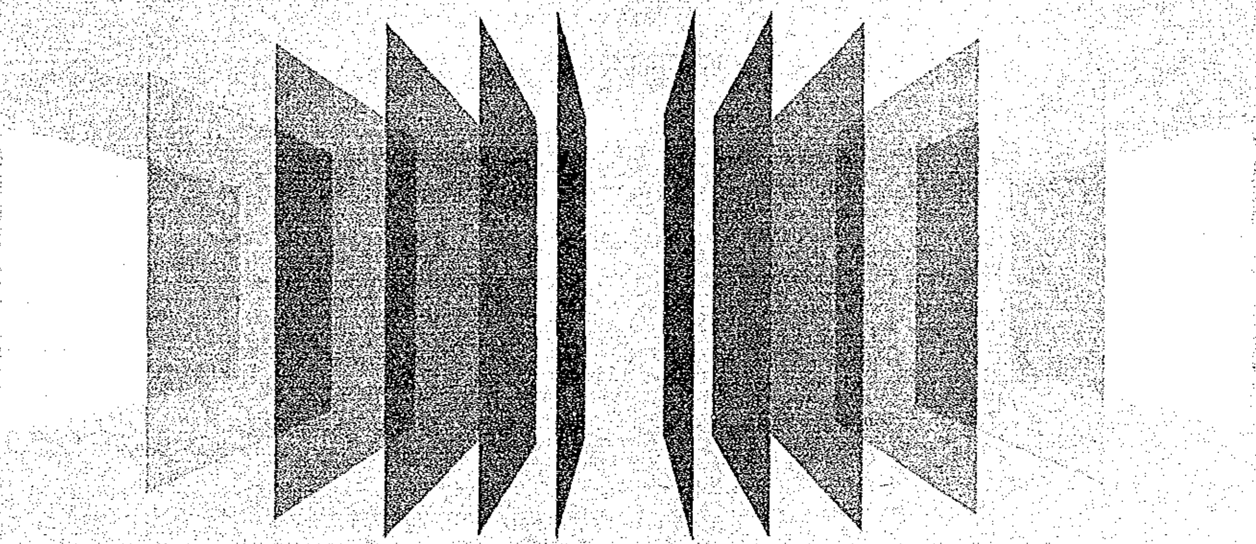
社会開発協力部報告書

No. 7

THE FEASIBILITY STUDY ON GUAYAQUIL CITY URBAN TRANSPORTATION PLAN IN THE REPUBLIC OF ECUADOR



FINAL REPORT

SUPPLEMENTARY VOLUME 2

MRT CONSTRUCTION AND MANAGEMENT PLAN, AND OTHER IMPROVEMENT PLANS
ECONOMIC AND FINANCIAL ANALYSIS, IMPREMENTATION PROGRAM

DECEMBER 1986

JAPAN INTERNATIONAL COOPERATION AGENCY

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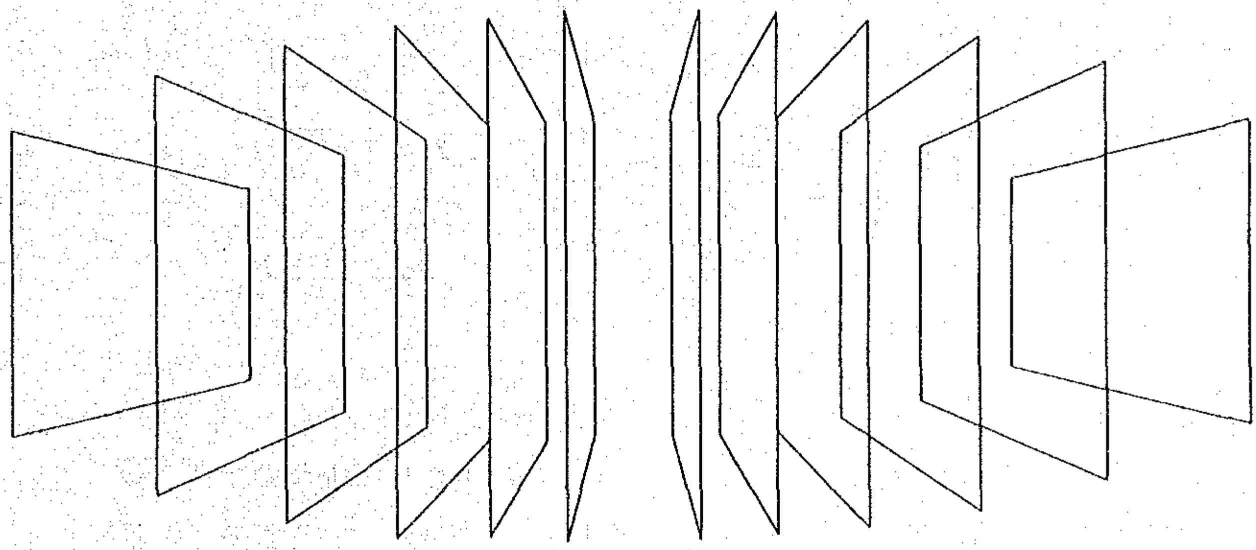

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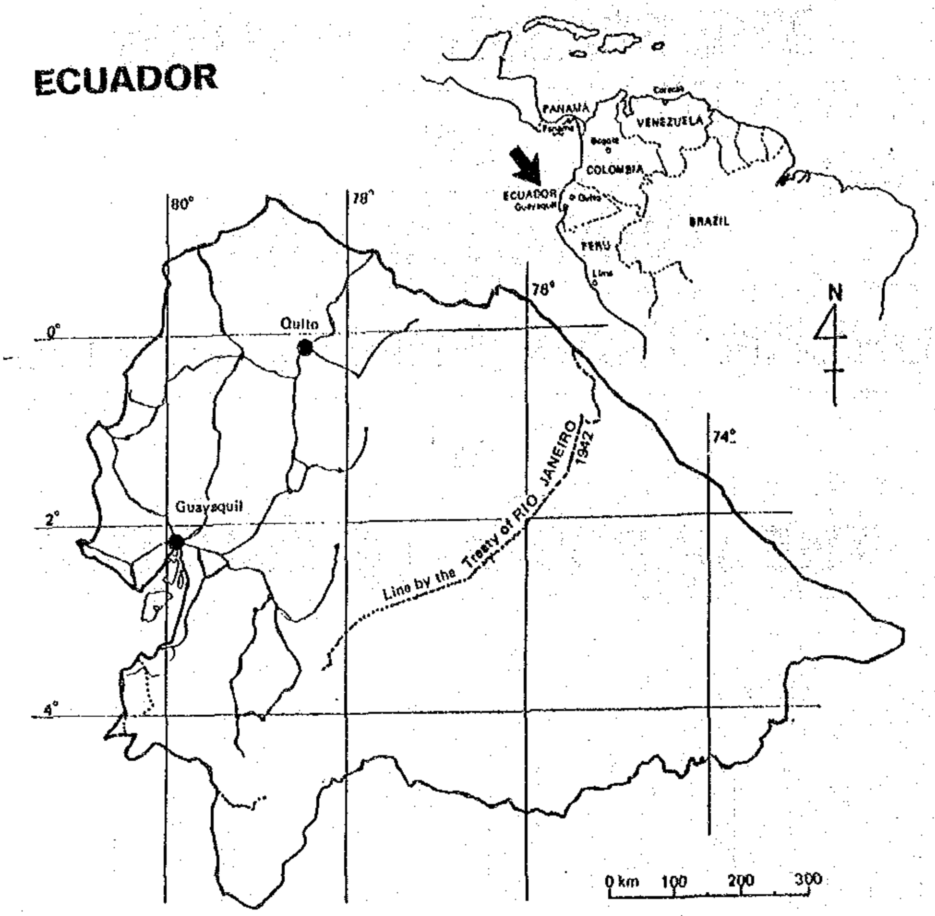
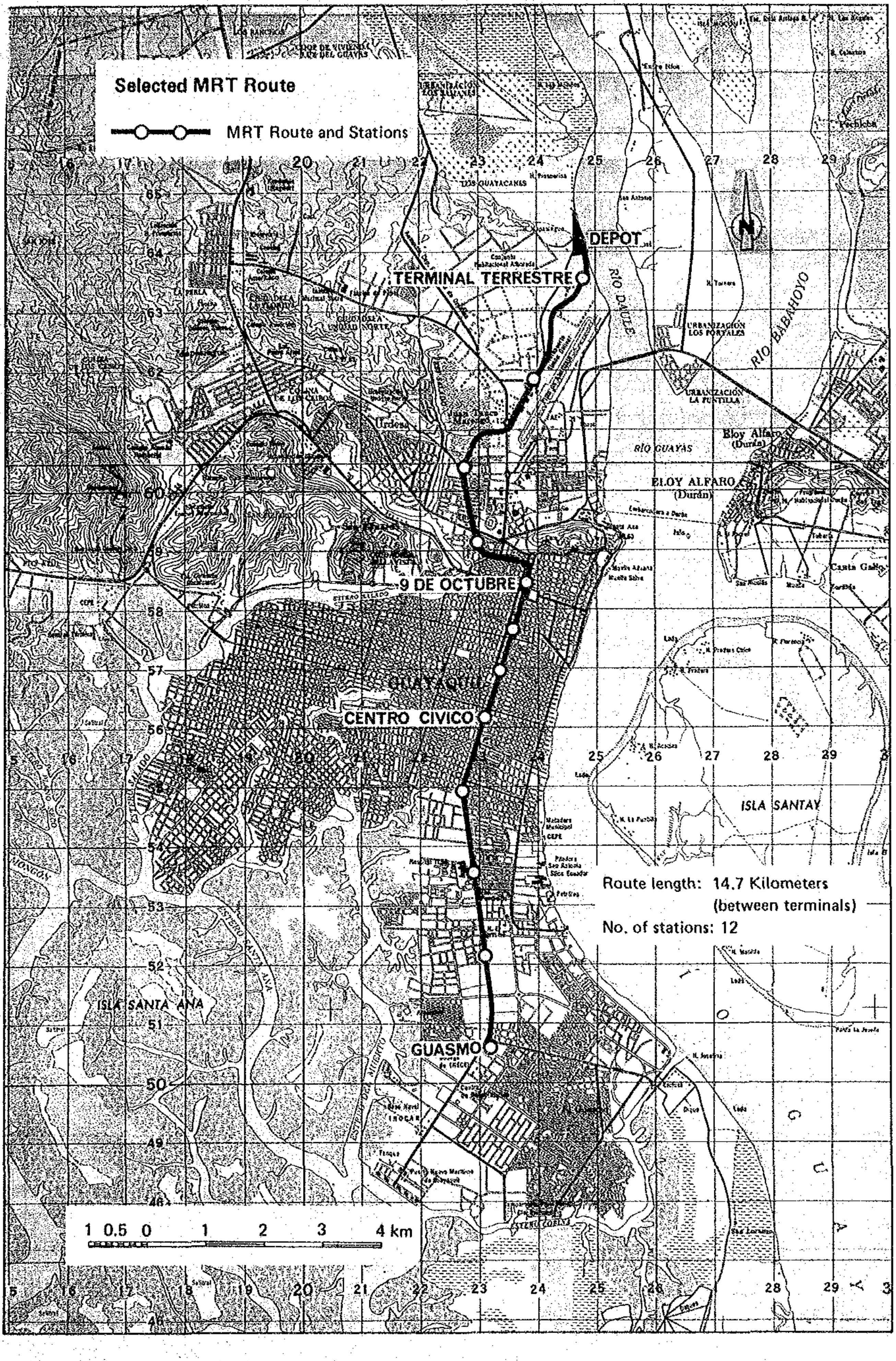


Area	;	270,670 Km^2 (after 1942)
Population & Growth Rate	;	9,378,000 (1985),2.91%/year (80-85)
Foreign Money Exchange rate	;	US 1$ = 95 Sucres in free market of the Central Bank (A) =120 Sucres in free market (Nov.1985)
Gross Domestic Products	;	6,503 mil.US $ (1983, 87 S./ $ by (A))
GDP Per Capita	;	734 US $ (1983, 8.857 mil. Population)
Productive Structure	;	Agriculture 13.5%, Mine & Manifacture 39.7%, Services,etc. 46.8% (1983)
International Trade	;	Export 2,583 mil. US $/ Import 1.458 , Balance 1,125 mil. US $ (1984)
National Budget of Govern - ment	;	953 mil.US $ (1983, 87 S. / $ by (A))
Index of Consumer's Prices	;	48.1%/ year (1983), 30.4 (84)


Selected MRT Route
MRT Route and Stations
DEPOT
TERMINAL TERRESTRE
9 DE OCTUBRE
CENTRO CIVICO
GUASMO
GUAYAQUIL
RIO DAULE
RIO BABAHOYO
RIO GUAYAS
ELOY ALFARO (Durán)
ISLA SANTAY
ISLA SANTA ANA
Route length: 14.7 Kilometers
(between terminals)
No. of stations: 12
1 0.5 0 1 2 3 4 km
N

FINAL REPORT

SUPPLEMENTARY VOLUME 2

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ABBREVIATION AND DEFINITION IN THIS REPORT

CBD	-------------	Central Business District (the area surrounded by Rio Guayas, Av. Quito and Av. Olmedo)
CONADE	-------------	Consejo Nacional de Desarrollo
CTG	-------------	Comisión de Tránsito del Guayas
EMELEC	-------------	Empresa Eléctrica del Ecuador
ENTE	--------------	Empresa Nacional de Ferrocarriles del Estado
FODUR	-------------	Unidad Ejecutora del Fondo de Dessarrollo Urbano de Guayaquil
INECEL	-------------	Instituto Ecuatoriano de Electrificación
INTEL	-------------	Instituto Ecuatoriano de Telecomunicaciones
INEC	-------------	Instituto Nacional de Estadística y Censos
JICA	-------------	Japan International Cooperation Agency
MRT	-------------	Mass Rapid Transportation
the M/P Study	-------------	the master plan study in 1983 by JICA
the Study, the F/S	-------------	this feasibility study
the Team	-------------	Japanese Study Team

PART 1

MRT CONSTRUCTION AND MANAGEMENT PLAN

PART 1 MRT CONSTRUCTION AND MANAGEMENT PLAN

1. Planning Policy

1-1 Makeup in this Part and Premises for Opening Year and their Sections

The purpose of this part is to work out a construction and management plan for the Light Urban Railway selected in the Supplementary Volume 1. However, for the economic evaluation and financial analysis of the project examined later, the plan must be prepared to cover various cases to decide the most feasible opening year, its section and extension.

These cases consist of some combinations of 5 section cases (Bsic Case, Case A, B, C and D; see Figure 1-1.1) and their opening years (1990, 1993 and 1996). Of these combinations, 10 cases shown in Table 1-1.1 are picked up and their plans are prepared in this part.

This part, in the first place, makes a construction and management plan in detail for the Basic Case which corresponds to the whole route with 14.7 kilometers long from Terminal Terrestre to Guasmo in the sections 2 to 7, and other 9 cases are summarized in the section 8.

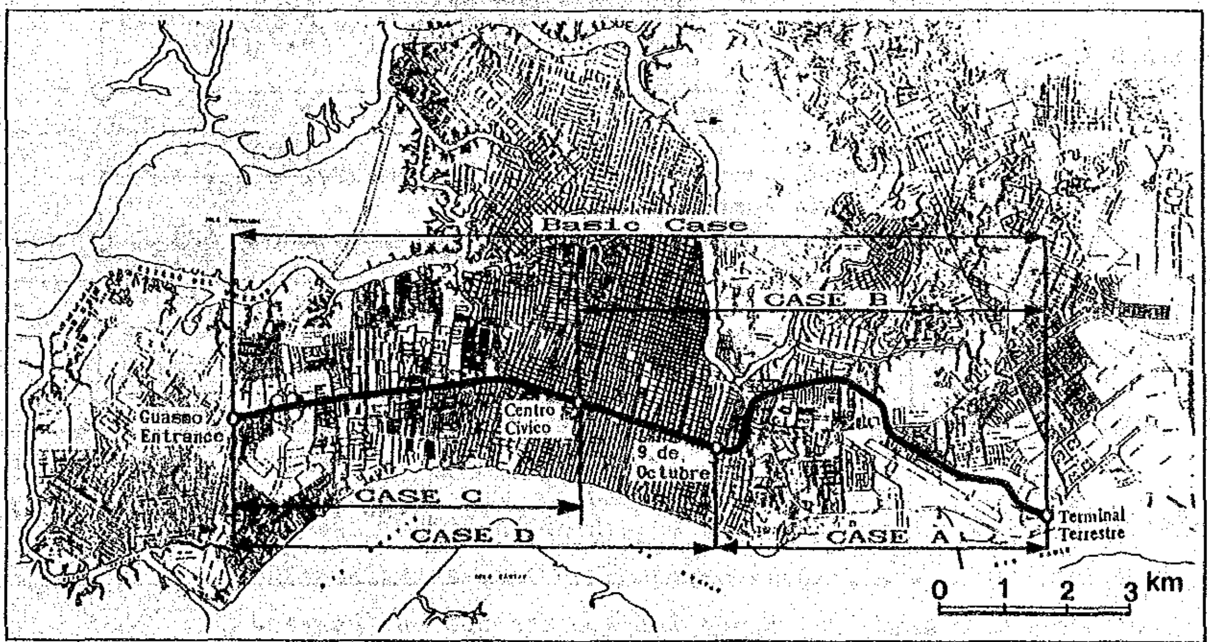


Figure 1-1.1 SECTION CASES AT FIRST STAGE

Table 1-1.1 TEST CASES

Tested Case	Opening Year and its Section
Basic Case	1990 (14.7 km): Guasmo – Centro Civico – 9 de Octubre – Terminal Terrestre
Case A-1	1993 (8.0 km); 1990 (6.7 km)
Case A-2	1996 (5.6 km); 1993 (2.4 km); 1990 (6.7 km)
Case B-1	1993 (5.6 km); 1990 (9.1 km)
Case C-1	1990 (5.6 km); 1993 (9.1 km)
Case C-2	1990 (5.6 km); 1993 (2.4 km); 1996 (6.7 km)
Case D-1	1990 (8.0 km); 1993 (6.7 km)
Case E	(No further construction); 1990 (6.7 km)
Case F	(No further construction); 1990 (9.1 km)
Case G	1990 (8.0 km); (No further construction)

1-2 Demand Assigned to whole Route (Basic Case)

1) Results of Demand Forecast

The demand such as the passenger volume between stations, the number of passengers getting on and off at each station etc., which have been forecast in the Supplementary Volume 1, is applied to this volume. The main items of the demand assigned to the whole route are as follows:

Table 1-1.2 DEMAND ASSIGNED TO WHOLE ROUTE

(Basic Case)

Item \ Year	1990	1993	1996	2000	2010 -
Number of passengers per day	401,000	447,000	482,000	530,000	646,000
Maximum number of passengers per day in one direction	105,000	121,000	131,000	145,000	177,000
Maximum number of passengers per hour in one direction	12,600	14,500	15,700	17,400	21,200

1-3 Basic Policies for Making Plan

Basic policies and other main items to be considered for making the plan are as follows:

(1) To make construction cost lower

(2) To make maintenance and management easy

(3) To meet the demand increase in future

(4) To make the plan adaptable to the route extension in future and connectable to the East-West Line proposed by the M/P

(5) To operate the MRT efficiently matching the local circumstances

(6) To make the plan coordinate with other plans related to the MRT construction (bus route reorganization, coordination between the bus systems and the MRT in main stations, road improvement, land use of the wayside, etc.)

2. Transport Plan

2-1 Outline of Planning Conditions

The basic planning conditions are set as follows:

(1) Operation Method

Shuttle operation only between the both terminals is adopted while the shuttle between intermediate stations and passing at intermediate stations are not permitted.

(2) Operation Control System

Train is controlled by the CTC (Centralized Traffic Control) installed in the depot while the station masters in main stations watch the train running under the CTC. Operation control in an emergency is carried out by train radio.

(3) Service Level

The service hours is set to be 18 hours from 5 a.m. until 11 p.m. The headway is set to be no longer than 10 minutes even in the off-peak hours. The passenger congestion rate for the nominal capacity is set with the following percentages as an approximate standard:

Peak hours in the morning and evening	: 220% or under
1 to 2 hours before and after peak hours	: 150% or under
Off-peak hours	: 100% or under

(4) Train Formation

Train length is 80 m or shorter. (16m/car x 5 car)

(5) Measures for Improving Transport Capacity of Trains

Effort should be made for increasing the transport capacity of trains in designing the performance and accommodation of rolling stock such as adopting a long seat, increasing maximum speed, etc.

(6) Reduction of Time for Setting Back at Terminals

Reduction of the time required for the setting back at terminals should be made to operate trains more efficiently.

2-2 Setting Principal Dimensions for Planning

Based on the basic conditions described in the above items, principal dimensions are set as follows:

1) Transport Demand

The maximum number of passengers per hour in one direction which decides the dimensions of the plan is as follows: (Refer to Table 1-1.2).

1st stage:	In 1990	12,600 person/hour in one direction
Last stage:	In 2010	21,200 person/hour in one direction

(For the details of transport demand, refer to the Supplementary Volume 1)

2) Route Conditions

The principal route conditions are as follows:

- Route length : 14.7 km for the Basic Case
- Number of stations : 12
- Minimum curve radius (R) : $R \geq 120$ m
- Maximum grade (i) : $i \leq 35$ ‰

(For the detailed alignment and profile, refer to Figures of the Preliminary Engineering Plans in a separate volume)

3) Transport Capacity

The transport capacity per train with 5 car formation (L = 16 m x 5 cars = 80 m) is as follows: (Formation of a train of 5 cars is shown in Appendix 1-1).

- Nominal capacity : 474 persons per train
- Maximum capacity for transport plan : 1,008 persons per train

- When filled to its maximum : 1,248 persons per train

4) Performance of Rolling Stock

The main performance of the rolling stock used for the run curve simulation (Appendix 1-2) is as follows:

Maximum speed = 80 km/hour

Acceleration and deceleration = 3.5 km/hr/sec

5) Stopping Time at Each Station

The stopping time at each station is set as follows:

At main station (3 stations) : 35 seconds

At other station (7 stations) : 25 seconds

6) Schedule Speed and Time

Based on the abovementioned conditions, the run curve simulation was carried out and the results are as follows:

Schedule speed : 30 km/hr

Schedule time : 29 minutes for one way

The schedule time is shown in Table 2-2.1.

7) Minimum Headway

Although it is possible to shorten the headway by detailed study of the running speed, the signal control system, etc., the minimum headway is supposed to be 3 minutes in this study to leave some margine for more transport demand in future (As for the basis of calculation, refer to Appendix 1-3).

Table 2-2.1 SCHEDULE TIME

Station No. (Main Station)	Distance between stations (m)	Running Time (second)		Stopping Time at station except both terminals (second)
		North-bound Train (from No.1 to No. 12 St)	South-bound Train (from No.12 to No.1 St)	
No.1 (Guasmo)				
	1,550	140	160	
No.2				25
	1,400	140	160	
No.3				25
	1,350	150	130	
No.4				25
	1,300	100	100	
No.5 (Centro Civico)				35
	830	80	80	
No.6				25
	740	70	70	
No.7				25
	780	80	70	
No.8 (9 de Octubre)				35
	1,450	130	150	
No.9				25
	1,350	130	110	
No. 10 (Policentro)				35
	1,900	200	210	
No.11				25
	2,040	240	220	
No.12 (Terminal Terrestre)				-
Total	14,690	1,460	1,460	280

(Note) 1. Running time is set based on the result of run-curve simulation.

2. Schedule time between both terminals is 1740 seconds (29.2 minutes). Accordingly, schedule speed is: (14.7 km/1,740) x 3600 = 30.4 km/hr = 30 km/hr

2-3 Transport Plan

1) Required Number of Trains and Headway

The required number of trains per hour in one direction (N) and its headway (H) are shown below:

Item \ Year	1990	1993	1996	2000	2010 -
Maximum number of passengers per hour in one direction (A)	12,600	14,500	15,700	17,400	21,200
Required number of trains (N) N = A/ (transport capacity: 1,008)	13	15	16	18	22
Headway (H) H=60/N(Minutes)	4.6	4.0	3.8	3.3	2.7

2) Train Operation Diagram

For an example, Figures 2-3.1 and 2-3.2 show the train operation diagrams in 1990 and 2000 both in peak hour and around it, considering the schedule time and headway in peak hour as well as efficient operation of trains.

3) Required Number of Rolling Stock

Required numbers of rolling stocks are estimated as bellow:

Item \ Year	1990	1993	1996	2000	2010 -
a. Schedule time (minutes)	29	29	29	29	29
b. Stopping time at terminals (minutes)	1	1	3.8	3.3	2.7
c. Number of operating trains in a peak hour c = (a+b)x2/ (headway)	* 13	15	18	* 19	24
d. Number of trains reserved for inspection and repair	1	1	2	2	3
e. Required number of rolling stocks e = (c+d)x5	70	80	100	105	135

(Note) Figures marked (*) are derived from the train operation diagrams.

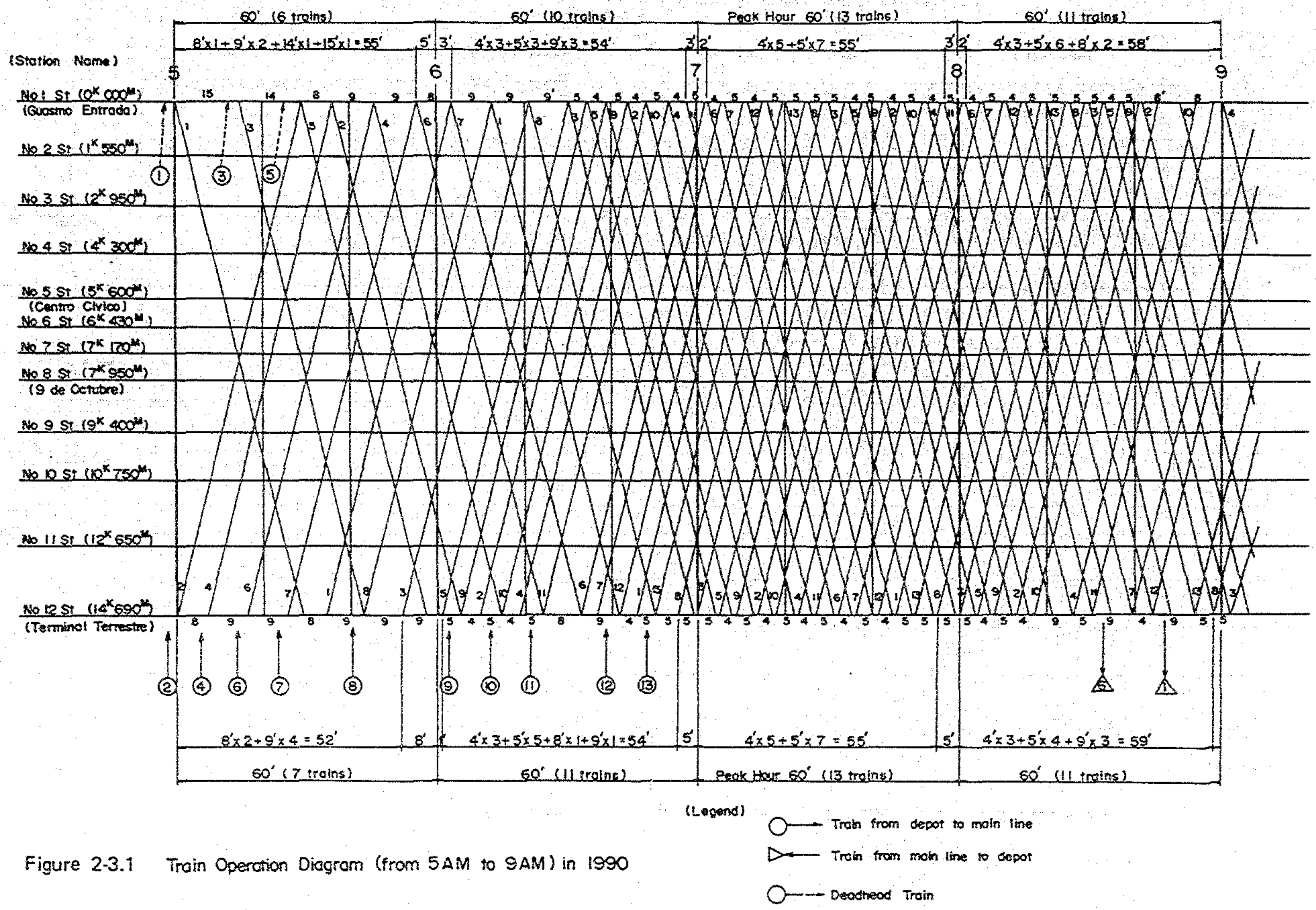


Figure 2-3.1 Train Operation Diagram (from 5AM to 9AM) in 1990

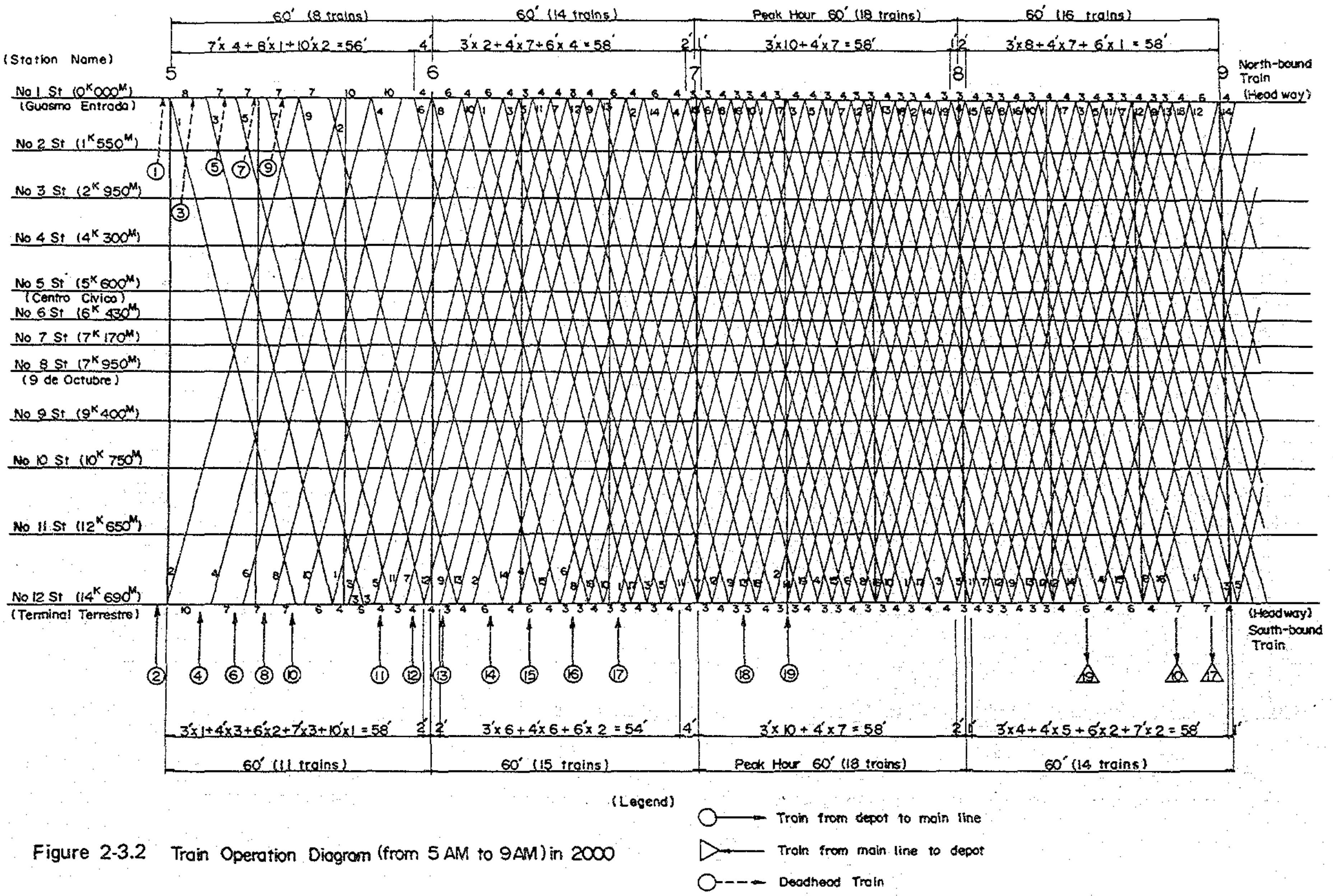


Figure 2-3.2 Train Operation Diagram (from 5 AM to 9 AM) in 2000

4) Number of Trains per Day

Table 2-2.2 shows the relationship among the hourly transport demand, number of trains, nominal transport capacity and operation service level in 1990 and 2000. The number of trains per day required for attaining the service level shown in the item 2-1(3) are shown below:

		(in 1990)	(in 2000)
Number of trains in both directions per day	:	176 x 2 = 352	229 x 2 = 458
Allowance including deadhead trains	:	8	12
		360	470

Based on the above results, those in other years are estimated as below:

in 1993 : 400 ; in 1996 : 430; in 2010 : 580

Table 2-2.2 HOURLY NUMBER OF TRAINS AND OPERATION SERVICE LEVEL

Operating Hour	Transport Demand (A) (Passenger per hour in one direction)			Number of Trains (B) (Train per hour in one direction) (Average Headway)		Nominal Transport Capacity (C) (Passengers per hour in one direction)		Service Level (Congestion Rate) (A/C) (%)	
	Rate (%)	in 1990	in 2000	in 1990	in 2000	in 1990	in 2000	in 1990	in 2000
5:00 ~ 6:00 (1)	2	2,100	2,900	6 (10')	8 (7.5')	2,800	3,800	80	80
6:00 ~ 7:00 (1)	6	6,300	8,700	10 (6')	14 (4.3')	4,700	6,600	130	130
7:00 ~ 8:00 (1)	12	12,600	17,400	13 (3.3')	18 (3.3')	6,100	8,500	210	210
8:00 ~ 10:00 (2)	7	7,350	10,150	11 (5.5')	14 (4.3')	5,200	6,600	140	150
10:00 ~ 12:00 (2)	5	5,250	7,250	11 (5.5')	14 (4.3')	5,200	6,600	100	110
12:00 ~ 14:00 (2)	6	6,300	8,700	11 (5.5')	14 (4.3')	5,200	6,600	120	130
14:00 ~ 16:00 (2)	5	5,250	7,250	11 (5.5')	14 (4.3')	5,200	6,600	100	110
16:00 ~ 19:00 (3)	8	8,400	11,600	11 (5.5')	14 (4.3')	5,200	6,600	160	180
19:00 ~ 21:00 (2)	3.5	3,700	5,100	8 (7.5')	11 (5.5')	3,800	5,200	100	100
21:00 ~ 22:00 (1)	2	2,100	2,900	6 (10')	8 (7.5')	2,800	3,800	80	80
22:00 ~ 23:00 (1)	1	1,050	1,450	4 (15')	5 (12')	1,900	2,400	60	60
Total (18 hours)	100	105,000	145,000	176	229	83,400	108,500	(Average) 126	(Average) 134

Note: 1. Hourly transport demand is assumptive figures expected from hourly flactuation of the existing urban bus passenger flow shown in the Supplementary volume 1, Figure 1-3.2.

2. (C) = (B) x (Nominal transport capacity per train) = (B) x 474

3. Construction Plan

3-1 Outline

In this section, a complete construction plan of the selected Light Urban Railway system for the Basic Case (14.7 km, from Terminal Terrestre to Guasmo) will be worked out to cover the whole system: trackway structures, stations, rolling stock, electrification, signalling and communication system, depot and maintenance shop, etc.

First, construction standards for structures' planning will be defined in section 3-2, then plan and profile of the route alignment will be selected in 3-3 and track structures, stations, etc. will be designed in 3-4 and 3-5, both based on the standards.

In 3-6, characteristics of the rolling stock and requirements of this route to them will be presented, then engineering specifications and their detailed plan will be clarified. Through 3-7 to 3-9, plans for all the electrical facilities such as substations, power distribution system, signalling, communication system, etc. will be also described in detail. And last, in 3-10, a plan for the car depot will be presented, introducing various inspections and their shops equipped there.

All the above items will be worked out economically, functionally, easy-constructed and maintenanced, and well-coordinated each other, etc., and finally continued to the cost estimation in section 5 later.

3-2 Construction Standards and Basic Items

1) Car and Construction Gauge

The car and construction gauge is as per shown in Figure 3-2.1.

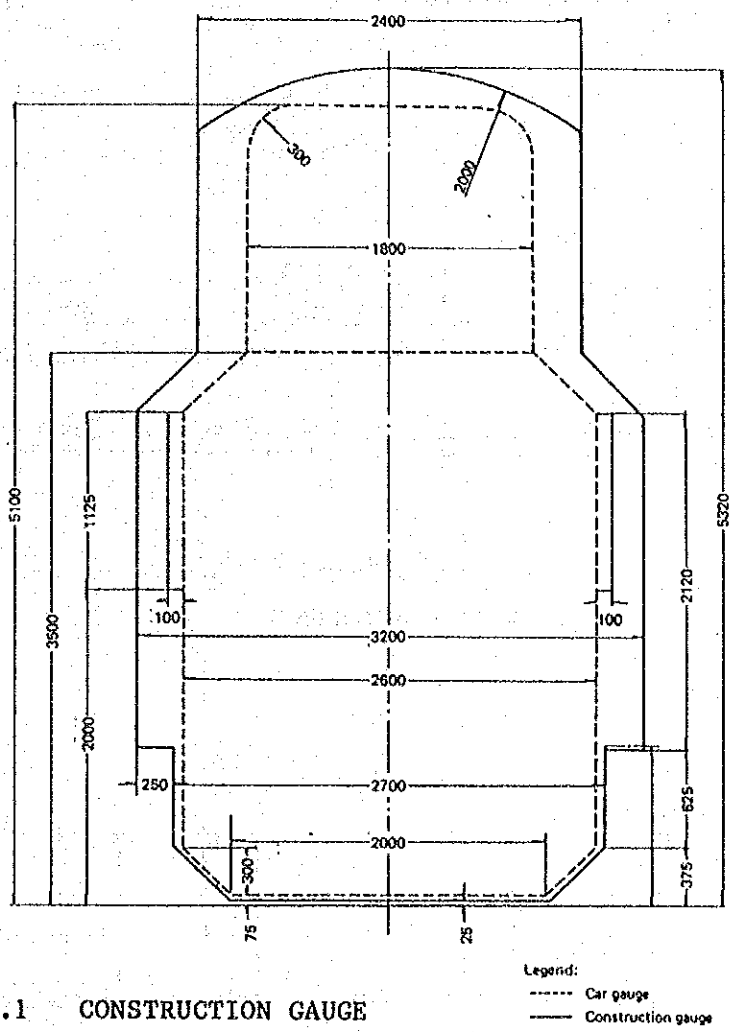


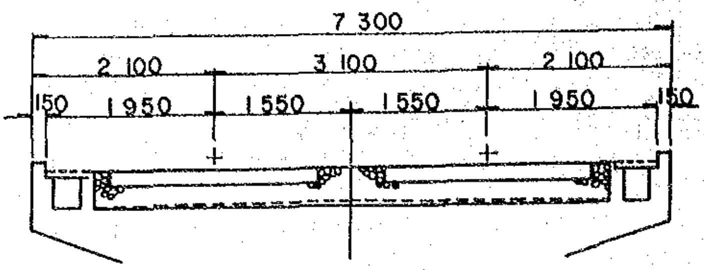
Figure 3-2.1 CONSTRUCTION GAUGE

2) Trackway Dimension

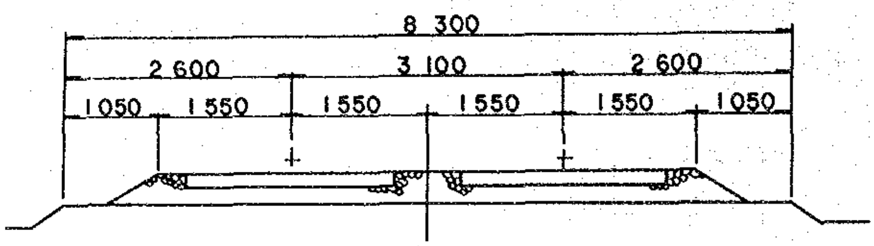
The trackway dimension is as per shown in Figure 3-2.2.

3) Design Standards

Designs f the railway plan, railway profile, structures and other facilities shall be subject to the standards shown in Table 3-2.1 and Figure 3-2.3.



Elevated section



On-the-ground section

Figure 3-2.2 TRACKWAY DIMENSION

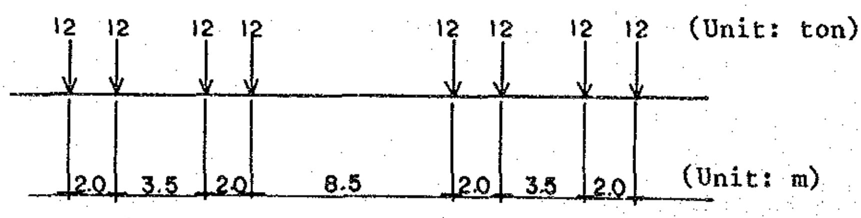


Figure 3-2.3 TRAIN LIVE LOAD

Table 3-2.1 DESIGN STANDARD

Route Plan, Profile and Structure		
Item	Standard	Remarks
Gauge	1,435 mm	
Maximum design speed	80 km/h	
Maximum curve radius	120 m	for main track
	100 m	for depot
	300 m	for station section
Maximum grade	3.5 %	for main track
	1.0 %	for station
Vertical curve	2,000 m	in horizontal curve R ≤ 800m
	3,000 m	in horizontal curve R > 800m
Track-center distance	3.1 m	for main track
	4.0 m	for depot
Rail	50 kg/m	
Sleeper	wooden	
Ballast thickness of track	200 mm	under the sleeper
Turnout	No. 8 (1:8)	for main track
	No. 6 (1:6)	for depot
Live load	12 ton/1 axle	train moving load
Over head clearance	4.7 m	clearance between the bottom of structures and the road surface

Electric Power, Signalling	
Electricity from power supplier	60 Hz, 3-phase 69 KV
Electricity traction power	DC 1500 V
Trolly wire suspention	simple catenary
Signal	color light type
Train control	CTC and ATS

Rolling stock		
Train length		80m (16m x 5)
Car performance	Acceleration	3.5 km/h/sec
	Deceleration	4.0 km/h/sec

3-3 Route Plan and Profile

1) Planning Conditions

In designing the route plan and profile, the standards shown in Table 3-2.1 shall be applied.

However, when the designed route plan and profile are restricted by topography, obstacles, etc., the design standard shall be loosened within a minimum range so as to meet the conditions.

2) Route Plan

Because the most part of the section utilizes the space over streets, the route plan is designed not only to match the topographical features of the streets but also to minimize hindrance to private-owned lands and buildings, etc.

The main points for route alignment are as follows:

(1) Av. 25 de Julio -- Av. Quito -- Calle Manuel Galecio -- Av. Delta -- Av. San Jorge

In this section, the route is selected over the center of the streets throughout the entire course. In a part of Av. 25 de Julio, however, the route is detoured toward the sidewalks (which will become a median strip in future when the street is widened as it has been planned) in order to avoid the underground obstacles.

(2) Av. San Jorge -- Av. las Americas -- Airport

In this section, the route utilizes the median strip of the streets, branching from the midway, crossing Av. las Americas and then entering into the airport site.

(3) Airport -- Terminal Terrestre

In this section, the route runs along the west side of the airport site, passing through the front of the airport terminal, running along the west side of Terminal Terrestre and then arriving at the front of Terminal Terrestre with consideration of the future design of the airport site.

(4) Depot

A depot is constructed in an open space located along the Guayas river in the north side of Terminal Terrestre.

3) Profile

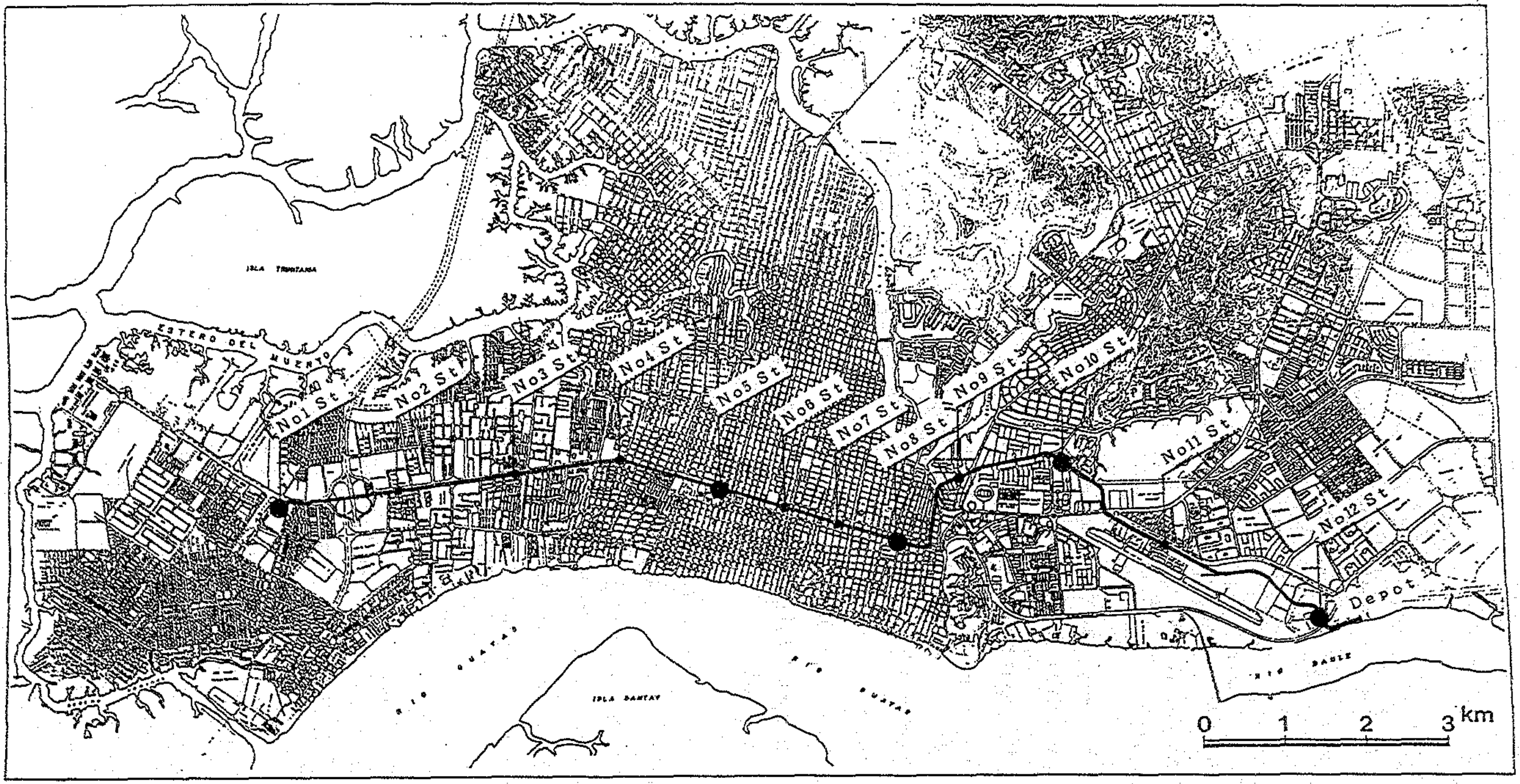
The route profile is subject to the design standards and, in addition, the following points are considered to decide its alignment:

- To avoid complex combination of the transition curves and vertical curves which may cause derailment
- Not to insert turnout in the heavy grade section

From the viewpoint of decreasing construction costs, it is also recommendable to attach importance to the following points:

- To lower the height of structures
- To avoid a bridge with a long span
- To adopt fill-up of the ground or the on-ground type trackway

Considering the abovementioned matters, design was executed as shown in Figure 3-3.2 and the height required for the main bridges and stations is shown in Table 3-3.1 and Table 3-3.2. On the other hand, the on-ground type trackway was selected in the airport site where the trackway will not give any hindrance to the Airport Master Plan in future.



Main Station	Kilometerage of Stations	No. 1 ST (0 K 000 M)	No. 7 ST (7 K 170 M)	
Standard Station		No. 2 " (1 K 550 M)	No. 8 " (7 K 950 M)	
		No. 3 " (2 K 950 M)	No. 9 " (9 K 400 M)	
		No. 4 " (4 K 500 M)	No. 10 " (10 K 750 M)	
		No. 5 " (5 K 600 M)	No. 11 " (12 K 650 M)	
		No. 6 " (6 K 430 M)	No. 12 " (14 K 690 M)	

THE FEASIBILITY STUDY ON GUAYAQUIL CITY URBAN TRANSPORTATION PLAN IN THE REPUBLIC OF ECUADOR

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Figure 3-3.1 ALIGNMENT OF RAILWAY

JAPAN INTERNATIONAL COOPERATION AGENCY

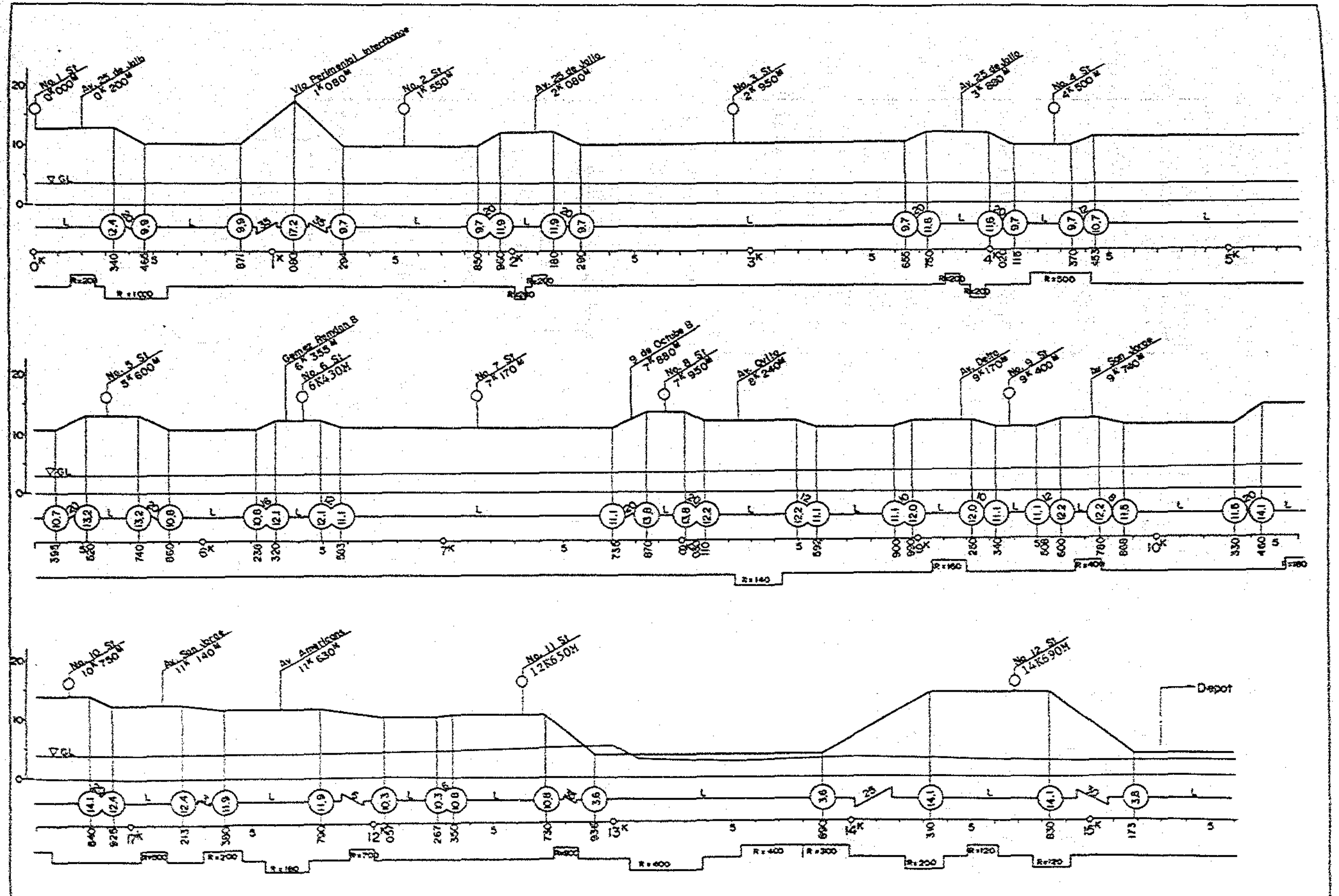


Figure 3-3.2 PROFILE

Table 3-3.1 REQUIRED HIGHT OF MAIN OVERPASS BRIDGES

Road Name	Distance from No. 1 station (Guasmo)	Number x Span (m)	Required Height (m)	Remarks
Av. 25 de Julio	0^k200^m	1 x 40	8.80	
Via Permmental Inter-change	1^k080^m	2 x 25	12.50	
Av. 25 de Julio	2^k080^m	2 x 30	8.40	portal pier
Calle Venezuela	5^k670^m	1 x 40	8.80	
Calle Portete	5^k750^m	1 x 40	8.80	
Av. Gomez Rendon	6^k355^m	1 x 40	8.80	
Av. 9 de Octubre	7^k880^m	1 x 40	8.80	
Av. Quito	8^k240^m	2 x 25 + 35	8.40	portal pier
Av. Delta	9^k170^m	2 x 35	8.40	portal pier
Av. San Jorge	9^k740^m	2 x 35	8.40	portal pier
Av. Las Americas	11^k630^m	2 x 35	7.90	

Table 3-3.2 REQUIRED HIGHT OF MAIN STATIONS

Station Name	Distance	Required Height (m)	Remarks
No 1 (Guasmo Entrada)	0^k000^m	8.80	reinforced concrete
No 5 (Centro Civico)	5^k600^m		
No 8 (9 de Octubre)	7^k950^m	10.00	steel
No 10 (Policentro)	10^k750^m		
No 12 (Terminal Terrestre)	14^k690^m	11.00	reinforced concrete

3-4 Track and Main Structures

1) Track

A section of the track structure is shown in Figure 3-4.1. The gauge is 1.435 meter (the standard) and a wooden tie is used for the sleeper which is obtained anywhere easely.

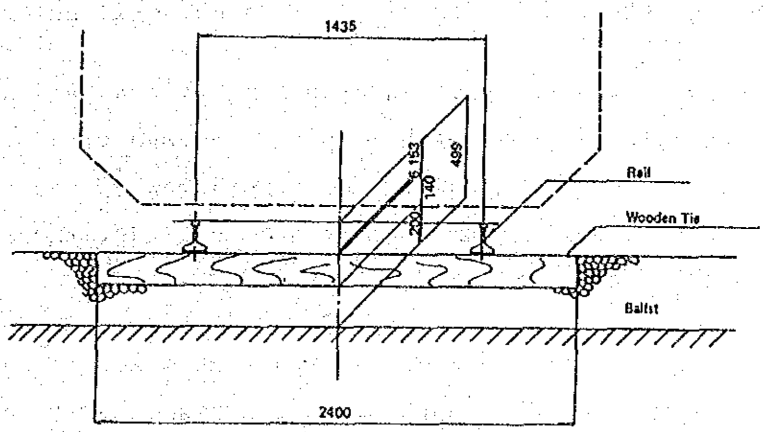


Figure 3-4.1 TRACK STRUCTURE

2) Trackway Structures

As elevated structural types, generally there are a girder bridge type and a rigid frame bridge type and, as a result of comparison and examination shown in Table 3-4.1, it was found that the rigid frame bridge type is more economical than the girder bridge type.

Table 3-4.1 COMPARISON OF ELEVATED STRUCTURES

Type	Cost	Ease in construction	Harmony with the wayside	Space utilization under structures
RC rigid frame	◎	○	○	△
RC girder viaduct	○	◎	○	○
PC girder viaduct	△	○	◎	◎

Note: ◎ Excellent ○ Better △ Normal

RC: Reinforced Concrete

PC: Prestressed Concrete

It is also necessary, however, to examine the conditions other than the abovementioned one in case of planning elevated structures in the urban area. For this study area, the structural type is determined based on the idea as follows:

(1) In the urban area, the size of spans should be uniform and the number of piers should be made as small as possible.

(2) The part of structures intersecting with a road should cross over the road with 1 span. In case of 2 or 3 spans required on account of the configuration of the crossing, the plan should be made so as not to hinder the road traffic therewith.

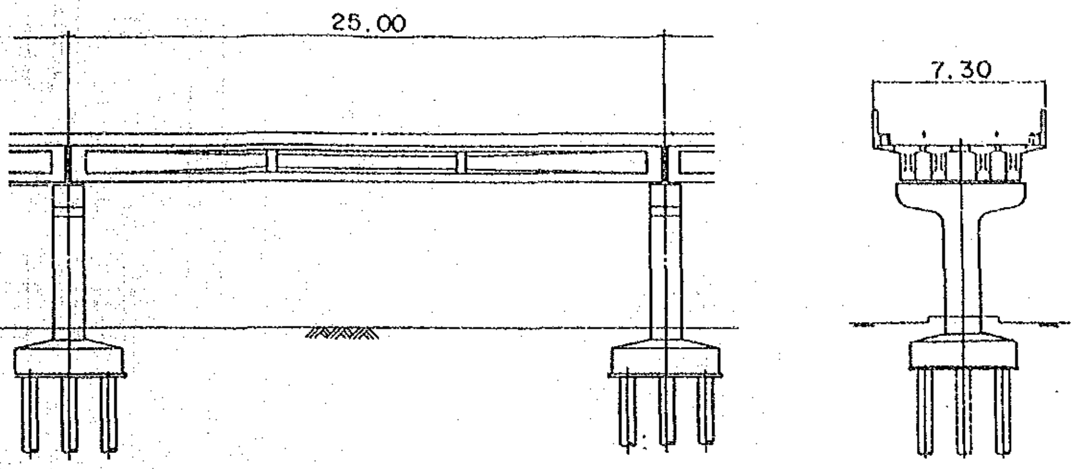
(3) Taking track maintenance into consideration, a concrete structure should be adopted as the trackway structure.

Based on the above matters, the prestressed concrete (PC) girder type with 20 to 30 meter span long was adopted for the structures on the roads in the urban area and the reinforced concrete (RC) rigid frame type with 8 meter span long was adopted for the structures which are not over the roads.

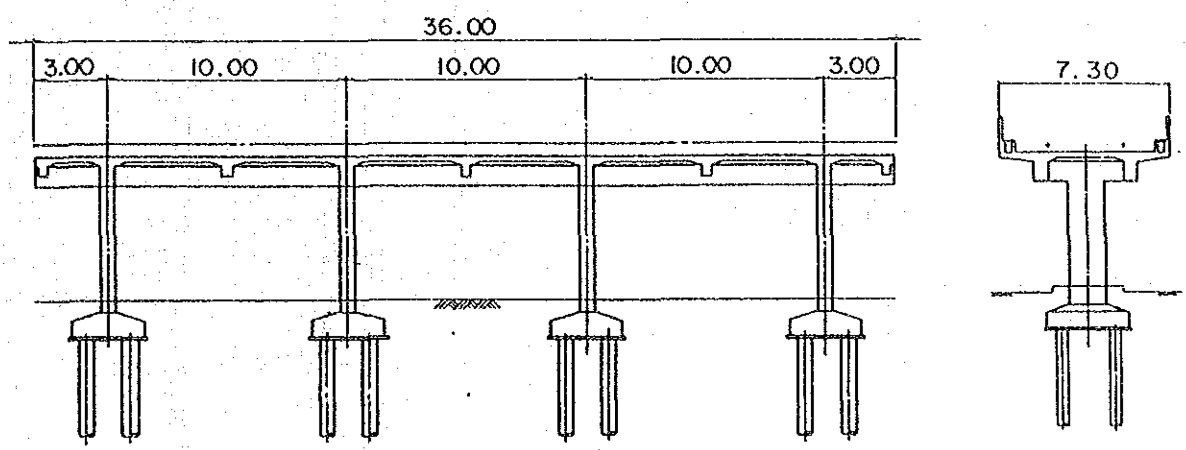
As shown in Table 3-3.1, 2 kinds of bridges, namely, Type A (1 span) and Type B (2 to 3 spans) were adopted for the bridges crossing over the roads. As for the station structures the steel rigid frame type with 20 meter span was adopted in the urban area because these structures are subject to the load of platform shed, platform, concourse, station office, etc. whereas the reinforced concrete rigid frame type with 10 to 12 meter span was adopted to the structures of stations located out of the urban area. Cast-in-place concrete pile was adopted to foundation and a hard diluvium stratum was used for supporting foundation properly.

Figures 3-4.2 to 3-4.4 show the general view of each type of structures. (Examples of structural analysis are shown in Appendix 1-4.)

Prestressed Concrete Girder



Reinforced Concrete Rigid Frame (Type "A")



Reinforced Concrete Rigid Frame (Type "B")

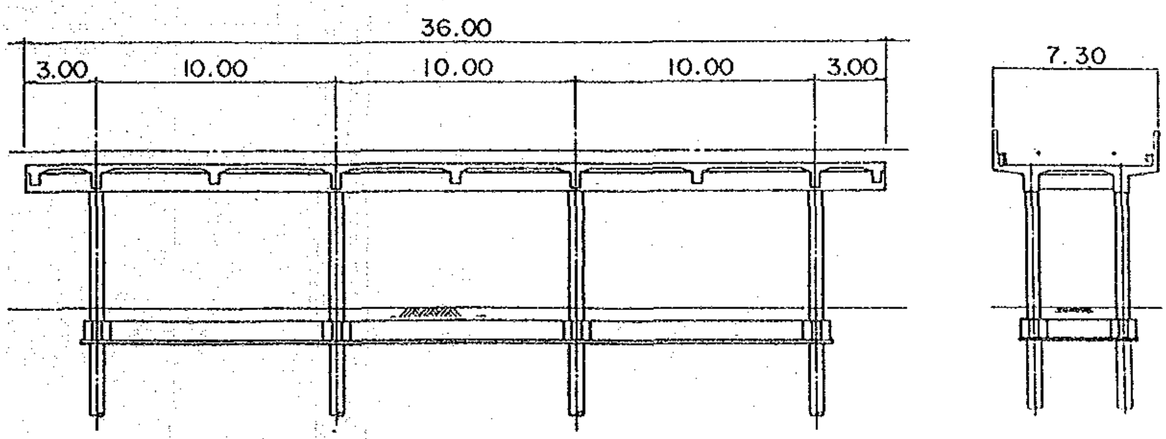


Figure 3-4.2 STANDARD STRUCTURE FOR ELEVATED TRACKS

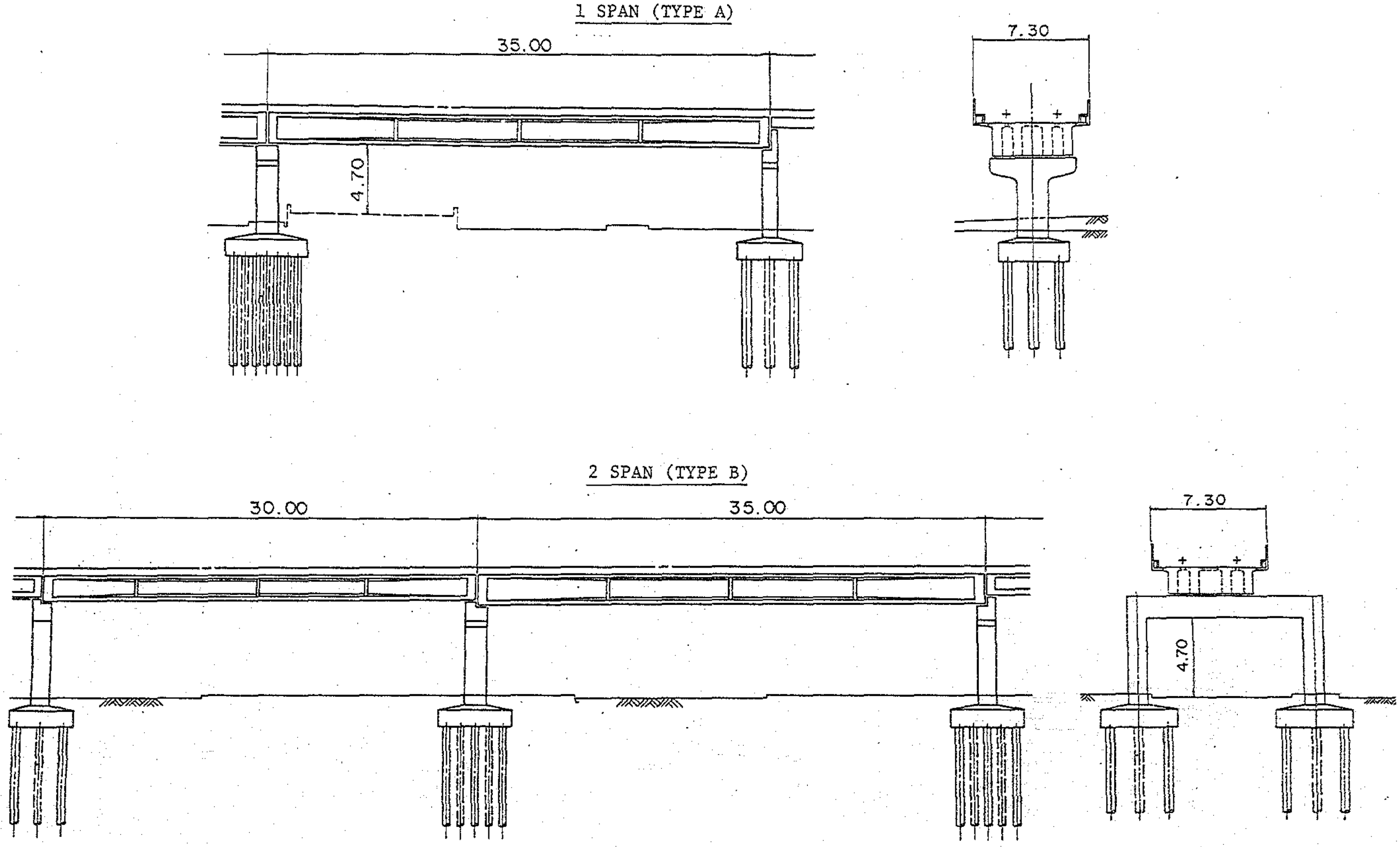


Figure 3-4.3 SPECIAL STRUCTURE FOR ELEVATED TRACKS

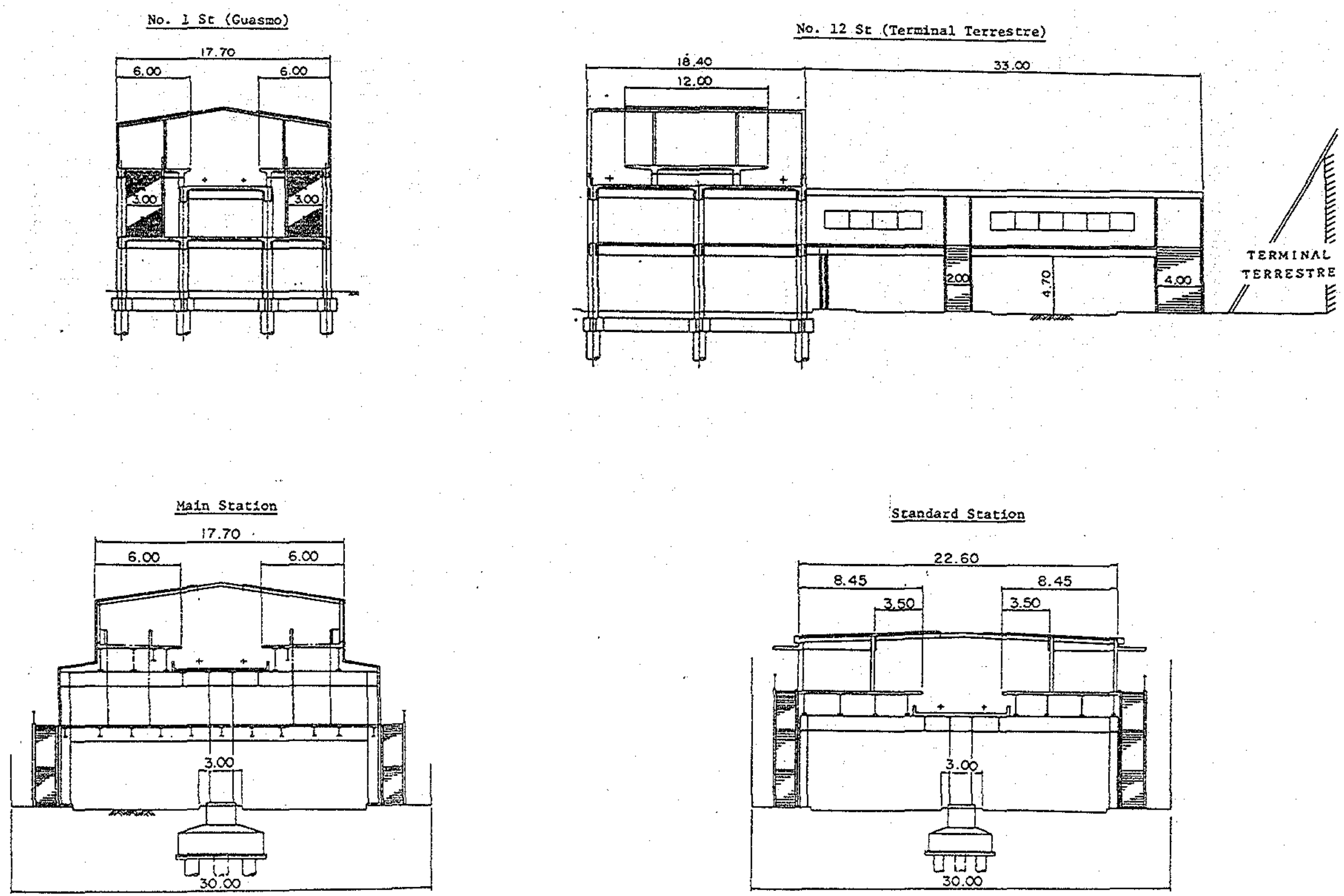


Figure 3-4.4 SECTION VIEW OF STATIONS

3-5 Stations

The scale of stations is classified as follows in accordance with the number of passengers utilizing respective station:

Main stations:

No. 1 Station ———————— (Guasmo Entrada)
No. 5 Station ———————— (Centro Civico)
No. 8 Station ———————— (9 de Octubre)
No.10 Station ———————— (Policentro)
No.12 Station ———————— (Terminal Terrestre)

Standard stations: 7 stations other than the above main stations.

The station facilities are provided under the elevated structures for the main stations and in the central part of the structures for the standard stations so that the structures may be utilized easily by passengers as well as allowing the stations to treat the passenger flows smoothly.

1) Main Facilities in Station

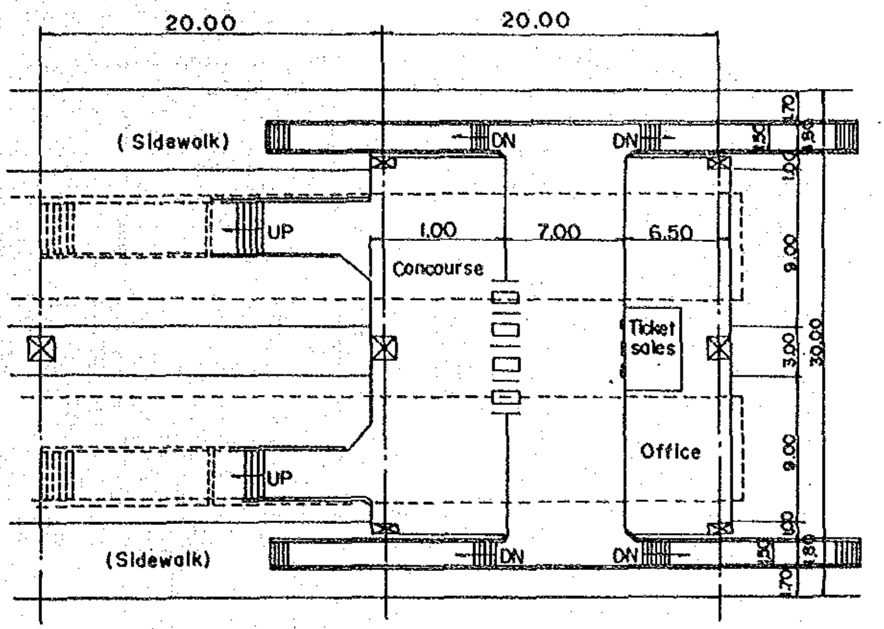
The main facilities of a station are as follows:

- Guiding facilities : Concourse, passage, etc.
- Passenger facilities : Ticket sales, ticket barrier, etc.
- Station office facilities: Room for station master and staff, etc.

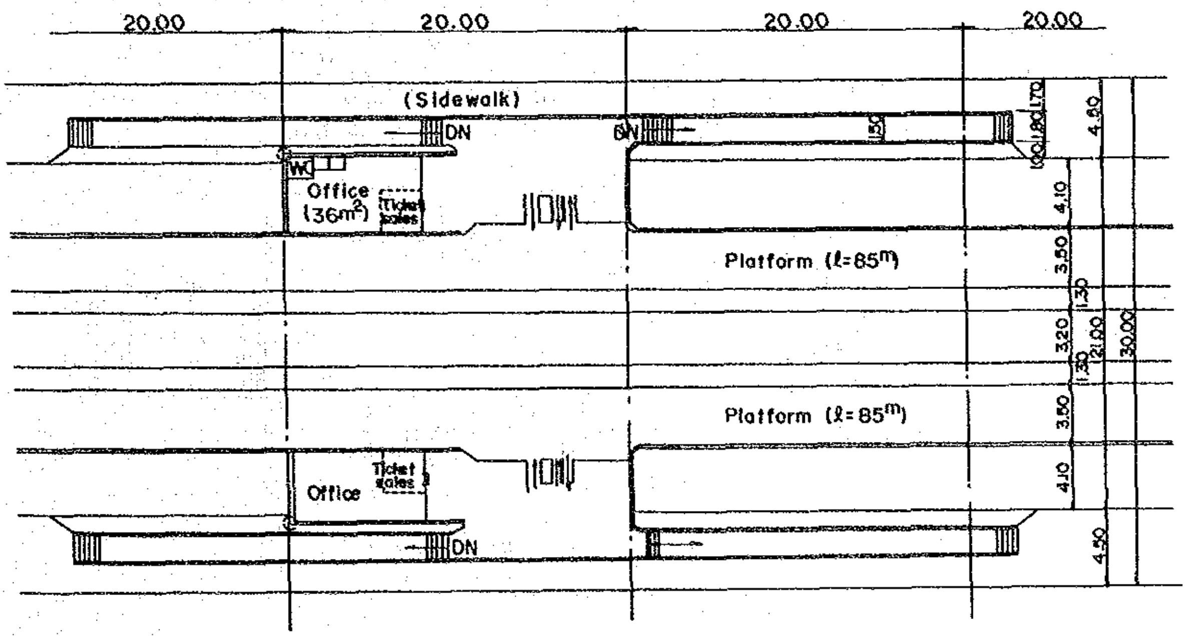
Figures 3-5.1 shows the station layouts.

2) Platform

- The length of platform is 85 meters by adding 5 meters of allowance to 80 meters of the train length.
- As a type of platform, the island type is adopted to No. 12 Station which has a large number of passengers whereas the separate type is adopted to other stations.

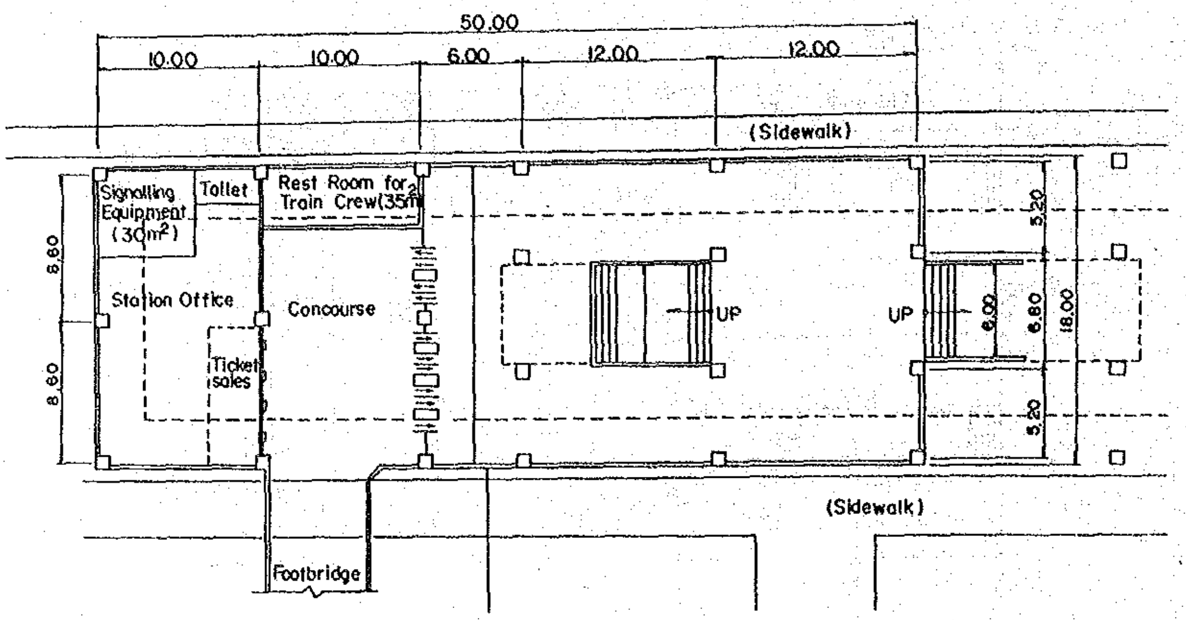


Main Station

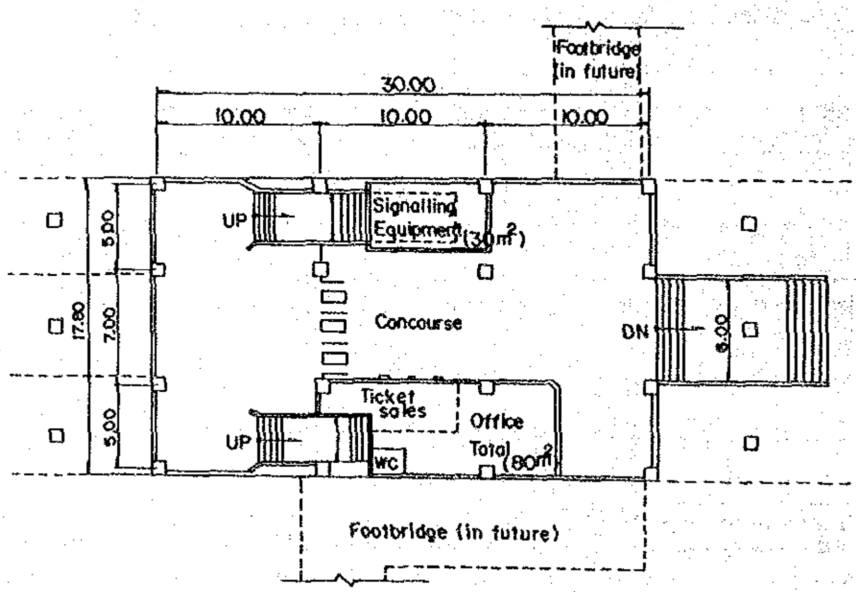


Standard Station

Figure 3-5.1 (1) LAYOUT OF STATIONS (1)



No. 12 St (Terminal Terrestre)



No. 1 St (Guasmo Entrada)

Figure 3-5.1 (2) LAYOUT OF STATIONS (2)

- The width of platform is 12 meters for No. 12 Station, 6 meters for other main stations and 3.5 meters for the standard stations respectively considering the number of passengers to utilize each station.

3) Platform Shed

For each station, a platform shed is provided in the portion near the stage and concourse.

4) Connection with Other Transport Means

For No. 12 Station, a foot-bridge is provided for connecting with the Terminal Terrestre.

5) Other Related Facility Plan

As the related facilities to be provided as station facilities, there are many for offering services to getting on and off passengers (public facilities, commercial facilities, etc.), facilities incidental to station services (parkings, connecting bus terminals, etc.) and so on, which display their terminal functions in combination with the station squares as one body.

It is recommendable for these related facilities, therefore, to plan and provide such a station square as matching the circumstances surrounding each station.

3-6 Rolling Stock Plan

1) General

This rolling stock plan has been laid out to perform the mass rapid transportation of passengers effectively. Therefore, it contains the rolling stock:

a. Which is functional with the capability of satisfying transportation requirements even at the peak of rush hours.

b. Which gives good riding comfort and accommodation.

c. In which both reliability and safety are incorporated.

d. Of which the production cost is low and ground facilities are inexpensive.

e. Of which the maintenance cost and the operation cost such as electric power rate, etc. are low.

f. Of which the handling and maintenance are easy.

g. Of which material is hard to take fire and burn.

h. Which has the least chance of obsolescence in future.

Satisfying the above requirements, it shall be a modern rolling stock designed on the basis of ample informations obtained through actual usage in Japan.

2) Kinds of Rolling Stock and Train Formation

This rolling stock consists of motored cars (abbreviated as "M") and trailer (abbreviated as "T"). Two motored cars are connected to perform one power unit, one of which is a motored car with controller (abbreviated as "Mc") and the other is equipped with the auxiliary power source appratus. This system is adopted with the intention of reducing the production cost and facilitating the arrangement of under-floor equipments.

b. This rolling stock shall be run with the train consist of 4 M and 1 T which is equal to McMTMMc according to the above abbreviation. All motors are collectively controlled by Mc car's control appratus.

3) Conditions of Operation

Table 3-6.1 CONDITIONS OF OPERATION

Electricity	DC 1500 V
Gauge	1435 mm
Max. Gradient	35 0/00
Min. Radius of Curvature	100 m

4) Rolling Stock Gauge

In order to reduce the construction cost of stations, it is desirable to minimize the rolling stock gauge. On the other hand, there is a necessity of securing sufficient dimensions which are required for the rolling stock performance in meeting transportation requirements, and at the same time in maintaining riding comfort of passengers.

Figure 3-6.1 illustrates the result of the above consideration.

5) Nominal Capacity

The nominal capacity of passengers is the sum total of the number of seats and the number of standing lots and for standing passengers, a car is equipped with some appropriate supports such as hand hold and straps, etc. The projected maximum number of passengers shall be 220% of the above-mentioned capacity, providing the minimum floor space for each standing passenger.

The Table 3-6.2 shows the capacity of the passengers.

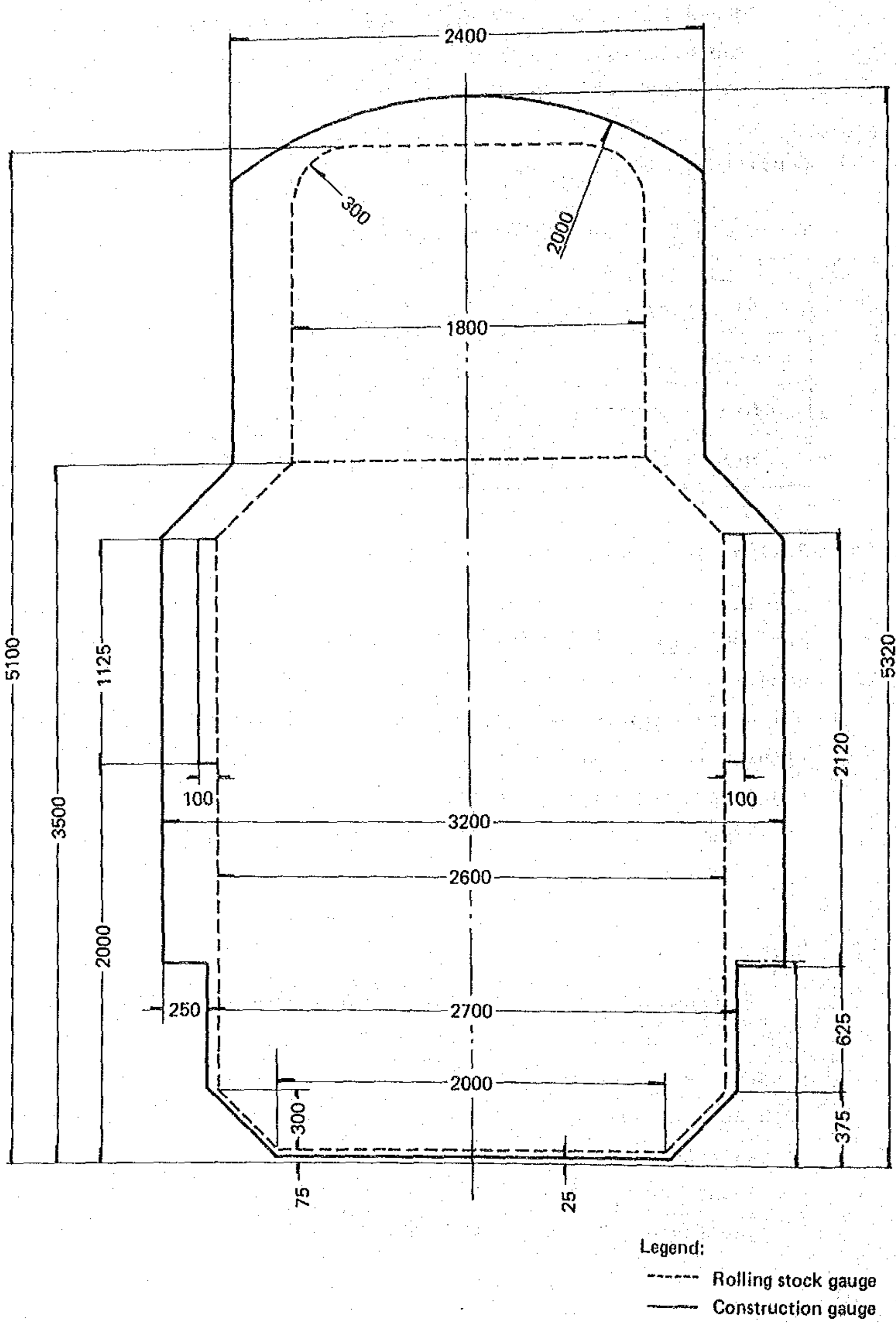


Figure 3-6.1 ROLLING STOCK GAUGE

Table 3-6.2 PASSENGER CAPACITY

Item		Leading car	Intermediate car	Whole train (5 vehicles)
Nominal Capacity	Seating	36	44	204
	Standing	54	54	270
	Total	90	98	474
Projected max. number of passengers	Seating	36	44	204
	Standing	156	164	804
	Total	192	208	1008

6) External and Principal Dimension

a. Figure 3-6.2 and 3-6.3 show the overall measurements of the rolling stock and the arrangements of doors, windows, driving cab, etc. The interior height from floor surface to ceiling has been decided in full consideration of passengers' comfort.

The height from rail surface to floor surface inside the car has been decided so as to give ample space for assembling under-floor equipments.

The car length and width have been set in conformity with the standard car of Japan with the view of reducing the production cost, etc.

Side doors for passengers are provided at 3 locations on each side of the car.

b. Coupling of Cars

The two electric cars in a power unit (Mc M) are coupled with a semi-permanent coupler. Automatic coupler which enables easy coupling is used to on a trailer and the both ends of the unit.

c. Axle Load

Arrangement of equipments and apparatuses is made so as to equalize as much as possible the load of each car on

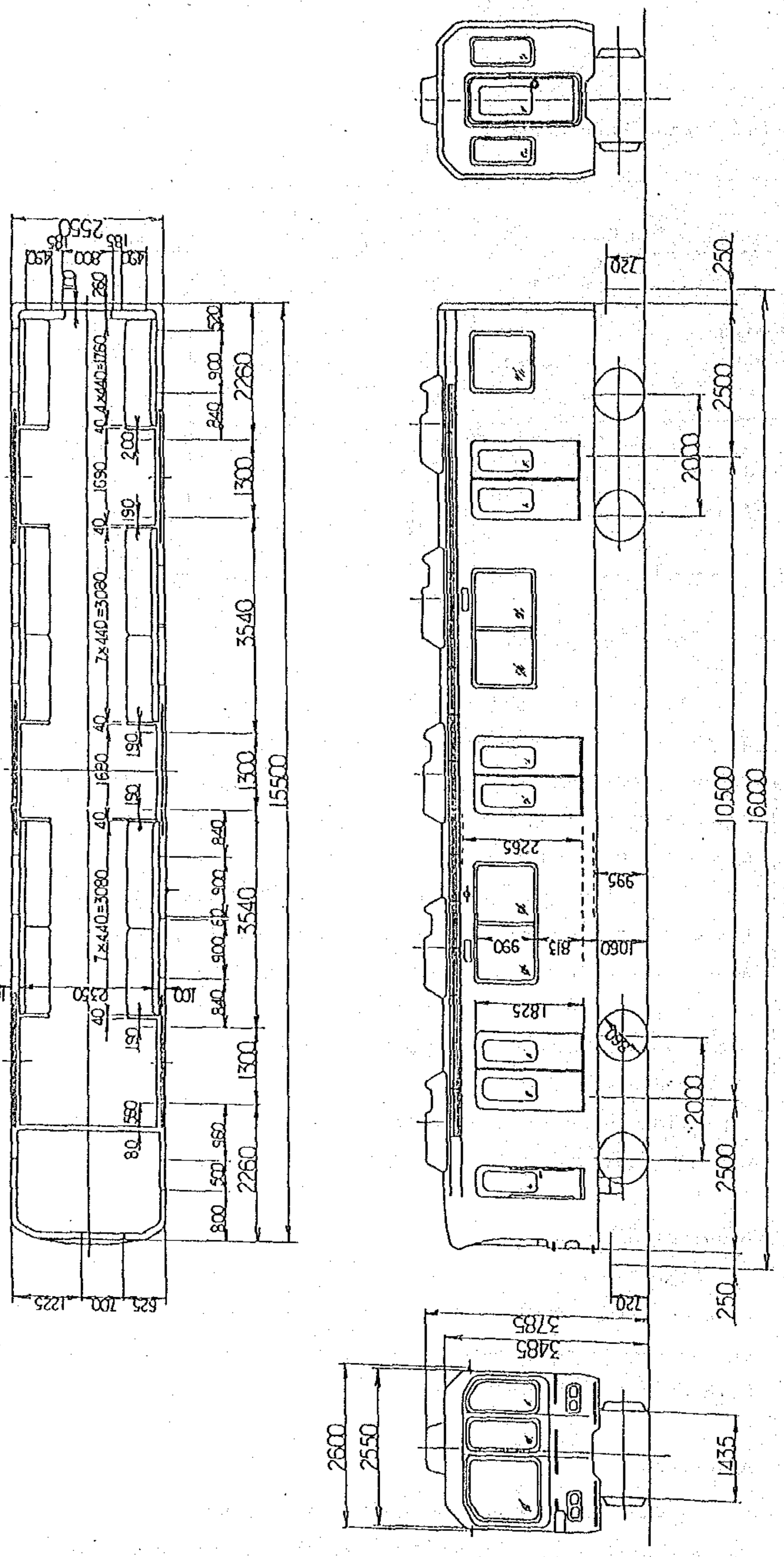


Figure 3-6.2 HEAD MOTORED CAR (Mc)

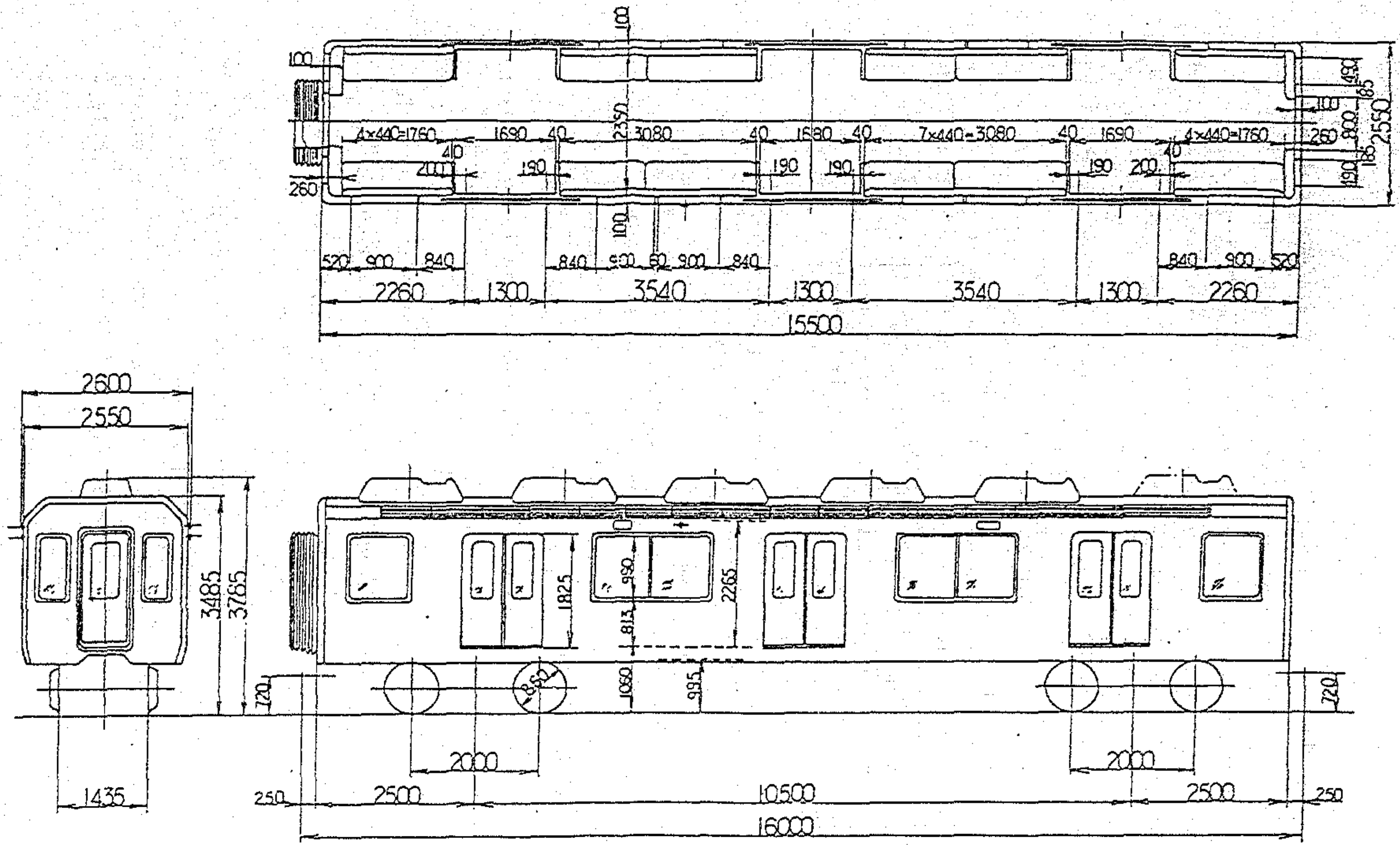


Figure 3-6.3 INTERMEDIATE MOTORED CAR (M)

the wheels. The maximum axle load is designed not to exceed 12 tons even when transporting ultra full passengers.

7) Principal Feature and Performance

a. Basic Performance

Table 3-6.3 BASIC PERFORMANCE

Item	Description
Max. running speed	80 km/h
Acceleration	3.5 km/h/s
Deceleration	4.0 km/h/s
Deceleration in case of emergency	4.5 km/h/s
Schedule speed	30.0 km/h

b. Inside Equipments

Passenger room and driver's cab are designed so as to secure safety and comfort.

b-1 In order to prevent fire breakout, most of the materials used for cars shall be incombustible. For those parts where incombustible materials can not be used, materials of hard to take fire and burn shall be used.

b-2 The side doors for passengers are double sliding doors. Ordinarily, these doors are opened or shut automatically and simultaneously by operating door switch in the driver's cab. In case of emergency, however, they shall be able to be opened individually.

b-3 Side windows are of open/shut style.

b-4 Communication devices shall be installed for the driver and the conductor to signal and communicate with each other. A public addressing device for the conductor shall be also installed. The latter shall be usable even during power failure.

b-5 Spare power source apparatus shall be equipped to ensure the operation of emergency devices. Spare lights are also installed inside the car.

b-6 Seating shall be of a long bench style, providing 440 mm width per passenger. Holding straps shall be installed for the benefit of standing passengers over the front of benches.

b-7 Air-conditioning system shall be equipped.

c. Truck

The truck shall not only ensure good riding comfort, low noise, and light weight, but also have the structure suitable for passing through sharp curves.

d. Main Systems

The controlling and braking systems of this rolling stock are as follows.

Table 3-6.4 MAIN SYSTEMS

Item	System
Controlling system	Series parallel, field weakening, dynamic brake. Multiple unit control
Braking system	Electro/magnetic straight air brake with dynamic brake, and hand brake
Safety system	Automatic train stop device (ATS)

d-1 Controlling system

Rheostatic controlling system is adopted. Although high frequency advanced thyrister-chopper system is gaining popularity these days, the above system has been adopted as a result of technical and economic comparison.

d-2 Braking system

The electromagnetic straight air brake with dynamic brake is being adopted since rheostatic controlling system permits the use of dynamic brake. It is designed in such a way that automatic air brake works in case of emergency.

d-3 Safety system

The automatic train stop system (ATS) not only gives a warning to the crew when they overlook the stop signal, but also automatically stops the train before the said signal, thus preventing accidents such as head-on or end on collisions.

e. Ordinarily, the train shall be operated with the schedule speed of 30 km/h, having a margin of 10% recovery. Stopping time shall be 35 seconds at major station and 25 seconds at other stations. The operation plan is made so that the 5-car train packed to ultra full capacity is capable of reaching the adjacent station after restarting from stopped position on the track of 35 0/00 upward slope with 160 m radius curvature even if 50% of the main motor are inoperative.

f. Air-conditioning

Air-conditioning system is equipped to serve the passengers.

g. Principal Specifications of Rolling Stock

Main specifications of the rolling stock are set as follows to meet the requirements stated above.

Table 3-6.5 PRINCIPAL SPECIFICATIONS

Item	Description		
1. Type of car and its empty weight			
Mc	Approx. 32 tons		
M	Approx. 32 tons		
T	Approx. 25 tons		
2. Passenger load	(persons/car)	(persons/car)	(persons/car)
Seat	36	44	44
Nominal total capacity	90	98	98
Ultra full capacity (Weight)*	246 (14.8 tons)	264 (15.8 tons)	264 (15.8 tons)
	* based on 60 kg. per person including baggage		
3. Car body	All-aluminum light alloy welded structure		
(1) Length between buffers	16,000 mm		
(2) Car body length	15,500 mm		
(3) Car body width	2,550 mm		
(4) Max. height (from rail surface to upper part of cooler)	3,758 mm		
(5) Floor height (from rail surface)	1,060 mm		
(6) Room height (from floor surface)	2,265 mm		
(7) Distance between centre pivot of truck	10,500 mm		
(8) Number of sidedoors	3 on each side, double sliding door style		
	(continue)		

Item	Description
4. Truck and power transmission device	
System	Steel plate welded structure, air spring truck
Rigid wheel base Wheel diameter	2,000 mm 860 mm
5. Current collector system	Pantograph
6. Main motor system	D.C. series motor with self draft, mounted on frame
One hour rated output	120 kW
Voltage	375 V
Electric current	350 A
7. Controlling system and device	Series parallel, field weakening dynamic brake, multiple unit control
8. Motor generator	Approx. 180 kVA
9. Motor driven air compressor	12 kW (30 min. rated)
10. Signalling and protectig system	ATS system
11. Braking system	Electromagnetic straight air brake with dynamic brake and hand brake
12. Coupling device	Tight lock coupler with straight air pipe. Semi-permanent bar type coupler
13. Lighting	Average 300 lux in passenger car (750 mm above floor level)
14. Air-conditioning	Unit cooler individually mounted on roof

3-7 Electrification

1) Electrification Plan

The MRT system will be electified to meet environmental requirements and operational characteristics of urban transportation system.

Electric system on major transmission lines of the power supply company (EMELEC) is 60Hz, 60kV. The lines are located closely along the selected MRT route; they have enough short circuit capacity for the MRT system; and they are provided as overhead system. These lines are simply sectioned and T-branched by polemounted disconnectig switches. (see Appendix 1-5. to 1-7)

Because T-branching is adopted on the transmission line to a customer substation, MRT substations will be constructed at a necessary point under a few restrictions of the power supplier; installation cost of incoming line will be decreased.
On the other hand, detailed design studies should be made on actual MRT system concerning the influence of voltage flicker, high harmonics, etc., because the incoming line will not be installed exclusively and will be connected with other customers on the same transmission line.

Electric system for traction power feeding to the MRT car is roughly classified into AC and DC. In general, DC system is advantageous for a densely operated railway constructed in the urban area, from the view point of economy and influence to environment such as electro-magnetic interference. Therefore, DC feeding system will be adopted, and nominal voltage will be 1500V taking into account such conditions as electrical characteristics of operating trains, minimum operation headway, track condition, etc.

Substations for the MRT system will be installed to feed traction power to trains; they will be provided with parallel feeding system, and their interval will be about four (4) km, which is given by calculation of rectifier capacity, voltage drop on parallel feeding contact line system, etc.
Countermeasures will be necessary for compensation of voltage drop of the contact line system caused by high operation density.

2) MRT Substations

Substations will be planned at five locations with 60Hz, 69kV, single circuit power receiving system including silicon rectifiers, feeding equipment, etc. Locations of the substations will be as shown in Figure 3-7.1. The substations will be of outdoor type, and provided with a house for high-speed circuit breakers and control equipment. And they will be remote controlled and supervised from the substation control center located in the car depot.

Two sets of rectifiers with capacity of 2000kW each will be installed at each substation; however, two substations (No.1 at Guasmo; & No.5 at the car depot) will be provided with one set of 2000kW rectifier and power distribution equipment which includes a power transformer and distribution panel. Typical single line diagram of the substation main circuit will be as shown in Figure 3-7.2.

Feeder circuits will be divided into four circuits which are connected with the contact line system toward south and north on each south and north bound track, and the DC high-speed circuit breakers will be installed on each feeder circuit for protection of the lines. Schematic feeding system main circuit will be as shown in Figure 3-7.3.

3) Overhead Contact Line System

The contact line system will be provided to distribute and supply traction power to operating trains; and this system will consist of feeder lines, trolley lines and supporting structures. Feeders will be installed for compensation of voltage drop on contact line system.

Composition of the trolley line will be determined by the train operation conditions which are maximum operation speed, minimum operation headway, power demand of operating train, etc. Simple catenary system, therefore, will be adopted taking into account these factors, and standardization of the maintenance and minimization of variety of wire fitting parts.