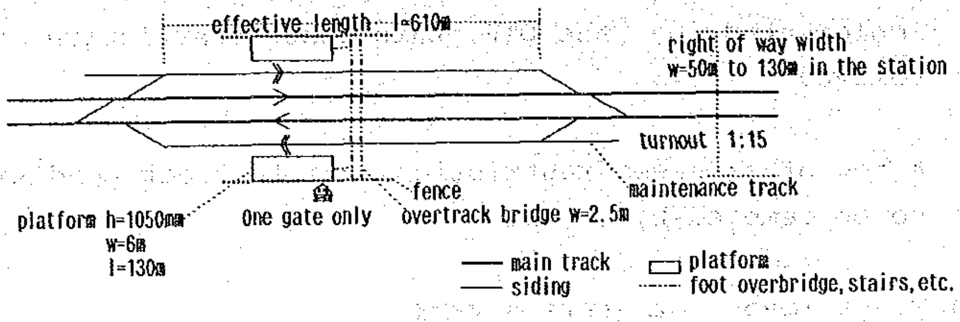


Fig. 7-1-2 Standard Track Layout in DTP

(9) DMU depot

DMU Depots with two stabling tracks and an inspection track with shelter are provided at Rawang and Seremban station yards.

(10) K.L. station

The K.L. central station has only four main tracks with three platforms. Since the main building is a historical islamic building of aesthetic design, construction of additional tracks / platforms by remodeling the station building will not be allowed. The height of the central platform remains low (650 mm) even after the DTP.

Parcel is handled at the Rawang and west side of the station yard using 2 siding tracks. There is a plan to shift the parcel tracks to the eastern part of the

Brickfield yard. A postal track stretches to the Rawang and east side, where new platform is provided in DTP, to handle DMU trains.

(11) Brickfield complex

Various MRA field organs are located here, such as a passenger coach shed, a diesel locomotive shed, a rail bus shed, and a rescue crane base on the west side of the main track, while on the east side, a freight station, go-downs and an inland custom clearance depot, a marshalling yard, a freight car shed, freight car storage tracks and a parmanent way maintenance depot.

(12) At-grade crossing with road

At a level crossing, the road traffic is blocked for approximately 20 minutes for each train passing. The total blocking time will increase in proportion to the increase in the railway traffic. Therefore, the Ministry of Works has a plan to grade-separate all of the 20 public crossings between Rawang and Seremban and also abolish private crossings.

7-1-2 General Principles for Track Improvement in RBCS

Requirements:

What the commuter service makes the railway operation peculiar is the mass transportation, one directioned and concentrated flow during a few hours of the day.

Hence, the following requirements should be satisfied in planning the station track layout for RBCS.

1) Short headway
2) Punctuality
3) Riding comfort
4) Easy transfer

The principle improvements required for the RBCS are mentioned below:

(1) Alignment

Some transition curves and cant are to be added to improve DMU speed in the station yards where their track layouts are modified in the RBCS Project.

Ir calculating the transition length, the equation L2 = EV/126 (Refer to chapter 7-1-1 (5)) becomes critical, when the curve radii are over 400 m. Measures for speed-up recommended to be taken in the future are described in Appendix 7-1-1, by showing the examples in Japan.

(2) Platform

The platform length in the DTP (130 m) is to be lengthened to 165 m, in consideration of the 7-car formation of a DMU train and a marginal length of 14.5 m.
In some station yards whose track layouts are modified in the RBCS Plan, additional space is to be secured to facilitate the future extension of the platform up to 225 m, allowing 10 car-DMU formation.

Rawang, Kajang and Bangi will have island-type platforms with 8 m width to secure the space of the passengers' queue and escalators by the side of staircase (Refer to Appendices 7-1-6 and 7-1-7).

(3) Turnout

In the DTP, turnouts on the main tracks are to be upgraded from No. 9 to No. 15 which allows passing speed of 48 km/h when branching off.
Since the deceleration performance of DMU for RBCS is planned at the same level with that of DMU for DTP, the No. 15 turnouts on the main tracks are acceptable for the RBCS plan.
On the siding tracks where train speed is low, No. 9 turnouts (permissible speed of 28 km/h) are used.

(4) Station track layout

In the DTP, two passing-through tracks run in the center of a yard and two sidings each with a platform are laid in the outer sides of the passing-through tracks. (Refer to Fig. 7-1-2) This track layout is suitable for an express train to run-through the station while freight/local trains refuge at the sidings.
However, from the viewpoints of commuter train operation this track layout will cause the following problems;

1) At every stop, a DMU train has to branch off the turnout with the restricted speed of 48 km/h. From here to the fixed stopping point, it has to keep running for another 300 - 400 m because of the long siding length designed for a freight train.

   In the meantime, passengers suffer two types of discomforts; Viz. a sudden lateral force when the train branches off, due to the non-transition curve at the turnouts, and a forward force due to two brake applications.

2) Too early brake application at the turnout makes the train headway longer.

3) Passengers' transfer is impossible between a rapid DMU train and a local DMU train.

To solve these problems, the track layout with two island platforms as shown in Fig. 7-1-3 is recommendable. In this layout, a local DMU train can stop on the main track unless refusing the express/rapid trains is required.

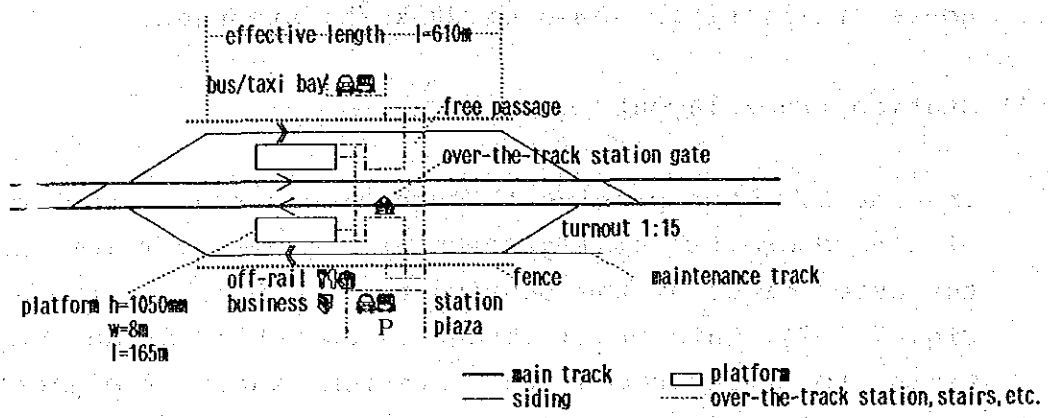


Fig. 7-1-3 Recommended Track Layout in RBCS

In the RBCS plan, however, in order to save the investment, the modification of the station track layout from side-platform type to island-platform type is planned only for Kajang and Bangi stations, where passenger transfer between DMU trains occur regularly.

In the above two stations, passing-through tracks are located at the outer sides of the station yards and the turn-around/siding tracks are laid in the inner part. This will minimize the traffic disturbance arising from the level crossing of train route between a turning-around DMU train and a passing-through long distance/freight trains. (Refer to Fig. 7-1-4(3))

(5) DMU stabling track

To enable efficient DMU rostering, DMU depots and stabling tracks are planned to be laid at Rawang, Seremban, Kajang, Bangi and Kuala Lumpur (Brickfield). A tentative DMU stabling plan is shown in Table 7-1-1.

(6) New halts

Considering the progress of the regional development plans such as housing and industrial areas along the railway corridor, as mentioned in Chapter 13-3-2, three halts, H1, H2 and H3, are newly constructed in the RBCS. (Refer to Table 7-1-2)

Their locations are decided taking account of future population distribution around the halts, access roads, feeder-bus service and track conditions.

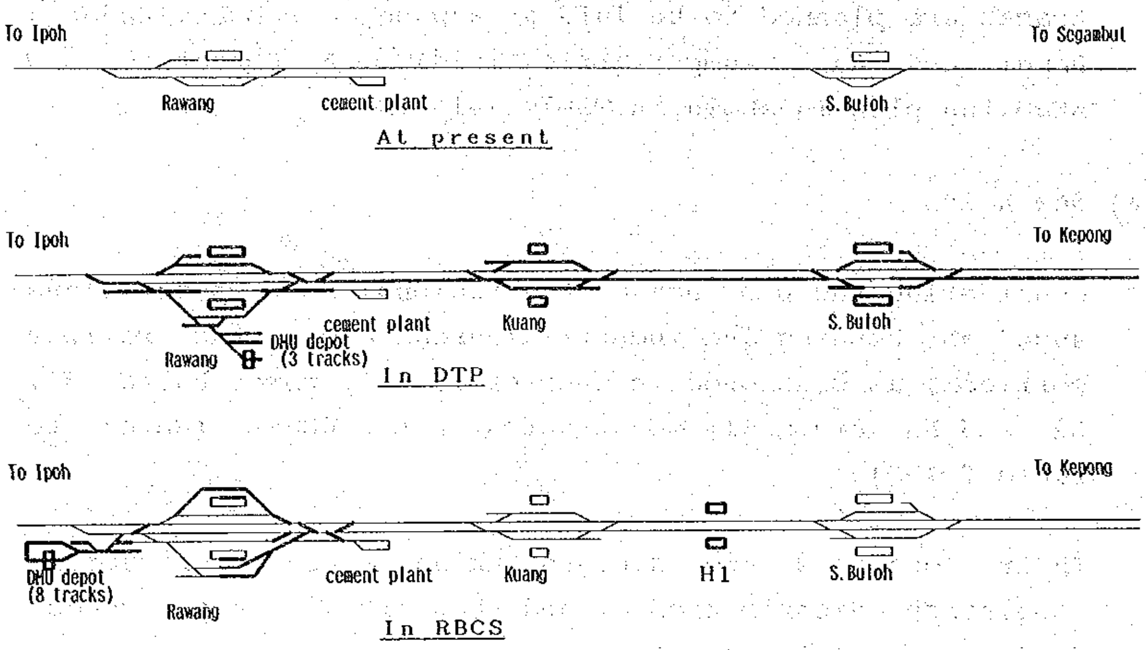
For example, the H1 halt is located at 365.5 km between Kuang Station and Sungai Buloh station. Around here there is a housing development plan called "HARTA KEMUNCAK", in the framework of the Sungai Buloh Satellite Town Project. H1 will be inaugurated in 2002 when the halt will have 6,900 passengers per day.

Since only local DMUs stop at these halts, siding tracks are not constructed, and only side platforms are constructed. Station staff will be posted to these halts to handle considerable number of passengers, while Nilai and Tiroi halts built by DTP will be unmanned due to their small passenger traffic.

Platform track conditions such as curvature and gradient of the newly established halts are fairly good except around 5 per mil gradient at H1 and H2. It is permissible in view of high braking performance of DMUs.

Note: JR regulates the maximum gradient of 10 per mil and the minimum curve radius of 400 m.

(1) Rawang–Sungai Buloh



(2) Kepong–Segambut

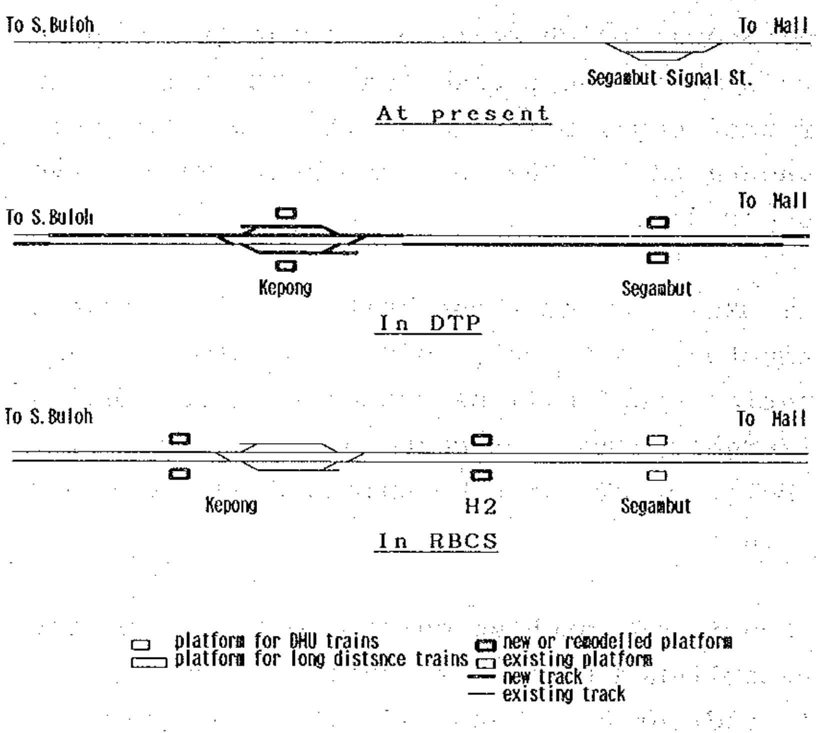


Fig. 7-1-4(1) Modification of Track Layout (between Rawang and Segambut)

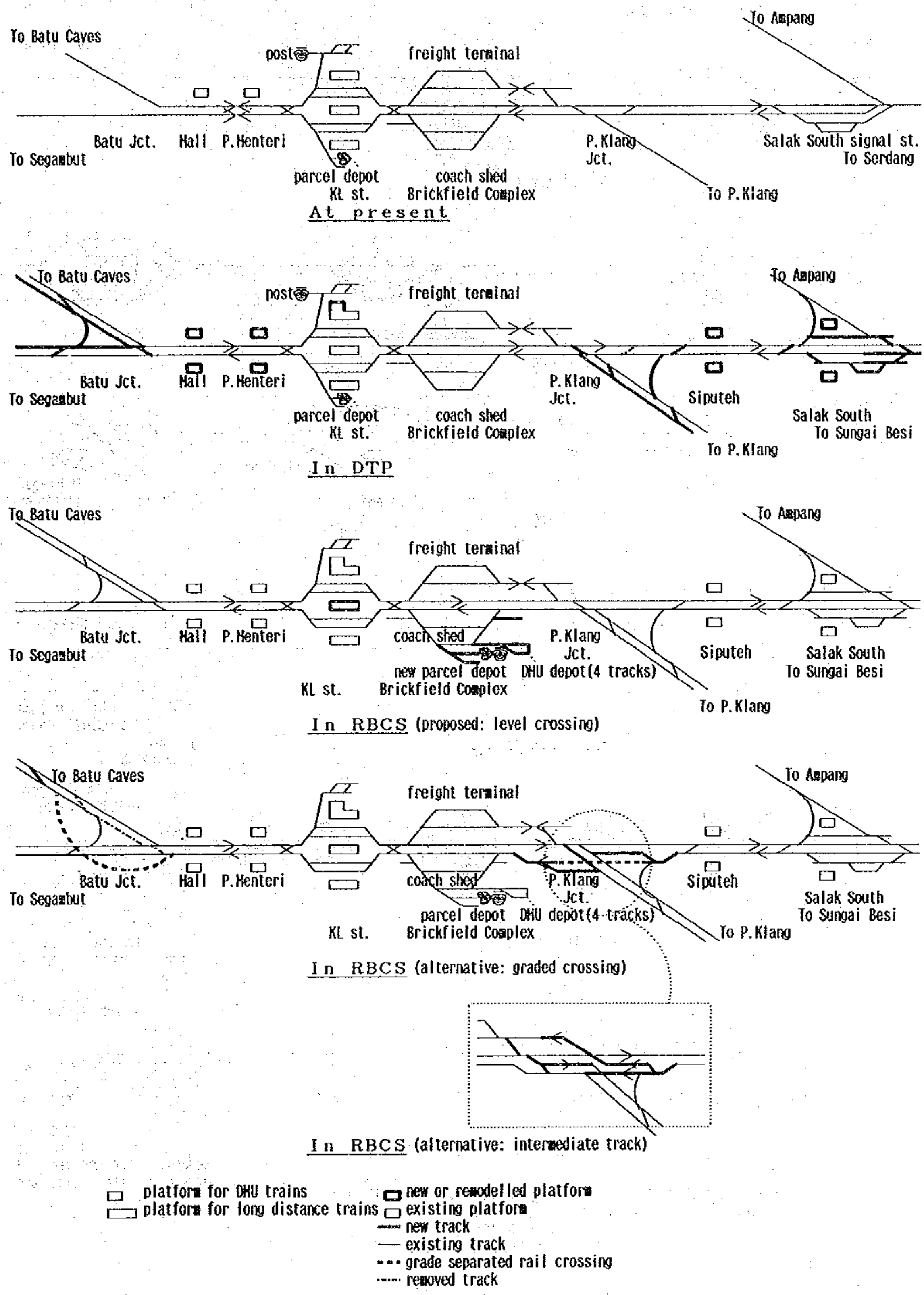


Fig. 7-1-4 (2) Modification of Track Layout
(between Batu Jct. and Salak South)

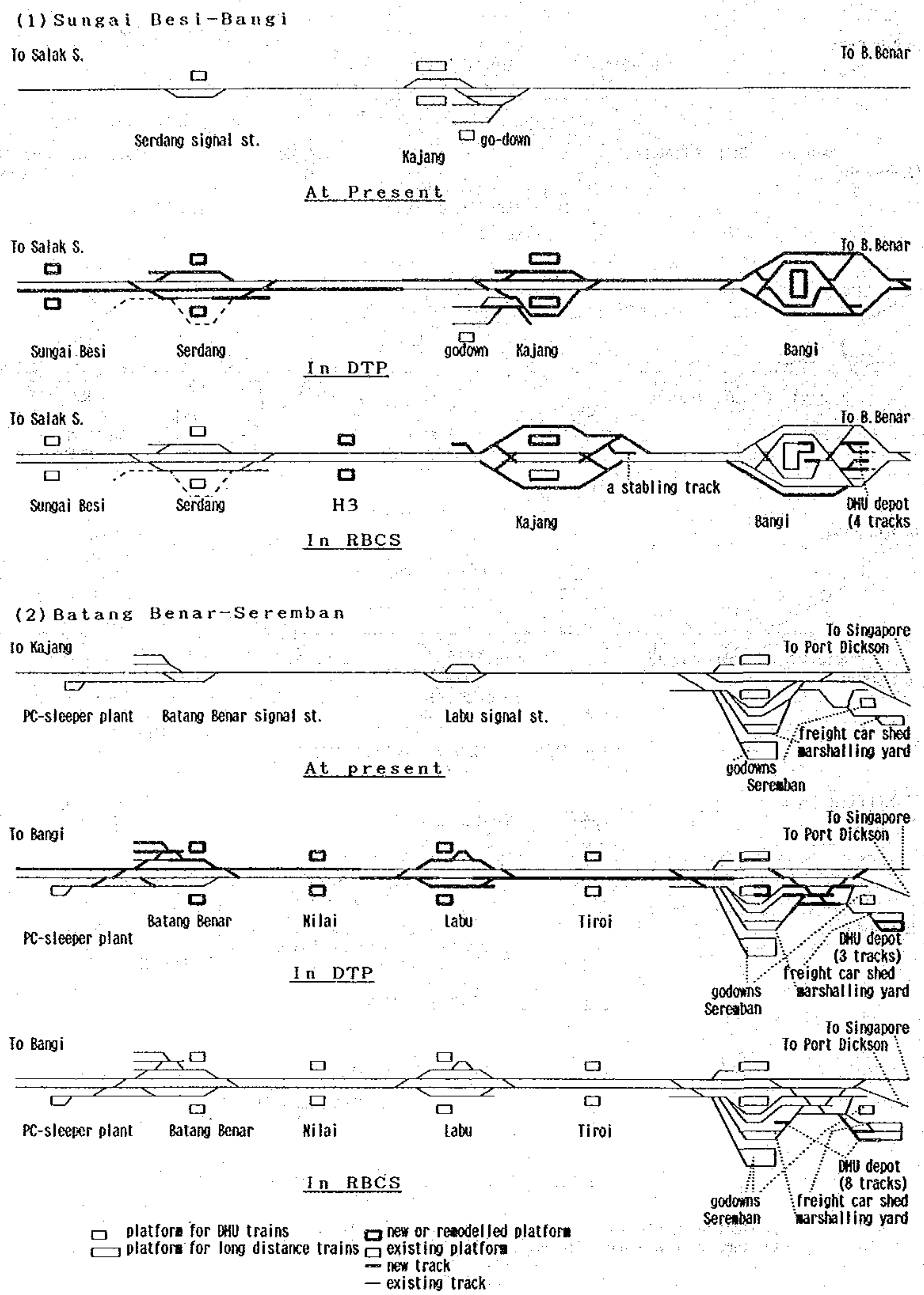


Fig. 7-1-4 (3) Modification of Track Layout (between Sungai Besi and Seremban)

Table 7-1-1 DMU Stabling Tracks in 2005

Location	Number of trains stabling over night		Remarks
	at platform	at stabling track	
Rawang	1	8#	*One stabling track with no over night trains. **Two stabling tracks with 3 one-car trains. ***For overhaul #Including one service reserve train for each location
K.L./Brickfield		4#	
Kajang		0 (1)*	
Bangi		4	
Seremban		6 + 3#*	
Sentul		1***	
Total	1	23 + 3	

Table 7-1-2 Modification of Stations

RBCS Stations (inauguration year)	At Present: Location (a) km	At Present: Trains handled (b)	At Present: Station type (c)	DTP: Trains handled (d)	DTP: Station type (e)	DTP: No. of tracks w/platform Main (f)	DTP: No. of tracks w/platform Sidings (g)	RBCS: New location (h) km	RBCS: Trains handled (i)	RBCS: Station type (j)	RBCS: No. of tracks w/platform Main (k)	RBCS: No. of tracks w/platform Sidings (l)	RBCS: Specific alignment Gradient (m) per mil	RBCS: Specific alignment Curve (n) m	Inauguration year of transfer station LRT (p) year	Inauguration year of transfer station Monorail (q) year
1 Rawang	355.5	LBF	S	LDF	S	0	3		LDF	S	0	4				
2 Kuang	363.2	↓	↓	D	S	0	2		D	S	0	2				
3 H1(2002)		↓	↓	↓	↓			365.5	D	H	2	0	5.1pm	straight		
4 Sungai Buloh	369.8	LB	S	LD	S	0	2		LD	S	0	2				
5 Kepong(2002)#1	376.9	↓	↓	D	S	0	2	375.7	D	S	2	0			2002	
6 H2(1997)		↓	↓	↓	↓			378.5	D	H	2	0	5.0pm			
7 Segambut	380.5	↓	S	D	H	2	0		D	H	2	0				
8a Batu Jct.		↓	↓	↓	b				↓	b			level	R=380m		
9 Mall #3	384.6	↓	h	D	H	2	0	384.2	D	H	2	0			1998	1993
10 J.P. Menteri	385.6	↓	h	D	H	2	0	385.7	D	H	2	0			1998	1993
8b Kuala Lumpur	387.5	LB	S	LD	S	2	3		RLD	S	2	2			1998	1993
8c Brickfield		↓F	b	↓F	b				↓F	b						
8d Port Klang Jct.	390.1	↓	b	↓	b				↓	b			level		1998	1993
11 Siputeh	391.3	↓	↓	D	H	2	0		D	H	2	0				
12 Salak South	394.5	↓	S	D	S	0	2		D	S	0	2				
13 Sungai Besi	399.0	↓	↓	D	H	2	0		D	H	2	0			2010	
14 Serdang	404.1	↓	S	D	S	0	2		D	S	0	2				
15 H3(1997)		↓	↓	↓	↓	2	0	408.8	D	H	2	0	level			
16 Kajang #2	414.3	LF	S	LDF	S	1	2	414.7	RLD	S	2	2	level			
17 Bangi	425.6	↓	↓	D	S	0	2		D	S	0	3				
18 Batang Benar	435.2	↓F	S	DF	S	0	2		DF	S	0	2				
19 Nilai	439.7	↓	↓	D	H	2	0		D	H	2	0				
20 Labu	446.7	↓	S	D	S	0	2		D	S	0	2				
21 Tiroi	452.0	↓	↓	D	H	2	0		D	H	2	0				
22 Seremban	460.8	LF	S	LDF	S	2	1		RLDF	S	2	1				

(b),(d),(i) Train type which stops at the station/halt :R = rapid train (no additional charge), L = long distance train & D = DMU train, F = freight train, B = rail bus, ↓ = no trains to be handled
(c),(e),(j) S = Station where trains cross or pass, b = Signalling station
H = Halt, h = Halt only for rail bus between Port Klang and Sentul

#1 The location of the platforms is moved in 2002
#2 The location of the station is moved in DTP
#3 Mall is not observed handling passengers at present.

7-1-3 Track Layout Improvement Plan for Main Stations

(1) Rawang station

The Rawang station plays an important role not only as the northernmost terminal of RBCS network but also as a station dealing with long distance passenger trains and freight trains carrying cement.

Major improvements planned are as follows:

1) Relocation of the Stabling tracks to the North

Since DMU trains go out into the car depot frequently, the yard is constructed adjacent to the station interlinked with a straight tracks to minimize the turn-around time. (Refer to Fig. 7-1-5(1))

At the newly constructed west gate a station plaza will be provided to facilitate transfer to feeder mode. (Refer to Fig. 7-1-11)

In this context, an alternative track layout plan is not preferable, because this plan will occupy the land for the station plaza, when DMU depot is extended in RBCS.

2) Platforms

West island platform of 1050 mm height is extended from 130 m to 165 m. It is widened from 6 m to 8 m to allow longer passenger queues waiting for first departure RBCS trains, and introducing elevators for handicapped people in future. Side platform in the east is changed to an island type by adding a new siding.

To cope with the future extension of the double tracking project to the north and increasing long distance trains, the layout shown on Fig. 7-1-5(2) is recommendable. Here another island-type platform is added to eliminate level crossing which will give rise to traffic disturbance among turn-around DMU trains and passing-through long distance trains.

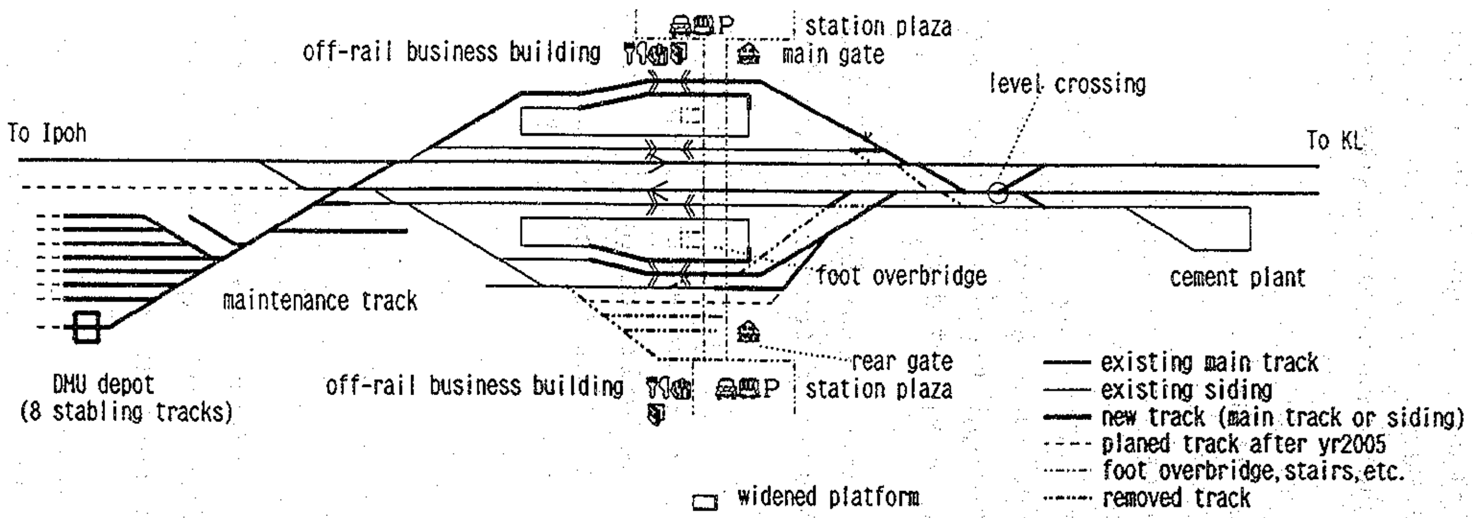


Fig. 7-1-5 (1) Track Layout of Rawang Station in RBCS

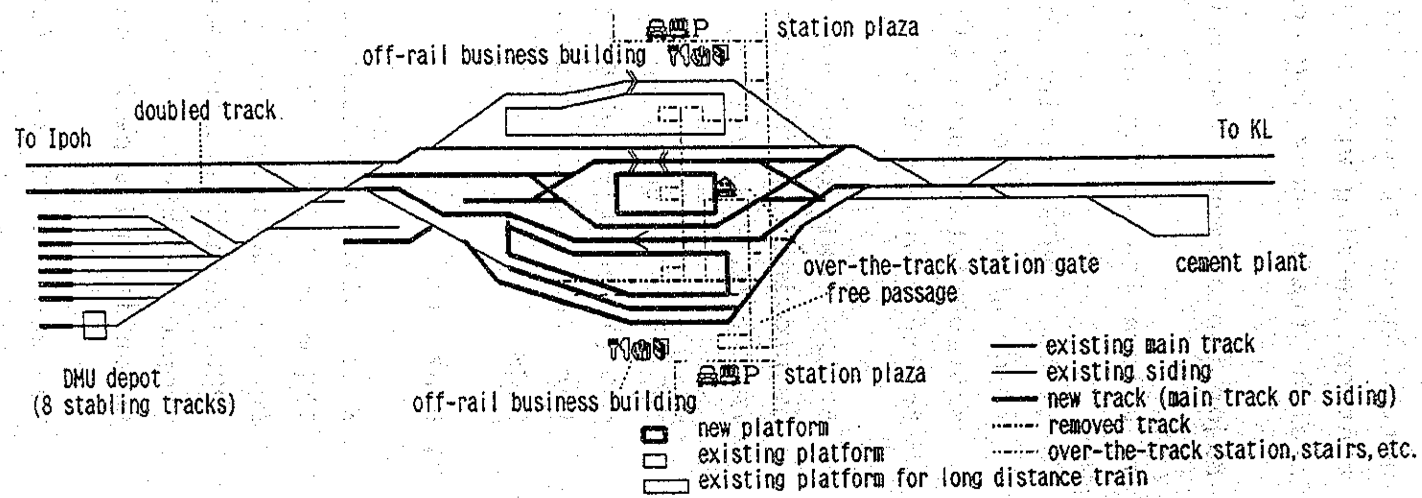


Fig. 7-1-5 (2) Track Layout of Rawang Station after 2005

(2) New Kepong station

In the year 2002, up and down RBCS platforms are shifted by 1.2 km to the north to facilitate transfer to the newly inaugurated LRT station and to the bus.
(Refer to Fig. 7-1-6)

The existing sidings will remain for freight trains use. Since trains are controlled by CTC, the above separation of platform location will not cause any problems.

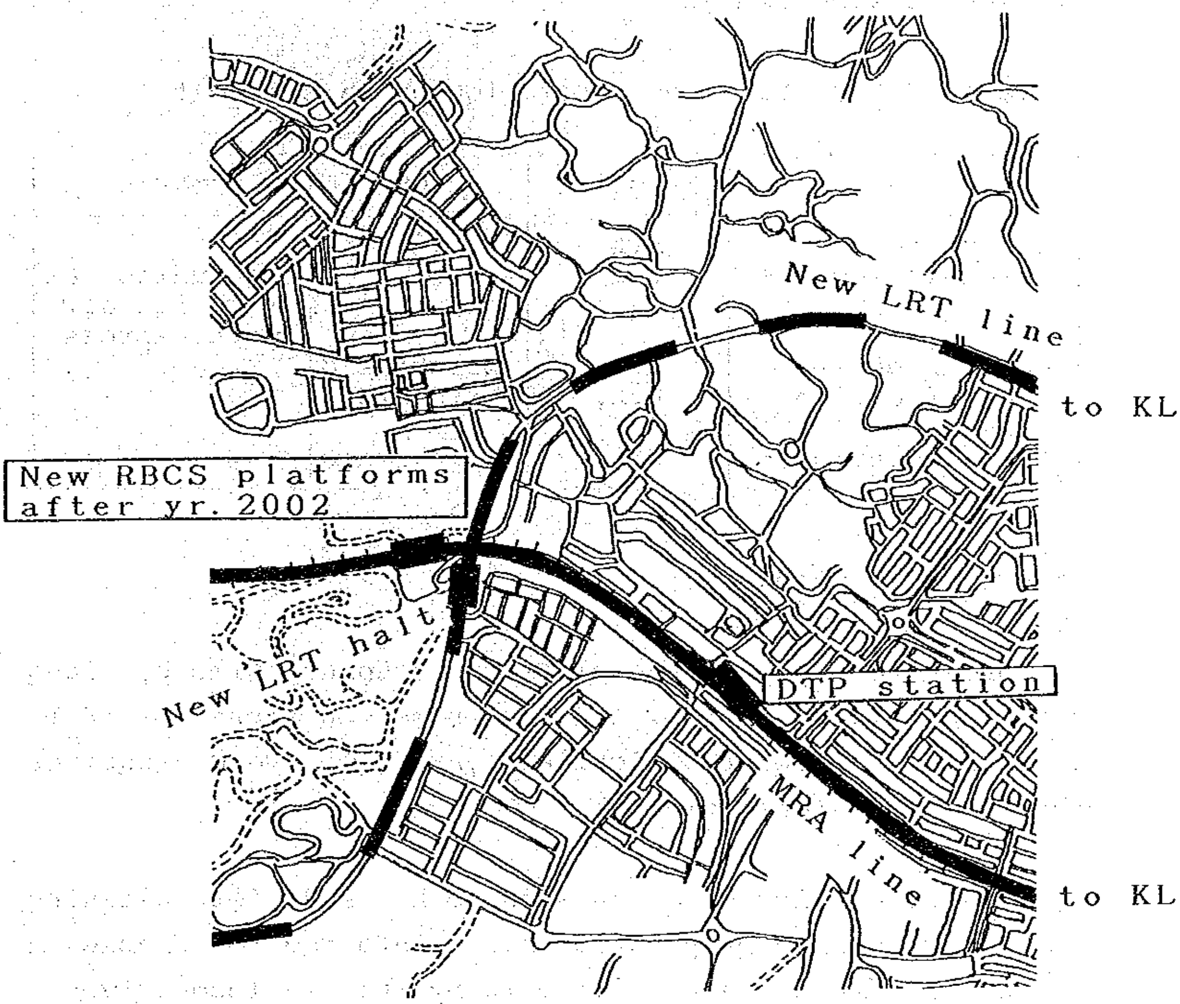


Fig. 7-1-6 Location of Kepong Station in DTP/RBCS

(3) Kuala Lumpur station

In K.L. station the height of the middle platform is increased up to 1050 mm.

With the reason stated in (4) below, the main parcel handling functions are moved to the Brickfield yard as listed in Table 7-1-3.

Hence the existing parcel tracks in K.L. station are removed. A postal track in the east side of the K.L. station is also removed.

Table 7-1-3 Function Separation of Parcel/Post

	Existing	RBCS	Remarks
Deposit	K.L.	K.L.	
Check-in luggage	K.L.	K.L.	Including the work for air-port express
General parcel	K.L.	Brickfield	
Classification /Relay	K.L.	Brickfield	
Postal service	K.L.	Brickfield	

(4) Brickfield complex

In order to minimize the platform occupancy time by long distance trains at K.L. station, some functions of K.L. are to be shifted to Brickfield yard. The yard requires the following improvements;

1) Two tracks in the coach shed to be used for cleaning and catering preparation are reinforced to enable a long distance train to move in by its own locomotives.

2) New tracks with platforms and buildings for parcel and postal handling are to be constructed.

The above-mentioned new tracks should be laid in the coach shed side of the main tracks. This location would minimize the parcel-car shunting locomotives hindering the main traffic.

Paved access roads to the two facilities mentioned 1) and 2) are newly built.

3) A turn-out track in the north side is rehabilitated, while a southside one is newly built. The effective length of the both tracks will be 260 m to enable to shunt the long distance passenger trains.

   To enable hauling locomotives to run into the yard, related tracks are also rehabilitated.

4) Four stabling tracks of 185 m are constructed. (Refer to Fig. 7-1-7) The construction of the box-culverts will be good enough to lengthen the tracks for future ten-car operation.

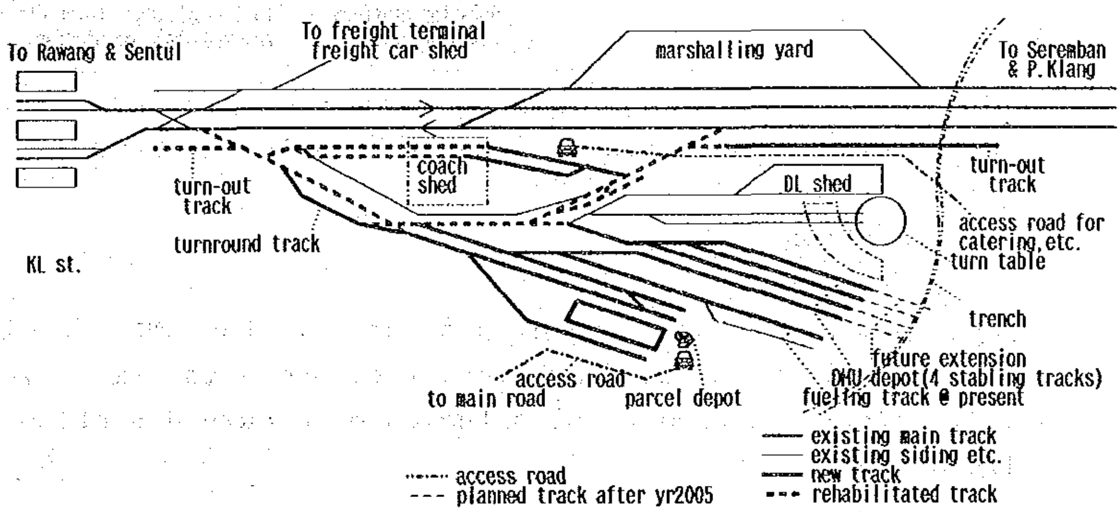


Fig. 7-1-7 Track Layout of Brickfield Complex in RBCS

(5) Kajang station

Kajang is the only station between K.L. and Seremban where rapid DMU trains and long distance passenger trains stop.

In the DTP, the station will be moved to the Seremban side by approximately 400 m from the existing position to avoid existing sharp curve of 402 m radius of main line tracks.

In the RBCS, the track layout is changed to the island platform type with two passing-through tracks in the outer side of the yard. This is intended to facilitate the passenger transfer between rapid and local DMU trains, for freight handling will be abandoned. (Refer to Fig. 7-1-8)

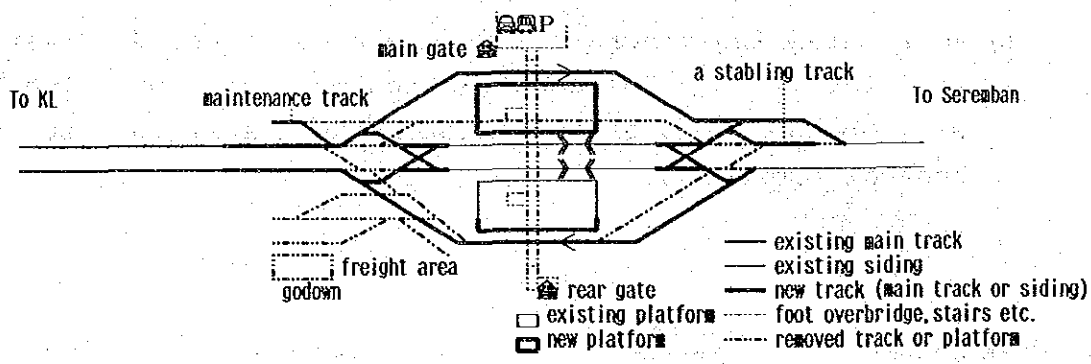


Fig. 7-1-8 Track Layout of Kajang Station in RBCS

(6) Bangi station

Bangi station is not used at present. In the DTP, it will be revived with the track layout as shown in Fig. 7-1-4(3). It is planned to be situated on a curved section of 410 m radius.

In the RBCS, the track alignment is not improved due to the severe topographical constraints arising from a river on the south side.

The station scale, however, is to be enlarged to cope with a large number of commuters forecasted. Existing at-grade crossing of the road to be grade-separated in DTP, will be shifted by 230 m to Kajang side. Then the track layout is modified to an inside island-platform type with siding tracks and to passing-through tracks running out of them. (Refer to Fig. 7-1-9).

Since the number of shuttle trains between Bangi and Seremban is scarce, construction of one island-type platform with a short track in its Seremban side for use of shuttle trains is considered enough. Consequently passenger between transfer becomes more convenient.

In this plan, four stabling tracks of 240 m are to be constructed on the Seremban side to facilitate the trains moving into stabling tracks without changing train direction and without level-crossing other main tracks. A new siding for K.L. bound freight trains is added to mitigate the adverse effects in case of traffic disorder.

Alternatives are described in Appendix 7-1-2.

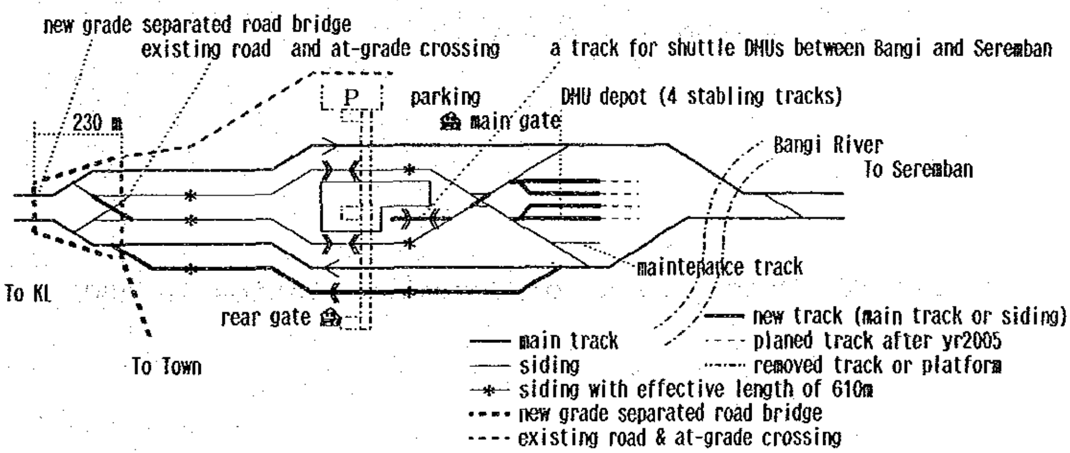


Fig. 7-1-9 Track Layout of Bangi Station in RBCS

(7) Seremban station

Seremban station is the southernmost terminal of the RBCS network, and it is a large station with a marshalling yard. To enable the operation between platform tracks and DMU depot, eight stabling tracks are constructed in the open spaces in and near the DMU depot. Among them, six tracks will have enough length for stabling 10-car trains in future. The effective length of the two tracks are 80 m for stabling three one-car trains shuttling between Bangi and Seremban. (Refer to Fig. 7-1-10)

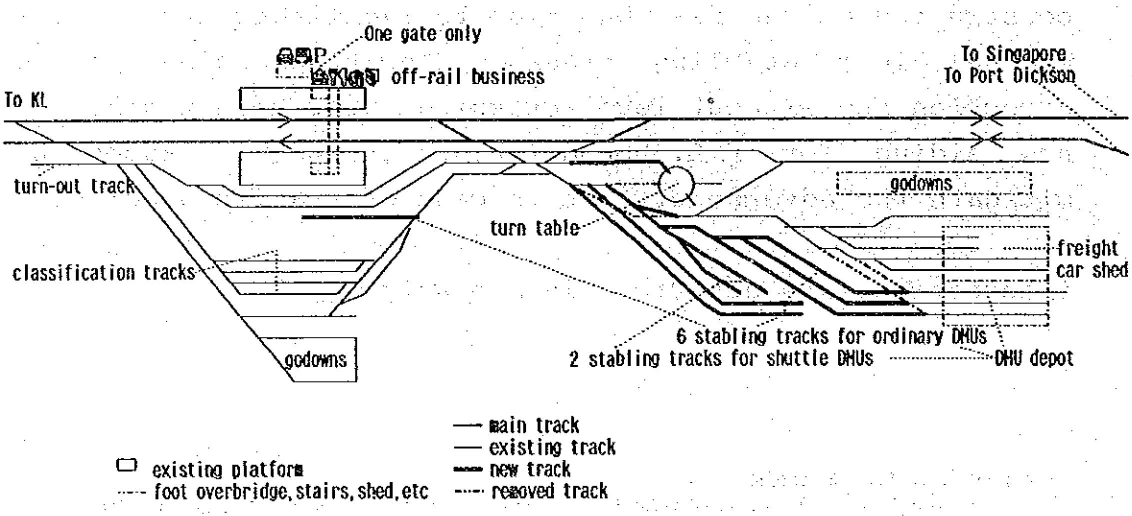


Fig. 7-1-10 Track Layout of Seremban Station in RBCS

(8) Traffic interference at Port Klang Jct. and Batu Jct.

As mentioned in Appendix 5-7, the interference ratio at the captioned two junctions will reach 40% to 57% by 2005. This figure is still lower than 60%, which is considered (in Japan) as a critical level over which the grade separation should be made. But it is recommended to mitigate the traffic interference at level crossing junctions between two traffic flows, either by grade separation or employment of the intermediate track method. (Refer to Fig. 7-1-4(2))

7-1-4 Maintenance System

(1) Track length and maintenance staff number

Track layouts of five stations/yards are improved in RBCS, laying tracks of total length of 6,765 m (Refer to Table 7-1-4). The increased track length turns out to be 6,336 m, where siding length is counted as one-third of main track and where No. 15 turnout is counted, in work volume, as equivalent to 55 m.

Hence, three track maintenance staffs are required, when calculated based on the DTP standard of 0.5 staffs per kilometer.

The cost required for the above-mentioned staff will be included in the total annual maintenance cost of the track. That of all civil work including it is calculated by maintenance-ratio method; i.e., 3.1% of the construction cost. (Refer to Chapter 12-3-2)

(2) Track irregularity and track maintenance work

In 2005, in case of "with-the-RBCS project" 142 trains including 98 DMU trains will be operated per day, increasing to 440% compared with 32 trains in 1990.

In 2005, 63 trains composed of 14 long distance passenger trains, 30 freight trains and 19 DMU trains introduced by DTP, will run in case of "without-the-RBCS project."

The number of trains in "without-the-project" case will be 44% of the "with-the-project" case. (Refer to Table 7-1-5.) In "with-the-project" case, the increase of annual passing tonnage and average train speed from 1990 to 2005 will be 159% and 113% respectively; deteriorating the track condition accordingly. The track condition, on the other hand, will be reinforced by DTP, by adopting continuous welded rail, concrete sleeper, ballast renewal, etc.

In principle, required track maintenance work is in proportion to the growth ratio of track irregularity. The theory to show the relationship between the growth in track irregularity and related factors is given in Appendix 7-1-3.

Calculation results of the required maintenance work volume are also given in Appendix 7-1-3. Here, the difference of its volume between "with-the-project" case and "without-the-project" case in 2005 will be 17%.

In RBCS, however, it is planned that the above increase in maintenance work volume will be dealt with by improving work productivity. (Refer to Appendix 7-1-4.)

Table 7-1-4 Laying/Removal of Track/Turnout by RBCS

Stations & Yards	Unit	Rawang	Brickfield	Kajang	Bangi	Seremban	Total
Track (*1)	m						
a. Laying	m	3,769 m	2,278 m	1,364 m	1,668 m	1,220 m	10,299 m
b. Removal	m	1,200 m	732 m	1,148 m	278 m	176 m	3,534 m
Increase (a-b)	m	2,569 m	1,546 m	216 m	1,390 m	1,044 m	6,765 m
Turnout							
a. Laying	No.	27	17	16	13	8	81
b. Removal	No.	13	4	14	0	3	34
Increase (a-b)	No.	14	13	2	13	5	47
Increased length*2 In terms of main track length	m	1,998 m	1,401 m *3	563 m	1,880 m	494 m	6,336 m

*1 Excluding turnout length.

*2 Accumulated track length in terms of main track length is calculated reducing the siding track length to 1/3 and converting turnout 1:15 and turnout 1:9 to the track length of 55 m and 35 m respectively.

*3 Some siding tracks are rehabilitated up to the level of main track.

Table 7-1-5 The Increase of Trains, Average Velocity and Passing Tonnage (between Batu Jct. and Rawang)

	No. of daily trains		Average*1 velocity		Annual passing tonnage			
	'90	'05	'90	'05	'90	'05	tons*2 per train	Remarks
	Trains	Trains	km/h	km/h	million tons	million tons		
Long distance passenger train	8	14	60	70	1.66	2.91	570 t	a1
Freight	20	30	38	45	5.04	7.56	690 t	a2
Rail Bus	4	0	60	-	0.15	-	100 t	a3
DMU purchased by DTP (33 cars)	-	19	-	53	-	2.18	315 t	a4
"without-the-project case"								
Total	32	63			6.85	12.65		b=a1+a2 +a3+a4
For one track	32	31.5			6.85	6.33		c=b/2
Average			46.8	53.0				
DMUs purchased by RBCS (139 cars)	-	79	-	53	-	9.08	315 t	d
"with-the-project case"								
Total	32	142			6.85	21.73		e=b+d
For one track	32	71			6.85	10.87		f=e/2
Average			46.8	53.0				

*1 Average train speed excluding standing time at stations.

*2 Estimated by the Team.

7-1-5 Station Building/Facilities/Plaza

MRA station building, facilities and plazas have not been designed for the convenience of the commuter type of passengers because MRA has had few commuter train service. Although some considerations are given in the new stations to be constructed under DTP, some of the existing stations will remain as it is.

In the RBCS, however, the number of commuter passengers will increase by more than twenty-fold, it will be necessary to come up with new ideas for the design of the stations, facilities, and the station plazas. Also, there will be stations which will require rear gates.

Table 7-1-6 gives a bird's eye view of what should be planned at the station along the Corridor. It considers the RBCS requirements in 2005. The traffic demand estimated in Chapter 4 is taken account. For estimating the scale of the facilities, some formulae developed through JNR (Japanese National Railways) experiences are applied. Land acquisition preparing for the station front plazas will also be necessary, though MRA owns a 50 - 130 m width of their R/W.

(1) Station building

1) Stations not requiring any modifications

Since, the following stations have few passengers, more or less 100 daily, the stations provided by the DTP can be used as it is.

- Batang Benar
- Nilai
- Labu
- Tiroi

2) Stations requiring minor modifications

The following stations will require installation of some facilities such as ticket windows, entry wickets, kiosks, and other related facilities.

- Kuang
- Sungai Buloh
- Kuala Lumpur
- Serdang
- Bangi
- Seremban

3) Stations requiring new station buildings (Including newly built halts)

(Refer to Appendix 7-1-5 for new station building standards).

- H 1 (a new halt)
- Kepong (moved to new location)
- H 2 (a new halt)
- Segambut
- Mall
- J.P. Menteri
- Siputeh
- Sungai Besi
- H 3 (a new halt)

4) Remodeled stations constructed under DTP

The stations originally constructed under the DTP, but requiring to be remodeled are as follows:

- Rawang
- Salak South
- Kajang

5) Stations requiring rear station gates

(Refer to Appendix 7-1-5 for rear station gate establishing standards).

- Rawang
- Sungai Buloh
- H 2
- Segambut
- Sungai Besi
- Serdang
- Kajang
- Bangi

6) Over-the-track stations

The following stations will be remodeled to the over-the-track stations due to the large volumes of passengers, or geographical conditions. The one-half of the cost for their free public passageway will be borne by the Government:

- Mall
- J.P. Menteri
- Salak South

(2) Station facilities

Station facilities are planned according to the JNR criteria. (Refer to Appendix 7-1-6.)

1) Platform shelters

Platform shelters will be constructed to cover 50 - 80% of the platform length.

2) Foot overbridges

To cope with the increase in passengers, the wider overbridges are newly constructed, or overbridges of 2.5 m width are constructed besides ones in the DTP. These are in the stations as follows:

- Rawang
- H 2
- Segembut
- Mall
- J.P. Menteri
- Kuala Lumpur
- Salak South
- Sungai Besi
- Serdang
- Kajang

3) Ticket windows

40% of the total number of passengers are assumed to buy a ticket for each trip (the remainder of 60% assumed as using season tickets or commuter passes) at the station. One cash paying window will be provided at each of the front and rear gates, and other windows required will be replaced by ticket vending machines.

4) Passenger wickets

The most effective method to check the tickets of a large numbner of passengers is the passenger wickets. Hence, all stations except Batang Benar, Nilai, Labu, and Tiroi will be installed with them. The required number of wickets are calculated for front and rear gates with 30 - 50% allowances. The minimum number of wickets is two per front or rear gate.

5) Toilet

Toilets will be provided at all stations for both inside and outside of the passenger wicket.

6) Kiosks

At kiosks, newspapers, coffee, and other items will be sold for commuter's convenience.

7) Other passenger amenities

Passenger amenities, such as coin lockers, public telephones, etc. will be provided at each station, with reserve space for passenger waiting space, baggage room, etc.

8) Facilities for the physically handicapped

Raised floor marker blocks will be embedded in the passageways for the blind, and there will be one passenger wicket wide enough for wheelchairs to pass through. Escalators will be provided at over-the-track stations.

(3) Station plaza

The Station Plaza is a contact point with the public at large, and utilized for the off-rail business activities. In this study, the cost for station plaza including feeder-bus bays at each station is presumed to be borne by the Government. (Refer to Appendices 7-1-7 and 7-1-9)

(4) Major improvements of railway stations

1) Rawang

Rawang is the northernmost terminal station of the RBCS line, and it will handle a large number of commuter trains as well as long distance trains. The station building is located on the east side of the station yard, and situated in a depressed area lower than the front road by 3 m, making it difficult for buses and taxis to approach the station. Under the RBCS plan, the station will be reconstructed to be flush with the front road level, to facilitate the road vehicles to make their approach to the station. (Refer to Fig.7-1-11)

It is recommended to remodel the station to an over-the-track station as shown in Fig. 7-1-12, providing a free-passageway to connect the east-west towns.

2) Sungai Buloh

Under the DTP, the station building will be constructed on the opposite side of the town. Under the RBCS, a rear station gate will be additionally constructed on the town side for the convenience of the residents.

3) Mall

The Mall station is located between a highway and a hill, lacking direct approach to any of the Mall shopping complex, Music Hall, Bus Terminal, etc. Since, there is no space to construct a station building and a station plaza, it is planned to be remodeled into an over-the-track station, provided with free passageways to the buildings in the neighbourhood and with transfer facilities to the LRT and monorail. (Refer to Fig. 7-1-13)

4) J.P. Menteri

There are many governmental offices on the hill side, and to the east beyond a highway and the Gombak river, there is a commercial center. Access to them is difficult. Hence the station is planned to be remodeled into an over-the-track type, providing access to the commercial center by an overbridge passage and connecting with the LRT and monorail. (Refer to Fig. 7-1-14)
A rear station gate is also planned to provide access to the Government offices on the K.L. side.

5) Kuala Lumpur

The existing north gate which constructed in an over-the-track station type (not used at present) will be remodeled to accommodate a larger number of commuters. Main remodeling items are ticket vending windows, wickets, raising of the central platform, construction of staircases, installing escalators, and widening of the over-the-track passageways. Also, an overbridge will be constructed to permit better transfer between passengers of the Rawang-Seremban and the Sentul-Port Klang Lines. An overbridge connecting to the business center, the LRT/ monorail stations, and to the bus stands will be constructed. After the move of the parcel depot to the Brickfield yard, the remaining space will be utilized for bus bays, taxi pool, and off-rail business activities. (Refer to Fig. 7-1-15, and 7-1-16)

6) Siputeh

A highway runs close by to the west side of the station obstructing the approach to the town. An overbridge will be planned, therefore, crossing over the highway.

7) Salak South

Salak South Station is the junction between the Rawang-Seremban Line and the Ampang Line. Since a volume of passenger traffic is the next to Kuala Lumpur, and there is a large business development plan on the east side of the station, it is planned as an over-the-track station. (Refer to 7-1-17)

8) H 2, Segambut, Sungai Besi, Serdang

These stations will have comparatively large volume of passenger traffic, so it is recommendable that they would be remodeled to the over-the-track type in the future. Especially, Sungai Besi is the next to Salak South in the number of passengers handled, and would be planned to be a junction station with the LRT in 2010, so it is highly recommended to reconstruct it as an over-the-track station.

9) Kajang

Track layout and platform configurations are remodeled to the island type. Further reconstruction to an over-the-track station is recommended in future, so that the residents near-by the station can utilize the over-the-track passageway without detouring some 3 km to across the track which is envisaged after closing the level crossing in DTP.

Table 7-1-6 Improvement of the Commuter Facilities

	Station Building							Ticket Window			Wicket			Overbridge			Free Passage-way	Station Plaza			
	Present	DTP	RBCS					Present	DTP	RBCS	Present	DTP	RBCS	Present	DTP	RBCS		Present	DTP	RBCS	
		Area m2	Area m2	Ground stn	Over-Track stn	Rear stn (m2)	Modifying (m2)			(Vending Machine)					(Width) m	(Width) m	(Width) m			Plaza m2	Bus stop m2
Rawang	◎	370	540	○	–	○	–	1	2	3+(4)	–	3	5	–	2.5	3.5	–	◎	◎	5000	1 ×600
Kuang	–	370	370	–	–	–	–	–	2	2	–	3	3	–	2.5	2.5	–	–	–	–	2 ×600
H 1	–	–	340	○	–	–	–	–	–	1+(1)	–	–	2	–	–	2.5	–	–	–	–	2 ×600
Sungai Buloh	◎	370	480	–	–	(110) ○	–	1	2	3+(1)	–	3	4	–	2.5	2.5	–	–	–	–	4 ×600
Kepong	–	370	340*1	○	–	–	–	–	2	1+(2)	–	3	2	–	2.5	2.5	–	–	–	2500	–
H 2	–	–	450	○	–	○	–	–	–	2+(3)	–	–	4	–	–	3.5	–	–	–	–	2 ×600
Segambut	–	–	450	○	–	○	–	–	–	2+(5)	–	–	6	–	2.5	2.5+2.5	–	–	–	8000	–
Mall	–	–	600	–	○	–	–	–	–	2+(6)	–	–	4	–	2.5	6.0	5.0	–	–	–	–
J.P. Menteri	–	–	740	–	○	○	–	–	–	3+(9)	–	–	7	–	2.5	2.5+6.0	4.0	–	–	2000	–
K.L.	◎	◎	◎	–	–	–	(300) ○	◎	◎	*2 2+(14)	◎	◎	*2 10	◎	◎	*3 3.0+3.5	*3 2.5+4.0+4.0	◎	◎	◎	4 ×600
Siputeh	–	–	340	○	–	–	–	–	–	1+(2)	–	–	2	–	2.5	2.5	2.5	–	–	–	3 ×600
Salak South	–	370	1010	–	○	–	–	–	2	1+(10)	–	3	6	–	2.5	6.0	6.0	–	–	12000	–
Sungai Besi	–	–	450	○	–	○	–	–	–	2+(8)	–	–	7	–	2.5	2.5+2.5	–	–	–	9000	2 ×600
Siputeh	–	370	480	–	–	(110) ○	–	–	2	2+(4)	–	3	4	–	2.5	2.5+2.5	–	–	–	–	4 ×600
H 3	–	–	340	○	–	–	–	–	–	1+(2)	–	–	2	–	–	2.5	–	–	–	–	2 ×600
Kajang	◎	370	540	○	–	○	–	1	2	3+(5)	–	3	5	–	2.5	3.5	–	◎	◎	5500	1 ×600
Bangi	–	370	480	–	–	(100) ○	–	–	2	2+(2)	–	3	4	–	2.5	2.5	–	–	–	1500	2 ×600
Batang Benar	–	370	370	–	–	–	–	–	2	2	–	3	3	–	2.5	2.5	–	–	–	–	–
Nilai	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2.5	2.5	–	–	–	–	–
Labu	◎	370	370	–	–	–	–	1	2	2	–	3	3	–	2.5	2.5	–	–	–	–	–
Tiroi	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2.5	2.5	–	–	–	–	–
Seremban	◎	◎	◎	–	–	–	(300) ○	2	2	2+(3)	1	1	3	◎	◎	◎	–	◎	◎	◎	–

Note : ◎ : Existing
○ : New construction/ modifying or installation
St. Name : Long distance trains stop.
*1 : New location
*2 : Existing number of ticket windows and wickets for long distance train is excluded.
*3 : Existing overbridges are excluded.
(It is newly constructed or installed at the different number between Present, DTP and RBCS.)
* : The basic data calulated by the JNR Specification are shown in Appendix 7-1-10

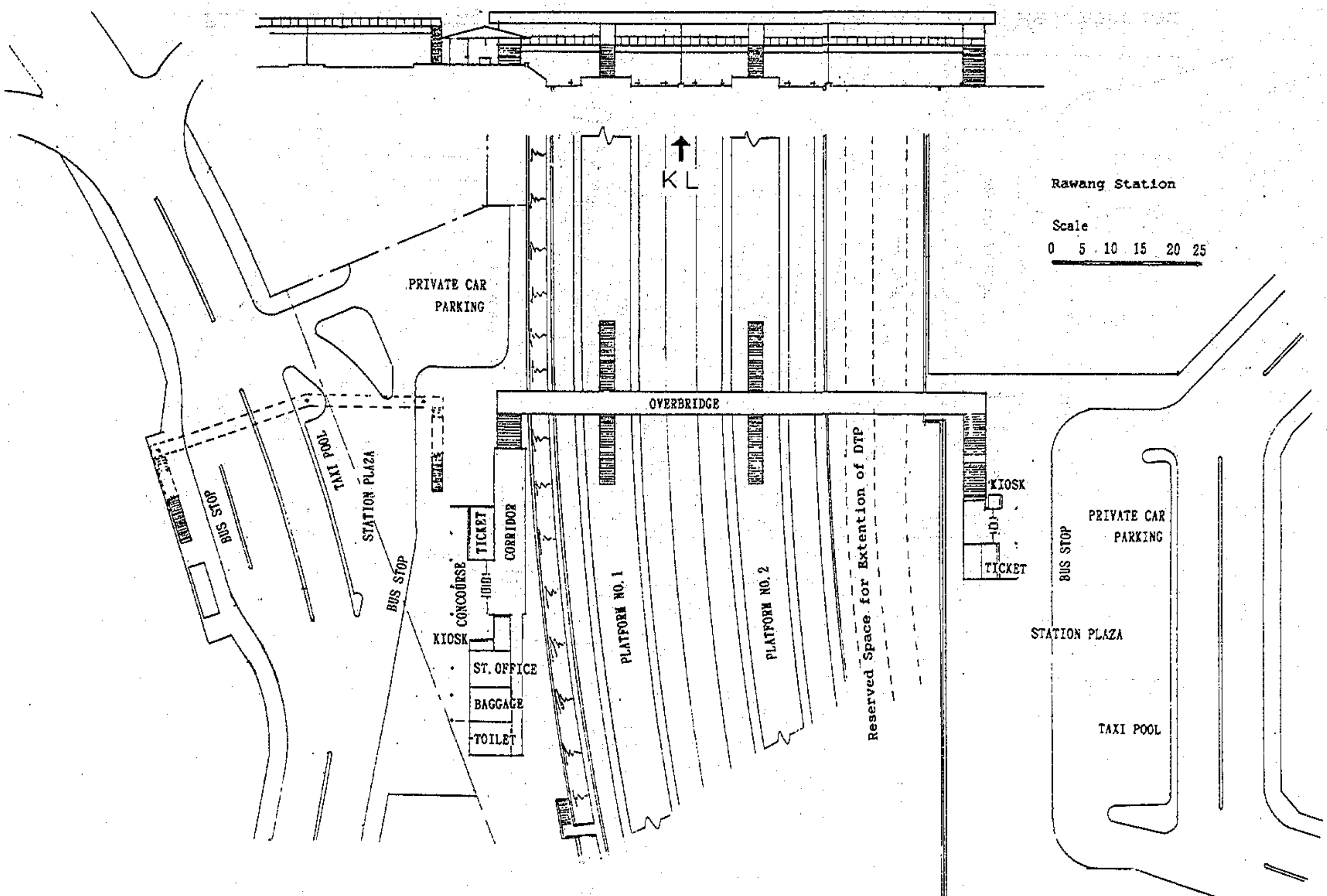


Fig. 7-1-11 Rawang Station in RBCS

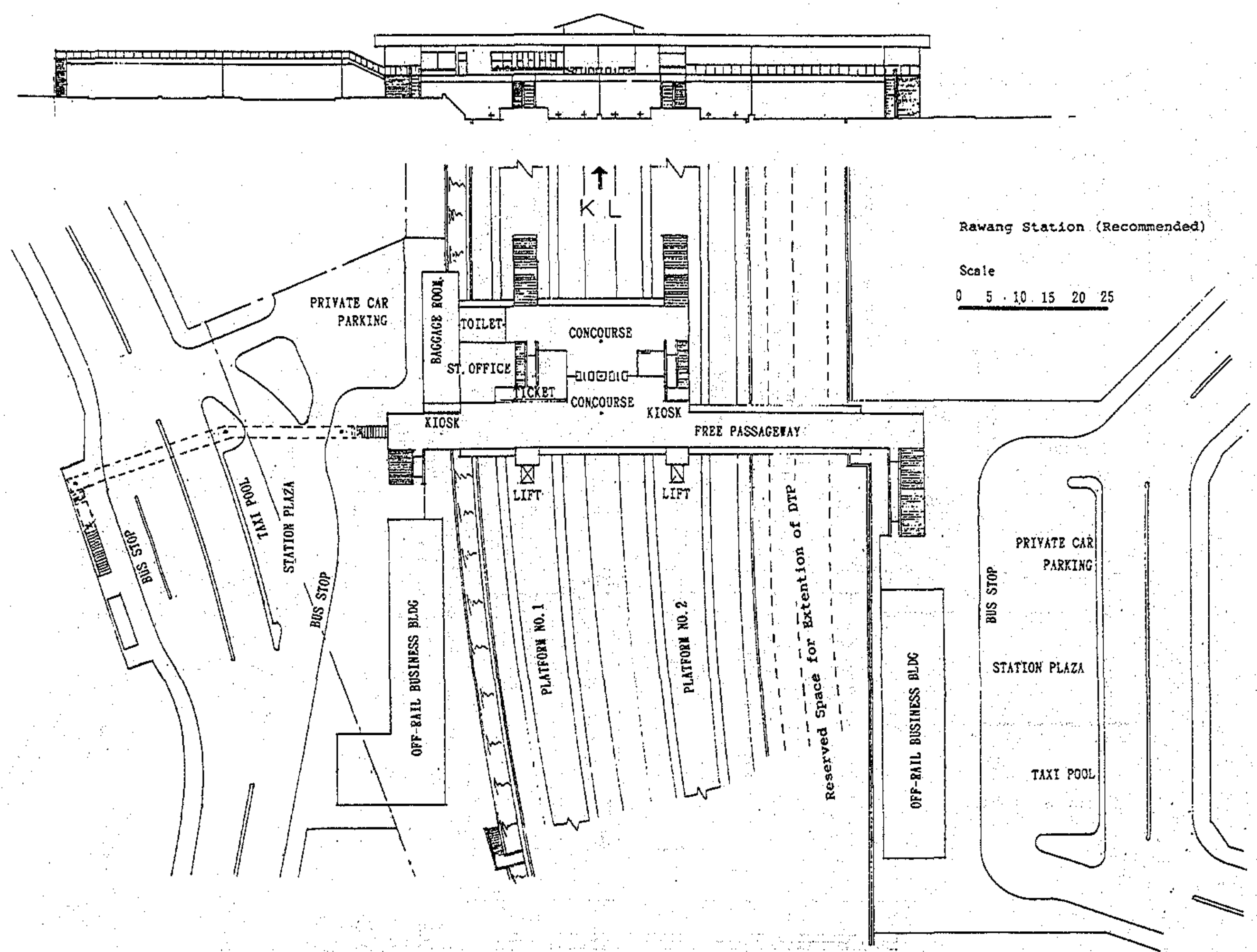


Fig. 7-1-12 Rawang Station (Over-Track Style Station: Recommended)

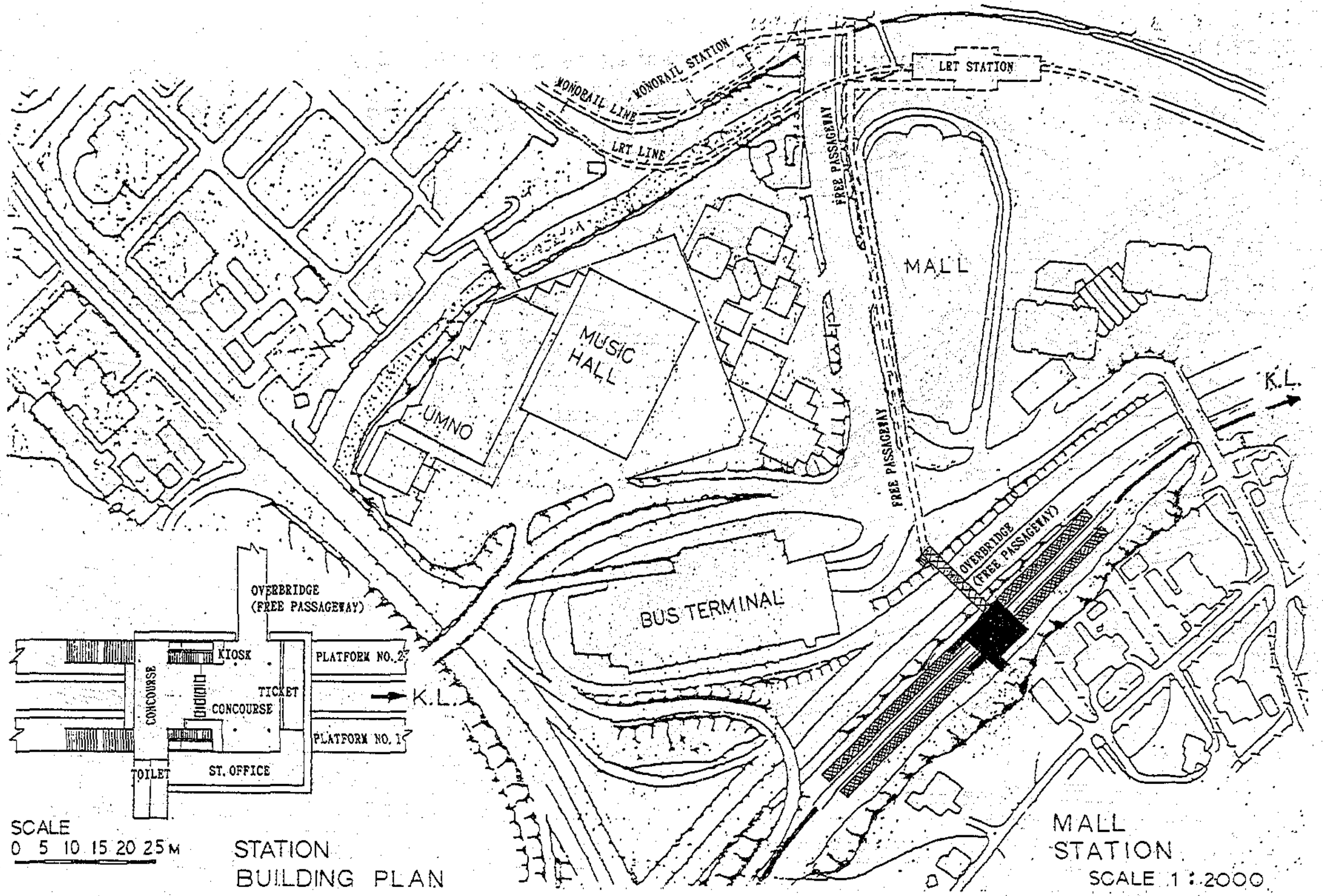


Fig. 7-1-13 Mall Station in RBCS

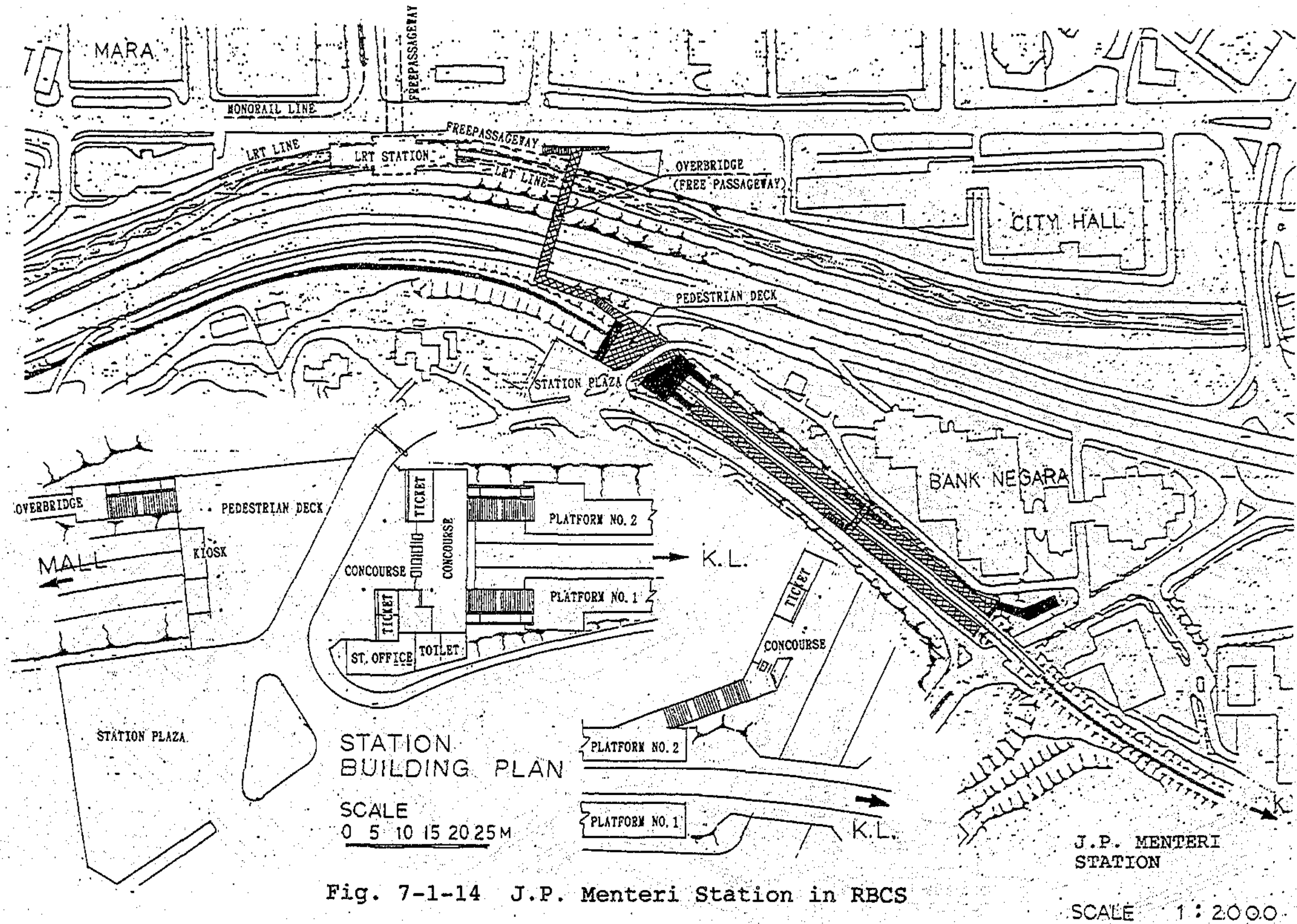
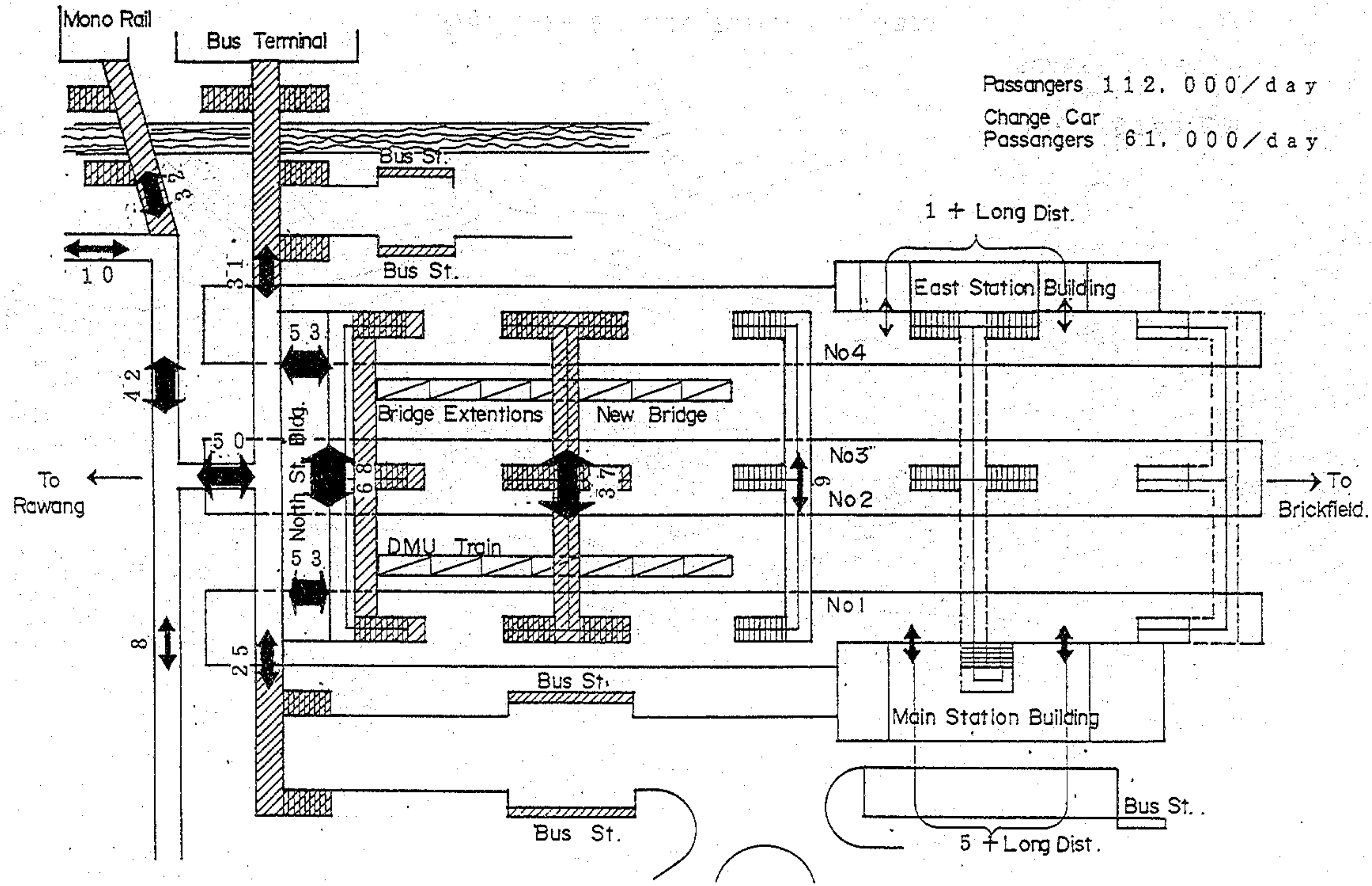


Fig. 7-1-14 J.P. Menteri Station in RBCS



New Construction (proposed)

Fig. 7-1-15 Commuter Passageway at K.L. Station in RBCS

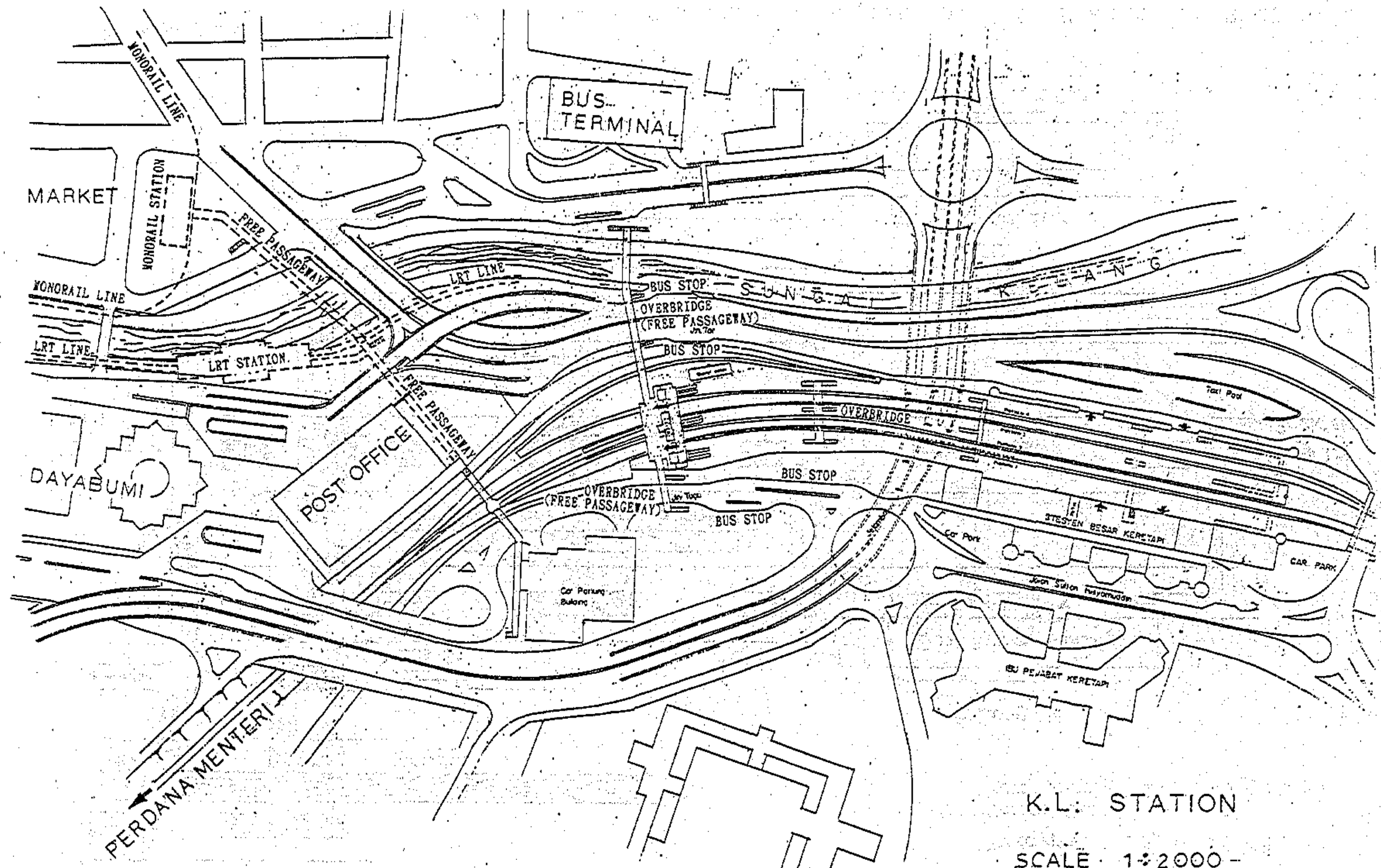


Fig. 7-1-16 K.L. Station in RBCS

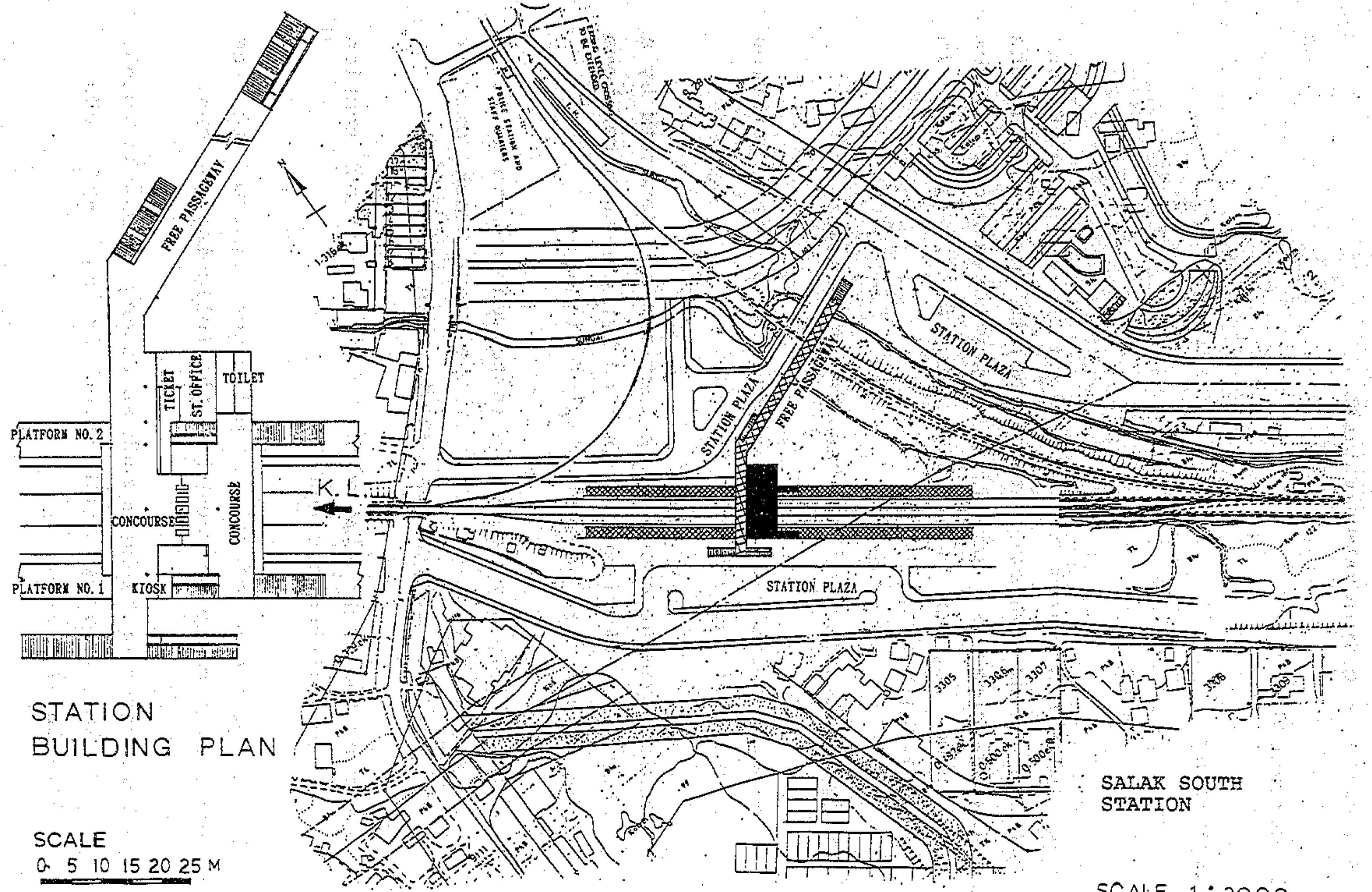


Fig. 7-1-17 Salak South Station in RBCS