# THE REPUBLIC OF KOREA

## REPORT
## ON
## THE FEASIBILITY STUDY
## OF
## THE RAPID TRANSIT LINE NO. 2
## CONSTRUCTION PROJECT
## IN
## SEOUL

DECEMBER 1977

JAPAN INTERNATIONAL COOPERATION AGENCY

取扱注意

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# PREFACE

In response to the request of the Government of the Republic of Korea, the Government of Japan agreed to conduct a feasibility study for the Rapid Transit Line No. 2 Construction Project in Seoul, and the Japan International Cooperation Agency (JICA) conducted the study.

In view of the importance of the project, JICA organized a study team consisting of 15 experts headed by Mr. Shiro Kawamura, Director of Electrical Engineering Department, Japan Railway Construction Public Corporation, and sent it to Korea for a period of 35 days from April 20 to May 24, 1977.

This feasibility study report was prepared as a result of the study made in Japan following the field study made in Seoul on the Rapid Transit Line No. 2.

We hope that this report will contribute to the development of urban mass transportation system in Seoul and also serve for promoting friendly relations between Korea and Japan.

I would like to express my deep appreciation to the Government of the Republic of Korea and all the people concerned who have extended unstinted cooperation in this study.

December 1977

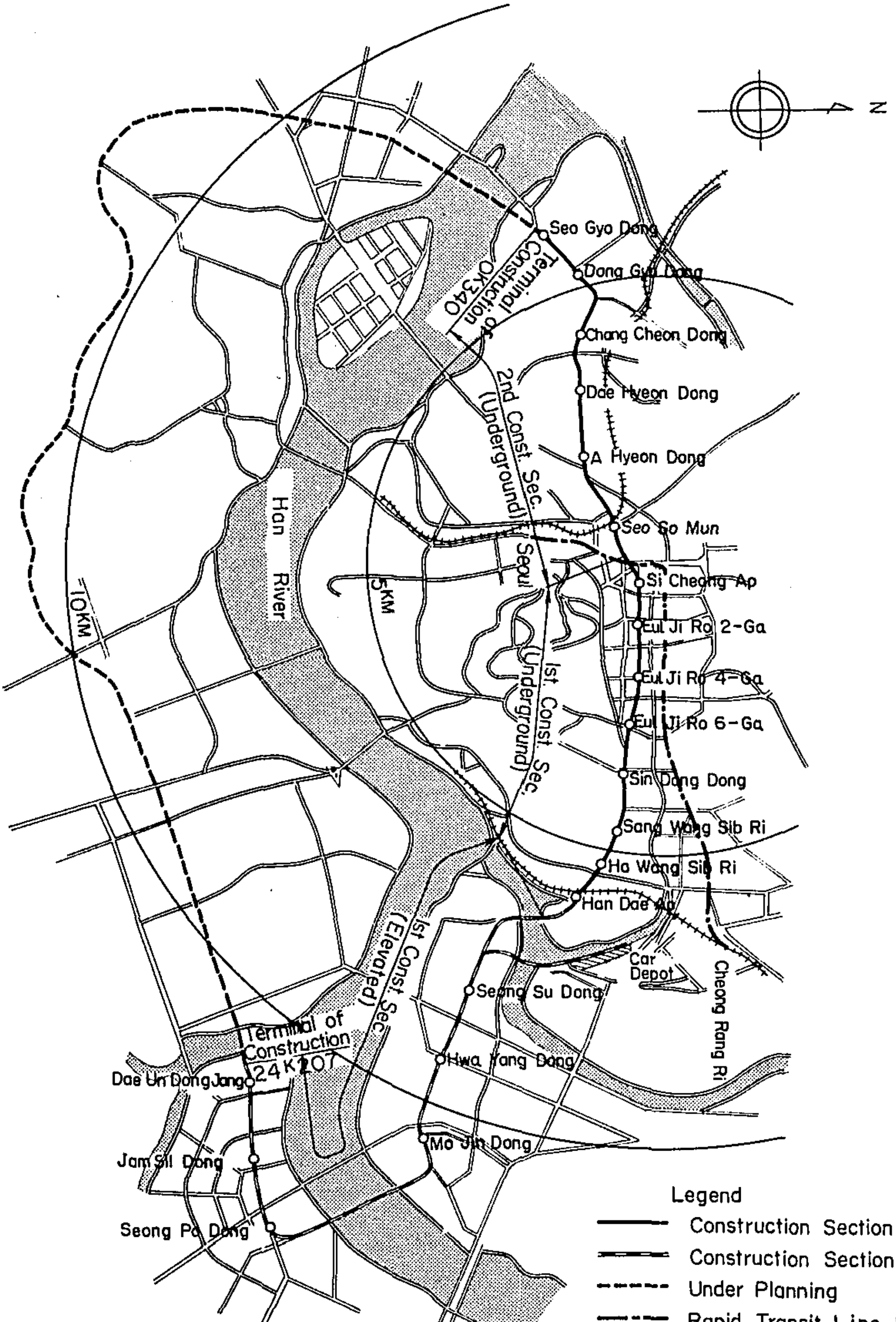

Shinsaku Hogen
President
Japan International Cooperation Agency
Tokyo, Japan

CONTENTS

Page

# SUMMARY AND CONCLUSION

## ROUTE MAP OF LINE NO.2




Legend

- Construction Section (Underground)
- Construction Section (Elevated)
- Under Planning
- Rapid Transit Line No.1

## SUMMARY AND CONCLUSION

### A. Conclusion

1. The road passenger traffic in Seoul represented by the bus transport has already exceeded the capacity of the road network. In addition, taking into consideration the increase in the traffic demand with remarkable social and economic development in near future and the necessity as an important infrastructure for the "Three Nuclei Development Plan", the construction of the northern half of the proposed Rapid Transit Line No. 2 is one of the most important projects in the Republic of Korea.

As this project necessitates as long as five years and a half, which is quite similar as in the case of every other infrastructure with long construction period, the practical research should make a good start at the earliest possible date for the realization of the project.

2. According to the economic analysis based on the nation-wide scale, this project is clearly feasible.

3. As to the financial analysis based on a self-supporting accounting system of the management, if one of the following alternatives is taken in the accounting system and the deficit in the initial years after inauguration of the operation is disposed of, this project is also feasible. The alternatives are:

a) When the basic fare is determined to be 40 Won, as in the case of the Line No. 1, the Seoul City or the Government should subsidize the deficit of running cost before depreciation every year until the year when the earnings exceed the running cost. In this case, the subsidy means amount for which no refund is required.

b) If the deficit of running cost is expended by the Seoul City or the Government every year until the year when the earnings exceed the running cost and such yearly expenditure would be refunded yearly therefrom, the basic fare would be 60 Won.

In addition, the capital investment shared by the Government and the Seoul City would be the subsidies without the necessity for refund.

4. In view of civil, electric and other engineering, this project is feasible. For planning the project, the JICA's Team endeavored to realize the optimum effects with the least amount of investment, taking curtailment of operation cost into consideration.

5. As the results, the Team has reached the conclusion that the Line No. 2 should be of 1,435 mm track, DC 1,500 V and 23.9 km route length between Seo Gyo Dong and Dae Un Dong Jang, in which underground section is 12.8 km locating in the business and downtown districts and the elevated section is 11.1 km, locating in the suburbs.

6. As the route length is considerably long, the staged construction would be preferable in view of design and construction volume as well as the necessary fund. From the technical and operating viewpoint, the section between City Hall and Dae Un Dong Jang would be inaugurated first.

7. The total construction cost of the Line No. 2 is 185 billion Won in the May 1977 price standard. Adding 4.8 billion Won, which corresponds to a portion of the construction cost of the car depot borne by the Line No. 1, the total construction cost is 189.8 billion Won. In the above amount, the foreign currency portion for No. 2 and No. 1 Lines are 55.9 billion and 1.6 billion, respectively, totalling 57.5 billion Won.

B. Summary

1. General Description

This summary is composed of the essence of each chapter in order.

In response to the request made by the Government of the Republic of Korea, the Government of Japan decided to provide technical cooperation for the "Rapid Transit Line No. 2 Construction Project in Seoul" through the Japan International Cooperation Agency (JICA). JICA despatched a Technical Advisory Team composed of seven members headed by Mr. N. Fukuzaki in September and October 1976. The team made consultation services for the difficult problems of the Line No. 2 Project with Korean governmental officials concerned. The team also performed preliminary study of the project in all aspects.

JICA despatched a Feasibility Study Survey Team composed of 15 members headed by Mr. S. Kawamura for 35 days from April 20 to May 24, 1977. The Team discussed the project in detail with the Korean specialists to make clear the difficult problems, collected necessary data and made field studies.

After the Team returning to Japan, JICA organized the working group and the supervisory commission for preparation of this feasibility report.

JICA and Feasibility Study Team Members express hereby the most heartfelt thanks to the Governmental Organizations, especially to the Seoul Metropolitan Government (SMG), Economic Planning Board (EPD), Korean Institute of Science and

Technology (KIST), and to the officials of the Japanese Embassy in the Republic of Korea.

## 2. Current Situation of Transport Facilities in Seoul

### a) Current Situation of Public Transport Facilities

The Rapid Transit Line No. 1 (Seoul Station - Cheong Ryang Ri 9.54 km) was opened to public in August 1974. The through-traffic service between the Korean National Railway (KNR) and the Line No. 1 is jointly being carried out.

Along with the Line No. 1 mentioned above, the railway network comprises the electrified and non-electrified commutation lines of KNR. The lines diverge radially, with the hub of the city as its center towards northern direction (the Gyeong Weon R.R. for Eui Jeong Bu), north-western direction (the Gyeong Eui R.R. for Su Saeg) and southern and western directions (Gyeong Bu R.R. for Su Weon and Gyeong Eui R.R. for In Cheon).

As for the main highway network, three rings and 14 radial roads are now being planned. As of 1976, all the afore-mentioned projects have almost been completed, except for three radials and the outermost ring. It is indeed true that the Line No. 1 has reduced the traffic congestion, but the surface transport as represented by the buses weighs the greater share as ever.

As for the passenger fares, it is stipulated that the uniform fare for bus is 35 Won, the basic fare for taxi is 200 Won, the Line No. 1 is 40 Won and the KNR is 40 Won( less than 9 km) plus 10 for each additional three km.

b) Traffic Characteristics

It has been found out that in Seoul the trips with the definite objectives in December 1973 totaled 8,566,000, while those by transport mode totaled 9,578,000. These figures correspond to 1.35 and 1.52 trips per person per day, respectively.

The numbers of motor vehicle holdings are 96,600 cars as of 1976, the ratio of which being 1.43 times as against 1971 and 2.75 times as against 1968. The ratios of buses and passenger cars are 7.4 percent and 56.9 percent, respectively. The ratio of bus holdings is exceedingly high when compared with major cities in other countries. At present about 5,000 buses are in service over 155 routes, which carry 69 percent of the total urban transportation, excluding the pedestrians.

According to the transport survey conducted in July 1976 as classified by the bus routes, the number of passengers carried during three hours of rush period from seven to ten o'clock in the morning reached 1,777,929, the total number per day being 6,118,264. According to the transport survey in March 1977, the number of rush hour passengers per day on the rapid transit Line No. 1 totaled 361,900. When the inflow and outflow connecting passengers of the KNR are added, the above number is increased to 403,000. It is worth noting that the number of passengers carried during the rush hours from 7:30 to 9:30 in the morning totaled 76,500, corresponding to 21.1 percent of the traffic volume over the whole day. The concentration ratio of passengers during the rush hours is exceedingly high.

## 3. Traffic Planning and Demand Forecast

### a) The Framework of Traffic Demand Forecast

The "General City Development Plan" of the SMG, 1972, mentions that the readjustment of the organized and efficient transport system is the fundamental policy. On the other hand, the development concept with the three nuclei of the city aims at maintaining the current metropolitan center as the one nucleus. As for the two remaining nuclei, Yeong Deung Po district will be set up as the industrial center, with Yeong Dong and Jam Sil Dong district, which involve the population of one million. The plan aims at purifying the municipal function. It also envisages to introduce the regional system as classified by the various uses.

### b) The Traffic Demand Forecast

The construction of the rapid transit will bring about a great effect on the selection among the various means of transportation from the standpoint of the users. Based on the traffic demand forecast made by KIST, the number of users of the rapid transit, which is a link of mass transport means, has been assessed. In consideration of the probable changes of the conditions, e.g., the total population in future, the population increase as differentiable from each zone, the number of trips per person, etc., the forecast figures by KIST have been reviewed.

As for our forecasts, the total traffic volume by origin, the bulk of concentration, the distribution situation of the OD survey results have been utilized. Also taken into consideration are the share of transportation means and distribution of traffic volume of the urban railway network, including the KNR. Furthermore, some modifications have been introduced as to readjustment of the highway and the railway network in future, time required for each trip and the related passenger fares.

In consideration of the fact that the population of Seoul in 1976 was 7,255,000, it has been assumed that the population would be 8,479,000 in 1982 and 8,795,000 in 1984, the growth rate of which amounts to 1.17 and 1.21 times, respectively. As for the total number of trips, it has been assumed to be 13,465,000 trips in 1982 and 14,221,000 trips in 1984, based on the 1973 figure of 9,578,000 trips. The afore-mentioned ones correspond to 1.41 and 1.48 times, respectively.

c) Line No. 2 as a Transportation System

The substance of public mass transportation system in Seoul is mainly maintained by bus. There is, however, a tendency that the traffic jam is gradually emerging. Even under the current situation, the need of adding public mass transport facilities is keenly felt. Furthermore, the urban activities are invigorating economically and socially now and in future, resulting in the steady increase in the trip number in general. This will entail the growing necessity for the inexpensive and high-speed mass transport system with safety and comfort. Among the general public residing in these areas, the greater demand than ever will arise for the efficient urban transport system. In principal cities of the world, the subway is accepted as indispensable means. Similarly, in Seoul, the effective and fruitful construction of the Line No. 1 is positively justified.

As for the Line No. 2 which traverses the urban areas from east to west, a voluminous traffic demand is sure to arise. Consequently some countermeasures against the traffic jam near the Eul Ji Ro is to be urgently taken. In this connection, in strengthening the municipal function in the urban planning of the three-necleus urban centers, the line will play an overwhelmingly viable role as a major factor of the traffic planning. It is to be stressed that the Line No. 2 is the most important route, second only to the Line No. 1. Of the routes connecting three nuclei, it may be safely asserted that the first option for opening to the public will be granted to the half-circular part at the north side of the Han between Seo Gyo Dong and Dae Un Dong Jang, where a considerable increase of traffic volume is expected. As for the half-circular part south of the Han, it would be better to set up the construction planning after the relevant traffic demands are precisely ascertained.

d) Estimation of Line No. 2 Users

When the results of OD survey for the urban mass transit system passengers obtained from the assumptions shared by the various transportation means are plotted over the rapid transit network, the forecasted passengers number would amount to 1,380,000 in 1982 and 1,540,000 in 1984.

As for the users of the Line No. 2, as of 1982 at the time of the partial opening of services to public, passengers within its own bounds would be 350,000, while through passengers who change to other lines would be 130,000. These would be 480,000 in the aggregate. According to estimates for 1984 at the time of the complete opening of services to public, the number will reach 480,000; 260,000; and 460,000, respectively. After the lapse of ten years of public services, in 1984, the total numbers of passengers who utilize the Line No. 2 are estimated to be 920,000.

As the users of the Line No. 2 are mostly commuters and students, the most congested sections during the rush hours would be those which are adjacent to the urban center. Under the supposition that the peak ratio would be 21.7 percent and the one-way frequented direction ratio would be 60 percent, the maximum utilization of passengers during the peak hours would be as follows:

| | | | |
|---|---|---|---|
| 1982 | Sang Wang Sib Ri - Sin Dang Dong | 28,965 prsns/h | one-way |
| 1984 | A Hyeon Dong - Seo So Mun | 38,969 prsns/h | Do. |
| 1994 | A Hyeon Dong - Seo So Mun | 48,249 prsns/h | Do. |

4. Route Planning

The proposed Line No. 2 starts from Seo Gyo Dong and emerges from the underground near Han Dae Ap, through Dong Gyo Dong, Dae Hyon Dong, Seo So Mun, City Hall, Eul Ji Ro 6-Ga, and Ha Wang Sib Ri. From there, it gose on to Dae Un Dong Jang over the elevated railway through Seong Su Dong, Mo Jin Dong, and Jam Sil Dong. The extension of the foregoing is 23.9 km, plus 1.1 km of connecting tracks to and from the car depot.

In deciding alignment and longitudinal profile, special regard has been paid to the major factors, such as construction cost, operation and maintenance cost of this project, which would become necessary when it is opened to the general public. Under these circumstances, it has been proposed that the urban areas would be linked by the subway (extension 12.8 km), while the suburban areas would be served by the elevated railway (extension 11.1 km). The underground portion is mostly of cut-and-cover tunnels, with the aim of shallow structure as practically as possible. The sections between Seo Gyo Dong and City Hall being undulated, the rock tunnelling method is to be partially adopted. The section farther south from the Seong Dong River is proposed to be constructed as the elevated railway with the longer distance between the two adjacent stations, so that the schedule speed may be increased.

Over this route, 14 subway stations and six elevated stations are to be installed. The average distance between two adjacent stations is 1,227 m, the shortest one being 686 m and the longest one 3,576 m, at the crossing site of the Han River.

5. Operation Planning

As for the operation of trains, it has been planned out as follows, taking into consideration, the passengers' convenience and the efficient utilization of rolling stock and facilities.

The maximum transportation capacity is based on the maximum one-way traffic volume during rush hours derived from the afore-mentioned Paragraph 3. Care has been devoted to the objective so that the average utilization ratio per hour would be held down under around 190 percent.

Train operation:

All the trains stop at every station with neither shuttle operation nor division nor combination of trains in the intermediate stations.

Train consist:

The operation headway being considered concurrently, the train consist has been concluded that eight cars would be the optimum number. Furthermore, as no division or combination will be performed, it is proposed that the train consist would be eight rail-cars comprising two control cars and six intermediate motor cars.

Operation headway:

| | Rush | Daytime | Early in the morning; late at night |
|---|---|---|---|
| (1) Partial opening to public service | 5 min. | 8 min. | more than 10 min. |
| (2) Total opening to public service | 3.5 min. | 6 min. | Do. |

Number of trains per day:

(1) 320 trains

(2) 430 trains

Schedule time and schedule speed:

| | Schedule time | Schedule speed |
|---|---|---|
| (1) City Hall - Dae Un Dong Jang | 31 min. | 32.3 km/h |
| (2) Seo Gyo Dong - Dae Un Dong Jang | 41 min. | 34.1 km/h |

Required number of train consists and cars:

| | Train consists | Cars |
|---|---|---|
| (1) | 18 | 144 |
| (2) | 30 | 240 |

All the required rolling stock is assigned to the car depot which is to be constructed at Gun Ja Dong.

## 6. Rolling Stock

The design of the rolling stock used for the Line No. 2 is to be based on the cars now in use for the Line No. 1 aiming at the interchangeability of the parts.

The kinds of the cars are the head trailer car with controller and the intermediate motored cars, which are grouped into one unit for curtailing purpose of the cost. The fleet of cars will be 144 cars in 1982 at the time of the partial opening and 240 cars in 1984 at the time of the total opening. For improvement of passengers' riding comfortability, two-axle bogies with air-springs are recommendable.

The major categories of the cars are as follows:

| | |
|---|---|
| Distance between coupling faces: | 20,000 mm |
| Car body length: | 19,500 mm |
| Car body width: | 3,180 mm |
| Height of roof: | 3,800 mm |
| Material and finishing: | Light-weight steel construction<br>Outside painted |
| Side Door: | 4 doors each side (double-leaf door) |

The main systems of cars are as follows:

| | |
|---|---|
| Control system: | Rheostatic control, series-parallel control, field control |
| Brake system: | Dynamic brake and electro-magnetic straight brake |

## 7. Civil Work Planning

The design standard of the Line No. 2 which constitutes the base of civil engineering planning, is roughly the same as that of the Line No. 1, but the height of the rolling stock gauge and construction gauge is each lowered by 200 mm, and gauge for elevated structure is newly planned. The main standards are as follows:

Track gauge: 1,435 mm
Power collection system: Overhead contact line system
Power system: DC 1,500 V
Rolling stock gauge (W x H): 3,200 x 4,550 mm
Construction Gauge (W x H): 3,600 x 4,950 mm (Underground section)
3,600 x 5,700 mm (Elevated section)
Minimum curve radius: 180 m (Main line)
Maximum gradient: 35/1,000 (Main line)
10/1,000 (Station)

As to the underground structures, the double line box tunnel is adopted at the sections with cut-and-cover method between stations. The structure of the underground stations is mostly two-level box tunnel. In case of the rock tunnel, two single line tunnels in parallel and double track tunnel are planned.

The elevated structures are almost constructed on the road. Therefore, in order to prevent hindrances to the road traffic, and to aim at facilitating construction, the elevated prestressed concrete girder bridge with standard span of 20 m supported by single-pier structure is planned. As grade separation with the crossing road necessitates the longer span of 30 - 40 m, the composite girder is planned, taking into consideration noise prevention and economical construction. The elevated stations are designed with the elevated reinforced concrete rigid frame bridge structure. The upper ballastless deck steel girder bridges are planned over the Seong Dong River and the Han River.

The track structure is planned, considering smooth train operation and curtailed maintenance cost. Rails to be used are of 50 kg N. As for the tie and the ballast, the reinforced concrete blocks of short length embedded in track concrete are to be laid out in the underground section. Whereas, in the elevated section, prestressed concrete ties with ballast would be used.

8. Electric Facilities

The power system of the Line No. 2 is of DC 1,500 V and the signal is the double track line automatic signal system as same as those now in use in the Line No. 1.

As to the power source system and feeding system, electric power in 22 - 22.9 kV will be supplied by the following substations of the Korean Electric Company (KECO) to the traction substations, where the power transformed into 1,500 V.

| KECO's substation | Traction substation |
|---|---|
| Dong In Ri | Chang Cheon Dong |
| Sun Hwa Dong | City Hall |
| Heung In | Ha Wang Sib Ri |
| | Mo Jin Dong |
| Jam Sil | Jam Sil Dong |

Between each KECO's substation and traction substation, a circuit of transmission line is installed. In addition, between some traction substations, a connecting high voltage transmission circuit will be constructed to provide the double circuit power supply system to each substation to avoid power supply failure.

In the City Hall, Ha Wang Sib Ri and Jam Sil traction substations, a high voltage power source will simultaneously be installed. All substations are controlled not on the spot but remotely at the power control center. As to the overhead contact line system, the overhead trolley bar system is employed in the underground section, whereas the heavy simple catenary system is used in the elevated section. The standard height of the overhead contact line system is as follows:

| Overhead contact line system | Standard height(mm) |
|---|---|
| Overhead trolley bar system | 4,750 |
| Heavy simple catenary | 5,200 |

The major facilities of signal and safety devices planned in the Line No. 2 are the wayside signal system, the electric relay interlocking system, the automatic train stop system (ATS) and the total traffic control system (TTC).

The major facilities of railway telecommunications are the private telephone, directive telephone, train radio telephone, despatcher telephone (Electric Power), despatcher telephone (Train Operation), facsimile, etc. The main difference from the Line No. 1 in the field of telecommunications is that the train radio of the Line No. 2 is adopted as the inductive radio system.

9. Ventilation and Air-conditioning System

As in the case of the Line No. 1, major ventilation method in the underground sections is the natural ventilation system by means of the piston ventilation effect of trains in motion. In the rock tunnel, where the natural ventilation is not effective, the mechanical ventilation system will be installed.

As to the ventilation of platforms and concourses, only the mechanical ventilation is adopted at the outset, but it has been planned out, so that the installation of refrigerators might be enabled, in consideration of the rise in temperature in future.

10. Car Depot

The car depot means the facility complex including storage tracks, car inspection shed, and workshop. The track and structure maintenance depots are housed therein.

The capacity of the car depot in 1984 is to be for 170 AC/DC cars for the Line No. 1 and 240 DC cars for the Line No. 2, totaling 410 cars in 47 train consists.

The storage tracks are laid out so as to be arranged that the trains can directly enter to and go out from any storage track without switching back on the lead track. Because of the limited available space of the right-of-way, the capacity of car storage cannot be enlarged beyond this plan so that new car depot shall be installed at the Gang Nam district when the Line No. 2 is extended to make a loop line, requiring the increased cars.

Inspection of the cars in train formation in the inspection shed and workshop shall be facilitated.

Eight inspection tracks are to be installed in the inspection shed and capacity of the car body shop of the workshop is to be 18 car bodies in 1984.

The planned facility of the workshop will be sufficient for the increased cars in case when the Line No. 2 is increased and/or other lines are constructed, by means of extending the cycle of inspection and shortening the required days for inspection.

11. Construction Schedule and Partial Operation

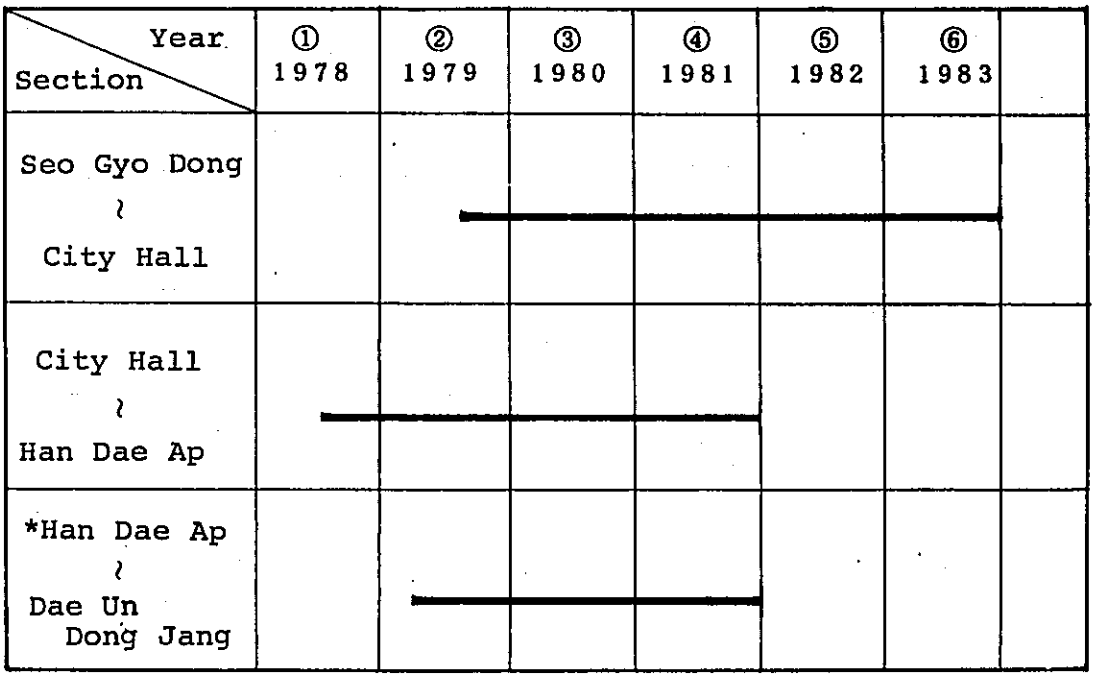
As the route length of the Line No. 2 is about 24 km, based on the procedures of detailed design, construction, budgeting, etc., it would be better to adopt the construction by stage.

Taking into consideration the technical problems, greater amount of earnings after opening the operation, location of the car depot, etc., the order of construction is planned; at first, the construction work for the underground section between City Hall and Han Dae Ap are to be commenced; the section between Han Dae Ap and Dae Un Dong Jang would be the next; after completing the construction work of the above two sections, partial operation will be realized; as to the section between Seo Gyo Dong and City Hall, the cut-and-cover portions, which are used for the construction base of the rock tunnel, will be constructed first; and then, other cut-and-cover portions and rock tunnels are successively executed.

By the completion of the section between Seo Gyo Dong and City Hall, this project is fully completed and opened to the public.

It is estimated that five years and a half will be required for operation of full length of the project after commencing the construction work.

Construction Schedule




Remark:

* Including car depot siding

12. Construction Organization and Operating Staff

The scale of the Line No. 2 construction is about 2.5 times the Line No. 1 and the scheduled construction takes as long as 5.5 years. Therefore, strengthening of the staff of the Construction Dept. is essential. For this purpose, reemployment of experienced engineers in the Line No. 1 construction project or recruiting of the experienced railway engineers would become necessary. In addition, the domestic and overseas consultants would also be retained.

The operating staff of the Line No. 2 after completion is assumed to be 100 employees per kilometer considering technical standard, pay scale, standard of automation, etc. In this case, the total employees at the stage of total line operation in 1984 will become 2,400 persons or so which correspond to about 2.5 times the existing number of employees. In recruiting many new unexperienced staff, the cautious training schedule is absolutely essential. As the total system of Line No. 2 is almost the same as the Line No. 1, availing of the latter in training is possible. Therefore, it is recommendable that the staff would be increased step by step from two years before the partial operation starts for training.

13. Construction Cost and Operation Cost

The approximate construction cost of the Line No. 2 is 185 billion Won, of which the foreign currency portion is 55.9 billion Won. The domestic construction cost is estimated, based on the local market price in May 1977, when the field investigation was carried out, and on the salary scale for the labor cost in the same period. As for the cost of imported materials and equipment, the following foreign exchange rate in the beginning of May 1977 is adopted.

US$1 = ¥280 = 480 Won

The car depot constructed in this project is utilized for cars of both No. 1 and No. 2 Lines. In the abovementioned construction cost, 7.1 billion Won is included, which corresponds to 60 percent of the car depot construction cost according to the ratio of cars of Line No. 2 against total number of railcars. When 4.8 billion Won, 40 percent of the construction cost to be borne by the

Line No. 1, is added, total sum becomes 189.8 billion Won.

The imported materials to be purchased with the foreign currency are railcars, rails and fastenings, a part of signal systems, major parts of transformer facilities, etc., the costs of which are calculated at CIF. The import duties and consumers' tax are assumed to be 20 percent in total, which are added in the domestic currency portion.

The item of engineering fee and overhead includes costs for detailed engineering, construction supervision, training, test run, etc., which are summed up in the domestic currency portion. Should there be any engineering services to be entrusted to the overseas consultants, some additional foreign currency would be required.

The operation cost is estimated to be 4.42 billion Won in partial operation stage and 6.53 billion Won after total operation stage, based on the operating staff and the operation planning.

Detail of the construction cost and operation cost is as attached table.

## Construction Cost

Unit: million Won

| | Main Line | | | Car Depot | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|
| | D.C. | F.C. | Total | D.C. | F.C. | Total | D.C. | F.C. | Total |
| Right-of-Way | 2,328 | 0 | 2,328 | 0 | 0 | 0 | 2,328 | 0 | 2,328 |
| Civil work | 86,889 | 924 | 87,813 | 908 | 0 | 908 | 87,797 | 924 | 88,721 |
| Building | 8,131 | 0 | 8,131 | 1,840 | 0 | 1,840 | 9,971 | 0 | 9,971 |
| Track | 3,682 | 2,452 | 6,134 | 560 | 640 | 1,200 | 4,242 | 3,092 | 7,334 |
| Electric and Mechanical Work | 10,277 | 8,728 | 19,005 | 1,412 | 1,768 | 3,180 | 11,689 | 10,496 | 22,185 |
| Total | 111,307 | 12,104 | 123,411 | 4,720 | 2,408 | 7,128 | 116,027 | 14,512 | 130,539 |
| Engineering and Overhead | 4,533 | 0 | 4,533 | Included in Main Line | | | 4,533 | 0 | 4,533 |
| Railcar | 8,527 | 41,401 | 49,928 | 0 | 0 | 0 | 8,527 | 41,401 | 49,928 |
| Grand Total | 124,367 | 53,505 | 177,872 | 4,720 | 2,408 | 7,128 | 129,087 | 55,913 | 185,000 |

Note: D.C. denotes domestic currency.
F.C. denotes foreign currency.

Car Depot Construction Cost
to be borne with the Line No. 1

Unit: million Won

| | |
|---|---|
| Domestic Currency Portion | 3,147 |
| Foreign Currency Portion | 1,605 |
| Total | 4,752 |

Operation Cost

Unit: million Won

| Item \ Year | | 1982 | 1983 | 1984 | --- | 2011 |
|---|---|---|---|---|---|---|
| Personnel Cost | D.C. | 2,530 | 2,530 | 3,430 | 3,430 | 3,430 |
| Maintenance Cost | D.C. | 300 | 300 | 450 | 450 | 450 |
| | F.C. | 450 | 450 | 750 | 750 | 750 |
| Power Cost | D.C. | 700 | 700 | 1,300 | 1,300 | 1,300 |
| Overhead | D.C. | 440 | 440 | 600 | 600 | 600 |
| Total | D.C. | 3,880 | 3,880 | 5,630 | 5,630 | 5,630 |
| | F.C. | 540 | 540 | 900 | 900 | 900 |
| | Grand Total | 4,420 | 4,420 | 6,530 | 6,530 | 6,530 |

14. Financial Analysis

The results of financial analysis of the project are summarized as follows:

a) As for the repayment plan, such factors as term-end balance, peak amount of loan capital repayment and interest payable are to be clarified. These figures are shown in the following table.

(Unit: billion Won)

| Ratio of borrowing to total project cost: | 55% | 40% |
|---|---|---|
| 1. Borrowings (loan and municipal bond) | 101.8 | 74.0 |
| 2. Peak amount of term-end debt outstanding | 102.5 | 74.4 |
| 3. Peak amount of loan and bond repayment | 18.7 | 9.7 |
| 4. Interest payable in total | 60.7 | 41.0 |

b) As for the financing program, the crucial time is when the operation subidy from Seoul Municipal Government (SMG) to cover the operation of the Line No. 2 becomes unnecessary and when the accumulated said subsidy is completely repaid to the SMG. In case the minimum fare being 40 Won, even if the ratio of the construction subsidies both from the state and SMG to finance the project cost is raised from 45 percent to 60 percent and the interest rate to the municipal bonds is reduced from 14 percent to six percent, the inflow in a single year after the opening of operation and the accumulated operation deficits which are covered by the municipal budget will not be recovered within 20 years of operation. The financial status, therefore, is assumed to be considerably serious under the condition that the accumulated amounts from the municipal budgets to cover the deficits has to be repaid from revenue.

c) As for the revenue and expenditure plan, the crucial time is when the revenue will surpass the expenditure and also when the accumulated deficits be recovered. Even though the ratio of the construction subsidies is raised and the interest rate to the bonds is reduced as in the case of the financing program, the revenue will not surpass the expenditure till the 16th year after the opening of operation and the deficits brought forward will not be recovered within 20 years of operation.

d) For the reasons mentioned above, the soundness of the financial status will not be attained if the fare rate is maintained at the same level as that of the Line No. 1. Other conditions being the same, it is advisable to increase the basic fare to more than 60 Won.

e) As the increase of the construction subsidies for the project and the decrease of interest rate to the municipal bonds only have limited effects on the financial conditions of the project, a periodic increase in the minimum fare will be required to ensure the required incomes. In addition, it will be necessary to work out the overall expenditure curtailment policy such as promotion of rationalization.

f) Taking into consideration the repayment, financing, revenue and expenditure plans altogether, the optimum case is that the minimum fare is increased to 60 Won, absolutely from the financial viewpoint.

## 15. Economic Analysis

### A. Cost and Benefit

The economic project cost of the Line No. 2 is estimated to be 168,253 million Won (1977 constant price), while the economic operating cost be 6,380 million Won when the whole line is opened to traffic in 1984.

The benefit identified with the difference of the economic costs with and without the implementation of the Line No. 2 Project are estimated as follows:

(Unit: million Won)

| | In the year starting full operation (1984) |
|---|---|
| ° Benefits from diverted passengers | 4,620 |
| ° Benefits from transport facilities | 11,810 |
| ° Benefits from undiverted passengers | 16,500 |
| ° Benefits from transport facilities due to undiverted traffic (Reduced operating and maintaining costs to traffic facilities because of relieved traffic congestion) | 6,620 |

B. Cost-Benefit Analysis

As a result of the cost-benefit analysis, the project has turned out feasible with a 30-year project life at a discount rate of 15 percent.

| | |
|---|---|
| Present value of costs | 287,540 million Won |
| Present value of benefits | 338,960 |
| (Present value as of 1984) | |
| B/C ratio | 1.18 |
| Internal rate of return | 17.6% |

If the benefit generated during the period of partial operation is ommitted from the calculation, the present value of the benefits is reduced by about 50 billion Won, which implies the necessity of the partial operation.

| | |
|---|---|
| Present value of benefits | 289,900 million Won |
| B/C ratio | 1.01 |

C. Sensitivity Analysis

1) Project Life and Discount Rate

If discount rate is less than 17 percent, the project is feasible regardless of changes in the length of the project life.

2) Unit Value of Time Benefit

The unit value of time benefit will be increased by 40 percent, if it is calculated only for the population of more than 15 years, which is assumed to be real working population. With this value which is expected to reflect more precisely the time benefit, the project is sufficiently feasible even at the discount rate of less than 19 percent.

3) Economic Project Cost

A ten percent cost overrun will not change the conclusion that the project is feasible. While a three to four percent fall in the cost causes the project to be feasible even at 18 percent discount rate.

4) Estimated Population

With a ten percent fall in the estimated population, the project will still be feasible.

5) Number of Passengers diverted to the Line No. 2

The project is also feasible if the estimated number of passengers who are to use the Line No. 2 is reduced by ten percent.

# 1. INTRODUCTION

## 1.1 Background

In response to the request made by the Government of the Republic of Korea, the Japanese Government despatched a survey team in 1970, headed by Mr. Ryohei Kakumoto, the then President of the Japan Transport Economics Research Center, to study the urban traffic situation in Seoul metropolitan area. The aim of this team was to consolidate realization of the mass transit system to ease the too congested road traffic in Seoul metropolitan area, with road transport as its nucleus. In that report were suggested five routes of rapid transit railways in that area.

Among the five routes, the Line No. 1, 9.54 km in route length, was taken up first, which was opened to traffic on August 15, 1974 with technical and financial aids from Japan partially.

The Government of Korea decided to include the Rapid Transit Line No. 2 in her Fourth Five-Year Plan as one of the most important projects and requested the Japanese Government to make the comprehensive technical cooperation. The Government of Japan, accepting this request, decided to make a feasibility study through the Japan International Cooperation Agency (JICA). Before sending the main team, the JICA despatched a Technical Advisory Team for 21 days from September 29 to October 19, 1976, to give technical advices to the Korean officials concerned on the problems of the fundamental issues and the construction planning. The Technical Advisory Team made an overall preliminary study of the Rapid Transit Line No. 2 Construction Project solving in cooperation with them the difficult phases of the said project. The basic plan of the Rapid Transit Line No. 2 presented by the Government of Korea as well as the results of the field investigations and the data collected were analyzed scrupulously.

Based on the survey results of the Technical Advisory

Team, the Feasibility Study Team headed by Mr. Shiro Kawamura, Director of the Electric Department, Japan Railway Construction Public Corporation, stayed in the Republic of Korea for 35 days from April 20 to May 24, 1977, to study the economic and technical feasibility of this project. Each member of the Team made detailed discussions and studies on his own speciality with the Korean officials and counterparts. The members also collected necessary data and made field investigations energetically. The Feasibility Study Team discussed the major technical items of the specification with the relevant authorities for preparing the Final Report. The Team submitted the Interim Report before leaving Seoul.

After the return of the Team, the Supervisory Committee, consisting of seven members and the Working Group were organized to prepare the Final Report.

The Draft of Final Report was completed in October, 1977. The Draft Report Explanatory Mission stayed in Seoul from November 21 to November 30 the same year, to expatiate the contents to the Korean Authorities concerned who gave their consent to the Mission about the content. The Final Report, both in Japanese and English, has been prepared which is now respectfully submitted.

### 1.2 Scope of Survey

The aim of this study is to survey technical and economic feasibility of a part of the Rapid Transit Line No. 2, i.e., a 24-km section between Seogyo Dong and Dae Un Dong Jang via City Hall, Eul Ji Ro and Mo Jin Dong together with a railcar depot including the related siding, 1.1 km in route length.

The scope has been agreed between the Korean and the Japanese Government to include the following items.

a) Investigation into current situations of urban traffic and planning of the related network, planned by the Korean Government

b) Estimation of the future traffic demand

c) Transport planning

d) Construction planning

e) Construction cost estimates and scheduling

f) Financial analysis

g) Economic analysis

## 1.3 Member of Survey Team

The members of the Technical Advisory Team in 1976, as previously mentioned were:

| | | |
|---|---|---|
| Team Leader | Naoharu FUKUZAKI | Japan Railway Technical Service |
| Member | Yusaku KAWASHIMA | Ministry of Transport |
| Do. | Denshiro YAMANAKA | Japanese National Railways |
| Do. | Haruo NISHIYAMA | Do. |
| Do. | Kazumitsu MORIYA | Teito Rapid Transit Authority |
| Do. | Ichiro SEKIGUCHI | Do. |
| Do. | Ko MOTEGI | Japan International Cooperation Agency |

The Feasibility Study Team was composed of 15 members as mentioned hereinafter:

| | | |
|---|---|---|
| Team Leader | Shiro KAWAMURA | Japan Railway Construction Public Corporation |
| Member | Masuo SUDO | Ministry of Transport |
| Do. | Kazumitsu MORIYA | Teito Rapid Transit Authority |
| Do. | Kazuo MATSUEDA | Do. |
| Do. | Ichiro SEKIGUCHI | Do. |
| Do. | Denshiro YAMANAKA | Japanese National Rail-ways |
| Do. | Tadao MIYAUCHI | Do. |
| Do. | Hiroshi KAMIYA | Japan Transportation Machinery Consultants Co., Ltd. |

| | | |
|---|---|---|
| Member | Masakazu IDA | Japan Transportation Consultants, Inc. |
| Do. | Eiichi ARAI | Do. |
| Do. | Mikio MATSUZAWA | Japan Electric Consulting Co., Ltd. |
| Do. | Takao HATANAKA | Do. |
| Do. | Shigeru NOMOTO | Pacific Consultants International |
| Do. | Masahiko MATSUMOTO | Do. |
| Do. | Shoji SHIMBO | Japan International Cooperation Agency |

The feasibility study report has been prepared by the Working Group under the supervision of the Supervisory Committee. It was composed of seven members, whose names were:

| | |
|---|---|
| Chairman | Shiro KAWAMURA |
| Member | Masuo SUDO |
| Do. | Kazumitsu MORIYA |
| Do. | Kazuo MATSUEDA |
| Do. | Ichiro SEKIGUCHI |
| Do. | Tadao MIYAUCHI |
| Do. | Naoharu FUKUZAKI |

The Working Group is composed of 41 members selected from Japan Transportation Consultants, Inc., Pacific Consultants International, Japan Electric Consulting Co., Ltd., and Japan Transportation Machinery Co., Ltd.

The draft of the Final Report was brought to Seoul. The Draft Final Report Explanation Mission was composed of four members. They were:

| | |
|---|---|
| Team Leader | Shiro KAWAMURA |
| Member | Masuo SUDO |
| Do. | Kazumitsu MORIYA |
| Do. | Shigeru NOMOTO |
| Do. | Shoji SHIMBO |

### 1.4 Acknowledgment

All the team members join in their gratitude to the Korean Government Organizations, including Seoul Metropolitan Government (SMG), Economic Planning Board (EPB), Korean Institute of Science and Technology (KIST), as well as Japanese Embassy in Korea for their extensive help, kind advice and in particular for information supplied. Without these, the Feasibility Study Team could not fulfil its duty, making field study and data collection, within rather limited period. The Japan International Cooperation Agency and the Feasibility Study Team members hereby express their most heartfelt thanks to the Korean Organizations and their staff. In the narrow space of this Report, it is regrettable that listing up all the officials who have cooperated with the Team is impossible. The names of some of the Korean officials concerned are among others:

a) Seoul Metropolitan Government (SMG)

| | |
|---|---|
| Mayor | Mr. Gu Ja Chun |
| 1st Vice-Mayor | Mr. Kim Seong Bae |
| 2nd Vice-Mayor | Mr. Gag Hwang Seob |

b) Bureau of Rapid Transit (SMG)

| | |
|---|---|
| Head | Mr. Kim In Joo |
| Person in Charge of Management | Mr. Choi Sang Gon |
| Person in Charge of Technology | Mr. Sin Mun Soo |
| Chief, Management Section | Mr. Yun Nag Whan |
| Chief, Engineering Section | Mr. La Cheong Kyun |
| Chief, Accounting Section | Mr. Park Sung Deog |
| Chief, Construction Section | Mr. Lee Pyeong Jae |
| Chief, Transportation Section | Mr. Weon Si Yeon |
| Chief, Electric Car Section | Mr. Bae Weon Gon |
| Chief, Electric Section | Mr. Seo In Weon |

c) Tourist and Transportation Bureau

| | |
|---|---|
| Chief, 1st Transportation Section | Mr. Lee Chung Uoo |

d) City Administration Bureau

| | |
|---|---|
| Chief, City Planning Section | Mr. Kim Byeong Lin |

e) Economic Planning Board (EPB)

| | |
|---|---|
| Aid to Assistant Secretary (Economic Cooperation) | Mr. Lee San Ki |
| Director, Economic Cooperation Bureau | Mr. Cha Hwa Joon |
| Regulator, Economic Cooperation Bureau | Mr. Park Gyeong Dong |

f) Korean Institute of Science and Technology (KIST)

| | |
|---|---|
| Deputy Chief | Mr. Yang Jae Hyeung |
| Chief, Study Room of Transportation Economy | Mr. Hwang Keu Bug |

g) Korean National Railroad (KNR)

| | |
|---|---|
| Director, Electric Bureau | Mr. Hwang Hae Jeong |
| Director, Rolling Stock Bureau | Mr. Im Yeong Teg |
| Chief, Electrification Section | Mr. Kim Jae Keun |
| Chief, Rolling Stock and Electric Section, Design Office | Mr. Byun Seong Yu |

h) Japanese Embassy in Korea

| | |
|---|---|
| Ambassador Extraordinary and Plenipotentiary | H.E. Akira Nishiyama |
| Minister | Mr. Toshikazu Maeda |
| Councillor | Mr. Haruyuki Mabuchi |
| Do. | Mr. Naohiro Kumagai |
| Do. | Mr. Mamoru Mizuguchi |
| Secretary | Mr. Masao Horiuchi |
| Do. | Mr. Nobukazu Takahashi |
| Do. | Mr. Tadao Mukasa |
| Do. | Mr. Isamu Kuroiwa |
| Do. | Mr. Taizo Hori |
| Do. | Mr. Masatoshi Muto |

i) Representative Office in Seoul, Overseas Economic Cooperation Fund, Japan

| | |
|---|---|
| Representative | Mr. Yuji Takahashi |
| Assistant Representative | Mr. Masaichi Ishiguro |

# 2. Present Traffic Condition in Seoul

## 2.1 Urban Traffic System

In August 1974 the Rapid Transit Line No. 1 was opened, and the existing KNR lines that serve the suburban area of Seoul were electrified at the same time. As the result, a part of the road traffic was diverted to the rapid transit system, but the surface traffic represented by the bus service still plays an important role. In the following sections the present traffic condition in Seoul, its traffic network will be divided into railways and roads.

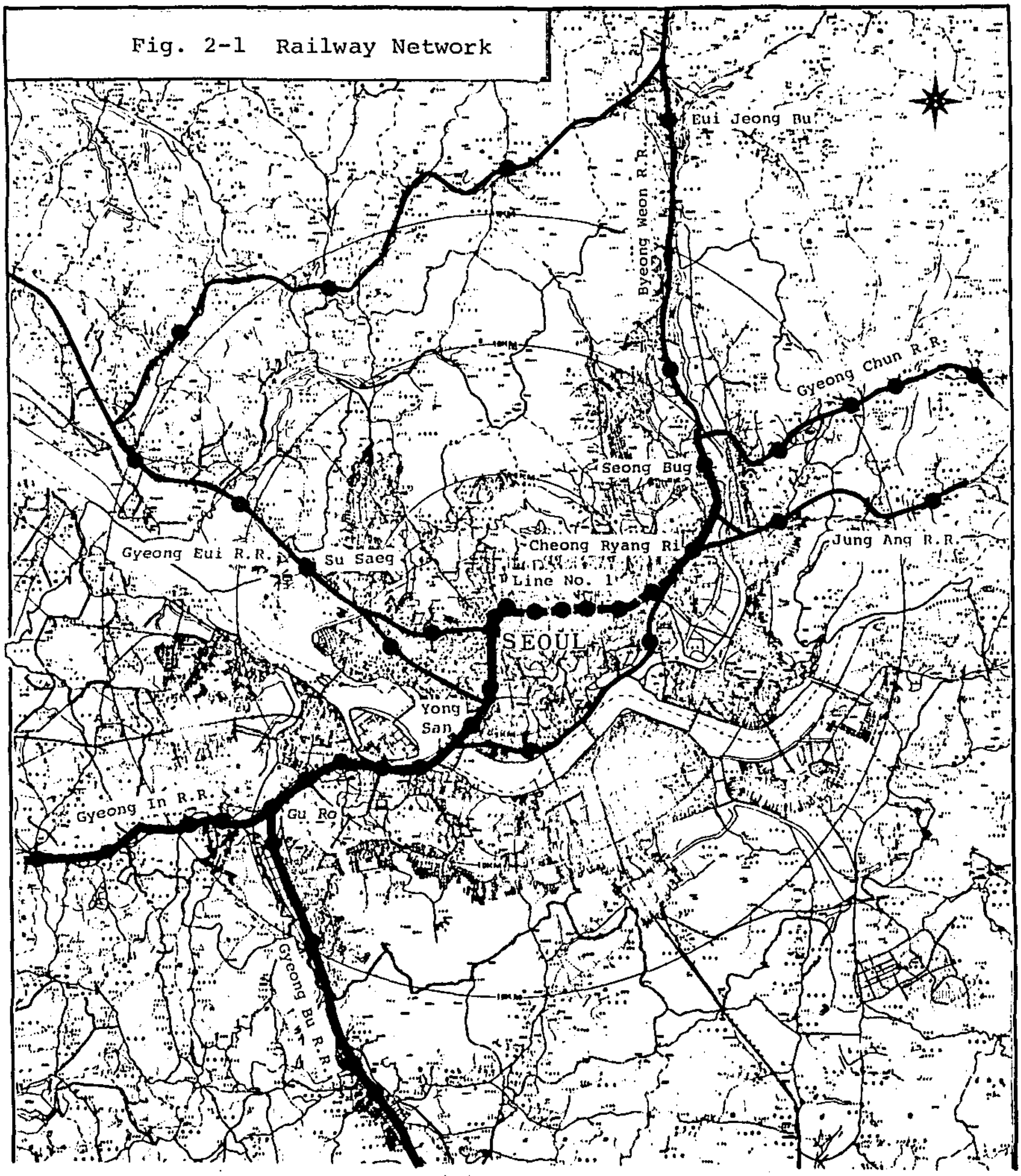
### 2.1.1 Railways

The railway network in Seoul comprises the underground rapid transit, the electrified section and the non-electrified section of KNR, radiating from the city center in the north-eastern, southwestern, northern and western directions, forming a loop at the center.

The Line No. 1 with a length of 9.54 km that was opened on August 15, 1974 runs underground between Seoul Station and Cheong Ryang Ri. The Line No. 1 is connected with the KNR at both terminals. The average station space is of 0.98 km. The 60 AC/DC electric railcars (10-train consists, 6-car each) serve the Line No. 1 at 5.5-minute intervals during rush hours and at 11-minute intervals at ordinary times from 4:00 a.m. till 11:30 p.m. All the trains run as far as Gu Ro, and some are farther operated to Su Weon, In Cheon or Seong Bug.

The electrified sections of the KNR are suburban lines in Seoul which were electrified at the same time as the Line No. 1 was opened and is served with 125 cars (21-train consists, 6-car each) that operate with AC 25 kV, 50 Hz. The operating length and train intervals during rush hours are as follows:

Fig. 2-1 Railway Network




Legend:

- Station
- Rapid Transit (Line No. 1)
- Electrified Section (KNR)
- Non-Electrified Section (KNR)

| | | | |
|---|---|---|---|
| Seoul | - | Su Weon | 41.5 km |
| Seoul | - | In Cheon | 38.4 km |
| Cheong Ryang Ri | - | Seong Bug | 5.6 km |
| Guro | - | Su Weon | 15 min. |
| Do. | - | In Cheon | 10 min. |
| Cheong Ryang Ri | - | Seong Bug | 10 min. |
| Do. | - | Guro | 5 min. |

According to the Fourth 5-Year Development Plan that started in 1977, the following sections are to be electrified.

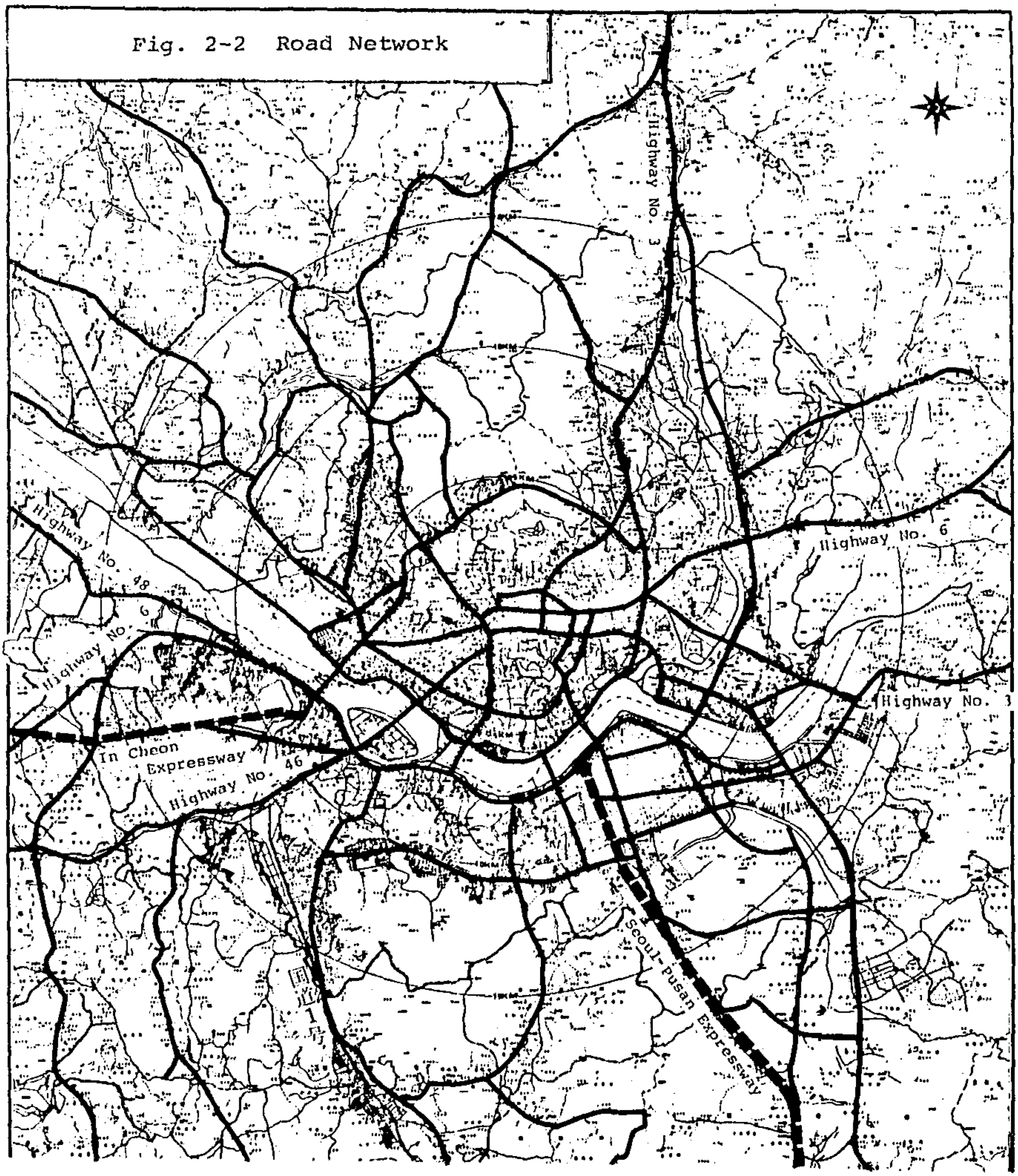
| | | | |
|---|---|---|---|
| Eui Jeong Bu | - | Seong Bug | 13.1 km |
| Seoul | - | Su Saeg | 8.5 km |
| Yong San | - | Do. | 9.6 km |

### 2.1.2 Road

The road network of Seoul consists of two central loops and of more than ten radial lines. Two of the radials are the In Cheon and Seoul-Pusan Expressways. The trunk-line roads include National Highway No. 1 that extends from South to North, Highway No. 3 from East to North and Highway No. 6 from East to West.

This road network has a total length of 6,005 km and total areas of 45.73 sq.km in 1976. The road rate in Seoul is 7.3 percent. Although it is higher than that of Tokyo, 5.7 percent for the metropolitan area, the pavement rate is 38.9 percent (1973) for Seoul, and 67.5 percent (1973) for the Tokyo Metropolitan Area. This difference in pavement rate indicates that the roads of Seoul need more improvement when compared with those of Tokyo.

Fig. 2-2 Road Network




Legend: Expressway

Ordinary Road

Table 2-1 Road Facilities in Seoul (December 1976)

| Facility | Number | Facility | Number |
|---|---|---|---|
| Bridges | 420 (9 Bridges over the Han) | Viaducts | 125 |
| Tunnels | 5 | Signals | 150 |
| Underpasses | 25 | Parking lots | 724 (0.419 sq.km) |
| Elevated roads | 9 | Bus stops | 1,655 |

[Source: Materials from Tourism and Transportation]

Table 2-2 Road Condition in Seoul (December 1976)

| Road width | Total Length (m) | Area (sq.m) | Percentage in Total | Remarks |
|---|---|---|---|---|
| 5 m or less | 1,789,297 | 5,942,818 | 13.0 | Road rate |
| 10 m | 2,944,115 | 16,845,766 | 36.8 | Seoul: 7.3% |
| 20 m | 650,664 | 7,206,215 | 15.8 | Tokyo: 5.7% |
| 20 m or more | 621,408 | 15,732,714 | 34.4 | |
| Total | 6,005,483 | 45,726,513 | 100.0 | |

[Source: Materials from Tourism and Transportation]

The Seoul Municipal Government (SMG) plans a network of radial and circular roads in order to alleviate traffic congestion, developing a road traffic system, as the city grew rapidly. This plan aims to construct the 3 loops and 14 radial roads, and the loops are to be at 2 km, 5 km and 10 km apart from the city center. The construction of new roads and the improvement of existing ones have been promoted year by year, and all the planned roads excluding 3 radials and the outermost loop have nearly been completed by 1976.

Fig. 2-3 Planned Urban Road Network

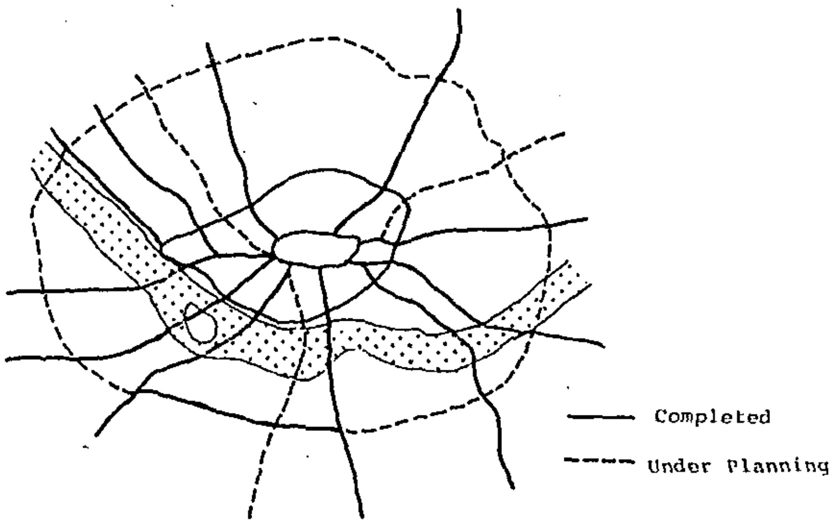



Table 2-3 Planned Urban Road

| Type | Road width (m) | Number | Total Length (km) |
|---|---|---|---|
| Broad road | 40 -- 100 | 31 | 145.2 |
| Broad third-class road | 20 -- 35 | 162 | 633.3 |
| Medium third-class road | 12 -- 20 | 307 | 598.5 |
| Narrow road | 12 m or less | - | 440.0 |
| Total | | 500 | 1,817.0 |

[Source: Official Bulletin of Seoul]

## 2.2 Fare Structure

Public surface transport is provided by buses, railways and taxis in Seoul. Except for the bus service which adopts a flat rate system, the other two operators adopt a fare system which adds a distance-proportional fare to the base fare.

The flat rate for the bus is 35 Won, the base fare for the taxi 200 Won, and the base fare for the railway including subway 40 Won. The railway gives a discount to school children and students and commuters at different rates.

When the fares of these public transport systems in Seoul are compared with those in Tokyo, the flat rate for the bus service in Seoul equals 22 percent of that in Tokyo, the base fare of the taxi, 34 percent, and the base fare of the railway, 28 percent. The nominal public transport fares in Seoul are much lower than those in Tokyo. It is reasonable, when the difference in income per capita between the two metropolises is taken into considered. As the fare of the bus service is the lowest, buses are gaining increasing popularity in Seoul.

Table 2-4 Public Transport Fare System in Seoul and Tokyo

| Type of Transport \ City | Seoul | Tokyo | Remarks |
|---|---|---|---|
| Bus | 35 Won | 90 yen (159 Won) | Commuter discount in Tokyo alone |
| Taxi | (2 km)<br>200 Won + 30 Won/2 km | (2 km)<br>330 yen + 60 yen/0.405 km<br>(584 Won) (106 Won) | |
| Subway | (8 km)<br>400 Won + 3.6 Won/1 km | (3 km)<br>80 yen + 20 yen/4 km<br>(142 Won)(35 Won) | Commuter discount in both cities |
| National railways | 1 -- 9 km 40 Won<br>10 -- 12 50<br>13 -- 14 60<br>15 -- 17 70<br>18 -- 20 80<br>21 -- 23 90<br>24 -- 26 100<br>27 -- 28 110<br>29 -- 31 120<br>32 -- 34 130<br>35 -- 37 140 | 1 -- 3 km 60 yen (106 Won)<br>4 -- 5 70 (124 )<br>6 -- 10 80 (142 )<br>11 -- 15 110 (195 )<br>16 -- 20 150 (265 )<br>21 -- 25 190 (336 )<br>26 -- 30 230 (407 )<br>31 -- 35 270 (478 )<br>36 -- 40 310 (549 )<br>41 -- 45 340 (601 )<br>46 -- 50 380 (673 ) | Commuter discount in both cities<br><br>* 100 Yen = 177 Won |

[Source: Fare Tables of the subway and national railways in Seoul and Tokyo]

## 2.3 Traffic Characteristics

Traffic behavior is drived from the movement of people, and people are generally carried by such public transports as railways and buses. This section will first deal with the general characteristics of passenger traffic in Seoul and then the features of the two representative public transports, railways and buses, resulting in discussions of passenger traffic by the type of public transport.

### 2.3.1 General

According to the person trip survey taken by the KIST in December 1973, the number of purpose-trips was 8,566,191 and the number of made trips. 9,578,022. These figures indicate that 56.3 percent of the total population in Seoul which was 6,289,556 in 1973 mode-trips. This percentage increased by 8.2 percent compared with 48.1 percent in 1970, which shows that the citizens of Seoul have become more active than before.

Table 2-5 Person Trip in Seoul

| Item / Year | Population (thsnd) A | Purpose-Trip B | Mode-Trip C | Number of Purpose-Trip per Person B/A | Number of Mode-Trip per Person C/A |
|---|---|---|---|---|---|
| 1970 | 5,526 | 6,740,084 | 7,521,300 | 1.22 | 1.36 |
| 1973 | 6,290 | 8,566,191 | 9,578,022 | 1.36 | 1.52 |
| Rate of Increase (%) | 13.8 | 27.1 | 27.3 | 11.5 | 11.8 |

[Source: Engineering and Economic Survey for the Construction of the Loop Line, via Gang Bug and Gang Nam]

The average number of purpose-trip made by the each population was 1.4 trips. This figure indicates that the greater parts of trips made by the citizens of Seoul are of essential purpose, since the corresponding figures in big cities of the foreign countries are 1.6 to 2.2 trips/person. Be that as it may, the number of trips in Seoul has been on the increase year by year. As the activities of citizens in Seoul are becoming more and more brisk with increasing income, employment opportunity and leisure pursuit, it is likely that the number of trips will increase in a still sharper curve in the years ahead.

Table 2-6 Settled Population and Traffic Population

| Item / Year | Settled Population (thsnd) | Settled Population Increase Rate (%) | Traffic Population (thsnd) | Traffic Population Increase Rate (%) | Average Riding Frequency | Social Increase Rate (%) |
|---|---|---|---|---|---|---|
| 1971 | 5,850 | - | 6,276 | - | 1.14 | 3.9 |
| 1972 | 6,076 | 3.86 | 7,048 | 12.3 | 1.16 | 2.0 |
| 1973 | 6,290 | 3.52 | 7,422 | 5.3 | 1.18 | 1.4 |
| 1974 | 6,542 | 4.01 | 7,850 | 5.8 | 1.20 | 2.3 |
| 1975 | 6,889 | 5.30 | 8,450 | 7.6 | 1.22 | 3.6 |
| 1976 | 7,255 | 5.31 | 8,959 | 6.0 | 1.24 | 3.6 |

[Source: Materials from Tourism and Transportation]

Of the total number of purpose-trip in 1973, school attendants accounted for 24.5 percent, office commuters 20.5 percent, trips for business 4.5 percent, for amusement 1.5 percent and for homecoming 47.5 percent.

School attendants, office commuters and homecoming trips in all accounted for as much as 92.5 percent of all purpose-trips made by citizens in Seoul in 1973.

Table 2-7 Trip by Purpose (1973)

| Trip | Percentage in Total |
|---|---|
| School attendant | 24.5 |
| Office commuter | 20.5 |
| Homecoming trip | 47.5 |
| Business trip | 4.5 |
| Amusement trip | 1.5 |
| Shopping | 0.8 |
| Others | 0.7 |
| Total | 100.0 |

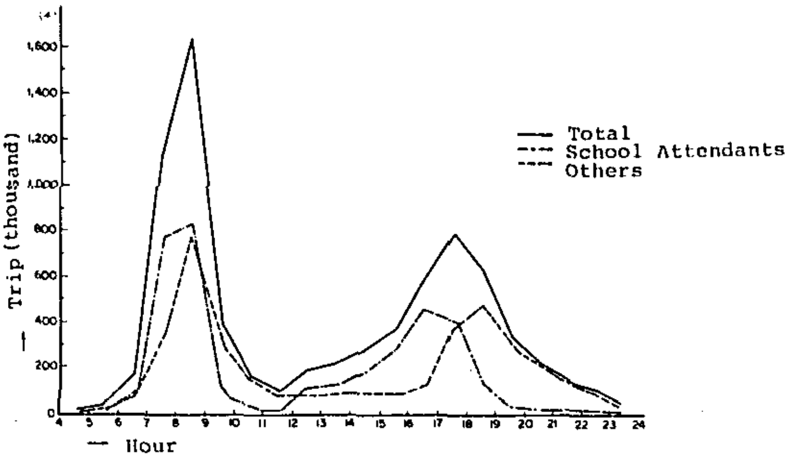
[Source: Engineering and Economic Survey for the Construction of the Loop Line, via Gang Bug and Gang Nam)

Trip generation shows a peak level once in every morning and afternoon, as in the case of other big cities in the world, which is clear from the hourly trip distribution shown in Fig. 2-4. During the morning rush hour inbound trips account for the greater percentage of passenger traffic between the city center and its suburbs, and reverse is the case with afternoon. The morning rush is of a shorter duration than that in the afternoon, and the concentration ratio of trips during the morning rush hour between 7 and 9 a.m. is as many as 36.5 percent of the daily total. In the still shorter period of 30 minutes between 8 and 8:30 a.m. 13.3 percent of daily trips occur in Seoul.

Total motor traffic that flows in and out the city center is 36,000 to 37,000 units each, and 18 to 19 percent of the motor traffic arise during the rush hour.

In the daily total, 2,722,500 trips a day or 32.1 percent of all are related to the city center traffic. Of them, inbound trips account for 1.5 percent, outbound trips 18.4 percent, and through trips 12.2 percent.

Fig. 2-4  Hourly Trip Distribution




Seoul is divided into southern and northern parts by the Han.  On account of the geographic constraints traffic has been mainly dependent on the streets extending east to west with a few radial roads which has been built in order to connect tht city center with the surburban districts. With such an historical background, the city expanded its administrative districts and formed several subcenters. As a matter of necessity, east-west traffic has been predominant.  In recent years, however, there has been a shift to north-south traffic as a result of population growth especially in the Gang Nam district.  The heavy east-west traffic can also be easily inferred from the characteristic bus service network which is overlapped east and west.

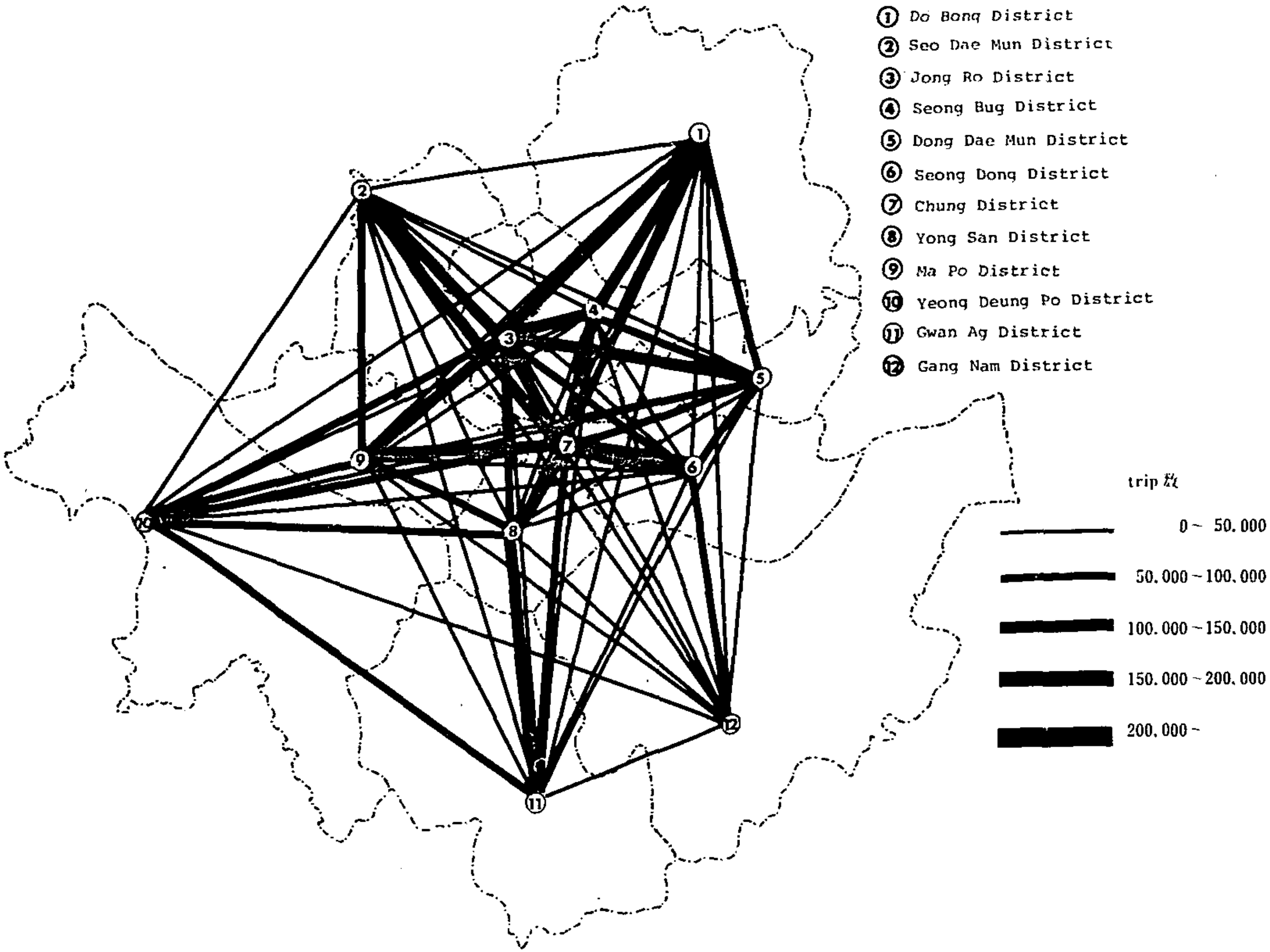
Table 2-8  Motor Traffic in and out City Center

(Units/Day)

| Traffic Volume / Direction | Total traffic Volume | Hourly Traffic Volume | Rush-hour Traffic Volume |
|---|---|---|---|
| Incoming | 373,177 | 18,659 | 70,285 |
| Outgoing | 363,900 | 18,195 | 64,421 |
| (Balance) | (9,277) | (446) | (5,864) |
| Total | 737,077 | 36,854 (614/min) | 134,706 |

[Source:  Materials from Tourism and Transportation]

Fig. 2-5 Desired Traffic among Districts (1973)



The recent years have witnessed a steep rise in the number of registered motor vehicles. As of 1976 vehicles registered totaled 96,557 in Seoul. This number is 1.4 times that in 1971 and 2.7 times that in 1968. The diffusion rate of vehicles rose from 123 persons/vehicle in 1968 to 86 persons/vehicle in 1971 and to 75 persons/vehicle in 1976.

Table 2-9 The Number of Registered Vehicles

| Type | Item \ Year | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 (end of March) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bus | Vehicles | 3,809 | 4,475 | 4,805 | 5,518 | 5,546 | 5,957 | 6,315 | 6,634 | 7,117 | 7,554 |
| | Index | (100) | (117) | (126) | (145) | (146) | (156) | (166) | (174) | (187) | (198) |
| Passenger car | Vehicles | 19,938 | 29,111 | 34,870 | 39,054 | 40,753 | 45,331 | 44,813 | 47,881 | 54,954 | 58,024 |
| | Index | (100) | (146) | (175) | (196) | (204) | (272) | (225) | (240) | (276) | (291) |
| Truck | Vehicles | 11,388 | 14,333 | 19,325 | 20,923 | 20,463 | 22,922 | 26,854 | 28,307 | 31,775 | 33,122 |
| | Index | (100) | (126) | (169) | (184) | (180) | (201) | (236) | (249) | (279) | (290) |
| Others | Vehicles | - | 1,709 | 1,442 | 1,780 | 1,910 | 2,093 | 2,311 | 2,585 | 2,711 | 2,750 |
| | Index | | (100) | ( 84) | (104) | (112) | (122) | (135) | (151) | (159) | (161) |
| Total | Vehicles | 35,135 | 49,628 | 60,442 | 67,275 | 68,492 | 76,303 | 80,248 | 85,407 | 96,557 | 101,000 |
| | Index | (100) | (141) | (172) | (192) | (195) | (217) | (228) | (243) | (275) | (288) |
| | Population per vehicle | 123 | 96 | 91 | 87 | 89 | 82 | 82 | 81 | 75 | - |

[Source: Materials from Tourism and Transportation)

By types of vehicles, passenger cars account for 56.9 percent, truck 32.9 percent, buses 7.4 percent and other types 2.8 percent of the total number of registered vehicles. As compared with the levels of 1968, the number of buses was 1.87 times greater in 1976, while the numbers of passengers cars and trucks were 2.76 and 2.79 times greater, respectively.

The percentage of buses is 7.4 in Seoul, while it is low as 0.7 percent in Tokyo. This remarkable difference between the two cities seems to afford evidence to indicate that public transport is provided mainly by buses in Seoul.

Table 2-11 shows the condition of road transport in Seoul. As is clear from this table, buses are operated with the highest frequency among other vehicles. Each bus is operated 17 trips daily. As the average length of service routes is 21 km, the daily average distance traveled is 357 km. In Tokyo, on the other hand, the daily distance traveled does not exceed 120 km in any case. These statistical data indicate that buses are operated by far more efficiently in Seoul than in Tokyo.

Table 2-10 Numbers of Registered Vehicles in Seoul and Tokyo

| Item / Division | Seoul | | Tokyo | | A/B | Remarks |
|---|---|---|---|---|---|---|
| | Number of Vehicles (A) | Percentage in Total | Number of Vehicles (B) | Percentage in Total | | |
| Bus | 7,117 | 7.4 | 18,156 | 0.7 | 2.6 | Diffusion Rate |
| Passenger car | 54,954 | 56.9 | 1,370,629 | 51.8 | 24.9 | Seoul: 75 persons/ vehicle |
| Truck | 31,775 | 32.9 | 755,083 | 28.5 | 23.8 | Tokyo: 4.4 persons/ vehicle |
| Others | 2,711 | 2.8 | 502,083 | 19.0 | 185.2 | |
| Total | 96,557 | 100.0 | 2,646,659 | 100.0 | 27.4 | |

[Source: Materials from Tourism and Transportation]

Table 2-11 Operating Rate by Type of Vehicle

| Item / Type of Vehicles | Operating Rate (Times/Day) | Number of Vehicles | Percentage in Total | Remarks |
|---|---|---|---|---|
| Bus | 17 | 121,162 | 16.3 | Operating rate in Tokyo (1974) |
| Passenger car | 10 | 544,762 | 74.0 | Passenger car: 5.1 times/day |
| Truck | 2.5 | 68,179 | 9.3 | Truck: 3.5 times/day |
| Others | 3.4 | 2,974 | 10.4 | Bus: 3 to 24 times/day (40 to 2.2 km) |

[Source: Materials from Tourism and Transportation]

2.3.2 Rapid Transit Railway

The Line No. 1 which was opened on August 15, 1974, and connects with the Gyeong Bu R.R. and the Gyong In R.R. of the KNR offers greater convenience to passengers who travel in and out the Metropolis.

In March 1977 a survey was made to investigate the traffic on the Line No. 1 during the rush hours. According to this survey, the total passenger volume of the Line No. 1 is 361,900, and of them 58,600 or 16.2 percent are commuters. The daily transit passengers between Seoul Station, the junction, and the stations beyond over the KNR is 41,000. Accordingly, the real passenger volume on the Line No. 1 totals 403,000 a day.

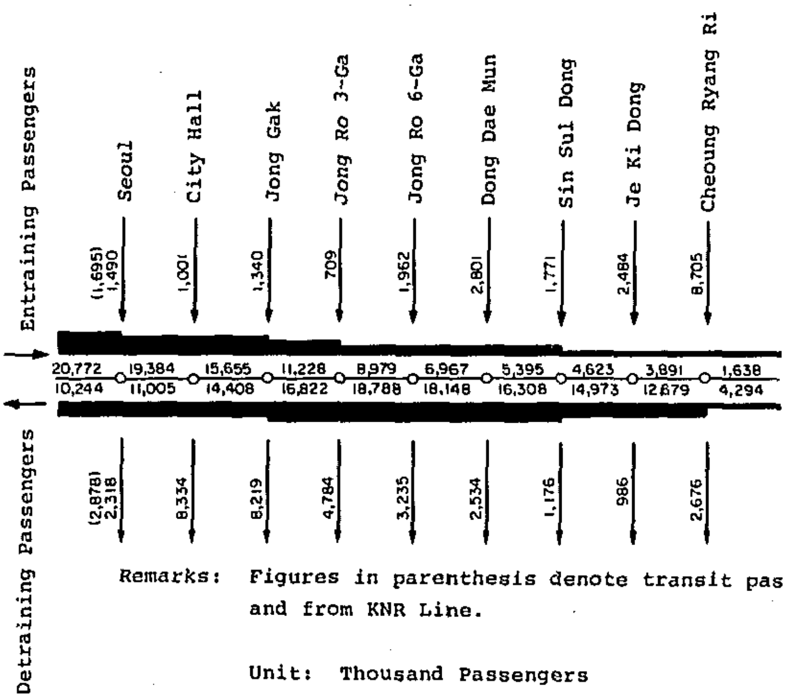
The rush-hour passenger volume between 7:30 and 9:30 a.m. is 76,500 persons or 21.1 percent of the daily total, and commuters account for 8.1 percent of this peak passenger volume. When the transit passenger traffic between Seoul Station and the KNR is added to the peak passengers, it totals 85,400 persons. Between 7:30 and 8:30 a.m. the line carries 31,900 passengers or 8.8 percent of the daily total passenger volume and between 8:30 and 9:30 a.m. carries 44,600 passengers or 12.3 percent of the total.

The entraining passenger volume between 7:30 and 9:30 a.m. is in Cheong Ryang Ri, 15,500, which is the largest among the others. This figure accounts for 38.8 percent of 40,000 passengers getting on trains each day. The corresponding figure for Dong Dae-Mun is 4,400 or 11.0 percent, and that for Je Ki Dong Station 5,300 or 13.3 percent. At Seoul Station 3,400 passengers gets on trains between 7:30 and 9:30 a.m. every day, and the total entraining passenger volume totals 7,500, when the transit passengers from the KNR are added. The detraining passenger volume handled between 7:30 and 9:30 a.m. is largest at Jong Kak, totaling 13,600. This figure is 24.7 percent of 55,000 passengers getting off at the station each day. The corresponding figures for City Hall, Jong Ro 5-Ga and Jong Ro 3-Ga are 12,600 or 22.9 percent, 6,800 or 12.4 percent and 5,500 or 10.0 percent, respectively. With an addition of 4,800 transit passengers for the KNR, the passengers who detrain at Seoul Station between 7:30 and 9:30 a.m. total 8,600 or 15.6 percent so that Seoul Station ranks the third behind Jong Gak and City Hall. The students who get off at Jong Gak with student's discount tickets number 4,250, accounting for 31.3 percent of the daily detraining passengers at the station. This figure accounts for 38.8 percent of the total of 10,940 students who travel on the Line with the student's tickets.

The concentration of people in central districts during the morning rush hour is well reflected in the passenger distribution at stations just discussed. This morning passenger distribution is suggestive of the fact that the city center of Seoul is the area sandwiched by City Hall Station and Jong Gak Station bristling with public buildings.

The route served by the railway is divided into five sections: Seoul-Station -- Cheong Ryang Ri (Line No. 1); Seong Bug -- Cheong Ryang Ri; Seoul --Gu Ro; Gu Ro -- Su Weon; and Gu Ro -- In Cheon. The transit passengers into the Line No. 1 total 18,850, and those from the above number 33,850. Of them 11 and 20 percent are accounted for by the passengers to and from Seong Bug District; 39 and 34 percent passengers

Fig. 2-6 Passenger Traffic on Line No. 1 during Rush Hours (8:30 - 9:30 a.m.)




Remarks: Figures in parenthesis denote transit passengers to and from KNR Line.

Unit: Thousand Passengers

to and from Gu Ro District; 15 and 12 percent by the passengers to and from Su Weon District; and 36 and 34 percent to and from In Cheong District. The figures indicate that there is busy traffic along a line, Cheong Ryang Ri -- Seoul -- Gu Ro -- In Cheon .

### 2.3.3 Bus

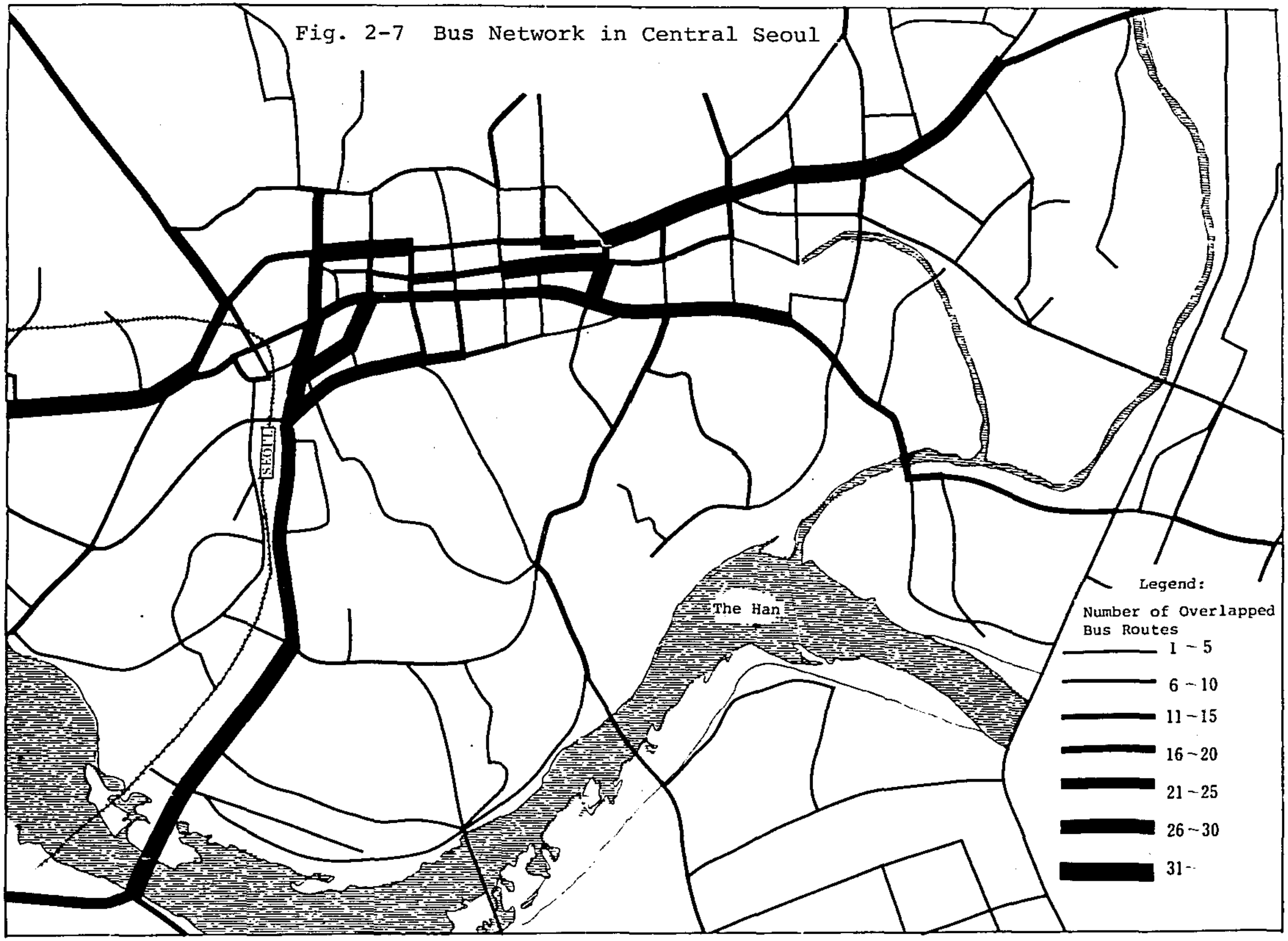
As of 1976, 69 percent of the total passenger traffic, excluding pedestrains, in Seoul travel by bus. Bus is now the most important urban transport means. About 5,000 buses serve 155 routes, covering wide areas of the city and even reaching neighboring cities such as Eui Jeong Bu, An Yang, and Seong Nam. In Seoul almost all the streets are covered with bus routes and such streets lead to the city center. Practically, only a little more than 10 out of 155 bus routes do not connect with the city center. This network has the merit that passengers can reach almost all desired destinations by changing once at the central terminal, with the demerit that passengers wishing to make a bus trip among the suburban areas inevitably through the city center.

Incidentally, 60 of the 155 bus routes connect with Seoul Station; Twenty-five routes with Jong Ro 2-Ga; 40 routes with Dong Dae Mun; 20 routes with Cheong Gye Cheon 5-Ga; 30 routes with Eul Ji Ro 6-Ga; and 20 routes with Tae Gye Ro 3-Ga. Bus routes overlap in the trunk roads of central Seoul so that many buses are obliged to stop at any unexpected time, feeding back to unusual traffic congestion.

The average bus route length is about 21 km, and the average operating time is about 1 hour. The bus intervals are very limited such that buses are operated at intervals of about 30 seconds during the rush hours. Buses are operated at intervals of 5 minutes or less during the ordinary time over the almost all service routes.

According to the survey of the bus services by route taken in July 1976, 1,777,929 passengers are carried by buses between 7 and 10 a.m. in Seoul, accounting for 29.1

Fig. 2-7  Bus Network in Central Seoul



percent of the total number of 6,118,264 persons who travel by bus each day. Bus traffic is estimated at 0.84 trip per person per day, as the population of Seoul in 1976 totaled 7,250,000.

The number of bus passengers sharply rises in the period of 15 minutes between 7:00 and 7:15 a.m. and gradually declines between 7:45 and 9:00. Congestion continues for 90 minutes from 7:00 to 8:30, reaching the peak level in the period of 30 minutes after 7 a.m. In this short period 433,330 passengers or 7.1 percent of the total daily bus passengers enter and leave central Seoul each day.

Traffic congestion begins at the boundary between the urban and the suburban districts, of Seoul during morning rush, ending in the heart of the city. The average number of bus stops is 38 per route, and as many as 24 stops of each route are located in busy areas where each bus carries more than 80 passengers. The average number of riding passengers during the rush hours in these busy areas is 110 persons per bus. The nominal capacity of bus is 80 persons, with the passenger index of 1.38, while the average number of riding passengers of all routes is 46 and the riding passenger index is 0.58.

The average bus load of all routes is 984 person·km/bus, and the total load during the rush hours is 12,557,869 person-km. According to the afore-mentioned survey, the average number of bus passengers during the specific rush hours is 140 and the total number during the specific rush hours is 1,777,929. As far as these numbers are concerned, the average trip length per passenger is about 7.0 km. As the average bus route length is 21 km, each passenger travels about one-third of the route each time.

### 2.3.4 Public Transportation Structure in Seoul

In Seoul passengers are carried by the subway, buses, taxi and private cars. As shown in Table 2-12, the public transportation of the city heavily depends on buses. Such being the case, bus passengers accounted for 68.9 percent of the total daily traffic volume and for 70.9 percent of the foregoing during the rush hours in 1976. Taxis are also an important mode of public transportation. They carry 17.0 percent of the total daily passenger volume. Buses and taxis therefore transport as much as 85.9 percent of all passengers in Seoul. This situation is hardly observable in other big cities in the world. On the other hand, Seoul has now only one subway.

The Line No. 1 carries no more than 4 percent of all passengers of the city. The heavy dependence on,the public road transport is doubtless, since the city has no railway network for mass transportation, and it is no exaggeration at all to say that the principal public transport of the city is by bus.

The railway transport network plays a very important role in Tokyo. The JNR, private network and subways transport 28.7, 23.3 and 17.9 percent, respectively, of the total passenger volume. The three railway systems account for as much as 69.6 percent of the total passenger volume generated in the Tokyo Metropolis. In this city, therefore, buses are subordinate to the railway transport.

Table 2-12 Passenger Volume by Transport Mode in Seoul (1976)

| Item / Mode | Total Daily Passenger Volume | | Passenger Volume during Rush Hours (6:00--10.00 a.m.) | | Remarks |
|---|---|---|---|---|---|
| | Passengers (thsnd) | Percentage in Total | Passengers (thsnd) | Percentage in Total | |
| Bus | 6,170 | 68.9 | 2,450 | 70.9 | Passenger volume during rush hours accounts for 38.6% of the total. |
| Taxi | 1,526 | 17.0 | 490 | 14.2 | |
| Line No. 1 | 380 | 4.2 | 140 | 4.1 | |
| Others | 883 | 9.9 | 375 | 10.9 | |
| Total | 8,959 | 100.0 | 3,455 | 100.0 | |

[Source: Materials from Tourism and Transportation]

Table 12-13 Passenger Volume by Transport Mode in Tokyo (1975)

| Mode \ Item | | Passengers (thsnd) | Percentage in Total |
|---|---|---|---|
| Railway | JNR | 2,787,949 | 28.7 |
| | Private railways | 2,277,314 | 23.3 |
| | Subways | 1,749,339 | 17.9 |
| | Total | 6,814,602 | 69.9 |
| Road transport | Streetcar | 49,418 | 0.5 |
| | Bus | 901,413 | 9.2 |
| | Hired car and taxi | 504,261 | 5.2 |
| | Private car | 1,485,735 | 15.2 |
| | Total | 2,940,827 | 30.1 |
| Grand Total | | 9,755,429 | 100.0 |

[Source: Annual Statistical Report of Urban Traffic, 1977]

# 3. Transport System Planning and Passenger Volume Forecast

## 3.1 Framework for Passenger Volume Forecast

### 3.1.1 General

The present "General City Development Plan" of Seoul Metropolitan Government (SMG) envisages to carry out the basic plan worked out in 1966. As a result of the rapid population growth in the late 1960's and the adoption of the "Multiple Purpose Land Development Plan" for the entire nation in 1971, the basic plan has been scrutinized precisely to keep abreast of the times, resulting in the "General City Development Plan" in 1972.

The "General City Development Plan" basically seeks:

1. Orderly arrangement of the infrastructure in the city so that each part of the domain may efficiently perform its functions;

2. Establishment of an organic and efficient transportation network; and

3. Provision of a comfortable living environment.

The SMG aims to achieve these goals in 10 years from 1972 to 1981, keeping the city population at 7,500,000 in 1981.

The plan to establish an organic and efficient transportation system aims to expand the rapid transit railways in the metropolitan district.

The "General City Development Plan" has as one of its chief objectives to prevent the overcrowding in the urban area of the city, dispersing its population.

For materializing these objectives the SMG announced the concept of developing Seoul into a multi-nucleus city which has such areas as existing city center, Yeong Deung Po, Yeong Dong and Jam Sil as subcenters.

At present various programs are being promoted in line with this concept, and special importance is laid on the Line No. 2 project which will connect the two subcenters with the city center.

3.1.2 Development of Three Nuclei of Seoul

The concept of developing Seoul into a multi-nucleus city is briefly reviewed hereunder. According to the plan, the city will have three nuclei; the present city center and two subcenters so that each part of the city may perform their functions in an orderly manner.

The Yeong Deung Po district, which is located at an important junction of transportation between Seoul and In Cheon and between Seoul and Su Weon, has grown up to be an industrial area in Seoul. The district of Yeong Deung Po being advantageously located this district with vast population supplies labor to the existing industrial area and the newly developed Gu Ro industrial complex. Thus this district has residential areas of Kwa Gog, Sin Jeong, Gae Bong and O Ryu with large-scale apartment complexes. This district will be developed into the subcenter through the further industrial promotion and improvement of the transportation system.

On the other hand, the district of Yeong Dong and Jam Sil aims to develop into the mainly residential subcenter which accommodates a population of one million. This subcenter will include the Yeong Dong district where the high-class residential complex is already existent and the Jam Sil district where new houses and athletic stadium will be built.

Various programs have been promoted in order to formulate this concept. One of the important programs is the expansion of the transport network which plays a leading role in the development of subcenters.

The SMG plans to give priority of development to the southern part of the city with a view to evenly distributing the population on both sides of the Han by depleting the thick population in the northern part and increasing the thin population in the southern part.

This plan is intrinsically valuable, as it aims to divert the heavy urban traffic to the southern part of the city by dispersing the population in the north over the southern part.

The concept of the multi-nucleus city is highly valuable as a sound policy of city development, as it is conducive to the rational city administration which leads to the community development.

3.1.3 Framework of Seoul Urban Area

According to the survey made by the SMG the city has a 7,254,958 inhabitants as of October 1, 1976.

This figure is 20.23 percent of the Korean population of 35,860,000. The citizens of Seoul live in a fractional territory which corresponds to 0.64 percent of the total land.

Table 3-1 Population of Korea and Seoul

(October 1, 1976)

| Item \ Division | Korea | Seoul (%) |
|---|---|---|
| Area (sq.km) | 98,484.10 | 627.06 ( 0.64) |
| Population | 35,860,000 | 7,254,958 (20.23) |
| Density (per sq.km) | 364 | 11,570 ( - ) |

Table 3-2 Population Concentration Tendency in Big Cities

| City | Concentration Ratio (%) |
| --- | --- |
| Seoul | 20.2 |
| Tehran | 12.8 |
| London | 15.3 |
| Tokyo | 8.4 |
| Bangkok | 5.4 |
| Paris | 5.1 |

[Source: Official Bulletin of Seoul, 1976]

Seoul carries weight not only in terms of population but in economic activities. The concentration of various activities in this city is overwhelming.

The population of Korea has increased to 141 percent since 1960, while the population of Seoul has risen to 279 percent. In the early 1960's the city accounted for 10 percent or so of the total population of Korea.

Commenting on the rapid concentration of population in Seoul, the KIST states in its report on the "Engineering and Economic Survey for the Construction of the Loop Line via Gang Bug and Gang Nam districts" as follows:

"Until 1960 the low living standard in the rural districts was the main cause of the migration of population into Seoul, but after 1960 commerce, manufacturing and service industries made such remarkable progress in Seoul that the central functions--political, economic, social, cultural, and educational, have been concentrated in the metropolitan city, causing the parallel rise in employment opportunities.
When population is concentrated excessively in the primary city of a country, not only the political, social and cultural activities but all economic activities related to both

production and consumption are concentrated in the same city with the result that a significant economic loss is incurred from the national point of view. Furthermore, the excessive concentration of population in the primary city also gives rise to a serious gap in income and social welfare among the primary city and other areas of the country to the detriment of the balanced development of the country as a whole."

The KIST points out that the population problems of Seoul should be coped with not so much a question of one city as that of affecting the interest of the whole nation, suggesting that programs to hold the population growth in Seoul in check be studied and carried through, in order to improve the development and improvement of all parts of the city to the optimum standards.

With these considerations in mind, the development framework of Seoul is studied in the following sections.

3.1.3.1 Population Planning

The "General City Development Plan, 1972" of SMG estimates the population of the city in 1981 to be 7,500,000.

This figure has been considered to be a reasonable estimate, provided that the annual average growth rate of population during the planning period between 1972 and 1981 can be held below 2.5 percent.

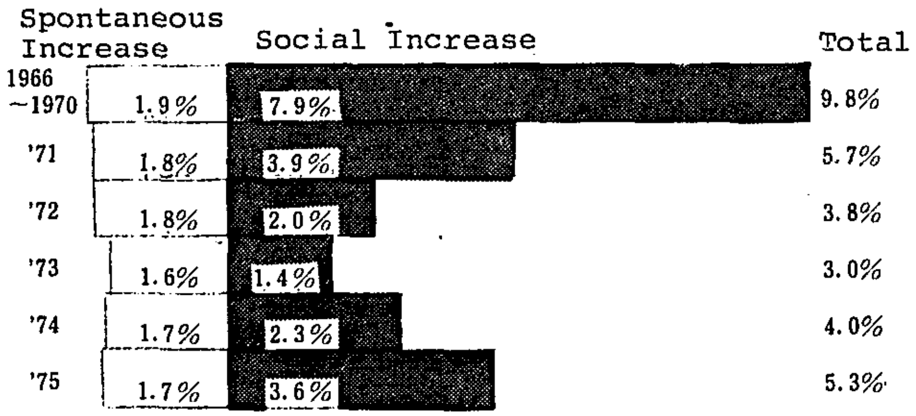
As population growth slowed down in the early 1970's (1970 to 1973), the estimate might be reasonable in the first few years of the 1970's. The actual population, however, rose again at a rate of 4 to 5 percent a year from 1973 through 1976. Even if measures are taken to hold population growth in check, it will be difficult to hold the population to 7,500,000 in 1981.

As the SMG has not announced any population plan after 1981 so far, the KIST assumed in its afore-mentioned Report that the SMG would abide by its population policy of up to 1981 till 1986 and estimated the population of Seoul in 1986 to be 8,140,000 accordingly.

The KIST describes the figure as a pessimistic estimate based on the assumption that the SMG will take measures to control population growth. It anticipates that, if adequate measures are not taken to control population and growth rate is 2.5 percent in 1981, the population in 1986 will be about 8,800,000.

According to the population growth chart shown in Fig. 3-1, much of the increase is ascribable to social factors. The spontaneous growth rate of population is 1.7 percent at present. There is already a considerable difference between the actual population and that estimated by the KIST in consideration of the population policy of Seoul. This fact suggests that the population is the most important problem to be solved.

Fig. 3-1 Population Growth Rate




Source: Official Bulletin of Seoul, 1976

For the above reasons the future population of Seoul is reviewed in detail in 3.2.2.

3.1.3.2 Economic Activities

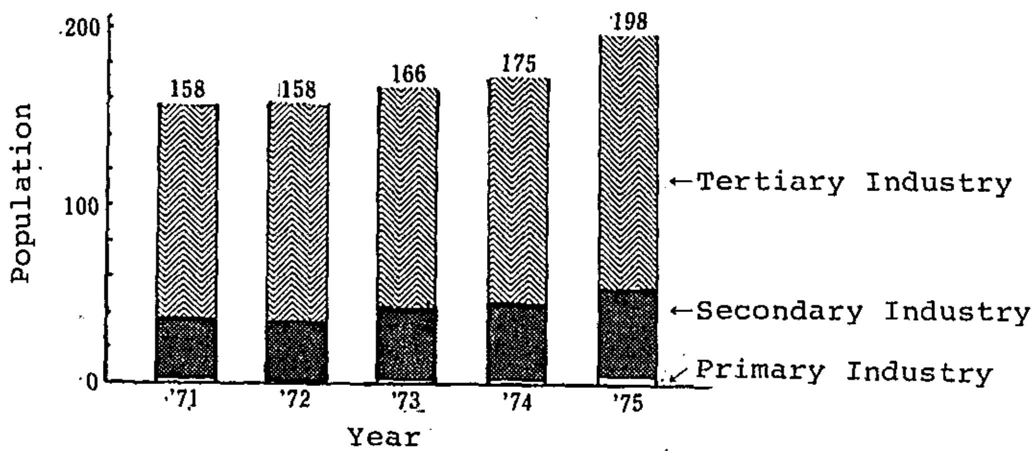
As of September 1975 the population of 14 years or over in Seoul was 4,685,600, 47.4 percent of which or 2,219,600 were engaged in economic activities. The greater part of non-participants were students and housewives.

In Seoul 89.2 percent of the working population or 1,979,600 persons were employed, and 10.8 percent or 240,000 persons were out of employment.

The national rate of unemployment is 4.1 percent which is lower than that of Seoul. This difference can be explained by the fact that greater numbers of people are employed in secondary and tertiary industries than in the primary industry which keeps workers longer than other sectors, as is discussed later. The rate of unemployment in Seoul declined from 20.6 percent in 1965 to 16.1 percent in 1967 and further down to 13.3 percent in 1970. The declining rate of unemployment indicates the improvement of the living standard of the nation and the increased stability of their way of living. As the Fourth 5-year Development Plan aims to achieve unemployment rate of about 4 percent, Seoul will probably maintain the rate slightly higher than 4 percent.

The working population distribution by industry in Seoul is typically an urban type which is characterized by the greater employment in the secondary and tertiary industries than in the primary industry. Any change has not occurred in recent years. As of 1975, of the total working population of 1,976,000, 1.4 percent or 28,400 are employed in the primary industry, whereas 25.8 percent or 512,900 in the secondary industry and 72.8 percent or 1,438,300 in the tertiary industry. The concentration of working population in the secondary and tertiary industries indicates that Seoul is the metropolis of Korea and has a significant part in earning income.

Fig. 3-2 Industrial Working Population




Unit: Ten thousand

Source: Official Bulletin of Seoul, 1976

The fact that the population employed in the tertiary industry is more than two times as great as that the population engaged in the secondary industry is in line with the national tendency, but the shift to the tertiary industry is particularly remarkable in Seoul. It indicates the increasing propensity to consume of the citizens in Seoul.

The working population has been increasing year by year mainly in the secondary and tertiary industries, but little change has taken place in the working population engaged in the primary industry. This fact indicates that the suburban agriculture of Seoul employs stable labor and maintains a stable productive structure.

According to the Fourth 5-year Development Plan, the average increase rate of working population is placed at 0.6 percent for the primary, 7.5 percent for the secondary and 3.5 percent for the tertiary industries, and these three are expected to employ 39.7, 26.1 and 34.2 percent of the total working population, respectively, in 1981.

The GNP of Korea was 10,442.4 billion Won at 1975 prices and the Fourth 5-year Development Plan envisages that the GNP will increase at an annual rate of 9.2 percent to reach 16,214.3 billion Won in 1981. The Korean GNP by industry is shown in Table 3-4.

The annual income per citizen was 195,819 Won in 1973, above about 70,000 Won from the national level of 124,495 Won. The amount of 70,000 Won nearly equals the 5-year increase in the average income of working citizens of Seoul. In other words, the income increased for five years ahead in Seoul than in other parts of Korea. The average income of working population in Seoul is about 1.6 times higher than that of the total working population of Korea. The total income of citizens of Seoul accounts for as much as 29.8 percent of the gross national income. This high income level in Seoul is the cause of the population gravitation.

Until 1970 the income level in Seoul was more than two times higher than the national level, but in 1973 the gap was narrowed down to 1.6 times. This averaging tendency was promoted in part by the Saemaeul movement which was strongly backed up by the government, and is closely related to the declining rate of social growth of population in Seoul.

Table 3-3 Working Population

[Thousand Persons]

| Year / Industry | 1976 | 1981 | 1981/1976 | Remarks |
|---|---|---|---|---|
| Primary | 5,699 (45.1) | 5,860 (39.7) | 1.03 | Figures in parentheses indicate percent proportion of the total |
| Secondary | 2,686 (21.2) | 3,854 (26.1) | 1.43 | |
| Tertiary | 4,255 (33.7) | 5,051 (34.2) | 1.19 | |
| Population employed | 12,640 (100.0) | 14,765 (100.0) | 1.17 | |
| Population out of unemployment ratio | 510 (3.9) | 581 (3.8) | 1.14 | |
| Working population | 13,150 | 15,346 | 1.11 | |

[Source: Fourth 5-year Development Plan]

Table 3-4 GNP by Industry

[Billion Won]

| Year / Industry | 1976 | 1981 | 1981/1976 |
|---|---|---|---|
| Primary | 2,464.0 | 2,997.8 | 1.22 |
| Secondary | 3,418.2 | 6,031.0 | 1.94 |
| Tertiary | 4,560.2 | 6,585.5 | 1.44 |
| Total | 10,442.4 | 16,214.3 | 1.55 |

[Source: Official Fourth 5-year Development Plan]

Table 3-5 National and Seoul Income Level

| Division | Year | 1969 | 1970 | 1971 | 1972 | 1973 |
|---|---|---|---|---|---|---|
| Seoul | Income of all citizens (billion Won) | 571.5 | 744.2 | 912.0 | 1,083.4 | 1,221.0 |
| A | Per capita income (Won) | 121,173 | 142,114 | 155,869 | 181,669 | 195,819 |
| Nation | National income (billion Won) | 1,724.1 | 2,137.7 | 2,601.9 | 3,241.9 | 4,096.5 |
| B | Per capita income (Won) | 50,044 | 68,201 | 81,696 | 100,181 | 124,495 |
| | Total income (%) | 33.1 | 34.8 | 35.0 | 33.4 | 29.8 |
| A/B | Per capita income (%) | 216.2 | 208.2 | 190.7 | 131.3 | 158.3 |

[Source: Official Bulletin of Seoul, 1976]

3.1.3.3 Registered Number of Automobiles

As noted in 2.3.1, the number of registered automobiles in Seoul is by far the smaller than in other big cities in the world. A survey gives the following numbers:

| Number of Registered Automobiles in Seoul | |
|---|---|
| 1970 | 60,442 |
| 1973 | 76,303 |
| 1976 | 96,557 |

When the assumption is made that the number of registered automobiles increases in proportion to the GNP per capita, the number of registered automobiles in 1984 is estimated to be 263,500, up about 270 percent from the current level.

3.1.4 Related Development Plans

The development plans which will exert an influence on the future land utilization in the urban area of Seoul are as follows:

High-rank Plans:

° Multipurpose Land Development Plan
° Development Plan

Low-rank Plans:

° General City Development Plan
° Special City Development Plan of Seoul

Area division plan and street arrangement plan:

° Wide Economic Area Development Plan of Seoul
° Rapid Transit Railway Project

### 3.1.5 Basic Concepts of Land Utilization and Population Relocation

The SMG worked out a land utilization plan based on several times, but it is still difficult to have a clear vision of the land utilization system.

In Seoul there coexist two land utilization systems, one of which is a pre-industrial system inherited from the historical background peculiar to the city and the other is a modern system brought about by the recent urbanization of the city. These two systems are both based on the land utilization system of the intrinsic origin.

At present coexistence is prevalent in part of the commercial and industrial zones, but the whole area of Seoul can be roughly divided into the central zone, the mixed urban residential-commercial zone, the suburban residential zone, and the quasi-industrial zone.

The area by the land utilization in Seoul in 1975 is as shown in Table 3-6. The mountainous district accounts for about 32 percent of the total city area of 627.06 sq.km. and the inhabitable district accounts for about 56 percent. The inhabitable district includes the cultivated fields which will be converted to the residential areas in future. The fields are concentrated in such southern districts of the Han as Yeong Deung Po, Gwan Ag, and Gang Nam districts excluding part of the Do Bong district.

The population distribution and its change with time are shown according to the district in Fig. 3-3. The growth of population is slow in each district in the north of the Han, while the population is rapidly growing in the Yeong Deung Po, Gwan Ag, and Gang Nam districts in the south of the Han. However, still about 67% of the total population in Seoul is concentrated in the districts north of the Han which causes various unfavorable effects.

Fig. 3-3 Population Distribution

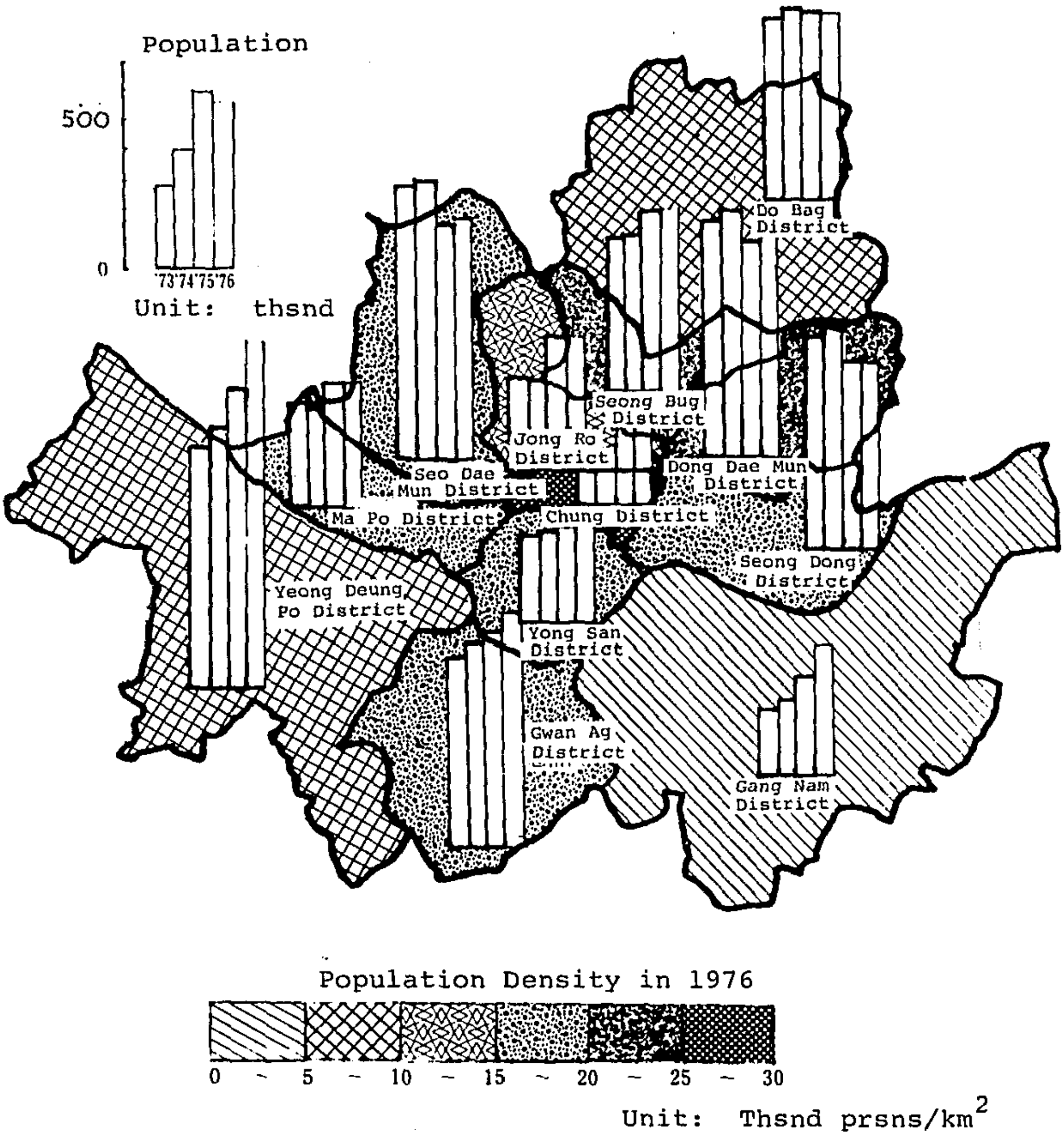


Table 3-6 Land Utilization in Seoul

| Category | Area (sq.km) | Proportion of Total (%) |
|---|---|---|
| Paddy field | 73.25 | 11.7 |
| Other cultivated field | 62.76 | 10.0 |
| Residential area | 148.56 | 23.7 |
| Forest | 199.27 | 31.8 |
| Roads | 27.08 | 4.3 |
| Rivers | 50.93 | 8.1 |
| Heath | 19.73 | 3.1 |
| Others | 45.48 | 7.3 |
| Total | 627.06 | 100.0 |

[Source: Official Bulletin of Seoul, 1976]

The SMG is planning to prevent overcrowding, dispersing the population from these districts as an important policy based on the "General City Development Plan". The concept which formulates this policy is implemented in a plan to develop mainly the southern part of the city with a view to developing Seoul into the three nuclei city. The SMG authorities aims to achieve the balanced development of all parts of the city by attaining equilibrium in population distribution between the northern and southern parts of the city with the Han in between.

The planned zoning of land in Seoul is shown in Fig. 3-4. The classified areas by category are shown in Table 3-8.

In Seoul the industrial zones are not designated in consideration of the necessity of preventing water pollution of the Han and the concentration of industry in the metropolis.

The whole area of Seoul is divided into the following four zones according to the distance from the city center, and the four zones are planned to be developed to perform the subsequent functions.

| | |
|---|---|
| Zone within a radius of 0 to 2 km | Administrative and commercial activities |
| Zone within a radius of 2 to 5 km | Multistory apartment houses and commercial activities |
| Zone within a radius of 5 to 10 km | Housing and subcenter of the city |
| Zone within a radius of 10 to 15 km | Housing and industry |

Table 3-7(1) Population by District (October 1, 1976)

| District \ Item | | Population | Density (per sq.km) | Remarks |
|---|---|---|---|---|
| Northern Part of Seoul City | Chung | 284,684 | 28.266 | Population in 23 wards of Tokyo: 8,428,840 |
| | Seong Bug | 613,619 | 24,712 | Density: 14,546 per sq.km |
| | Dong Dae Mun | 754,483 | 24,089 | |
| | Ma Po | 430,059 | 18,062 | Population by ward: |
| | Yong San | 338,801 | 15,855 | 70,851 -- 769,396 |
| | Seong Dong | 639,915 | 15,842 | |
| | Sae Dae Mun | 811,068 | 16,016 | Density by ward: |
| | Do Bong | 662,761 | 8,090 | 6,150 -- 22,979 per sq.km |
| | Jong Ro | 329,921 | 13,689 | (January 1, 1976) |
| Total | | 4,865,411 | 15,773 | |
| Southern Part of Seoul City | Yeong Deung Po | 1,164,581 | 9,156 | |
| | Gwang Ag | 784,655 | 15,028 | |
| | Gang Nam | 440,311 | 3,163 | |
| Total | | 7,254,958 | 11,570 | |

Table 3-7(2) Northern and Southern Parts of Seoul

| Item \ Division | North of the Han | South of the Han | Total |
|---|---|---|---|
| Area (sq.km) | 308.46 (49%) | 318.6 (51%) | 627.06 (100%) |
| Population (000s) | 4,865 (67%) | 2,390 (33%) | 7,255 (100%) |
| Density (per sq.km) | 15,770 | 7,500 | 11,570 |

Fig. 3-4 Zoning of Land

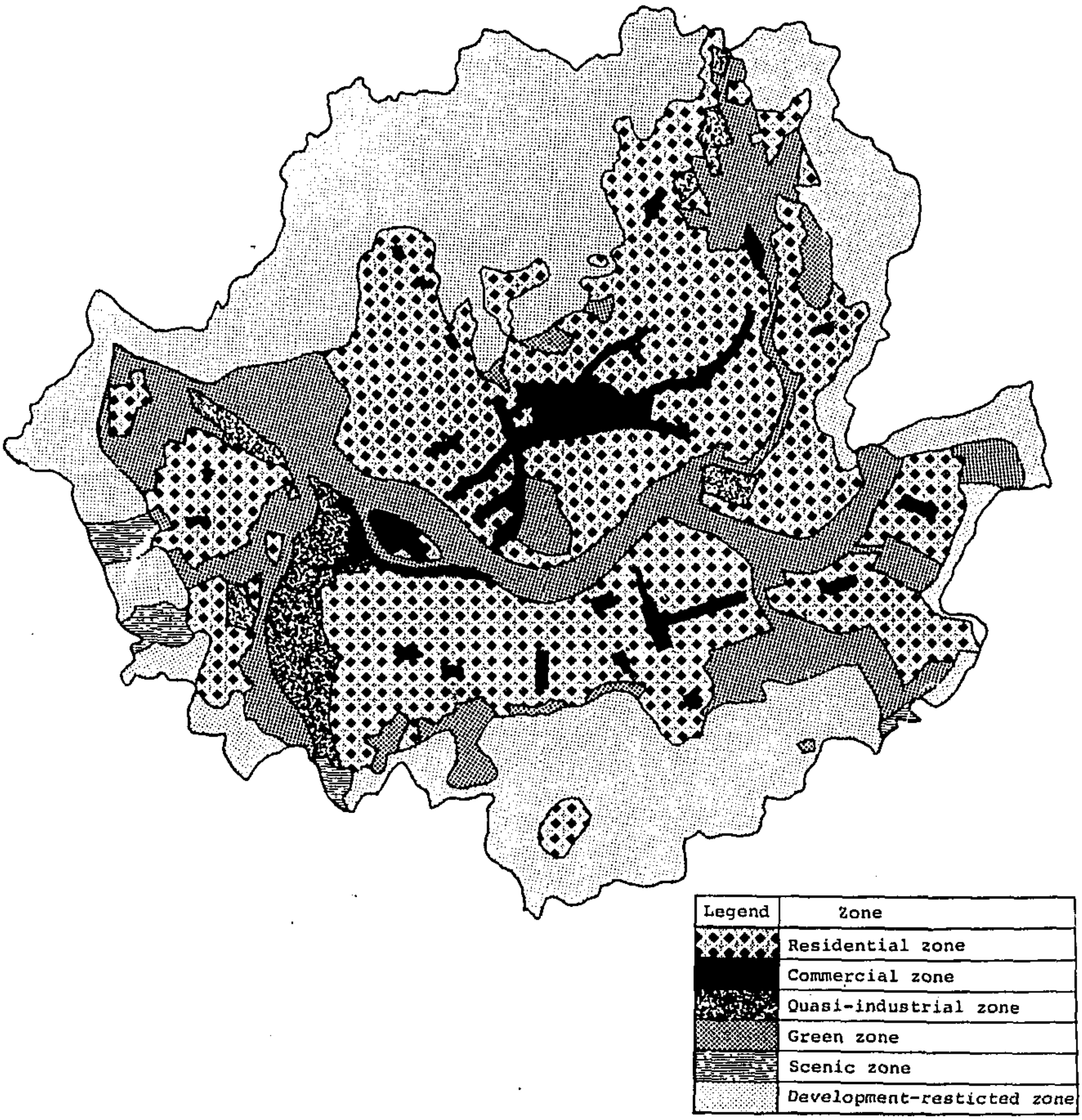


Table 3-8 Classified Areas of Land

| Purpose | Item | Area (sq.km) | Proportion to Total (%) | Remarks |
|---|---|---|---|---|
| Residential district | Residential | 280.637 | 38.9 | Urban area: 627.06 sq.km |
| | Quasi-residential | 1.692 | 0.2 | The scenic and development-restricted zones include the natural green belt. |
| | Exclusively residential | 3.935 | 0.6 | |
| | Total | 286.264 | 39.7 | |
| Commercial district | | 17.361 | 2.4 | |
| Quasi-industrial district | | 32.921 | 4.6 | |
| Green district | Natural green belt | 374.994 | 52.0 | |
| | Productive green belt | 9.336 | 1.3 | |
| | Total | 384.330 | 53.3 | |
| Grand Total | | 720.876 | 100.0 | |

[Source: Official Bulletin of Seoul, 1976)

### 3.2 Passenger Volume Forecast

#### 3.2.1 Method of Forecast

Mention will be made here of (1) data base, (2) target years, (3) estimation method, and (4) zoning all of which form the basis of passenger volume estimation.

##### 3.2.1.1 Data-Base

The person trip surveys taken by the KIST in Seoul in 1970 and in December 1973 provide the most basic data for this study. The survey results are roughly introduced in 2.3. The surveys were designed to collect detailed information on person trips according to 8 purposes of trip, i.e., school attendance, office commutation, homecoming, business, amusement, shopping, travelling and others and 5 modes of transportation, i.e., walking, bus, taxi, private car, and others.

These person trip surveys furnish information useful to the forecast of the future passenger volume of the Line No. 2. The information is expected to bring light to the characteristics of the person trips and of trips in each zone or between zones.

In addition to the above, the following surveys were also conducted to collect information on the traffic condition in Seoul, which also furnish this study with useful information.

- Survey of Traffic Flowing In and Out Central Seoul, Materials from the Tourism and Transportation Bureau
  --- November 16, 1976

- Survey of Bus Traffic by Route, SMG & KIST
  --- 16 to 17 November, 1976

- Survey of Rush hour Passenger Volume on the Line No. 1, SMG
  --- 14 to 20 March, 1977

3.2.1.2 Target Years

This study is conducted in order to determine the feasibility of the Line No. 2 Project. As the Line No. 2 is planned for the construction by stage, the estimation of the future passenger volume on the line is to be made for several target years accordingly.

- 1982 It is expected to open the Line No. 2 between City Hall and Dae Un Dong Jang in this year. It will play an important role in the transportation of a vast spectators for the Asian Athletics to be held in Seoul in 1982.

- 1984 The Line No. 2 between Seo Gyo Dong and Dae Un Dong Jang is expected to be wholly opened.

- 1994 This is the tenth year after the inauguration of the whole-line service. The reason why this year is selected is that ten years of regular service is considered to be an appropriate period of time for determining the effects of the growing population and increasing activities of citizens after along the Line No. 2. It is assumed that the rapid transit network and other conditions remain the same during this period.

3.2.1.3 Method of Estimation

Prior to the passenger volume estimation for the Line No. 2 the total and interzone traffic volumes in the related target years should be estimated. The passenger volume estimation in this study consists of the following steps, for which the detailed survey will be made later on:

1) The future population and land utilization are estimated on the assumption that the characteristics of interzone traffic are closely related to the population and land utilization of each zone.

2) The total future passenger volume in Seoul, total origin and destination passenger volume by zone are estimated on the basis of the estimated future population.

3) The Detroit method is applied to the generated passenger volume by each zone for estimating the interzone passenger distribution and an OD Table for each year will be derived.

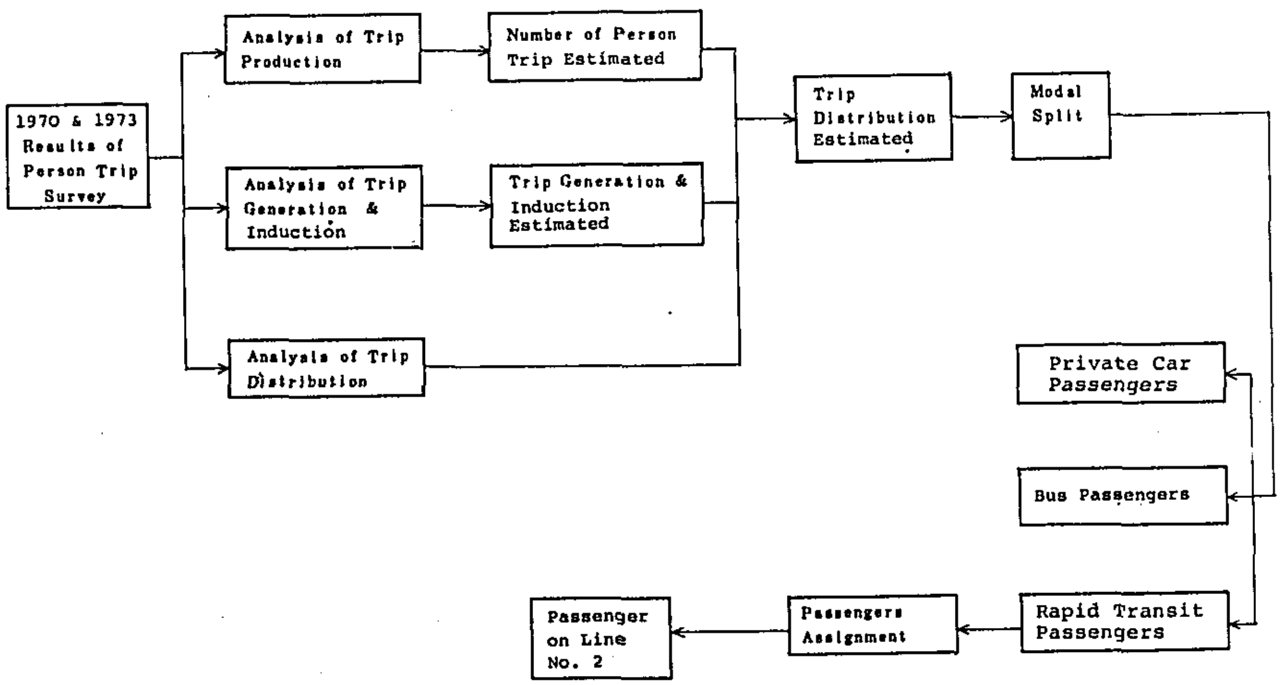
4) The future mode pattern of transportation is estimated, which is applied to the future OD table for determining the interzone mass transit traffic volume for the target years.

5) The modal split curves of the rapid transit and bus are plotted to estimate the passenger volume for the former. In this study the effects of the fare system of each transportation on passengers are taken into account.

6) The rapid transit passenger volume is assigned to each line to estimate the passenger volume on the Line No. 2, passenger volume between stations and passenger volume in each station.

The above steps in the estimation of the passenger volume are summarized by the flow chart in Fig. 3-5.

Fig. 3-5 Flow Chart for Passenger Traffic Volume Estimation



3.2.1.4 Zoning

As in the person trip survey taken in 1973, Seoul is divided into 87 zones. In this Report zones are grouped into 12 blocks.

| Block No. | Original Zone No. |
|---|---|
| 1 | 14, 15, 16, 17, 27, 28 |
| 2 | 76, 77, 78, 79, 80, 81, 82 |
| 3 | 1, 2, 3, 8, 18, 83, 84, 86 |
| 4 | 9, 10, 11, 12, 13, 85 |
| 5 | 19, 20, 21, 22, 23, 25, 26 |
| 6 | 24, 30, 31, 32, 33, 34, 38 |
| 7 | 4, 5, 6, 7, 29, 36, 37 |
| 8 | 39, 45, 46, 47, 56, 58 |
| 9 | 57, 59, 60, 71, 72, 73, 74, 75 |
| 10 | 54, 55, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 87 |
| 11 | 48, 49, 50, 51, 52, 53, 44 |
| 12 | 35, 40, 41, 42, 43 |

3.2.2 Population Estimation

3.2.2.1 Population Estimation in Seoul

The KIST decided the planned population, using the year 1973 as the base. At present the total population in 1976 has already been ascertained which differs considerably from the figures of the KIST. The planned population which was introduced by the KIST as a measure of the trend in population growth in Seoul therefore needs to be reviewed as shown in Fig. 3-8. The KIST gave the planned population of 6,865,000 in 1976, whereas Seoul actually had the population of 7,255,000 in that year. The difference is as wide as 390,000.

## Table 3-9 Zone Area

Unit: $km^2$

| Zone | Area | Remarks | Zone | Area | Remarks |
|---|---|---|---|---|---|
| 1 | 0.657 | | 45 | 1,835 | |
| 2 | 0.911 | | 46 | 5,704 | |
| 3 | 0.741 | | 47 | 9,425 | (5,588) |
| 4 | 1,052 | | 48 | 1,835 | (0.403) |
| 5 | 0.411 | | 49 | 4,575 | (0.790) |
| 6 | 0.781 | | 50 | 6,185 | |
| 7 | 0.771 | | 51 | 12,693 | |
| 8 | 1,417 | | 52 | 7,589 | |
| 9 | 1,534 | | 53 | 18,296 | |
| 10 | 1,634 | | 54 | 4,581 | |
| 11 | 2,489 | | 55 | 15,820 | |
| 12 | 3,880 | | 56 | 1,173 | |
| 13 | 3,017 | | 57 | 1,364 | |
| 14 | 2,782 | | 58 | 2,166 | (0.129) |
| 15 | 2,385 | | 59 | 2,446 | (0.201) |
| 16 | 16,903 | | 60 | 2,556 | (0.159) |
| 17 | 28,778 | | 61 | 4,852 | |
| 18 | 1,424 | | 62 | 1,774 | |
| 19 | 1,223 | | 63 | 2,184 | |
| 20 | 2,176 | Figures in paren- | 64 | 2,857 | |
| 21 | 1,262 | thesis are areas | 65 | 5,143 | (2,256) |
| 22 | 2,105 | of rivers, ponds, | 66 | 6,276 | |
| 23 | 2,575 | etc. | 67 | 10,821 | |
| 24 | 2,075 | | 68 | 12,277 | (0.574) |
| 25 | 2,800 | | 69 | 15,181 | (5,301) |
| 26 | 11,363 | | 70 | 37,526 | |
| 27 | 20,376 | | 71 | 1,162 | |
| 28 | 19,231 | | 72 | 4,114 | |
| 29 | 1,633 | | 73 | 6,414 | (2,155) |
| 30 | 1,132 | | 74 | 6,062 | |
| 31 | 1,715 | | 75 | 13,138 | (3,060) |
| 32 | 1,494 | | 76 | 1,019 | |
| 33 | 8,527 | (3,405) | 77 | 0.891 | |
| 34 | 18,959 | (0.646) | 78 | 3,319 | |
| 35 | 34,494 | (4,094) | 79 | 3,889 | |
| 36 | 2,677 | | 80 | 8,252 | |
| 37 | 3,249 | (0.088) | 81 | 6,788 | |
| 38 | 2,581 | (1,193) | 82 | 12,507 | |
| 39 | 4,080 | (0.502) | 83 | 2,700 | |
| 40 | 26,694 | (5,933) | 84 | 3,422 | |
| 41 | 46,273 | | 85 | 7,386 | |
| 42 | 18,912 | (4,109) | 86 | 10,614 | |
| 43 | 20,513 | | 87 | 8,562 | (5,622) |
| 44 | 36.813 | | Total | 627,059 | (Zone 44 is located) |

Fig. 3-6 Zoning Map

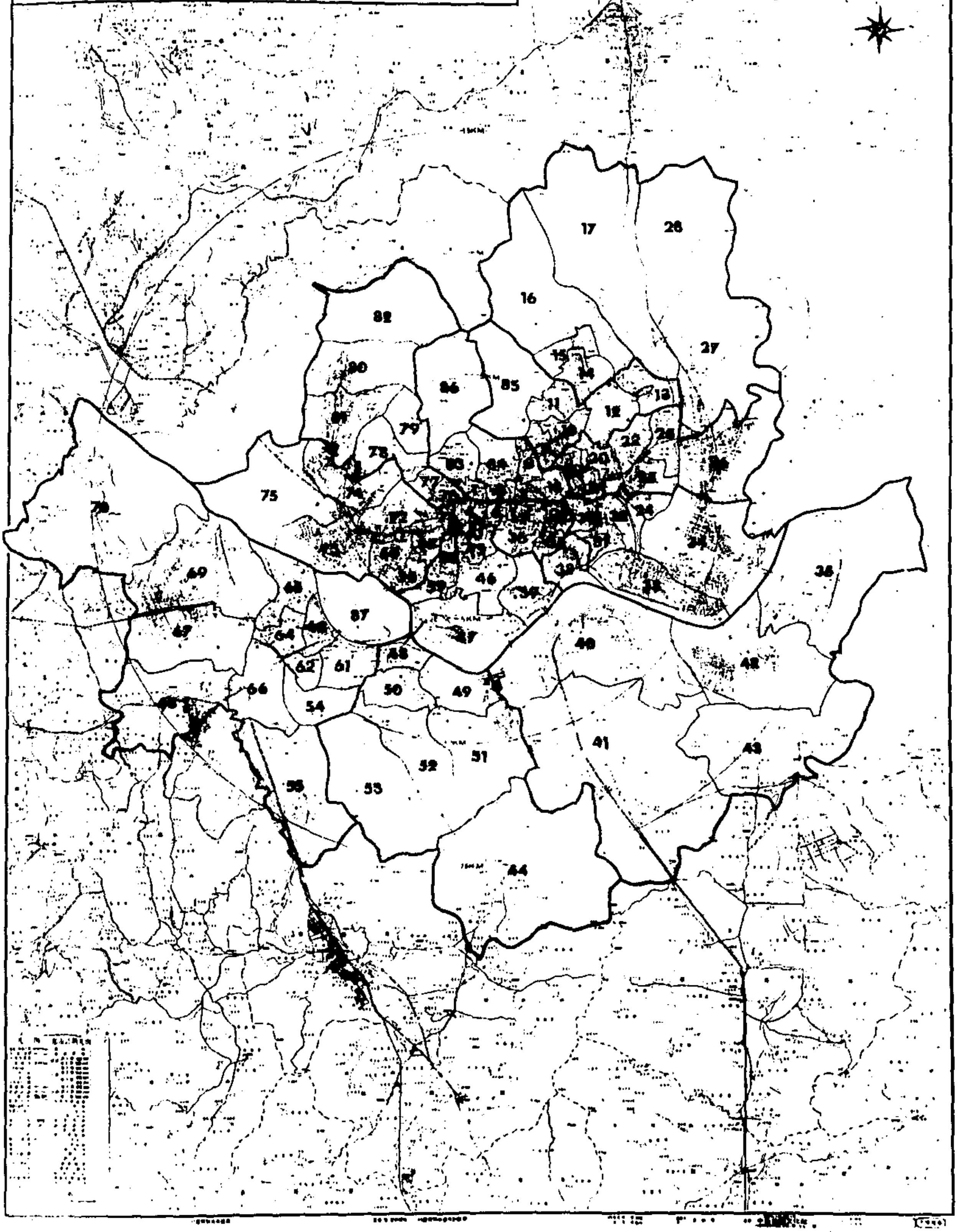


Fig. 3-7 Zoning Map (Block)

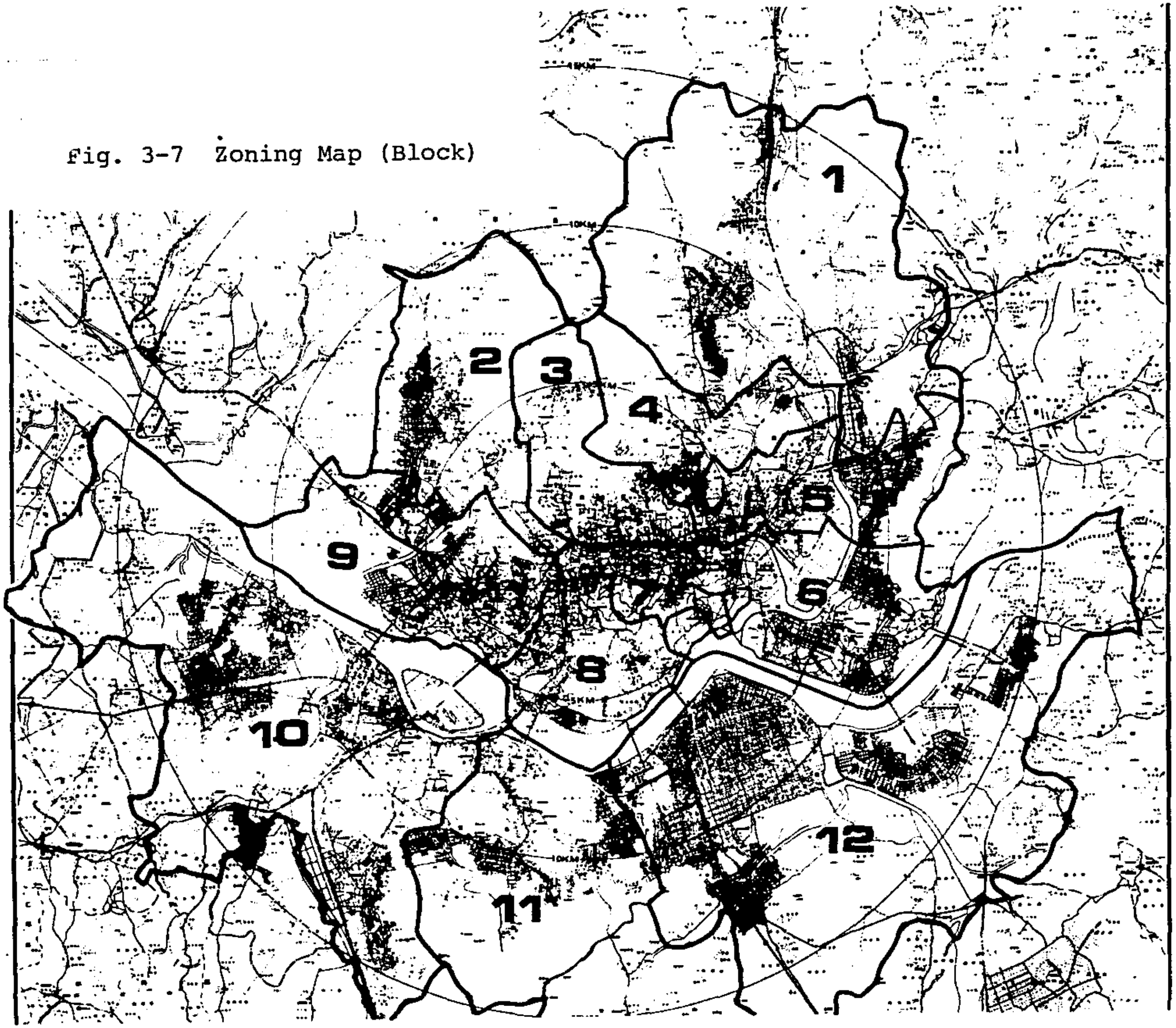


Fig. 3-8 Actual and Estimated Population Growth

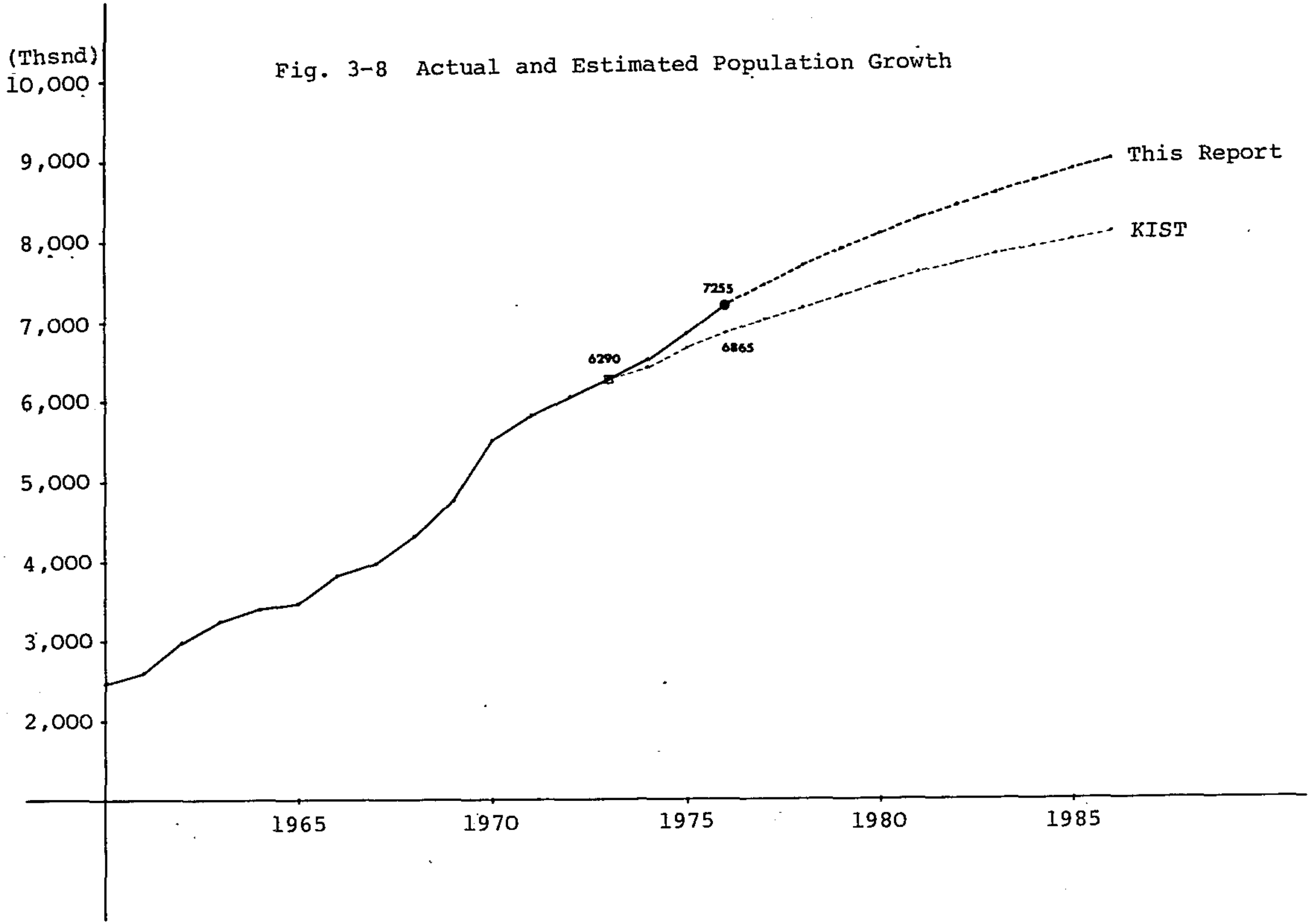
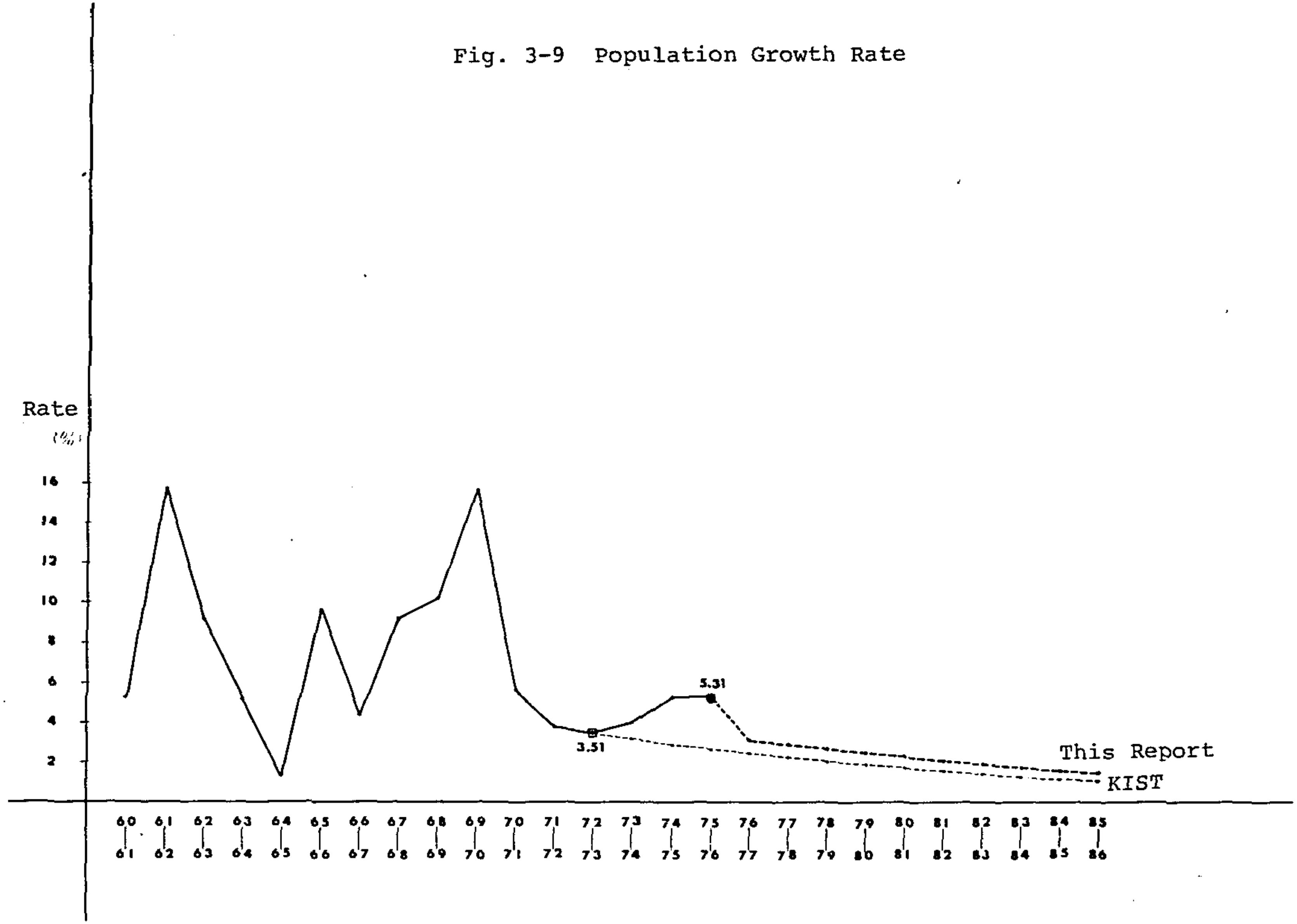


Fig. 3-9 Population Growth Rate



In this study, the future population of Seoul is estimated, starting from the population of 7,255,000 in 1976, applying the planned growth rate of the KIST to the years after 1977 and assuming that the gradual population control measures would be taken, as proposed by the KIST. The results obtained in this way are presented in Table 3-10.

Judging from the remarkable actual growth of population in Seoul, the estimate obtained in this way surely accrue the lower limit that will be attained when the population control measures exhibit their full effects.

3.2.2.2 Future Population Estimation

The population by zone in target years is in general estimated by determining the correlation between the materials which reveals the trend in the past few years and the variables which may affect the change in population and making use of that correlation in a regression model.

In this study the population by zone in the target years is estimated, using the actual population distribution by zone in 1973 and the estimated population distribution by zone in 1980.

In other words, the proportion to the total population in 1973 and 1980 is calculated for each zone and the growth rate of population in each zone is determined. The growth rates of population are adjusted by the administrative factors, and the proportion of the total population was multiplied by the growth rate of population in each zone. The value thus obtained was used in the estimation of the population by zone in the target year.

Table 3-10 Projected Future Population in Seoul

| Year | SMG Plan | | KIST Plan | | This Study | |
|---|---|---|---|---|---|---|
| | Population (000s) | Growth Rate (%) | Population (000s) | Growth Rate (%) | Population (000s) | Growth Rate (%) |
| 1973 | 6,290 | 3.51 | *6,290 | 3.51 | *6,290 | 3.51 |
| 1974 | 6,800 | 8.1 | 6,491 | 3.20 | 6,542 | 4.01 |
| 1975 | 7,000 | 2.9 | 6,683 | 2.96 | *6,889 | 5.30 |
| 1976 | 7,150 | 2.1 | 6,865 | 2.72 | *7,255 | 5.31 |
| 1977 | 7,250 | 1.4 | 7,037 | 2.51 | 7,487 | 3.20 |
| 1978 | 7,330 | 1.1 | 7,199 | 2.30 | 7,709 | 2.97 |
| 1979 | 7,400 | 1.0 | 7,351 | 2.11 | 7,918 | 2.71 |
| 1980 | 7,450 | 0.7 | 7,493 | 1.93 | 8,117 | 2.51 |
| 1981 | 7,500 | 0.7 | 7,625 | 1.76 | 8,304 | 2.30 |
| 1982 | | | 7,747 | 1.60 | 8,479 | 2.11 |
| 1983 | | | 7,859 | 1.45 | 8,643 | 1.93 |
| 1984 | | | 7,962 | 1.31 | 8,795 | 1.76 |
| 1985 | | | 8,057 | 1.19 | 8,936 | 1.60 |
| 1986 | | | 8,144 | 1.08 | 9,065 | 1.45 |

* The figure with asterisk indicate the actual number.

In the population estimate of this type a consistency and a high degree of credibility are required, as the growth rate of population is adjusted by variables. In this study the trend in population in the past few years, trend in 1973-80 and trend in land utilization are taken into consideration. All zones are grouped into five rings, which would represent the trend in population in the years after 1980.

Ring 1 Zones where the population is expected to grow in a steep curve after 1980: 40, 41, 42, 43, 44, 51, 52, 53, 55, 66, 67, 68, 69, 70, 87 (15 zones in all)

Ring 2 Zones where the population is expected to grow in a gentle curve after 1980: 13, 16, 17, 26, 27, 28, 33, 35, 54, 61, 62, 75, 80, 81, 82 (16 zones in all)

Ring 3 Zones where the population is expected to cease to grow after 1980: 10, 11, 12, 14, 15, 22, 23, 24, 25, 30, 31, 32, 37, 38, 39, 46, 47, 48, 49, 50, 59, 60, 63, 64, 65, 72, 73, 74, 78, 79, 83, 84, 85, 86 (34 zones in all)

Ring 4 Zones where the population is expected to cease to grow or decrease slightly after 1980: 8, 9, 18, 19, 20, 21, 29, 36, 56, 57, 58, 71, 76, 77 (14 zones in all)

Ring 5 Zones where the population is expected to decrease after 1980: 1, 2, 3, 4, 5, 6, 7, 45 (8 zones in all)

### 3.2.3 Estimation of Person Trips

The total number of person trips and origin and destination trips by zone in the target years are estimated, using the data furnished by the person trip survey taken by the SMG in 1973. Customarily, person trips are estimated according to the purpose. As far as the person trips in Seoul are concerned at present, the trips made for office attendance, school attendance and homecoming account for 90 percent or more of the total person trips. In this study, therefore, all purposes of person trips instead of by each purpose are taken into account.

The total number of person trips in the target years is estimated according to the flow chart shown in Fig. 3-13.

Table 3-11 Population of Seoul as classified by Zone and by Year

| Zone | 1973 | 1982 | 1984 | Zone | 1973 | 1982 | 1984 |
|---|---|---|---|---|---|---|---|
| 1 | 18,708 | 19,522 | 18,920 | 45 | 50,975 | 61,120 | 61,602 |
| 2 | 20,156 | 20,711 | 19,976 | 46 | 66,327 | 74,550 | 73,844 |
| 3 | 18,971 | 19,044 | 18,233 | 47 | 72,887 | 72,582 | 69,306 |
| 4 | 10,830 | 12,723 | 12,755 | 48 | 71,365 | 81,341 | 80,884 |
| 5 | 10,560 | 11,437 | 11,209 | 49 | 68,912 | 73,276 | 71,424 |
| 6 | 20,086 | 20,682 | 19,961 | 50 | 87,587 | 103,351 | 103,733 |
| 7 | 20,967 | 21,048 | 20,151 | 51 | 88,880 | 138,522 | 147,919 |
| 8 | 39,452 | 39,304 | 37,535 | 52 | 148,180 | 219,541 | 232,155 |
| 9 | 65,233 | 64,703 | 61,701 | 53 | 104,641 | 165,623 | 177,366 |
| 10 | 74,229 | 84,881 | 84,479 | 54 | 54,868 | 100,308 | 110,070 |
| 11 | 92,455 | 94,223 | 90,643 | 55 | 102,446 | 141,230 | 147,125 |
| 12 | 139,573 | 165,478 | 166,297 | 56 | 54,472 | 58,465 | 57,146 |
| 13 | 96,777 | 108,935 | 107,948 | 57 | 78,473 | 121,279 | 129,301 |
| 14 | 80,541 | 125,662 | 134,213 | 58 | 61,415 | 68,397 | 67,575 |
| 15 | 101,148 | 153,018 | 162,473 | 59 | 101,699 | 112,743 | 111,242 |
| 16 | 122,138 | 149,421 | 151,373 | 60 | 78,356 | 95,989 | 97,276 |
| 17 | 116,977 | 144,339 | 146,538 | 61 | 109,416 | 94,821 | 86,117 |
| 18 | 99,136 | 118,134 | 118,875 | 62 | 65,671 | 72,516 | 71,470 |
| 19 | 59,489 | 62,900 | 61,206 | 63 | 49,192 | 52,160 | 50,799 |
| 20 | 63,946 | 63,580 | 60,679 | 64 | 54,097 | 58,896 | 57,810 |
| 21 | 38,837 | 63,702 | 68,657 | 65 | 64,615 | 70,902 | 69,754 |
| 22 | 53,277 | 57,381 | 56,145 | 66 | 111,583 | 189,643 | 205,655 |
| 23 | 85,313 | 101,231 | 101,754 | 67 | 60,940 | 80,527 | 83,101 |
| 24 | 128,130 | 175,981 | 183,178 | 68 | 74,520 | 153,682 | 171,613 |
| 25 | 104,649 | 122,188 | 122,298 | 69 | 82,168 | 148,645 | 162,843 |
| 26 | 161,253 | 139,276 | 126,322 | 70 | 61,576 | 95,467 | 101,843 |
| 27 | 70,056 | 87,841 | 89,532 | 71 | 61,129 | 67,104 | 66,024 |
| 28 | 109,763 | 197,104 | 215,680 | 72 | 76,423 | 87,554 | 87,185 |
| 29 | 75,897 | 72,073 | 67,723 | 73 | 90,793 | 104,685 | 104,425 |
| 30 | 94,836 | 98,148 | 94,878 | 74 | 161,884 | 202,935 | 206,831 |
| 31 | 84,781 | 109,815 | 112,802 | 75 | 62,275 | 88,126 | 92,318 |
| 32 | 48,154 | 61,707 | 63,225 | 76 | 46,766 | 51,151 | 50,275 |
| 33 | 93,783 | 100,645 | 98,372 | 77 | 60,637 | 70,422 | 70,384 |
| 34 | 124,933 | 118,298 | 111,045 | 78 | 70,840 | 82,884 | 83,003 |
| 35 | 108,005 | 162,327 | 172,138 | 79 | 89,206 | 102,851 | 102,594 |
| 36 | 26,312 | 30,903 | 30,979 | 80 | 104,783 | 131,636 | 134,233 |
| 37 | 120,856 | 140,670 | 140,678 | 81 | 123,906 | 137,829 | 136,126 |
| 38 | 91,609 | 104,437 | 103,856 | 82 | 35,122 | 47,481 | 49,251 |
| 39 | 64,455 | 79,054 | 80,138 | 83 | 34,864 | 37,982 | 37,289 |
| 40 | 26,719 | 308,139 | 382,325 | 84 | 47,612 | 54,438 | 54,179 |
| 41 | 26,835 | 299,970 | 371,932 | 85 | 69,583 | 82,948 | 83,477 |
| 42 | 25,911 | 152,834 | 185,684 | 86 | 24,938 | 26,222 | 25,473 |
| 43 | 43,184 | 93,099 | 104,572 | 87 | 7,205 | 20,607 | 23,880 |
| 44 | 0 | 0 | 0 | Total | 6,272,147 | 8,479,000 | 8,795,000 |

Fig. 3-10 Population Density in Seoul (1973)

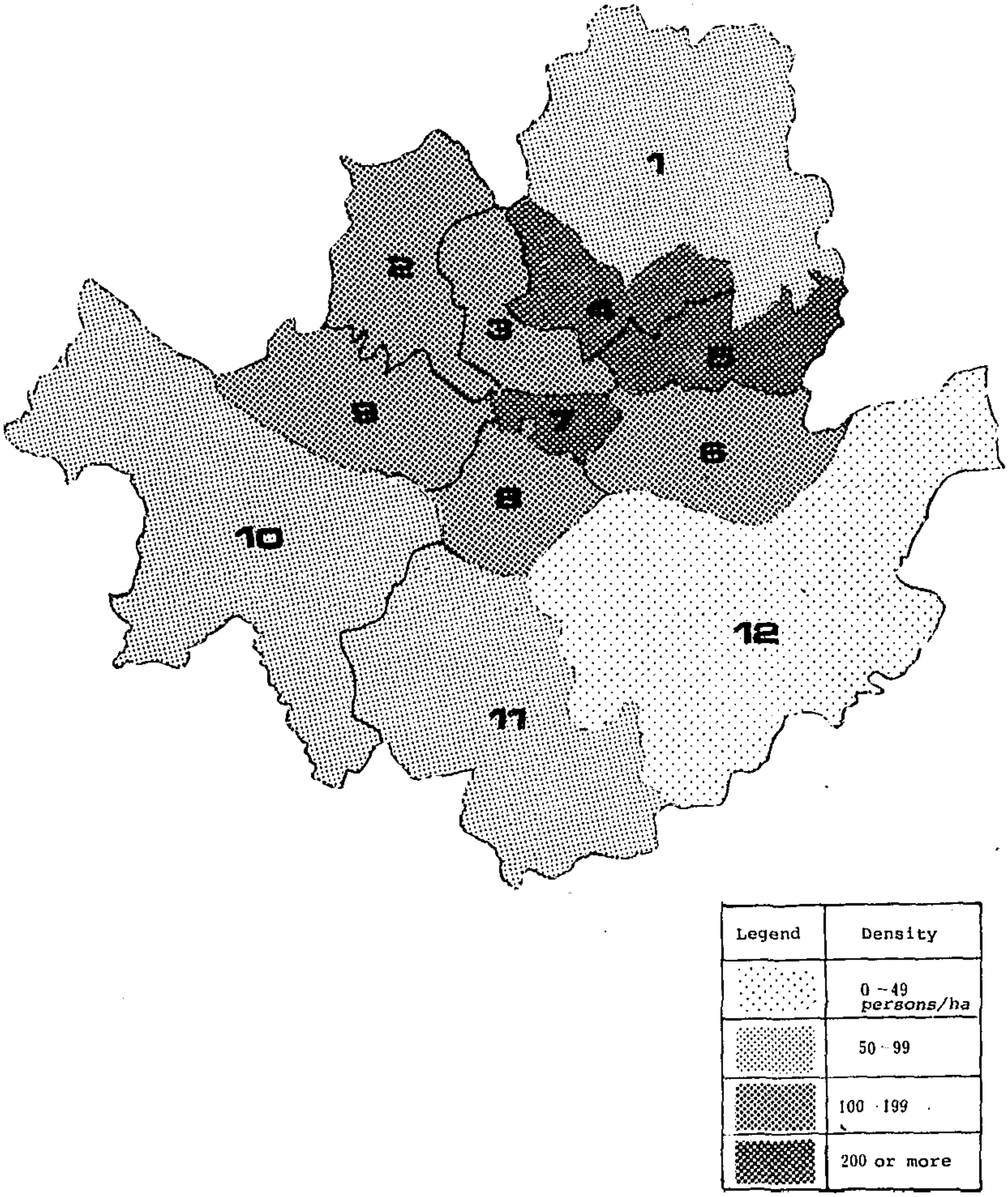


Fig. 3-11  Population Density in Seoul (1984)

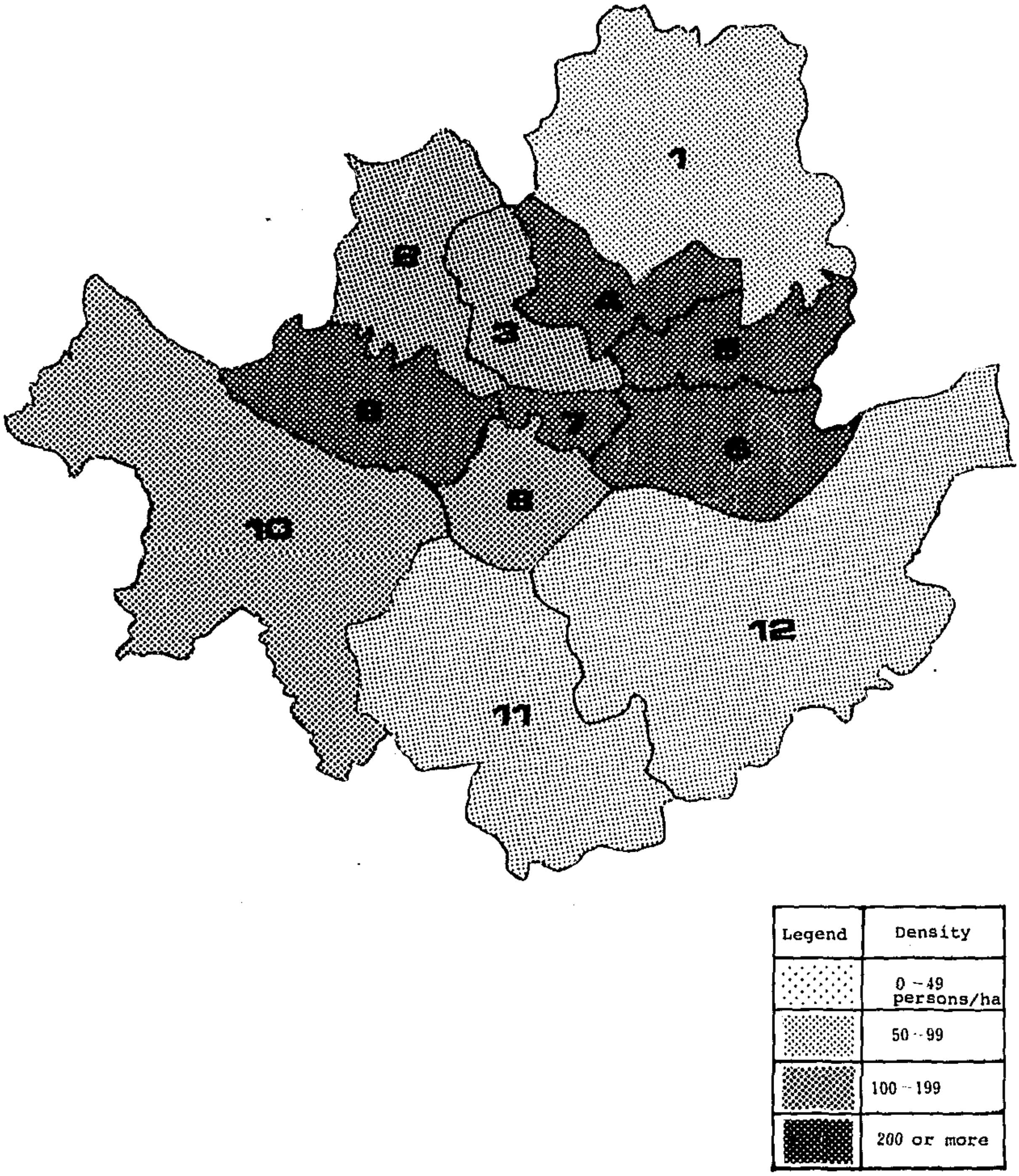


Fig. 3-12 Population Density in Seoul (1994)

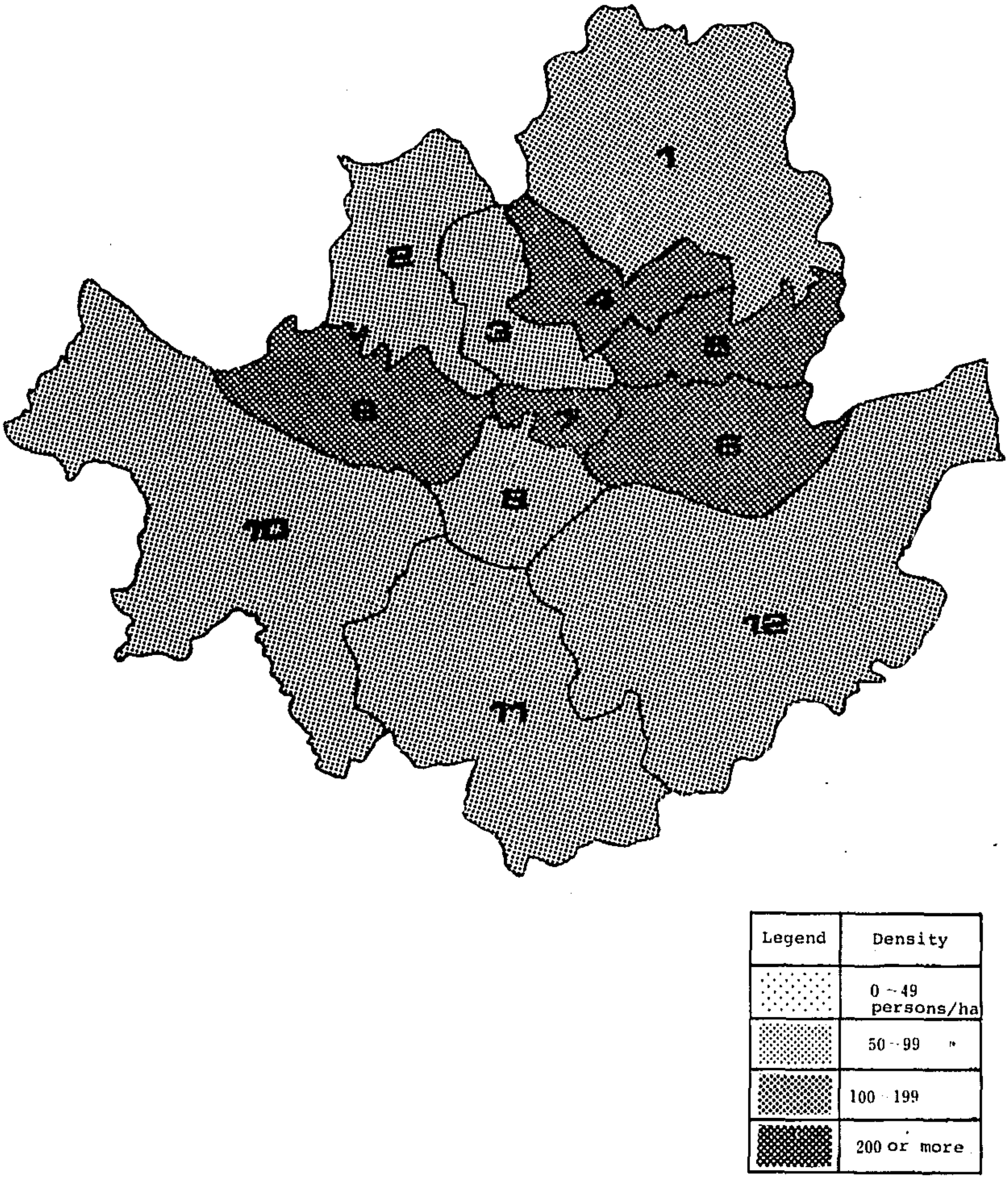
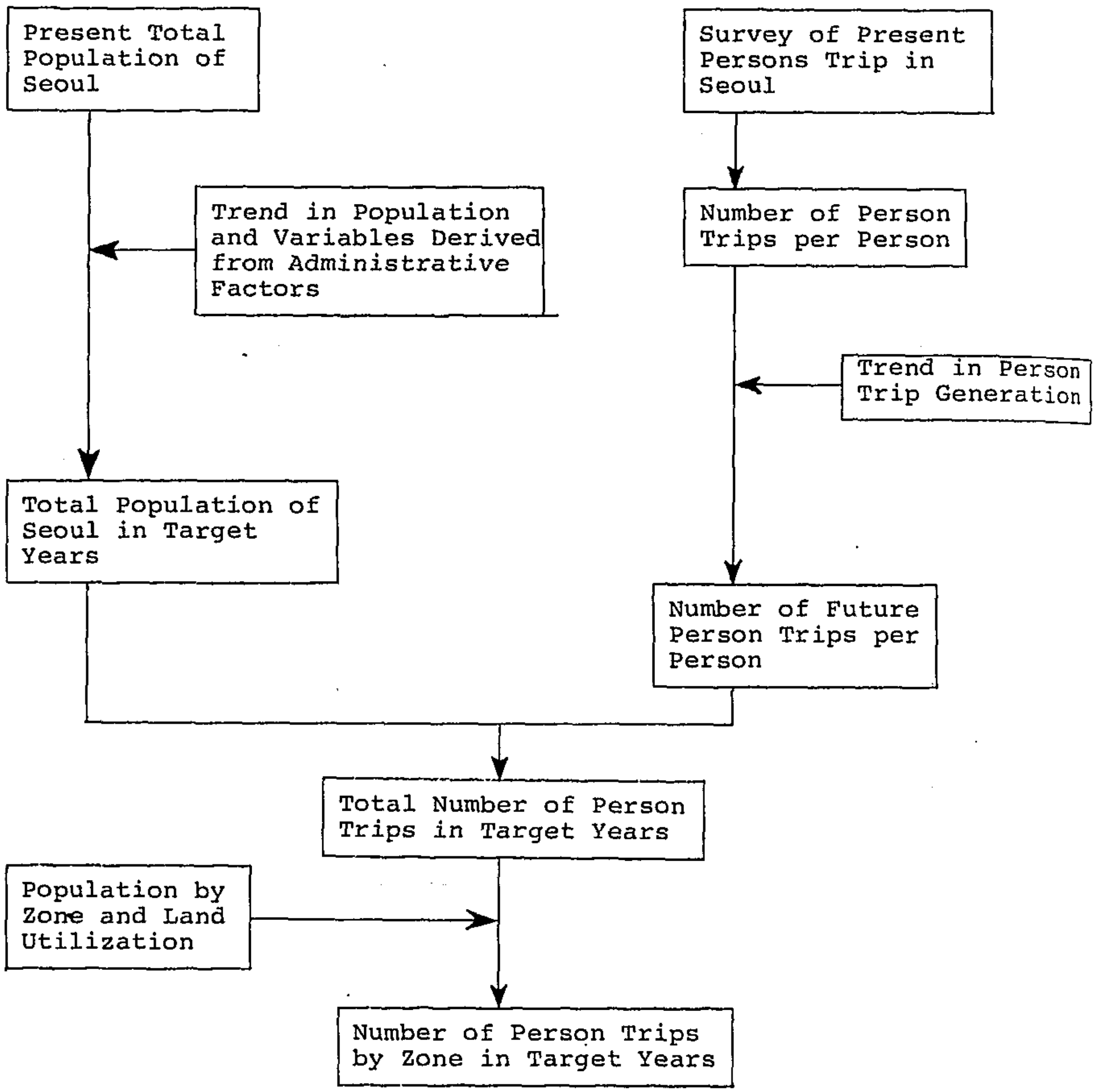


Fig. 3-13 Flow Chart for Person Trip Estimation



3.2.3.1 General

The future traffic volume is assumed in general practice by estimating the total traffic volume and that by zone as well as checking one against the other.

In the estimation of the volume of traffic that originates in a given area the correlation between traffic volume and the characteristics of the area, such as population, land utilization, employment and social and economic factors, are to be determined so as to obtain accurate statistical data of arrivals, departures and purposes of trips.

The method of estimation of the origin and destination trips by zone are discussed later and mention is made as to the method of estimation of the total traffic volume in the city.

The first step in the estimation of the total future traffic volume consists in dividing its future population into groups according to the social and economic factors, e.g., occupation and income. The rate of change, i.e., increase or decrease in traffic generation in each group is estimated, and the population of each group is multiplied by the estimated rate of change. Similarly, the data of a city and a foreign city which bear relatively close resemblance to each other is used in the estimation of the average traffic volume per person, which is multiplied by the population of the city. In another way the future traffic volume of a city may be estimated by analyzing the trend in the traffic of the city in the past years. In this study the total traffic volumes in the target years are estimated by making use of the OD surveys taken by the SMG in 1970 and 1973 and the total traffic volume in Seoul in 1980 which has already been estimated.

3.2.3.2 Estimation of Total Future Traffic

The average traffic volume per person in 1973 is 1.52 trips, and the corresponding figure for 1970 is 1.36 trips. The rate of traffic growth can therefore be placed at about 0.16 trip. When the average annual growth rate of traffic is determined from this trend, the average traffic volume per person in the target year and the total future traffic volume can be estimated as shown in Table 3-12.

Considering the geographic conditions of Seoul and the fact that the trips traversing the city border account for less than 1 percent, the city will be considered one closed area and the traversing trips will be left out.

When 20 and 30 years ahead are envisaged the population of Seoul would continue to grow, gradually though. Accordingly, the total number of person trips in Seoul will increase by 1.5 to 2.0 times in the years ahead.

Table 3-12 Future Person Trip Generation

| Year | Population (thsnd) | Trip Generation per Person | Growth Rate | Total Trips | Growth Rate |
|---|---|---|---|---|---|
| 1973 | 6,290 | 1.522 | -- | 9,578,022 | - |
| 1981 | 8,304 | 1.574 | 1.32 | 13,070,496 | 1.36 |
| 1982 | 8,479 | 1.588 | 1.35 | 13,464,652 | 1.41 |
| 1983 | 8,643 | 1.603 | 1.37 | 13,854,729 | 1.45 |
| 1984 | 8,795 | 1.617 | 1.40 | 14,221,515 | 1.48 |
| 1985 | 8,936 | 1.631 | 1.42 | 14,574,616 | 1.52 |
| 1986 | 9,065 | 1.645 | 1.44 | 14,911,925 | 1.56 |

3.2.3.3 Estimation of Future Origin and Destination Trips

The future origin and destination trips by zone are estimated in the same way as in the case of the population by zone. In other words, the growth rate of traffic of each zone determined from the actual traffic in 1973 and the estimated traffic in 1980 is used in the estimation of the future origin and destination trips. The growth rate of traffic of each zone is adjusted by the administrative factors converted to the variable quantities.

The origin and destination trips by zone in the target years estimated in this way are presented in Table 3-13.

3.2.4 Estimation of Traffic Distribution

3.2.4.1 Selection of Appropriate Model of Estimation

The table which shows interzone traffic is called an OD (Origin-Destination) table. It is indispensable to the planning and administration of a public traffic system. The OD traffic is estimated from the future origin and destination trips.

Many methods of estimation have already been developed, i.e., growth factor methods, gravity model method, opportunity model method, and multiple linear regression model method. Of these, the growth factor method consists in the calculation of the approximate future OD traffic volume (X'ij) from the growth rate of traffic determined from the OD table, containing known values and making $\sum_{i=1}^{n} X'_{ij}$ and $\sum_{j=1}^{n} X'_{ij}$ coverage to Xi and Yj, respectively. The required growth rate of traffic is that of the whole area or is obtainable by combining those of the relevant zones. This method is relatively easy to understand and has been developed the earliest among all methods.

Of the various variants on the growth factor method, the Detroit method is the most practical to use. As this method allows the use of the numbers of the origin and destination

Table 3-13 Yearly Origin and Destination Trips

| Zone | 1973 | 1982 | 1984 | Zone | 1973 | 1982 | 1984 |
|---|---|---|---|---|---|---|---|
| 1 | 284,989 | 342,574 | 322,407 | 45 | 288,760 | 486,083 | 506,089 |
| 2 | 238,675 | 305,175 | 293,594 | 46 | 377,853 | 487,651 | 470,654 |
| 3 | 242,346 | 306,958 | 294,357 | 47 | 155,778 | 254,567 | 263,131 |
| 4 | 313,627 | 478,597 | 485,965 | 48 | 149,343 | 235,640 | 241,409 |
| 5 | 162,634 | 218,275 | 213,393 | 49 | 116,277 | 171,277 | 172,217 |
| 6 | 368,586 | 463,205 | 442,996 | 50 | 155,825 | 228,965 | 230,062 |
| 7 | 306,506 | 364,664 | 341,895 | 51 | 114,009 | 283,502 | 318,049 |
| 8 | 124,689 | 222,518 | 234,830 | 52 | 243,688 | 474,284 | 509,810 |
| 9 | 214,088 | 257,815 | 242,805 | 53 | 158,748 | 347,767 | 382,199 |
| 10 | 180,434 | 294,016 | 303,691 | 54 | 85,628 | 219,157 | 246,915 |
| 11 | 200,262 | 240,869 | 226,744 | 55 | 184,036 | 391,309 | 427,776 |
| 12 | 224,642 | 350,800 | 358,411 | 56 | 125,770 | 276,478 | 304,033 |
| 13 | 154,367 | 268,696 | 281,968 | 57 | 176,102 | 292,098 | 303,039 |
| 14 | 207,253 | 334,196 | 344,289 | 58 | 145,083 | 255,427 | 268,742 |
| 15 | 175,126 | 355,639 | 385,475 | 59 | 171,622 | 289,158 | 301,127 |
| 16 | 282,440 | 529,430 | 564,708 | 60 | 136,386 | 234,794 | 245,758 |
| 17 | 251,492 | 517,032 | 561,716 | 61 | 223,761 | 331,417 | 333,757 |
| 18 | 319,339 | 533,933 | 555,003 | 62 | 74,065 | 181,918 | 203,699 |
| 19 | 214,581 | 357,579 | 371,389 | 63 | 345,114 | 345,487 | 329,283 |
| 20 | 91.256 | 165,872 | 175,763 | 64 | 111,100 | 223,181 | 241,399 |
| 21 | 94,909 | 180,243 | 192,775 | 65 | 187,444 | 257,343 | 253,401 |
| 22 | 210,668 | 263,146 | 251,128 | 66 | 213,482 | 441,555 | 480,259 |
| 23 | 168,497 | 276,490 | 286,084 | 67 | 131,187 | 319,067 | 356,738 |
| 24 | 187,618 | 370,674 | 399,633 | 68 | 158,763 | 298,151 | 318,144 |
| 25 | 224,559 | 321,369 | 320,448 | 69 | 111,398 | 335,198 | 385,878 |
| 26 | 279,860 | 495,149 | 521,539 | 70 | 147,258 | 244,239 | 253,380 |
| 27 | 118,992 | 274,606 | 304,465 | 71 | 128,834 | 293,546 | 324,775 |
| 28 | 179,116 | 409,337 | 453,117 | 72 | 288,745 | 592,580 | 643,576 |
| 29 | 136,086 | 313,852 | 347,945 | 73 | 183,269 | 306,525 | 318,650 |
| 30 | 172,744 | 313,553 | 332,144 | 74 | 237,188 | 461,389 | 495,902 |
| 31 | 231,858 | 327,495 | 325,287 | 75 | 77,671 | 204,520 | 231,364 |
| 32 | 113,008 | 163,770 | 163,902 | 76 | 193,424 | 281,846 | 282,514 |
| 33 | 211,454 | 359,818 | 375,594 | 77 | 75,932 | 165,580 | 181,828 |
| 34 | 248,455 | 430,819 | 451,696 | 78 | 125,365 | 214,502 | 224,197 |
| 35 | 207,874 | 452,215 | 496,380 | 79 | 141,541 | 240,194 | 250,563 |
| 36 | 166,921 | 292,165 | 306,980 | 80 | 209,219 | 364,175 | 382,163 |
| 37 | 314,300 | 458,852 | 460,197 | 81 | 191,909 | 365,819 | 391,563 |
| 38 | 131,383 | 248,338 | 265,349 | 82 | 45,353 | 144,067 | 166,913 |
| 39 | 123,819 | 228,324 | 242,692 | 83 | 109,324 | 173,974 | 178,620 |
| 40 | 43,179 | 537,873 | 676,206 | 84 | 145,907 | 253,556 | 265,972 |
| 41 | 57,802 | 388,836 | 477,657 | 85 | 110,941 | 187,908 | 195,932 |
| 42 | 48,378 | 282,048 | 343,762 | 86 | 45,060 | 94,739 | 103,358 |
| 43 | 56,675 | 282,891 | 341,365 | 87 | 16,754 | 94,989 | 115,579 |
| 44 | 626 | 3,976 | 4,869 | Total | 15,101,020 | 26,929,304 | 28,443,030 |

Fig. 3-14 Trip Generation Density (1973)

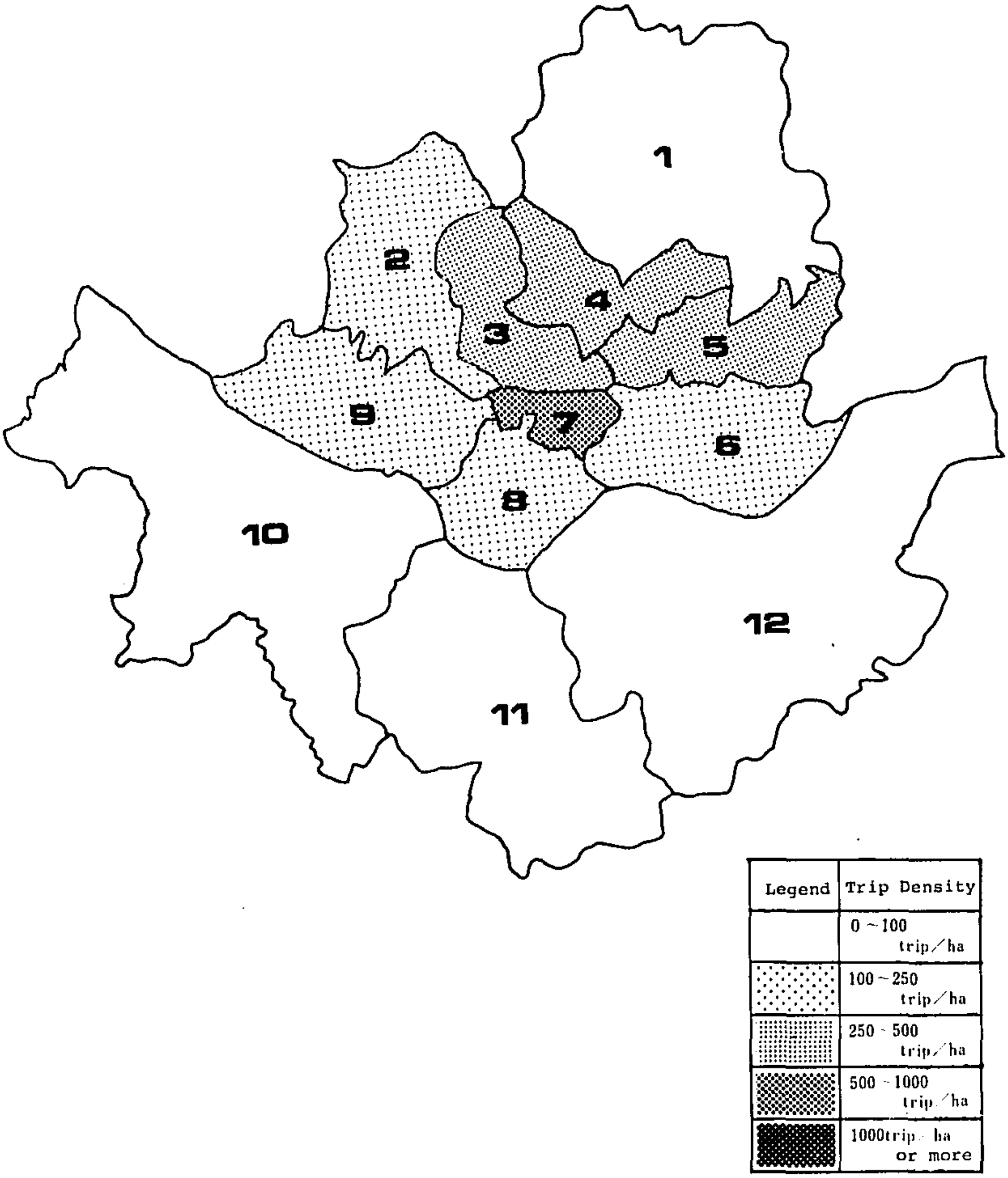


Fig. 3-15 Trip Generation Density (1982)

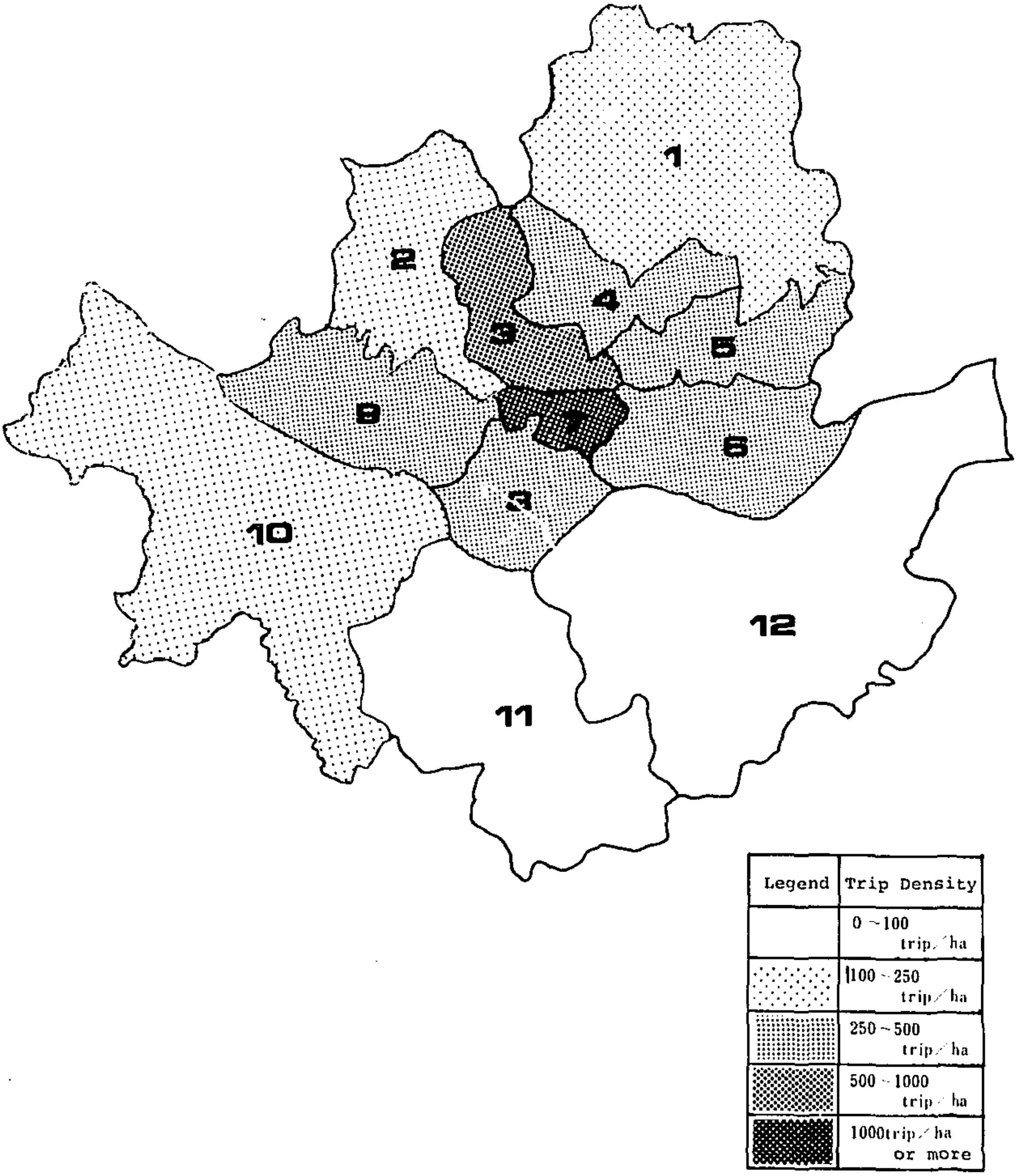


Fig. 3-16 Trip Generation Density (1984)

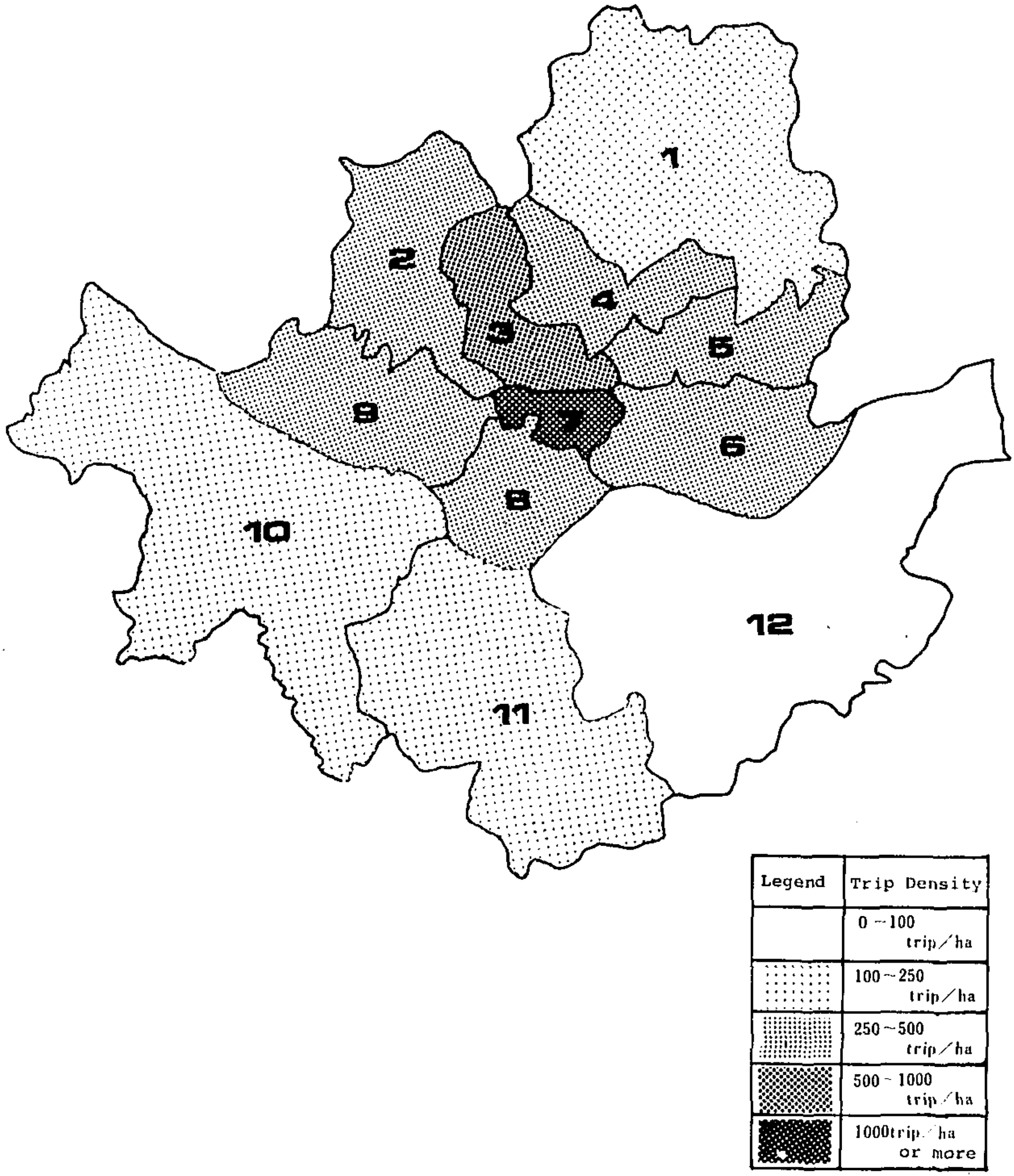
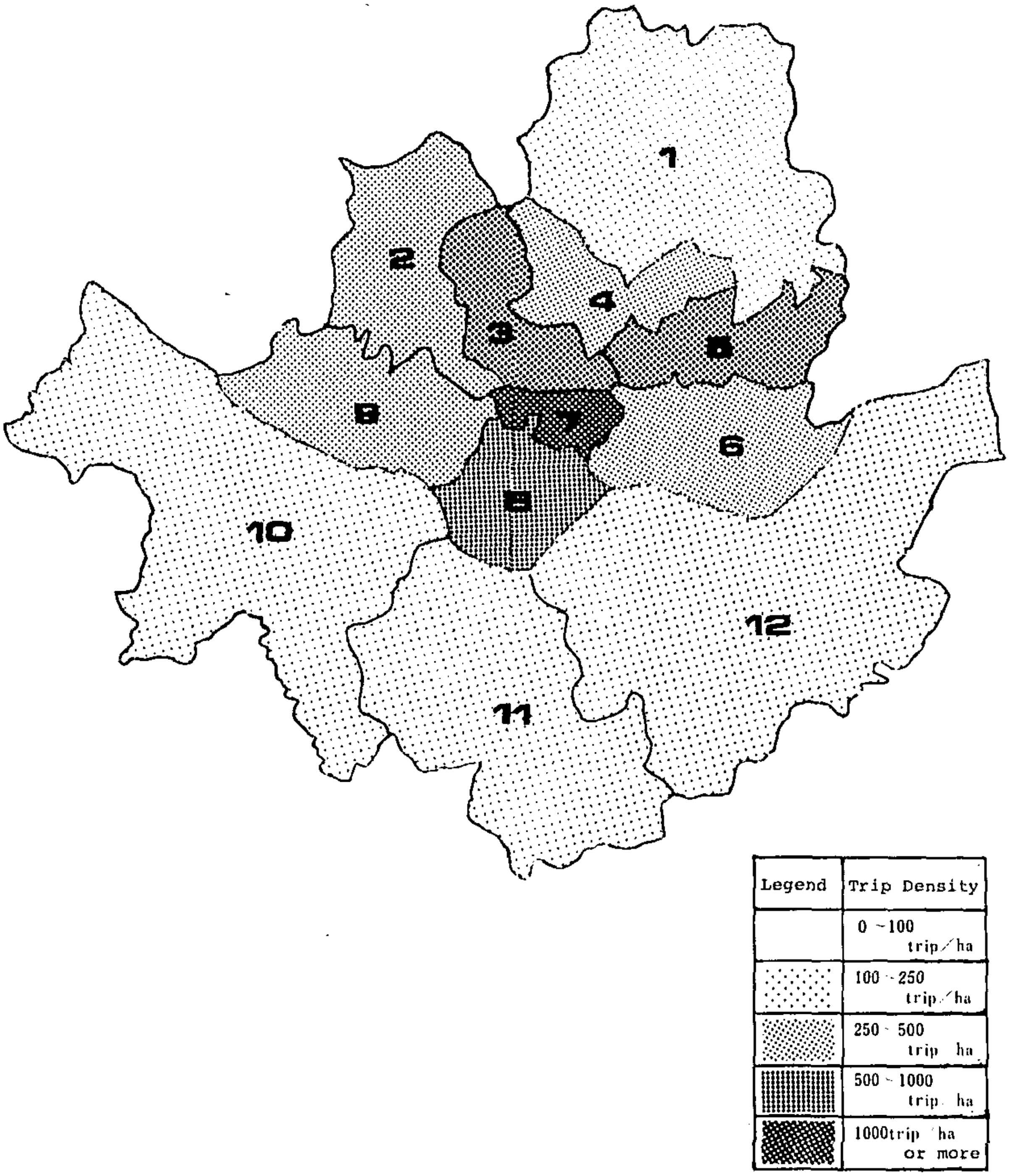


Fig. 3-17  Trip Generation Density (1994)



trips instead of trip generation and induction, it is adopted in this study.

3.4.2.2 Traffic Estimation by Detroit Method

The Detroit model was developed in the Detroit Metropolitan Area Traffic Study and its basis and assumptions are as follows:

The traffic volume from Zone i to Zone j increases in proportion to traffic growth rate Fi of Zone i and also changes in proportion to the ratio of trip induction growth rate Gj of Zone j to trip induction growth rate G (= X/T) of the whole area.

$$X'ij = Tij \times Fi \times (Gj/G)$$

$$(i,j = 1, 2, \ldots\ldots., n)$$

The first approximate value is obtained by the above equation and the approximating operation is repeated until Fi and Gj becomes 1.00.

(Present OD Table)

Tij : OD trips originating in Zone i and terminating in Zone j

Ti : Origin trips in Zone i, $Ti = \sum_{j=1}^{n} Tij$

Uj : Destination trips in Zone j, $Uj = \sum_{i=1}^{n} Tij$

T : Total trips, $T = \sum_{i=1}^{n} Ti = \sum_{j=1}^{n} Uj$

n : Number of zones

(Future OD Table)

Xij : Future OD trips originating in Zone i and terminating in Zone j

$Xi$ : Future origin trips in Zone i, $Xi = \sum_{j=1}^{n} Xij$

$Yj$ : Future destination trips in Zone j, $Yj = \sum_{i=1}^{n} Xij$

$X$ : Total future trips, $X = \sum_{i=1}^{n} Xi = \sum_{j=1}^{n} Yj$

$G$ : Growth rate of total OD trips

$G = X/T$

$Fi$ : Growth rate of origin trips in Zone i

$Fi = Xi/Ti$
$(i = 1, 2, \ldots\ldots n)$

$Gj$ : Growth rate of destination trips in Zone j

$Gj : Yj/Uj$
$(j = 1, 2, \ldots\ldots\ldots n)$

Origin trips $\sum_{j=1}^{n} X'ij = Xi'$ and destination trips $\sum_{i=1}^{n} X'ij = Y'j$ of each zone that are computed by the first approximation commonly do not coincide with future origin trips Xi and future destination trips Yj. The differences can be eliminated by the following repetitive calculation.

$$F'i = Xi/X'i \qquad (i = 1, 2, \ldots\ldots n)$$

$$G'j = Yj/Y'j \qquad (j = 1, 2, \ldots\ldots n)$$

$$G = X/X'$$

And the second approximates of Xij are calculated by the next equation.

$$Xji'' = Xi'j \times F'i \times (G'j/G')$$

This calculation is repeated until the necessary level of accuracy is achieved.

Correction coefficients Fi and Gj serve as a measure of the progress of corrective calculation, but it is impossible for all Fi's and Gj's to equal exactly 1.0. An attempt to make them equal 1.0 is wasteful of time and money. In this study, therefore, the calculation has been repeated until the difference between the corrective value of each zone and its estimated value has become smaller than 1.0.

The OD trip in the target years, 1982, 1984 and 1994 is estimated by the method described above. The inter-block lines desired are shown in Figs. 3-18 through -20.

## 3.3 Planning of Urban Transit System

### 3.3.1 Necessity of New Mass Transit System

The most important factor that induces traffic in Seoul city is the growth of population. The population has been growing at a rate that is well beyond the improving capacity of the transport systems in Seoul. The insufficiency of transport means is clear in the city, especially during the morning and evening rush hours.

The growth of the city, especially furthered by specialization of its functions, population growth and expansion of social activities sequentially involves an increase in traffic. The increase in income resulting from economic growth induces people to wish for a more comfortable environment and diversity of the way of life in a limited time. The SMG is expected to provide a more comfortable transport means in order to fill the needs of the citizens, and to this end the traffic problems are to be solved beforehand.

As mentioned in the preceding chapter, the SMG is confronted with the following traffic problems.

First, traffic has been increasing in a sharp curve in Seoul since 1968. As the activities of citizens diversify and increase, the number of means-trips is expected to increase to about 13,460,000 in 1982 and as many as 14,220,000 trips

Fig. 3-18 Inter-Block Lines Desired by All Citizens (1982)

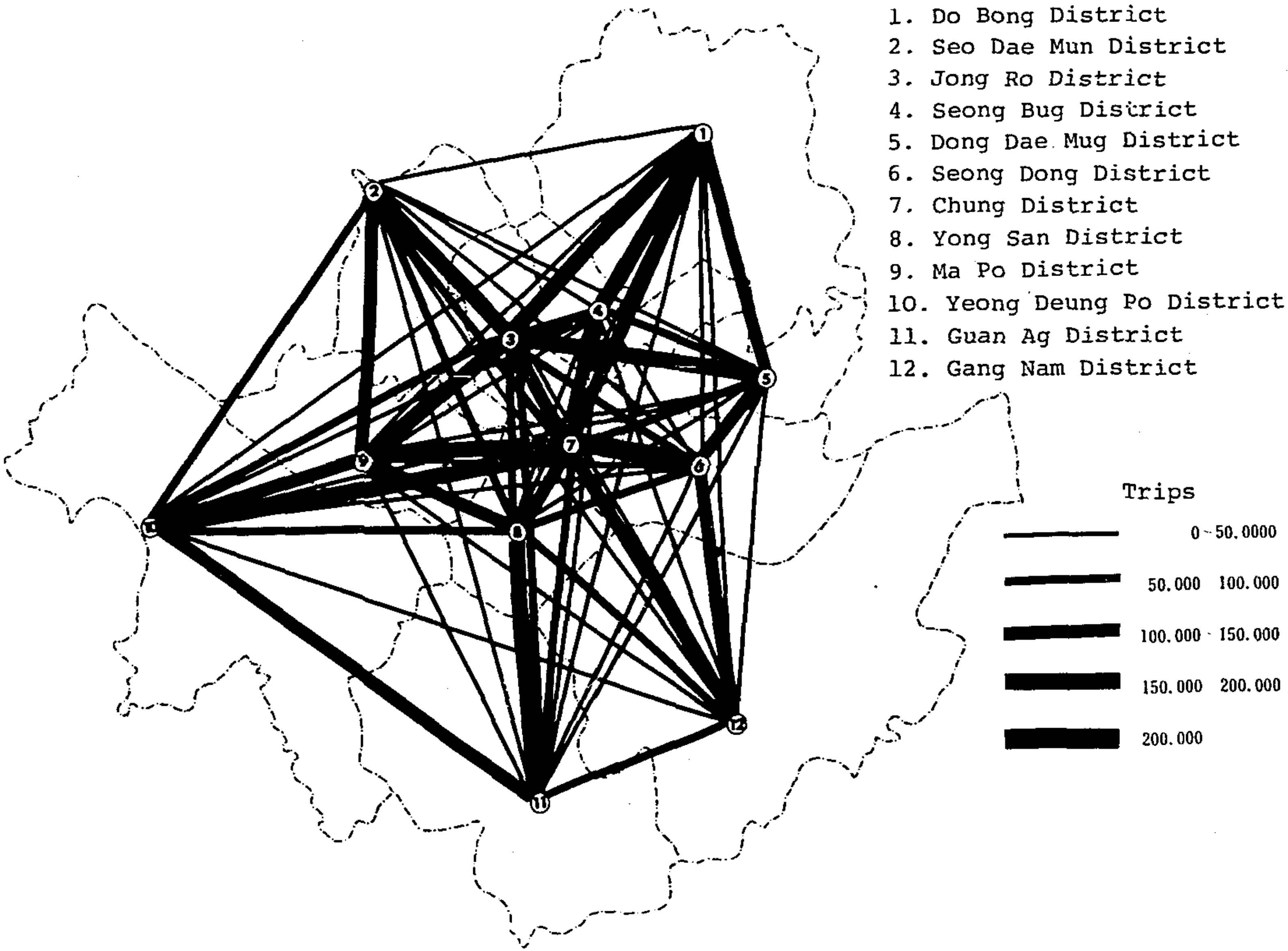
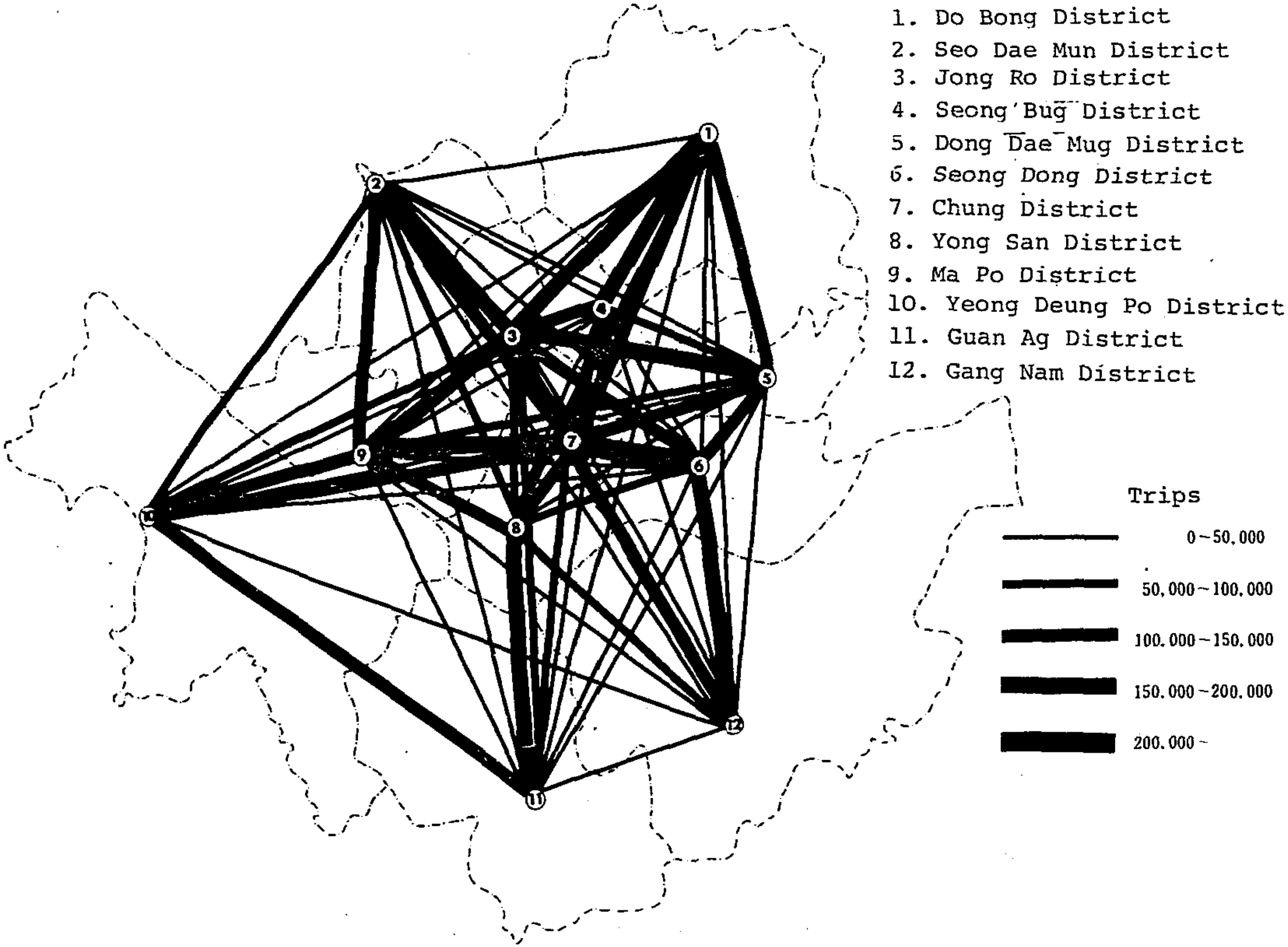
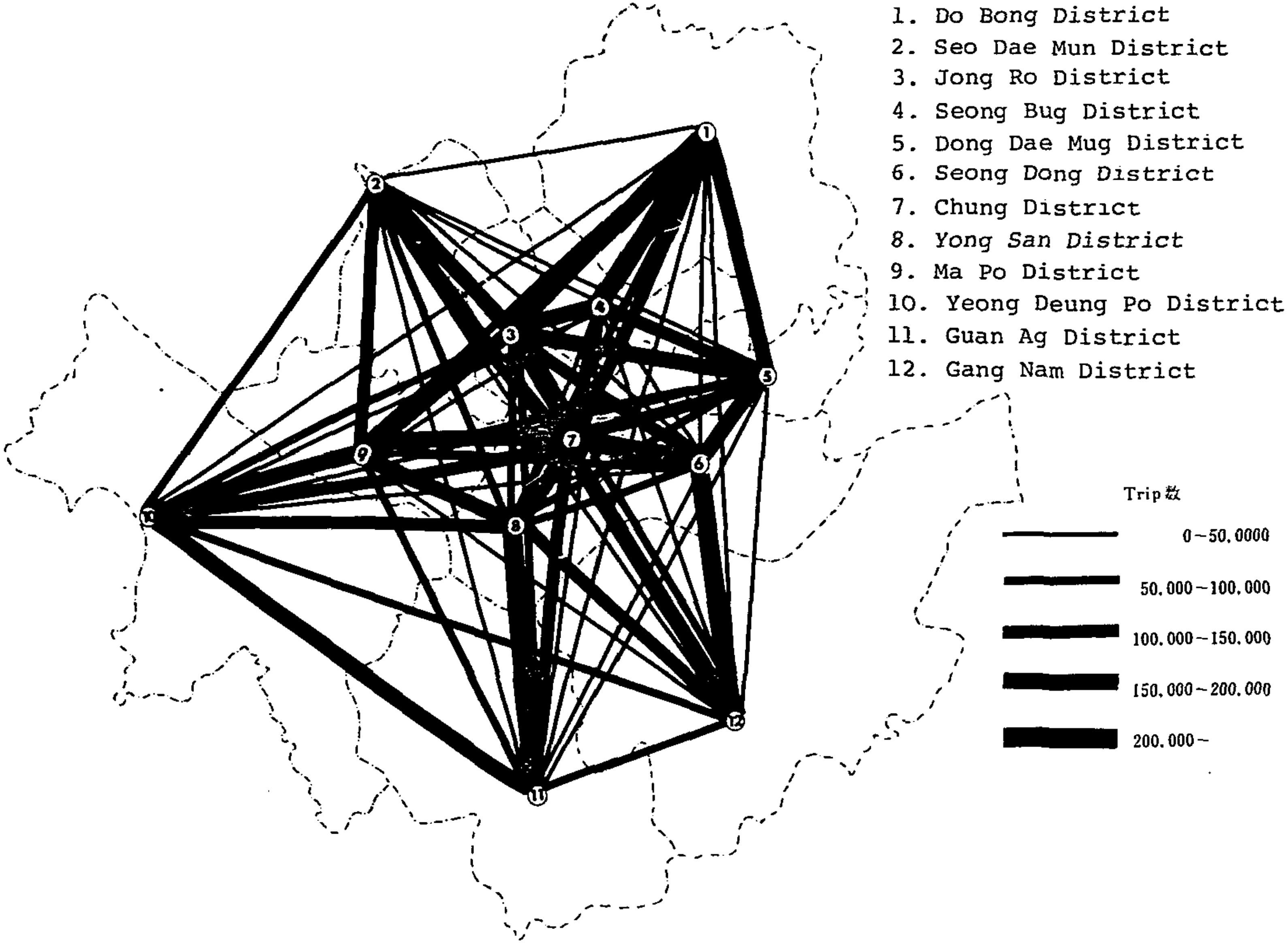


Fig. 3-19 Inter-Block Lines Desired by All Citizens (1984)




1. Do Bong District
2. Seo Dae Mun District
3. Jong Ro District
4. Seong Bug District
5. Dong Dae Mug District
6. Seong Dong District
7. Chung District
8. Yong San District
9. Ma Po District
10. Yeong Deung Po District
11. Guan Ag District
12. Gang Nam District

Fig. 3-20 Inter-Block Lines Desired by All Citizens (1994)



in 1984. These figures are 1.41 and 1.48 times the level of 9,580,000 trips in 1973. Such enormous passenger traffic needs cannot be met unless a new mass transit system is added, as traffic congestion is already quite heavy.

Second, although Seoul is a big city, it has only one busy area at its center without any subcenters. As a result, traffic to and from central Seoul is extremely congested and public road transport is obviously in short supply. Furthermore, the 14 radial trunk roads leading to central Seoul can no more be widened, and no new radial road can be built. Extreme road traffic congestion not only reduces the efficiency of transport but impairs the functions of the city.

Third, great traffic congestion in the peak hours common in all big cities is particularly prevalent in Seoul. As a matter of fact, as much as 36.5 percent of the total daily traffic occurs in the morning two hours, and about 18.9 percent in the evening peak hours. It is desirable that a mass transit system will be provided for such an enormous traffic volume in rush hours.

Fourth, as city redevelopment proceeds, the center of Seoul will acquire increasing importance, while a new residential district development is planned over a radius of 15 km of the city in order to provide a comfortable living environment for the citizens. As a result, citizens will have to commute between home and business or school for a greater distance than before. To cope with such a new situation the need for a rapid transit system is the greater to ensure the safety and comfort of passengers.

For these reasons, Seoul is necessitated to have a new system of public transportation. And this new transport is to be planned to help solve, as early as possible and effectively, the traffic problems with which Seoul is now confronted.

### 3.3.2 Study of New Public Transportation System

The urban public transportation system is divisible into transport service for the citizens' trip from one place to the other for various purposes and that for essential supplies for sustaining the urban life.

The principal mode of transportation on which the citizens of Seoul have thus far relied has been road transport. Since the opening of the Line No. 1, road traffic congestion has been alleviated to some extent.

#### 3.3.2.1 Considerations for Selection of Optimum Transportation System

It is necessary to take into account such factors as speed, capacity, accessibility, riding comfort, fare, land occupancy, inter-mode connection, safety, and inevitable pollution in order to make an appropriate choice among public transportation systems.

Other things being equal, an expeditious transit system may attract greater traffic demand. However, speed is not the only factor that affects on the traffic volume. It is also closely related to the fare. Taxis are much faster than buses, but are not in so much demand as buses, because of the high fare.

Even a public transportation system that carries passengers at a desired speed for a reasonable fare does not fulfil the purpose, if its capacity is too small. That is why buses which satisfy the three conditions, speed, fare and comfort, can no more play a principal role in urban public transportation, when the passenger volume exceeds a certain limit.

Accessibility is also an important factor that affects the selection of a public transportation system. By accessibility is meant here the degree of distance traveled afoot to reach the means of transportation. As the bus and subway serve the stations along the fixed routes, their passengers must usually walk a considerable distance to reach the station from the origin and to the destination. The accessibility of the bus and subway is lower than that of taxis and private cars.

Riding quality is a sensational and subjective factor. In the selection of the optimum public transportation system, the riding quality is to be taken into consideration, as passengers prefer greater comfort in selecting public as well as private transport means. As the rapid transit is preferred to the buses by reason of riding quality, much improvement has been worked out to increase the riding comfort of the railcars in many countries.

Land occupancy is another important factor from the standpoint of land utilization. Public road transport occupies a greater surface area than the railways. One of the reasons why private cars cannot play a major role in urban transportation in most countries is an extremely high degree of land occupancy.

#### 3.3.2.2 Traffic Network Planning

The efficiency of inter-mode connection needs a careful study in traffic network planning. The taxis and private cars have the higher ability of inter-mode connection, as they can provide door-to-door service, while the buses and subways can not provide any transport service between the stations, and the origins and destinations.

Another important traffic problem which plagues the public transit system operators is traffic accident. The automobiles are controlled by the drivers independently of one another and the road network, whereas the railway systems are mechanically and electrically controlled. As a matter of fact, there are reports on the railway systems that mention greater safety of both passengers and pedestrians against accidents than any road transport modes.

Urban air pollution by transport modes has direct relations with the health of citizens. The air in the streets located near the trunk roads are polluted by carbon monoxide gas exhausted by automobiles. When air pollution is taken into account, the expansion of the road transport is not necessarily desirable. When air and noise pollution is considered, the subway is unrivaled as an urban public transport.

Three principal transports are compared with one another concerning the factors described in Table 3-14. When viewed in the light of the increasing traffic, the limit of road capacity, and mass transportation in the rush hours, three factors, among others, are considered to be particularly important: transport capacity, land occupany and fare. When the future air and noise pollution by traffic and the safety of urban transit systems are also considered, a new public traffic network in which the rapid railway system plays a major role in public transportation seems indispensable to the balanced growth of the whole areas of Seoul.

### 3.3.3 Transit Railway System in Major Cities

It is the monorail that has recently been developed as a mass transit system. It was developed as a version on the conventional electric railway operating electric cars on an elevated track. As the terminology has an insinuation of a modern sense, the monorail has been referred to far and wide as a new mass transit system. The monorails are operated on a commercial basis in few cities. One is in Tokyo which covers a route length of 13.2 km connecting the urban center with the airport. Another is in Seattle which covers a route length of 2 km. Some other monorails are also operated in other cities for special purpose, e.g., in some leisure lands.

The Tokyo Monorail serves with only five stations including two terminals and is inferior in accessibility and line capacity to underground and surface railway systems. The monorail is advantageous in shuttling service between two points, but does not effectively function when trains stop at many stations. Furthermore, it is technically difficult to

Table 3-14 Comparison among Major Transport Modes

| Factor \ Mode | Bus | Railway | Private car |
|---|---|---|---|
| Speed | Slower than at present | Faster than at present | Slower than at present |
| Capacity | Less efficient than at present | Increased greatly | Less efficient than at present |
| Accessibility | Good | Limited to neighboring areas | Excellent |
| Comfort | Least | Medium | Superior |
| Land occupancy | Medium | Very low | Very high |
| Fare | Low | Low | High |
| Efficiency of inter-mode connection | Lower | Lowest | Superior |
| Safety | Lower | Superior | Medium |
| Inevitable Pollution | Inferior | Good | Inferior |
| Energy Efficiency | Good | Highest | Inferior |

Remarks: Relative appraisals have been worked out among three modes.

branch off from the main line. Although it has the advantages of low construction costs and a shorter construction period over the underground and surface railways, it poses problems as a mass transit system.

The rapid electric railway system has been adopted as an urban mass transit system in 44 cities in 22 countries including Seoul. It was in 1863 that an underground railway was opened with steam operation in London, and in the early 20th century many cities have come to possess subways. With the advent of automobiles, however, subway construction has slowed down to some extent since then.

In the 1960's not only the existing subways were expanded but new lines were built in 27 cities. General information on the mass transit systems of the major cities is given in Table 3-15.

### 3.3.4 Transition of Rapid Transit Network Plan

A plan for the urban transit system in Seoul has long been under discussion, but it was not until 1961 when traffic congestion became serious that the Planning Section of the Railway Bureau undertook a systematic study for subway construction with the view of finding a radical solution to the traffic problem. However, this plan was abandoned, as the study revealed that the construction of a subway would involve an enormous capital investment.

Later the "Plan of Development of a Wide Economic Area of Seoul" was mapped out, which proposed the construction of four subway lines with a total route length of 66.3 km. On the basis of this plan, the rapid transit railway network has been taken up as a basic urban traffic plan of Seoul in 1966. To formulate this plan the new bureau for the rapid transit construction was established.

Table 3-15 Rapid Transit Railways of the World

| City & Country / Item | Tokyo | | Osaka | London | N.Y. (NYCTA) | N.Y. (PATH) | Paris (Urban Subway) | Paris (Subway Railway) | Moscow |
|---|---|---|---|---|---|---|---|---|---|
| | Japan | | | U.K. | U.S.A. | | France | | U.S.S.R. |
| Name of Enterprise | Teito Rapid Transit Authority | Bureau of Transportation of the Tokyo Metropolitan Government | Bureau of Transportation of the Osaka Prefectural Government | London Transport Executive | New York City Transit Authority | Port Authority Trans-Hudson Corporation | Regie Autonome des Transports Parisiens | do. | Moskovski Metropoliten Imeni V.L. Lenina |
| Established | 1941 | - | - | 1970 | 1953 | 1962 | 1948 | | - |
| Population (000s) | 8,590 | | 2,750 | 7,300 | 8,000 | 16,200 | 2,300 | 7,400 | 7,400 |
| Inauguration of service | 1927 | 1960 | 1933 | 1863 | 1868 | 1908 | 1900 | 1938 | 1935 |
| Operating Kilometerage | | | | | | | | | |
| Underground section | 102.4 | 35.7 | 59.8 | 156.8 | 220.5 | 12.7 | 168.8 | 14.3 | 146.5 |
| Other sections | 21.5 | 3.6 | 10.4 | 224.3 | 150.6 | 9.7 | 12.4 | 60.6 | 18.0 |
| Total | 123.9 | 39.3 | 70.2 | 381.1 | 371.1 | 22.4 | 181.2 | 74.9 | 164.5 |
| Number of lines | 6 | 2 | 6 | 8 | - | 1 | 16 | 3 | 7 |
| Number of stations | 115 | 42 | 57 | 248 | 461 | 13 | 350 | 51 | 103 |
| Scheduled speed (km/h) | 24.9--44.9 | 30.9--31.5 | 29.0--33.5 | 32.5 | 48 | 34.4 | 22 | 40.4 | 41.4 |
| Fare Structure | Section System ¥80 1 section ¥100 2 sections | Section System ¥80 1 section ¥100 2 sections | Section System ¥80 1 section ¥90 2 sections | Zone and Distance Proportional System *Inner Zone* 10P 1 mile 15P 15 " 20P 23 " 100P 25 mile, or more *Outer Zone* 10P 1.2 mile 15P 2 " 20P 3 " 100P 27 mile, or more | Flat Rate System $0.50 | Flat Rate System $0.30 | Flat Rate System 1st Class Fr.2.50 2nd Class Fr.1.60 | Section System 1st Class Fr.1.50-- 7.20 2nd Class Fr. 1 -- 4.80 | Flat Rate System 0.05 Rubl |
| Performance | | | | | | | | | |
| Passengers carried (million persons) | 1,462 | 287 | 759 | 601 | 1,077.6 | 38.3 | 1,055.4 | 130.4 | 1,966.4 |
| Car-kilometer (in million km) | 152.0 | 34.5 | 57.2 | 333 | 484.5 | 17.1 | 218 | 33.4 | 350 |
| Number of cars | 1,497 | 308 | 660 | 4,646 | 6,685 | 298 | 3,509 | 469 | 2,269 |
| Average accommodation capacity | 128 | 154 | 132 | 162--289 | 200--350 | 140--170 | 142--355 | 262--290 | 164--170 |
| Gauge (m) | 1.067; 1.435 | 1.067; 1.435 | 1.435 | 1.435 | 1.435 | 1.435 | 1.435 | 1.435 | 1.524 |
| Voltage (V) | DC 600; 1,500 | DC 1,500 | DC 750; 1,500 | DC 600 | DC 625 | DC 650 | DC 750 | DC 1,500 | DC 825 |
| Power feeding | Third rail and overhead contact line | Overhead contact line | Third rail and overhead contact line | Third rail and fourth rail | Third rail | Third rail | Third rail | Overhead contact line | Third rail |
| Train formation in the peak hours | 10--5 | 6 | 8--4 | 8 | 10 | 7 | — | 9 | 7 |
| Train intervals in the peak hours (min.sec) | 1.50--5.00 | 2.30--4.00 | 2.15--5.00 | 1.30--2.00 | 4.00 | 1.30--6.00 | 1.35--3.50 | 1.00--5.00 | 1.20 |
| Number of employees | 10,375 | 4,955 | 6,320 | 21,000 | - | 1,046 | 14,472 | | 17,000 |

In 1971 the basic urban traffic plan evolved into the metropolitan rapid transit railway construction plan, and the previous plans were revised or adjusted according to this metropolitan rapid transit railway construction plan, and in April of that year the construction of the Line No. 1 started. This line was opened in August 1974. In December 1971 a route survey was completed for the Lines 2, 3, 4 and 5 in part that passed within a radius of 5 km of the city center.

At the outset, the rapid transit construction plan, envisaged that the construction of Line No. 2 would be completed in 1976, starting in 1974. Later the revision of the plan became unavoidable so that the plans to build Lines No. 2 and No. 3 were revised in 1974. As a result of the revision of the basic urban traffic plan, the revision of plans to build lines 2, 3, 4 and 5 became inevitable. Later a plan to build a loop line was made public with the plan of development of the three nuclei city.

The transit system planning of Seoul may be summarized in chronological order as follows:

1962: Planning of a subway in Seoul by the Railway Bureau

1965: Planning of the rapid transit railway system by the SMG

1966: Application for loans to finance the construction of a rapid transit line

1970: Establishment of a special bureau for rapid transit construction

Publication of a plan to build the metropolitan rapid transit railway system

Route survey and soil exploration for the construction of the Line No. 1

Proposition of 5 transit railway networks by OTCA, headed by Dr. R. Kakumoto

1971: Construction of a metropolitan railway started

Electrification of KNR commutation lines in and around Seoul

Construction of the Line No. 1 started

1974: The Line No. 1 opened to traffic

Fundamental construction plan for the Lines No. 2 and No. 3 started

1975: Plan to build a loop line in line with the development of a multi-nucleus city made public

1976: Technical Advisory Team dispatched from JICA for the Line No. 2, between Seo Gyo Dong and Dae Un Don Jang.

3.3.5 Rapid Transit Network Plan

3.3.5.1 General

When the construction of the Line No. 1 started in Seoul in 1971, a plan to build the rapid transit lines including the Line No. 1 by stage was announced. This plan was invested with an aim to expand the rapid transit network in order to make it a principal mass transit system in the city. This network plan has the following background.

First, as the road transport was approaching to the limit of its capacity, a rapid transit network with the efficient traffic capacity in Seoul is to be developed as a major mass transit system.

Second, the railway is to go underground in the highly built-up area of the city providing a rapid, comfortable, safe and accurate transport services at reasonable fare.

Third, the rapid transit system is to be expanded so that the maximum commutation time might not exceed one hour and the routes are to be planned so that the greater part of traffic volume among the suburban residential areas and the central Seoul might be carried in about 20 to 30 minutes; in order to disperse the dense population of central Seoul, achieve the orderly development of the whole areas of the city, tighten the organic ties among different parts of the city emphasizing the functional characteristics of each part.

Fourth, the urban rapid transit railway network is to be planned with stress on the connection with the existing traffic systems, including the trunk roads, the integration with the existing suburban railways. The emphasis is made in consideration of the trend in the development of the two future axes of activities, i.e., Seoul - In Cheon Industrial axes and Seoul - Su Won Business and Residential Axes.

Fifth, the rapid transit railway network is to be planned so that it might go far enough to serve new suburban residential areas which would be developed in the future. The construction of underground shopping centers, underground parking lots, and other public facilities like underpasses are to be promoted at the expense of beneficiaries in anticipation of the scarcity of land in the highly built-up area in central Seoul.

Fig. 3-21 Planned Rapid Transit Railway Network

3.3.5.2 Priority Study

Opinions may be diverse as to which line should be given the priority in sequence of the Line No. 1. However, it is recommended for the reasons mentioned hereunder the Line No. 2 should be given the priority as originally planned by the SMG.

The districts in the north of the Han are to be reviewed. First, as the proposed route of the Line No. 2 extends east and west in the urban center, it will attract as much traffic volume as the Line No. 1. Second, it is expected to help alleviate the congestion of traffic that will probably be the heaviest along Eul Ji Ro. Thirdly, the Line No. 2 will play a very important role in the promotion of the division of functions among various parts of a three nuclei city.

The construction of the Line No. 2 in the half-circle located south of the Han should be planned, when the traffic demand is clarified in future.

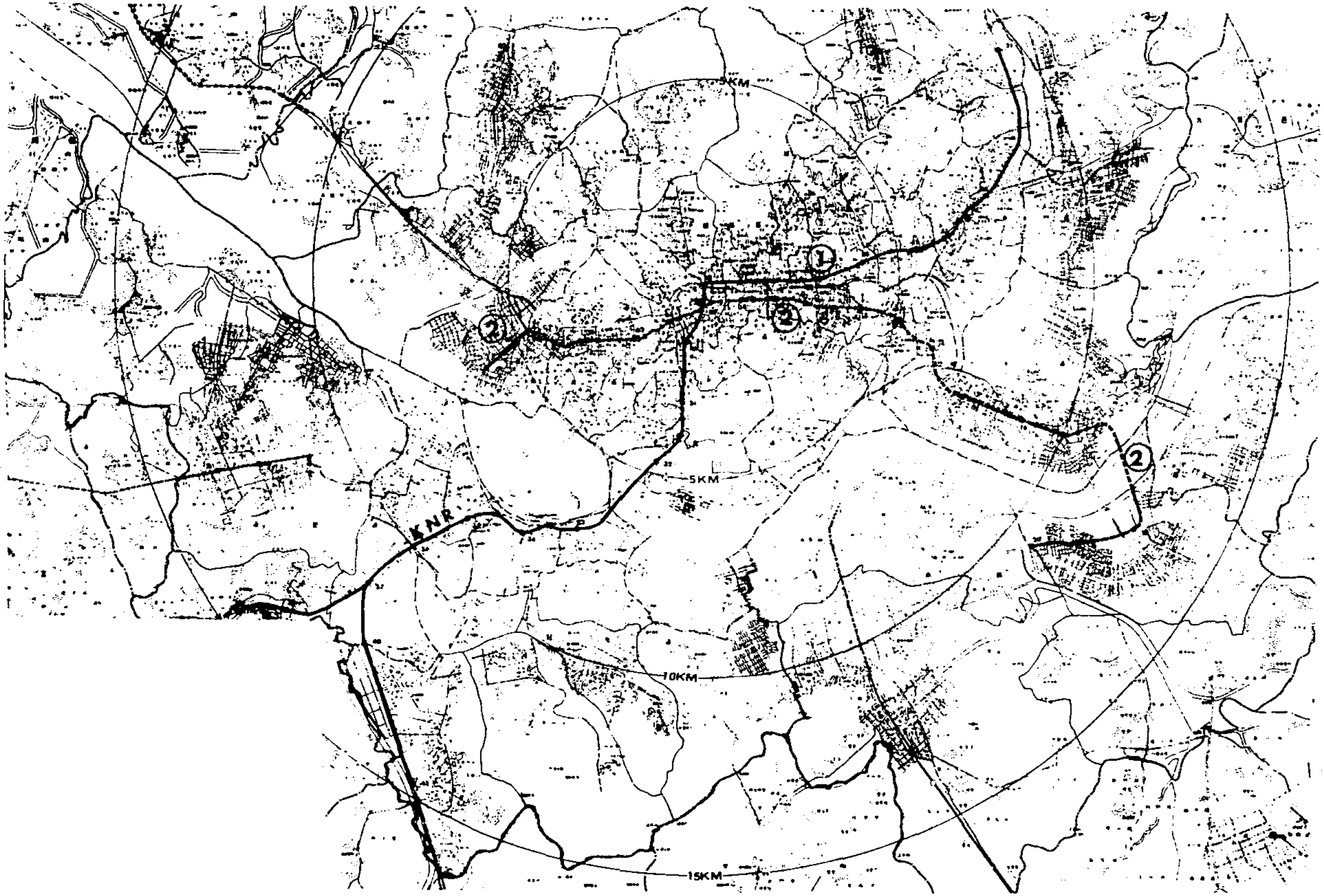
Lines No. 3 and No. 4 are alike in nature and will extend from the residential district north of the Han to the district south of the Han through the city center of Seoul. As both Lines No. 3 and No. 4 will pass through the highly built-up area in the north of the Han, they will attract heavy traffic, but as they will bring the greater part of its traffic into central Seoul, the Line No. 1 alone cannot possibly serve all the traffic needs. It is therefore desirable that Lines No. 3 and No. 4 would be built after the completion of Line No. 2, and the necessary inter-mode connection requirements are to be met so as to allow smooth traffic flow in central Seoul.

3.3.6 Basic Plan of Line No. 2

3.3.6.1 Line No. 2 as a Circle Line

The Line No. 2 was originally planned as a radial line, but later it was modified to be a circle line, presumably because of the plan to develop three nuclei city. As the city center, the Yeong Deung Po district and the Gang Nam district form three centers of administrative, industrial and

Fig. 3-22  Route of Line No. 2



commercial activities of the city. There being the considerable flow of balanced traffic among these centers, a loop is assumed to serve the better than a radial line.

However, the Gang Nam district once assumed to grow as the center of commercial activities in the southern area of the city has acquired the character of the residential district for various reasons, losing most of the character as the center of commercial activities. In other words, the traffic from the city center to the Gang Ham and Yeong Deung Po districts is expected to grow considerably in the future, while the traffic between the Gang Nam and the Yeong Deung Po districts is expected to show only a slight increase for the time being.

If there is no adequate traffic volume in part of the loop line, its operating index would be the lower accordingly. As that part has a route length of over 10 km, the construction of the circular Line No. 2 is not to be initiated in full length simultaneously.

The next problem is the decision in locating the terminals. When the heavy traffic in the Gang Nam district is considered, the line is to be extended to the residential district in the south of the Han.

On the other hand, not much traffic can be expected in the commercial district of Yeong Deung Po, south of the Han. As Gu Ro and Yeong Deung Po Stations of the KNR are located beyond the Yeong Deung Po district, the line is to be extended as far as the Gwan Ag district so as to induce much traffic. However, as its extension up to that point entails the enormous cost, it is recommended for the time being that the terminal of the Line No. 2 is located at the north bank of the Han and that the connecting buses are operated for the traffic in the southern districts of the river.

3.3.6.2 Partial Opening of Line No. 2

The Line No. 2 is to be opened by stage, partly because its route length is longer than that of the Line No. 1 and in addition because it is hard and costly to build over the whole length at the same time.

The part of the line which can be opened in 1982 is the section between City Hall and Dae Un Dong Jang.

3.4 Passenger Volume Estimation of Line No. 2

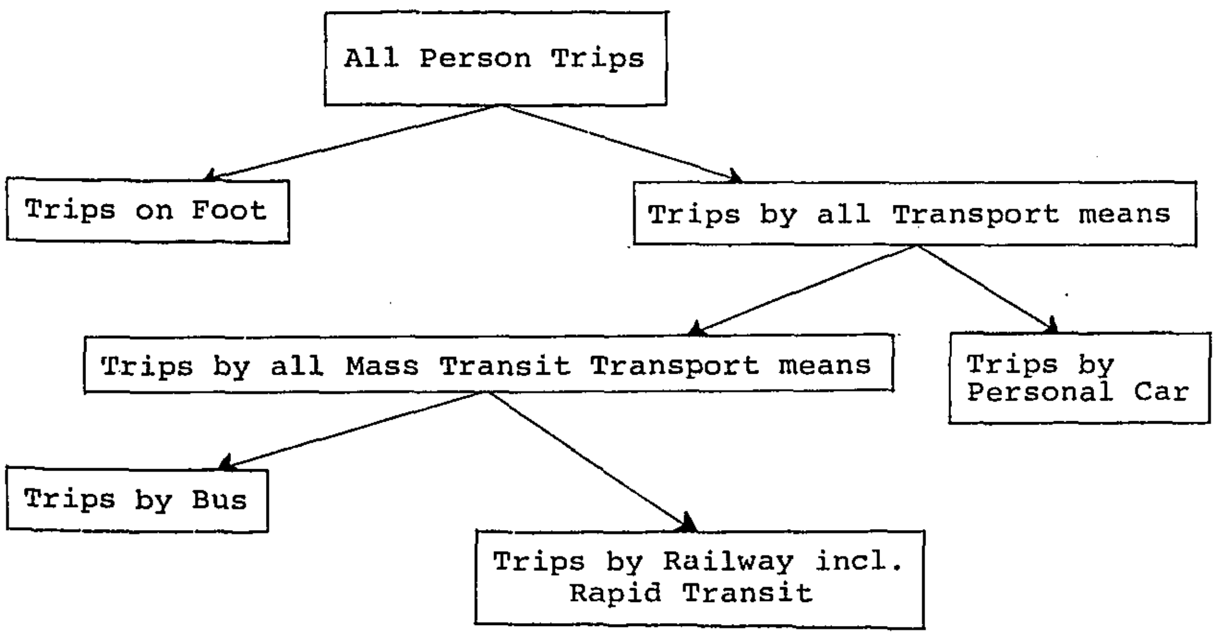
3.4.1 Modal Split

The modal split models used in the traffic estimation include the all-zone model, the trip-end-model, the trip interchange model, and the route model. When the Line No. 2 is opened to public, the interzone travelling time may be shortened considerably. As a result, the modal split of traffic will also be modified. In case of such a change in the modal split, the traffic volume by mode is estimated with the aid of the all-zone model and the trip interchange model.

3.4.1.1 Method of Estimation

The traffic volume by mode of transportation is estimated in steps shown in Fig. 3-23.

Fig. 3-23 Flow Chart for Estimating Traffic Volume by Mode



The variable used in the traffic estimation is the travelling time. It is further divided into walking time, waiting time and transferring time. In dividing the trips by all mass transit transport means into trips by railway including rapid transit and trips by bus, the fares are included in the input data.

The traffic volume by transport mode in relation to the travelling time greatly varies with the trip purpose and the number of private cars owned. In the case of Seoul, however, the trips made for the purposes of office and school attendance account for the greater part of all trips in the city, and the number of private cars is relatively small. For these reasons the modal split curves are plotted in this study for all the trip purposes regardless of the ownership of private cars.

In 1973 a person trip survey was taken in Seoul, but the Line No. 1 was not in existence at that time. It is therefore impossible to estimate the future traffic volume by mode of transportation, based on this trip survey. The model split curve of the railway including rapid transit is therefore plotted, using the all-purpose trip data derived from the person trip which has been taken in the Tokyo metropolitan area.

#### 3.4.1.2 Estimation of Trips by Public Transport

In 1973 the major mass transport mainly relied on buses, and the trips by bus accounted for as much as 79.26 percent of all trips excluding the pedestrians in the whole area of Seoul. In the target years both buses and rapid transit railway will exist as public transport means. The traffic volumes of the Line No. 1 and the electrified connection lines of the KNR is to be reexamined. Based on the existing share of bus in all the trips, the number of trips by public transport in the target years is estimated hereunder.

The factors which exert a significant effect on the trips by bus are pedestrians and the private cars utilizers. The number of registered automobiles which stood at 96,557 in 1976 is expected to increase by about 2.6 times to 255,300 in 1984. It will still be comparatively small for the size of population of the city. As the number of automobiles increases, the number of trips by bus decreases. On the other hand, however, as the living standard improves, many of pedestrians will divert to the bus services. It appears that there is little difference in ratio if any between trips by cars and those by buses in 1973.

The trips by public transport in the target years is estimated by regarding the trips within the zone as trips on foot and assuming trips by public transport to be at 79.26 percent of the interzone trips.

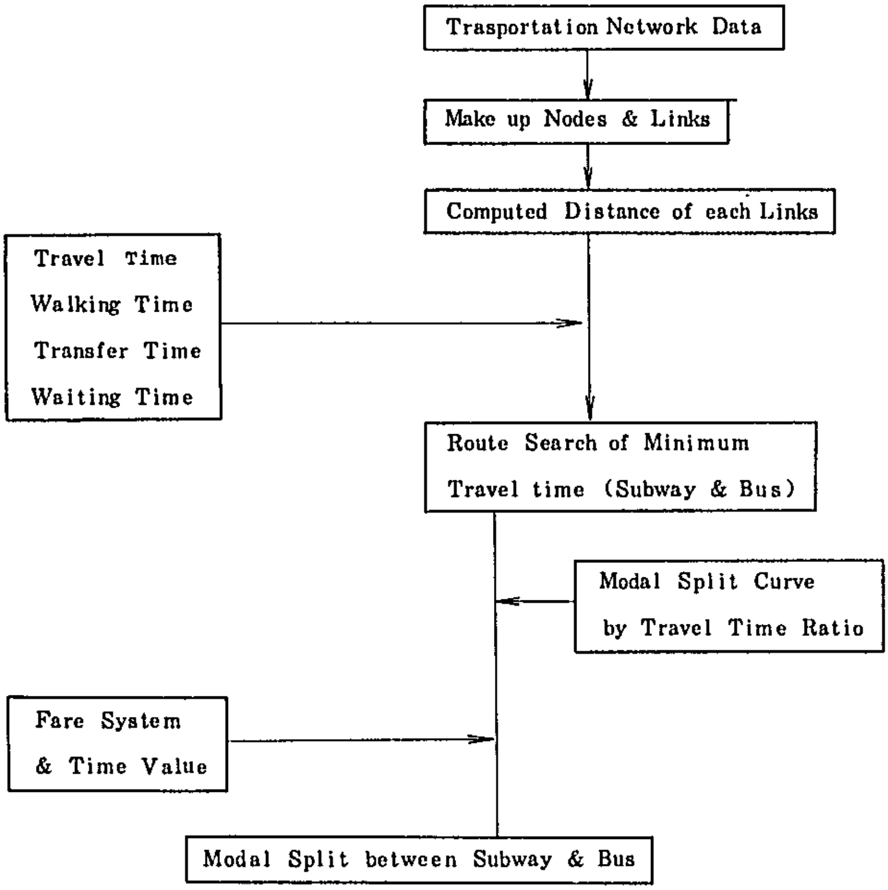
Table 3-16 Future Trips by Public Transport

| Year | Total Number of Trips | Trips by Public Transport | Trips by Other Modes |
|---|---|---|---|
| 1973 | 9,578,022 | 5,553,423 (0.58) | 4,024,598 (0.42) |
| 1982 | 13,464,652 | 7,253,383 (0.54) | 6,211,269 (0.46) |
| 1984 | 14,221,515 | 7,587,535 (0.53) | 6,633,980 (0.47) |
| 1994 | 17,406,026 | 9,190,958 (0.53) | 8,215,068 (0.47) |

3.4.1.3 Estimation of Rapid Transit Railway Passengers

Generally speaking, the estimation of subway traffic requires the consideration of the operation method, fare, saving time, and riding quality of all the traffic systems. The future rapid transit traffic volume is estimated from the trips by public transport according to the flow chart in Fig. 3-24, using the modal split curve for the railways including subway.

Fig. 3-24 Flow Chart for Modal Split




(1) Networks

The following traffic networks are presented.

(a) Bus Network

The bus network is worked out based on the existing bus routes.

(b) Rapid Transit Railway Network

The subway network is presented in accordance with the construction plan of the Line No. 2 by stage. Bus service is taken into account in planning the terminals. The Line No. 1 and the electrified commutation Lines of the KNR are also studied.

The rapid transit traffic in the target years is estimated on the basis of the above networks, while the following network is also used so as to obtain parametric values for use in economic analysis.

(c) Present Rapid Transit Network

This network consists of the Line No. 1 and the electrified commutation lines of the KNR.

(2) Conditions of the Network

(a) The scheduled speed of the rapid transit line and the electrified commutation lines of the KNR is assumed to be 27 km/h. The KIST has made the same assumption.

(b) The scheduled speed of buses is assumed to be 20 km/h. The assumption is made that the rapid transit system is faster by 0.78 minute per km than the bus.

(c) The assumption is made that bus service is provided if the rapid transit or railway station is 1 km or more apart from the zone center and that passengers will prefer walking if the stations are located within the said distances.

(d) The connecting passengers between the Lines No. 1 and No. 2 can only utilize the City Hall Station.

(e) The present fare system of the rapid transit system and buses are assumed to remain unchanged, provided the length of one bus ride is decided to be 6 km in consideration of the present average bus trip length.

(f) The time value is derived from the economic analysis with 1976 prices as the base.

(3) Modal Split Curve Plotting

The modal split curve is plotted by the binary mode choice method which consists in dividing the trips by public transport into trips by rapid transit and by bus. As previously noted, the modal split curve of rapid transit traffic is plotted, using the data derived from the person trip survey taken in the Tokyo metropolitan area and its suburbs as shown in Fig. 3-25.

(4) Rapid Transit Railway Passengers

The rapid transit traffic can be estimated from the modal split curve as is shown below. When trips by rapid transit are assumed to account for about 20 percent of all trips of by public transport, the rapid transit can be estimated to be about 1,380,000 passengers in 1982, 1,550,000 passengers in 1984 and 1,870,000 passengers in 1994.

Trips by bus accounted for 58 percent of all person trips in 1973, the proportion of bus trips is expected to decline to 44 percent in 1982 and 42 percent in 1984 when the Line No. 2 is completed.

Fig. 3-25 Modal Split Curve of Railway

$$\text{Rate of Trips by Railway} = \frac{\text{Trips by Railway}}{\text{Trips by Railway + Trips by bus}}$$

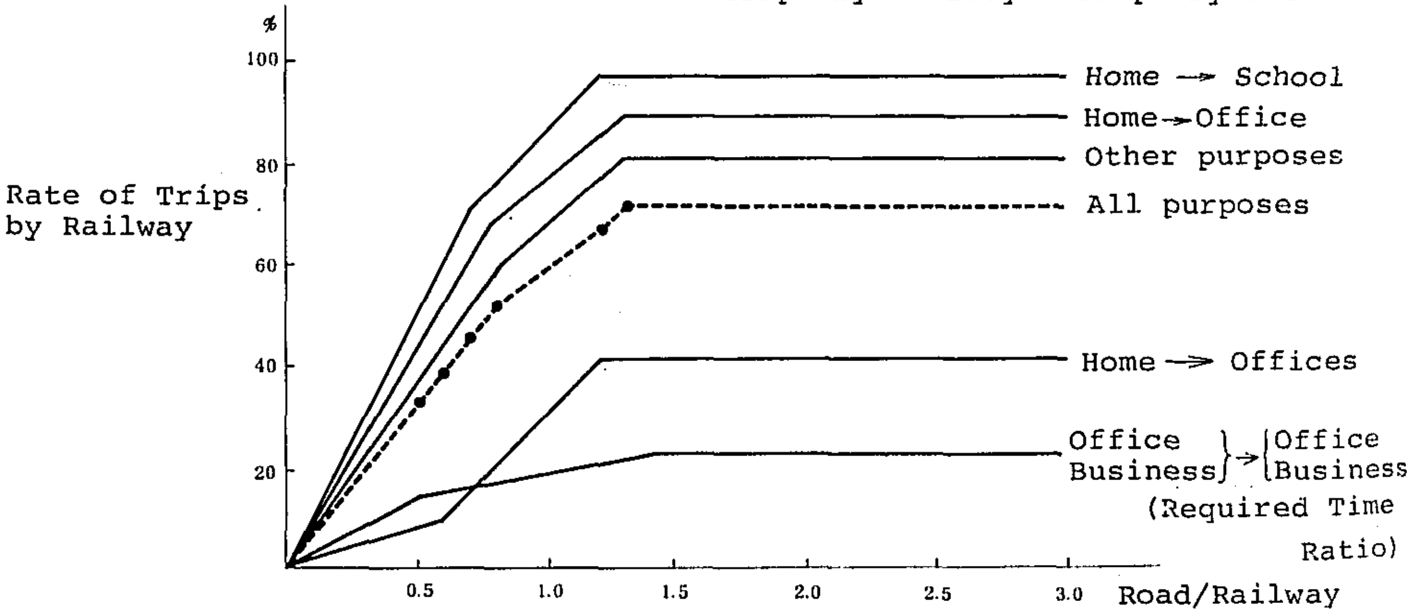


Table 3-17 Rapid Transit and Bus Passengers

| Year | Trips by Public Transport | Trips by Rapid Transit | Trips by Bus |
|---|---|---|---|
| 1982 | 7,253,383 (1.00) | 1,380,767 (0.19) | 5,872,616 (0.81) |
| 1984 | 7,587,535 (1.00) | 1,547,656 (0.20) | 6,039,879 (0.80) |
| 1994 | 9,190,958 (1.00) | 1,870,570 (0.20) | 7,320,388 (0.80) |

### 3.4.2 Passengers of Line No. 2

The future traffic on the Line No. 2 is estimated by assigning all the subway OD's in the rapid transit railway network according to the concept of minimum path with the aid of a computer.

The output from the computer-aided data processing includes:

a) Number of passengers by section

b) Passenger volume by station

c) Station OD table

d) Passenger-kilometer and average travel distance

#### 3.4.2.1 Total Passengers

The future passenger volume of the Line No. 2 can be estimated by passenger assignment, as shown in Table 3-20.

In 1982 when the Line No. 2 is opened partially, the passengers within this line are expected to account for about 350,000 or 25 percent of the total rapid transit passengers. When the connecting passengers from the Line No. 1 is added, the passengers of the Line No. 2 will reach about 480,000 in 1982.

In 1984 when the Line No. 2 is wholly opened, the passengers within this line increase to about 480,000. Adding the passengers from the Line No. 1, the passengers of the Line No. 2 total about 750,000, which is nearly half the total numbers of passengers of the two rapid transit lines.

In 1994, 10 years after the full opening of the Line No. 2 the passengers will probably be about 1.2 times greater in number, as compared with the level of 1984. In other words, about 900,000 persons will use the Line No. 2 in 1994.

Table 3-18 Passengers of Line No. 2

| Year | Passengers within Line No. 2 | Connecting Passengers from Line No. 1 | Total | Passengers of Two Lines No. 1 and 2 |
|---|---|---|---|---|
| 1982 | 345,561 (25%) | 130,499 (9%) | 476,060 (34%) | 1,380,767 (100%) |
| 1984 | 483,455 (31%) | 261,349 (17%) | 744,804 (48%) | 1,547,656 (100%) |
| 1994 | 596,795 (32%) | 321,854 (17%) | 918,649 (49%) | 1,870,570 (100%) |

3.4.2.2 Passengers by Section

The number of passengers of the Line No. 2 by section is estimated by assigning the OD's in the rapid transit network.

The section that is expected to attract the maximum daily passenger volume in 1982, when the Line No. 2 is partially opened, between City Hall and Eul Ji Ro 2-Ga, and its traffic is estimated to be about 300,000 persons in both directions. The traffic between Seong Pa Dong and Dae Un Dong Jang via Jam Sil is not expected to be around 20,000 persons in 1982, because the Line No. 2 can not absorb enough traffic originating from the Gang Nam district. Also in

1984 when the Line No. 2 is wholly opened, the section between City Hall and Eul Ji Ro 2-Ga will be most crowded. As the section between Seo Gyo Dong and City Hall is opened by that time, the line will absorb the traffic originating from not only the Ma Po district but the Yeong Deung Po district.

The daily passenger volume by section in the target year is estimated. In planning the train schedule, however, it becomes necessary to estimate the hourly passenger volume.

The greater part of the subway passengers are assumed to be commuters between home, office or school. As the section between Seo Su Mun and Sin Dang Dong is located at the heart of the city, business trips is also originate here tremendously. It seems reasonable to anticipate that the maximum hourly traffic will arise in the sections located near the heart of the city. When the inbound peak ratio and the one-way traffic ratio are assumed to be 21.7 and 60 percent, respectively, the hourly maximum passenger volume is estimated as follows:

° 1982 Section between Sin Dang Dong and Sang Wang Sib Ri

222,395 x 0.217 x 0.6 = 28,956 prsns/h One direction

° 1984 Section between A Hyeon Dong and Seo So Mun

299,298 x 0.217 x 0.6 = 38,969 prsns/h One direction

° 1994 Section between A Hyeon Dong and Seo So Mun

370,578 x 0.217 x 0.6 = 48,249 prsns/h One direction

3.4.2.3 Passenger Volume by Station

City Hall where the Line No. 2 connects with the Line No. 1 is expected to serve the heaviest passenger traffic of all stations. The passenger volume of this station is estimated to be about 290,000 persons in 1982, 330,000 persons in 1984 and 410,000 in 1994, when the connecting passengers from the Line No. 1 are included. Eul Ji Ro 2-Ga ranks the second, followed by Chang Cheon Dong and Dae Hyeon Dong.

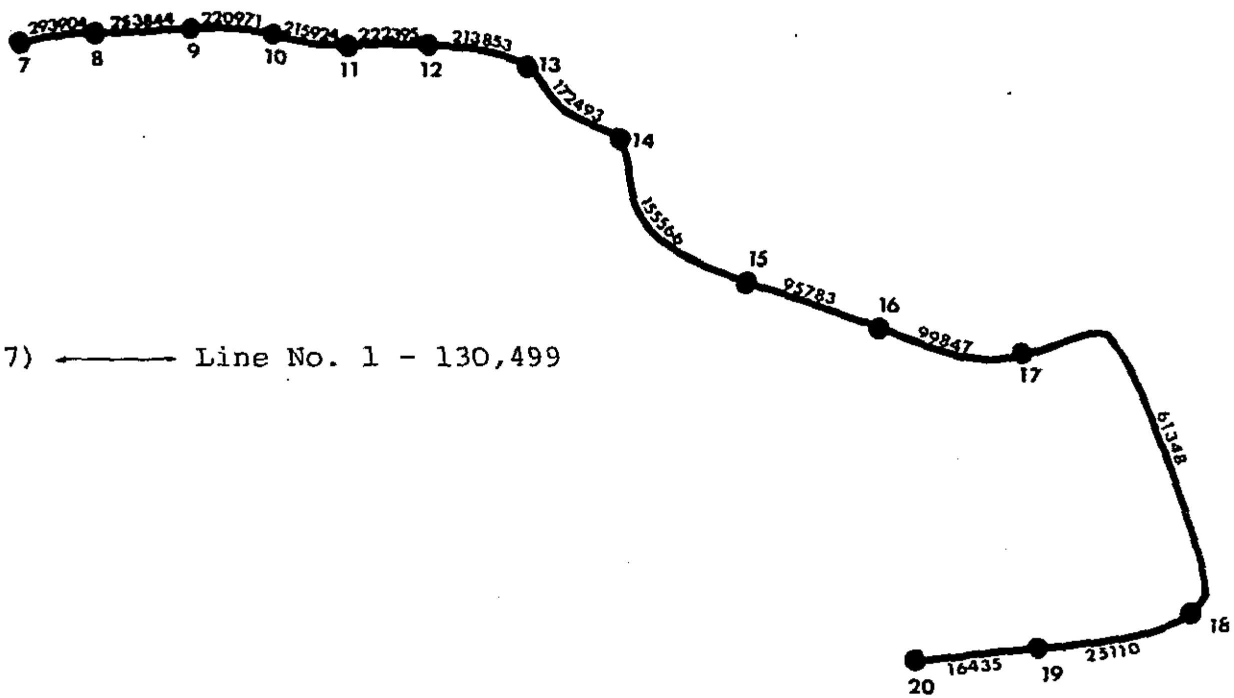
### 3.4.2.4 Average Trip Length

The Daily total travelling time and distance of passengers on Lines No. 1 and No. 2 are as shown in Table 3-21. For the Line No. 2 the average trip length is estimated to be 4.55 km in 1982, 5.30 km in 1984 and 5.42 km in 1994. When the Line No. 1 is included, the average trip length in the said years is estimated to be 7.21 km, 7.73 km and 7.86 km, respectively, the average travelling distance will increase year by year.

Table 3-19 Passenger Volume by Section

| Section | Distance | 1982 | 1984 | 1994 |
|---|---|---|---|---|
| 1. Seo Gyo Dong | | | | |
| | km<br>0.940 | * | 82,704 | 100,966 |
| 2. Dong Gyo Dong | | | | |
| | 1.120 | * | 105,527 | 127,866 |
| 3. Chang Cheon Dong | | | | |
| | 0.900 | * | 217,037 | 265,552 |
| 4. Dae Hyeon Dong | | | | |
| | 1.200 | * | 292,881 | 363,114 |
| 5. A Hyeon Dong | | | | |
| | 1.350 | * | 299,298 | 370,578 |
| 6. Seo So Mun | | | | |
| | 1.113 | * | 315,601 | 389.659 |
| 7. City Hall | | | | |
| | 0.695 | 293,904 | 319,414 | 389,754 |
| 8. Eul Ji Ro 2-Ga | | | | |
| | 0.822 | 253,844 | 276,052 | 340,597 |
| 9. Eul Ji Ro 4-Ga | | | | |
| | 0.815 | 220,971 | 244,005 | 305,651 |
| 10. Eul Ji Ro 6-Ga | | | | |
| | 0.928 | 215,924 | 236,891 | 297,603 |
| 11. Sin Dang Dong | | | | |
| | 0.855 | 222,395 | 241,271 | 302,098 |
| 12. Sang Wang Sib Ri | | | | |
| | 0.686 | 213,853 | 232,955 | 292,900 |
| 13. Ha Wang Sib Ri | | | | |
| | 0.730 | 172,493 | 191,173 | 244,565 |
| 14. Han Rae Ap | | | | |
| | 2.577 | 155,566 | 173,050 | 222,340 |
| 15. Seong Su Dong | | | | |
| | 1.257 | 95,783 | 111,051 | 148,295 |
| 16. Hwa Yang Dong | | | | |
| | 1.324 | 99,847 | 115,806 | 154,674 |
| 17. Mo Jin Dong | | | | |
| | 3.576 | 61,348 | 73,487 | 100,635 |
| 18. Seong Pa Dong | | | | |
| | 1.142 | 25,110 | 30,604 | 42,526 |
| 19. Jam Sil Dong | | | | |
| | 1.287 | 16,435 | 19,987 | 27,730 |
| 20. Dae Un Dong Jang | | | | |

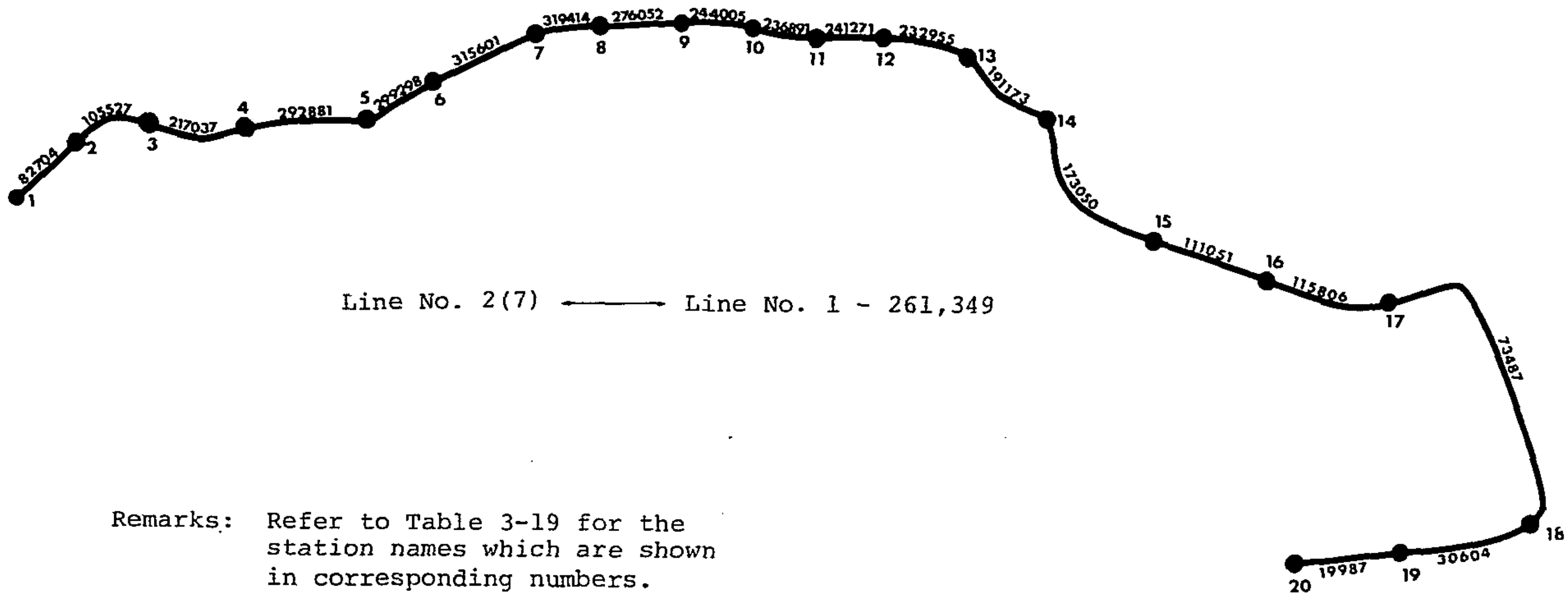
Fig. 3-26 Line No. 2
Assigned Traffic Volume in 1982




Line No. 2 (7) ←——→ Line No. 1 - 130,499

Remarks: Refer to Table 3-19 for the station names which are shown in corresponding numbers.

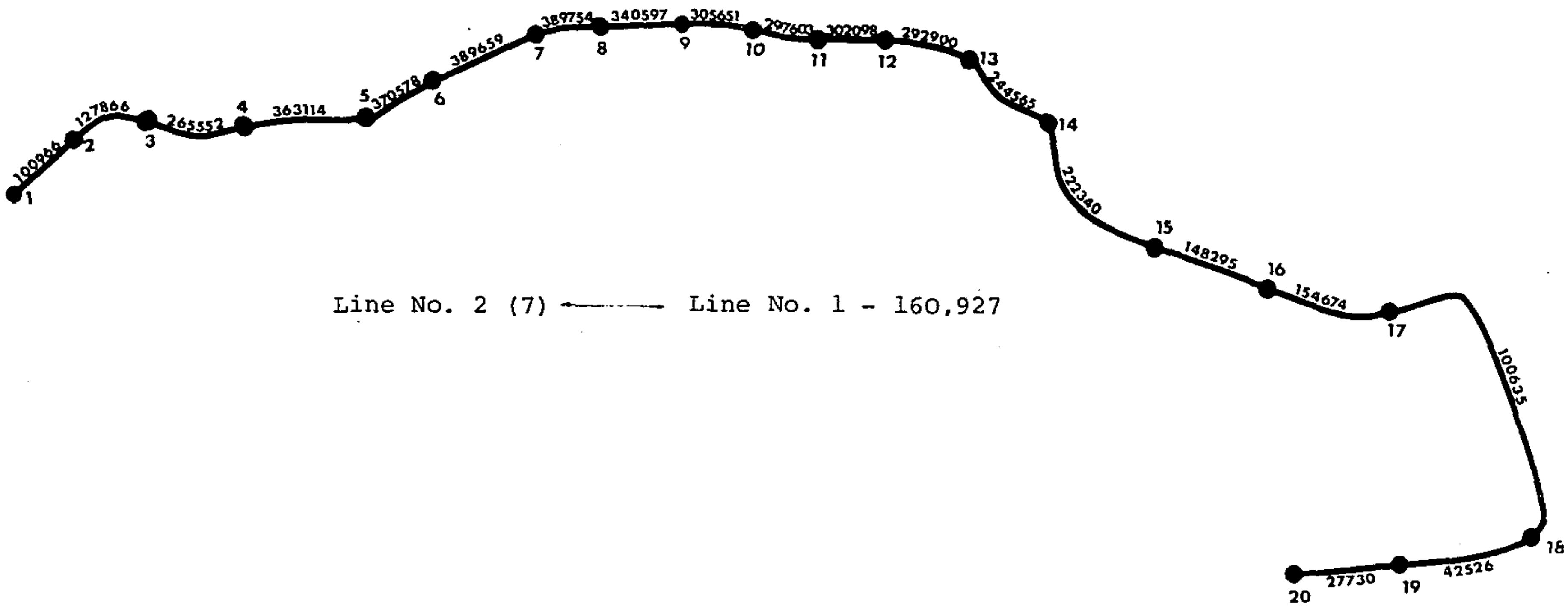
Fig. 3-27  Line No. 2
Assigned Traffic Volume in 1984




Line No. 2(7) ←——→ Line No. 1 - 261,349

Remarks: Refer to Table 3-19 for the station names which are shown in corresponding numbers.

No. 3-28 Line No. 2
Assigned Trip Volume in 1994




Remarks: Refer to Table 3-19 for the station names which are shown in corresponding numbers.

Table 3-20 Passenger Volume by Station

| Station | 1982 | 1984 | 1994 |
|---|---|---|---|
| 1. Seo Gyo Dong | * | 82,704 | 100,966 |
| 2. Dong Gyo Dong | * | 28,009 | 33,454 |
| 3. Chang Cheon Dong | * | 129,864 | 160,608 |
| 4. Dae Hyeon Dong | * | 90,878 | 116,240 |
| 5. A Hyeon Dong | * | 26,781 | 33,094 |
| 6. Seo So Mun | * | 83,237 | 102,185 |
| 7. City Hall | 293,904 | 334,179 | 406,919 |
| 8. Eul Ji Ro 2-Ga | 157,176 | 166,424 | 198,709 |
| 9. Eul Ji Ro 4-Ga | 34,831 | 34,183 | 37,672 |
| 10. Eul Ji Ro 6-Ga | 57,897 | 61,872 | 73,362 |
| 11. Sin Dang Dong | 52,653 | 58,146 | 72,113 |
| 12. Sang Wang Sib Ri | 27,216 | 29,194 | 36,198 |
| 13. Ha Wang Sib Ri | 79,864 | 85,194 | 104,867 |
| 14. Han Dae Ap | 46,973 | 50,291 | 61,879 |
| 15. Seong Su Dong | 66,167 | 69,349 | 83,747 |
| 16. Hwa Yang Dong | 8,344 | 9,869 | 13,329 |
| 17. Mo Jin Dong | 44,883 | 49,669 | 63,741 |
| 18. Seong Pa Dong | 54,066 | 65,179 | 89,797 |
| 19. Jam Sil Dong | 11,711 | 14,599 | 20,688 |
| 20. Dae Un Dong Jang | 16,435 | 19,987 | 27,730 |
| Total | 952,120 | 1,489,608 | 1,837,298 |

Table 3-21 Total Travelling Time and Distance

| Year | Line No. | Pass.km/day | Pass.minute/day |
|---|---|---|---|
| 1982 | 2 | 2,168,255 | 4,818,347 |
| | 1 | 7,791,322 | 17,314,048 |
| | Total | 9,959,577 | 22,132,395 |
| 1984 | 2 | 3,944,362 | 8,765,254 |
| | 1 | 8,011,357 | 17,603,015 |
| | Total | 11,955,719 | 26,368,269 |
| 1994 | 2 | 4,978,813 | 11,064,033 |
| | 1 | 9,620,216 | 21,378,252 |
| | Total | 14,599,029 | 32,442,285 |

Fig. 3-29 Passenger Volume of Line No. 2 in 1982

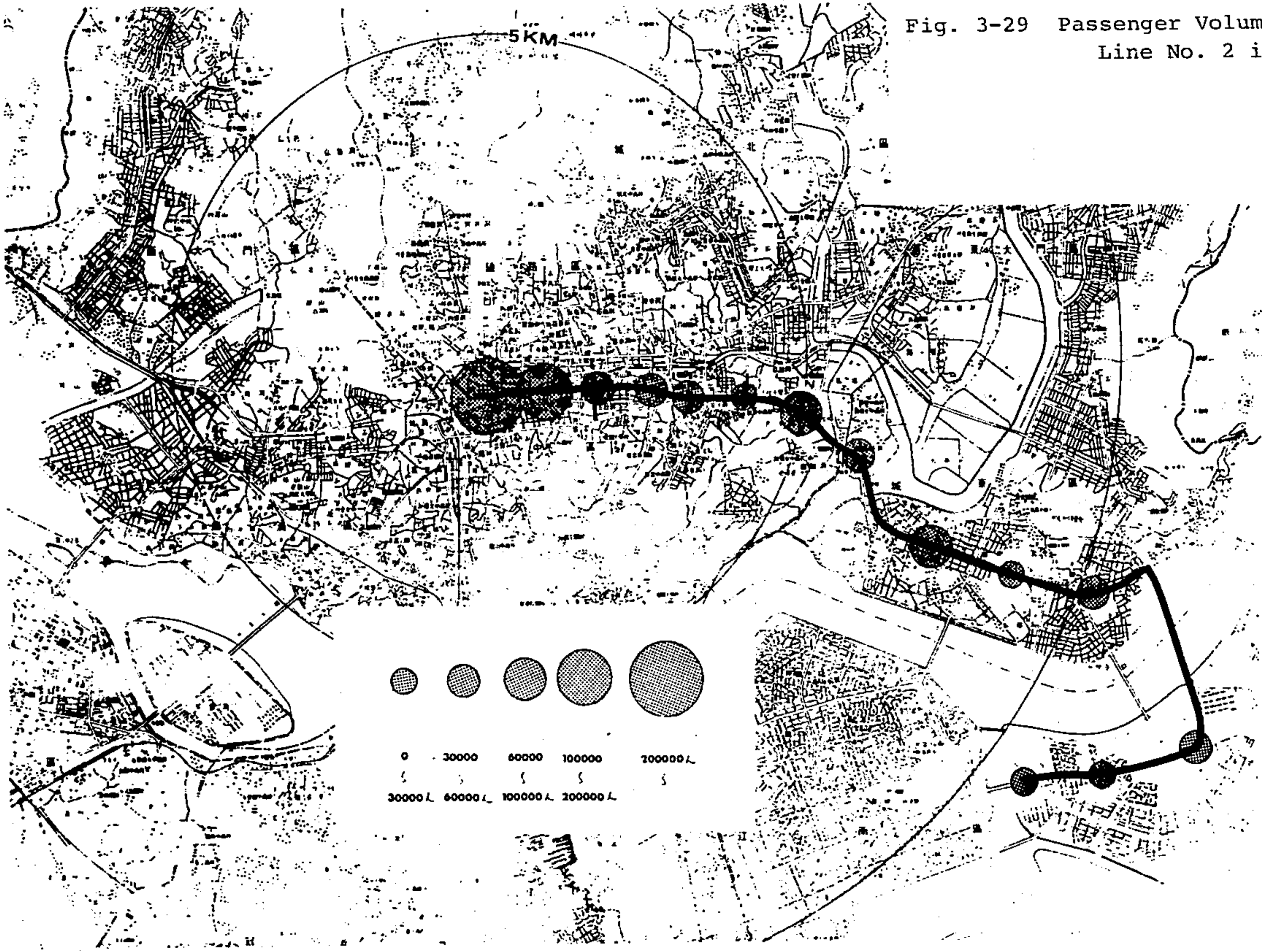


Fig. 3-30 Passenger Volume of Line No. 2 in 1989

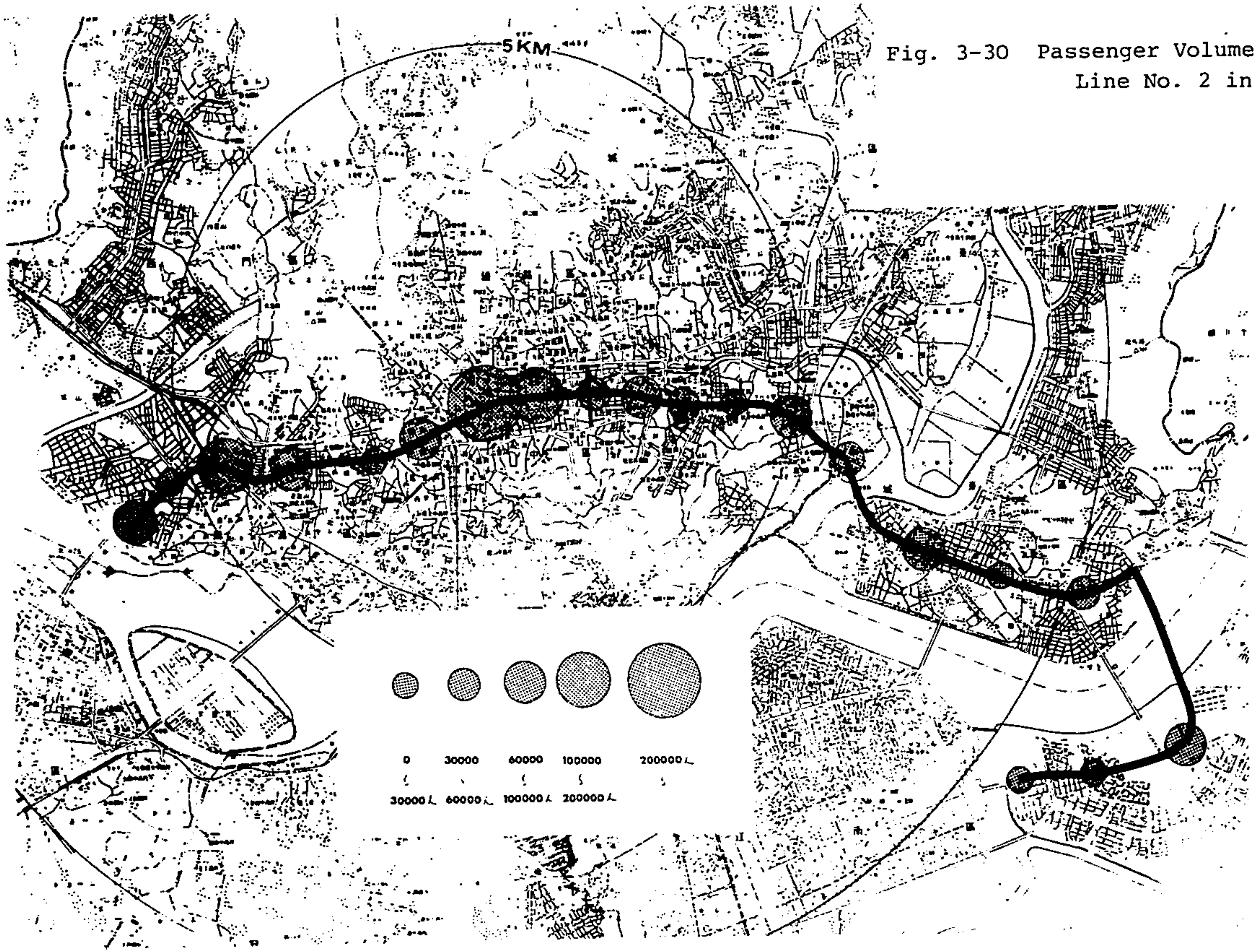
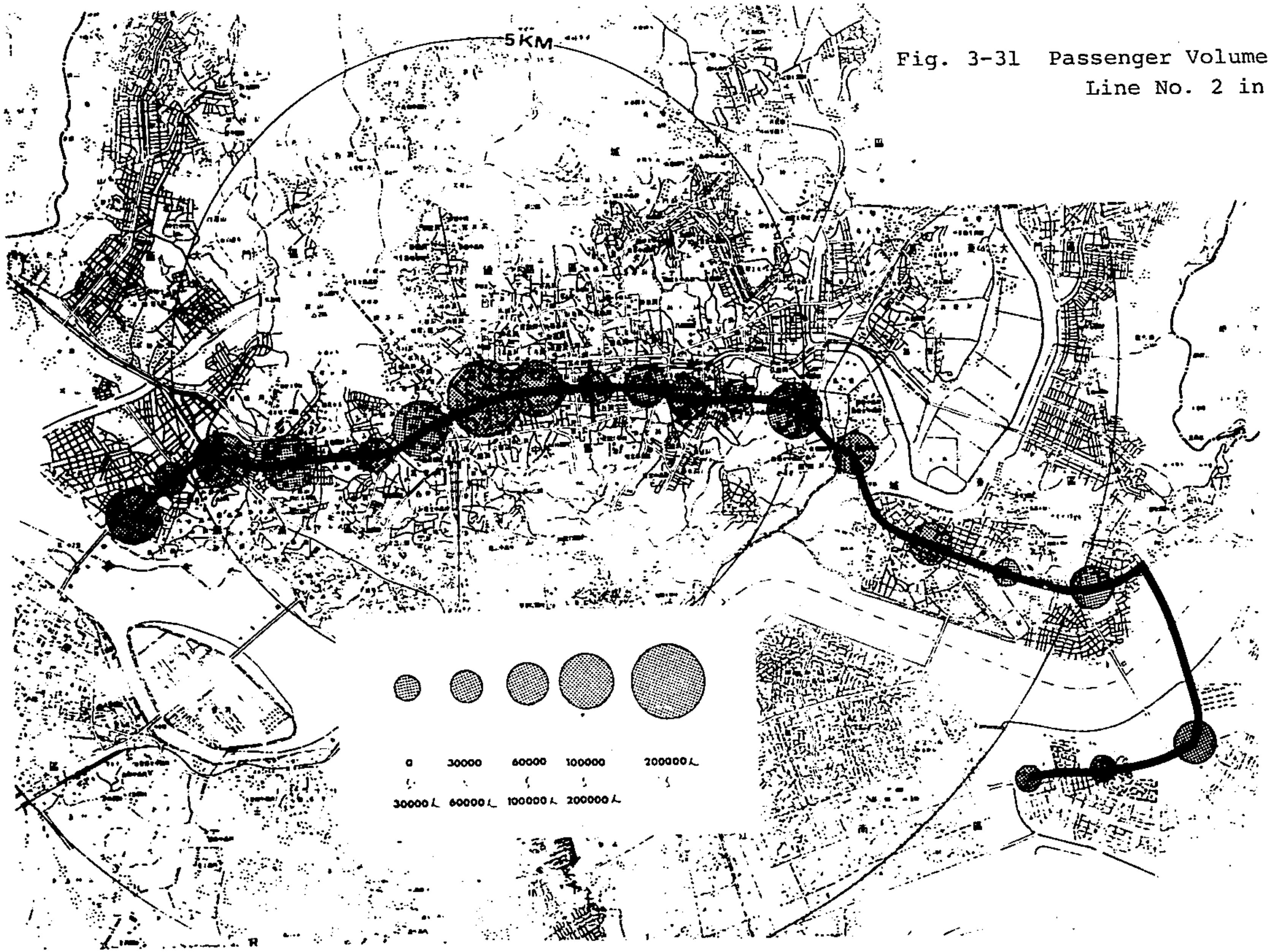


Fig. 3-31 Passenger Volume of Line No. 2 in 1994



# 4. Route Location

## 4.1 Outline of Route

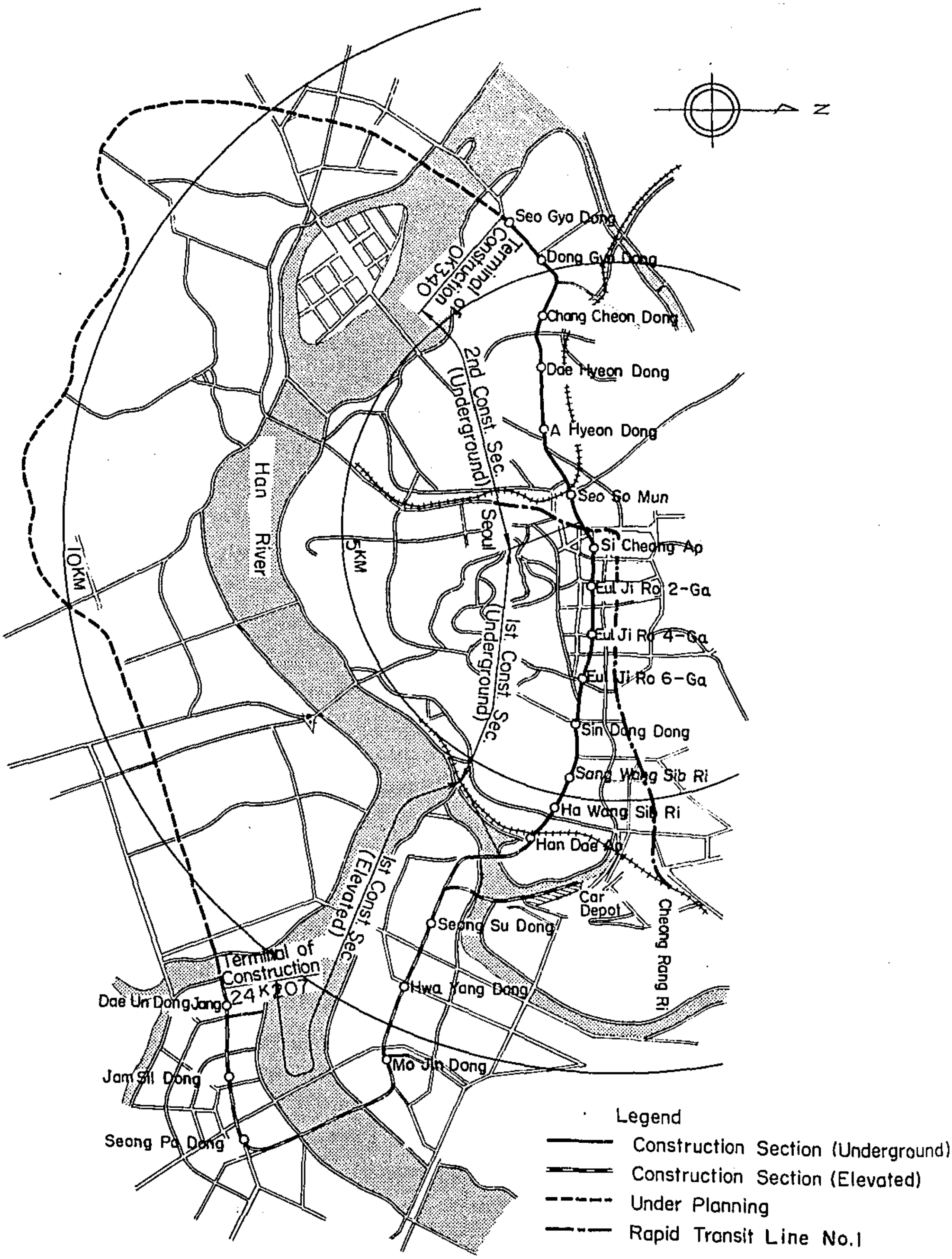
As shown in Fig. 4-1, Line No. 2 originates from Seo Gyo Dong in Ma Po District, north of the Han Gang Bridge No. 2; goes northward under the main road as a subway passes through Dong Gyo Dong and A Hyeon Dong under the elevated road, reaches City Hall after crossing Geong Eui Railroad of KNR and Rapid Transit Line No. 1; passing under the Eul Ji Ro, it reaches Han Dae Ap via Ha Wang Sib Ri; then the route is planned to be an elevated railway, passing over the Seong Dong River upstream the Seong Dong Bridge; after passing Seong Su Dong and Mo Jin Dong, the line crosses over the Han River upstream the Jam Sil Bridge; then the line leads to Jam Sil Dong where many residential apartment houses are located; the line reaches Dae Un Dong Jang where the huge athletic stadium is now under construction; and, after passing Yeong Dong and Yeong Deung Po where urbanization is anticipated, crossing again the Han River, the line reaches Seo Gyo Dong.

The total length of this bow-shaped loop line is 47.7 km with 14 underground stations and 23 elevated stations. The length of the section between Seo Gyo Dong and Dae Un Dong Jang, which is the object of this feasibility study, is 23.9 km with 14 underground stations and 6 elevated stations.

## 4.2 Outline of Geology

There are results of test drilling performed at roughly every 100 meters between City Hall and Ha Wang Sib Ri. For other sections, only results of boring thrice around A Hyeon Dong and results twice upstream the Seong Dong Bridge are available. It is difficult to pricesely recognize the geological conditions along the full length of the route only by the results mentioned above. The test results of boring show the kinds of soil and the standard penetration test (N-value). No dynamic tests such as compression test and shear test have so far been available.

Fig. 4-1 Route Map of Line No.2



According to the results of field survey and test drilling, the geological condition along the Line No. 2 is assumed to be the one indicated in Fig. 4-2. Thus, the subsurface geological system is divided into three layers, i.e., top soil, weathered granitic rock and soft or hard granitic rock.

The geological condition along Eul Ji Ro Street is as follows: soil is composed of fill, clay and clayey sand with N-value of 4-12. This comparatively soft top soil is thick around Eul Ji Ro whereas thin around Ha Wang Sib Ri in the range between 1.5 and 8.6 meters. The second is of 1.8 - 16 meter thick, being variable by each locality, which is the pale gray or yellow-brownish weathered pegmatic granite with mica. The uppermost part of the weathered granite between 0.5 - 1.5 meter is rather soft with the N-value of 15 - 22, but under that depth the weathered granite is very hard in view of geotechnics with N-value of more than 50. The third layer is the basal granitic rock but somewhat soft. The thickness of 4 - 7 meter is nearly even in this district. The standard penetration test is impossible. This rock will be slightly weathered along fairly developed joints and will be apt to be separated into blocks.

In the vicinity of the Seong Dong Bridge, the thickness of top soil is 12 - 17 meter under which granitic rock is exposed. The latter is expected to be of sufficient bearing layer to the piles of the bridge piers. In detailed design stage, test boring is advisable at each pier site for the river crossing and every 100 meter in other section. In the neighborhood of A Hyeon Dong, the top soil as well as weathered rock are thin. The third layer, slightly weathered rock is of 0.3 - 7.5 meter thick, the substance of which is not different from that in Eul Ji Ro. The base rock is very hard gneiss. However, it is quite possible to have joint system in dip of 0 - 30° and further detailed survey by such means as electric and seismic prospecting is required when the rock tunneling method is adopted.

It has been recognized that underground water is widespread all over the route. Before starting the construction work it is essential to make further study on underground water for setting up the countermeasures.

## 4.3 Alignment and Profile of Route

### 4.3.1 General

The route shall be convenient for many passengers, profitable, and appropriate for curtailing construction, operation and maintenance costs. In addition, the route shall not deviate from the alignment including major passing points in the Government Master Plan. Therefore, in deciding alignment and profile, it is necessary to take into consideration not only landform, geological aspects, land utility conditions, existing structures and buildings but also curtailment of various costs, safety during construction, countermeasures against pollution, etc.

### 4.3.2 Decision of Alignment and Profile

In deciding alignment and profile, the following items are the most important conditions.

(1) Alignment

a. Relation to the buildings, structures, underground facilities, public utilities, etc.

b. Location and type of stations

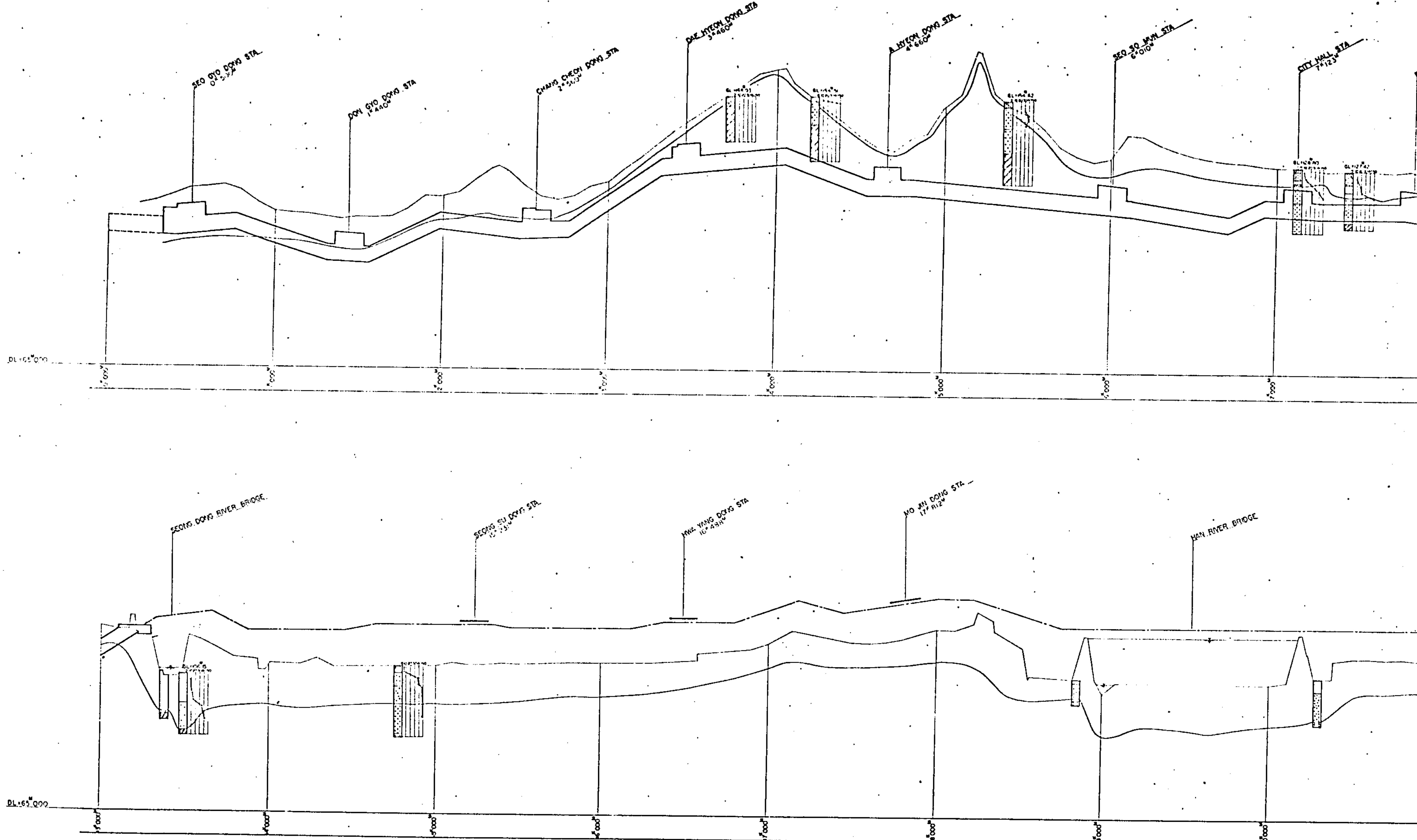
c. Curve radius when the line passes privately owned land

d. Transferring facilities to and from the existing and planned railways

e. Role as an infrastructure in urban planning

f. Effect on road traffic during construction

g. Effect on civic life and business activities of the inhabitants along the route during construction


SEO GYO DONG STA
DON GYO DONG STA
1K440M
CHANG CHEON DONG STA
DAE HYEON DONG STA
3K460M
A HYEON DONG STA
4K660M
SEO SO MUN STA
6K010M
CITY HALL STA
7K123M
SEONG DONG RIVER BRIDGE
SEONG SU DONG STA
HWA YANG DONG STA
MO JIN DONG STA
17K812M
HAN RIVER BRIDGE

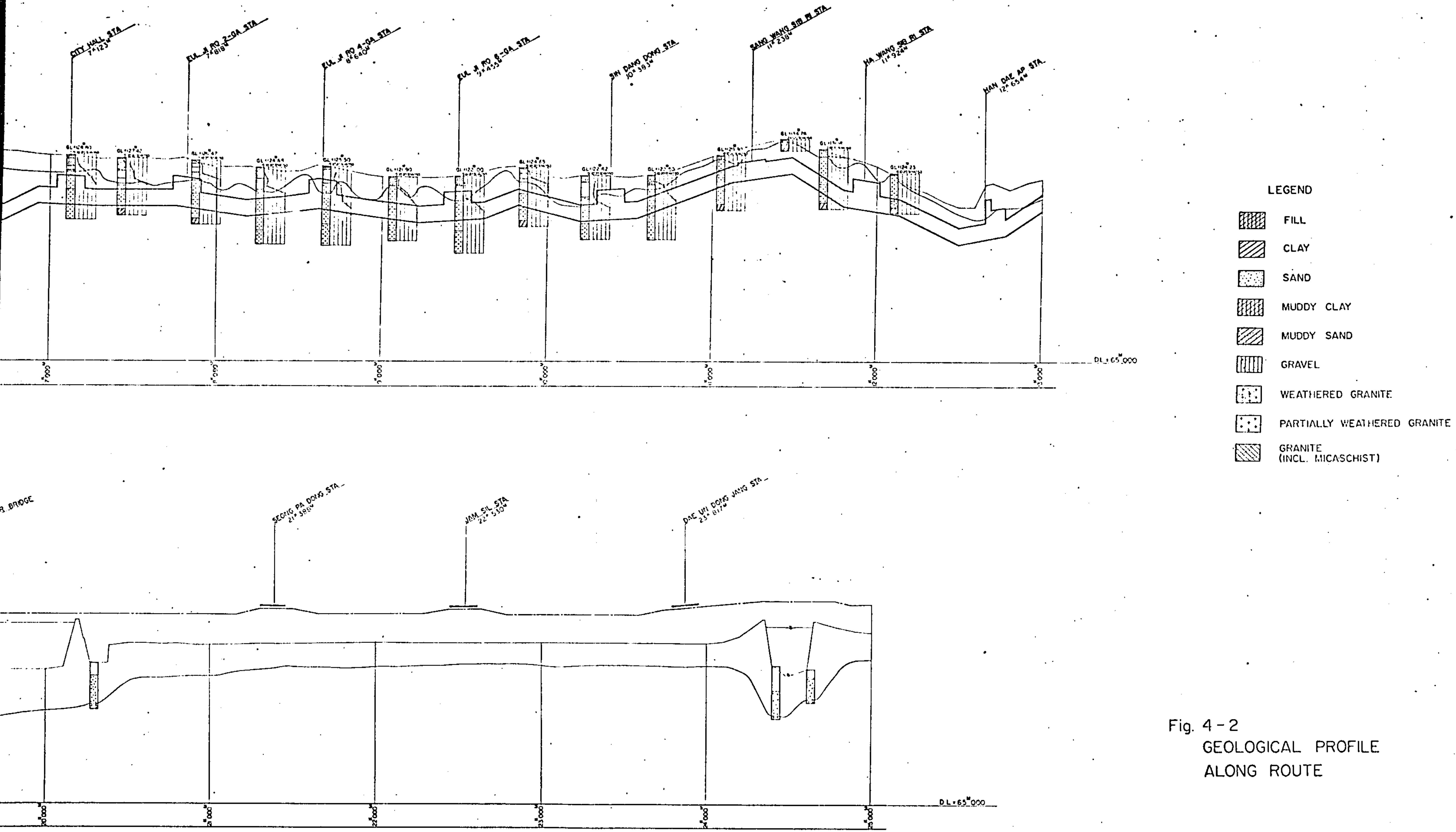
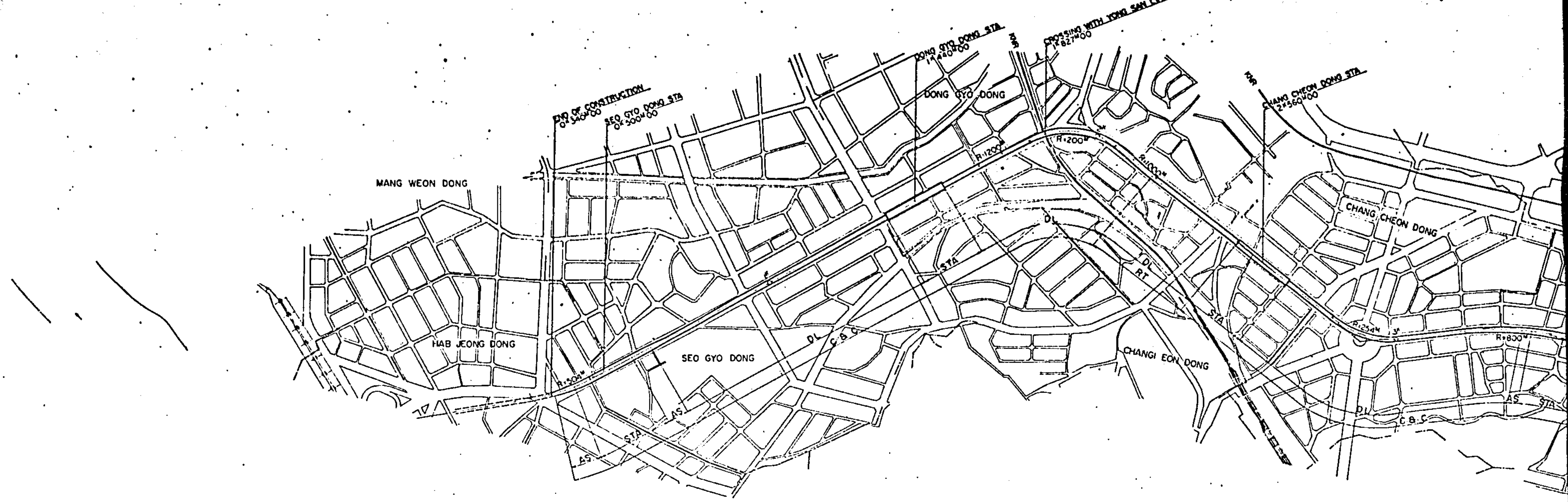
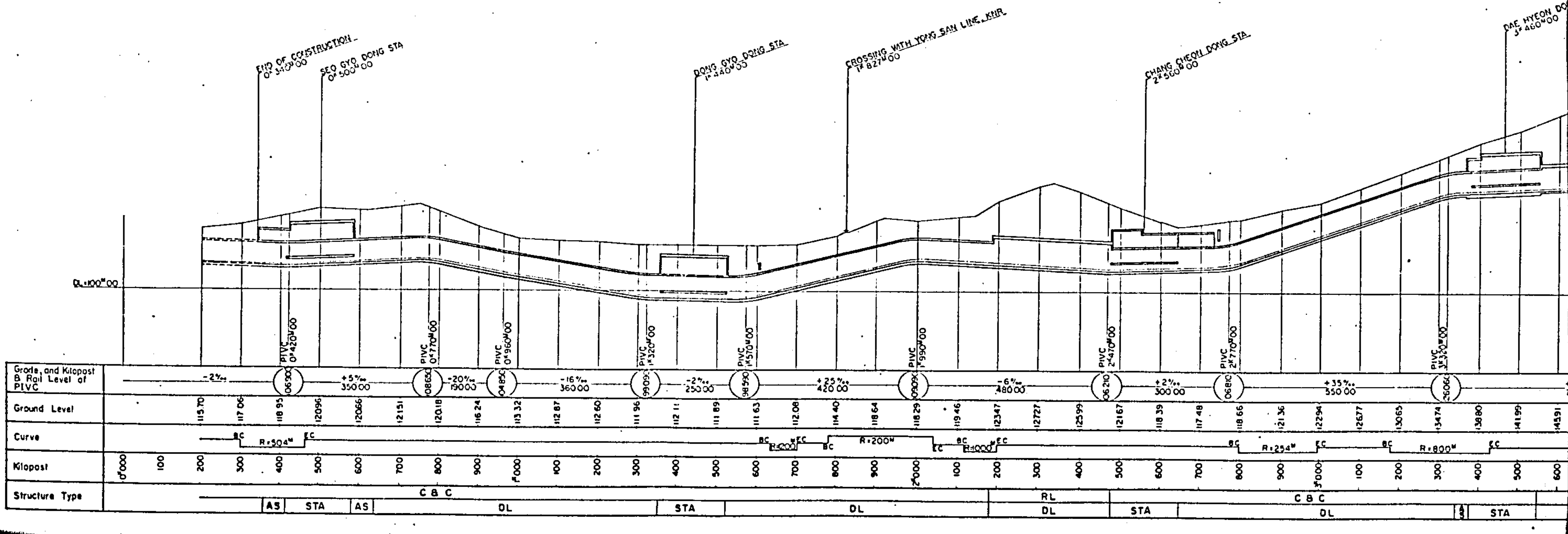
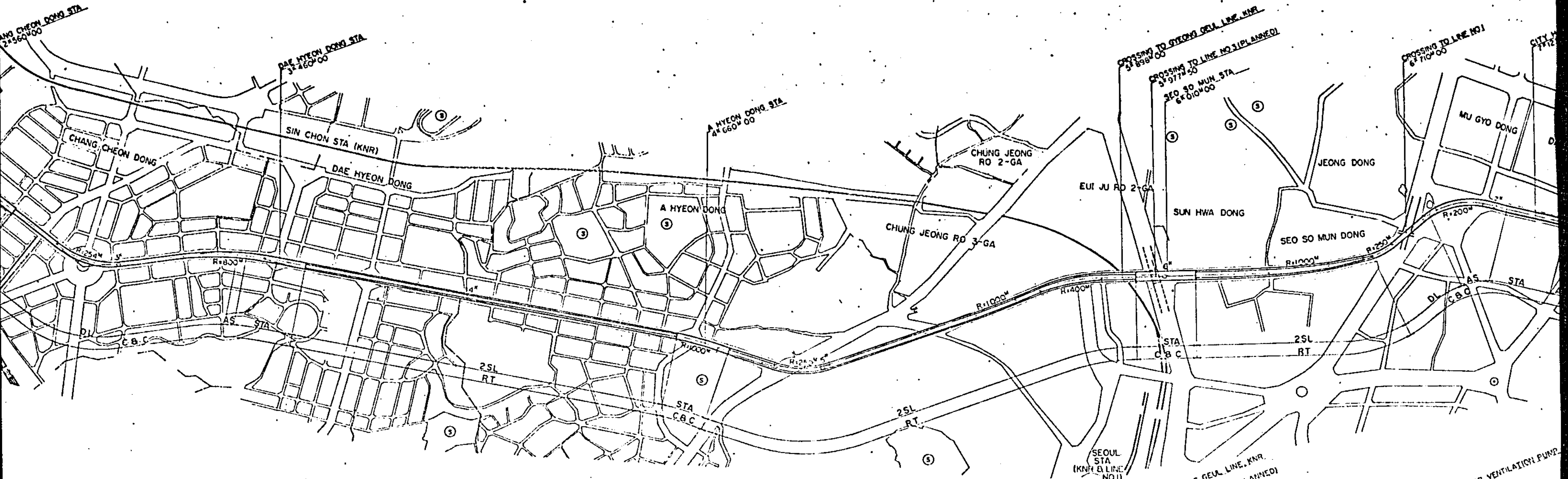
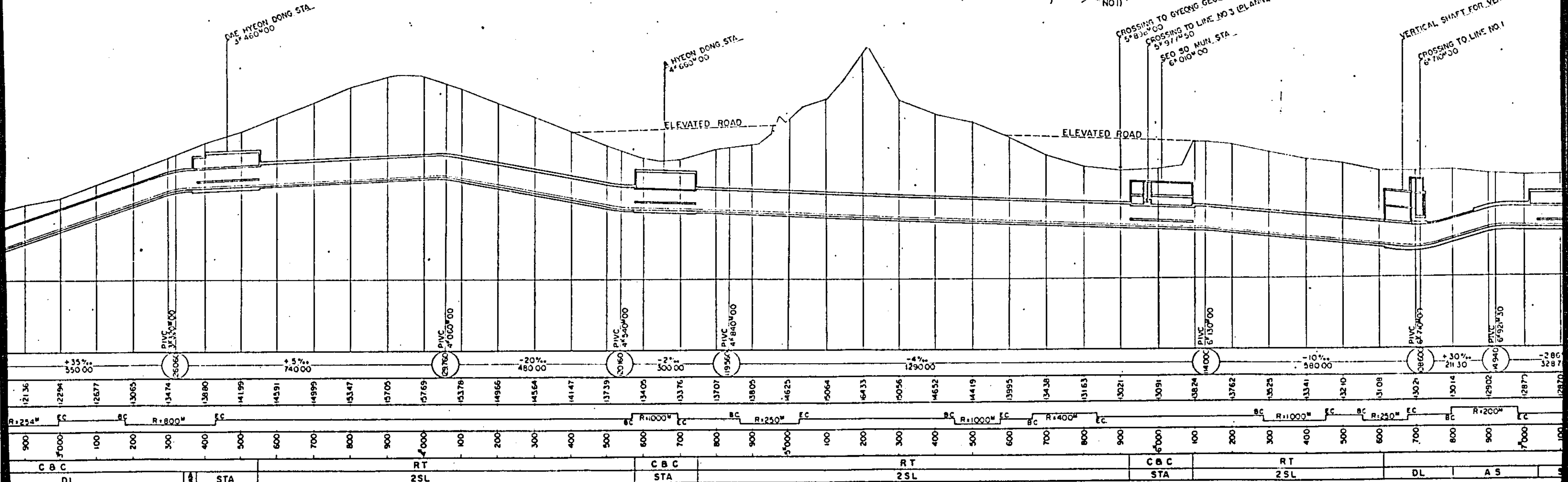


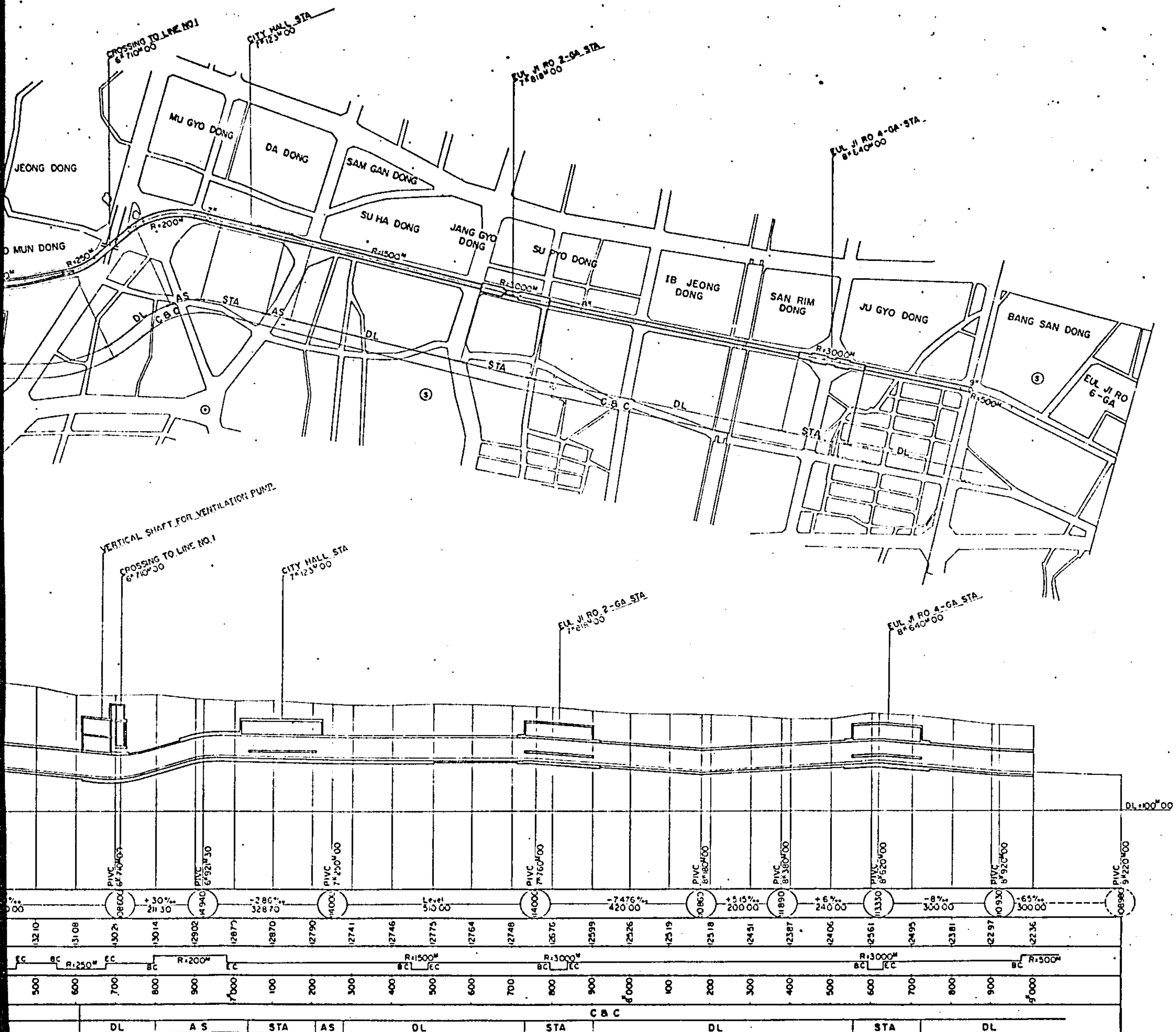

Fig. 4-2 GEOLOGICAL PROFILE ALONG ROUTE


MANG WEON DONG
HAB JEONG DONG
SEO GYO DONG
DONG GYO DONG
CHANGI EON DONG
CHANG CHEON DONG
END OF CONSTRUCTION 0K340M00
SEO GYO DONG STA 0K500M00
DONG GYO DONG STA 1K440M00
CROSSING WITH YONG SAN LINE, KNR 1K827M00
CHANG CHEON DONG STA 2K560M00
KNR
R=504M
R=1200M
R=200M
R=1000M
R=254M
R=800M
DL
C & C
AS
STA
RT


END OF CONSTRUCTION 0K340M00
SEO GYO DONG STA 0K500M00
DONG GYO DONG STA 1K440M00
CROSSING WITH YONG SAN LINE, KNR 1K827M00
CHANG CHEON DONG STA 2K560M00
DAE HYEON DO 3K460M00
DL=100M00
PIVC 0K420M00
PIVC 0K770M00
PIVC 0K960M00
PIVC 1K320M00
PIVC 1K570M00
PIVC 1K990M00
PIVC 2K470M00
PIVC 2K770M00
PIVC 3K320M00
Grade, and Kilopost & Rail Level of PIVC
-2‰
06900
+5‰ 350.00
08650
-20‰ 190.00
04850
-16‰ 360.00
99090
-2‰ 250.00
98590
+25‰ 420.00
09090
-6‰ 480.00
06210
+2‰ 300.00
06810
+35‰ 550.00
26060
Ground Level
115.70
117.06
118.95
120.96
120.66
121.51
120.18
116.24
113.32
112.87
112.60
111.96
112.11
111.89
111.63
112.08
114.40
118.64
118.29
119.46
123.47
127.27
125.99
121.67
118.39
117.48
118.66
121.36
122.94
126.77
130.65
134.74
138.80
141.99
145.91
Curve
BC R=504M EC
BC R=200 EC
BC R=200M EC
BC R=1000 EC
BC R=254M EC
BC R=800M EC
Kilopost
0K000
100
200
300
400
500
600
700
800
900
1K000
100
200
300
400
500
600
700
800
900
2K000
100
200
300
400
500
600
700
800
900
3K000
100
200
300
400
500
600
Structure Type
C & C
AS
STA
AS
DL
STA
DL
RL
DL
C & C
STA
DL
STA


CHANG CHEON DONG STA. 2K560M00
DAE HYEON DONG STA. 3K460M00
CHANG CHEON DONG
SIN CHON STA (KNR)
DAE HYEON DONG
A HYEON DONG STA. 4K660M00
A HYEON DONG
CHUNG JEONG RO 2-GA
CHUNG JEONG RO 3-GA
EUI JU RO 2-GA
CROSSING TO GYEONG GEUL LINE, KNR 5K898M00
CROSSING TO LINE NO.3 (PLANNED) 5K977M50
SEO SO MUN STA. 6K010M00
SUN HWA DONG
JEONG DONG
SEO SO MUN DONG
CROSSING TO LINE NO.1 6K710M00
MU GYO DONG
SEOUL STA (KNR & LINE NO.1)
R=254M
R=800M
R=1000M
R=250M
R=400M
R=200M
AS
STA
DL
C.B.C
2SL
RT

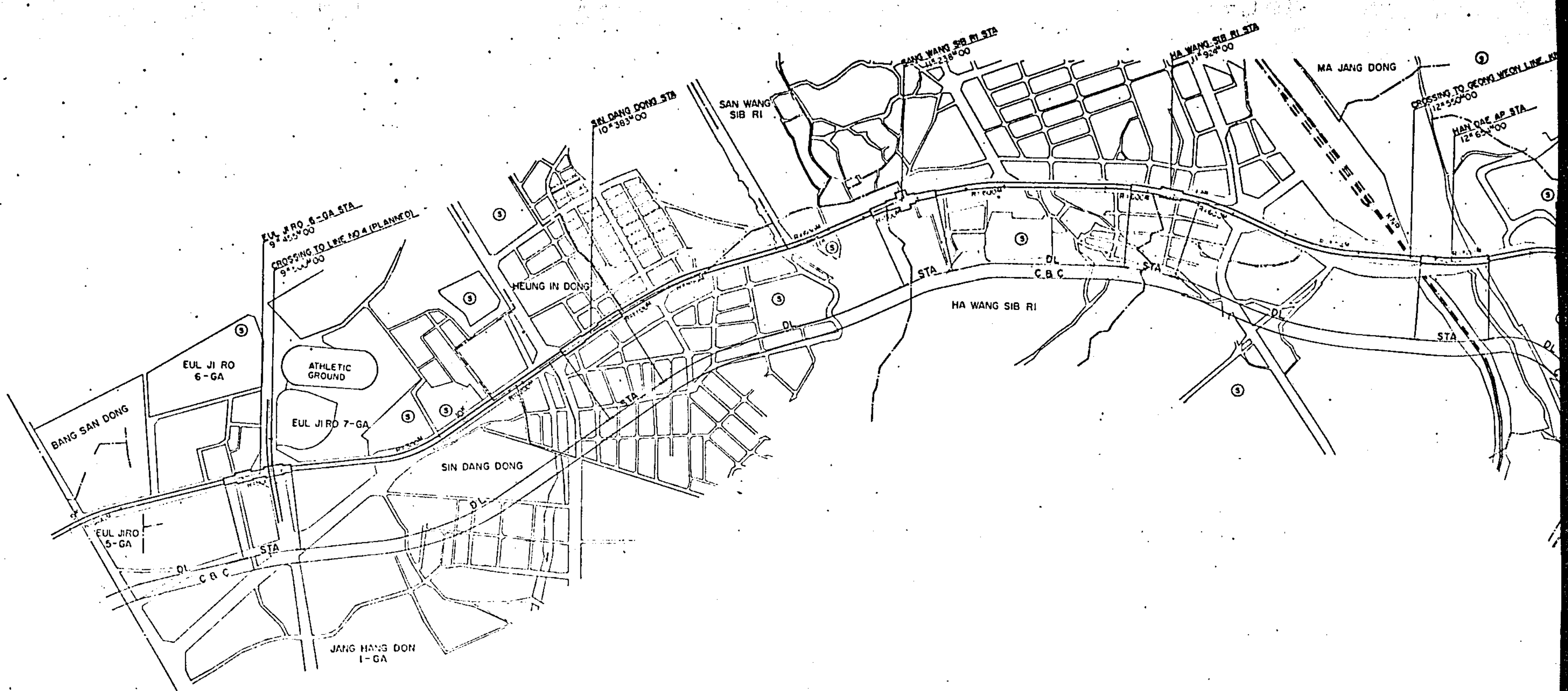

DAE HYEON DONG STA. 3K460M00
A HYEON DONG STA. 4K660M00
ELEVATED ROAD
CROSSING TO GYEONG GEUL LINE, KNR 5K898M00
CROSSING TO LINE NO.3 (PLANNED) 5K977M50
SEO SO MUN STA. 6K010M00
VERTICAL SHAFT FOR VENTILATION PUMP
CROSSING TO LINE NO.1 6K710M00
PIVC 3K340M00
PIVC 4K060M00
PIVC 4K540M00
PIVC 4K840M00
PIVC 6K130M00
PIVC 6K740M00
PIVC 6K923M30
+35‰ 350.00
+5‰ 740.00
-20‰ 480.00
-2‰ 300.00
-4‰ 1290.00
-10‰ 580.00
+30‰ 21.30
R=254M
R=800M
R=1000M
R=250M
R=1000M
R=400M
R=1000M
R=250M
R=200M
C.B.C
DL
STA
RT
2SL
AS

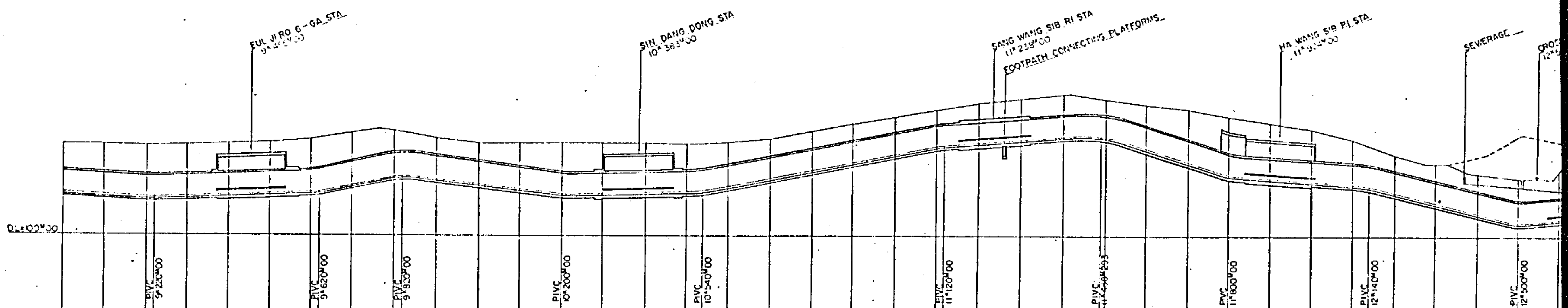



## ABBREVIATIONS

| | |
|---|---|
| STA | Station (Station Center) |
| PIVC | Point of Intersection of Vertical Curves |
| BC | Beginning Point of Curve |
| EC | End Point of Curve |
| R | Curve Radius |
| C&C | Cut-and-Cover (Box Tunnel) |
| AS | Approach Section to Station |
| RT | Rock Tunnel |
| DL | Double Line |
| 2SL | 2-Single Lines |
| Ⓢ | School |

Fig. 4-3
PLAN & PROFILE (1)
$0^{K}340^{M} \sim 9^{K}000^{M}$
(SEO GYO DONG-EUL JI RO 4-GA)



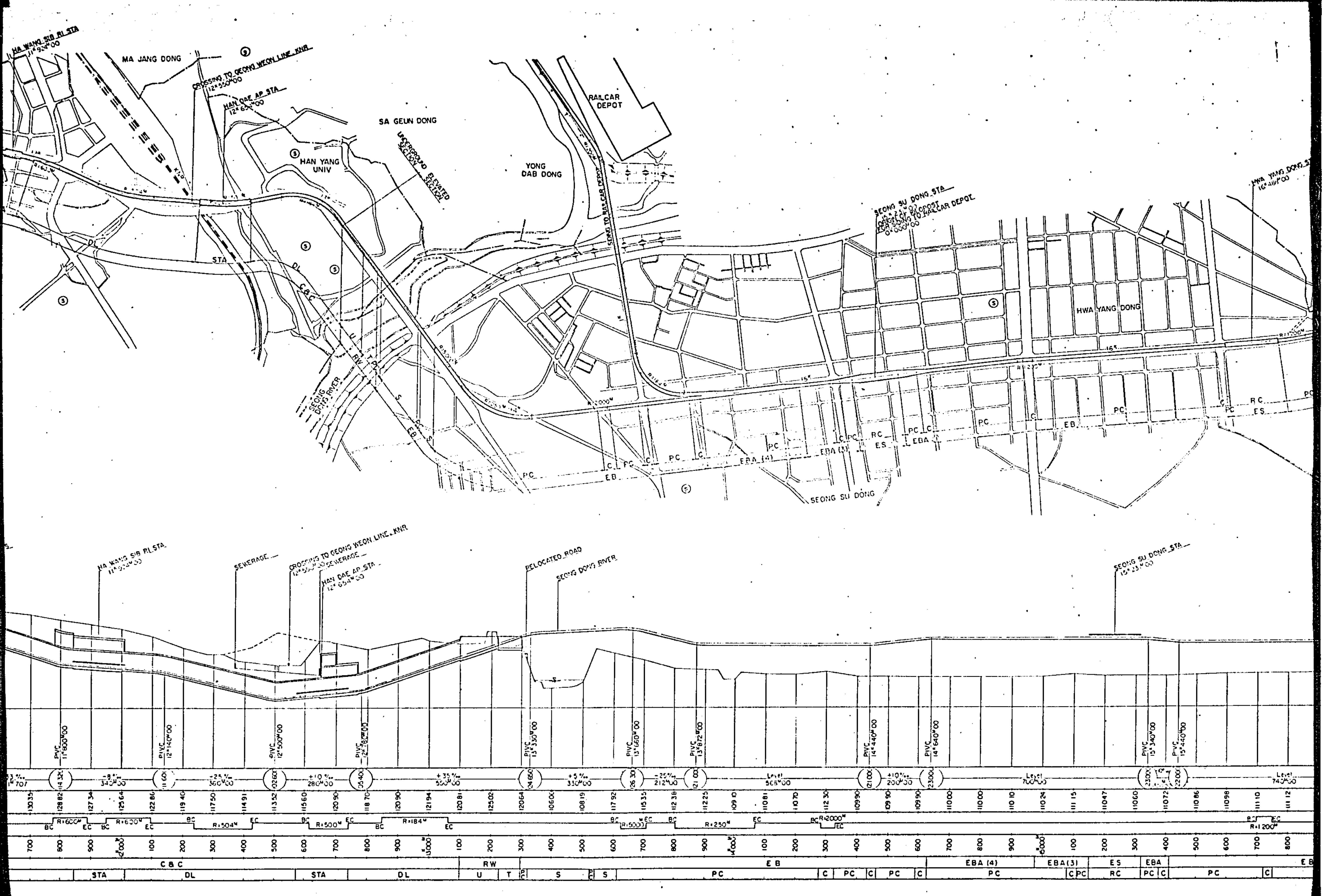

**Grade, and Kilopost & Rail Level of PIVC**

| | Rail Level of PIVC |
| --- | --- |
| -6.5 ‰ 300M00 | (108 98) |
| +3.7 ‰ 400M00 | (104 60) |
| +20.5 ‰ 200M00 | (114 56) |
| -13 ‰ 380M00 | (109 62) |
| +3 ‰ 340M00 | (106 40) |
| +19 ‰ 580M00 | (121 64) |
| +8 ‰ 368M293 | (124 60) |
| -33 ‰ 311M707 | (114 32) |
| -8 ‰ 340M00 | (111 60) |
| -25 ‰ 360M00 | (102 60) |

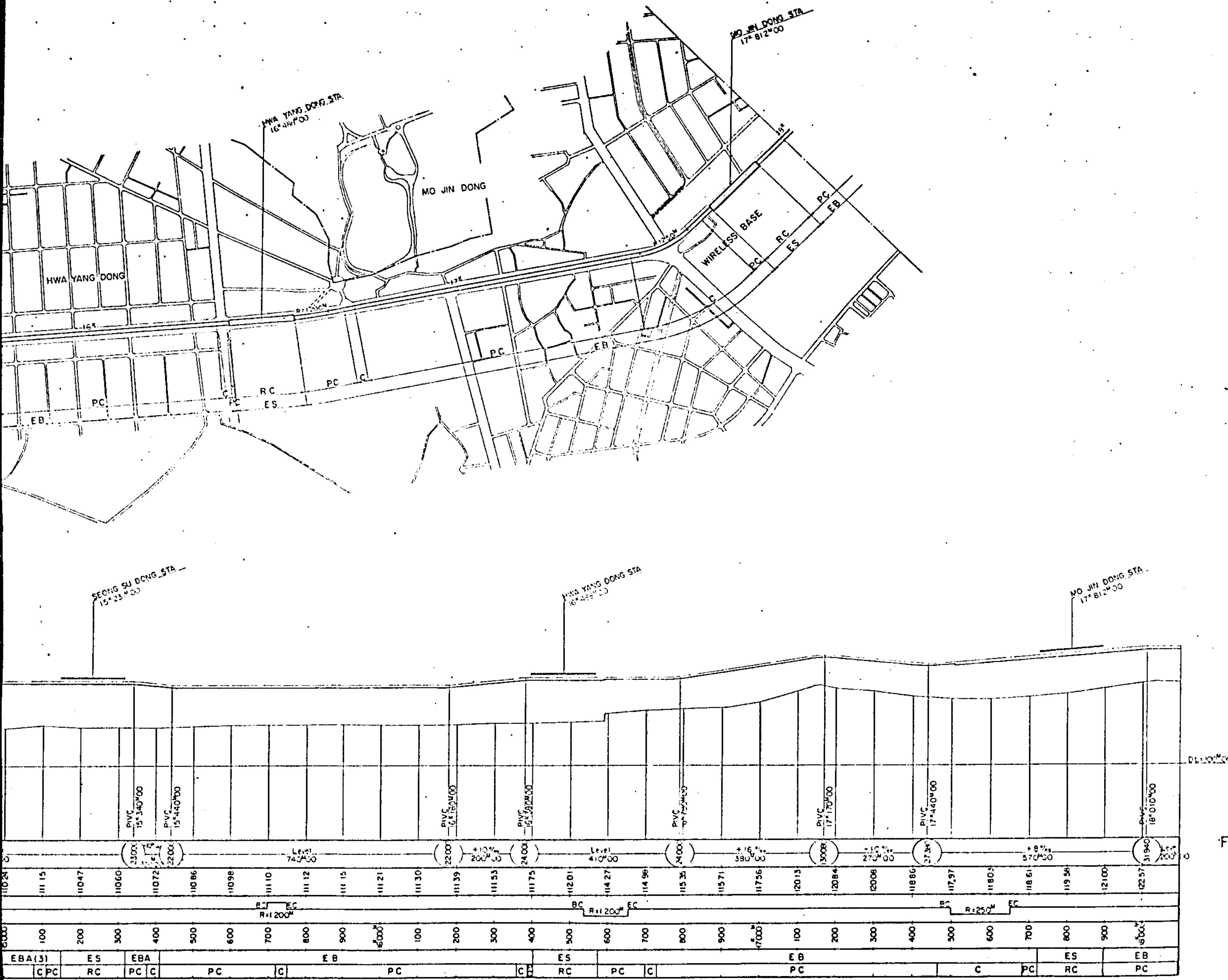
| Kilopost | Ground Level |
| --- | --- |
| 9k000 | 122 36 |
| 100 | 122 17 |
| 200 | 121 97 |
| 300 | 122 07 |
| 400 | 122 27 |
| 500 | 122 57 |
| 600 | 123 46 |
| 700 | 125 23 |
| 800 | 125 49 |
| 900 | 123 68 |
| 10k000 | 122 33 |
| 100 | 122 06 |
| 200 | 122 43 |
| 300 | 122 51 |
| 400 | 122 32 |
| 500 | 122 07 |
| 600 | 122 56 |
| 700 | 123 38 |
| 800 | 125 17 |
| 900 | 126 96 |
| 11k000 | 128 69 |
| 100 | 130 30 |
| 200 | 131 91 |
| 300 | 132 91 |
| 400 | 134 27 |
| 500 | 133 39 |
| 600 | 131 79 |
| 700 | 130 35 |
| 800 | 128 82 |
| 900 | 127 34 |
| 12k000 | 125 64 |
| 100 | 122 86 |
| 200 | 119 40 |
| 300 | 117 50 |
| 400 | 114 91 |
| 500 | 113 52 |
| 600 | 115 60 |

**Curve:** R=500M EC — BC R=900M EC — BC R=300M EC — BC R=1200M EC — BC R=1100M EC — BC R=450M EC — BC R=600M EC — BC R=500M EC — BC R=600M EC — BC R=600M EC — BC R=600M EC — BC R=504M EC — B

**Structure Type:** CBC — DL | STA | DL | STA | DL | STA | DL | STA | DL



HA WANG SIB RI STA
MA JANG DONG
CROSSING TO GEONG WEON LINE, KNR
HAN DAE AP STA
SA GEUN DONG
HAN YANG UNIV
UNDERGROUND SECTION
ELEVATED SECTION
YONG DAB DONG
RAILCAR DEPOT
SIDING TO RAILCAR DEPOT
SEONG SU DONG STA
HWA YANG DONG STA
HWA YANG DONG
SEONG DONG RIVER
SEONG SU DONG
SEVERAGE
RELOCATED ROAD
C B C
RW
E B
EBA (4)
EBA (3)
ES
EBA
STA
DL
PC




ABBREVIATIONS

| | |
|---|---|
| RW | Retaining Wall |
| U | U-Shaped |
| T | Inverted T-Shaped |
| RC | Rigid Frame Reinforced Concrete Structure |
| PC | Prestressed Concrete Girder |
| C | Composite Girder |
| S | Steel Girder |
| EB | Elevated Bridge (Double Line) |
| ES | Elevated Station ( do ) |
| (3X4) | 3 or 4 Tracks |
| EBA | Elevated Bridge (Approach Section to Station) |

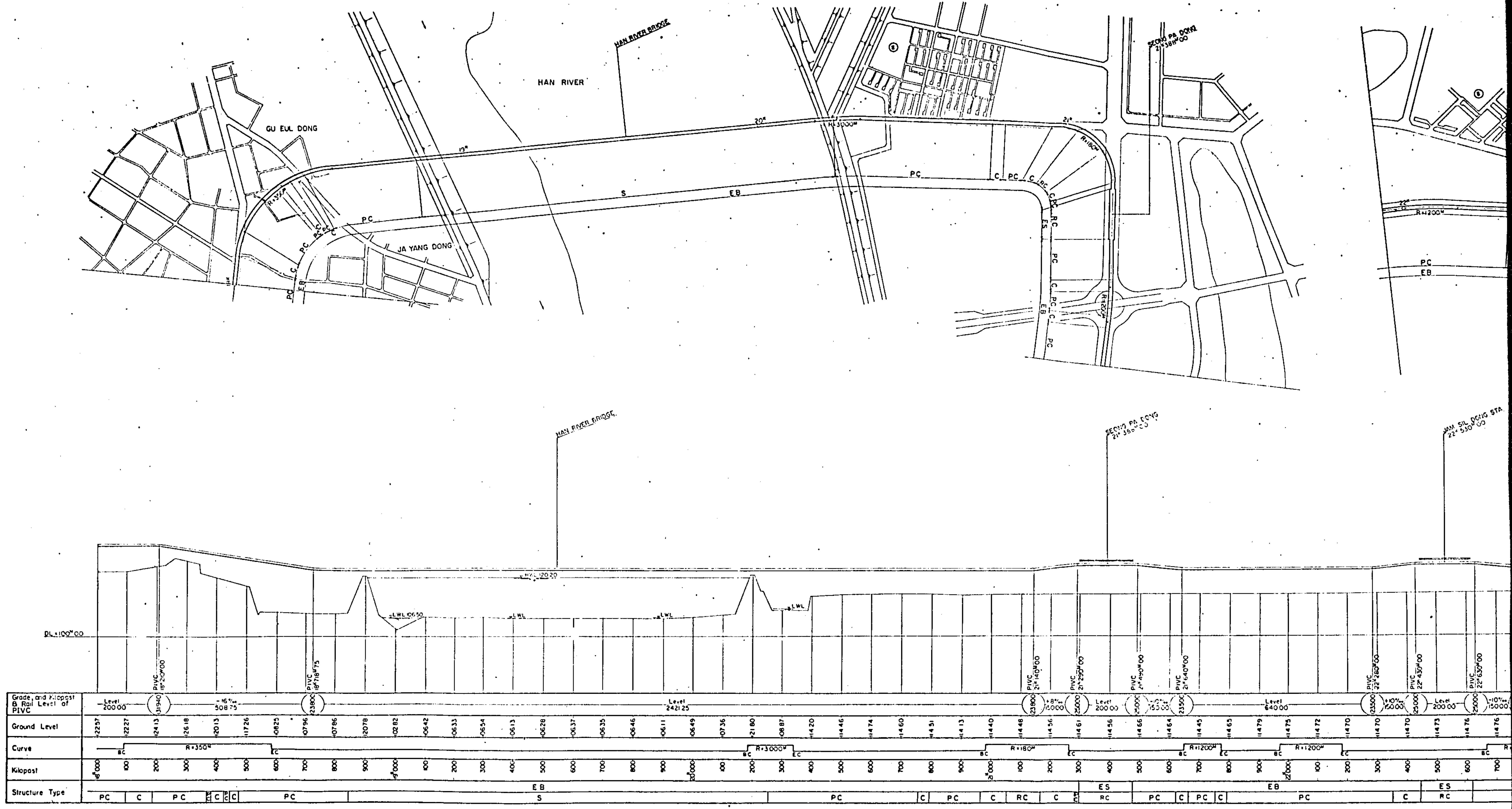
For other abbreviations, refer to Fig 4-4.

Fig. 4-4

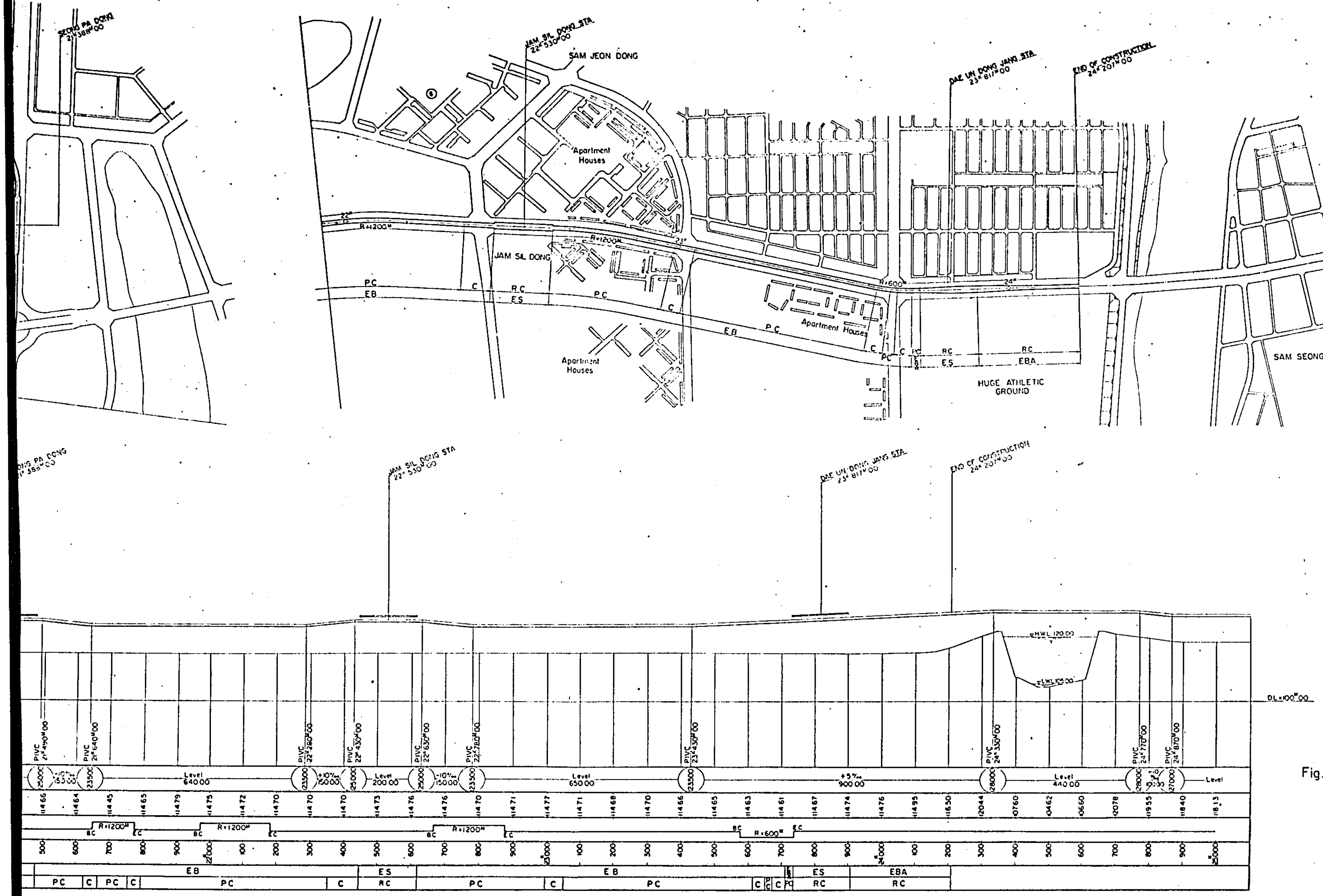
PLAN & PROFILE (2)

$9^{K}000^{M} \sim 18^{K}000^{M}$

(EUL JI RO 6-GA-MO JIN DONG)



GU EUL DONG
HAN RIVER
HAN RIVER BRIDGE
JA YANG DONG
SEONG PA DONG
JAM SIL DONG STA.
DL=100.00
Grade, and Kilopost & Rail Level of PIVC
Ground Level
Curve
Kilopost
Structure Type




ABBREVIATIONS
REFER TO Figs.
4-3 and -4

Fig. 4-5
PLAN & PLOFILE (3)
$18^{K}000^{M} \sim 24^{K}340^{M}$
(SEONG PA DONG-DAE UN DONG JANG)

(2) Profile

a. Consideration on train operation

b. Minimized earthwork, maximum gradient in and between stations

c. Consideration for relation between route and other subways or underground structures under planning

d. Relation between route and buried public utilities both existing and planned

e. Required gradient for drainage and location of pump

f. Consideration on convenience for construction work

Taking above conditions into consideration, the line is located under the middle of the road and the curves between stations are planned with the largest possible radius, avoiding to pass the privately owned land as hard as possible.

In case of the subway section, the cut-and-cover method is adopted. The profile is nearly parallel to the undulated landform to minimize earthwork. However, if cut-and-cover method is applied to the section between Seo Gyo Dong and City Hall, undesirable profile for train operation will result because of the too complicated landform. Therefore, the rock tunnels are planned in some parts of the said section to curtail the construction and operation costs.

As the area located east of the Seong Dong River is the suburban district, the elevated railway system is adopted to cut down the construction cost. For raising train operation speed, steep gradient and sharp curve are to be avoided as far as possible.

The plan and profile of the Line No. 2 between Seo Gyo Dong and Dae Un Dong Jang are as shown in Fig. 4-3 through 4-5.

### 4.3.3 Outline of Alignment and Profile

(1) Seo Gyo Dong Station

The Line No. 2 is expected to be extended farther to Yeong Deung Po District crossing the Han River in future for forming a loop line. Whether crossing the river by means of a bridge or a tunnel is not clear at the stage of the feasibility study. Considering gradient of the approach section to the tunnel or the bridge, the location of the Seo Gyo Dong Station is decided so that the choice of the two alternatives may be possible without any modification of the station. In addition, Seo Gyo Dong Station is the terminal of this project. For the shuttle services, a scissors crossing will be installed at the Dong Gyo Dong side apart from an island type platform. Considering the overnight storage of a railcar train set, the gradient in the station area is to be 5 in 1,000.

(2) Between Dong Gyo Dong and Chang Cheon Dong

Around the kilopost of 1.900 km, a sharp curve with 200 m radius is necessary to avoid adverse effect on the privately owned land. As undulation of the land surface is obvious around the kilopost of 2.300 km, if the route profile is taken as to parallel the surface, up- and down-grading will successively appear alternately, causing disadvantage for train operation. Necessary large-scale earthwork also calls for higher construction costs. Therefore, the double-line rock tunnel method is adopted for this particular section and the tunnel structure is kept at deep position under the ground. By this way, the gradient is properly designed, i.e., 6 in 1,000 for tunnel section, and 2 in 1,000 for Chang Cheon Dong Station.

(3) Between Chang Cheon Dong and Dae Hyeon Dong

Taking into consideration the existing sewerage near Chang Cheon Dong Station, which crosses the Line No. 2, and location of A Hyeon Dong Station, the gradient of this section is to be 35 in 1,000 to parallel with the gradient of the road.

(4) Between Dae Hyeon Dong and Crossing with Rapid Transit Line No. 1 (6.700 km)

The section between A Hyeon Dong and Seo So Mun is in rugged terrain and the road, under which Line No. 2 is constructed, traverses the wide low plain with the elevated bridge. If the gradient of the Line No. 2 is designed to parallel with the gradient of the road, steep up- and down-grading will alternately occur and formation level will be deep in many localities, especially in cases of crossing under the existing Line No. 1.

Therefore, in order to curtail the operation, maintenance and construction costs, the rock tunnel method is adopted for the sections between stations. As to the construction method of the stations, cut-and-cover method is adopted, taking into consideration the necessity of minimizing earthwork. The profile of the Route No. 2 is quite acceptable for the scrupulous process mentioned above.

As this section is close to the foundations of the elevated road, two single line rock tunnels located at both sides of foundations are planned. In relation to the two single line tunnels, the underground two level island platform is adopted for Dae Hyeon Dong, A Hyeon Dong and Seo So Mun Stations.

Because of the unavoidable alignment, the route will pass under the private land with rock tunnel, the depth of which is 13 - 41 m under the ground.

The Line No. 2 is planned to cross the Line No. 3 at Seo So Mun in future. Considering necessary depth for the rock tunnel of the Line No. 2, it is planned that the Line No. 2 crosses under the Line No. 3.

(5) Between City Hall and Ha Wang Sib Ri

This section is comparatively flat and the road alignment is nearly straight. The Line No. 2 is designed to go under the central position of the road.

Eul Ji Ro 6-Ga Station is planned in view of passengers' convenience to and from the Line No. 4 in future.

The fresh rock is exposed around Sang Wang Sib Ri Station and excavation into rock is difficult. To minimize the excavating amount, a single level underground station is taken for Sang Wang Sib Ri Station.

(6) Between Ha Wang Sib Ri and the Seong Dong River

As to the section around 12.500 km, if the Line No. 2 is located under the road, the construction might be very difficult, because there are two crossing sewerages and Gyeong Weon Railroad of KNR. In addition, the road is of a bank structure. Therefore, it is planned that the Line No. 2 passes through private land partially.

A 180 meter curve is used at about 13.000 km for locating City Hall Station. As this part is the transition section to the elevated railway, the gradient 35 in 1,000 is adopted.

(7) Between the Seong Dong River and the Han River

The gentle gradient is planned for the elevated railway section, but gradient 25 in 1,000 is necessary for the road crossing portion near the Seong Dong River.

As Seong Su Dong Station is the junction to the railcar depot siding, two island platforms with an inside loop line facing both platforms will be installed.

The planned route in front of the wireless base will affect the activities of the base. If such disturbances are foreseeable, it is necessary to relocate the alignment so that the detailed study is recommendable on this subject.

(8) Between Han River and Dae Un Dong Jang

At 21.500 km, close to Seong Pa Dong Station, a sharp curve with radius of 180 meter is used to minimize passing space through privately owned land.

As Dae Un Dong Jang is a terminal station of this project, a scissors crossing will be installed at the Jam Sil Dong side. Considering concentration of the passengers after the games are over at the studium, an island type platform is planned. The storage tracks will be laid at the Han River side considering the future extension. The gradient of station section and storage tracks are advocated to be 5 in 1,000 also in contemplation for the future extension.

4.4 Location and Interval of Stations

The location of the station should be decided properly so that the related rapid transit line itself and the transit railway system as a whole may function effectively in full accord with other transport system and urban facilities. In addition, the location of the stations shall be convenient for the passengers' accessibility and transferring to the other modes of transport. It is also in line with the master city planning for the future zoning.

In general principle, the interval of the two adjoining stations is 0.7 - 1.0 km in urban district in view of passengers' convenience and 1.5 km or thereabout in suburban districts for gaining the schedule speed of the trains. Too short interval of stations cannot maintain rapid operation, causing increase of the costs by elongation of operation time, increase in train consist, additions of signal and safety devices, train crew, station staff, etc., even though inhabitants along the lines may be satisfied. Especially, when intermediate stations are planned, a most careful study is required.

The location of each station is as shown Table 4-1. Average distance of stations is 935 meter in the underground railway whereas 1,517 meters in the elevated railway, except for the section crossing over the Han River.

Table 4-1 Station

| | Station | Kilopost at Center of Station (km) | Station Interval (km) |
|---|---|---|---|
| | Beginning Point of Construction | 0.340 | |
| 1 | Seo Gyo Dong | 0.500 | |
| | | | 0.940 |
| 2 | Dong Gyo Dong | 1.440 | |
| | | | 1.120 |
| 3 | Chang Cheon Dong | 2.560 | |
| | | | 0.900 |
| 4 | Dae Hyeon Dong | 3.460 | |
| | | | 1.200 |
| 5 | A Hyeon Dong | 4.660 | |
| | | | 1.350 |
| 6 | Seo So Mun | 6.010 | |
| | | | 1.113 |
| 7 | City Hall | 7.123 | |
| | | | 0.695 |
| 8 | Eul Ji Ro 2-Ga | 7.818 | |
| | | | 0.822 |
| 9 | Eul Ji Ro 4-Ga | 8.640 | |
| | | | 0.815 |
| 10 | Eul Ji Ro 6-Ga | 9.455 | |
| | | | 0.928 |
| 11 | Sin Dang Dong | 10.383 | |
| | | | 0.855 |
| 12 | Sang Wang Sib Ri | 11.238 | |
| | | | 0.686 |
| 13 | Ha Wang Sib Ri | 11.924 | |
| | | | 0.730 |
| 14 | Han Dae Ap | 12.654 | |
| | | | 2.577 |
| 15 | Seong Su Dong | 15.231 | |
| | | | 1.257 |
| 16 | Hwa Yang Dong | 16.488 | |
| | | | 1.324 |
| 17 | Mo Jin Dong | 17.812 | |
| | | | 3.576 |
| 18 | Seong Pa Dong | 21.388 | |
| | | | 1.142 |
| 19 | Jam Sil Dong | 22.530 | |
| | | | 1.287 |
| 20 | Dae Un Dong Jang | 23.817 | |
| | End of Construction | 24.207 | |

## 4.5 Outline of Major Stations

### (1) Seo Gyo Dong Station

This station, the terminal of this project is located to the north of Han Gang Bridge No. 2. Around the station are many residential districts. The location of the station is decided in view of the future extension of the Line No. 2.

### (2) Dae Hyeon Dong Station

It is the connecting station to Sin Chon Station of the Gyeon Eul Railroad, KNR. The station is located in the central position of schools and shopping areas.

### (3) Seo So Mun Station

This station is located at the crossing of two major roads and will become connecting station to the Line No. 3 in future.

### (4) City Hall Station

This station is the connecting point to the Line No. 1 and located just under the urban center of Seoul. Around the station are governmental offices, hotels, banks, shops and restaurants.

### (5) Eul Ji Ro 2-Ga Station

Being located at the center of the business district, it serves as the Myeong Dong district which is the most bustling quarter in Seoul.

### (6) Eul Ji Ro 6-Ga Station

This station is the connecting point to the Line No. 4 in future. There are theaters, the Seoul Stadium and shopping districts around the station.

### (7) Seong Su Dong Station

In the vicinity are the residential and manufacturing industry districts. This station is a junction of the rail-car depot siding.

(8) Mo Jin Dong Station

This station is located at the trunk road and near the wireless base.

(9) Seong Pa Dong

Being located to the south of the Han River, this station serves a part of the passengers from the apartment houses in Jam Sil district. It is located at the proper point for bus connection to and from Cheon Ho Dong.

(10) Jam Sil Dong Station

The station is located at the center of the apartment house complex in Jam Sil district. Lots of commuters and students will avail themselves of this station in the morning and in the evening. The highest peak ratio of commuters will be recorded in this station.

(11) Dae Un Dong Jang Station

This station is close to the huge asthletic studium which accommodates 200,000 spectators. When the Line No. 2 is opened and proper connecting bus system is organized, passengers from Seong Nam City which is located 4 km south of this station, a satelite city of Seoul, will increase tremendously.

4.6 Major Items of Line No. 2

Major items of the Line No. 2 between Seo Gyo Dong and Dae Un Dong Jang are as follows:

1) Route Length

| | |
|---|---|
| Construction Length: | 23.867 km |
| Length of Operating Kilometers: | 23.317 km |
| (Between centers of terminals) | |

2) Station

Stations classified by type are as follows:

Table 4-2 Station Type

| | Type of Platform | | Total |
|---|---|---|---|
| | Island Platform | Separate Platform | |
| Underground Section | 5 | 9 | 14 |
| Elevated Section | 2 | 4 | 6 |
| Total | 7 | 13 | 20 |

3) Structure

Railway structures of the main line classified by type are as follows:

Table 4-3 Structure Type

| | Type | Section | Aggregate Route Length |
|---|---|---|---|
| Underground Section | Cut-and-Cover (Box Tunnel) | Station, Double Line | 9,740 m |
| | Single Line Rock Tunnel | 2-Single Lines | 2,724 |
| | Double Line Rock Tunnel | Double Line | 295 |
| Elevated Section | Prestressed Concrete Girder Elevated Bridge | Do. | 6,043 |
| | Composite Girder Elevated Bridge | Do. | 1,204 |
| | P.C. Rigid Frame Elevated Bridge | Station, Double Line | 1,974 |
| | Deck Steel Girder Bridge | River | 1,689 |
| | Earthwork with Retaining Wall | Transition Portion between Underground and Elevated Sections | 198 |
| Total | | | 23,867 m |

4) Minimum Curve Radius

| | | |
|---|---|---|
| Underground Section | Near Han Dae Ap | 180 m |
| Elevated Section | Near Seong Pa Dong | 180 |

5) Steepest Grade

| | | | |
|---|---|---|---|
| Main Line | Underground Section | Near 3.000 km and Near Han Dae Ap | 35 in 1,000 |
| | Elevated Section | Near Seong Dong River | 25 in 1,000 |
| Station | Underground Station | Han Dae Ap | 10 in 1,000 |
| | Elevated Station | Dae Un Dong Jang | 5 in 1,000 |

6) River Bridge

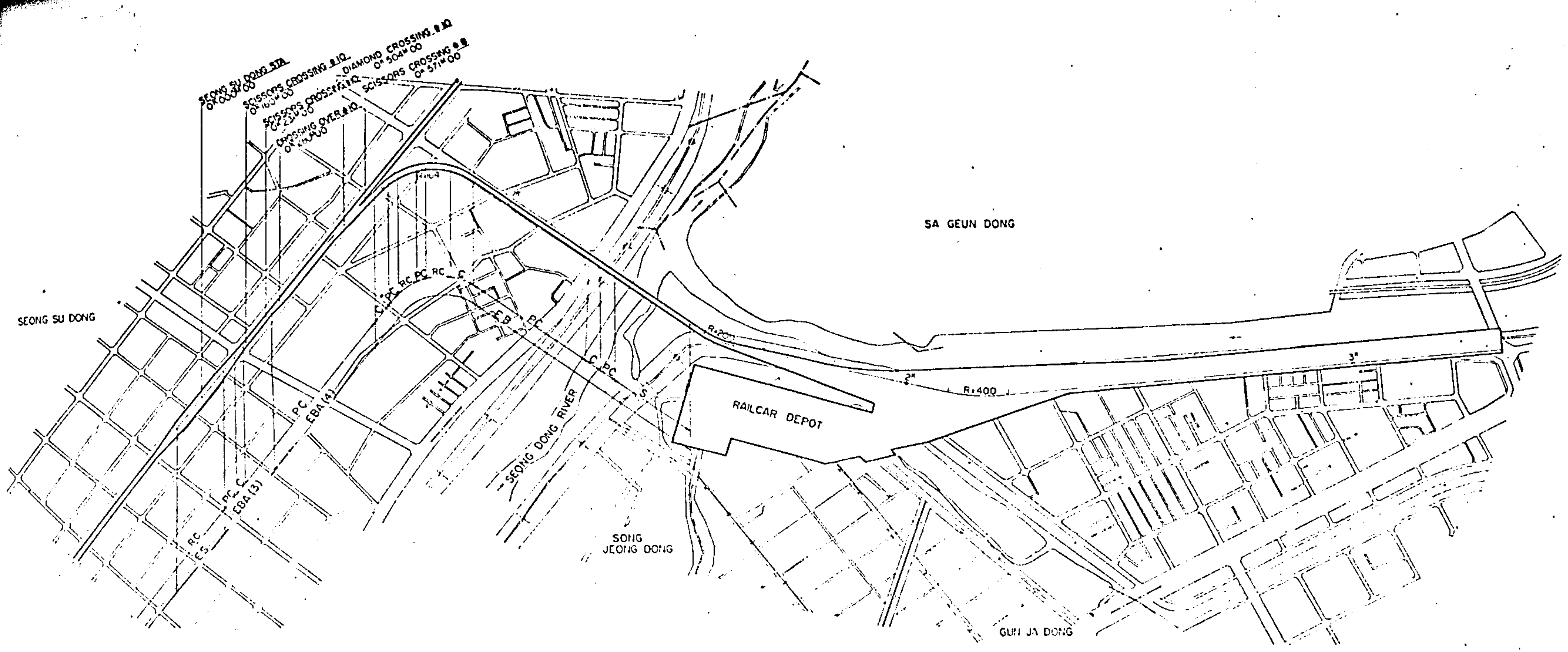
| | |
|---|---|
| Seong Dong River | 240 m |
| Han River | 1,310 |

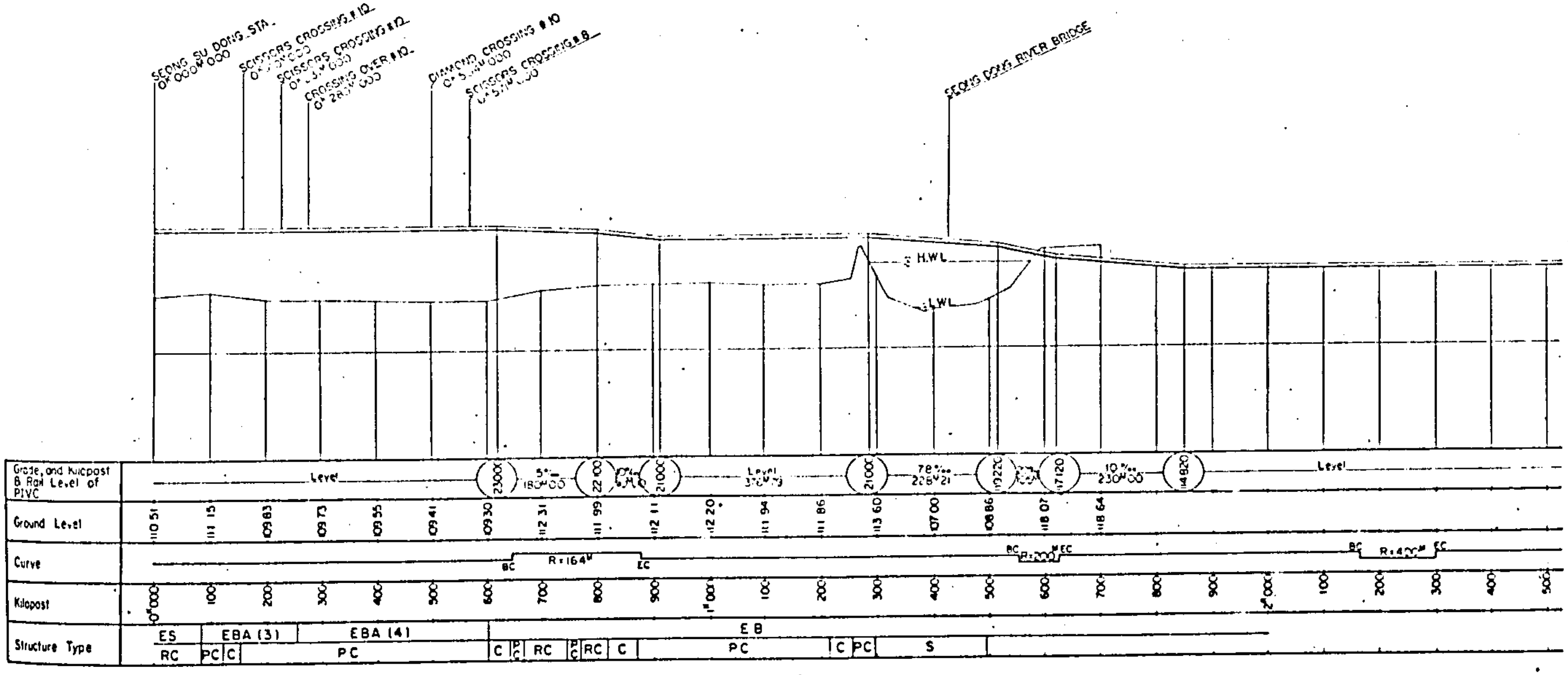
7) Crossing Other Railways

The other railways which cross the Line No. 2 are as shown in Table 4-4:

Table 4-4 Railways Crossing Line No. 2

| Crossing Point or Station | Crossing Railways | Passenger Connection | Existing or Planned |
|---|---|---|---|
| Dong Gyo Dong | Yong San R.R., KNR | No | Existing |
| Seo So Mun | Cheon Geul R.R., KNR | No | Existing |
| Do. | Rapid Transit Line No. 3 | Yes | Planned |
| City Hall | Do. No. 1 | Yes | Existing |
| Eul Ji Ro 6-Ga | Do. No. 4 | Yes | Planned |
| Han Dae Ap | Gyeong Weon R.R., KNR | No | Existing |




ABBREVIATIONS
REFER TO Figs.
4-3 and 4

Fig. 4-6
PLAN & PROFILE
(SIDING TO RAILCAR DEPOT)

8) Track Layout

Track layout of the Line No. 2 between Seo Gyo Dong and Dae Un Dong Jang is as shown in Fig. 4-7.

## 4.7 Car Depot and Siding

### 4.7.1 Railcar Depot

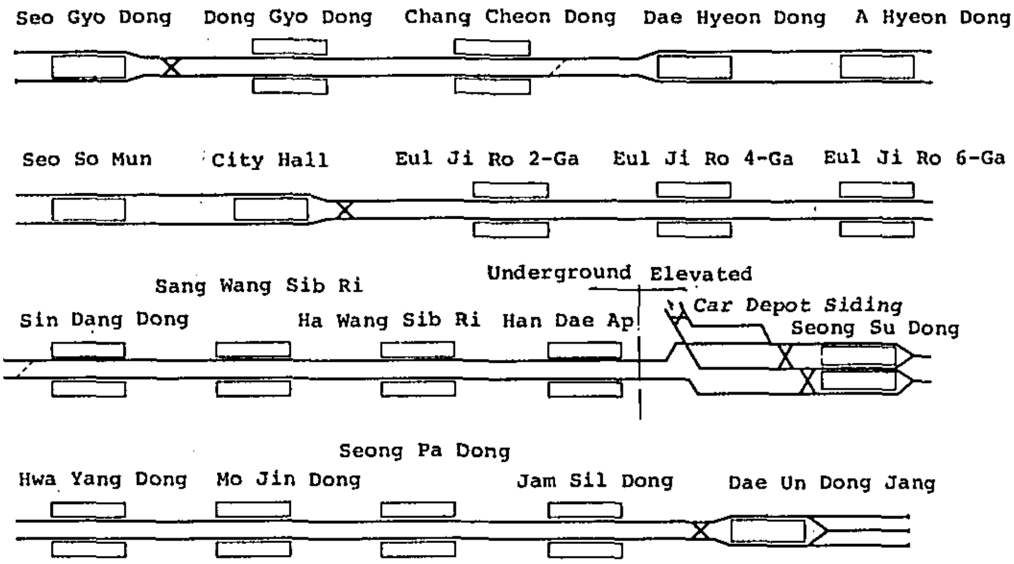
The railcar depot for the Line No. 2 will be shared with the Line No. 1 which is being constructed at Gun Ja Dong. The railcar depot is located at 1.2 km north of the Line No. 2. The area is 174,000 sqare meters, storage capacity is 410 railcars and the total area of buildings is 44,000 square meters. The right of way has already been secured. As the land was used for the water reservoir, the ground level is too low which requires soil filling of 350,000 cubic meters. The soil for this purpose will be supplied with the waste from the Line No. 2 construction and other civil works in Seoul. In addition, installation of a girder for crossing the waterway and retaining wall at the boundary of the river will be required for the railcar depot construction.

### 4.7.2 Car Depot Siding

Taking into consideration the geographical conditions, easy construction, economy, layout of joint station and train operation, the branching station decided to be Seong Su Dong, as shown in Fig. 4-6 and 7. The outline of the siding is as follows:

| | | |
|---|---|---|
| (1) | Route Length | Between Seong Su Dong and Car Depot 1.097 km |
| (2) | Curve Radius | 160m-curve is used at the branching off section from the main line; 200m-curve is used at the approach section to the railcar depot. |
| (3) | Grade | 20 in 1,000 is used at the approach section to the railcar depot. |

Fig. 4-7 Schematic Track Layout of Line No. 2 between Seo Gyo Dong and Dae Un Dong Jang




(4) Structure

| | |
|---|---|
| P.C. Elevated Bridge | 435 m |
| Composite Elevated Bridge | 133 |
| Reinforced Concrete Elevated Bridge | 155 |
| Deck Steel Girder Bridge | 200 |
| Bank | 174 |

(5) River Bridge Seong Dong River 220 m

As the left side of the Seong Dong River is lower than the high water level, a part of the river is to be filled.

### 4.7.3 Layout of Junction Station

There are two kinds of layout for the junction station in view of the crossing method between the main line and the car depot siding, both being of the double track. One is the level crossing type and the other is grade separated type. For deciding the type of layout, in addition to the operational convenience such as the train arrival and departure from the depot, shunting, shuttle operation in case of some troubles etc., safety operation, maintenance, construction cost, workability as well as regional speciality, urban development, etc. should be synthetically taken into consideration.

The results of the study on the above conditions are that the layout of the Seong Su Dong Station is level crossing type as shown in Fig. 4-7. This station has two island type platforms with a loop line at the inside position. By this layout, train operation and maintenance work will be performed quite satisfactorily, even when the train interval is shortened in the future.

In general, in case of crossing between the two main lines, the grade separation crossing is introduced. Where the main line and siding of the railcar shed is crossed, level crossing is used predominantly and the grade separation crossing is rather few.

# 5. Train Operation

## 5.1 Transportation Planning

### 5.1.1 Fundamentals of Planning

All the trains are expected to stop at all stations. When the line is placed in service partially, the train is operated between City Hall and Dae Un Dong Jang; and when the overall line is placed in service, it is to be operated between Seo Gyo Dong and Dae Un Dong Jang. In addition, the shuttle service on the way, the splitting up and combination of train consists would not be effected in this case.

### 5.1.2 Establishment of Transport Capacity

#### 5.1.2.1 Congestion Ratio

It is recommendable that the average congestion ratio per hour during rush hours at the time of partial placing in service in 1982 and the overall opening of service in 1984 would be held down less than 190%. The smooth transportation is assured of thereby at the traffic peak during the rush hours.

#### 5.1.2.2 Business Hours

It is expected that the initial departure time and the final arrival time at the terminal would be the same as in the case of the Line No. 1. The approximate time would be as shown hereunder.

| | |
|---|---|
| The first-train departure time | 4:30 a.m. |
| The last-train arrival time | 11:30 p.m. |

#### 5.1.2.3 Transportation Unit

The rolling stock in use would be, as shown in Chapter 6, the same as those on the Line No. 1, with the same seating capacity. The traffic demands and passengers' convenience would concurrently be taken into consideration. At the time of the overall placing in service, eight-coach consists would be in use with the least headway of 3.5 minutes. While at the time of partial placing in service, the same eight-coach consists with the least headway of 5 minutes, slightly longer than the former, would be recommendable.

#### 5.1.2.4 Traffic Capacity

The traffic capacity in the most congested section at the time of the partial placing in service in 1982 and the overall opening in 1984 is as shown in Table 5-1:

Table 5-1 Traffic Volume

| year | Item / Section | Rush Hours (Traffic Volume per hour) | | | | | Slack Hours (Time interval) | |
|---|---|---|---|---|---|---|---|---|
| | | Traffic Volume (one-way) | Traffic Capacity (one-way) | Train consist | Operation headway | Average Congestion ratio | Daytime | Early morn., Mid-night |
| 1982 | Sin Dang Dong . Sang Wang Sib Ri | 28,956 prsns | 15,072 prsns | 8 rail-car | 5 min. | 192% | 8 min. | 10 min. or longer |
| 1984 | A Hyon Dong . Seo So Mun | 38,969 prsns | 21,531 prsns | 8 rail-car | 3.5 min | 181% | 6 min | 10 min. or longer |

The traffic volume is expected to increase gradually after 1984, as is described in Chapter 3. A further decrease in the operation headway would be taken into consideration in future as the necessity arises.

## 5.2 Operation Planning

### 5.2.1 Operating Hours

#### 5.2.1.1 Conditions of Assessment

a) Train consist

The consist would be made up of light coaches, i.e.,

Tc M M' M M' M M' Tc

b) Utilization ratio

In consideration of the situation during peak hours, 230% is assessed.

c) The maximum speed

Between the two way stations, there are two sections which are over two km. Furthermore, when the line is extended to Gang Num District over the Han River, the distance between the stations would naturally be lengthened and the design maximum speed is to be 95 km/h.

d) Accleration and deceleration
In order to have sufficient allowances for making up for the delay, 2.5 km/h/sec has been adopted in each case.

e) Initial braking speed 70 km/h

f) Stopping time as intermediate stations

In consideration of the fact that the passengers would not be well accustomed to getting on and off the trains at the time of partial placing in service, 30 minutes have been adopted. As to the stopping time when all the stations are placed in service, 30 seconds are adopted as a principle, when in some stations 20 seconds have been diagramed.
Furthermore, the marginal time for the partial placing in service has been allowed slightly in comparison with that of the total placing in service.

5.2.1.2 Schedule Time and Schedule Speed

The running time between stations are shown in Table 5-2 and 5-3, as assessed in accordance with the aforementioned conditions. The time and the speed in line with schedule at the time of both partial and the total placing in service are as follows:

Partial placing in service (City Hall - Dae Un Dong Jang)

| Schedule time | Schedule speed |
|---|---|
| 31 min. | 32.3 km/h |

Total placing in service (Seo Gyo Dong. Dae Un Dong Jang)

| | |
|---|---|
| 41 min. | 34.1 km/h |

5.2.2 Train Diagram

The train diagram is to be set up taking into consideration the aforementioned running time, based on the following conditions.

a) The shuttling time at both terminals during the rush hours would be 6.5 minutes for the partial placing in service and 4.5 minutes for the total.

b) The storage of a car consist during the night would be effected at City Hall, Seong Su Dong and Dae Un Dong Jang Stations for the partial placing in service, while the night storage during the total placing in service would be effected at Seo Gyo Dong, Seong Su Dong and Dae Un Dong Jang Stations. The foregoing conditions and the running time intervals have been taken into consideration. The tentative train diagram has thus been worked out. The number of trains operated per day is as follows:

| | |
|---|---|
| For the partial placing | 320 trains |
| For the total placing | 430 trains |

5.3 Required Number of Rolling Stock

The number of train consist in service is dependent on the operation time interval, the schedule time, and the shuttling time at both terminals.

To wit, the required number is given by the following equation:

$$N = \frac{(T + t) \times 2}{p}$$

where, N: Number of train consist in service

T: Schedule time

t: Shuttling time at both terminals

p: Operating time interval

In this way, the number of train consist in service is as follows:

Partial placing in service ..... 15 train sets
Total placing in service ....... 26 train sets

As for the reserve consist, the following car sets are kept in reserve.

| | Partial placing in service | Total placing in service |
|---|---|---|
| Operation car set in reserve | 1 | 1 |
| Do. for monthly inspection | 1 | 2 |
| Do. for overall inspection | 1 | 1 |

Therefore, the required car sets in reserve would be as follows:

| Partial placing in service | Total placing in service |
|---|---|
| 18 | 30 |

The required number of railcars is as follows:

| Partial placing in service | Total placing in service |
|---|---|
| 144 | 240 |

All the aforementioned railcars are assigned to the car depot which is to be installed at Fun Ja Dong. As a matter of principle, the railcars in operation are kept on the storage track at the car depot. However, from the operation necessity, three train consists only are to be kept in Dae Un Dong Jang, Seong Su Dong and Seo Gyo Dong Stations. (as for the partial placing in service, City Hall will take its place)

5.4 Required Number of Train Crew

As for the train crew, their duties aboard the train would be assigned to both motorman and conductor, one man each in every case.

The required number of motormen is obtained by the following equation:

$$N = \frac{(eT + t_l + t_w)\ n}{L} (1 + s)$$

N: Required number of motormen

e: Operation ratio of rolling stock

= 73% (for the partial placing in service)

68% (for the total placing in service)

T: Service hours per day (19 hrs.)

$t_l$: Average hours required for inspection per train consist in service (6hrs.)

$t_w$: Average lead time per train consist in service (4.5 hrs.)

n: Number of operating train consist in service
= 15 (for the partial placing in service)
= 26 (for the total placing in service)

s: Reserve ratio ( = 0.1)

L: Actual working hours per person (7 hrs.)

The required number of motormen calculated by means of the aforementioned equation is as follows:

57 prsns (for the partial placing in service)
96 prsns (for the total placing in service)

The number of conductors is to be the same as the motormen.

The train crew control office is to be installed within the car depot compound. Likewise, to be installed are the service office and the resthouse for the train crew at Seo Gyo Dong, Seong Su Dong and Dae Un Dong Jang.

Table 5-2 Operation Time between Station (Partial Placing in Service)

| Down | | | Station | Up | | | Kilometrage at Station Center | Station Distance |
|---|---|---|---|---|---|---|---|---|
| Total | Stopping Time | Operation Time | | Operation Time | Stopping Time | Total | | |
| | | | City Hall | | | min.sec. 31. 00 | km 7.123 | |
| | | min.sec. 1. 30 | | min.sec 1. 20 | | | | km 0.695 |
| min.sec. 1. 30 | min.sec. 0. 30 | | Eul Ji Ro 2-Ga | | min.sec. 0. 30 | 29. 10 | 7.818 | |
| | | 1. 20 | | 1. 30 | | | | 0.822 |
| 3. 20 | 0. 30 | | Eul Ji Ro 4-Ga | | 0. 30 | 27. 10 | 8.640 | |
| | | 1. 30 | | 1. 20 | | | | 0.815 |
| 5. 20 | 0. 30 | | Eul Ji Ro 6-Ga | | 0. 30 | 25. 20 | 9.455 | |
| | | 1. 30 | | 1. 30 | | | | 0.928 |
| 7. 20 | 0. 30 | | Sin Dang Dong | | 0. 30 | 23. 20 | 10.383 | |
| | | 1. 40 | | 1. 30 | | | | 0.855 |
| 9. 30 | 0. 30 | | Sang Wang Sib Ri | | 0. 30 | 21. 20 | 11.238 | |
| | | 1. 20 | | 1. 20 | | | | 0.686 |
| 11. 20 | 0. 30 | | Ha Wang Sib Ri | | 0. 30 | 19. 30 | 11.924 | |
| | | 1. 20 | | 1. 20 | | | | 0.730 |
| 13. 10 | 0. 30 | | Han Dea Ap | | 0. 30 | 17. 40 | 12.654 | |
| | | 3. 30 | | 3. 30 | | | | 2.577 |
| 17. 10 | 0. 30 | | Seong Su Dong | | 0. 30 | 13. 40 | 15.231 | |
| | | 1. 40 | | 1. 40 | | | | 1.257 |
| 19. 20 | 0. 30 | | Hwa Yang Dong | | 0. 30 | 11. 30 | 16.488 | |
| | | 1. 50 | | 1. 50 | | | | 1.324 |
| 21. 40 | 0. 30 | | Mo Jin Dong | | 0. 30 | 9. 10 | 17.812 | |
| | | 4. 00 | | 4. 20 | | | | 3.576 |
| 26. 10 | 0. 30 | | Seong Pa Dong | | 0. 30 | 4. 20 | 21.338 | |
| | | 1. 40 | | 1. 30 | | | | 1.142 |
| 28. 20 | 0. 30 | | Jam Sil Dong | | 0. 30 | 2. 20 | 22.530 | |
| | | 2. 10 | | 2. 20 | | | | 1.287 |
| 31. 00 | | | Dae Un Dong Jang | | | | 23.817 | |

Table 5-3 Operation Time between Stations (Total Placing in Service)

| Down | | | Station | Up | | | Kilometrage at Station Center | Station Distance |
|---|---|---|---|---|---|---|---|---|
| Total | Stopping Time | Operation Time | | Operation Time | Stopping Time | Total | | |
| | | min.sec. | Seo Gyo Dong | min.sec | | min.sec. 41. 00 | km 0.500 | |
| | | 1. 30 | | 1. 50 | | | | km 0.940 |
| min.sec. 1. 30 | min.sec. 0. 30 | | Dong Gyo Dong | | 0. 30 | 39. 10 | 1.440 | |
| | | 1. 50 | | 1. 50 | | | | 1.120 |
| 3. 50 | 0. 20 | | Chang Cheon Dong | | 0. 20 | 36. 50 | 2.560 | |
| | | 1. 30 | | 1. 20 | | | | 0.900 |
| 5. 40 | 0. 20 | | Dae Hyeon Dong | | 0. 20 | 35. 10 | 3.460 | |
| | | 1. 40 | | 1. 50 | | | | 1.200 |
| 7. 40 | 0. 30 | | A Hyeon Dong | | 0. 30 | 33. 00 | 4.660 | |
| | | 1. 40 | | 1. 50 | | | | 1.350 |
| 9. 50 | 0. 30 | | Seo So Mun | | 0. 30 | 30. 40 | 6.010 | |
| | | 1. 40 | | 1. 40 | | | | 1.113 |
| 12. 00 | 0. 30 | | City Hall | | 0. 30 | 28. 30 | 7.123 | |
| | | 1. 20 | | 1. 10 | | | | 0.695 |
| 13. 50 | 0. 30 | | Eul Ji Ro 2-Ga | | 0. 30 | 26. 50 | 7.818 | |
| | | 1. 10 | | 1. 20 | | | | 0.822 |
| 15. 30 | 0. 30 | | Eul Ji Ro 4-Ga | | 0. 30 | 25. 00 | 8.640 | |
| | | 1. 20 | | 1. 10 | | | | 0.815 |
| 17. 20 | 0. 30 | | Eul Ji Ro 6-Ga | | 0. 30 | 23. 20 | 9.455 | |
| | | 1. 20 | | 1. 20 | | | | 0.928 |
| 19. 10 | 0. 30 | | Sin Dang Dong | | 0. 30 | 21. 30 | 10.383 | |
| | | 1. 30 | | 1. 20 | | | | 0.855 |
| 21. 10 | 0. 20 | | Sang Wang Sib Ri | | 0. 20 | 19. 40 | 11.238 | |
| | | 1. 10 | | 1. 10 | | | | 0.686 |
| 22. 40 | 0. 20 | | Ha Wang Sib Ri | | 0. 20 | 18. 10 | 11.924 | |
| | | 1. 10 | | 1. 10 | | | | 0.730 |
| 24. 10 | 0. 20 | | Han Dae Ap | | 0. 20 | 16. 40 | 12.654 | |
| | | 3. 30 | | 3. 20 | | | | 2.577 |
| 28. 00 | 0. 30 | | Seong Su Dong | | 0. 30 | 13. 00 | 15.231 | |
| | | 1. 30 | | 1. 30 | | | | 1.257 |
| 30. 00 | 0. 20 | | Hwa Yang Dong | | 0. 20 | 11. 00 | 16.488 | |
| | | 1. 50 | | 1. 40 | | | | 1.324 |
| 32. 10 | 0. 20 | | Mo Jin Dong | | 0. 20 | 9. 00 | 17.812 | |
| | | 4. 00 | | 4. 20 | | | | 3.576 |
| 36. 30 | 0. 20 | | Seong Pa Dong | | 0. 20 | 4. 20 | 21.338 | |
| | | 1. 30 | | 1. 20 | | | | 1.142 |
| 38. 20 | 0. 30 | | Jam Sil Dong | | 0. 30 | 2. 40 | 22.530 | |
| | | 2. 10 | | 2. 10 | | | | 1.287 |
| 41. 00 | | | Dae Un Dong Jang | | | | 23.817 | |

# 6. Rolling Stock

## 6.1 Train Consist and Kind of Rolling Stock

Rolling stock used for Line No. 2 is based upon that used for Line No. 1. In order to raise possibilities for the interchangeability of parts, it is planned to adopt common parts as far as possible.

The kind of rolling stock is the trailer car with controller (TC), and the intermediate motored car (M, M'). Two motored cars make up one unit, and eight traction motors are controlled as one group.

At the time of partial placing in service, the train will consist of eight cars which are as follows:

Tc M M' M M' M M' Tc

## 6.2 Conditions of Rolling Stock in Use

The conditions of the rolling stock in use are as shown in Table 6-1:

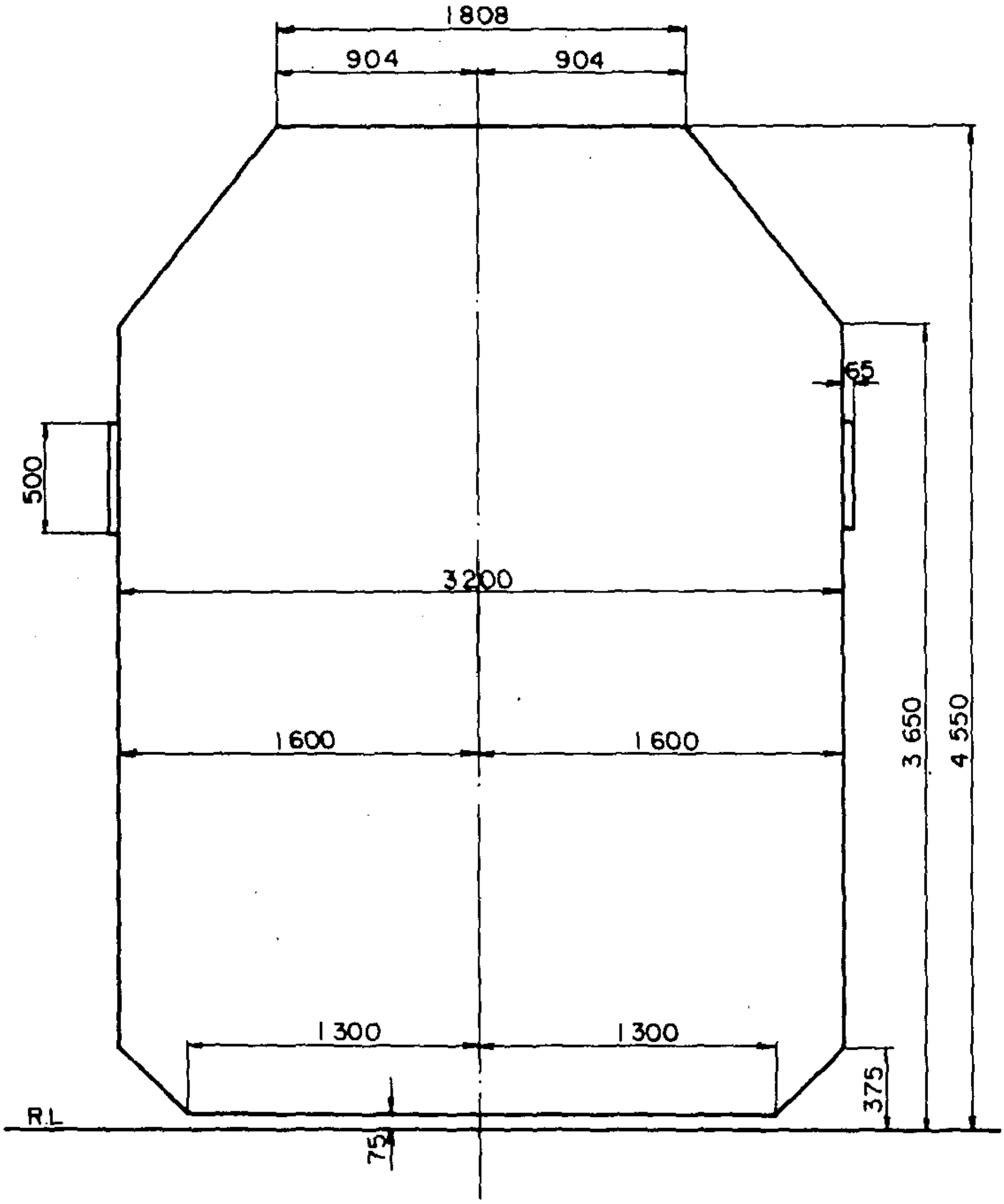
Table 6-1 Conditions of Rolling Stock in Use

| Item | Description |
|---|---|
| Electric System | DC 1,500V Overhead Traction Supply System |
| Track gauge | 1,435 mm |
| Maximum gradient | 35/1000 (Main line, Siding) |
| Minimum Curve Radius | 180m (Main line), 100m (Siding) |
| Stopping Time | 20-30 secs. at each station |
| Maximum Operating Speed | 95 km/h |
| Schedule Speed | 35 km/h |
| Load | 20 tons per car |

6.3 Rolling Stock Gauge

The rolling stock gauge is as shown in Fig. 6-1:

Fig. 6-1 Rolling Stock Gauge



## 6.4 Exterior and Principal Dimentions

The exterior of the rolling stock is almost the same as that of the Line No. 1. The right side running is adopted in operation of the Line No. 2. The home signals within the car depot are shared in common with cars for the Line No. 1. For this reason the driver's cab of the trailer car with controller (TC) is of the left side driver's seat type. The modern front design gives good visibility. The pantograph mounting part of the intermediate motored cars is not of the low roof system which is used for the A.C./D.C. cars of the Line No. 1. Adopting the exclusive D.C. feeding system and removing the lowered roof, the full length measures the same height.

The exterior of the rolling stock and its principal dimensions as well as the seating arrangements are as shown in Fig. 6-2 through 6-4.

Fig. 6-2 Trailer Car with Controller (Tc)

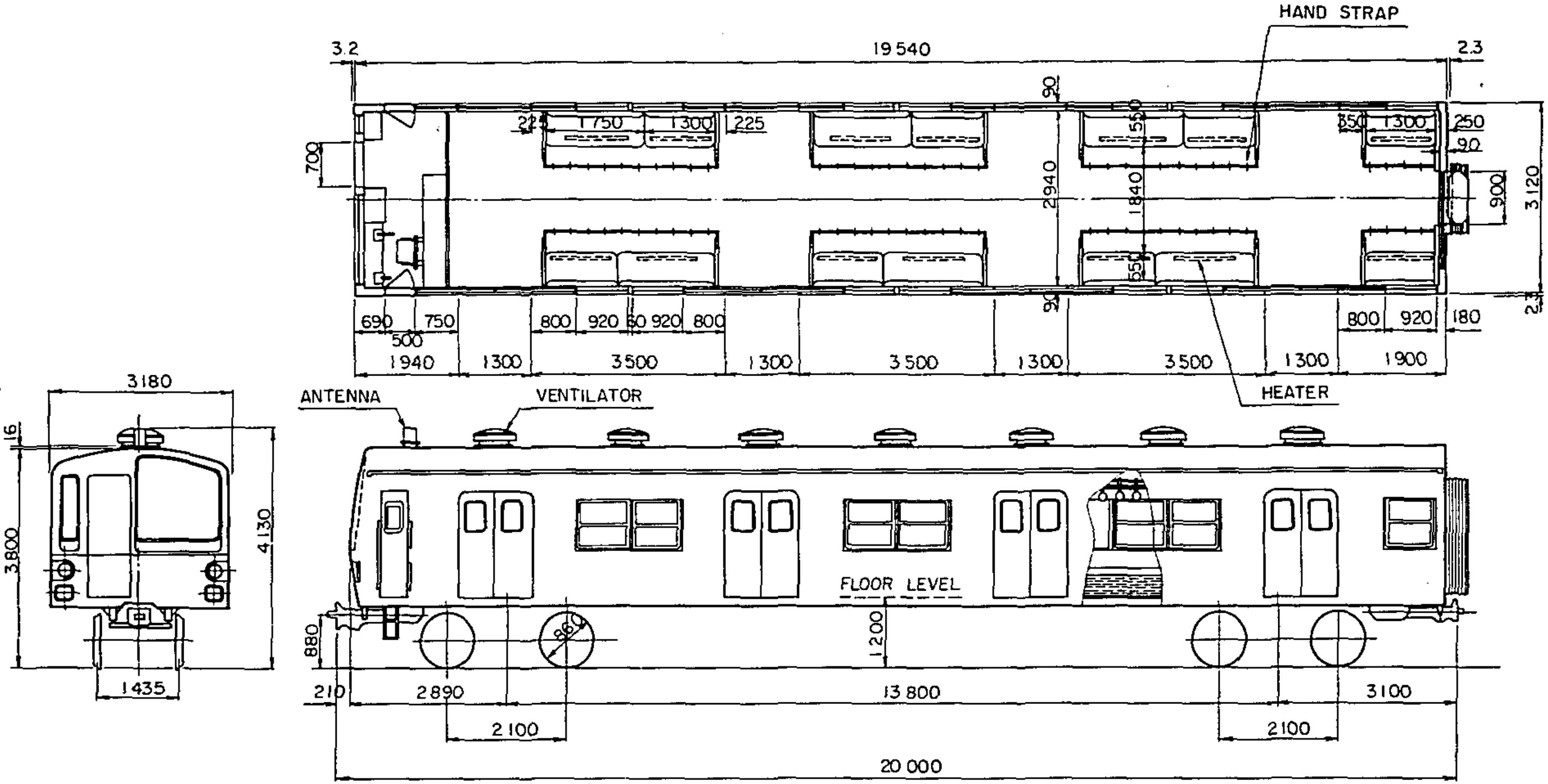


Fig. 6-3 Intermediate Motored Car (M)

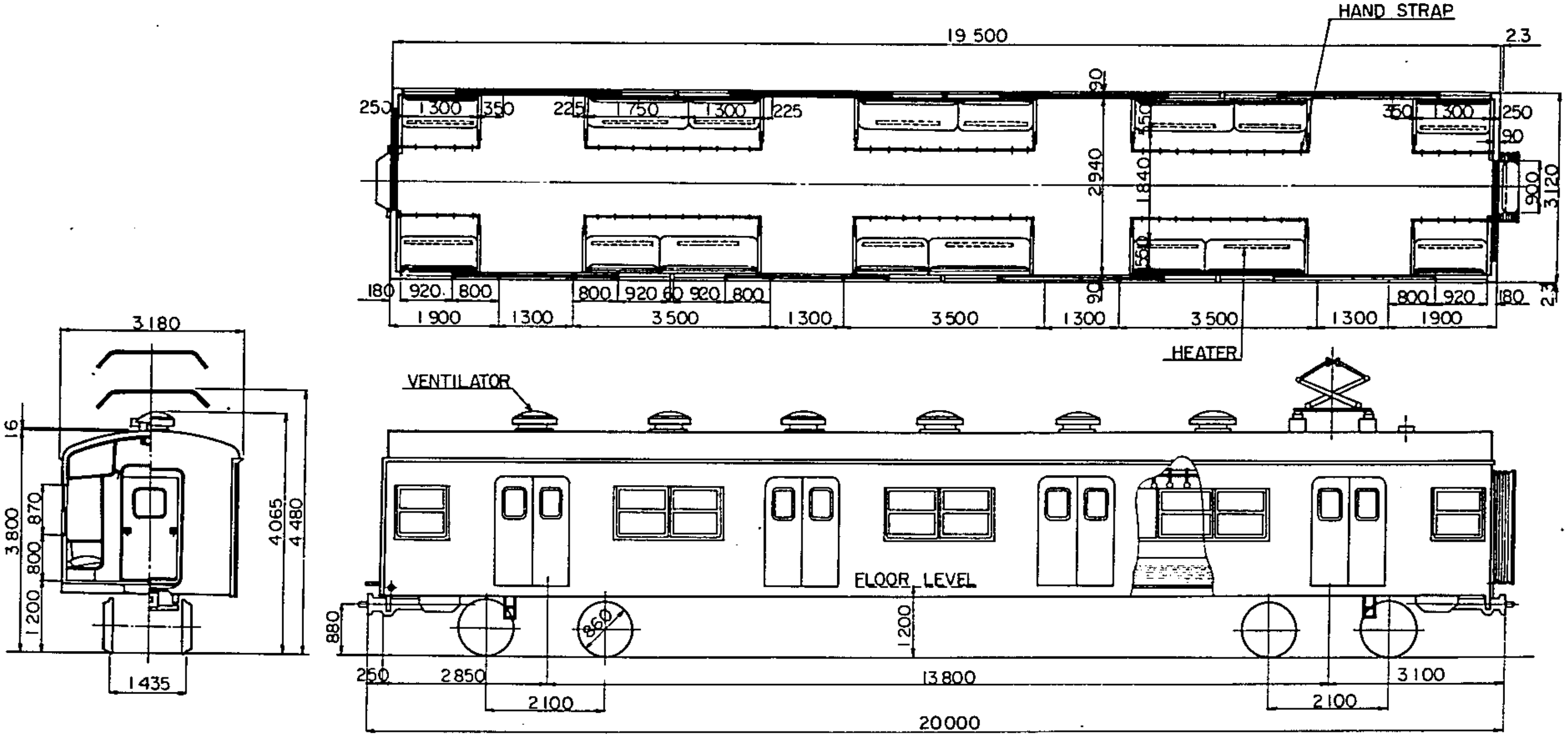
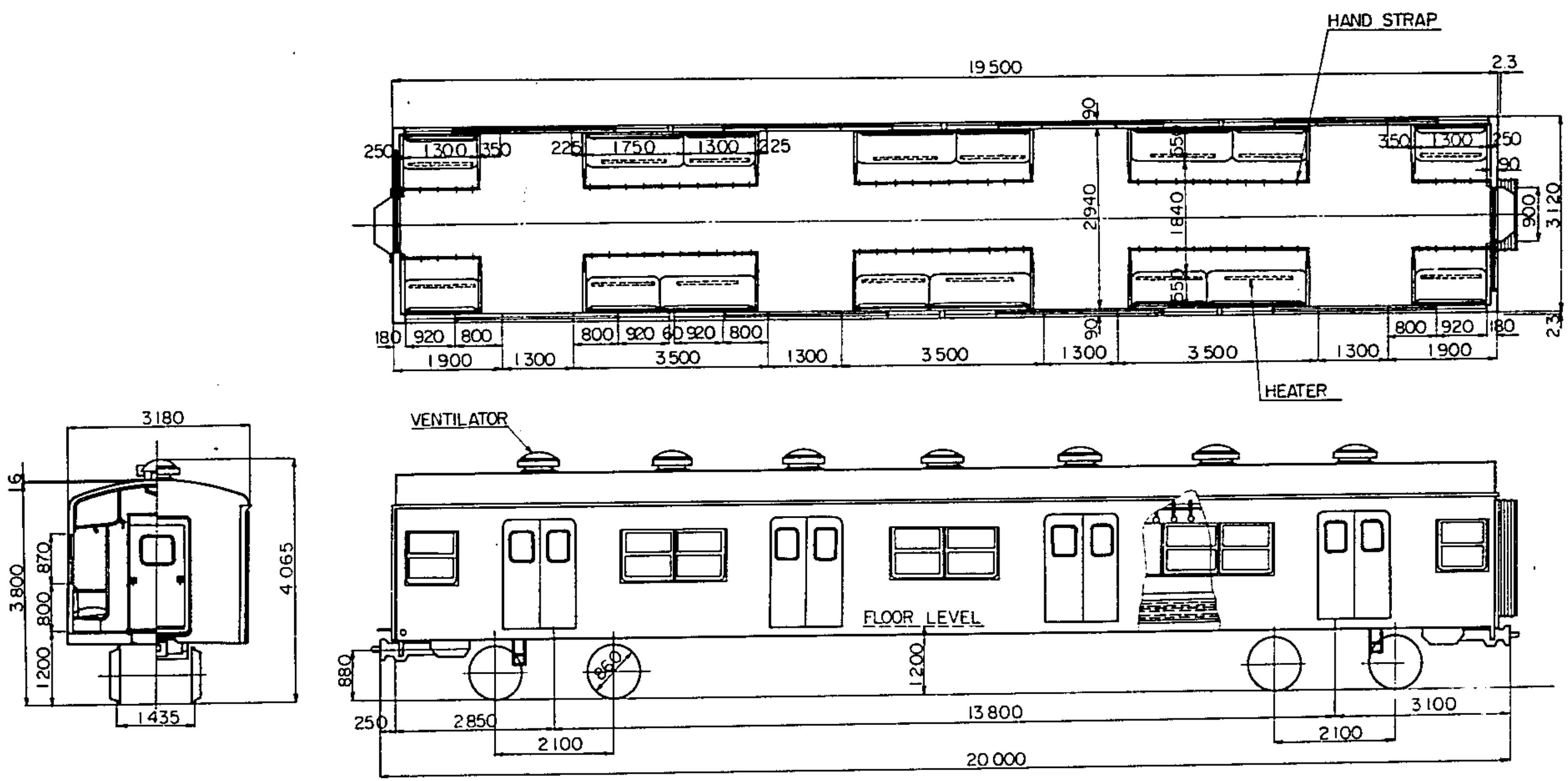


Fig. 6-4  Intermediate Motored Car (M')



## 6.5 Principal Feature and Performance

The rolling stock is planned taking consideration into the ground facilities and operating conditions of the Line No. 2, but the specifications are fundamentally the same as those for the rolling stock of the Line No. 1. Improvements in riding comfort and with regard to countermeasures against cold temperature are also planned.

### 6.5.1 Principal Specification

The principal specification of the rolling stock is as shown in Table 6-2:

### 6.5.2 Car Body Structure

The car body structure made of light weight steel and the various facilities inside of the railcars are the same as those of the Line No. 1. In consequence as mentioned before, the design of the front part of the driver's cab is modernized, and in case of emergency, passengers are enabled to get off trains easily from the both ends of the train through the driver's cab.

The door operating device of the sliding doors is installed with the re-opening device.

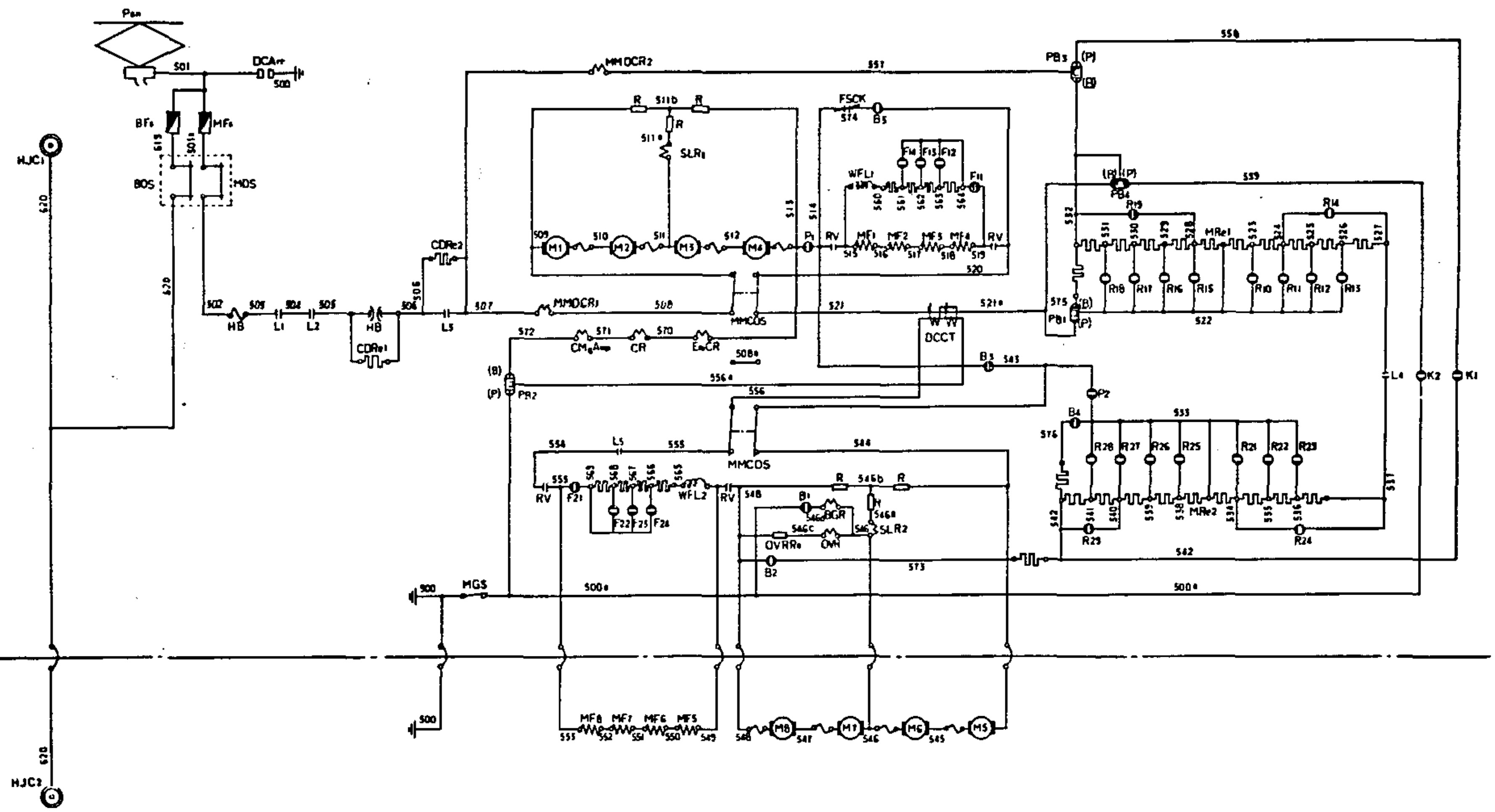
### 6.5.3 Bogie

In order to raise passengers' riding comfort, the 2-axle bogie with air spring is adopted.

### 6.5.4 Speed Control and Brake Equipment

From among the parts and devices which make up the speed control systems and braking devices of the rolling stock, improvements in the countermeasures against the drippings of the air and the against the freezing at night for airbrake system and others are carried out, based on the experience during the operation of the Line No. 1.

Fig. 6-5 Main Circuit Connection Diagram



### 6.5.5 Arrangement of Main Facilities

Since the A.C. facilities necessitated for the rolling stock of the Line No. 1 is not required herein, the D.C. overhead traction supply system is only equipped with the fleet of the Line No. 2. The arrangement of the main facilities has been changed, equalizing the axle load of cars M and M'.

Table 6-2 Principal Specifications

| Item | Description | Remarks |
|---|---|---|
| Type of rolling stock | Commutation type D.C. electric car | |
| Track gauge | 1,435 mm | |
| Rolling stock gauge | Shown in Fig. 6-1 | |
| Electric system | D.C. 1,500V | |
| Performance | | |
| 1 hour rating (MM') | 960 kW | |
| Max. running speed | 100 km/h | |
| Acceleration | 3.0 km/h/sec (8-car train) | (Load 20 tons/car) |
| Deceleration | Service brake: 3.5 km/h/sec | ( " ) |
| | Emergency brake: 4.0 km/h/sec | ( " ) |
| Tare weight | | |
| Intermediate motored car (M) | 41.1 tons | |
| Intermediate motored car (M') | 39.5 tons | |
| Trailer car with controller (Tc) | 31.8 tons | |
| Passenger capacity | Seating standing Total | |
| Intermediate motored car | 54 106 160 | |
| Trailer car with controller | 48 100 148 | |

| Item | Description | Remarks |
| --- | --- | --- |
| Car body | | |
| Structure | Steel made light-weight structure<br><br>Outside plate: painting treatment<br><br>Interior: no painting light metal alloy panel<br><br>Non-inflammable, sound-proof, heat-resistant design | |
| Length between coupling faces | 20,000 mm | |
| Body length | 19,500 mm | |
| Body width | 3,180 mm | |
| Height of roof | 3,800 mm | |
| Height of panto-graph (when folded) | 4,480 mm | |
| Distance between center pivots | 13,800 mm | |
| Floor height | 1,200 mm | |
| Side doors | 4 doors each side<br>Double-leaf sliding doors,<br>width 1,300 mm<br>height 1,860 mm | |
| Bogie | | |
| System | 2-axle bogie | Air spring attached |
| Wheel base | 2,100 mm | |
| Wheel diameter | 860 mm | |
| Brake equipment | Motored car: Tread-type brake<br><br>Trailer car: Disc brake | |

| Item | Description | Remarks |
|---|---|---|
| Power transmission device | | |
| System | Parallel Cardan drive | |
| Gear ratio | 15:87 = 1:5.80 | |
| Traction motor | | |
| System | Pulsating current series-wound with interpoles | |
| No. of poles | 4 | |
| 1 hour rating | | |
| Output | 120 kW | |
| Voltage | 375 V | |
| Current | 360 A | |
| Revolution | 1,650 r.p.m. | |
| Intensity of field | 80% weak field | |
| Cooling system | Self-ventilating | |
| Speed control | | |
| System | Rheostatic control, series-parallel control and field control | |
| Control equipment | Motor-driven cam-shaft contacter type | |
| Brake equipment | Rheostatic brake combined with electro-magnetic direct acting brake (automatic emergency brake system attached) | |
| Main circuit | Shown in Fig. 6-5 | |
| Current collection device | Pantograph | For overhead trolly-bar, cold and snow-proof |

| Item | Description | Remarks |
| --- | --- | --- |
| Main resistor | | |
| Resistor | Corrugated resistor bar | |
| Cooling system | Natural draft currents | |
| Motor generator set | D.C. 1,500V, 25kW output 25kVA | |
| Motor-driven air compressor | D.C. 1,500V, 12kW (30 minute rating) 2,000 lit./min. | |
| Battery | Alkaline battery 100V | |
| Accessory equipment of carbody | | |
| Lighting | 1 set | |
| Public address system | Distribution-type transistor amplifying device | |
| Electric fan | 40-cm fan | |
| Heater | Electric heater | |
| Passengers' emergency alarm device | Emergency alarm apparatus in passengers' room | |
| Train-operation safety apparatus | ATS with speed check | |
| Communication facilities | | |
| Train radio | Inductive radio | |
| Communication between driver and conductor | Telephone | |

# 7. Civil Works

## 7.1 Civil Work Design Standard

### 7.1.1 Outline

The construction gauge, permissible minimum curve radius, maximum gradient, superelevation, gauge widening, length of the transition curve, etc. required for designing track and civil structures are determined, after deciding the rolling stock structures and dimensions as well as the train operation speed.

The construction of the subway requires tremendous cost and the half is assigned for the civil work. To curtail the construction cost, the inner space of the structure shall be as small as possible for the rationalized profile of structure. For a solution, the third rail power feeding system may be introduced. However, in case of the Line No. 2, the third rail system will not be so advantageous, because the railcar depot is shared by the railcars of the Lines No. 1 and No. 2, the former being overhead contact line system. Furthermore, the installation cost of electric facilities and others for the elevated railway section might occupy the fairly larger portion of the total construction cost.

The major standards of the Line No. 2 are the same as those of the Line No. 1 as follows:

| | | |
|---|---|---|
| (1) | Track Gauge | 1,435 mm |
| (2) | Electric System | D.C. 1,500 V |
| (3) | Feeding System | Overhead contact wire system |

The operating line is on the right-side. The right-side line, on which trains are operated from Seo Gyo Dong to Dae Un Dong Jang, is called "A-Line", whereas the other line "B-Line".

### 7.1.2 Design Standard

The design standard which is the basic conception for designing civil structures is as shown in Table 7-1 for the underground section and Table 7-2 for the elevated section. The standard column has the basal figures for the design work but the relief regulations are framed for the unavoidable cases. As to the sidings, only deadhead trains are operated at a low speed, milder standards comparing with those of the main line are established.

(1) Minimum Curve Radius

Avoiding to reduce the train schedule speed and not to pass through private land as hard as possible, the permissible minimum curve radius is stipulated to be 180 meters. In cases where a curve is extended along the platform, the minimum curve radius is to be 500 meters, taking into consideration the better field of vision on the platform and unavoidable interval between platform and railcar caused by curved alignment.

(2) Length of Transition Curve

The transition curve is to be inserted in cases where the curve radius is 900 meters or less. The transition curve length is to be more than 600 times the superelevation.

(3) Superelevation

The superelevation is worked out by the following formula, as in the case of the Line No. 1:

$$C = 11.3\frac{V^2}{R} - C' \leqq 160 \text{ (mm)}$$

For designing the structures, the following formula is to be adopted in view of safety:

$$C = 11.3\frac{V^2}{R} \leqq 160 \text{ (mm)}$$

(4) Maximum Gradient

According to the performance of the railcar, the permissible maximum gradient is stipulated to be 35 in 1,000 for the main line whereas 45 in the sidings. In the station where storage or marshalling of the train, is

Table 7-1 Design Standard for Line No. 2 (Underground Section)

| Item | | Standard | Description |
|---|---|---|---|
| Track Gauge | | 1,435 mm | |
| Feeding System | | Overhead Contact | |
| Feeding Voltage | | 1,500 V | |
| Rolling Stock Length | | 20 m | |
| Rolling Stock Gauge (WxH) | | 3,200mmx4,550mm | Refer to Fig. 7-1. |
| Construction Gauge (WxH) | | 3,600mmx4,950mm | Do. |
| Minimum Curve Radius | Main Line | 180m | In special cases, 160 m can be used. |
| | Branching off from Main Line | 150 m | Lead curve radius of No. 8 turnout is permissible. |
| | Along Platform | 500 m | In unavoidable cases, 400 m can be used. |
| | Siding | 120 m | Rule for main line is applicable for important sidings. |
| | Branching off from Siding | 100 m | Lead curve radius of No. 6 turnout is permissible. |
| Length of Transition Curve | | L=600·C | Transition curve is to be inserted for curves in main line and important sidings, provided that radius of which is 900 m or less. For other sidings, transition curve is not necessary, except for the important sidings. In cases where the rule cannot be applicable, 450·C may be used. C means superelevation mentioned hereunder. |
| Length of Straight Section between Reversed Curves | | 20 m or more | If ruled distance cannot be secured, it can be shotened to 18 m. If even 18 m cannot be adopted, two transition curves are to be directly connected with each other, instead. |
| Superelevation C | | $C=11.3\frac{V^2}{R}$ (mm) | The maximum superelevation is 160mm, even if the calculated amount exceeds it. Superelevation along platform is determined separately. Decrease in superelevation is to be made over the full length of transition curve. If transition curve is not inserted, decrease is made over the straight section which is more than 600 times the superelevation. V: Speed (km/h) R: Curve radius (m) |
| Maximum Gradient | Main Line | 35/1,000 | |
| | Station yard | 10/1,000 | |
| | Siding | 45/1,000 | In cases where car storage is implemented, the gradient is to be within 5 in 1,000. |
| Minimum Gradient | | 2/1,000 | Except for those along platform and car storage track. |
| Minimum Curve Radius of Vertical Curve | | 3,000 m | In unavoidable cases, if the curve radius is 300 m or more, 2,000-m vertical curve can be used. In designing tunnel profile, if change of grade is less than 10 in 1,000 no special consideration is required. |
| Widening of Construction Gauge at Curve | | $w=\frac{24,000}{R}$ (mm) | w: Length to be widened, each side (mm) R: Curve radius (m) |
| Gauge Widening S | | S=2,250/R (mm) | Applied for curves with radius 800 m or less. S: Length to be widened inward of curve (mm) R: Curve radius (m) |
| Distance between Rail Level and Lower Surface of Ballast | Concrete Bed | 500 mm | |
| | Ballast Bed | 700 mm | In cases where countermeasures against noise and vibration are required, 800 mm. |
| Minimum Center-to-Center Distance of Double Track | With Center Pillar | 4,000mm + b | For curved section, another table is applied. b: Width of pillar |
| | Without Center Pillar | 4,000 m | In unavoidable cases, distance can be reduced to 3,800 m. In cases of curved section, distance is to be more than center-to-center distance in straight line plus 2w. |
| Minimum Curve Length | | 20 m or more | In unavoidable cases, the length may be shortened to 18 m. |

Remarks:

1. The minimum curve radius means that of inner track
2. The decision of curve radius is to be based on the inner track.
3. The widened length of the construction gauge at the curved section is to be gradually decreased from the curve end towards 20 m outside transition curve. In cases such as sidings and others where no transition curve is inserted, the decrease is to be made between the curve end and the point 20 meters outwards therefrom.

The type change in cases of cut-and-cover box tunnel shall be made, as a rule, at 20 meter outwards the end of the transition curve or 20 meter outwards the end of curve, if superelevation is not added.

4. Inner space of the cut-and-cover box tunnel for the straight section is as follows:

Height from rail level: 5,050 m
Width per single line: 4,100 m

Table 7-2 Design Standard for Line No. 2 (Elevated Section)

| Item | | Standard | Description |
|---|---|---|---|
| | Track Gauge | 1,435 mm | |
| | Feeding System | Overhead Contact | |
| | Feeding Voltage | 1,500 V | |
| | Rolling Stock Length | 20 m | |
| | Rolling Stock Gauge (WxH) | 3,200mmx4,550mm | Refer to Fig. 7-1 |
| | Construction Gauge | 3,600mmx5,700mm | Do. |
| Minimum Curve Radius | Main Line | 180m | In special case, 160 m can be used. |
| | Branching off from Main Line | 150m | Lead curve radius of the No. 8 turnout is permissible. |
| | Along Platform | 500m | In unavoidable cases, 400m can be used. |
| | Siding | 120m | Rule for main line is applicable for important sidings. |
| | Branching off from Siding | 100m | Lead curve radius of No. 6 turnout is permissible. |
| | Length of Transition Curve | L=600·C | Transition curve is to be inserted for curves in main line and important sidings, provided that radius of which is 900 m or less. For other sidings, transition curve is not necessary, except for the important important sidings. In cases where the rule cannot be applicable, 450·C may be used. C means superelevation mentioned hereunder. |
| | Length of Straight Section between Reserved Curves | 20 m or more | If ruled distance cannot be secureed, it can be shortned to 18 m. If even 18 m is not adoptable, two transition curves are to be directly connected each other, instead. |
| | Superelevation C | $C=11.3\frac{V^2}{R}$ (mm) | The maximum superelevation is 160 mm , even if calculated amount exceeds it. Superelevation along platform is determined separately. Decrease in superelevation is to be made over the full length of tranition curve. If transition curve is not inserted, decreasing is made over the straight section which is more than 600 times the superelevation. V: Speed (km/h) R: Curve radius (m) |
| Maximum Gradient | Main Line | 35/1,000 | |
| | Station yard | 10/1,000 | |
| | Siding | 45/1,000 | In cases where car storage is implemented, the gradient is to be 5 in 1,000. |
| | Minimum Gradient | Level | |
| | Minimum Curve Radius of Vertical Curve | 3,000m | In unavoidable cases, if the curve radius is more than 300 m or more, 2,000-m vertical curve can be used. In designing tunnel profile, if change of grade is less than 10 in 1,000, no special consideration is required. |
| | Widening of Construction Gauge at Curve | $W=\frac{24,000}{R}$ (mm) | w: Length to the widened each side.(mm) R: Curve radius (m) |
| | Gauge Widening S | S=2,250/R(mm) | Applied for curve with radius 800 m or less. S: Length to be widened inward of curve (mm) R: Curve radius (m) |
| Distance between Rail Level and Lower Surface of Ballast | | 700 mm | |
| Minimum Center-to-Center Distance of Double Track | | 4,000 mm | In unavoidable cases, distance can be reduced to 3,800 m. In curved section, it is to be the length more than 1,600 x 2 + 500 + 2w. |
| Minimum Curve Length | | 20 m or more | In unavoidable cases, the length may be shortened to 18 m. |

Remarks:

1. The minimum curve radius mean that of the inner track.
2. The decision of curve radius is to be based on the inner track.
3. The widened length of the construction gauge at the curved section is to be gradually decreased from the curve end towards transition curve. In cases such as sidings and others where no transition curve is inserted, the decrease is to be made between curve end and the point 20 meters outwards therefrom.

performed, 5 in 1,000 is the permissible maximum gradient. The gradient in other stations is 10 in 1,000.

(5) Minimum Center-to-Center Distance of Double Track

Based on the rolling stock gauge, the minimum distance between center-to-center of the double track is to be 4,000 milimeters plus width of the center pillar in case of the underground section and 4,000 milimeters in case of the elevated section.

### 7.1.3 Rolling Stock Gauge and Construction Gauge

The construction gauge is determined based on the rolling stock gauge with a certain allowance to maintain the smooth train operation.

The height of the construction gauge for the Line No. 2 is lower than that for the Line No. 2 by 200 mm, because AC/DC railcars run through both KCR Lines and the Line No. 1, whereas the railcars exclusively used for D.C. system run within the Line No. 2. As to the width of the construction gauge, 3,600 mm is adopted as of the same width of the Line No. 1, based on the condition that opening of the windows of the railcars will be properly restricted.

Both the rolling stock and the construction gauges are as shown in Fig. 7-1.

### 7.1.4 Inner Profile of Structures

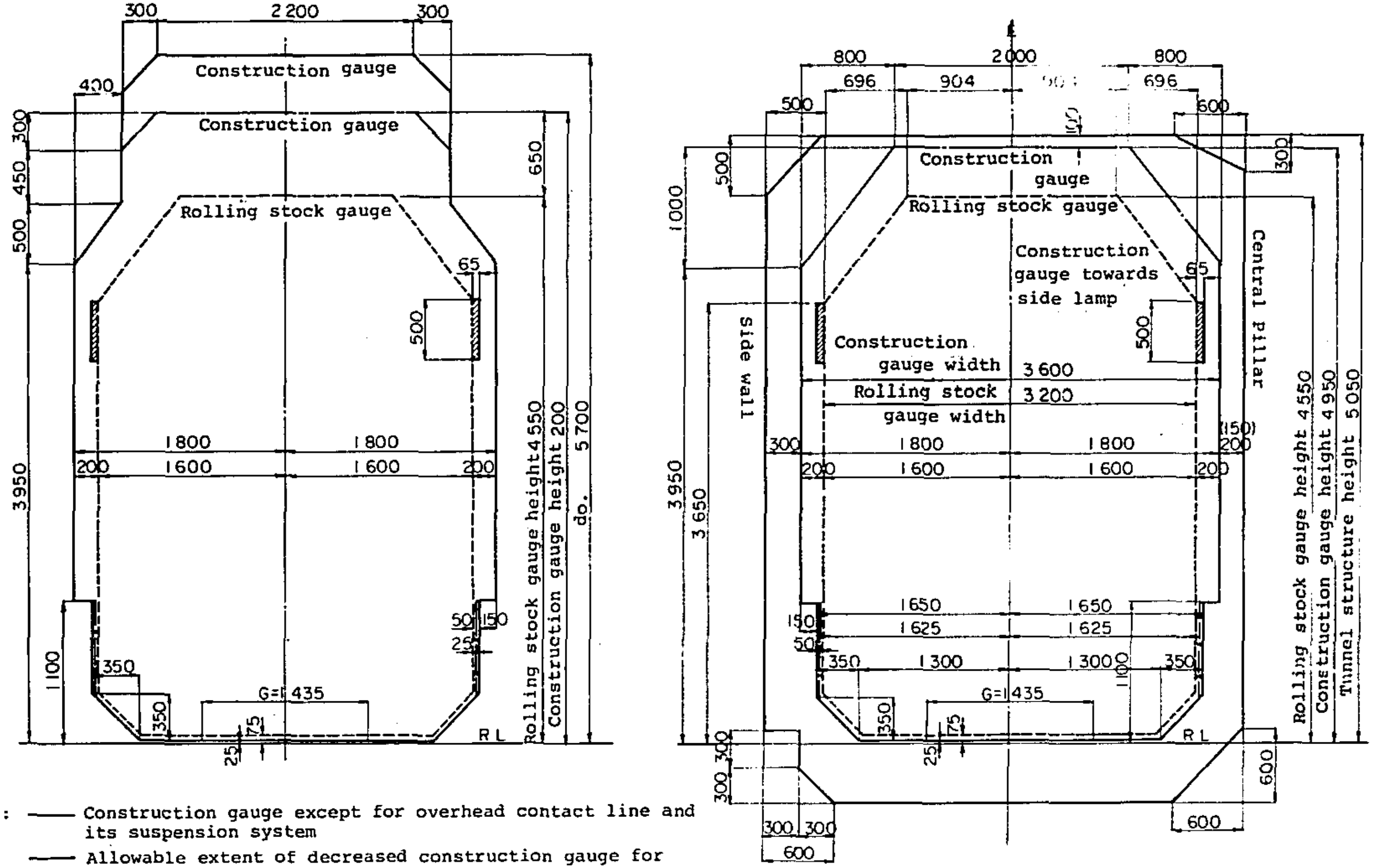
The cables of signal, telecommunications and powers, way-side signals, etc. are located outside the construction gauge in the tunnels. In addition to the above, footpath or refuge manhole against passing trains in tunnel is required for maintenance work. In case of rock tunnel, allowance for the construction tolerance is also required. In view of the foregoing, the inner profile of the structures is determined.

The allowance is varied according to the type of structure which is as shown in Table 7-3.

## Fig. 7-1 Rolling Stock Gauge and Construction Gauge

Elevated Bridge

Cut-and-Cover Box Tunnel




Remarks:
- —— Construction gauge except for overhead contact line and its suspension system
- —— Allowable extent of decreased construction gauge for tunnel and approach section
- —— Allowable extent of decreased construction gauge for bridge, overbridge, roof of platform, etc. and approach section, if necessary
- —·— Allowable extent of decreased construction gauge for platform
- ---- Rolling stock gauge including folded height of pantograph

Dimensions in parentheses denote that in station yard.

Table 7-3 Allowance for Construction Gauge

| Structure Type | Position | Allowance (mm) |
|---|---|---|
| Cut-and-Cover Box Tunnel (Double Line) | Upper | 100 |
| | Right and Left<br>Central Pillar Side | 200 |
| | Outer Side | 300 |
| Rock Tunnel (Double Line) | Upper shoulder (Rite) | 200 |
| | Right and Left | 800 |
| | Upper Shoulder (Left) | 200 |
| Rock Tunnel (Single Line) | Right and Left<br>At Footpath Side | 800 |
| | Other Side | 300 |
| Elevated Bridge (Double Line) | Right and Left | 800 |

In the curved section, shift caused by superelevation and widening of construction gauge by curve are further added to determine inner profile of the structures. The inner dimensions of the cut-and-cover box tunnel and the elevated bridge are as shown Tables 7-4 and -5, respectively.

As to the inner dimensions of the rock tunnel in the curved section, those for the straight section are to be applied through shifting the rail center from the tunnel center.

## 7.2 Type of Structure

### 7.2.1 Outline

The structures between Seo Gyo Dong and Dae Un Dong Jang are grouped into underground and elevated structures. Classification by structure type is as shown in Table 4-3 in 4.6.

### 7.2.2 Underground Structure

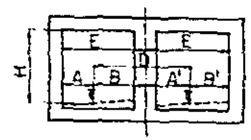
(1) Cut-and-Cover Box Tunnel

The box tunnel is the most common structure for constructing subways. The double line box tunnel, which is used in the sections between stations, are as shown in Fig. 7-2. As to the station structure, the underground two level island platform station, the underground two level separate platform station and the underground single level separate platform station are planned, the typical designs of which are as shown in Fig. 7-3.

(2) Rock Tunnel

The rock tunnel is ordinarily used for the road and railways in mountanuous land and not so often used for the rapid transit railways in the urban areas. The double line and single line tunnel is, however, planned in this project, because of the undulated land form. The typical profile of tunnels is as shown in Fig. 7-4.

Table 7-4 Inner Dimension of Cut-and-Cover Box Tunnel

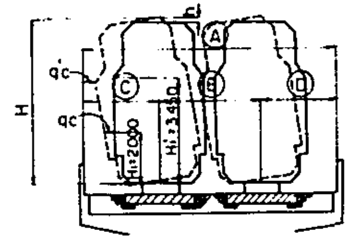



A = 1,800 + 300 + α
B = 1,800 + 200 + 225 + β
A' = 1,800 + 200 + 225 + α
B' = 1,800 + 300 + β
H = 4,950 + 100 + h

| Curve radius R (m) \ Dimension | Train Speed V (km/h) | Superelevation $C=11.3\frac{V^2}{R}$ (mm) | Transition curve length L=600C (m) | Widening of construction gauge by curve $w=\frac{24,000}{R}$ (mm) | Inward deviation by superelevation $q_c$ (mm) | Outward deviation by superelevation $q_e'=q_e \times 0.7$ (mm) | Height deviation by superelevation $h$ (mm) | Gauge widening $S=\frac{2,250}{R}$ (mm) | Inward widening of curve in total $\alpha=w+q_c+S$ (mm) | Outward widening of curve in total $\beta=w-q_e'$ (mm) | A | B | A' | B' | D | E | H |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 160 | 40 | 113 | 68 | 150 | 307 | 66 | 119 | 14 | 471 | 84 | 2,570 | 2,310 | 2,695 | 2,185 | 5,005 | 4,880 | |
| 180 | 45 | 127 | 76 | 133 | 344 | 75 | 132 | 13 | 432 | 58 | 2,575 | 2,260 | 2,700 | 2,135 | 4,960 | 4,835 | |
| 200 | 50 | 141 | 85 | 120 | 381 | 84 | 144 | 11 | 476 | 36 | | | | | | | |
| 250 | 60 | 160 | 96 | 96 | 431 | 94 | 160 | 9 | 534 | 2 | 2,635 | 2,230 | 2,760 | 2,105 | 4,990 | 4,865 | 5,200 |
| 300 | 65 | 159 | 95 | 80 | 428 | 95 | 159 | 8 | 531 | 0 | | | | | | | |
| 350 | 70 | 158 | 95 | 69 | 425 | 95 | 158 | 6 | 526 | 0 | | | | | | | |
| 400 | 75 | 159 | 95 | 60 | 428 | 95 | 159 | 6 | 529 | 0 | | | | | | | |
| 450 | 80 | 160 | 96 | 53 | 431 | 94 | 160 | 5 | 530 | 0 | | | | | | | |
| 500 | 80 | 145 | 87 | 48 | 392 | 87 | 147 | 5 | 484 | 0 | 2,585 | 2,225 | 2,710 | 2,100 | 4,935 | 4,810 | |
| 600 | 80 | 121 | 73 | 40 | 328 | 71 | 127 | 4 | 403 | 0 | | | | | | | |
| 800 | 80 | 90 | 54 | 30 | 245 | 52 | 98 | 3 | 300 | 0 | 2,400 | 2,225 | 2,525 | 2,100 | 4,750 | 4,625 | 5,150 |
| 1,000 | 80 | 72 | 0 | 24 | 197 | 41 | 80 | 0 | 238 | 0 | | | | | | | |
| 1,500 | 80 | 46 | 0 | 16 | 131 | 27 | 55 | 0 | 158 | 0 | 2,260 | 2,225 | 2,385 | 2,100 | 4,610 | 4,485 | 5,100 |
| 2,000 | 80 | 36 | 0 | 12 | 99 | 20 | 42 | 0 | 119 | 0 | | | | | | | |
| Straight line | 80 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2,100 | 2,225 | 2,225 | 2,100 | 4,450 | 4,325 | 5,050 |

Remarks: Central pillar width is to be 450 mm.

Table 7-5  Inner Dimension of Elevated and River Bridge

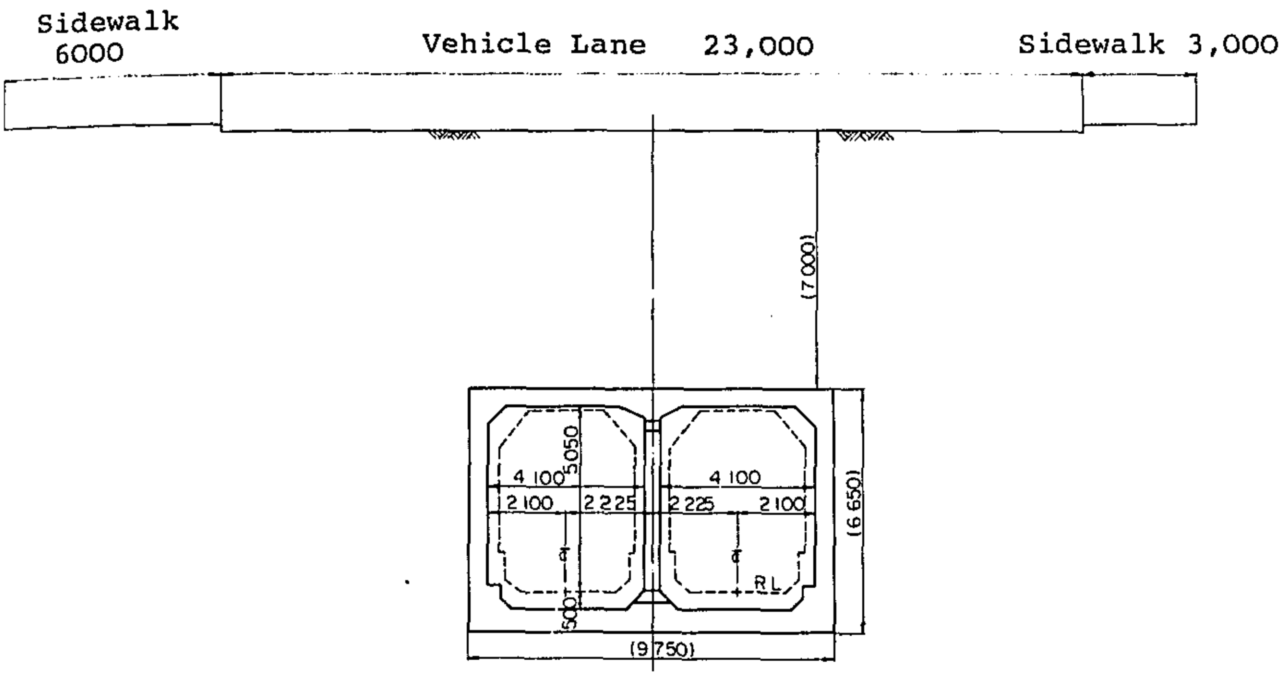



A=B+C+D
B=1,600×2+500+2W
C=1,800+900+α
D=1,800+900+β
H=6,200+h

| Curve radius R (m) \ Dimension | Train speed V (km/h) | Superelevation $C=11.3\frac{V^2}{R}$ (mm) | Transition curve length L=600C (m) | Widening of construction gauge by curve $w=\frac{24,000}{R}$ (mm) | Inward deviation by superelevation $q_c$ H=2,000 (mm) | Outward deviation by superelevation $q_e$ (mm) | Height deviation by superelevation $h$ (mm) | Gauge widening $S=\frac{2,250}{R}$ (mm) | Inward widening of curve in total $\alpha=w+q_c+S$ (mm) | Outward widening of curve in total $\beta=w-q_e$ (mm) | A | B | C | D | H |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 160 | 40 | 113 | 68 | 150 | 154 | 94 | 123 | 14 | 318 | 56 | 9,780 | 4,000 | 3,020 | 2,760 | 6,370 |
| 180 | 45 | 127 | 76 | 133 | 172 | 107 | 141 | 13 | 318 | 26 | 9,750 | 4,000 | 3,020 | 2,730 | |
| 200 | 50 | 141 | 85 | 120 | 191 | 120 | 148 | 11 | 322 | 0 | | | | | |
| 250 | 60 | 160 | 96 | 96 | 215 | 141 | 163 | 9 | 320 | 0 | 9,720 | 4,000 | 3,020 | 2,700 | |
| 300 | 65 | 159 | 95 | 80 | 213 | 135 | 163 | 8 | 301 | 0 | | | | | |
| 350 | 70 | 158 | 95 | 69 | 212 | 135 | 161 | 6 | 287 | 0 | 9,690 | 4,000 | 2,950 | 2,700 | |
| 400 | 75 | 159 | 95 | 60 | 213 | 136 | 163 | 6 | 279 | 0 | | | | | |
| 450 | 80 | 160 | 96 | 53 | 215 | 138 | 163 | 5 | 273 | 0 | | | | | |
| 500 | 85 | 160 | 96 | 48 | 215 | 138 | 163 | 5 | 268 | 0 | | | | | |
| 600 | 90 | 153 | 92 | 40 | 206 | 131 | 157 | 4 | 250 | 0 | 9,650 | 4,000 | 2,950 | 2,700 | |
| 800 | 95 | 127 | 76 | 30 | 172 | 107 | 141 | 3 | 205 | 0 | | | | | |
| 1,000 | 100 | 113 | 68 | 24 | 154 | 94 | 123 | 0 | 178 | 0 | 9,500 | 4,000 | 2,800 | 2,700 | |
| 1,500 | 100 | 75 | 45 | 16 | 103 | 60 | 86 | 0 | 119 | 0 | | | | | 6,300 |
| 2,000 | 100 | 57 | 34 | 12 | 78 | 46 | 67 | 0 | 90 | 0 | | | | | |
| Straight line | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9,400 | 4,000 | 2,700 | 2,700 | 6,200 |

Fig. 7-2 Standard Design of Double Line Cut-and-Cover Box Tunnel

Cross Section




Side View

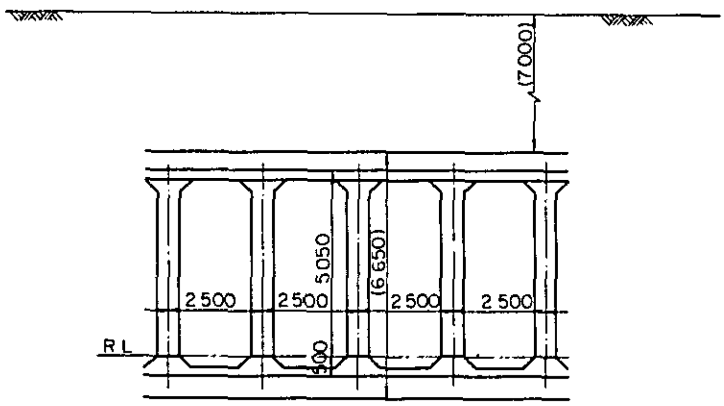
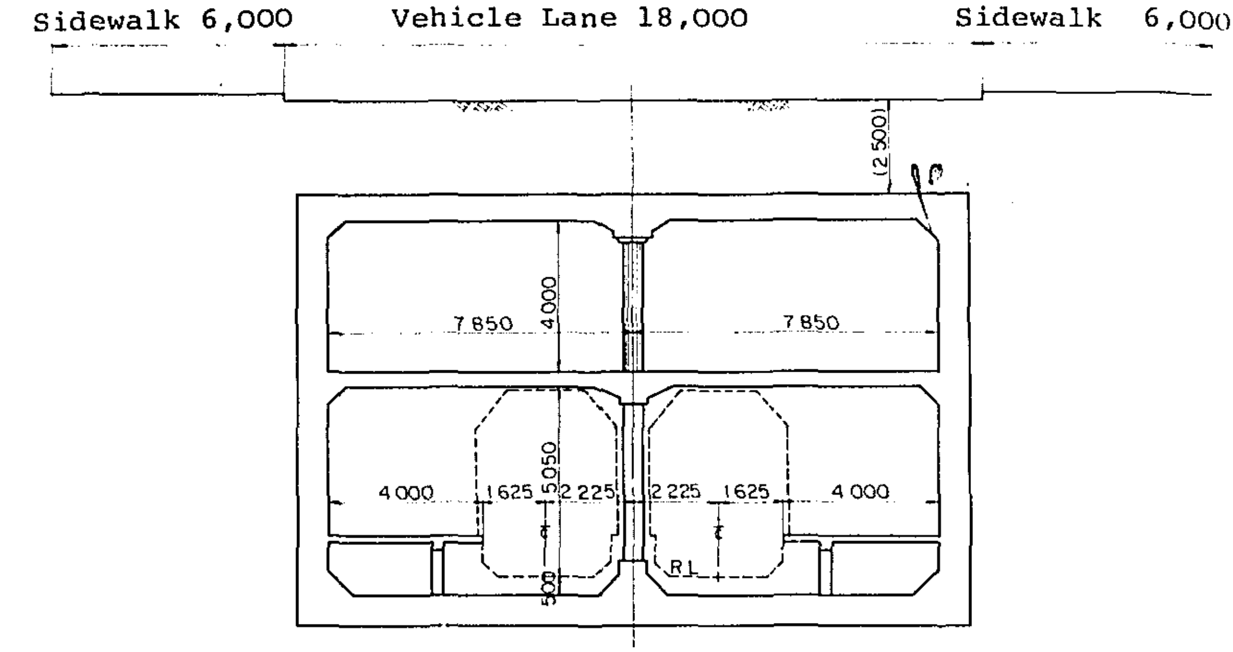


Fig. 7-3 Standard Design of Underground Station

Separate Platform




Island Platform

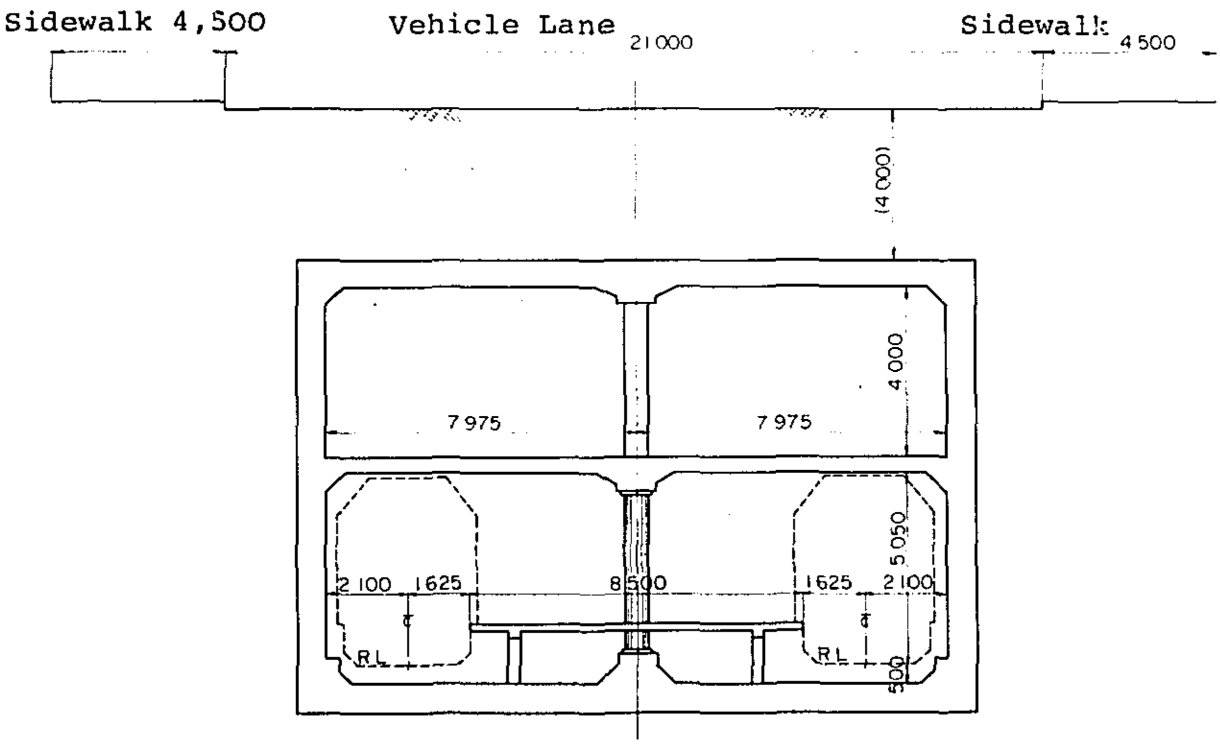
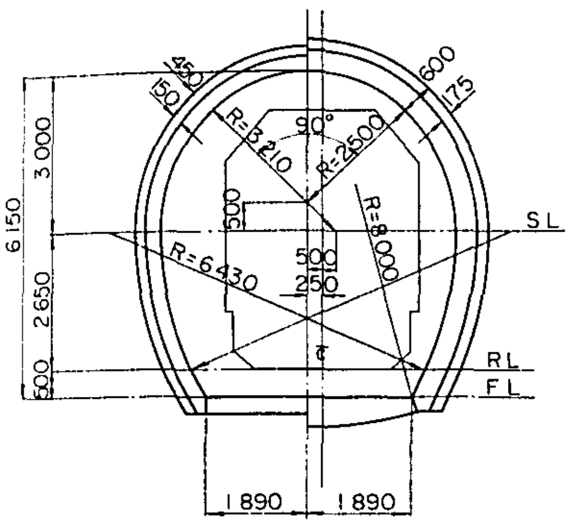


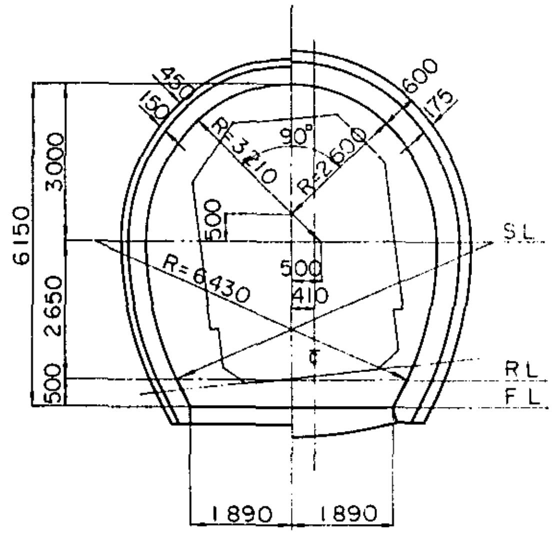
Fig. 7-4 Standard Profile of Rock Tunnel

Single Line Tunnel

Straight Section

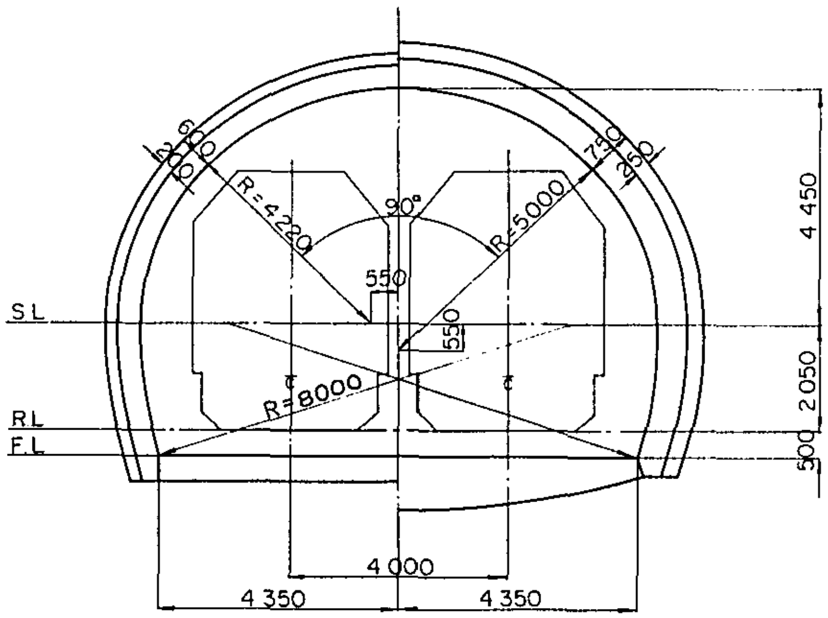



Curved Section




Double Line Tunnel

Straight Section



### 7.2.3 Elevated Structure

#### (1) Prestressed Concrete Elevated Bridge

As the elevated structures of the Line No. 2 is constructed mostly in the road, the single-pier supported PC girder bridge is taken up as the standard structure considering easy construction and the least hindrance to the road traffic. The standard span is to be 20 meters in view of easy construction and cost. For the adjustment purpose, PC girder for 15-meter span is supplementarily planned. To shorten the height of girder and to minimize weight, the structure is composed of four main girders per track. Refer to Fig. 7-5.

#### (2) Composite Girder Elevated Bridge

In crossing the road, the span length is to be as long as 30 to 40 meters and ballasted track will be introduced for preventing noise. Considering economic structure, the composite girder elevated bridge in Fig. 7-6 is planned. At the point near the kilopost of 13.580 km, where the height of girder is restricted, through steel girder bridge with ballast is introduced as shown in Fig. 7-7.

#### (3) Rigid Frame Reinforced Concrete Elevated Bridge

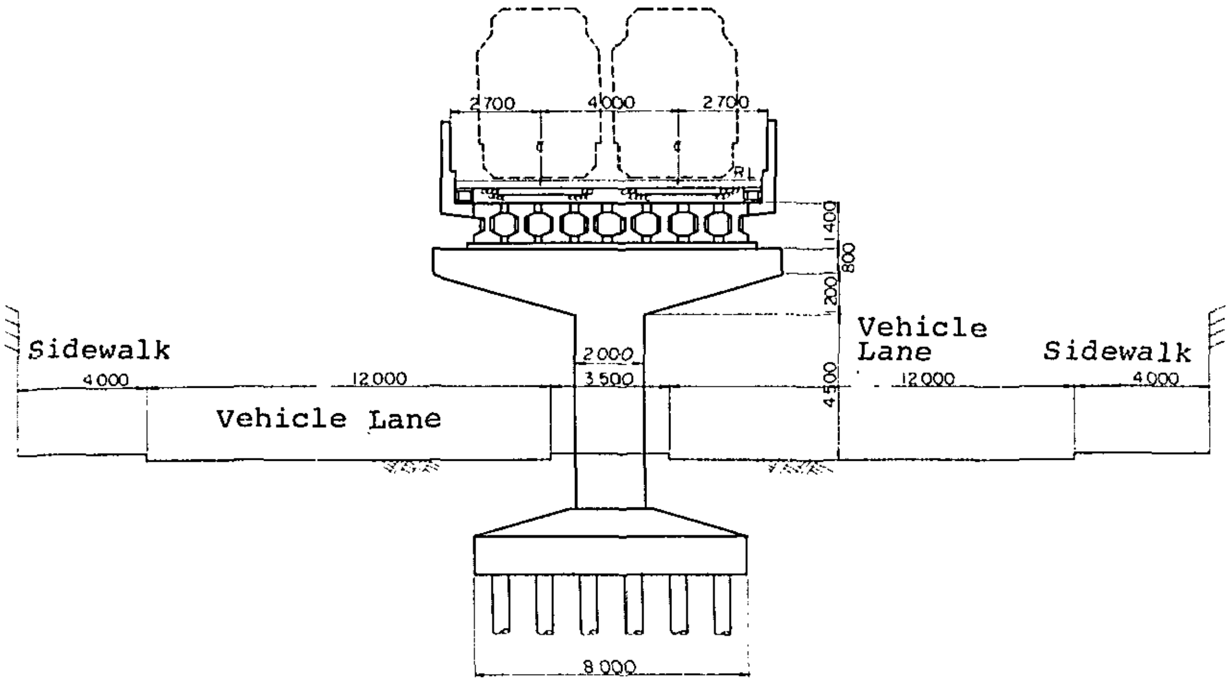
The rigid frame reinforced concrete elevated bridge as shown in Figs. 7-8 through -10 is to be adopted for the station and sharp curve section. The station is the two-storied elevated station on the center of the road. The lower story is used for business such as ticket issuing and examining as well as the space for facilities. The platform and tracks are located at the upper story.

#### (4) Deck Girder Steel Bridge

The deck steel open-floor bridge is planned for crossing the Seong Dong River and the Han River, as shown in Fig. 7-11. The Seong Dong Bridge has five spans 42 meter long each. The Han River Bridge has 32 spans of 40 meter long each with three spans of 30 meters.

Fig. 7-5 Standard Design of Prestressed Concrete Elevated Bridge

Profile




Side View

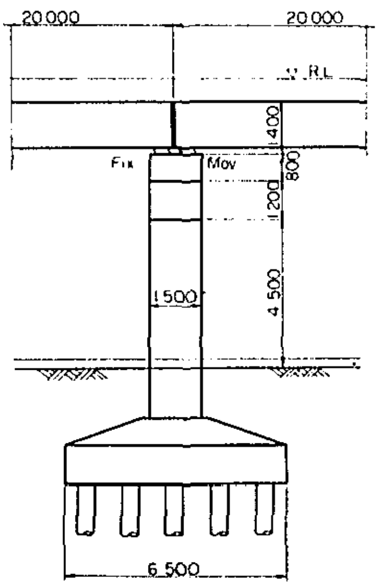
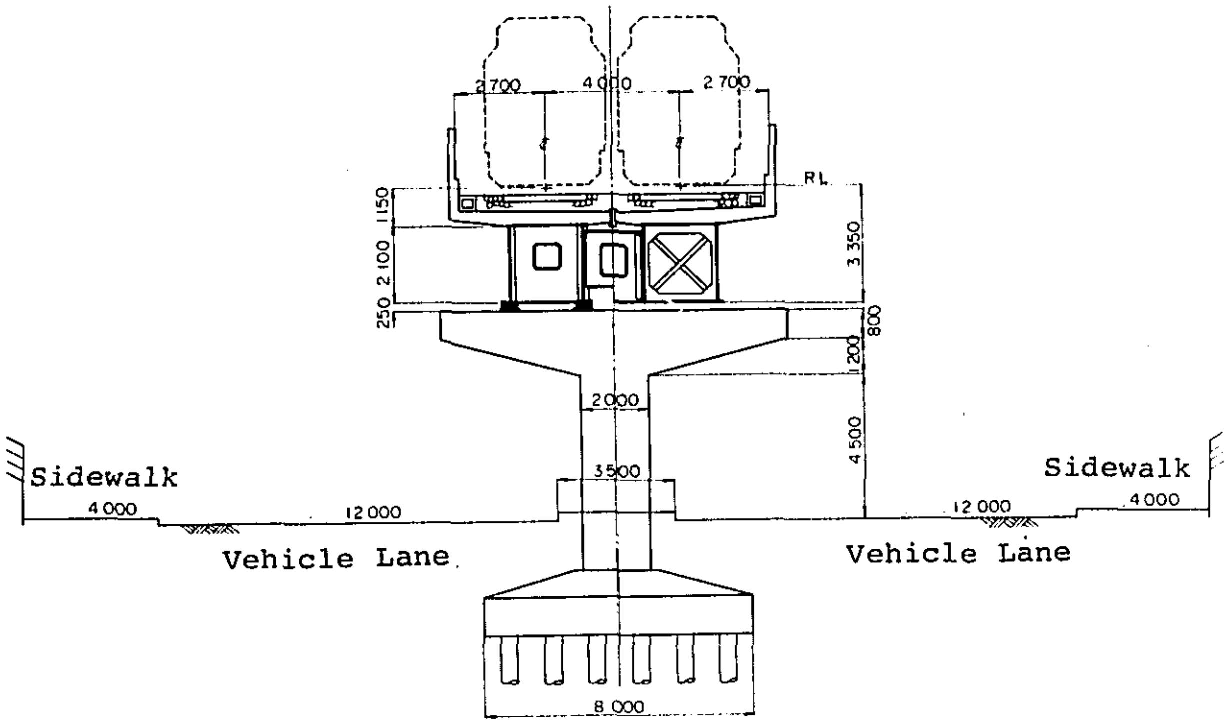


Fig. 7-6 Standard Design of Composite Girder Elevated Bridge

Profile

On Support Between Supports




Side View

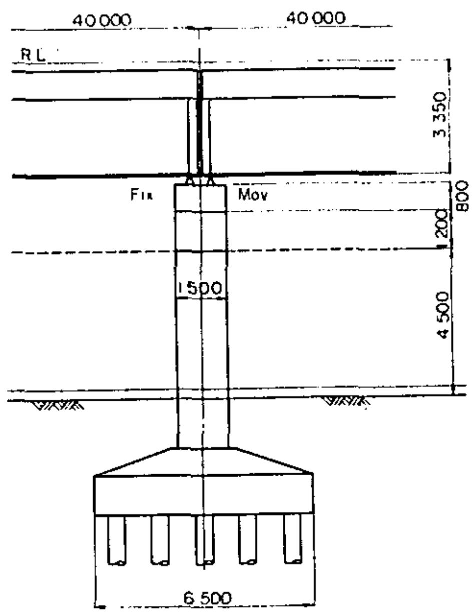
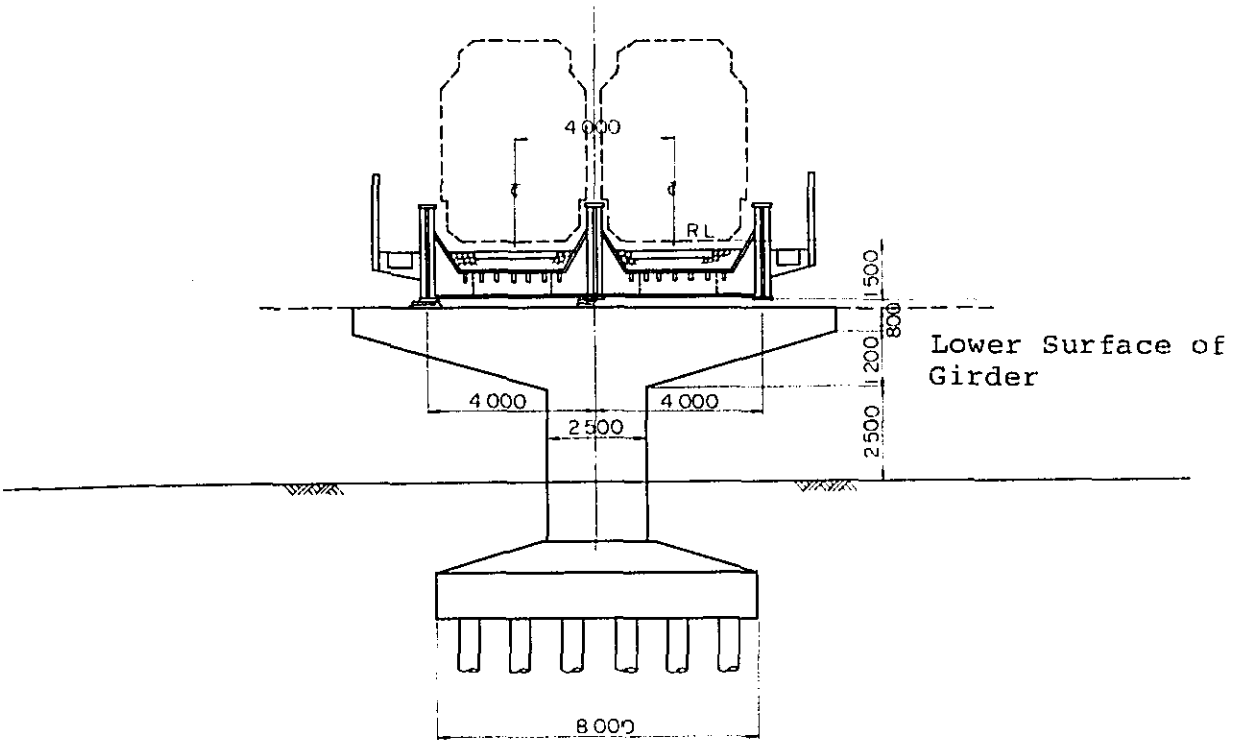


Fig. 7-7 Standard Design of Through Steel Girder Bridge

Profile




Side View

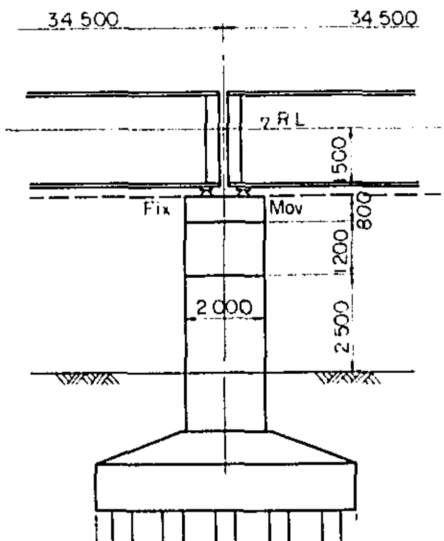
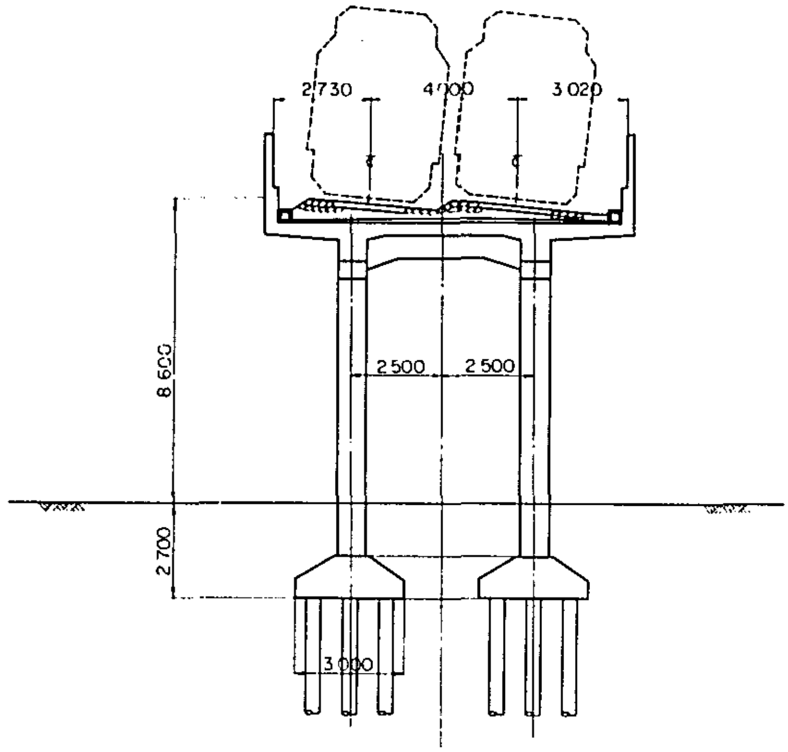


Fig. 7-8 Standard Design of Rigid Frame Reinforced Concrete Elevated Bridge

Profile




Side View

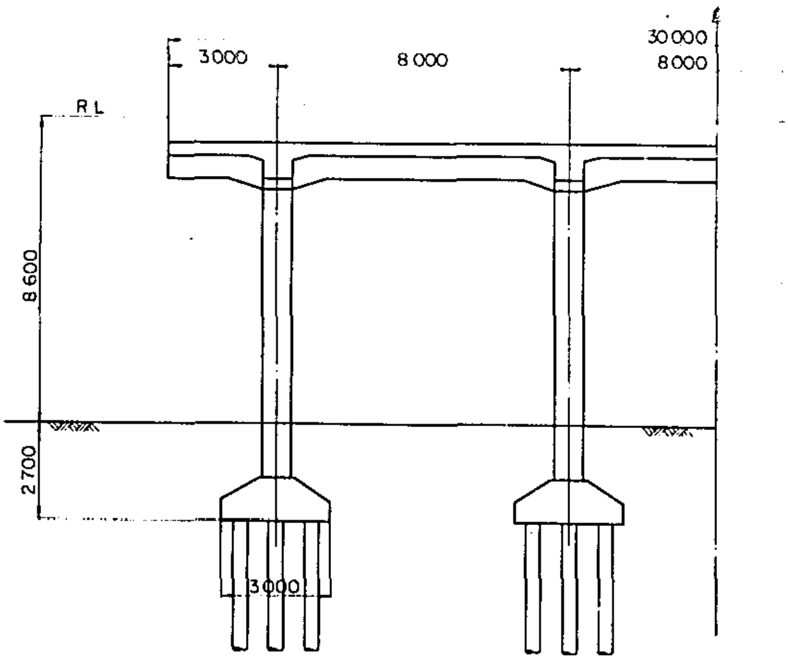


Fig. 7-9 Standard Design of Rigid Frame Reinforced Concrete Elevated Station - Separate Platform

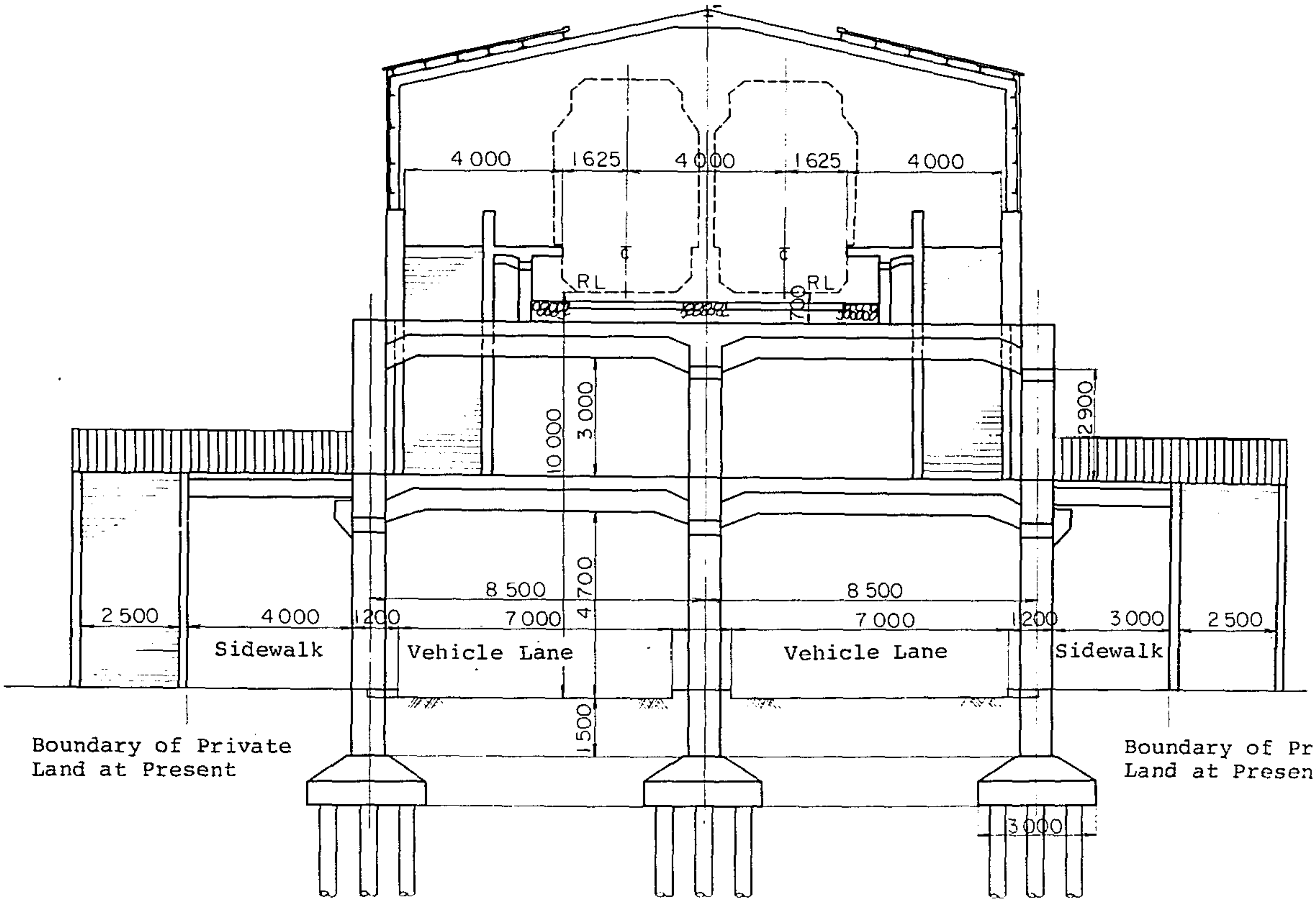


Fig. 7-10 Standard Design of Rigid Frame Reinforced Concrete Elevated Bridge - Island Platform

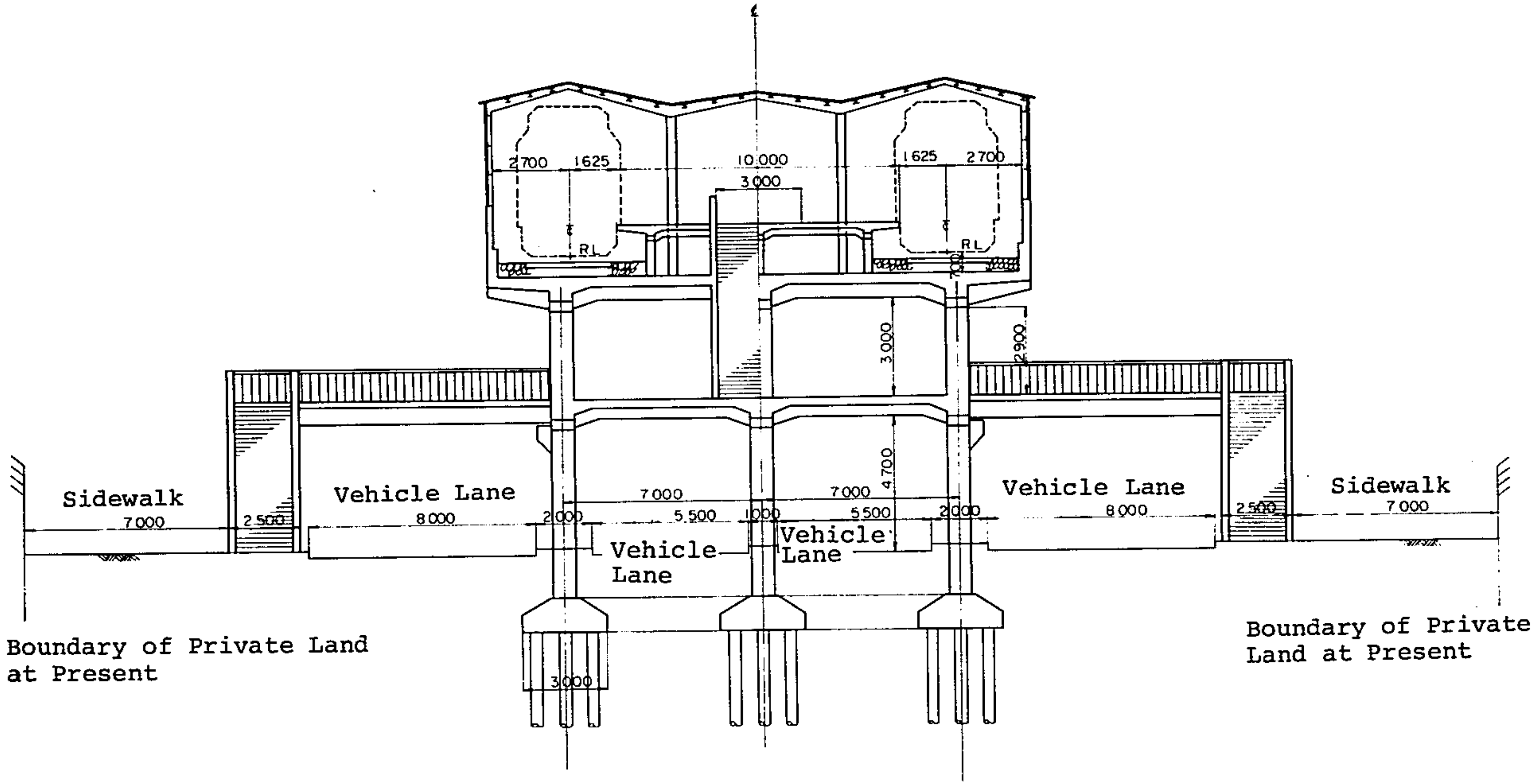
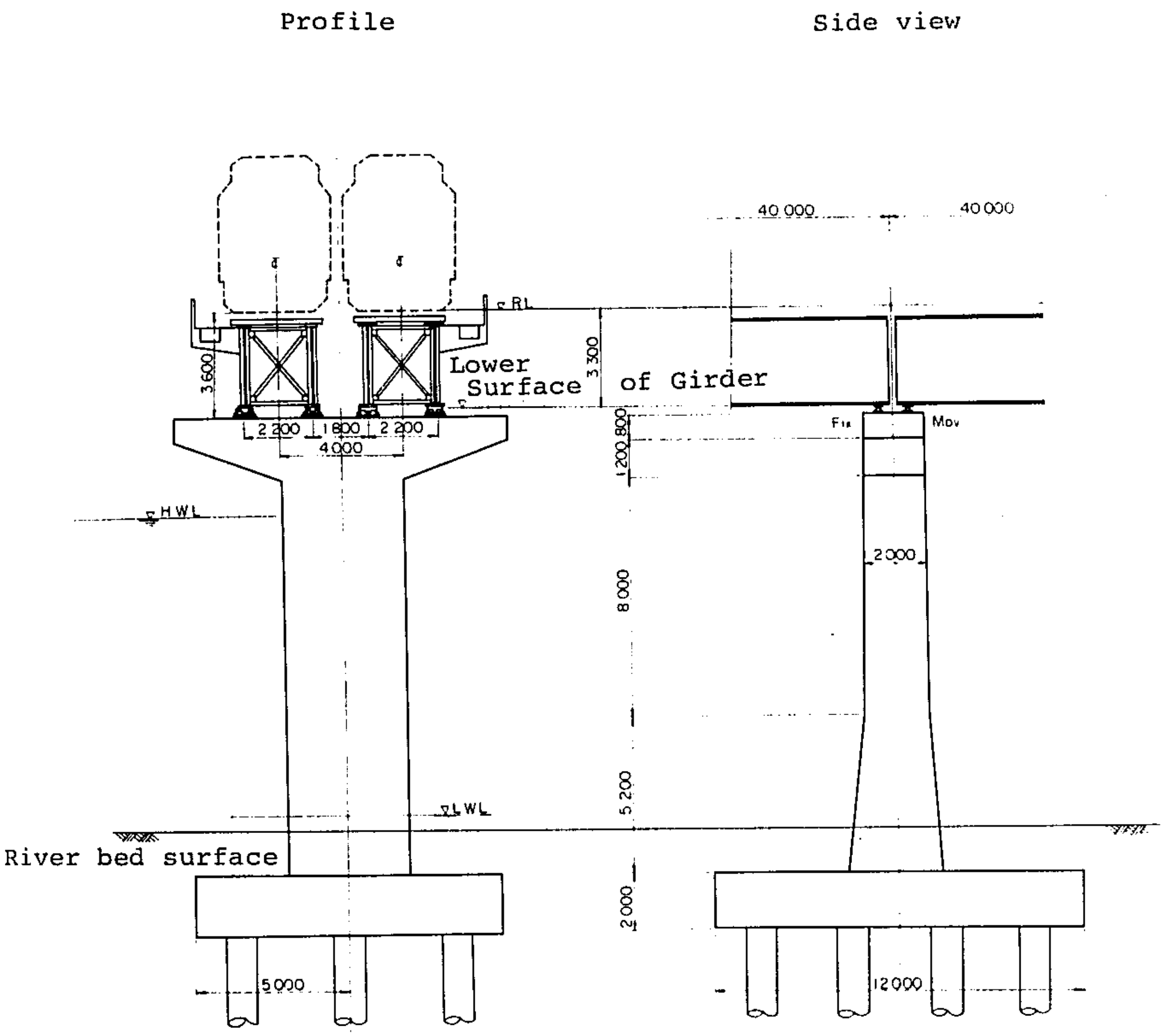


Fig. 7-11 Standard Design of Deck Steel Girder Bridge



(5) Retaining Wall

The transition section between elevated and underground sections near the kilopost of 13.200 km close to Han Dae Ap Station will be constructed with the "U" type and the "Inverted-T" type retaining wall.

## 7.3 Station

### 7.3.1 General

As the station is a facility for the passengers, their convenience and comfort are to be primarily considered. The major items to be studied are the scale of station, type and width of the platform, stairways, entrance and exit to the station, other facilities for passengers, ventilation, lighting, etc.

The stations are classified, according to their funtions into terminal stations, connecting stations and intermediate stations. The appropriate planning for each category is consequently essential. The grouping of stations is as follows:

| | |
|---|---|
| Terminal Station | Seo Gyo Dong, Dae Un Dong Jang |
| Connecting Station | Seo So Mun, City Hall, Eul Ji Ro 6-Ga |
| Intermediate Station | Other stations |

### 7.3.2 Scale of Station

The station shall have a proper scale in view of the assumed number of passengers in peak-hours for 10 - 15 years after opening to the public. In addition, the passenger number may increase rapidly with the development along the new line by the strong opening impact. In case of accident, even at the station, where the passengers are not so many in ordinary circumstances, security of passengers' safety, prompt refuge, etc. are absolutely required. Therefore, flexible considerations are the major requisites for station planning.

### 7.3.3 Platform

#### 7.3.3.1 Type of Platform

The platform is classified into island platform and separate platform. The island platform is so far generally used at the terminals and those in urban districts where passenger service is heavy. The separate platform has been used for the stations in suburban districts or intermediate stations where passengers are fewer. Recently two storied station with an island platform is often introduced in stations in suburban districts, because of the facts that the space may be secured for station business facilities, passengers' convenience and manpower curtailment by concentrating ticket issuing and examining services. Especially in the station where the passenger flow in one direction is much heavier than in other direction in peak-hours, the island platform is more advantageous in view of wider space for the passengers.

#### 7.3.3.2 Length of Platform

The length of platform is planned to be 170 meters based on the train length of 160 meters in case of 8-railcar consist with allowance of 10 meters.

#### 7.3.3.3 Effective Width of Platform

The width of platform is to be 4 - 7 meters for the separate platform and 7 - 11.5 meters for the island platform taking into consideration type of platform, location of stairways, passenger number during peak-hours, train interval, etc.

### 7.3.4 Stairway

The stairways connecting platform with concourse are to have a space by which all getting on and off passengers of a train can smoothly pass through before arrival of the next train. The location of stairways is determined on the scale of stations as follows:

(1) Located at the both ends of platform

(2) Located at the center of platform

(3) Located at the center and both ends

If the stairway location of adjoining stations is the same, it will result in the too congested railcars in a train consist. Therefore, location of the stairways in the different position within the adjoining stations is required, considering the special characteristics of each station.

Width of stairs is determined, based on the following capacity:

| | |
|---|---|
| Going up passengers per hour | 4,000 prsns. |
| Going down passengers per hour | 4,500 " |

### 7.3.5 Entrance to Station

The location and number of entrance to the station is to be determined according to the getting on and off passengers. The entrance type is classified into those on the sidewalk of the road, from the rented or the acquired land, and directly connected with buildings. The number of entrance in the case of the Line No. 2 is four as the standard. The minimum required width is 2.5 meters considering refuge of passengers in case of emergency.

### 7.3.6 Station Plaza

The station plaza is a space of traffic in the front. Especially for the suburban stations which have a wide hinterland, many connecting busses, cars, bicycles, etc. concentrate in front of the station. To avoid this pecuriar traffic congestion among cars and passengers, sufficient areas of the station plaza are required.

There is a formula to which getting on and off passengers are applied as a function. But at least 2,000 square meters are required according to experience in the past.

Among the elevated stations, the station plaza is planned for Mo Jin Dong, Seon Pa Dong and Dae Un Dong Jang stations. These three stations are located in suburban districts with wide hinterland, which will be developed in the future. As Dae Un Dong Jang Station will serve for the spectators of the new huge athletic stadium now under construction, the approval from the relevant authorities to construct acceptable station plaza in view of the gate station to the new stadium and urban planning is solicitated.

### 7.3.7 Station Service Facilities and Electric Facilities

#### (1) Station Service Facilities

Station service facilities will be located at the underground first floor in case of the underground station and the first story in case of the elevated station. The main facilities are as follows:

a. Station service room and storage

b. Resting room and conference room

c. Vending room for the ordinary and the season tickets as well as settlement of passenger fares

d. Public address room, office rooms for the platform and the signal staff

e. Ticket gate

f. Lavatories for passengers and staff

#### (2) Electric Facilities

The major facilities for electric system are as follows:

a. Traction substation, when the land acquisition for substation is impossible

b. Power distribution room, telecommunications and signal equipment room

c. Air-conditioning plant room

d. Drain pump room, sewerage pump room, extinguishing pump room

In addition to the above, such incidental facilities as water supply, drainage, purification for lavatories, fire-hydrant, automatic fire-alarm, etc. are to be taken into consideration.

The layout of the facilities in major stations are as shown in Fig. 7-12 through -15.

### 7.3.8 Building Material

There are many kinds of building material used for the interior of the station. In case of the underground station, the material shall stand against the high humidity and the high temperature which are incidental to the underground structure. Furthermore, the materials shall be of good quality in water-proof, fire-proof, durability as well as in maintenance and cost.

For the Line No. 2, the materials based mainly on fire-proof and water-proof which are those nearly the same used in Line No. 1.

The underground stations are classified into three classes, i.e., A, B, and C, whereas the elevated stations into two classes, i.e., A and B, according to the scale of station, passenger number, nature of the locating site, etc. The construction cost is calculated on the condition that the exterior and interior of the station will be finished with the appropriate materials according to the class of the station.

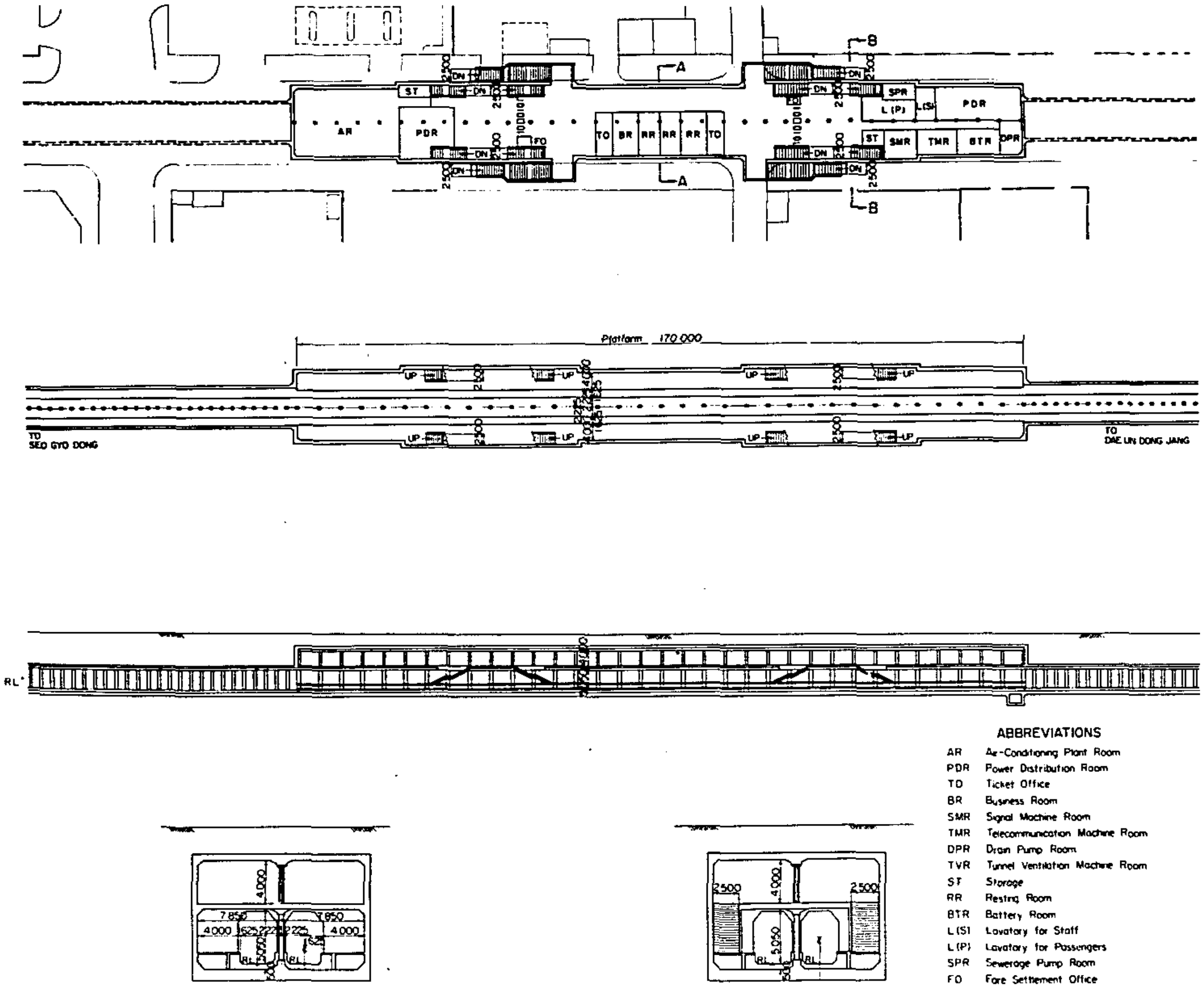
### 7.3.9 Main Features of Station

The main features of each station are summarized in Table 7-6.

## 7.4 Track Structure

The track is not only for safety train operation but also for giving good riding quality to the passengers and for inexpensive track maintenance cost. The wooden sleepers

Fig. 7-12 Underground Station Facility Layout with Separate Platforms (Dong Gyo Dong)




ABBREVIATIONS

| | |
|---|---|
| AR | Air-Conditioning Plant Room |
| PDR | Power Distribution Room |
| TO | Ticket Office |
| BR | Business Room |
| SMR | Signal Machine Room |
| TMR | Telecommunication Machine Room |
| DPR | Drain Pump Room |
| TVR | Tunnel Ventilation Machine Room |
| ST | Storage |
| RR | Resting Room |
| BTR | Battery Room |
| L(S) | Lavatory for Staff |
| L(P) | Lavatory for Passengers |
| SPR | Sewerage Pump Room |
| FO | Fare Settlement Office |
| Sta | Station |
| EPR | Extinguishing Pump Room |

Fig. 7-13 Underground Station Facility Layout with Island Platform (Dae Hyeon Dong)

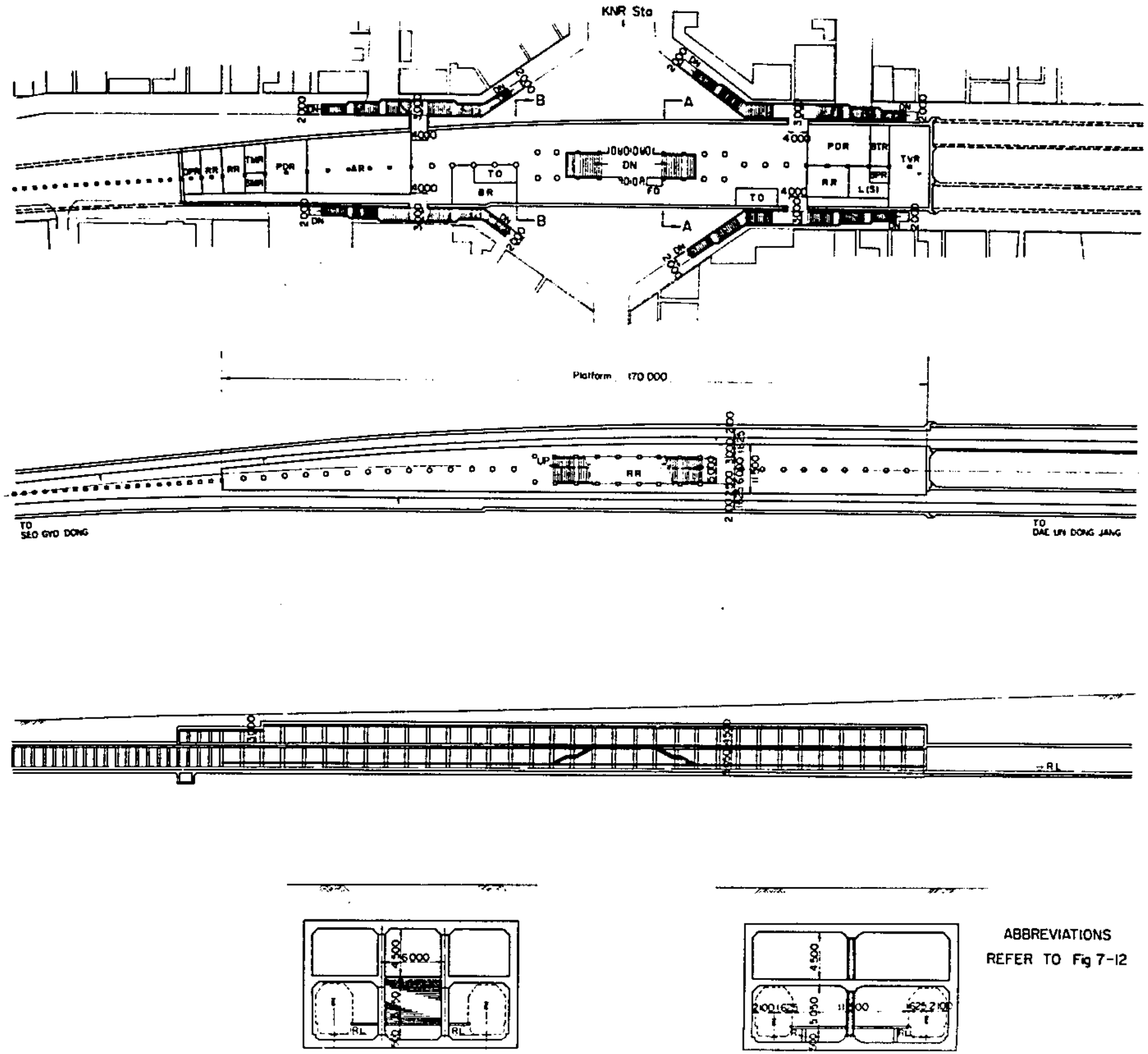


Fig 7-14 Underground Station Facility Layout with Island Platform under Elevated Road (A Hyeon Dong)

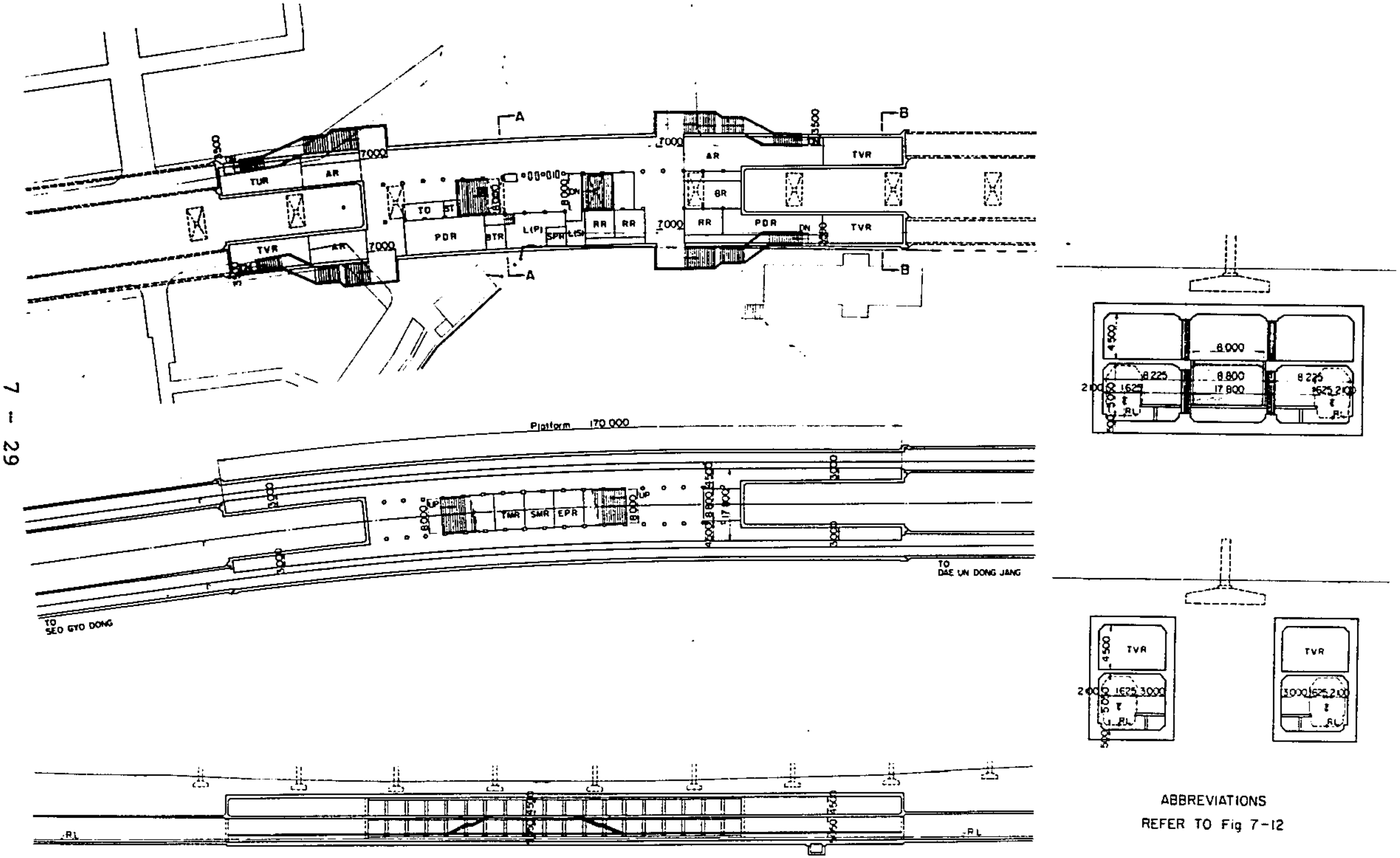
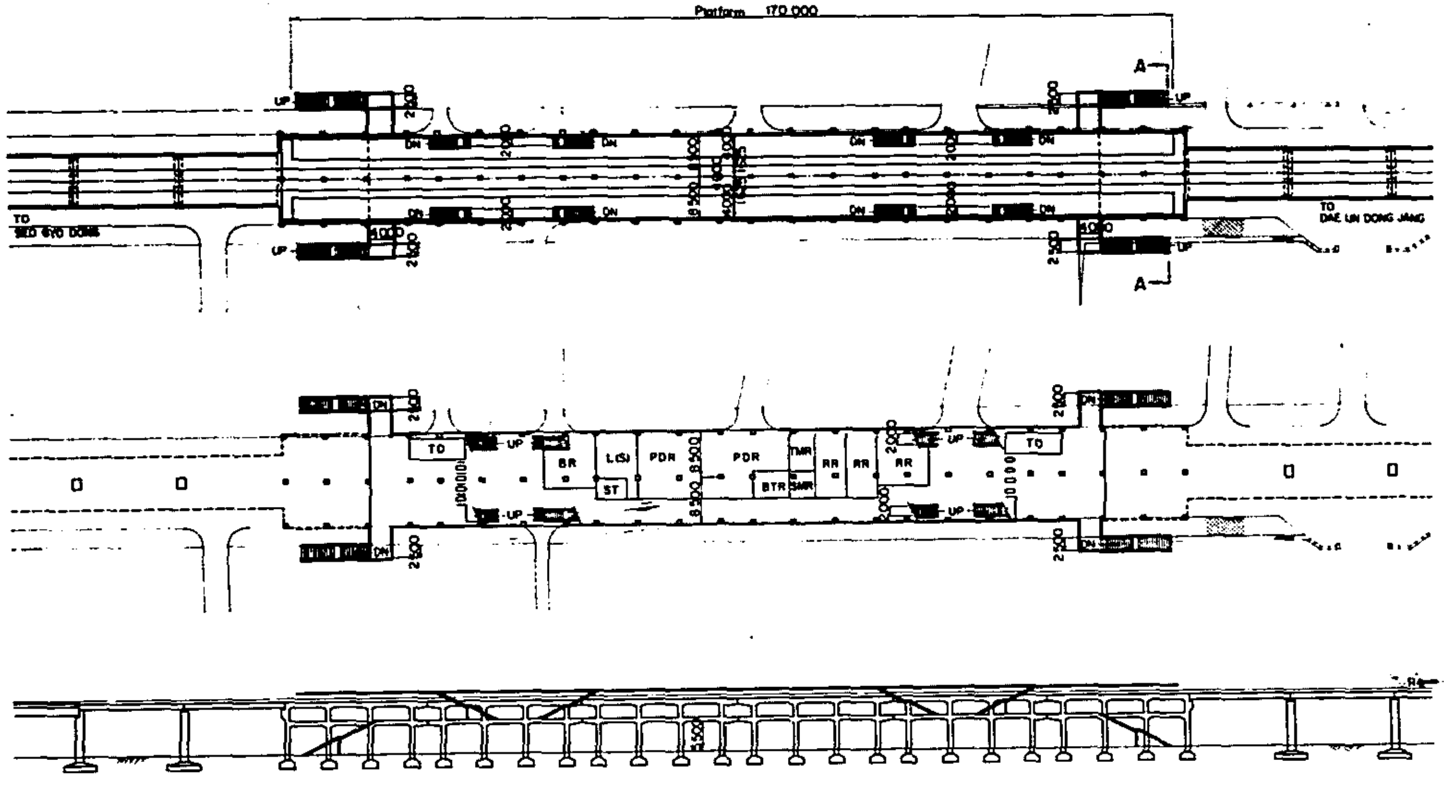
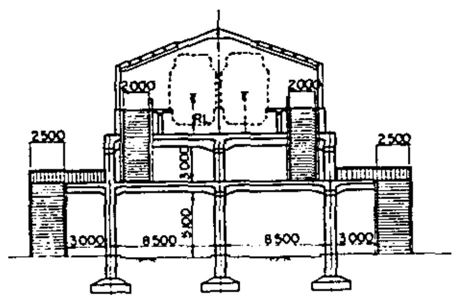


Fig. 7-15 Elevated Station Facility Layout
with Separate Platforms (Mo Jin Dong)




ABBREVIATIONS
REFER TO Fig 7-12

Table 7-6 Major Features of Stations

| Station | Type | Story | Platform | Platform Width (m) | Area ($m^2$) | Class |
|---|---|---|---|---|---|---|
| Seo Gyo Dong | Underground | 2 | Island | 8.0 | 5,300 | C |
| Dong Gyo Dong | do. | 2 | Separate | 4.0 | 5,300 | C |
| Chang Cheon Dong | do. | 2 | do. | 5.0 | 6,000 | B |
| Dae Hyeon Dong | do. | 2 | Island | 11.5 | 6,300 | C |
| A Hyeon Dong | do. | 2 | do. | 17.8 | 8,800 | C |
| Seo So Mun | do. | 2 | do. | 17.8 | 8,600 | B |
| City Hall | do. | 2 | do. | 11.0 | 7,300 | A |
| Eul Ji Ro 2-Ga | do. | 2 | Separate | 4.0 | 6,800 | B |
| Eul Ji Ro 4-Ga | do. | 2 | do. | (A)4.0(B)5.0 | 6,900 | B |
| Eul Ji Ro 6-Ga | do. | 2 | do. | (A)5.5(B)4.0 | 6,900 | B |
| Sin Dang Dong | do. | 2 | do. | 4.0 | 6,600 | C |
| Sang Wang Sib Ri | do. | 1 | do. | 4.0 | 3,700 | C |
| Ha Wang Sib Ri | do. | 2 | do. | 4.0 | 6,000 | C |
| Han Dae Ap | do. | 2 (partially 3) | do. | 4.0 | 5,800 | C |
| Seong Su Dong | Elevated | 2 | Island | 7.0 x 2 | 8,900 | B |
| Hwa Yang Dong | do. | 2 | Separate | 4.0 | 5,300 | B |
| Mo Jin Dong | do. | 2 | do. | 4.0 | 5,300 | B |
| Seong Pa Dong | do. | 2 | do. | 4.0 | 5,300 | B |
| Jam Sil Dong | do. | 2 | do. | 4.0 | 5,300 | B |
| Dae Un Dong Jang | do. | 2 | Island | 10.0 | 5,300 | A |

and ballasted track structures have been used for the Line No. 1. In case of the rapid transit railways in urban districts with lots of passing passengers, the concreted track with prestressed concrete sleepers is preferable for curtailing the maintenance cost and diminising the inner dimension of the structures.

The main features of the track structure for the Line No. 2 are as follows:

(1) 50 kg N-rail is used for the main line and 40 kg N-rail is for the sidings.

(2) The sleepers for the concreted track and ballasted track are both prestressed concrete sleeprs with double elastic fastenings.

(3) Turnouts branching off from the main line and those from sidings are of No. 10 and No. 8 turnouts, respectively.

(4) The line under the road is of the concreted track.

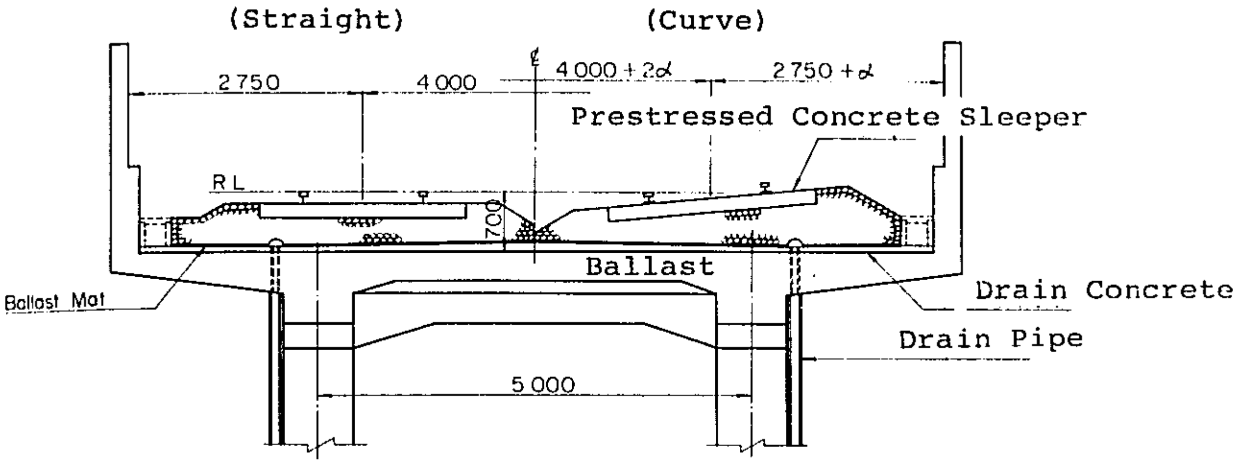
(5) The line under the private land and elevated section, where vibration and noise may cause social problem, is of ballasted track with vibration-proof mat.

(6) On the river bridge, open floor structure is introduced.

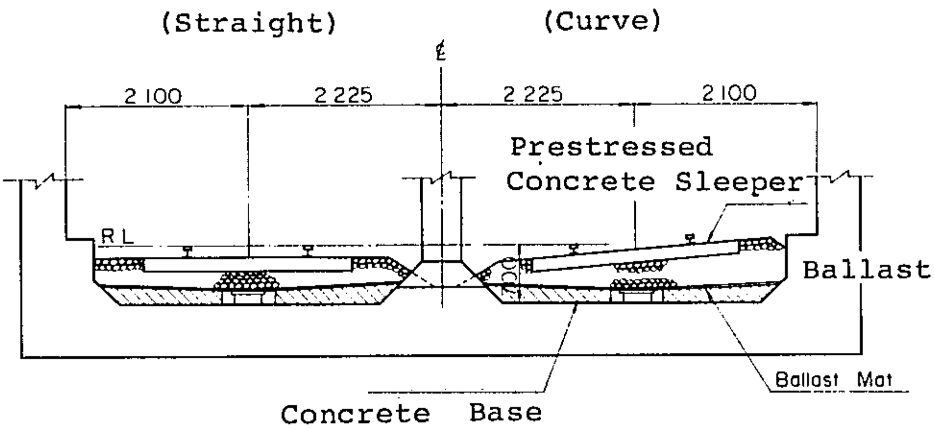
The typical profiles of the concreted track and ballasted track in the underground section as well as the ballasted track in the elevated section are as shown in Fig. 7-16. The double elastic fastening is as shown in Fig. 7-17. The summarized feature of the track structure is as shown in Table 7-7.

Fig. 7-16 Typical Profile of Track Structure

Ballasted Track in Elevated Section




Ballasted Track in Underground Section




Concreted Track in Underground Section

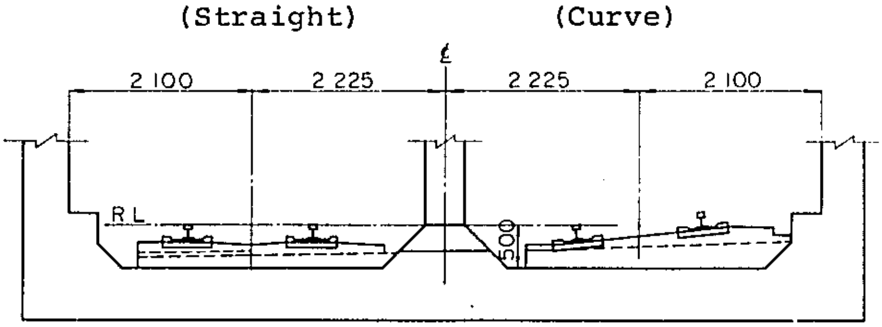


Fig. 7-17  Double Elastic Fastening

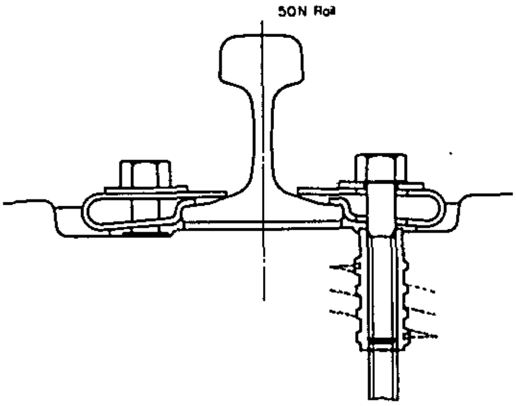



Table 7-7  Track Length by Type

| Type | Location | Main Line (Route m) | Car Depot Siding (Route m) | Total (Route m) |
|---|---|---|---|---|
| Concreted Track | Underground under road | 24,700 | -- | 24,700 |
| Ballasted Track | Underground under private land | 810 | -- | 810 |
| | Elevated | 20,090 | 1,790 | 21,880 |
| Open Floor Track | River Bridge | 3,240 | 400 | 3,640 |
| Total | | 48,840 | 2,190 | 51,030 |

## 7.5 Construction Planning

### 7.5.1 General

The construction work of the rapid transit railways is naturally executed in the city center or busy district and in many cases under or over the road. The accident during construction, therefore, affects seriously on many aspects other than the construction work itself. In view of secured preservation of the road and buried public utilities as well as safety and countermeasures against pollutions for the inhabitants along the construction sites, the highly skilled construction technics and the capable supervising activities are required.

The major classifications of the construction method for the Line No. 2 are the cut-and-cover box tunnel, the rock tunnel and the elevated bridge.

### 7.5.2 Cut-and-Cover Box Tunnel Construction Method

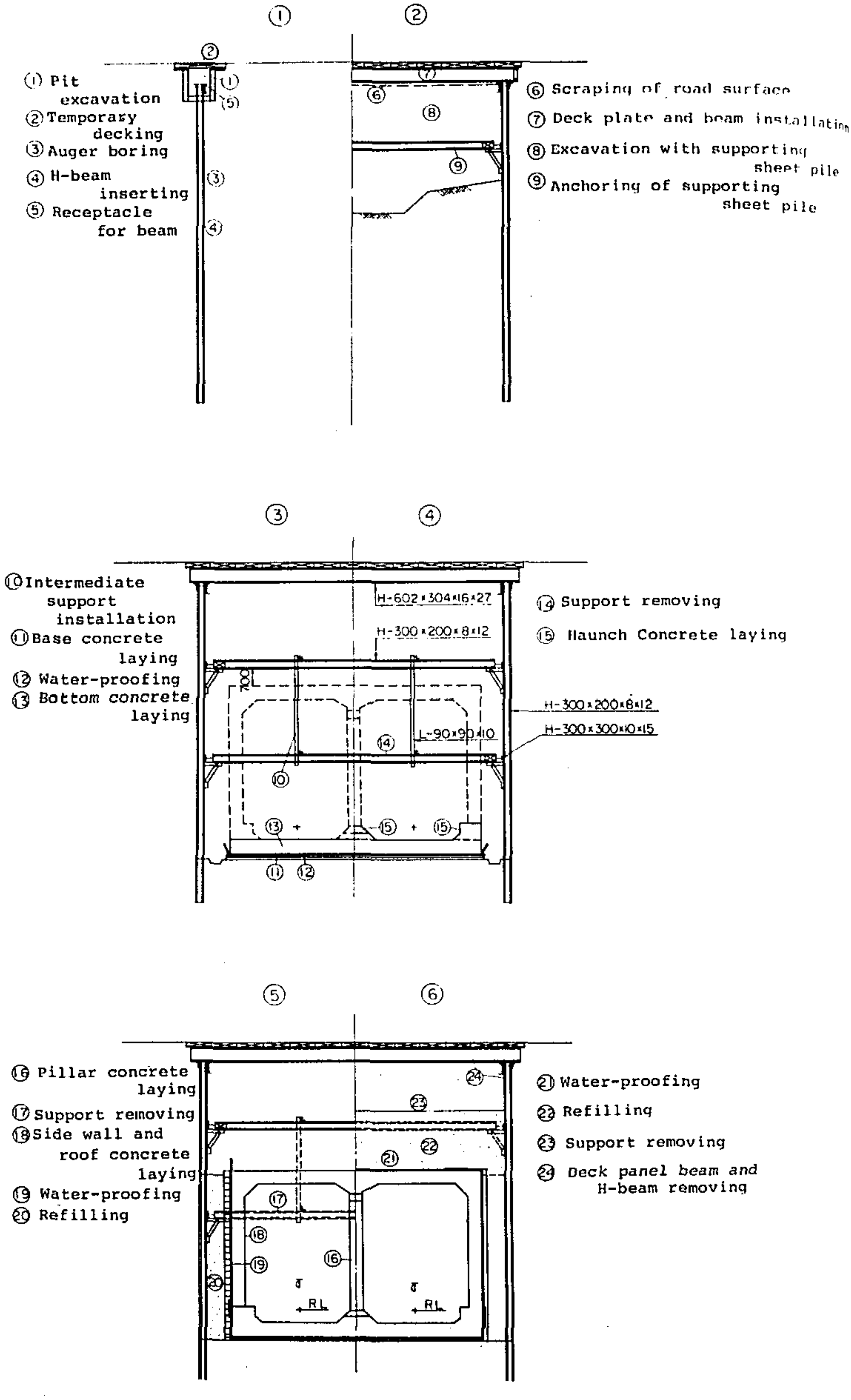
Cut-and-cover method is the most usual procedure, which is already experienced in the Line No. 1 in Seoul. The working process is, as shown in Fig. 7-18, in the following order: H-beam piling for supporting sheet pile, decking with steel plate over the construction site for maintaining vehicle traffic, excavation, box tunnel construction, filling, removing decking, removing H-beam and repaving of road surface.

As the water-proofing of the side wall is made at the outside of the box tunnel, one meter allowance in each side is planned for the excavation.

As to the piling method of H-beams, holes are drilled by auger and then H-beams are inserted therein. Selection of the auger machinery for hard layer will require relevant considerations.

For excavation of hard granitic rock, it is planned to introduce heavy construction machine to expedite construction period. The careful construction is required when the work

## Fig. 7-18 Working Order of Cut-and-Cover Construction Method



is executed at the crossings with sewerage. Special cautions are to be taken for securing and temporary bypassing of a sewerage near Han Dae Ap.

The underpinning work for the Line No. 1 is executed by the trench method taking the geological conditions into consideration.

As to the construction of the box tunnel under the elevated road near Dae Hyeon Dong, soil improvement, additional piling for supporting piers, temporary support of girder, etc. are required before constructing the Line No. 2.

### 7.5.3 Rock Tunnel Construction Method

Whereas the cut-and-cover method is to excavate soils and rocks vertically from the ground surface, the rock tunnelling method excavates soils and rocks horizontally. The latter has been introduced for the tunnelling work in mountainous region. So far this method has not been used in the urban districts, because of vibration caused by explosives, settlement of ground surface, etc. In the case of the Line No. 2 construction, the section between Don Gyo Dong and City Hall being highly undulated, overburden above the structures is naturally tremendous. Moreover, the hard rock layer is existent only few meters below the ground surface. Therefore, rock tunnel excavating method is much better comparing with the cut-and-cover method in view of construction and costs.

There are several kinds of rock tunnel excavating method, the major ones of which are:

(1) Upper-face excavating with side pilot tunnels method

(2) Upper-face excavating method

(3) Full-face excavating method

(4) Special excavating method

Taking geological conditions in Seoul into consideration, the upper-face excavating method will be most recommendable.

The H-beam support and concrete sublining placing method are planned for the section where overburden is negligible or rock conditions are not enough. When the rock condition is sufficient, sublining is executed with mortar-shooting. The water-proofing is not generally performed for the rock tunnel, but, in this project, proofing will be executed at the upper portion and at both sides for preventing dripping water in view of urban transit railway.

The order of work procedure is as shown in Fig. 7-19 which is applicable both for the single line and double line tunnels.

When the tunnel is constructed close to the elevated road, watching of the piers against distortion due to the tunnel excavation shall continuously be made. If any distortion is detected, the prompt necessary countermeasures are essential.

### 7.5.4 Elevated Section Construction Method

There are several types of structures in the elevated section and their construction methods. The proper selection among the structure types and methods in conformity with the field conditions is important.

The structure types include the following:

(1) Prestressed concrete girder elevated bridge

(2) Composite girder elevated bridge

(3) Reinforced concrete rigid frame elevated bridge

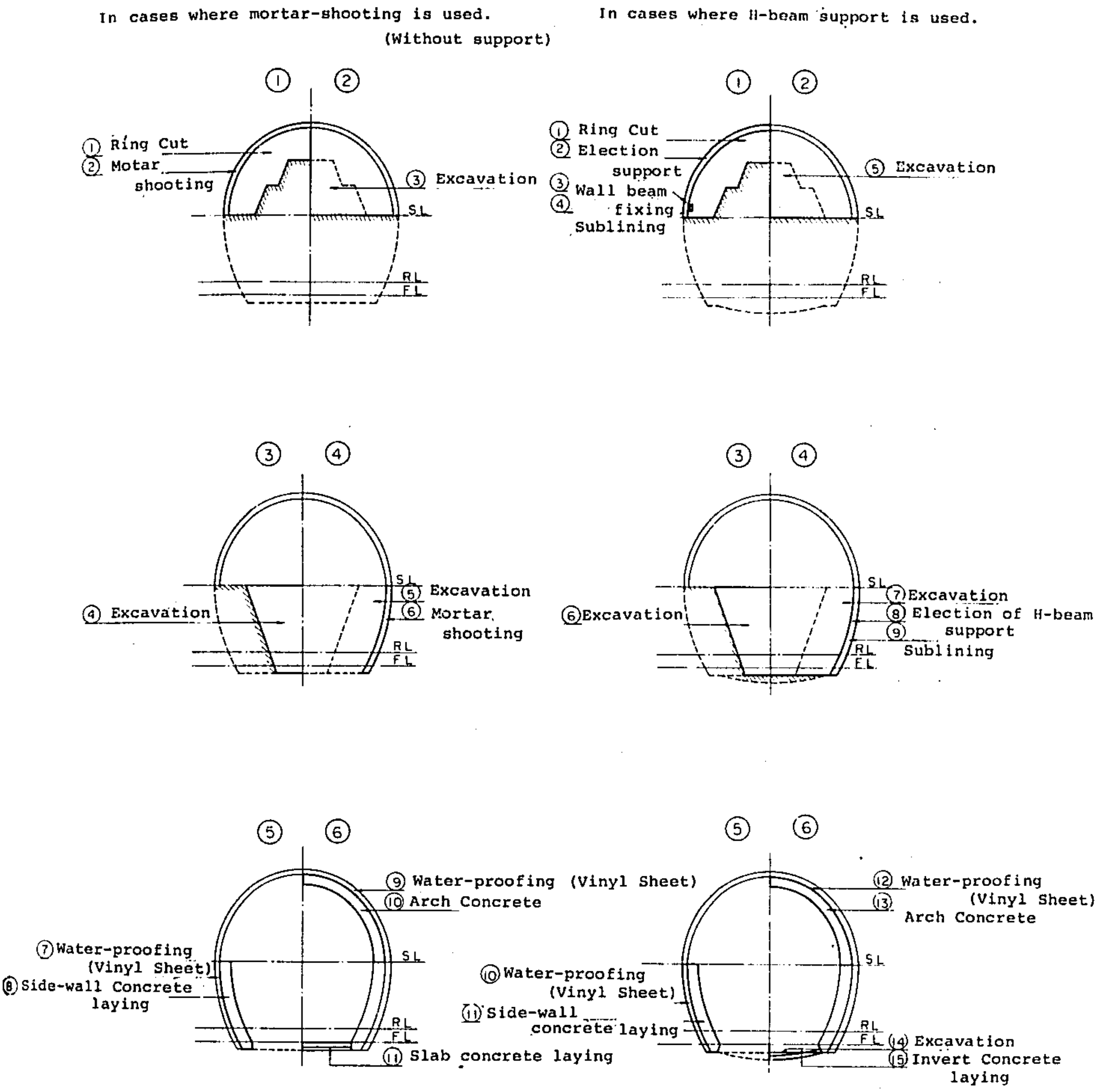
(4) Upper-deck steel girder river bridge

The construction method and others of each type are mentioned hereinafter:

(1) Prestressed Concrete Girder Elevated Bridge

The piers of the PC bridge is constructed in the order of driving the reinforced concrete pile, pit excavation and concrete placing for footing, concrete placing for the main

## Fig. 7-19 Working Order of Rock Tunnel Construction



body of pier. The PC girders will be produced at the work base installed nearby and the prefablicated girders are transported to the construction site by the traile truck. Then the girder is lifted up and placed at the proper position by means of the gantry crane. The RC pile is the centrifugal reinforced concrete pile with diameter of 500 mm. Refer to Fig. 7-2(

(2) Composite Girder Elevated Bridge

The pier construction method is the same as in the case above-mentioned. The kind of pile is also the same.

The composite girder is to be manufactured at the workshop and transported to the construction site. The girder is affixed with the temporary support and the crane car. Then, the slab concrete and handrail concrete are to be placed.

(3) Reinforced Concrete Rigid Frame Elevated Bridge

The bearing piles are of the centrifugal reinforced concrete piles with diameter of 500 mm. The working order is pile driving, footing, pier, slab concrete, and handrail concrete.

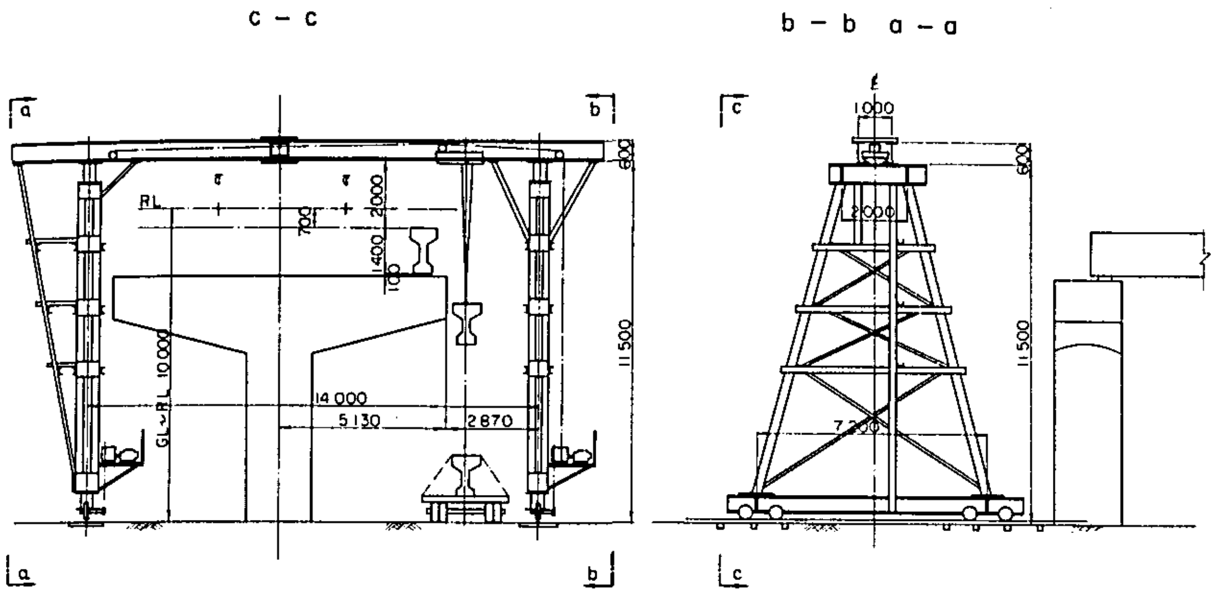
In addition, water-proof work is to be executed for the track slab in the station.

(4) Deck Steel Girder River Bridge

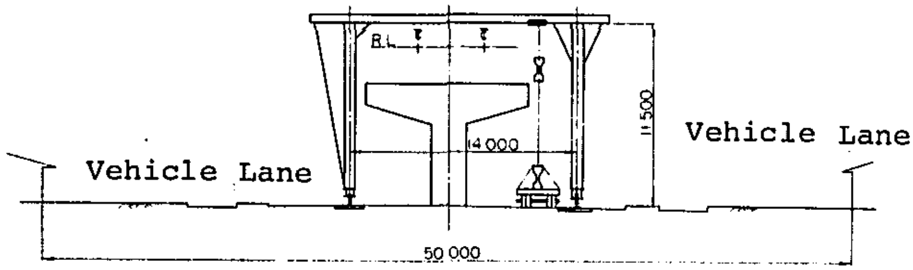
The cast-in-place pile of reverse circulation method will be introduced for the foundation pile.

The pit will be excavated with double line steel sheet pile for preventing inflow of water in cases where the work is executed in the river. The girder is manufactured in the workshop and transported to the site. The girder assembling on the river will be implemented by means of the cantilever method, whereas crane will be used for other portions without water flow.

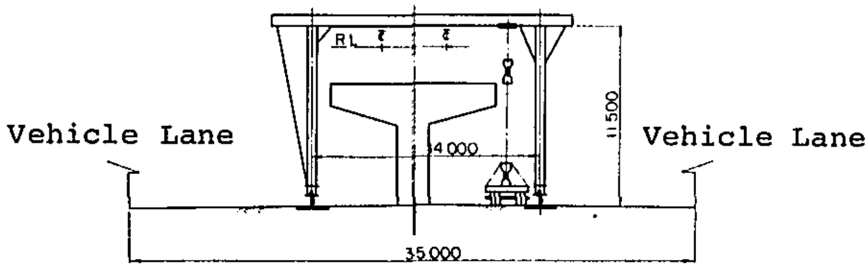
Fig. 7-20 Prestressed Concrete Girder Placing by Gantry Crane




Relation between construction work site and vehicle lane in case of 50-m road.




In case of 35-m road



# 8. Electric Facilities

## 8.1 Electric Power Supply System and Signal System

The electric power supply system is to be D.C. 1,500 V overhead contact wire system considering the following conditions:

(1) The electric power feeding and collection system is to be the same as those of the Line No. 1, because the car depot of the Line No. 1 will be shared in common with the Line No. 2.

(2) The D.C. 1,500 V system is the most economical and reliable, comparing with other systems for the mass transit electric railway in the major cities.

(3) The overhead contact wire system is more economical and safer than a third-rail system, because the elevated section is longer than the underground section, when due regard is given to the future extension of the Line No. 2 and farther construction of new lines.

The train protection system is to be the double track automatic block system in order to ensure the safety of high speed and high density operation as well as the higher efficiency.

## 8.2 Electric Power Source and Feeding System

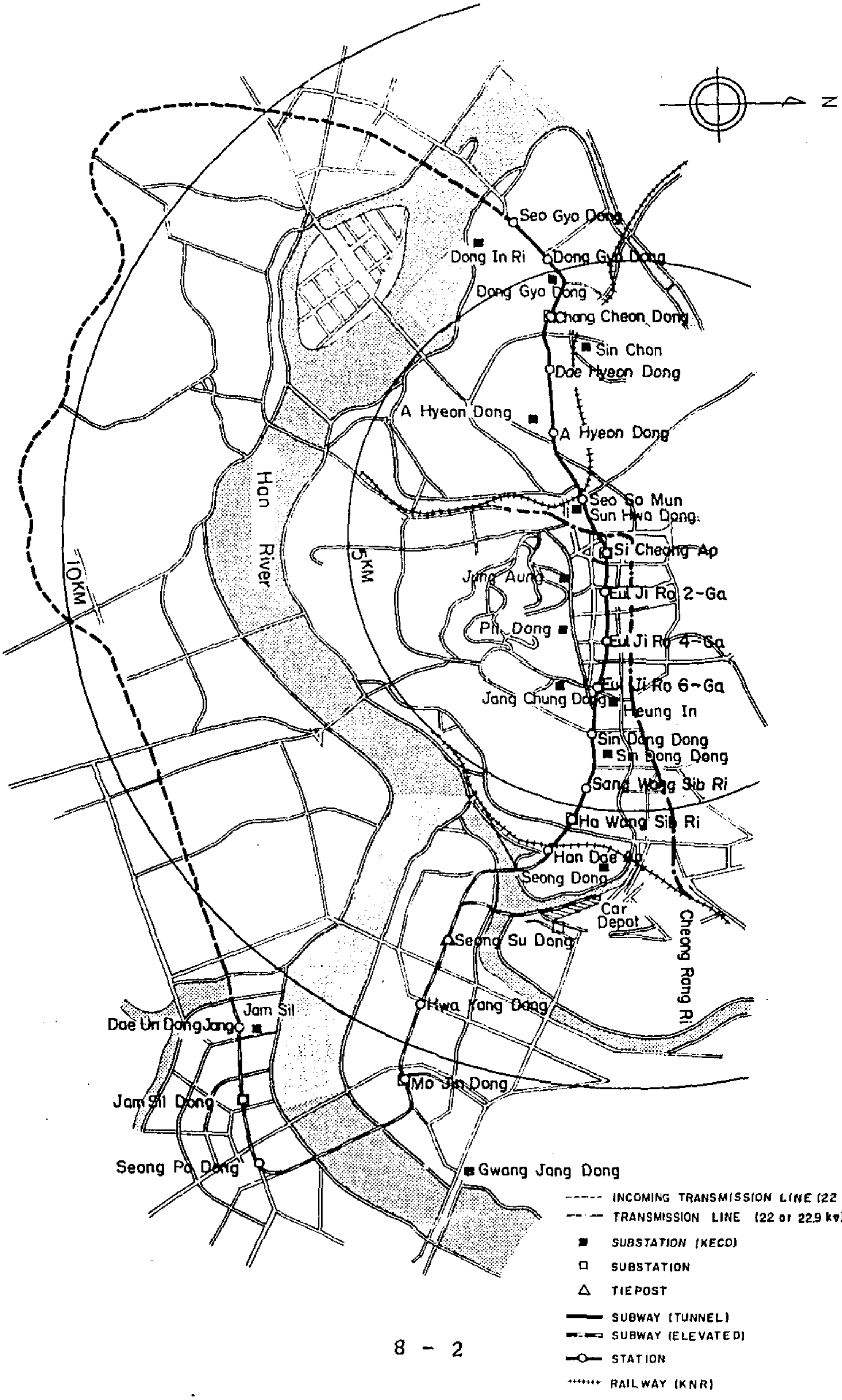
### 8.2.1 Electric Power Source

There are many substations of the Korean Electric Power Company (KECO) connecting with the 154 kV transmission line along the Line No. 2, as shown in Fig. 8-1. The substations in Table 8-1 is to be selected as the power source considering the following requirements:

(1) Reliability of electric power supply

(2) Short distance from the traction substation of the Line No. 2.

Fig.8-1 Layout of Electric Power System



(3) The traction substation is to be supplied from two KECO's electric power sources in order to make it free from power failure. Thus it is desirable that KECO's substations chosen for this purpose would be of the same voltage and the same system.

Table 8-1 Electric Power Sources

| Name of KECO's substation | Voltage (kV) | Power Capacity (MVA) | Location |
|---|---|---|---|
| Dong In Ri | 154/22 | 1,000 | Dong In Dong 66 |
| Sun Hwa Dong | 154/22 | 1,000 | Sun Hwa Dong 212 |
| Heung In | 154/22.9 | 1,000 | Sin Dong Dong 217 |
| Jam Sil | 154/22.9 | 1,000 | Jam Sil 8 |

### 8.2.2 Requisite Electric Power

The requisite peak power and annual power consumption in the years of partial opening and total opening of the Line No. 2 are estimated in Table 8-2. The KECO has a sufficient capacity to meet these demands.

Table 8-2 Requisite Electric Power Estimated

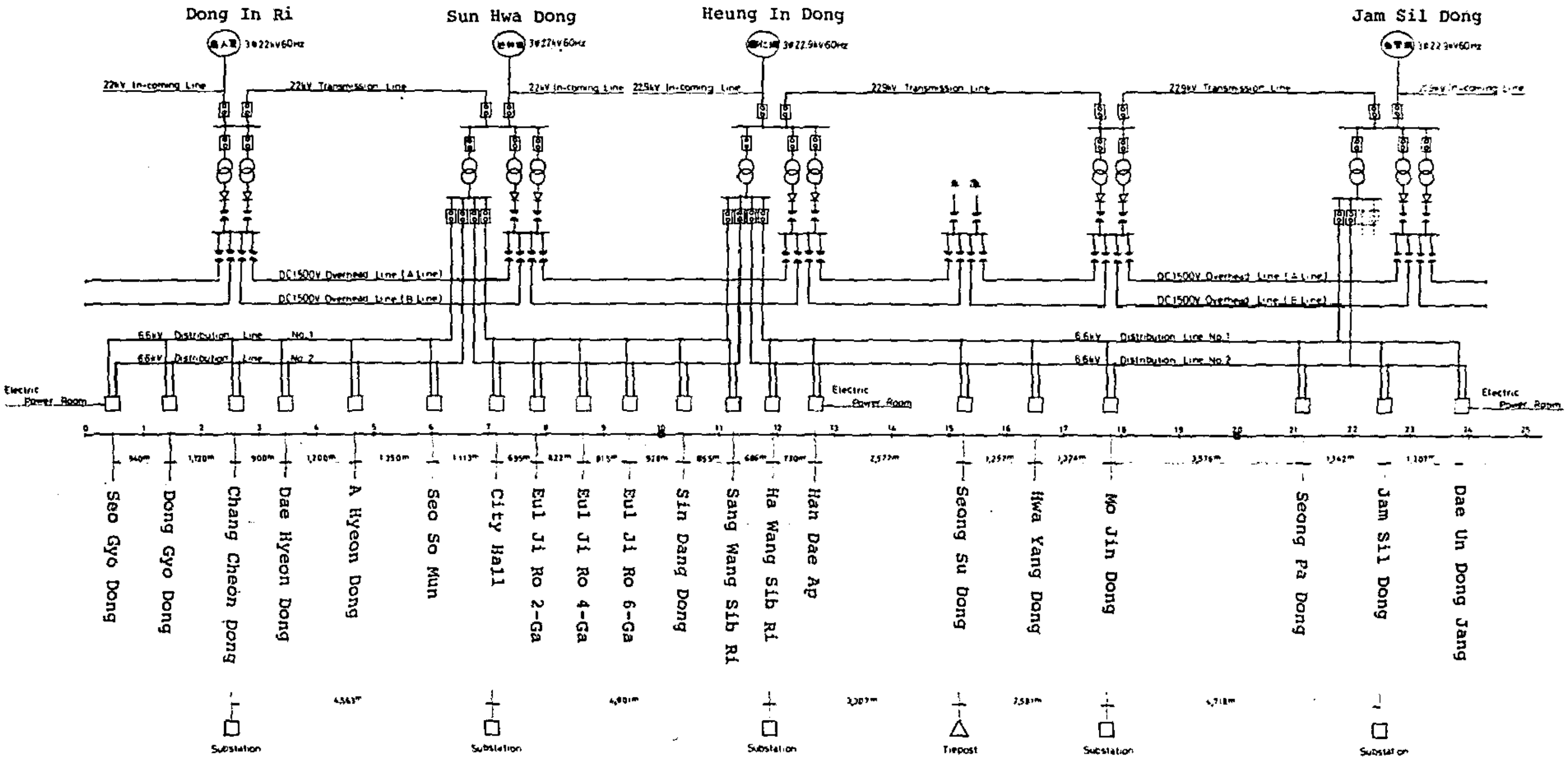
| Year | Peak Power Consumption | Annual Power Consumption |
|---|---|---|
| 1982 | 8,000 kW | 50,000 MWh |
| 1984 | 17,000 kW | 80,000 MWh |

### 8.2.3 Feeding System

The feeding network is shown in Fig. 8-2. Main features are as follows:

(1) Five D.C. substations are installed over the whole line of 24 km.

Fig. 8-2 D.C. Feeding, Transmission and Distribution System Diagram



(2) The feeding from a substation is separately done for lines A and B and for each direction. On each line the feeding between substations is parallel.

(3) A sectioning post is installed at Seong Su Dong for the parallel feeding between the main line substation and the existing Car Depot Substation.

(4) The feeding to the car depot siding is done from the Car Depot Substation.

8.2.3.1 Voltage Drop

(1) Minimum Voltage of Contact Wire System

The minimum voltage of contact wire system is to be the one which does not affect the characteristics of the traction motor and auxiliary machines of the electric cars. From this viewpoint, it should be over 1,000 V, the same as on Line No. 1, but this would be variable depending upon the characteristics of the car in use.

(2) Calculation of Voltage Drop

Voltage drop at the point of car pantograph is the sum of voltage drops at the KECO electric power source, at the D.C. converting equipment of traction substation and at the feeding circuit. Generally speaking, the voltage drop at the electric power source is so small that it is negligible. The D.C. converting equipment (silicon rectifier), voltage regulation of which is usually 6--8%, is so designed as to give a rated voltage of 1,500 V under the rated load. Therefore, under overload of 200%, the voltage becomes 1,410--1,380 V. Voltage drop in the feeding circuit depends on the electric resistance and the load current of the contact wire system. Resistance of the contact wire system is the product of the resistance per kilometer which is determined by the structure including the return circuit, as multiplied by the feeding distance. Ordinarily, however, the feeding distance is the only factor governing the voltage drop, because the loading current will be determined by the operation schedule, and also the structure of contact wire will be determined by the economic considerations and others.

Conditions of car operation under partial and total opening of the Line No. 2 are shown in Table 8-3. In Table 8-4 are given the results of voltage drop calculations considering conditions in Table 8-3 and an assumed train diagram.

Table 8-3 Conditions of Car Operation

| | Partial Opening (1982) | Total Opening (1984) |
|---|---|---|
| Train Consist | 6M2T | 6M2T |
| Minimum Headway | 5 min. | 3 min. 30 sec. |
| Schedule Speed | 30 - 35 km/h | 30 - 35 km/h |

Table 8-4 Voltage Drop

| | | Partial Opening | Total Opening |
|---|---|---|---|
| Maximum Voltage Drop | D.C. Traction Substation | 97 V | 58 V |
| | Contact Wire System | 167 V | 202 V |

8.2.3.2 Location of Traction Substation

Location of traction substations is mainly decided in view of the voltage drop mentioned above. In this project, the following conditions are considered in determining the location.

(1) Values in Table 8-3 are used as the conditions of train operation.

(2) As a countermeasure for source failure, each traction substation receives the power from two power sources and has D.C. converting equipment with a standby unit. Thus the extension of feeding from neighboring traction substation in time of emergency is not considered.

(3) For reasons of the construction cost saving and convenience for the maintenance, the number of traction substations is reduced as few as possible, and they are located at railway stations.

(4) Distance between substations is set up to make it easy to distinguish the accident current from the operation current for securing the feed protection.

(5) The output power of the Existing Car Depot substation near Seong Su Dong Station may be used partly for the main line through the sectioning post.

(6) Structure of the contact wire system by which the resistance is decided is as follows:

   (a) Feeder is not installed in the section where overhead contact-bar system is used.

   (b) Two feeders of Al 500 $mm^2$ are installed in the section of the overhead catenary contact wire system.

After examining the items mentioned above, the location of substations has been selected as shown in Fig. 8-1. Namely, three underground substations are to be located at Chang Cheon Dong, City Hall and Ha Wang Sib Ri, and two surface substations at Mo Jin Dong and Jam Sil Dong.

8.2.3.3 Receiving System

Five Traction substations are to receive the electric power from four substations of the KECO. The receiving system is to be as follows:

(1) As mentioned above, all traction substations are to be "Non failure system" with a standby electric power source, and therefore each of them is to receive electric power from two KECO's substations. There are KECO's substations of 22 kV and 22.9 kV, but the voltages of the two KECO's substations, from which one traction substation is supplied, should be the same.

(2) The number of the receiving points is to be as few as possible, so that the cost of the contracted electric charge may be inexpensive.

(3) Receiving distance should be as short as possible to reduce the voltage drop and the construction cost.

After examining above items, it has been decided to divide the traction substations into two groups. Each group, in which the link transmission line is installed, is to receive electric power from two KECO's substations. This system is found to be the most economical with the highest reliability of power supply. The receiving network is illustrated in Fig. 8-2.

### 8.2.4 Traction Substation

#### 8.2.4.1 Capacity of Traction Substation

Capacity of a traction substation is to enable to meet the average load per hour in the rush hours and the assumed maximum momentary load in its feeding section.

Results of calculation for partial and total operation are shown in Table 8-5.

Table 8-5 Capacity of Traction Substation

| Item \ Substation | | Chang Cheon Dong | City Hall | Ha Wang Sib Ri | Mo Jin Dong | Jam Sil Dong |
|---|---|---|---|---|---|---|
| Partial operation | Average load per hour (kW) | - | 1,919 | 3,399 | 3,439 | 3,135 |
| | Maximum momentary load (kW) | - | 5,774 | 8,529 | 8,600 | 8,062 |
| | Required capacity of converting equipment (kW) | - | 2,310 | 3,399 | 3,440 | 3,225 |
| | Capacity of a unit of converting equipment (kW) | - | 6,000 | 6,000 | 6,000 | 6,000 |
| | Required unit of converting equipment | - | 1 | 1 | 1 | 1 |
| | Required unit of standby equipment | - | 1 | 1 | 1 | 1 |
| | Total unit | - | 2 | 2 | 2 | 2 |
| Full operation | Average load per hour (kW) | 5,158 | 5,698 | 5,098 | 5,158 | 4,702 |
| | Maximum momentary load (kW) | 11,478 | 12,340 | 11,381 | 11,478 | 10,736 |
| | Required capacity of converting equipment (kW) | 5,158 | 5,698 | 5,098 | 5,158 | 4,702 |
| | Capacity of a unit of converting equipment (kW) | 6,000 | 6,000 | 6,000 | 6,000 | 6,000 |
| | Required unit of converting equipment | 1 | 1 | 1 | 1 | 1 |
| | Required unit of standby equipment | 1 | 1 | 1 | 1 | 1 |
| | Total unit | 2 | 2 | 2 | 2 | 2 |

8.2.4.2 Traction Substation Facilities

(1) Main Devices

The skeleton diagram and the layout of main devices are as shown in Figs. 8-3 and -4, respectively.

Main devices are as follows:

| | |
|---|---|
| D.C. converting equipment: | Silicon rectifier and transformer |
| A.C. circuit breaker: | VCB type |
| D.C. circuit breaker: | HSCB type |
| Disconnection switch: | Horizontal or vertical single break type |
| Distribution panel: | Vertical self-standing type |
| High voltage distribution panel: | Enclosed vertical self-standing type |
| High voltage transformer: | Oil-filled self-cooling type |
| Remote control: | Normally cyclic type remote control device |

(2) Protection System

The power receiving and the transmission systems, the buses, the main devices, the feeding system and the distribution system are to be protected separately. If an accident happens, the part with a trouble should be identified immediately and cut off so as not to allow the trouble to spread to other devices, lines and systems. It is important to coordinate protection with the KECO's substations.

The following items are to be especially taken up in the protection system.

(a) Receiving and Transmission System

The link transmission line connecting each traction substation receives and transmits the electric power. Therefore, the receiving and the sending ends are not

Fig. 8-3 Traction Substation Skeleton Diagram

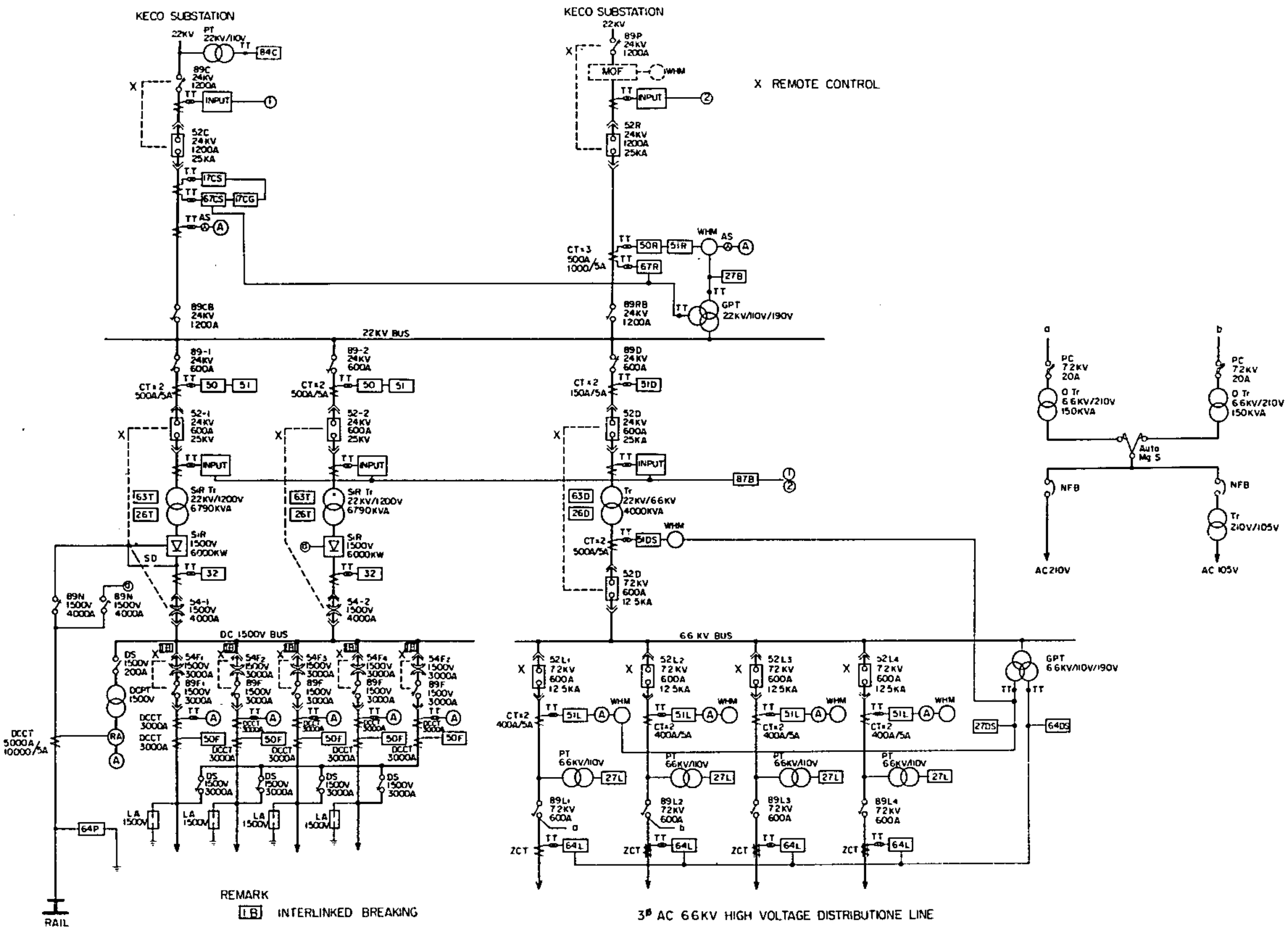
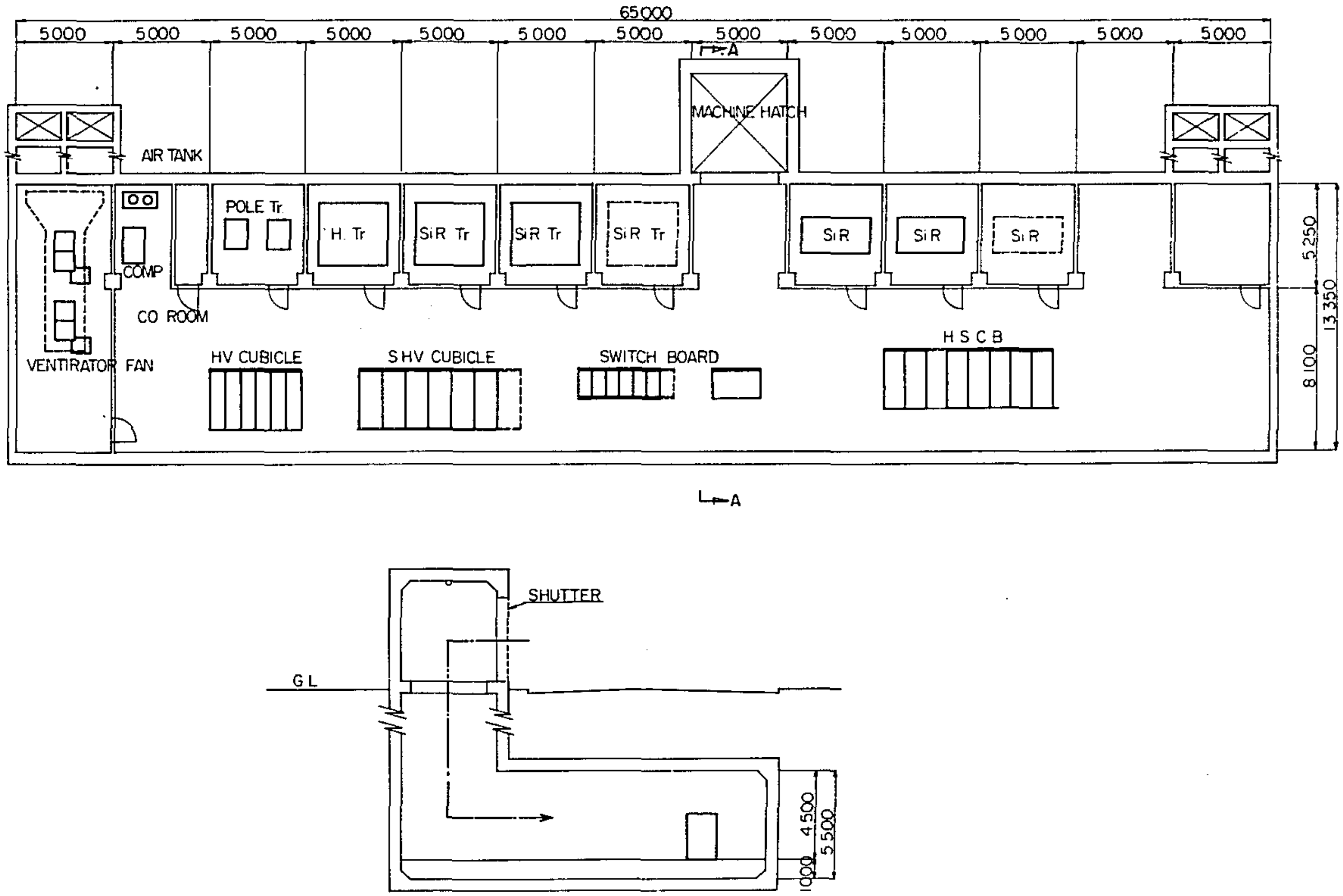


Fig. 8-4 Traction Substation Layout




SECTION A—A

fixed. For protecting the transmission line, the time adjusting type is not satisfactory, and such protection system as the pilot wire will be required.

(b) Feeding System

The feeding system should be protected by a ΔI type selective faulty current relay which selects and breaks the faulty current. Further, when the high speed circuit breaker acts at a substation, another circuit breaker of the related substation should be operated through an exclusive interlink line.

(3) Remote Control System

All traction substations should be an unattended type controlled and supervised remotely by a control center. The remote control system should be able to control, indicate and measure all traction substations, and it should be a normal cyclic type with high speed transmission and high reliability.

8.2.4.3 Sectioning Post

A skeleton diagram of the sectioning post is shown in Fig. 8-5. Main device is as follows:

D.C. Circuit Breaker: Two directional type HSCB

## 8.3 Contact Wire System

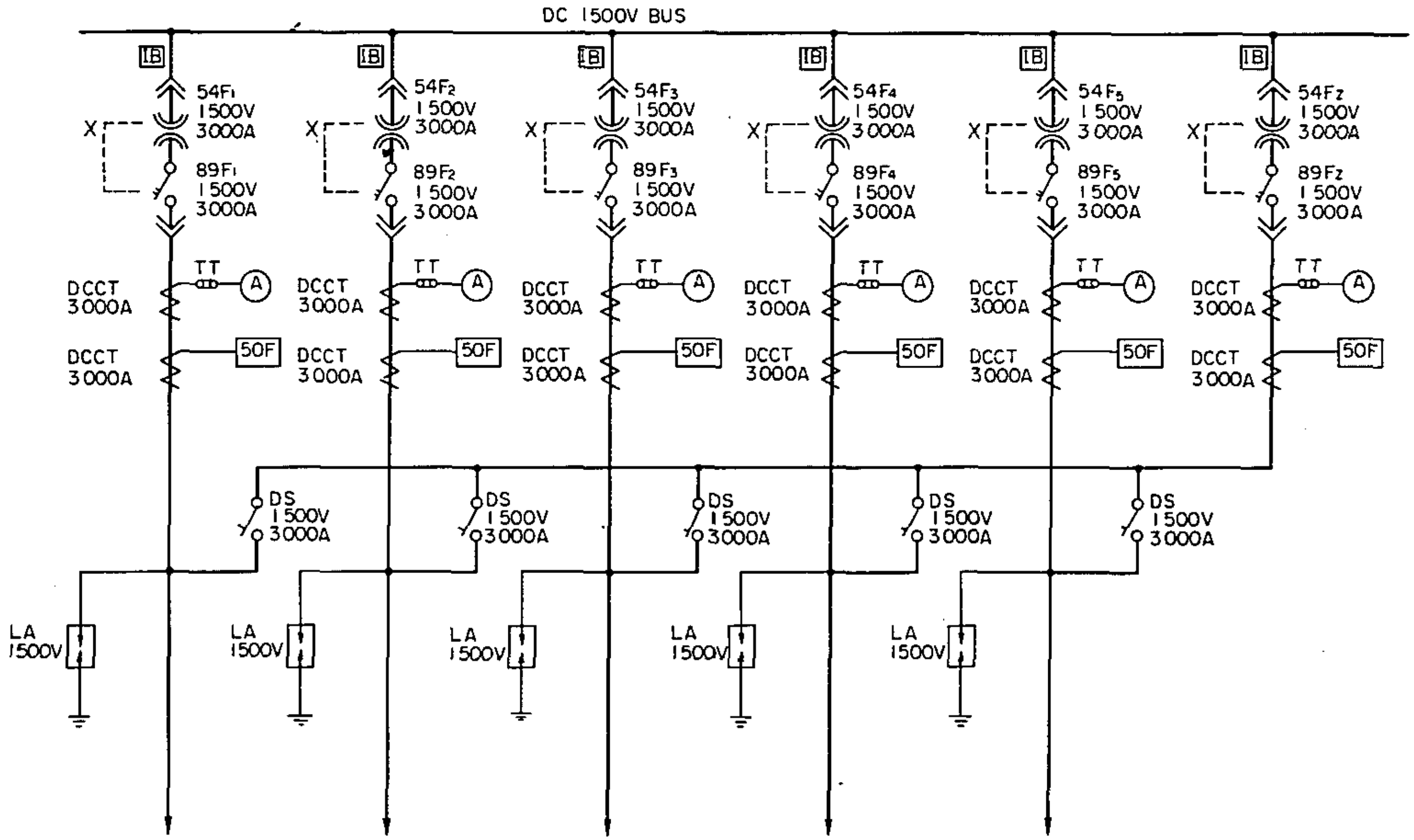
### 8.3.1 Selection of System

The contact wire system for the underground section is the overhead trolley-bar system. For the elevated main track it is the heavy simple catenary system, and for the car depot, car depot siding and a loopline in Seong Su Dong Station, is the simple catenary system. Reasons for this selection are as follows:

(1) The overhead trolley-bar system is free from breakdown accident, and it is also effective to reduce the cross-section of tunnel.

Fig. 8-5 Sectioning Post Skeleton Diagram

X REMOTE CONTROL




REMARK
IB INTERLINKED BREAKING

(2) The heavy simple catenary system, comparing with the double simple catenary system, is inexpensive with the same performance.

(3) In the car depot and the car depot siding as well as the loop line in Seong Su Dong Station where high speed train operation is not required, the most inexpensive simple catenary is desirable.

8.3.2 Standard Structure and Materials

A standard structure of the contact wire system in the box tunnel is shown in Fig. 8-6; one in the rock tunnel in Fig. 8-7; and one in the elevated section in Fig. 8-8. Main items of equipment are as follows:

(1) Overhead Trolley-Bar System

Major specification of the overhead trolley-bar system is shown in Table 8-6.

Table 8-6 Outline of Overhead Trolley-Bar System

| Height of Contact Line | Interval of Supporting Points | Lateral Deviation |
|---|---|---|
| 4,750 mm | 5 m | 200 mm |

Outline of structure is as follows:

(a) Support insulator of 250 mm in diameter is used.

(b) The contact wire is affixed to the T-type aluminum bar with the long ears.

(c) The contact wire is a trapezoid-type grooved 110 $mm^2$ hard-drawn copper wire.

(d) Expansion joint is installed at every 200 m, and anchoring is effected at midpoint.

(e) CV corrugated cable for 1,500 V is used at the positive outgoing line from the traction substation.

(f) Low voltage cable is used at the negative outgoing line.

Fig. 8-6 Electric Facilities (Box Tunnel)

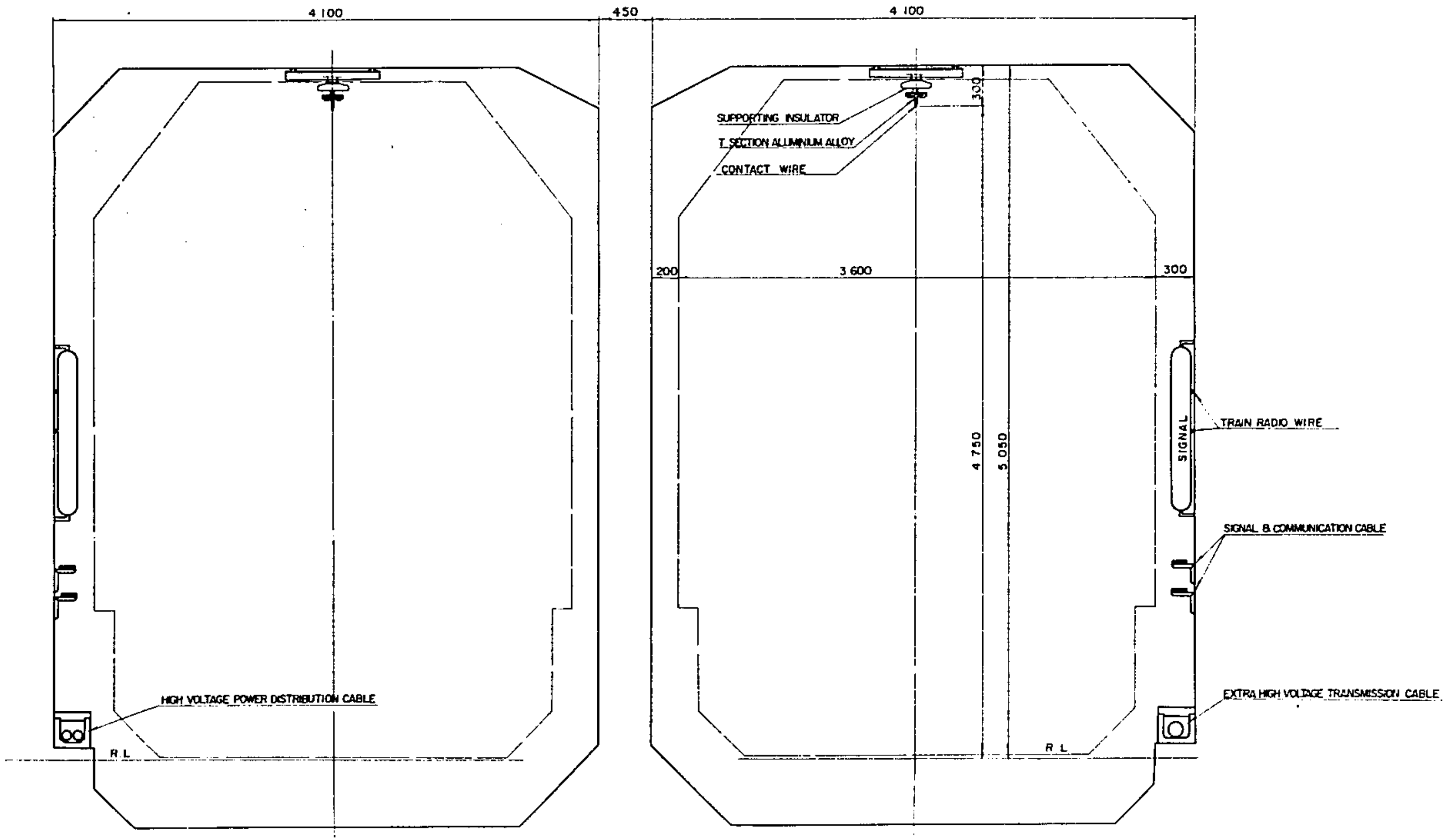


Fig. 8-7  Electric Facilities (Rock Tunnel)

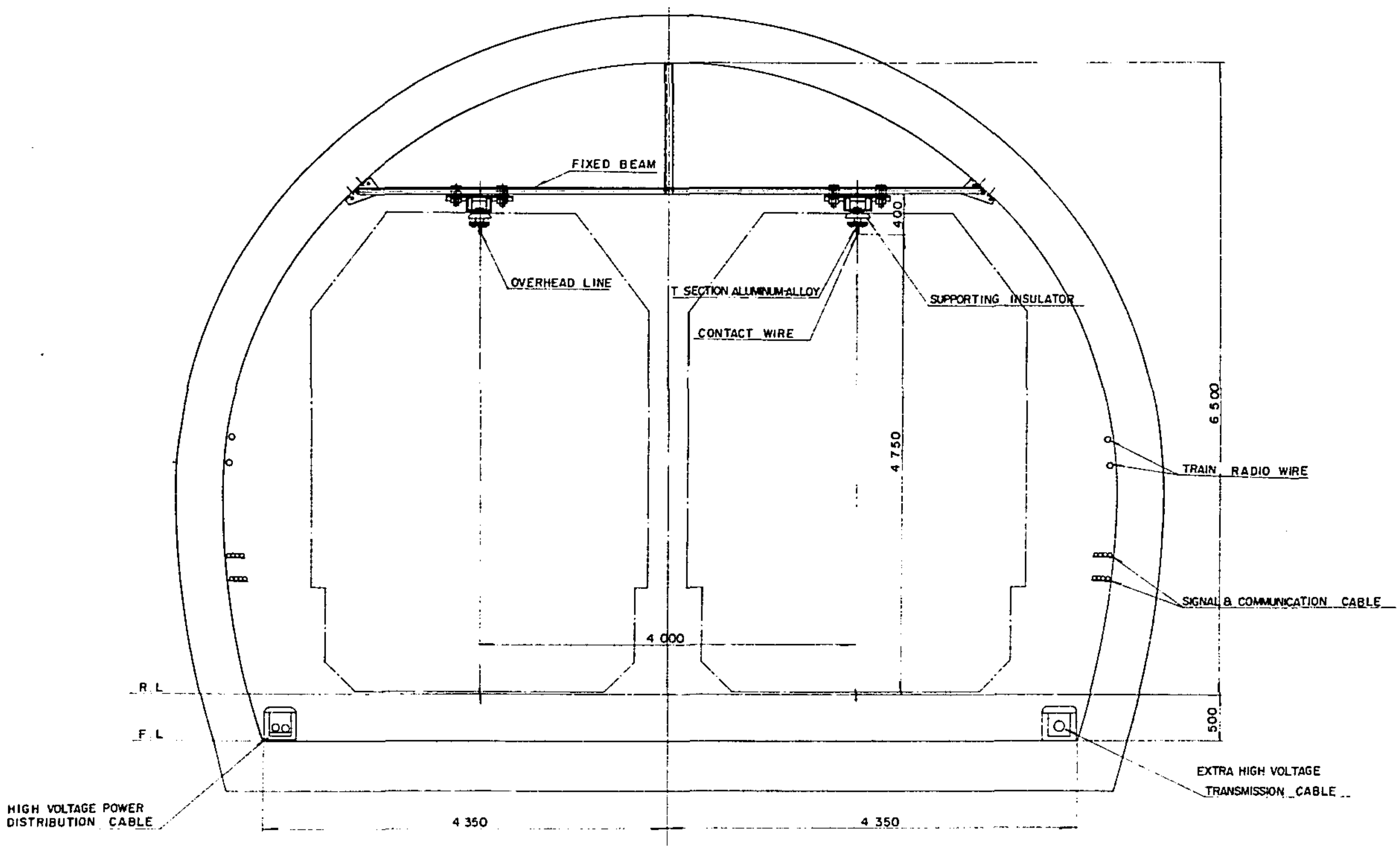
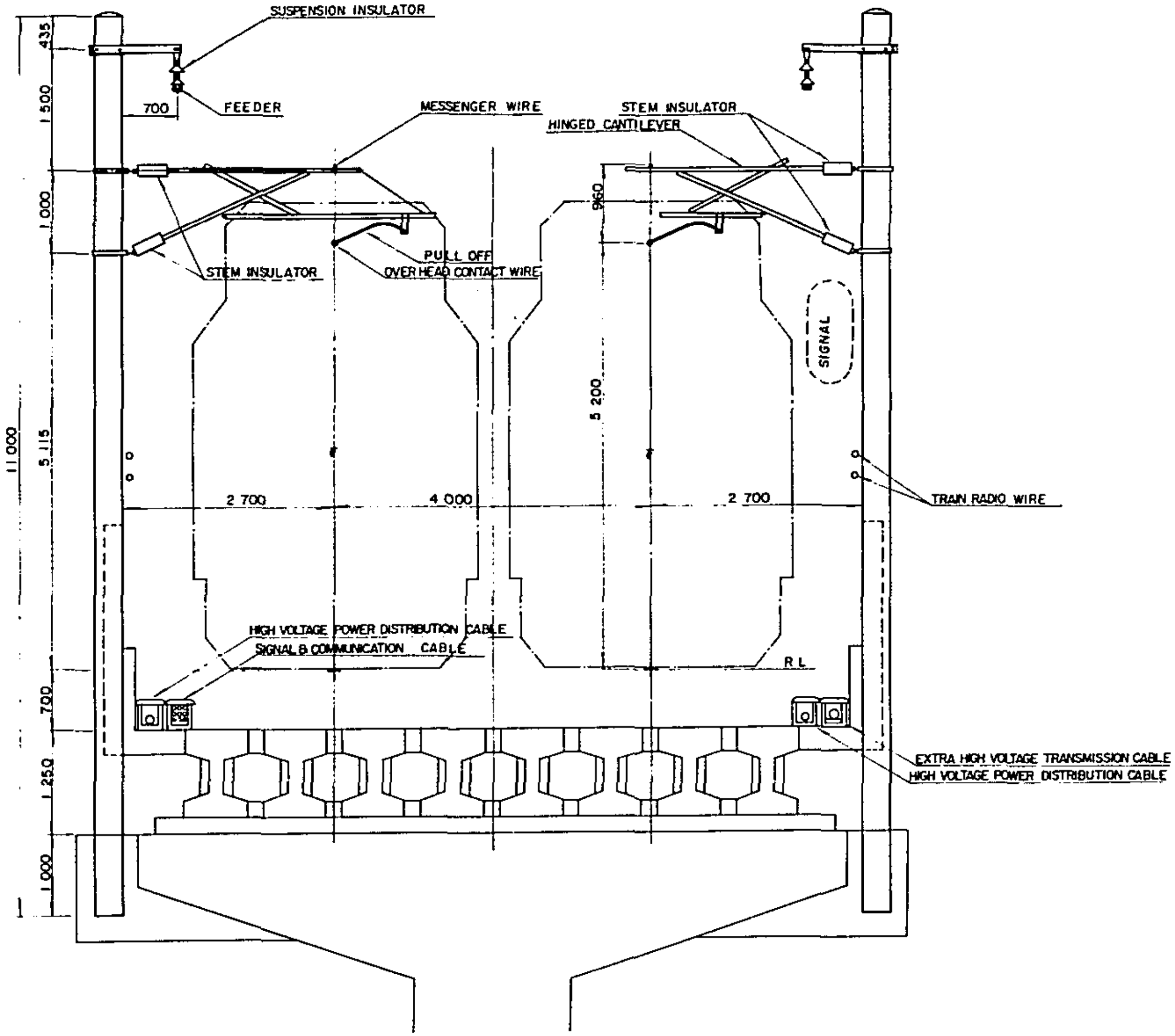


Fig. 8-8 Electric Facilities (Elevated Section)



(2) Catenary System

Major specification of the catenary system is shown in Table 8-7.

Table 8-7 Catenary System

| Height of Contact Line | Standard Span | Deviation | Gradient |
|---|---|---|---|
| Standard: 5,200 mm | 50 m | 200 mm | 5/1000 or less |
| Maximum: 5,400 mm | | | |
| Minimum: 4,850 mm | | | |

Outline of structure is as follows:

(a) Insulators are a set of two stem insulators or double suspension insulators of 180 mm in diameter.

(b) Classification and normal tension of the wire are shown in Table 8-8.

Table 8-8 Wire Description

| Classification and Materials | | | Tension | Remarks |
|---|---|---|---|---|
| Feeder | | Hard-drawn aluminum, 510 $mm^2$ | 600 kg | Tension unadjustable |
| Heavy Simple | Messenger wire | Galvanized steel wire, 135 $mm^2$ | 2,000 kg | With automatic tension adjuster |
| | Contact wire | Grooved hard-drawn copper wire, 170 $mm^2$ | 1,500 kg | Do. |
| Simple | Messenger wire | Galvanized steel wire, 90 $mm^2$ | 1,000 kg | Do. |
| | Contact wire | Grooved hard-drawn copper wire, 85 $mm^2$ | 750 kg | Do. |

(c) Positive and negative outgoing lines are the same as in the section of overhead trolley-bar system.

(d) Foundation of concrete pole in the elevated section is an inserted type as shown in Fig. 8-9.

(e) Hinged cantilever beam is used on the main line, and truss beam in the car depot.

(f) Double heavy simple catenary is installed at transition section to overhead trolley-bar system to avoid a sudden change of hardness.

(g) Lightning arrester is installed at every 500 m.

## 8.4 Transmission and Distribution System

### 8.4.1 Transmission System

#### 8.4.1.1 Receiving-Transmission Line

Receiving-transmission lines shown in Table 8-9 are installed from the KECO substation.

Table 8-9 Receiving-Transmission Line

| KECO substation | Traction substation | Voltage (kV) | Cable type | Size ($mm^2$) | Number of circuits | Length (km) | Remarks |
|---|---|---|---|---|---|---|---|
| Dong In Ri | Chang Cheon Dong | 22 | CV | 325 | 1 | 3.1 | |
| Sun Hwa Dong | City Hall | 22 | CV | 325 | 1 | 0.6 | Partly existing |
| Heung In | Ha Wang Sib Ri | 22.9 | CV | 400 | 1 | 2.7 | |
| Jam Sil | Jam Sil Dong | 22.9 | CV | 400 | 1 | 1.6 | |

The receiving cable is laid in an exclusive conduit line buried in the road between the KECO substation and the Line No. 2. In the tunnel, the receiving cable is laid in the concrete trough along the side wall, as shown in Fig. 8-6.

8.4.1.2 Link Transmission Line

Link transmission lines shown in Table 8-10 are installed between the Chang Cheon Dong Substation and the City Hall Substation, as well as between the Ha Wang Sib Ri Substation and the Jam Sil Dong Substation.

Table 8-10 Link Transmission Line

| Section | Voltage (kV) | Cable type | Size ($mm^2$) | Number of circuits | Length (km) | Remarks |
|---|---|---|---|---|---|---|
| Chang Cheon Dong - City Hall | 22 | CV | 150 | 1 | 4.8 | |
| Ha Wang Sib Ri - Jam Sil Dong | 22.9 | CV | 150 | 1 | 10.4 | Via Mo Jin Dong Substation |

The link transmission cable is laid in the concrete trough along the side wall as shown in Figs. 8-6 and -7, in the tunnel section, and, as shown in Fig. 8-8, in the elevated section. However, in the section between the Mo Jin Dong Substation which is located on the surface underground and the elevated railway, and between the Jam Sil Dong Substation which is also on the surface and the elevated railway, the cable is laid out in the exclusive conduit line.

8.4.2 Distribution System

8.4.2.1 High Voltage Distribution Line System

The high voltage distribution system is as shown in Fig. 8-2. Major items specified are as follows:

(1) The high voltage distribution line is three-phase, 6.6 kV, 60 Hz with two circuits of both-sides distributing type No. 1 and No. 2; and connection to substation is of $\pi$-type.

(2) Substations to which the high voltage distribution line is connected are as shown in Table 8-11:

Table 8-11 Substations for High Voltage Power Source

| Substation | Capacity |
|---|---|
| City Hall | 4,000 kVA |
| Ha Wang Sib Ri | 4,000 kVA |
| Jam Sil Dong | 4,000 kVA |

(3) Each channel has sufficient capacity to supply the necessary power for the whole load through a live channel when one channel fails.

(4) At the outgoing point of the City Hall Substation, a section switch is installed for an extended distribution. However, the extended distribution will be discontinued, when the both-sides distributing sections are completed between substations west of Seo Gyo Dong and the City Hall Substations in future expansion of the Subway.

(5) The high voltage distribution line in the car depot is supplied with the electric power of three-phase, 6.6 kV, 60 Hz from the existing substation. One looped circuit is installed centering around the southern depot, and a branch line is installed on the northern storage track.

8.4.2.2 High Voltage Distribution Line

The structure of high voltage distribution line is as shown in Table 8-12.

Table 8-12 High Voltage Distribution Line

| | Cable | Size | Support |
|---|---|---|---|
| Main Line | 6.6 kV, cross-linked polyethylene insulated polyvinyl chloride sheathed cable | 100 $mm^2$ | Cable trough |
| Car Depot | 6.6 kV, high voltage insulated cable | 22 - 38 $mm^2$ | Suspension insulator |

The cable trough is installed in each circuit. the size of cable installed in the end stations is not reduced considering future extension of the Line No. 2. Lightning arresters are installed on the overhead distribution line.

8.4.2.3 Distribution Room and Equipment

The distribution facilities are as follows:

(1) A distribution room is installed in each station. Following equipment is installed in the distribution room.

High voltage distribution panel: Unit enclosed vertical self-standing type

Transformer: Oil-filled self-cooling type

Low voltage distribution panel: Unit enclosed vertical self-standing type

Accumulator for emergency lighting and charging panel

(2) The high voltage distribution panel in the distribution room is supervised and controlled remotely from the control center.

(3) From the distribution room at stations of Seo Gyo Dong, City Hall, Seong Su Dong and Dae Un Dong

Jang, power for signalling is supplied with low voltage through an exclusive transformer.

(4) Accumulator for emergency lighting should have the capacity to supply up to one hour in time of A.C. failure.

(5) In the car depot, the transformer is installed at all loading points.

#### 8.4.2.4 Loads

Loads are as follows:

(1) In the tunnel, two drainage pumps, each serving as standby to the other, are installed at one site. Power source should be at low voltage.

(2) Illumination equipment and outlets for maintenance work are installed on the elevated railway.

(3) In the car depot, projectors are installed on the steel towers or gantry towers for overall illumination purposes.

## 8.5 Signal System

Key words for an urban rapid transit railway are "safety", "punctuality" and "speed" of the train operation. Therefore, the urban rapid transit railway should be a system for high-speed, high-density, safe and accurate operation. Such a system should be the one on the "fail-safe" principle. One of the important factors to fulfil above requirements is "signal system".

The signal system of the Line No. 2 should fulfil above requirements, with due considerations to the features of mechanization and automation, economy, past experience, reliability and easy maintenance in management of transportation. Main facilities are as follows:

(1) Block equipment
(2) Signal equipment
(3) Interlocking equipment
(4) Track circuit equipment
(5) Automatic train stop equipment (ATS)
(6) Total traffic control system (TTC)

### 8.5.1 Block Equipment

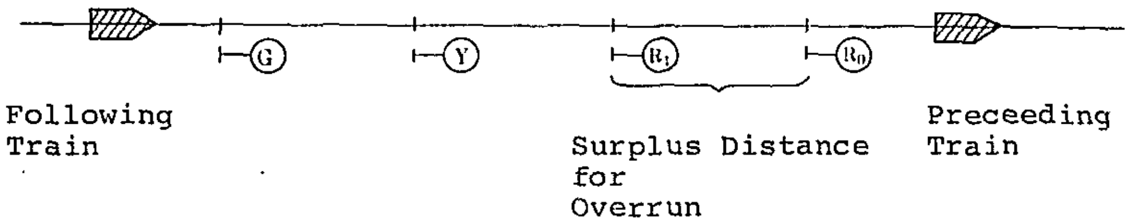
The block system is the double line automatic block system which is the same as adopted on the Line No. 1, and a block section is so set up as to permit operation of 8-car trains with the minimum headway to meet the future traffic demand.

### 8.5.2 Signal Equipment

The signal system of this project, considering the existing system of the Line No. 1, is wayside signal system with train operation by the crew.

There are two sections, i.e., tunnel and elevated, on planned route of the Line No. 2. If waywide signal system is adopted in the tunnel section, signal indications will easily be identified because the block section is rather short and there is nothing to disturb the signal indications such meteorological phenomena as dense fog, snow, etc. or obstacles along the rail side. In the elevated section, visibility of signal is likely to become worse. In this project the block section will be made so short to enable minimum headway that the unobstructed recognition of signal indications may be assured. Nevertheless, a backup system and a radio communication system between the crew and the train dispatcher should be installed to secure the train traffic and the safety as countermeasures in cases where train operation is disrupted by the sudden climatic change. If cab signal system is adopted, there will be no trouble in recognition of signal indications. There is, however, a possibility operation failure through the faulty equipment of the car. As a countermeasure against this situation, it will be possible to provide an emergency operation system.

If wayside signal system is adopted, considering above conditions, the signal indications should be of three-colored full-overlap control type (R-Lap type). Relations among trains and the signal indications are illustrated below.




Shunting signals are installed in the stations and the car depot where trains are shunted. Control devices for signal equipment are concentrated at the nearby relay room as far as technically possible.

### 8.5.3 Interlocking Equipment

The interlocking equipment installed in stations where necessary are controlled concentratedly by the total traffic control system (TTC), to be described later. In cases of the failure of TTC, every station should be able to control the interlocking system manually.

The station to be installed with the interlocking equipment is the one with turnouts within the yard.

There are many kinds of interlocking equipment with different capacities. In this project, the relay interlocking equipment (route lever type), the performance of which has already been testified on the Line No. 1, is to be adopted because of easy interface with the TTC system.

The shunting signal in the station is built in the inter locking equipment, and controlled by the TTC system accordingly.

The turnouts controlled by the interlocking equipment should be activated by A.C. electricity.

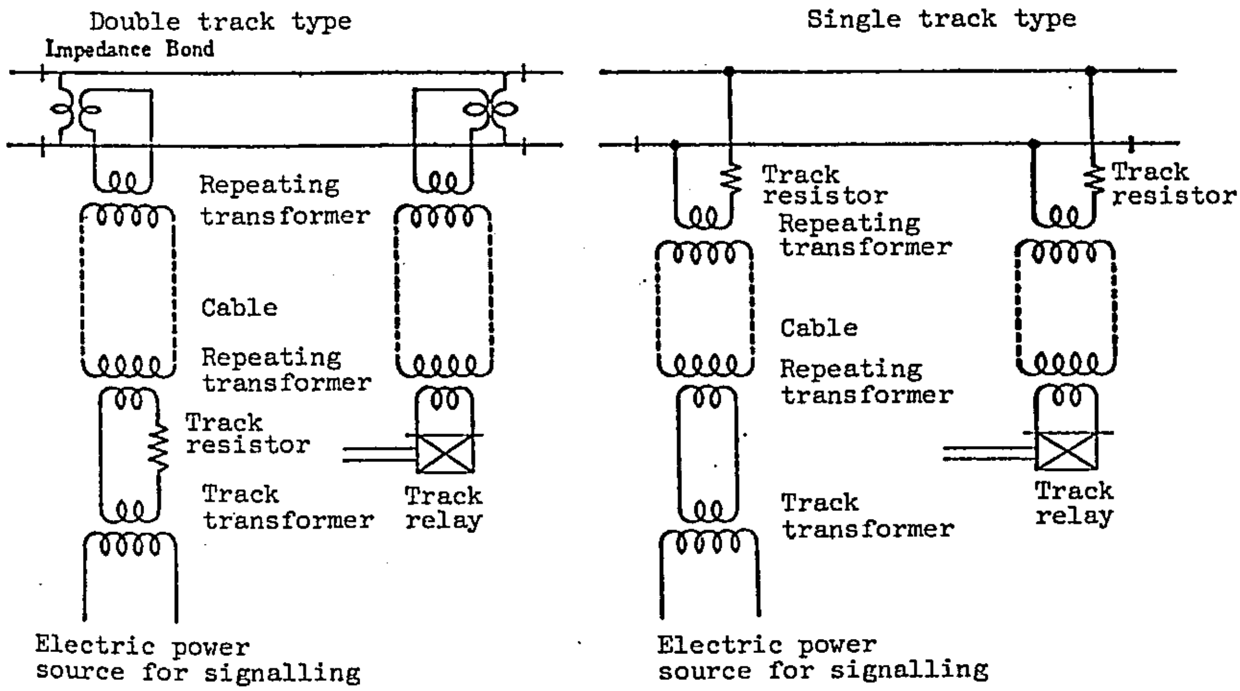
The relay interlocking equipment installed in the both terminals should be normally controlled by TTC, but in cases of the TTC control failure, the route can be set manually at the site, thereby assuring of the traffic safety.

The interlocking equipment in the car depot is of relay interlocking independently of the TTC system.

### 8.5.4 Track Circuit Equipment

The track circuit system is of the insulated double-rail type, in which A.C. signalling current flows into the track with traction current. Furthermore, the track circuit is of commercial frequency track circuit type which is regarded as the most reliable train detector, provided that the commercial frequency power source is of high quality.

Principal Track-Circuit Structure with Commercial Frequency



A rail insulator is to be installed at the boundary of track circuits, and an impedance bond is to be installed in the case of the double-rail track circuit. A rail bond for electric connection is to be installed at rail joint. An insulated single-rail type track circuit using the commercial frequency are installed in the car depot where track circuits are required.

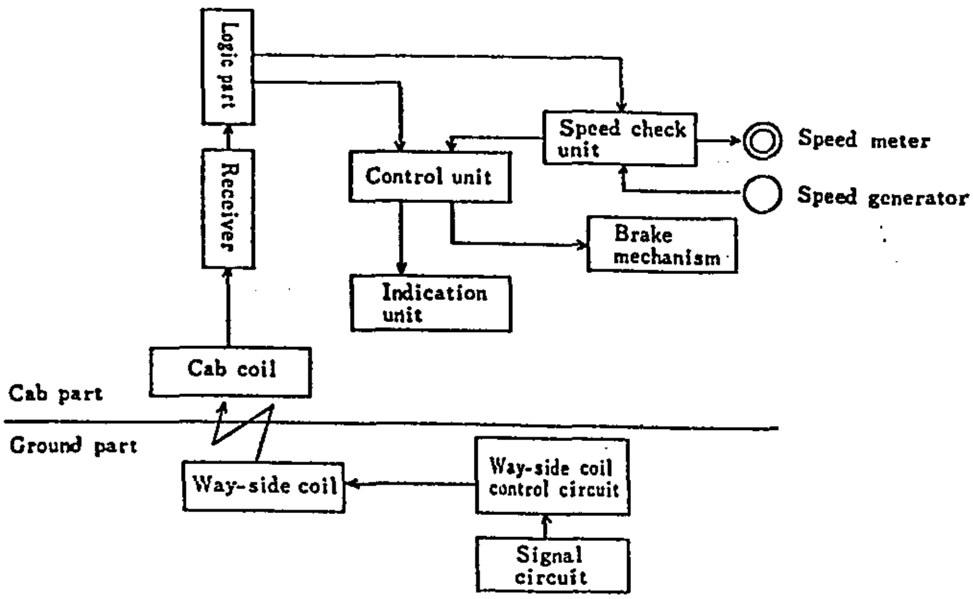
Equipment for the track circuit is concentrated just as in the case of control equipment for signalling.

### 8.5.5 Automatic Train Stop Equipment (ATS)

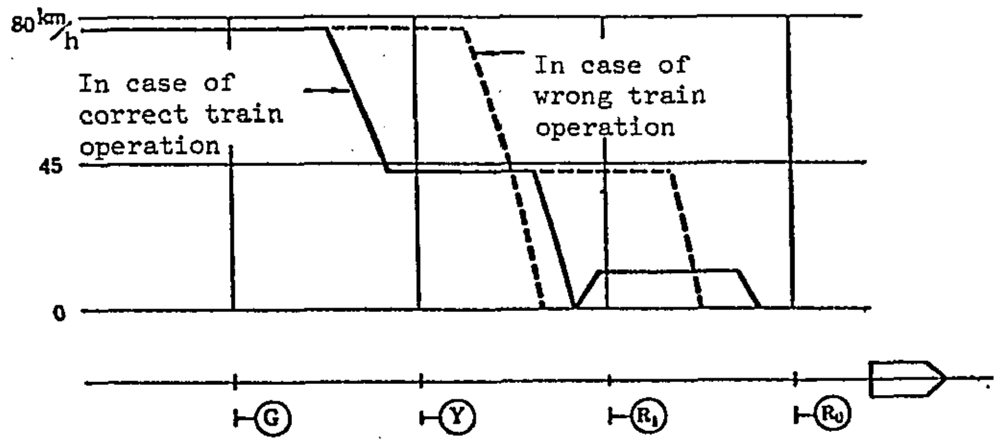
The automatic train stop equipment has been adopted widely and successfully as one of the backup systems for the safety train operation as mentioned in paragraph 8.5.2. If the latest automatic train control equipment which continuously and automatically controls train braking according to signal indication is adopted, the crew might become careless of signal indication and their willingness to work on his duty might be weakened. Speed reduction by manual control of the crew, who has been trained and became skillful for this purpose is more suitable to the high density operation than that by automatic control.

The automatic train stop equipment with capacity of speed check in steps depending on the indication of the signal guarantees full safety of the train operation. Signal system for the automatic train stop equipment should be the R-Lap type as mentioned before. The automatic train stop equipment for the Line No. 2 is to be of the same one as used for the Line No. 1. It is a multiple frequency shift type with point control by wayside coils of the ground equipment and the continuous speed check in the cab.

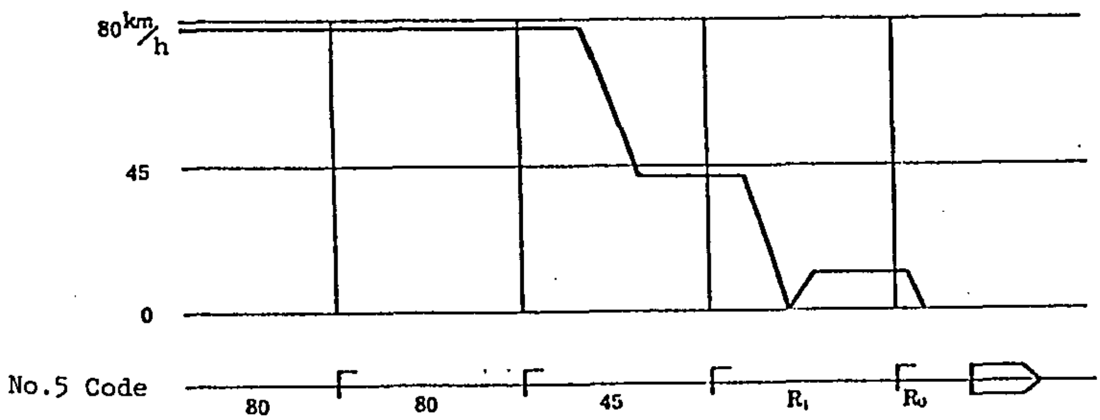
Principal Structure of ATS




Automatic Train Stop Equipment Control Curve




Cab-signal,
Automatic Train Control Equipment Control Curve



Also concerning the signal equipment, it should be noted that reduction in the capacity of train traffic will be inevitable over the elevated railway and the bridge when train operation is disrupted for a long time as signal indications cannot be recognized on account of the meteorological phenomena such as dense fog, snow, etc. The cab signal system with the automatic train control will be necessitated to secure the train operation even in such a case. In this report, however, adoption of wayside signal system is predicated.

### 8.5.6 Total Traffic Control System (TTC)

The total traffic control system should be installed to meet the requirements of urban train operation and management rationalization.

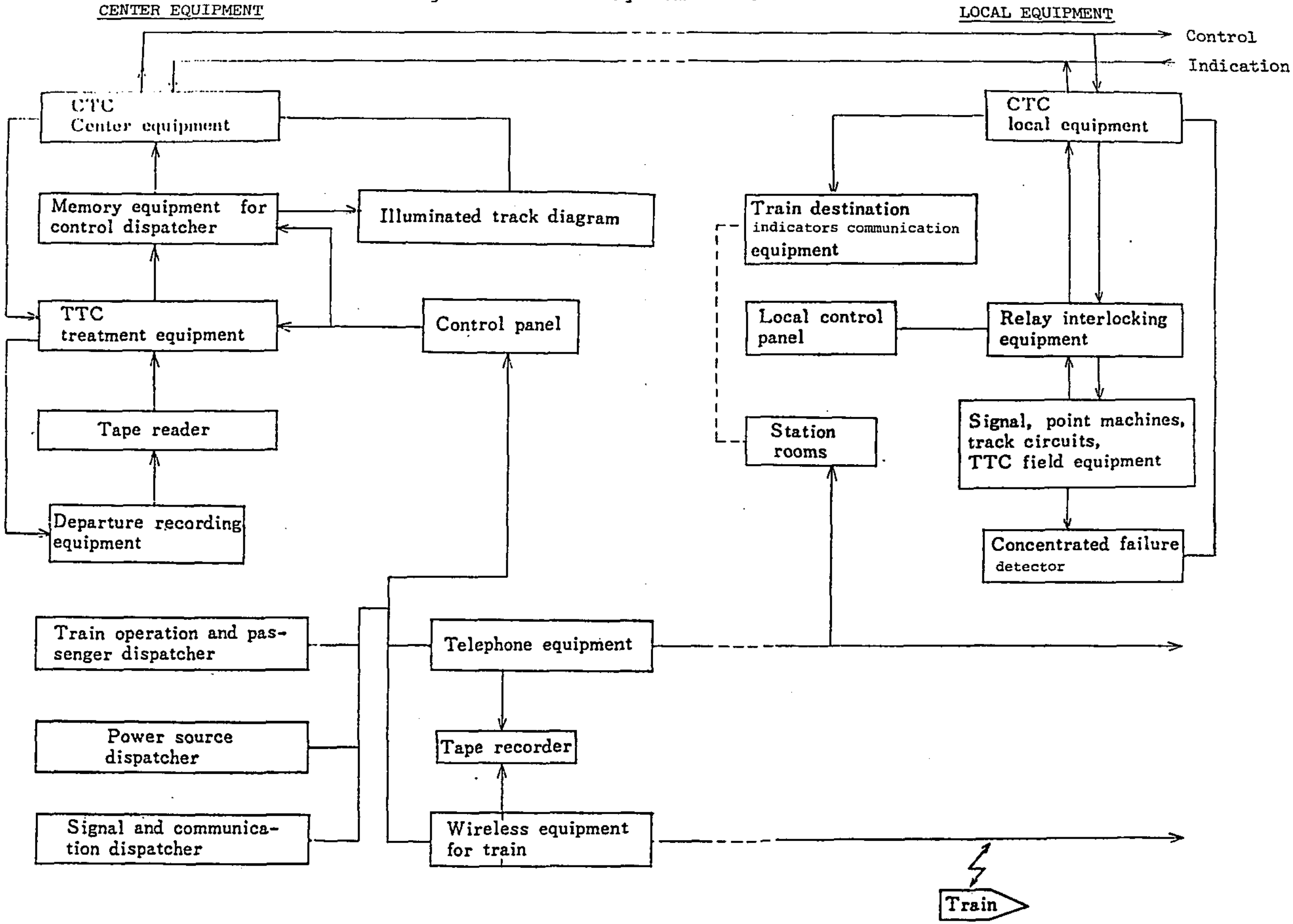
The total traffic control system for the Line No. 2 is to the one equivalent to or better than the total system adopted for the Line No. 1 for the already certified performance.

The most suitable location of control center in the total traffic control system is the Bureau of Rapid Transit, but it seems impossible. Considering future extension of the Line No. 2, the control center of the Line No. 1 will not afford sufficient space. Therefore the control center of the Line No. 2 is to be installed in the most important station for train operation with sufficiently spacious compound.

The structure of the total traffic control equipment is as shown in Fig. 8-9.

Main capacities of the total traffic control equipment are mentioned hereunder.

Fig. 8-9 T.T.C. System Chart



8.5.6.1 Items Controlled by Central Processor

(1) Route Control

The turnouts, the train route and the signal equipment of stations over the whole Line is automatically and remotely controlled, according to the operation schedule. The computer takes the place of the train dispatcher in all the handlings of signals, -- home, starting, shunting, etc. -- in normal situation. Whereas, the route control can be executed manually by the dispatcher under unusual circumstances. A changeover mechanism is to be provided with to enable switching of the central control to the site control.

(2) Traffic Supervision

Train position, indications of signal and train routes are indicated on the track diagram, and directions of train movement at intermediate stations are tracked on the train number indicator. Departure sign and departure time adjustment at major intermediate stations are instructed automatically. Train delay of more than the specified time is detected, to issue a warnings, thereby calling for attention of the train dispatcher.

(3) Traffic Recording

The arrival time, the departure time, the A-track or the B-track, the track number, the train number, delay marking, etc. are recorded automatically by the digital printer at the both terminals and major intermediate stations.

(4) Information Service

Train information displays at the departure stations and major intermediate stations are controlled automatically by the TTC center with data of the automatic route control equipment. It should be possible to install an additional equipment by which the announcement to passengers is enabled automatically in normal situation. In abnormal situation, the necessary announcement can be secured simultaneously from the train dispatcher to all the relevant stations.

(5) Communication with Trains and Stations

Communication systems such as the train radio, the dispatcher telephone, the emergency call telephone, the direct call telephone and the private telephone are to be provided, and especially, the content of important talks among trains and stations are to be recorded by the tape recorder.

8.5.6.2 Central Control Equipment

There are two types of code transmission equipment, connecting the control center and the controlled equipment, i.e., the pair pulse carrier code transmission type and the other the time code base band transmission type. The central control equipment of the Line No. 2 is to be of the former type just as in the case of the Line No. 1.

8.5.7 Power Source

The power source for signal is to be a no-failure type. That is to say, the power for signal is to be supplied from two circuits, and a changeover switch between the normal and the standby circuits is to be provided. The normal power source to be connected to electronic equipment should be of high quality and be used exclusively for signal equipment.

8.5.8 Line

A signal cable is to be used for signal circuits, and in the tunnel, it is installed on the tunnel wall with cable ladders. A concrete trough, a pit or a pipe is used to protect the cable at such required places as the elevated railways section, the crossing portion under the track, service entrance to equipment room and rising part of pole.

A communication cable is used in the transmission circuit for TTC.

8.5.9 Central Failure Detection Equipment

It takes a lot of time to repair the modern signal system with many kinds of devices and systems, which give grave influence on the general public.

Deterioration of the function and failure is to be predicted. Even if it is impossible, the failure is detected and repaired immediately.

Under this background, the central failure detection equipment should supervise the occurrence of failure and a condition beyond the specific tolerance. The central failure detection equipment has the following functions:

(1) Failure detection of the normal signal power source

(2) Detection of a snapped filament in the signal lamp

(3) Detection of drop in the receiving voltage of the track circuit

(4) Detection of earthing of the signal cable

(5) Failure detection of the total traffic control equipment

(6) Failure detection of the communication system

## 8.6 Communication System

An urban rapid transit railway requires assurances in high-speed, high-density, high-accuracy and high-safety train operation. Moreover in abnormal situation such as accidents, it should react speedily and reliably. To satisfy these conditions, the following facilities are to be installed:

Communication system for train operation control

Communication system for general administration

Communication system for maintenance of equipment

Communication system for passenger service

Considering the above, the following items are installed for the Line No. 2:

(1) Transmission equipment
(2) Telephone switchboard
(3) Direct call telephone

(4) Wayside service telephone
(5) Train radio
(6) Electric clock
(7) Station communication facilities
(8) Communication line

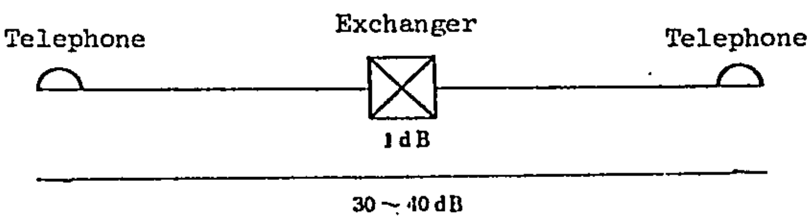
8.6.1 Transmission Equipment

If the articulation reference equivalent (AEN) of exchange telephone circuit is to be 55 dB or less, the permissible loss in the telephone Channel is 30 - 40 dB.

The performance of the exchange telephone circuit is governed by transmitted frequencies, connected communication equipment, frequency characteristics of the circuit, etc., the channel noise and the room noise as well as loss in the circuit.

The transmission performance should be such as follows to meet the CCITT recommendation that the sending and receiving reference equivalents totaling 33 dB be over 95% of the international call. "The AEN should be 49 dB for at least 90% of the subscribers to each exchange station." The AEN for an ordinary railway operation may be 50 - 60 dB. Thus it seems that the AEN for the Line No. 1 was set in design at 55 dB or less. The quality of circuit network of the Line No. 2 should give AEN 50 - 60 dB.

The direct call telephone circuit is to have 20 dB or less in case of individual call, and less than 40 dB or less in case of the simultaneous call including the branch loss. A branch loss of non-loaded cable is estimated to be 2.8 dB per one branch, accordingly a circuit with many branches is to be divided for use.




Loss of 0.9 mm insulated conductor: 0.67 dB/km

### 8.6.2 Exchange Telephone Equipment

The exchange telephone equipment for the Line No. 2 is to be the one that can be in unison with the EMP system of the Line No. 1, and can be adapted to the scale of the Line No. 2.

### 8.6.3 Direct Call Telephone

The following exclusive direct call telephone is to be installed to assure communications among required places in all cases, because the exchange telephone equipment of railway will sometimes be rendered useless in cases of accidents and other emergencies.

#### 8.6.3.1 Dispatcher Telephone

The dispatcher telephone of the control center is to be able to call all or some of the secondary telephones to give instructions about train operation. Two dispatcher telephones are to be provided, one is for train operation and the other for power supply; and they are to be installed in the control center together with the exchange telephone and the direct call telephone. Facsimile equipment is to be installed between the control center and each station to record the instructions assuring the execution.

#### 8.6.3.2 Exclusive Telephone for Train Operation between Stations

The exclusive telephones between stations for train operation are to be installed for substitution blocking in the event of signal failure.

### 8.6.4 Service Telephone for Wayside Work

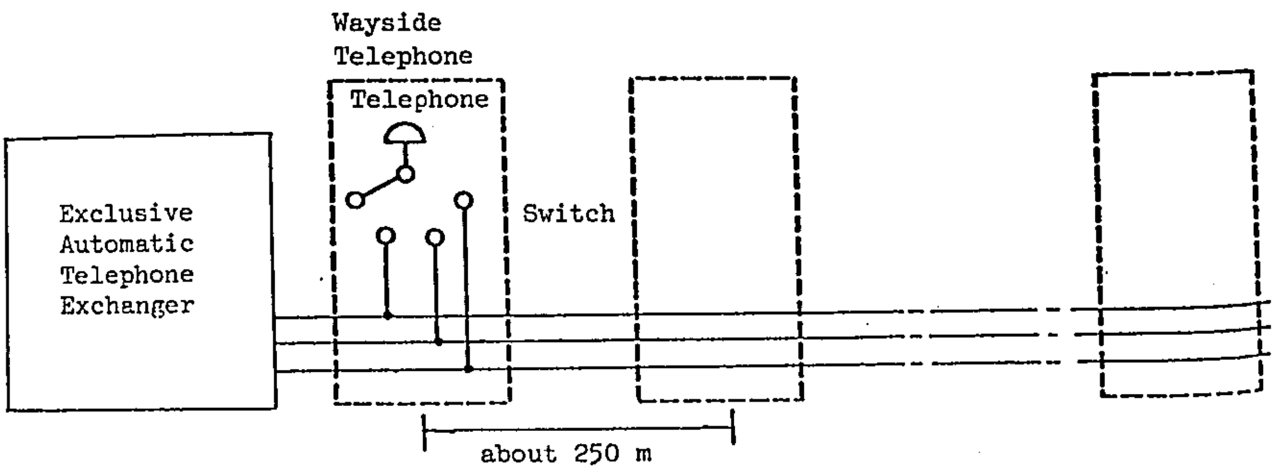
#### 8.6.4.1 Wayside Telephone

There are two types of communication systems for wayside workers, i.e., portable telephone and wayside telephone. In the former, the worker must carry a portable telephone with care against damage and loss being responsible for charging and exchanging the cell.

In the latter, telephone boxes with the trunk circuit, the exchange telephone circuit, the direct call telephone circuit, etc. are installed at regular intervals. This type is suitable to a railway with a broad communication network, requiring a complex system and with enough electricity.

The wayside telephone system for the Line No. 2 is a simple, reliable and easy type. It has three exchange telephone circuits, avoiding busy lines by the switch, ringing up by the dial the other party just as in the case of automatic telephone. Moreover, it should desirably have cutting-in function of when the line is busy.

Basic Structure of Wayside Telephone




8.6.4.2 Talk-back System

The talk-back system is installed in the station with the relay interlocking equipment. The master equipment is installed at the control panel of the relay interlocking equipment, and the secondary equipment (the speaker) is installed at the shunting signal or near the turnouts. This system is capable of mutual call by means of the key or the push-button. When the call operation is stopped, a communication circuit is formed automatically and thus mutual talk is possible.

This system is used for communication between operater of the relay interlocking equipment in station and the field staff, when TTC is out of order or under repair. It is also constantly used between operater of relay interlocking equipment of the car depot and the field staff. There are two types of field equipment, one to be fitted on the pole or the wall and the other to be set on the ground with a push button to be operated by foot. These types should be selectively installed depending upon the circumstances of the site.

8.6.5 Train Radio

The train radio is installed to provide the communications between the crew and the control center for the train dispatching and the emergency instruction at the time of accident. There are two types as follows:

8.6.5.1 Space Radio System (SR System)

This system is used on the Line No. 1 and the Korean National Railroad (KNR). It has been used at sections with clear visibility between the base station and the moving station; accordingly it is often used in the surface railway. But lately, this system has come to be used for subways as on the Line No. 1 as the result of a leakage coaxial cable, which has been developed and practically applied.

8.6.5.2 Inductive Radio System (IR System)

This system using a wave of 10 - 250 KHz is popularly used in subway. It communicates by magnetic coupling between a wayside induction cable and an antenna of car.

8.6.5.3 Selection of Train Radio System

The train radio system is to be selected after examining the purpose, the function, the reliability and the cost of each type.

In the system of the Line No. 1 it was necessary to consider the extension of railway service into the KNR's Line. In the case of the Line No. 2, it is possible to install an independent system. The train radio system for the Line No. 2 is to be the IR System, because of its reliability, cost and past experienced performance as well as its ability to work after introducing the thyristor chopper control system car with regeneration brakes which might be adopted in future.

8.6.5.4 Outline of IR System

(1) Equipment in the control center

The central control equipment and the operation panel for dispatcher are to be installed. The operation panel is to enable to control all the base stations, talking with cars and receiving the emergency information.

(2) Equipment in the base stations

This equipment is to send and receive the radio wave with the car. For communication purpose with the control center,the telephone system with the communication cable is applied.

(3) Moving station

One station each is to be installed at both ends of the train.

The moving station consists of a transmitter-receiver, a push-button for emergency information, an antenna and a speaker.

(4) Train radio line

An insulated wire with sufficient mechanical strength is to be laid on the wayside as the train radio line. The insulated wire is to be installed in spaces between rails or at a certain height along the railway line and a regular distance is to be kept between the antenna of car and the train radio line to maintain a constant coupling loss.

8.6.5.5 Outline of Operation

(1) Call for dispatcher to train

The dispatcher sets the key on the operation panel, and calls the train number; and when the train answers, the receiving lamp on the operation panel is lighted. Thereafter, the procedure is the same as with the ordinary telephone.

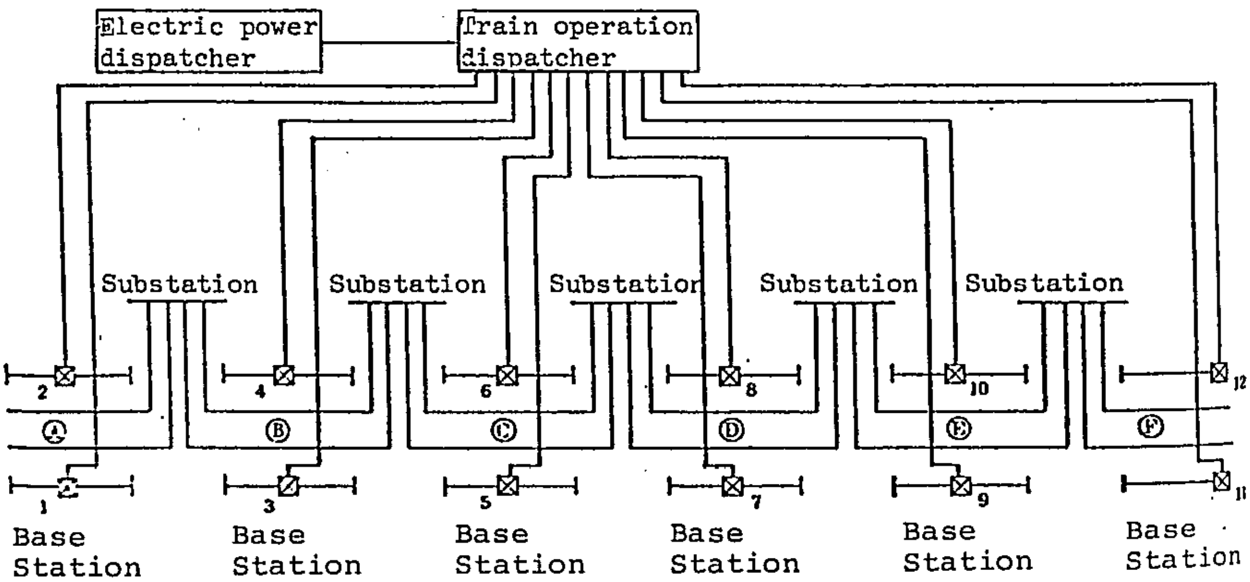
(2) Call from train to dispatcher

The crew handles the push-button and calls the dispatcher.

The receiving lamp on the operation panel of the dispatcher is lighted and the monitor speaker sounds, and the dispatcher sets the key to enable talking.

(3) Emergency information

By operating the push-button for the emergency information, the radio wave for emergency signal is transmitted, the lamp on the operation panel is on and at the same time, information is given to the electric power dispatcher. The radio service area from a base station is to be sectionalized coincidentally with the electric feeding section, so that the power dispatcher may be activated to stop a train in an emergency by cutting off power feeding to the section where the emergency information has been sent from.



Relation between Informing and Failure Sections

| Informing Section | Failure Section | Informing Section | Failure Section | Informing Section | Failure Section |
|---|---|---|---|---|---|
| 1 | A | 5 | BC | 9 | DE |
| 2 | AB | 6 | CD | 10 | EF |
| 3 | AB | 7 | CD | 11 | EF |
| 4 | BC | 8 | DE | 12 | F |

### 8.6.6 Electric Clock

The electric clock system consists of the one master clock and some secondary clocks controlled by A.C. pulse just as on the Line No. 1. This system is labor-saving because all secondary clocks work with the same precision as the master clock.

### 8.6.7 Station Facilities

The following communication facilities for the passenger service are to be provided in every station.

(1) Public address systems

The speakers are installed at the platforms and the concourse to address the passengers from the office and the platform.

(2) Train information display

The train information display is to be installed at the platform to indicate the arrival time and the destination of trains.

(3) Industrial television (ITV)

The ITV is to be installed to help the crew at the platform of a station located on a curved section where the visibility is poor.

8.6.8 Communication Line

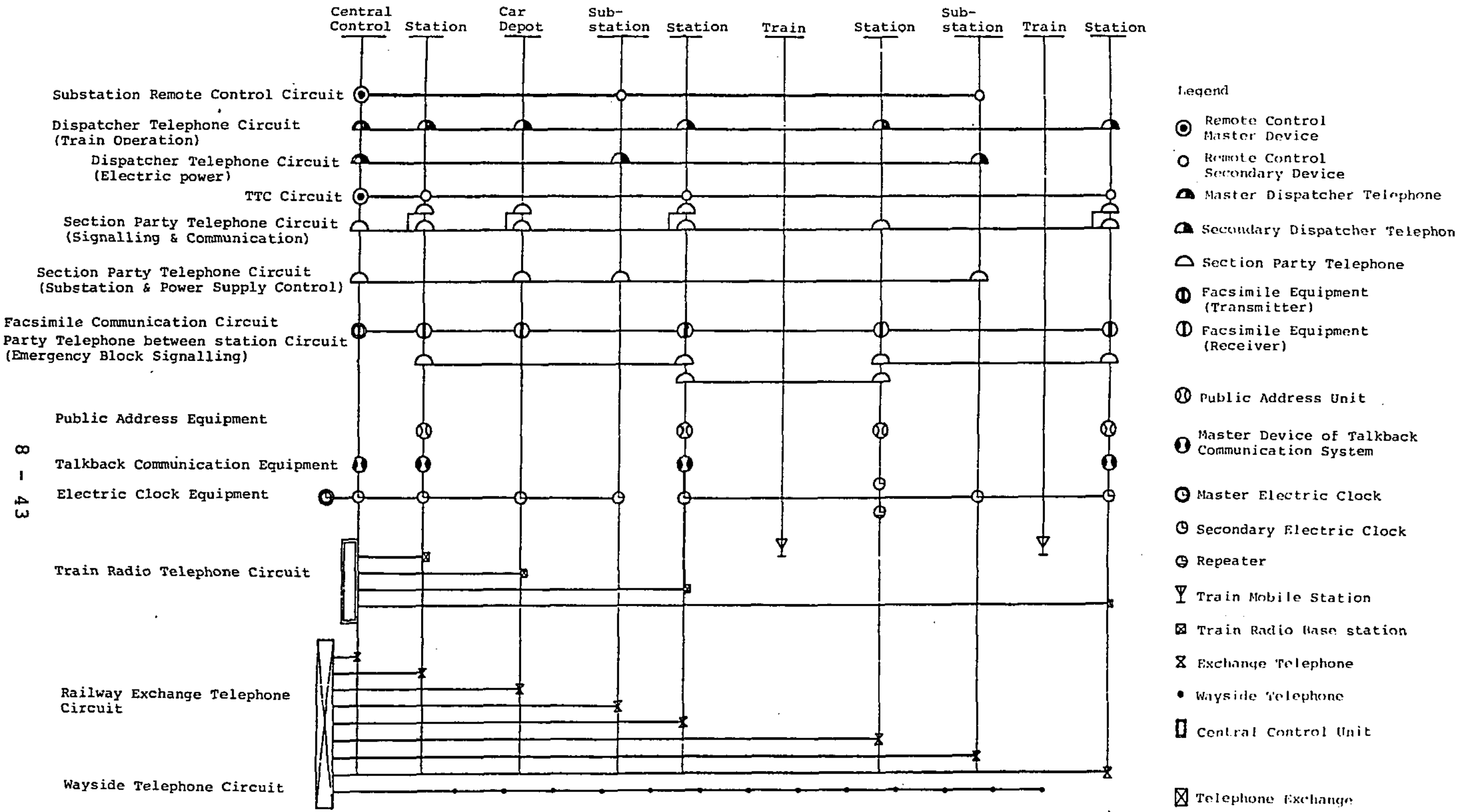
Communication cables include broadly the main cable, the auxiliary cable and the extension cable. The procedure of the installation is to be the same as the signal cable.

The main cable is to be used for the telephone circuit, the total traffic control circuit, the substation remote control circuit, the electric clock circuit and the train radio circuit. The auxiiliary cable is to be used for the wayside telephone circuit and a detour of important circuit. The extension cable is to be used for the lead-in circuit of the station. The cable materials are to be selected according to the purpose.

The connecting lines for the Lines No. 1 and No. 2 are to be installed in front of City Hall Station because some communication cables originate from the control center of the Line No. 1.

The communication system diagram is shown in Fig. 8-10.

Fig. 8-10 Communication System Diagram

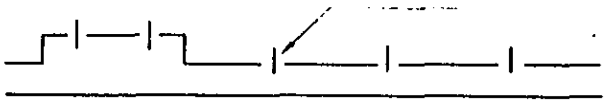
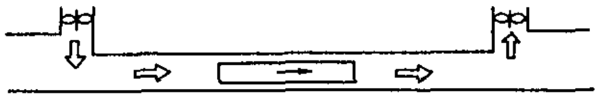
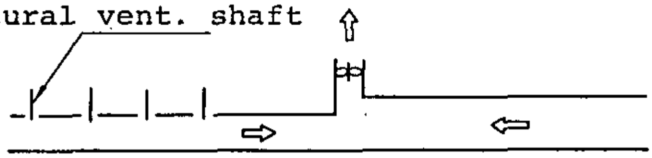


## 9. Ventilation and Air-conditioning System

### 9.1 Ventilation System for Tunnel Section

#### 9.1.1 Basic System

The following basic systems apply for each type of tunnel.

| Tunnel Type | Basic system |
|---|---|
| Cut-and-cover box tunnel (Double line) | Piston ventilation system (natural ventilation)<br><br>Station entrance Natural vent. shaft<br><br>Cross-sectional area of vent. shaft $4m^2$<br>Interval of vent. shafts approx. 100m |
| Rock tunnel (Single line) | Longitudinal ventilation system in the direction of train movement<br><br>Jet fan is installed in cases where ventilating volume with piston ventilation only is insufficient. |
| Rock tunnel (Double line) | Longitudinal ventilation system for intermediate exhaust<br><br>Vent. building<br>Natural vent. shaft<br> |

### 9.1.2 Design Condition

(1) Atmospheric Temperature

(C°)

| Season \ Time | 8.00 | 14.00 | 18.00 | 24.00 |
|---|---|---|---|---|
| Summer | 26.1 | 29.9 | 27.7 | 25.0 |
| Winter | -4.4 | | | |

(2) Inner Temperature of Tunnel in Summer

Dry bulb temperature 25°C - 35°C

(3) Geometric Condition of Tunnel

| Tunnel type \ Item | Cross-sectional area of inner space (m2) | Circumference of inner space (m) | Surface area of inner space ($m^2$/km) | Equivalent gradient (°/oo) |
|---|---|---|---|---|
| Cut-and-cover (Double line) | 41.0 | 27.5 | 27,500 | 8.5 |
| Rock tunnel (Single line) | 28.1 | 18.9 | 18,900 | 8.5 |
| Rock tunnel (Double line) | 56.9 | 27.7 | 27,700 | 8.5 |

(4) Train Condition

Weight:

M-car tare weight: 41t (Passenger capacity: 160)

Tc-car tare weight: 32t (Passenger capacity: 148)

Passengers: 57 kg per person

Train formation: Tc M M' M M' M M' Tc (6M2T)

Brake: Rheostatic brake (non-regenerative)

Speed control: Rheostatic control

Train dimensions:

Front cross-sectional area: approx. 12 $m^2$

Length: 160m

Width: 3.2m

### 9.1.3 Heat Source

The generated heat quantity one-way during peak hours (the evening rush hour between 17.30 and 18.30) can be calculated on the basis of various conditions with the results shown in the following table.

(kcal/h.km)

| Source \ Year | 1982 | 1984 |
|---|---|---|
| Trains | 170,000 | 203,000 |
| Passengers | 33,000 | 43,000 |
| Total | 203,000 | 246,000 |

### 9.1.4 Heat Sink of Wall

The heat sink of each tunnel during peak hours can be calculated on the basis of various conditions of air temperature. The results are as shown in the following table. However, the values shown in the following table are those per one-way, and the heat transmission towards the wall direction is with minus sign.

(kcal/h.km)

| Tunnel type | Heat sink |
|---|---|
| Cut-and-cover (Double line) | - 114,000 |
| Rock tunnel (Single line) | - 156,000 |
| Rock tunnel (Double line) | - 115,000 |

### 9.1.5 Air Flow of Piston Ventilation

The one-way piston air flow during peak hours has the following values based on the measured results and theoretical figures of existing underground railways.

($m^3$/h.km)

| Year / Tunnel type | 1982 | 1984 |
|---|---|---|
| Cut-and-cover (Double line) | 60,000 | 68,800 |
| Rock tunnel (Single line) | 148,000 | 170,000 |
| Rock tunnel (Double line) | Taken as 0 | |

### 9.1.6 Inner tunnel Temperature with Piston Ventilation

Calculations are made on the basis of the generated heat quantity, heat sink of the wall and the air flow, the results of which are shown in the following table.

(°C)

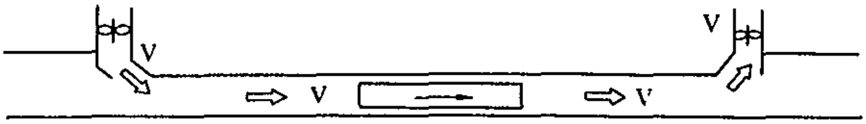
| Year / Tunnel type | 1982 | 1984 |
|---|---|---|
| Cut-and-cover (Double line) | 32.8 | 34.4 |
| Rock tunnel (Single line) | 28.8 | 29.5 |

The inner tunnel temperature with piston ventilation only will be below 35°C for a certain period. Since the absolute volume of ventilation in single line tunnels may be insufficient with piston ventilation only, it will be necessary to provide with the facility for supply and exhaust of air at both ends of the tunnel.

### 9.1.7 Tunnel Mechanical Ventilation System

(1) Single line rock tunnel

The calculation results of the necessary ventilation volume based upon the heat load within the tunnel are as shown in the following table:

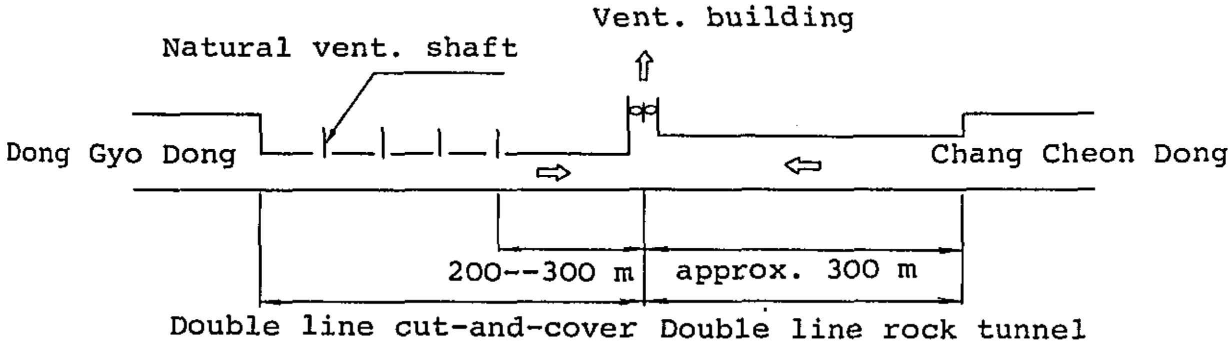



| Tunnel | $V(m^3/h)$ |
|---|---|
| Dae Hyeon Dong - A Hyeon Dong | 70,000 |
| A Hyeon Dong - Seo So Mun | 80,000 |
| Seo So Mun - Ventilation building | 41,000 |

The duct plan of the ventilating room of the tunnel at the end of the station is shown in Fig. 9-1.

(2) Double line rock tunnel

The length of this type is about 300 m covering the distance between Dong Gyo Dong and Chang Cheon Dong. Due to the fact that installing ventilation shafts in the tunnel section, would entail a considerable increase in construction costs, causing enormous difficulties, in the work. Ventilation will be effected by means of a ventilation room installed in the border area between the double line cut-and-cover and the double line rock tunnel. In order not to cause a decrease in ventilating efficiency the nearest one or two positions inside the box tunnel towards the rock tunnel for natural ventilation shaft are to be dispensed with.




Installed at every 100 m interval from Dong Gyo Dong, but not at the section 200--300 m distant from ventilation building.

Installed at the point which is approximately 300 m distant from Chang Cheon Dong.

The exhaust rate from the ventilation building is 100,000 $m^3/h$.

The duct plan of the ventilation room is as shown in Fig. 9-2.

## 9.2 Air-conditioning, Ventilation and Smoke Exhaust System in Station and Signal Machine Room

### 9.2.1 Ventilation and Smoke Exhaust System on Platform

The systems consist of those for air supply and exhaust. The rate of ventilation is 120,000 $m^3/h$ ( $\geqq$ 30 $m^3/h.m^2$) at each station. When smoke is exhausted, the air supply is to be suspended, the smoke exhaust-fan (30,000 $m^3/h$) is to be brought to action, and smoke is drown off with exhaust air from underneath the platform. On island platforms, as is shown in Fig. 9-3, air is supplied at the rate of 69,000 $m^3/h$ from the central part of the platform, and from the end of platform at the rate of 51,000 $m^3/h$. Air exhaustion is effected from underneath the platform at the rate of 120,000 $m^3/h$. On separate platforms, as is shown in Fig. 9-4, ducts are installed. Supply and exhaustion of air is carried out at the rate of 60,000 $m^3/h$ for each platform. The duct plan for side separate platforms is as shown in Fig. 9-5. The air supply unit has been prepared so that cooling coils may be installed in future.

### 9.2.2 Concourse Ventilation System

The systems consist of those for air supply and exhaust. The rate of air supply is 23 $m^3/h$ for each unit floor area ($m^2$). The rate of air exhaustion is 70% of the rate of air supply. An example of the duct plan is as shown in Fig. 9-6.

### 9.2.3 Air Conditioning and Ventilation System in Staff Room and Signal Machine Room

The staff rooms and signal relay rooms in the underground stations and the signal machine rooms of the elevated stations are equipped with package type-air conditioners either in the same room or in an air conditioning plant room; ducts are put inside the ceiling and the air is conditioned through an outlet in the ceiling. During the air conditioning is performed the rate of air intake from the outside is 10 $m^3/h$ per unit floor area ($m^2$), while, the rate being 30 $m^3/h$ during ventilation. Heating of the staff rooms of elevated stations is effected by oil or gas heaters. Smoke exhaustion is effectuated in the staff rooms in underground stations at the rate of 1 $m^3/min$ per unit floor area ($m^2$).

### 9.2.4 Ventilation System in Plant Room and Power Distribution Room

The systems consist of those for air supply and exhaust. The rate of ventilation is such that the temperature within the room does not exceed 40°C.

### 9.2.5 Traction Substation Ventilation System

This only consists of the system for air exhaust. It is activated by the room chamber system. A spare exhaust fan is installed.

### 9.2.6 Air Conditioning System in Car Depot

Package air conditioners with the central duct system are used in the office and staff room. Heating is conducted during winter season for essential places in the workshops and car inspection areas.

## 9.3 Refrigeration Plant

### 9.3.1 Platform Temperature with Ventilation only

(1) Heat Load

A rough estimate of the heat load due to heat source and heat sink on the platform area during peak hours on the basis of the various conditions involved is given in the following table.

(kcal/h)

| Year / Source | 1982 | 1984 |
|---|---|---|
| Trains | 225,000 | 269,000 |
| Passengers | 45,000 | 46,000 |
| Lighting | 43,000 | 43,000 |
| Heat Sink | - 52,000 | - 52,000 |
| Total | 261,000 | 306,000 |

(2) Platform Temperature

An estimate of the temperature during peak hours caused by the rates established for mechanical and piston ventilation and by the heat load, is shown in the following table, taking into account ventilation only.

(°C)

| Year / Item | 1982 | 1984 |
|---|---|---|
| Platform temperature | 33.7 | 34.6 |

It is thus foreseeable that cooling will become necessary, three years after the beginning of operation. The peak temperature will reach 35°C with the accompanying bad effects, such as the lowering of underground water level, etc.

9.3.2 Capacity of Refrigerator

If temperature and humidity for design condition for air-conditioners are 29°C and 65% respectively, the heat load at each station will be 360RT, as shown in the following table:

(RT)

| | |
|---|---|
| Internal Load | 140 |
| Air Flow Load | 135 |
| Outside Air Load | 50 |
| Pipe and Duct Loss | 35 |
| Total | 360 |

Thus the space required for the plant room including the space for ventilation equipment is about 500m$^2$.

### 9.3.3 Cooling System

A turbo refrigerator is installed in the plant room, cooling coils are inserted into the platform air supply unit and piping for chilled is carried on. The cooling tower is installed either above ground on the roof of an adjacent building or in a green belt area by a road. Cooling water is piped from the plant room. Two thirds of the exhaust air is recirculated.

Fig. 9-1 Ventilation Duct System for Single Line Rock Tunnel

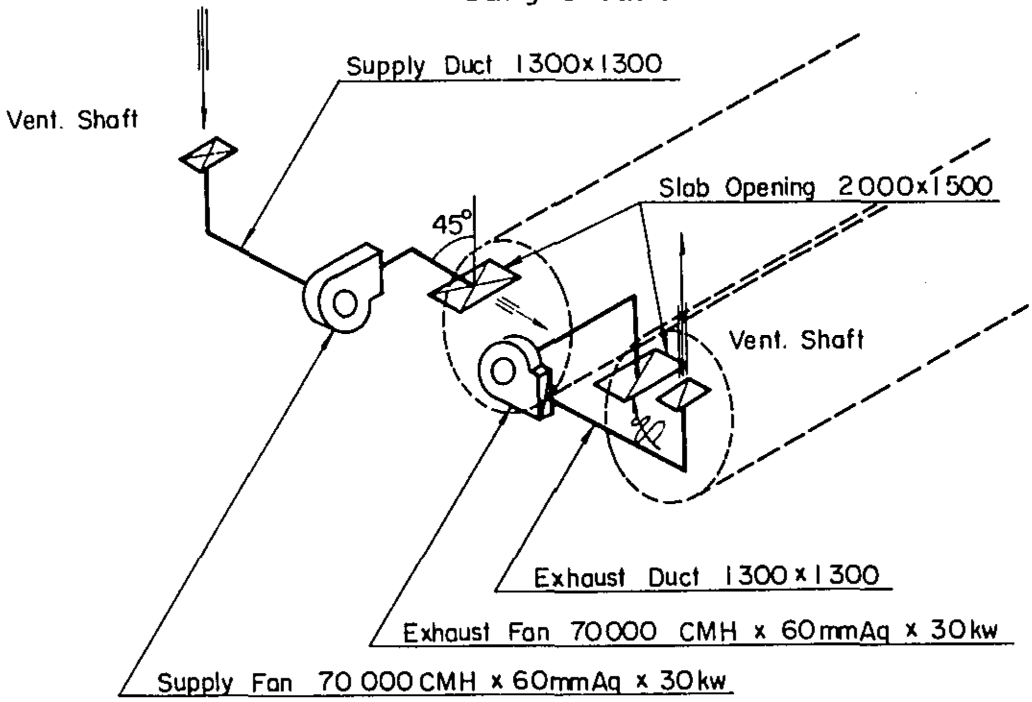



Fig. 9-2 Ventilation Duct System for Double Line Rock Tunnel

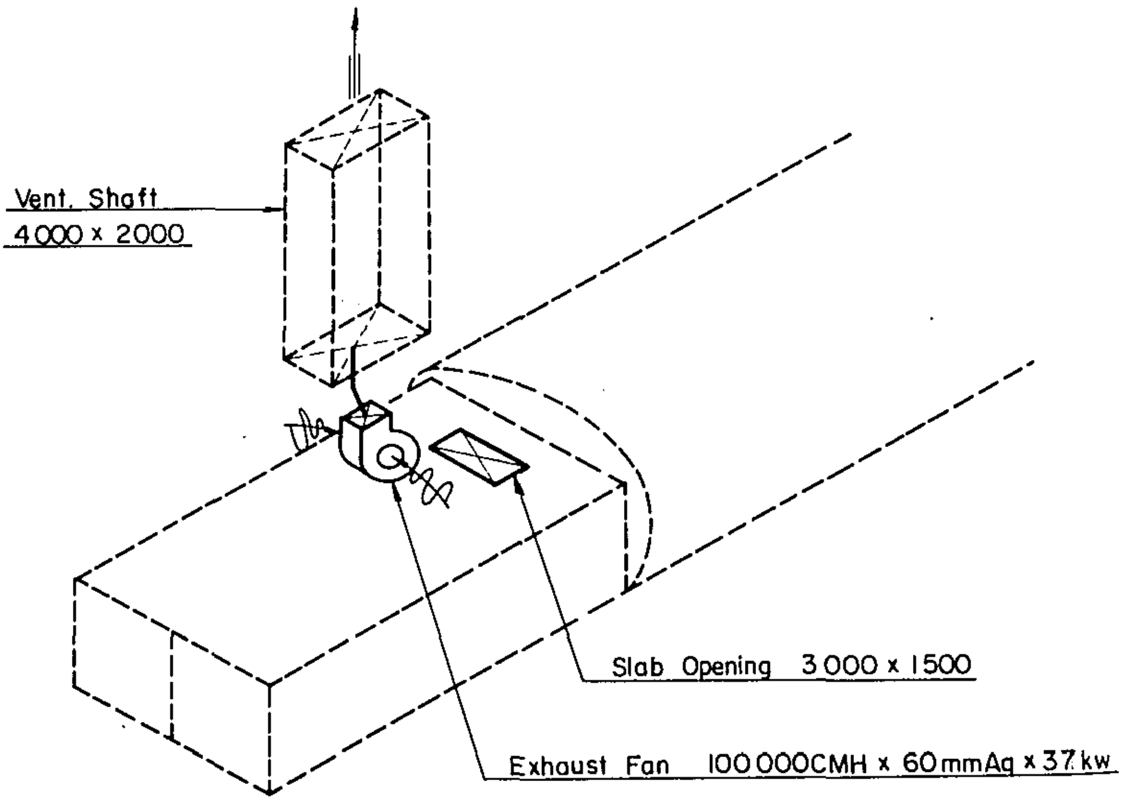


Fig. 9-3 Duct Layout for Island Platform

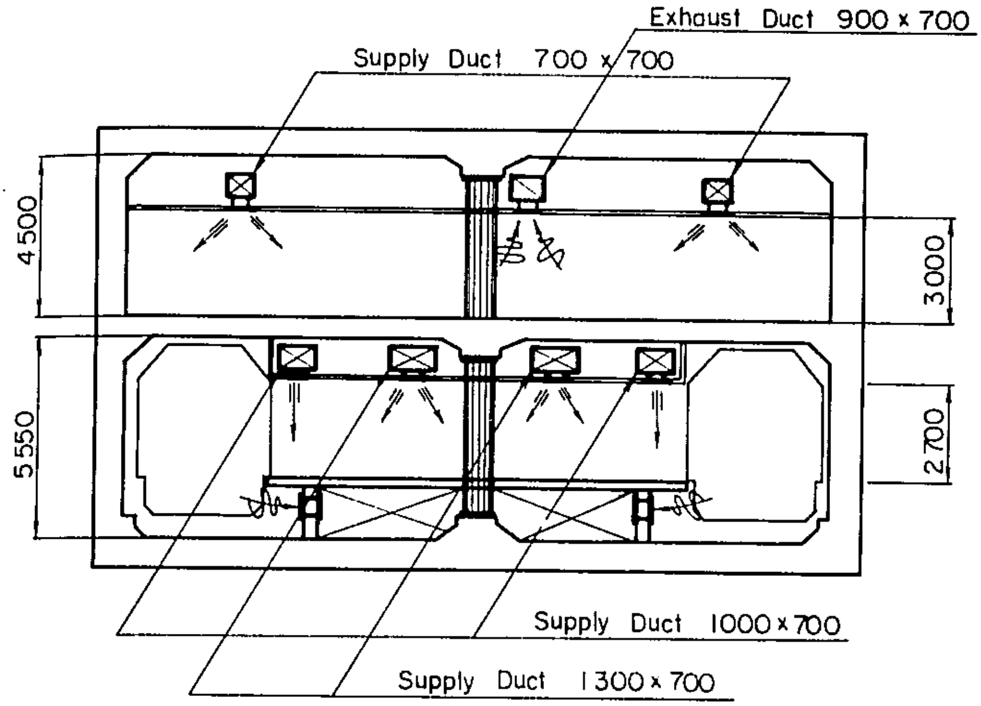



Fig. 9-4 Duct Layout for Separate Platforms

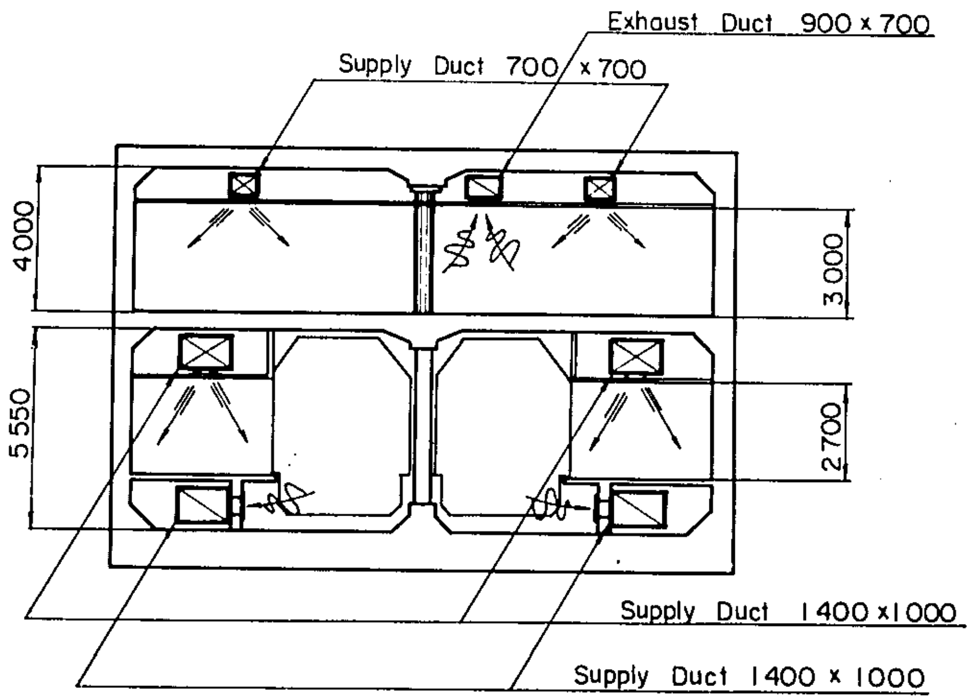


Fig. 9-5 Duct System for Separate Platforms

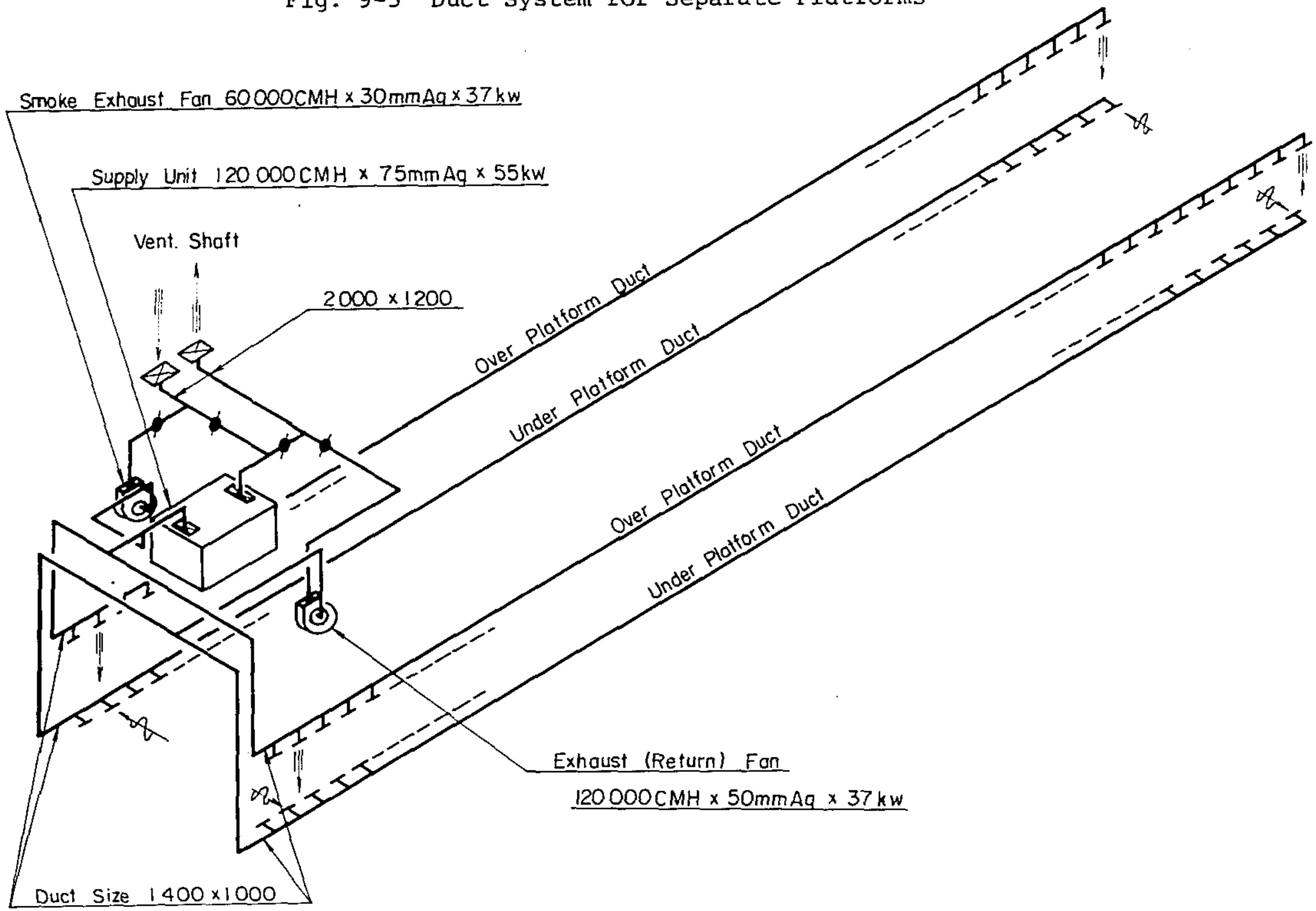
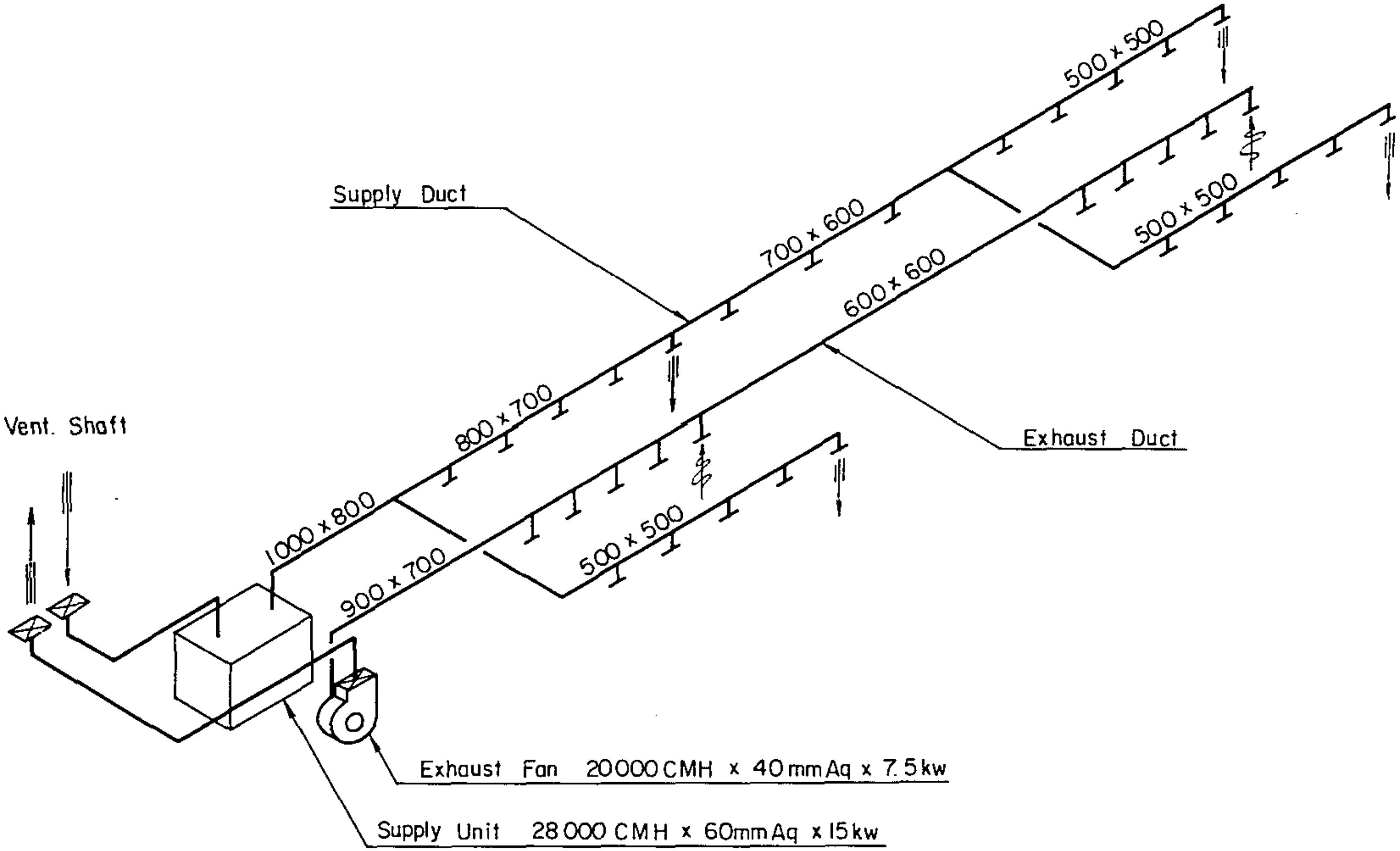


Fig. 9-6 Ventilation System for Concourse



# 10. Car Depot

## 10.1 General

The car depot constructed at Gun Ja Dong has been designed to cope with a total of 410 cars in 47 consists, this figure comprising the A.C./D.C. electric cars of Line No. 1, and the D.C. electric cars of Line No. 2 between Seo Gyo Dong and Dae Un Dong Jang. The necessary car storage and inspection facilities as well as maintenance facilities for ground installations and a crew office are provided at the depot.

In the future when the Line No. 2 becomes a loop line and the number of cars will increase, the construction of a new depot which will provide car storage and inspection facilities will become necessary. This depot is to be constructed in the Gang Nam district.

The facilities planned in this project are as follows:

(1) Storage facilities for train consists

(2) Car inspection facilities in full train formation
   a. Facilities for daily and monthly inspection
   b. Washing and cleaning facilities
   c. Wheel tread reprofiling facilities

(3) Workshop facilities for general and intermediate inspection of cars

(4) Track maintenance facilities

(5) Equipment maintenance facilities for those such as power supply, signals and communications

(6) Material supply office and material storing facilities

(7) Crew office

Since this depot is to be constructed on the bank of the river in Gun Ja Dong, there might be considerable restrictions in relation to the acquisition of the site. It will, therefore, be difficult to satisfy all the conditions relating to the above-mentioned arrangement, and the following plan is recommended taking into account the nature and function of each facility.

(1) Entering and leaving of the trains are from the north side for those of Line No. 1, and from the south side for those of Line No. 2.

(2) Storage facilities are grouped into those for Line No. 1 and those for Line No. 2. In both cases trains can enter or leave without switching back.

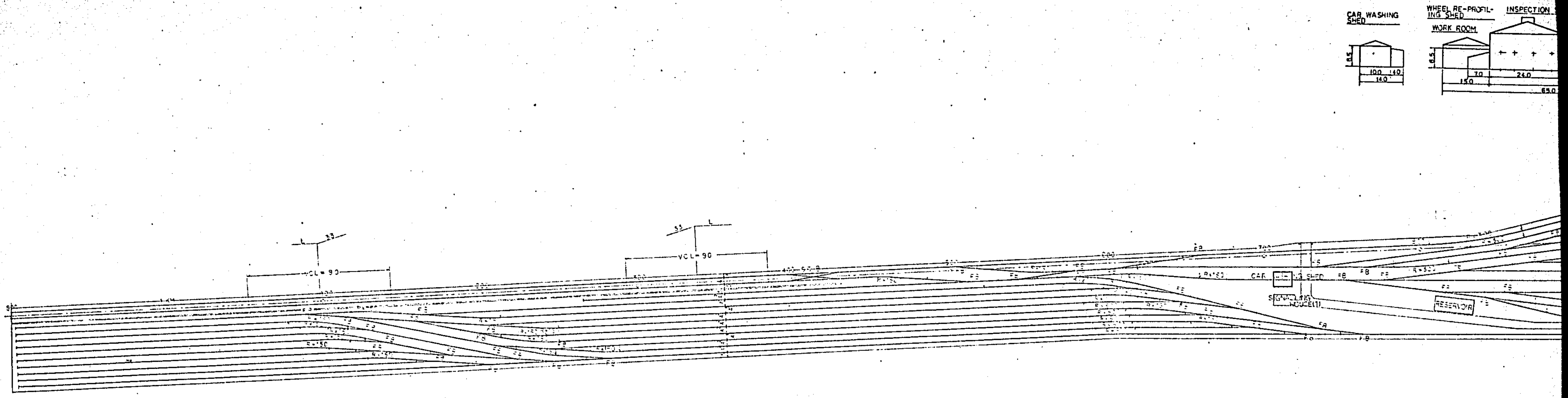
(3) Inspection facilities are concentrated virtually at the center of the depot, taking into account the existing facilities.

(4) Workshop facilities are located at the southern corner of the site.

(5) Temporary inspection facilities for the cars are provided in the workshop only.

(6) Offices for train operation and those concerned with inspection and repair of cars in addition to maintenance depot for track and others are so designed as to facilitate free entrance and exit to and from the outside.

The area required for the buildings relative to the above facilities is about 43,700 $m^2$, as shown in Table 10-1:



CAR WASHING SHED
WHEEL RE-PROFILING SHED
WORK ROOM
INSPECTION
VCL = 90
VCL = 90
RESERVOIR

# Fig. 10-1 CAR DEPOT LAYOUT

SCALE: 1/2000

SECTION OF BUILDING: 1/1000

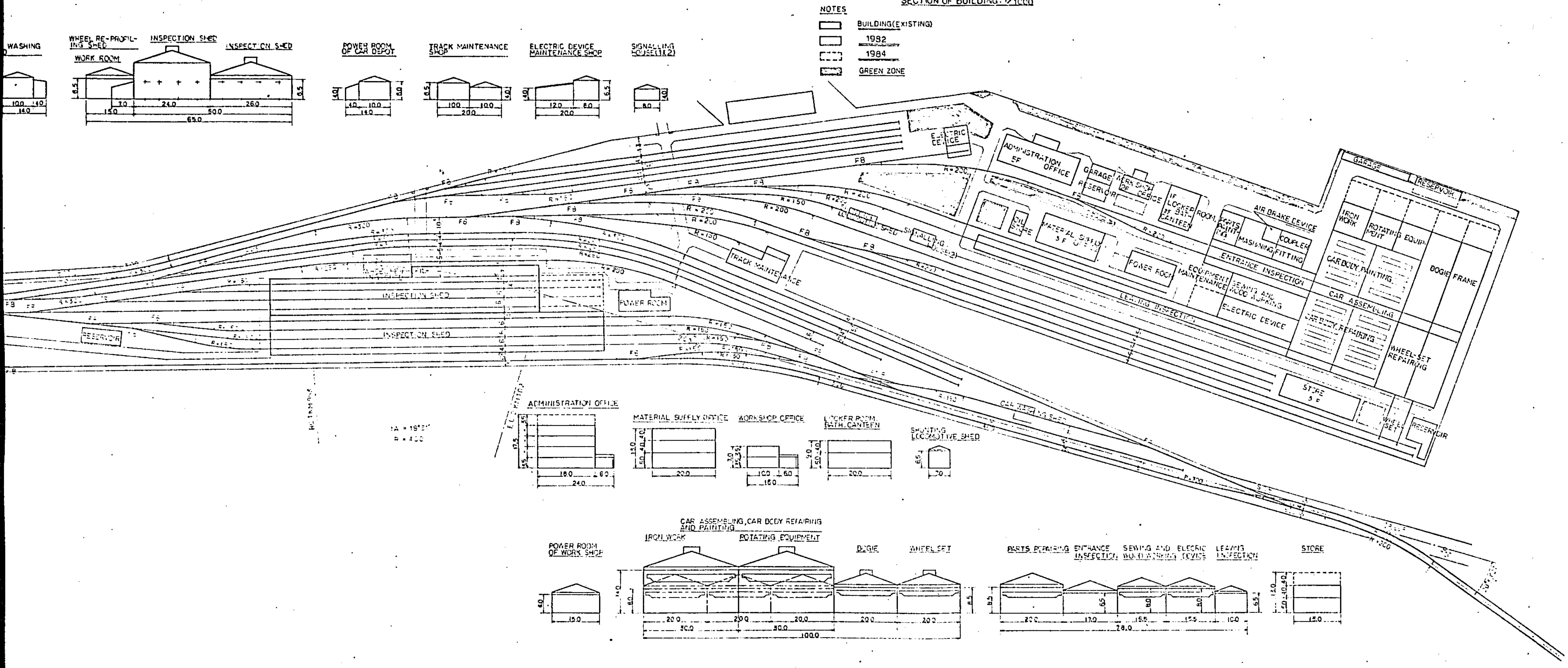


Table 10-1 Area of Buildings

(Unit : $m^2$)

| Item | 1982 | 1984 | Remarks |
|---|---|---|---|
| Buildings relative to car inspection shop | 12,300 | 13,900 | Including 4,790$m^2$ of the existing buildings |
| Workshop buildings | 19,000 | 24,400 | |
| Crew office and other buildings | 4,900 | 5,400 | |
| Total | 36,200 | 43,700 | |

The number of trains and cars in the planning of this depot is as shown in Table 10-2.

Table 10-2 Number of Cars

| Line | 1982 | | 1984 | |
|---|---|---|---|---|
| | No. of train consists | No. of cars | No. of train consists | No. of cars |
| Line No. 1 | 7 (8 cars/consist)<br>10 (10 do/do ) | 56<br>100 | 17 (10 cars/consist) | 170 |
| Line No. 2 | 18 (8 do/do ) | 144 | 30 (8 do/do ) | 240 |
| Total | 35 | 300 | 47 | 410 |

The car depot layout is as shown in Fig. 10-1.

## 10.2 Storage Facilities for Train Consists

All train consists, except for those kept overnight at the station for operating the earlier trains, are held in the storage and inspection tracks within the depot.

The storage capacity of the depot is as shown in Table 10-3:

Table 10-3 Rolling Stock Storage Schedule

(Unit: train consist)

| Item | 1982 | | | 1984 | | |
|---|---|---|---|---|---|---|
| | Line No. 1 | Line No. 2 | Total | Line No. 1 | Line No. 2 | Total |
| Total of train consists | 17 | 18 | 35 | 17 | 30 | 47 |
| No. of train consists kept at station | 2 | 3 | 5 | 2 | 3 | 5 |
| No. of train consists kept in car depot | 15 | 15 | 30 | 15 | 27 | 42 |
| Storage track | 11 | 11 | 22 | 11 | 23 | 34 |
| Inspection shed | 4 | 4 | 8 | 4 | 4 | 8 |

Remarks: Storage at station

Line No. 1 : Seoul Station,
Cheong Ryang Ri

Line No. 2 : Dae Un Dong Jang,
Seong Su Dong
City Hall (1982-1983)
Seo Gyo Dong (after 1984)

As far as storage tracks are concerned, it is the ideal to be one train per track. Considering the shape of the site, it is planned to use also tracks with two train consists per track.

The storage track schedule for the Line No. 1 and the Line No. 2 is as shown in Table 10-4.

Table 10-4 Storage Track Schedule

| Item | 1982 | | 1984 | | Remarks |
|---|---|---|---|---|---|
| | No. of track | No. of train consist | No. of track | No. of train consist | |
| 10 cars 1 consist/ track | 5 | 5 | 5 | 5 | For Line No. 1 |
| 10 cars 2 consists/ track | 3 | 6 | 3 | 6 | Do. |
| Subtotal | 8 | 11 | 8 | 11 | Do. |
| 8 cars 1 consist/ track | -- | -- | 9 | 9 | For Line No. 2 |
| 8 cars 2 consists/ track | 6 | 12 | 8 | 16 | Do. |
| Subtotal | 6 | 12 | 17 | 25 | Do. |
| Total | 14 | 23 | 25 | 36 | |

This schedule meets the rolling stock storage conditions necessary to the car depot as shown in Table 10-3.

These storage tracks are divided into two groups, one for Line No. 1 and the other for Line No. 2, being arranged so that trains in both cases can enter and leave without switching back.

Lead tracks for the exclusive use are provided for these storage track groups. Car movement between the storage track groups and the inspection shed availing of the lead track is planned so as not to cause any trouble to arriving and leaving of the trains from the car depot.

One track each of the car depot sidings entering and leaving the Lines No. 1 and No. 2 is extended to connect with each other, serving as the connecting track. This track is to be used for the through track entering and leaving the workshop, the trial-run track and the wheel reprofiling track.

## 10.3 Condition for Planning Car Inspection Facilities

### 10.3.1 Type, Cycle and Location of Car Inspection

The types of car inspection, the inspection cycle and features are the same as the cars used in the Line No. 1.

The places where inspections are to be carried out are as shown in Table 10-5, based upon the relationship among the time needed for inspection, the distribution of rolling stock operated, the degree of disassembly accompanying the inspection and the rationalization of the facilities needed.

Table 10-5 Types of Inspection, Inspection Cycle, and Location

| Types of inspection | Inspection period | | Location |
|---|---|---|---|
| | Cycle | Running distance | |
| General inspection | within 3 years | | Workshop |
| Intermediate inspection | within 1.5 years | within 250,000 km | Do. |
| Monthly inspection | within 30 days | | Inspection shed |
| Daily inspection | within 48 hours | | Do. |
| Temporary inspection | -- | | Workshop |

In the future, it will be necessary to reconsider the possibility of changing to a new system of the inspection cycle.

### 10.3.2 Car Cleaning

Car cleaning is as itemized in Table 10-6:

Table 10-6 Car Cleaning

| Type | Cycle |
|---|---|
| Large-scale cleaning | 30 days |
| Medium-scale cleaning | 6 days |
| Small-scale cleaning | Daily |

| | |
|---|---|
| Car body washing | 2 days |

### 10.3.3 Working Methods

(1) Workshop

a. For the general and intermediate inspections, the cars are led into the workshop in full train formation.

b. In order to equalize the work load, inspection is executed after the train formation being divided in the following way:

8 cars/consist: TcMM', MM', MM'Tc

10 cars/consist: TcMM', MM', MM'Tc, TT

c. Train consists for trial-runs are classified into workshop trial-run, and main line trial-run.

The main line trial-run is to be carried out after preparing the operating diagram in advance.

d. Temporary inspections, except for the light repairs, are all carried out at the workshop.

(2) Inspection Shed

a. The monthly inspections are to be made during the daytime in full train formation without disconnecting.

b. The daily inspections are to be made day and night in full train formation without disconnecting using the available train intervals.

c. Reprofiling of the wheel tread are to be made during the daytime in full train formation without disconnecting using the available train intervals.

d. Repairs of parts replaced during inspection are carried out at the workshop.

e. Car cleaning is to be made day and night in full train formation without disconnecting using the available train intervals.

Washing of the car bodies is carried out with an automatic car washer for the train in motion.

10.3.4 Annual Working Days in Workshops and Inspection Shed

(1) Workshop 270 days

(2) Inspection Shed

| | |
|---|---|
| Monthly inspection | 270 days |
| Daily inspection | 365 days |
| Large-scale cleaning | 365 days |
| Medium-scale cleaning | 365 days |
| Wheel reprofiling | 270 days |

10.3.5 Inspection Amount and Standard Hours Required for Inspection

(1) Inspection Amount

The amount of annual inspection is determined according to the following formula:

$$I = N \cdot a$$

where,

I : Amount (consists/year or cars/year)

N : Number of total consists or cars

a : Frequency of inspection (times/year)

The inspection cycle is decided by the inspection cycle laid down in the inspection type.

The inspection amount in the workshop and in the inspection shed are shown in the Tables 10-7 and -8, respectively.

Table 10-7 Inspection Amount in Workshop

(Unit : cars/year)

| Type | 1982 | 1984 |
|---|---|---|
| General inspection | 100 | 137 |
| Intermediate inspection | 100 | 137 |
| Temporary inspection | 30 | 41 |
| Total | 230 | 315 |

Table 10-8 Inspection Amount in Inspection Shed

(Unit: train consists)

| Type | Number of consists inspected per year | | Average number of consists inspected per day | |
|---|---|---|---|---|
| | 1982 | 1984 | 1982 | 1984 |
| Monthly inspection | 403 | 541 | 1.5 | 2.0 |
| Daily inspection | 5,670 | 7,614 | 15.5 | 20.9 |
| Total | 6,073 | 8,155 | 17.0 | 22.9 |
| Large-scale cleaning | 403 | 541 | 1.1 | 1.5 |
| Medium-scale cleaning | 1,890 | 2,538 | 5.2 | 6.9 |
| Total | 2,293 | 3,079 | 6.3 | 8.4 |
| Car body washing | 6,073 | 8,155 | 17.0 | 22.9 |

(2) Standard Hours Required for Inspection

a. Workshop

The number of days in the main shop for the general and intermediate inspection of rolling stock divided into 2 or 3 cars, and the number of days of the trains in the workshop including those for the final test and the trial-run are as follows:

(a) Number of days in the main shop

| | |
|---|---|
| General inspection | 14 days |
| Intermediate inspection | 12 days |

(b) Number of staying days in the workshop

| | | |
|---|---|---|
| General inspection | 8 cars/ train | 19 days |
| | 10 " | 20 " |
| Inter-mediate inspection | 8 " | 17 " |
| | 10 " | 18 " |

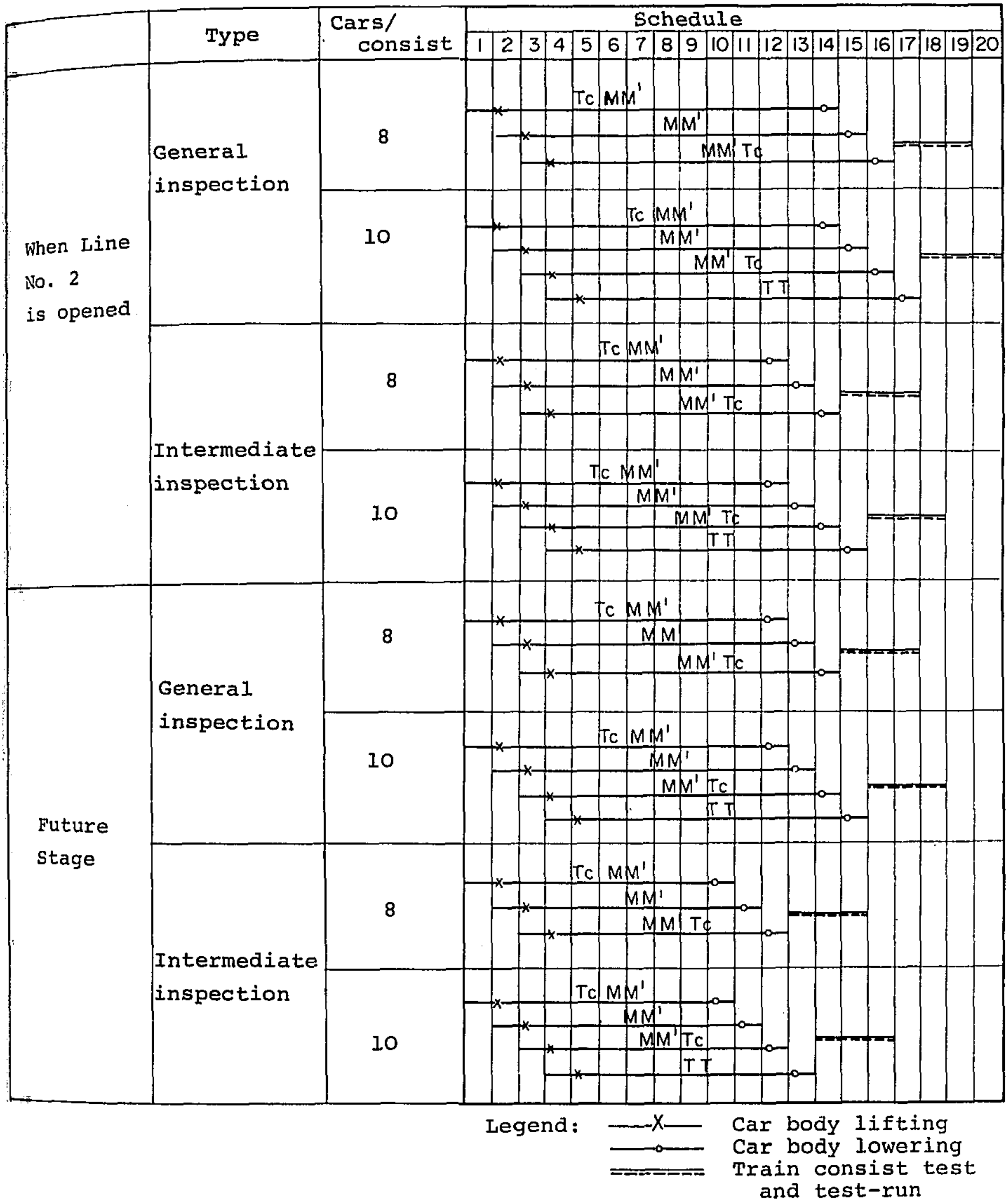
In the future, raising of operational efficiency can be expected. Consequently 10 percent of the required days can be reduced. The standard working schedule at the initial and the future stages of operation of the Line No. 2 is as shown in Table 10-9.

b. Inspection shed

The hours required for inspection per consist, taking into account the content of the inspection items and the utilization of the train intervals of the service is shown hereunder.

| | |
|---|---|
| Monthly inspection | 7 hours/consist |
| Daily inspection | 1 hour/consist |

Table 10-9 Standard Working Schedule Diagram for General and Intermediate Inspection



The hours required for large- and medium-scale cleaning is as follows.

| | |
|---|---|
| Large-scale cleaning | 4 hours/consist |
| Medium-scale cleaning | 1 hour/consist |

## 10.4 Workshop Facilities Planning

### 10.4.1 Outline

(1) The scale of the facilities is to be such that it is possible to carry out the general and intermediate inspection of cars accepted in the workshop within the specified days.

(2) They are expected to have the capacity for temporarily occurred inspection and repair of cars.

(3) Facilities needed in the above-mentioned work are to be reasonably arranged to correspond with the working flow.

### 10.4.2 Scale of Facilities

The scale of the workshop facilities is shown in Table 10-11 taking into account the standard required days in the workshop as shown in Table 10-10, based on the inspection amount in the workshop and the required standard inspection days.

Table 10-10 Number of Cars Accepted in Workshop Simultaneously

(Unit : cars)

| Type of inspection | 1982 | | 1984 | |
|---|---|---|---|---|
| | in the workshop | in the main shop | in the workshop | in the main shop |
| General inspection | 8.6 | 6.2 | 11.8 | 8.5 |
| Intermediate inspection | 7.7 | 5.3 | 10.6 | 7.3 |
| Temporary inspection | 0.7 | 0.7 | 1.0 | 1.0 |
| Total | 17.0 | 12.2 | 23.4 | 16.8 |

Table 10-11 Scale of Workshop Facilities

| Item | 1982 | 1984 |
|---|---|---|
| Car body repair shop<br>Car body painting shop | 14 cars | 18 cars |
| Entering inspection shed | 1 track for 3 cars | 1 track for 3 cars |
| Leaving inspection shed | 1 track for 3 cars | 1 track for 3 cars |
| Train adjustment shed | 1 track for 10 cars | 1 track for 10 cars |

### 10.4.3 Planning and Layout of Shops

Entering inspection, leaving inspection, car body lifting, car body lowering, disassembly and assembly of the bogie are all connected with each other in a series which is the main working flow.

With this main current as the center, the shops for car body repair and painting, for the bogie, wheel set, traction motor and for repair shops of the other parts are arranged, considering the special features of each work and strengthening of the coordination and rationalization of management.

(1) Entering Inspection Shed and Leaving Inspection Shed

Two exclusive inspection tracks with the effective length of three cars are provided in the same building. Two "W-type" inspection pits as well as checking scaffold for roof equipment are installed for the purpose of inspection work.

(2) Lifting and Lowering Shop, Repair Shop and Painting Shop for Car Bodies

The car body lifting and lowering shop is located at the extended site for the two tracks of entering and leaving inspection. The car body repair shop is located on both sides centering the car body lifting and lowering shop, a part of which is allotted to the car body paint shop.

In this layout, car body lifting, repairing, painting and lowering can all be carried out effectively within the same shop by an overhead travelling crane.

Thus decrease in the time required for moving the car bodies and work control efficiency is realized. The car accepting capacity per shop is 9 cars, and so 18 cars per two shops. However, since the accepting capacity of 14 cars is sufficient for the initial period, the spare area is used as a repair shop for the bogie and electrical rotating equipment.

(3) Repair Shop for Bogie, Wheel-set and Electrical Rotating Equipment

A bogie disassembly and assembly shop is located at the extended site of the two tracks of car body lifting and lowering shop. With this at the center, a wheel-set repair shop on one side and a bogie repair shop on the other side are installed. An electrical rotating equipment repair shop is situated adjacent to the bogie repair shop, strengthening the work coordination among three repair shops and aiming at the rationalized transportation.

The facilities at the initial period are to be planned, taking into consideration for the extension of the bogie repair shop and the electrical rotating equipment repair shop in the future.

(4) Parts Repair Shop and Other Shops

The repair shops for the electrical devices, air-brake parts, couplers, windows, sheet cushions and vestibule diaphragms of cars are located at either the right or left side of the entering and leaving inspection shed, in consideration of the intended workability.

Since this position is adjacent to the car body repair shop, the transportation distance between the two is shortened.

A machinery shop is also located in the same building as these shops.

The scale and layout of these repair shops and working areas are planned in consideration for the future extension.

Inside the above-mentioned repair shops, the roller bearing inspection areas require dust protection measures. Therefore a partition from other types of work is provided.

(5) Final Train Adjustment Shed

A final train adjustment shed with a single inspection track for a 10-car train consist is spotted on the extended site of the western tip of the car body repair shop.

In this track are installed an inspection pit and checking scaffold for roof equipment, to adjust the cars after final tests and trial runs.

This inspection track extends into the car body repair shop which enables to serve as a car entering and leaving track for the temporary inspection.

(6) Workshop Trial-Run Track

A workshop trial-run track is branched off from the connecting tracks of Lines No. 1 and 2, and is laid out along the boundary line on the west side of the workshop.

An A.C./D.C. changing section (A.C. 25kV, D.C. 1,500V) for the test of the cars used on the Line No. 1 is installed on the trolley wire of the trial-run track.

(7) Power Room, Office, etc.

Other facilities such as the power room and offices which are not directly connected with operation are integrated in consideration of the use of other facilities.

### 10.4.4 Mechanical Facilities

The various machinery provided in the workshop, including the existing ones are planned out with emphasis on the following items.

(1) Electrical and mechanical testing apparatus for inspecting the performance and function of the cars and supplementary processing machinery.

(2) Machinery for improvement of the working environment in such works as car body painting, car body washing and cleaning of parts.

(3) Machinery for ensuring working safety in such works as the transportation and movement of heavy materials.

## 10.5 Planning of Facilities in Inspection Shed

### 10.5.1 Outline

The outline of the facilities for car inspection in the inspection shed is given below.

(1) Facilities for monthly and daily inspection as well as cleaning facilities are integrated in one place. The shops connected with these and the facilities for reprofiling of wheel tread are consolidated for the better work management.

(2) Existing inspection shed is used as it is.

### 10.5.2 Scale of Facilities

The required number of inspection and cleaning track; which is as shown in Table 10-12, is decided from the amount of inspection per day taking into account the undulation ratio per inspection.

Table 10-12 No. of Inspection and Cleaning Track in Inspection Shed

| Item | Working capacity (Consist/Day/Track) | 1982 | | 1984 | |
|---|---|---|---|---|---|
| | | No. of consist/day | No. of track required | No. of consist/day | No. of track required |
| Monthly inspection track | 1 | 1.7 | 1.7 | 2.2 | 2.2 |
| Daily inspection track | 8 | 18.6 | 2.3 | 25.1 | 3.1 |
| Large-scale cleaning track | 2 | 1.2 | 0.6 } 1.3 | 1.6 | 0.8 } 1.7 |
| Medium-scale cleaning track | 8 | 5.7 | 0.7 } | 7.6 | 0.9 } |

The difference of required number of tracks between the scale of facilities in 1982 and 1984 is one track only as shown in Table 10-13. Because of this reason, planning is made on the basis of the scale for 1984. The length of each track is to be sufficient for the 10-car train consist.

Table 10-13 Facilities of Inspection Shed

| Item | 1982 | 1984 | Remarks |
|---|---|---|---|
| Monthly inspection track | 2 tracks | 3 tracks | Length of each track: sufficient for 10-car train consist |
| Daily inspection track | 3 | 3 | |
| Large-scale cleaning track | } 2 | } 2 | |
| Medium-scale cleaning track | } | } | |
| Total | 7 | 8 | |
| Wheel reprofiling track | 1 | 1 | |

10.5.3 Planning and Layout of Each Facility

(1) Inspection Shed

Inspection shed consists of two buildings. New building is newly constructed, connecting with the existing one. As a result, two buildings are equipped with four tracks each totaling eight, which satisfy the above-mentioned required number.

The length of the inspection shed is to be sufficient for the 10-car train consist of the Line No. 1.

Three tracks among the eight tracks are used exclusively for the monthly inspection, while the other five are used both for the daily inspection and for washing and cleaning.

An inspection pit and the necessary supplementary facilities are provided with each track for the work safety.

Attached working places are provided connected with this shed.

(2) Wheel Reprofiling Shed

A wheel re-profiling shed is constructed adjacent to the east of the inspection shed.

The wheel reprofiling track laid before and behind the machine is to be long enough to accept 10-car train consist without causing any hindrance to the other tracks, wherever the reprofiling work is executed within the consist.

(3) Car Body Washing Machine

Car body washing machine for the outside of the car is installed on the track which is available for inspection and cleaning purposes in the inspection shed.

The washing machine installed on the north side of the inspection shed is the main and the one on the south side is the secondary.

### 10.5.4 Mechanical Facilities

Besides the wheel reprofiling machine and the car washing machine, a simple testing apparatus are also planned.

These machinery are planned taking into consideration the existing one provided for the Line No. 1.

## 10.6 Maintenance Depot and Other Facilities

The maintenance depot and other facilities planned in this car depot are as follows:

Crew Office

Track Maintenance Depot

Power Supply, Communications and Signal Maintenance Depot

Materials Supply Office and Storage

Workshop Office, Inspection Shed, Maintenance Depot Office

Locker Room, Bath, Canteen and other Welfare Facilities

These facilities are laid out in the most suitable places taking into consideration their various functions and connections with the inside and outside of the depot.

Their layout is as shown in Fig. 10-1.

## 11. Construction Schedule and Partial Operation

The proposed Line No. 2 has a route length of 24 km between Seo Gyo Dong and Dae Un Dong Jang. To construct this line it requires a large amount of funds. A quantity of labor force, mechanical power as well as massive design and supervisory services are to be provided by the Head Office, Bureau of Rapid Transit. The construction by stage is generally adopted to build a rapid transit railway with a route length of over 20 km, i.e., a part of the line is preferentially completed so as to start the partial operation, which is condusive to recovering the funds and to training the staff. Simultaneously with this partial operation, the construction works for the rest of the line are implemented successively.

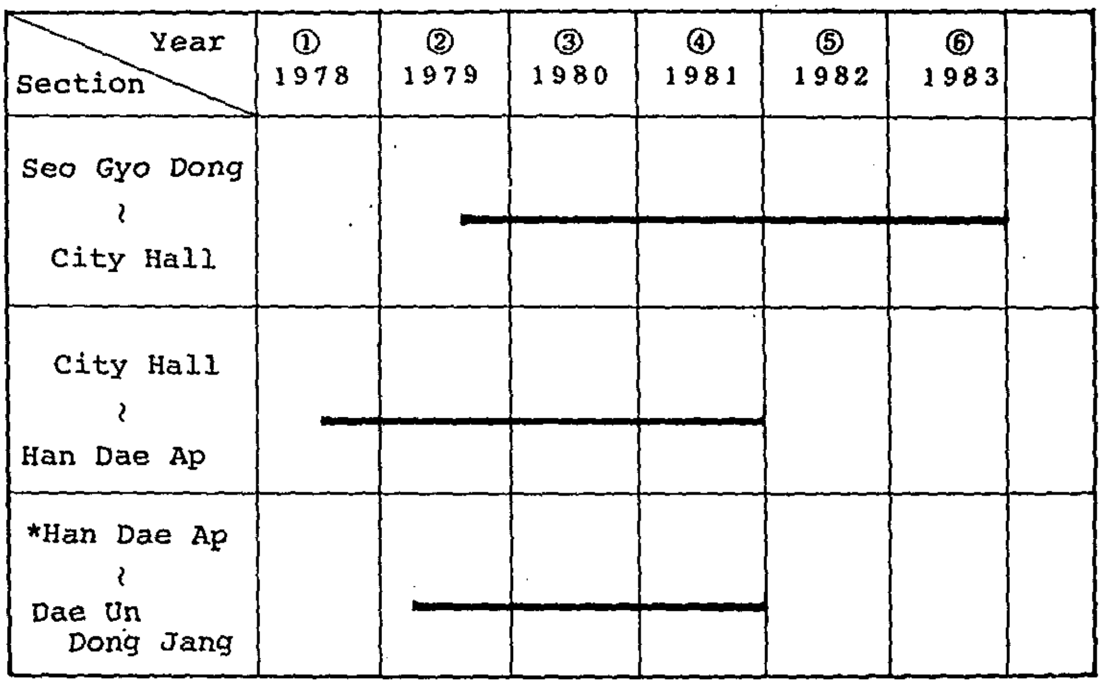
With elaborated studies as to which section of the Line No. 2 should be commenced at first, it is recommended that the section east of the City Hall Station be given the priority, taking into account technical problems, location of the railcar depot, the Asian Games in 1982, profitability of this section, etc.

The partial operation between the City Hall Station and Dae Un Dong Jang should be realized before the Asian Games in 1982, in the following order of construction: the construction work is commenced at first for the underground section between City Hall and Han Dae Ap where surface traffic is exceedingly heavy. Then the construction of the elevated section follows, because this section takes less time to complete than the underground section.

While the construction of the above two sections is implemented, the cut-and-cover portions which are used for the construction bases of the rock tunnels between Seo Gyo Dong and City Hall are constructed first, then other cut-and-cover portions and rock tunnels are successively executed. This order of the construction would be advantageous in terms of the capital utilization and staff training purpose. Therefore, it is advisable to divide the whole route between Seo Gyo Dong and Dae Un Dong Jang into three sections to get the optimal execution order.

The construction and operation schedule by section is shown in Fig. 11-1.

Fig. 11-1 Construction Schedule




Remark:

* Including connecting track to car depot.

# 12. Construction Organization and Operating Staff

## 12.1 Strengthening of Construction Organization

Bureau of Rapid Transit, SMG, in charge of the operation of the Line No. 1 and the rapid transit railway construction project, presently consists of, under the Head of Bureau, two Persons in charge of management and technology, seven sections, 19 sub-sections and 19 field offices.

As the scale of the Line No. 2 construction project in question is about 2.5 times the Line No. 1 and the scheduled construction period will be as long as 5.5 years, the construction organization should be strengthened. Because of these reasons, it is desirable to separate the Construction Section from the operating sections of the Line No. 1 to concentrate on the construction works of the Line No. 2. At the same time, the strengthening of the staff for design and supervision is essential.

The early implementation of the Line Nos. 3 and 4 being expected judging from the present traffic situation in Seoul, it is worth studying to make the Construction Section an independent organization at a certain stage.

For the strengthening of the construction organization, it is advisable to reemploy, if possible, the experienced engineers in the Line No. 1 construction project, many of whom have left for other jobs since the line opened to traffic three years ago, or to recruite experienced railway engineers.

It is also necessary to make use of technical know-how of the domestic consulting firms. In addition, a part of the engineering services in train operation, rolling stock and electric aspects might be entrusted to overseas consultants.

## 12.2 Operating Staff and Training Schedule

The number of staff required to operate a rapid transit railway is generally 80 to 100 employees per kilometer, though the figure varies depending upon scale and characteristics of the line, level of automation, etc.

The operating staff of the Line No. 2 after completion is assumed to be 100 employees per kilometer, considering pay scale, skilled level, mechanization stage, etc. in Korea.

In this case, the total employees at the stage of total line operation will become 2,400 persons or so which correspond to about 2.5 times the existing number of employees. The operation of the Line No. 2 could even be more difficult than its construction, in recruiting many unexperienced staff, and a cautious training schedule is absolutely essential.

The experience accumulated in the Line No. 1 will be very helpful to work out a training schedule for the Line No. 2. Besides, as the technical standard of the Line No. 2 is almost the same as that of the Line No. 1, it is possible to avail of the latter in training, which enables to start the practical training considerably earlier. It is, therefore, desirable to increase the required staff by degrees from two years before the partial operation for training purpose.

# 13. Construction Cost and Operation Cost

## 13.1 Construction Cost

The approximate construction cost of the Line No. 2 is estimated to be 185 billion Won, including the costs of right-of-way and railcars, the breakdown of which is as shown in Table 13-1. As the car depot constructed in this project is utilized for cars of both No. 1 and No. 2 Lines, the construction cost of the depot is divided into two lines by the ratio of the number of railcars of Line No. 1 and Line No. 2 against the total. In the above construction cost is included 7.1 billion Won or 60 percent of the total car depot construction cost borne by Line No. 2. When 4.8 billion Won or 40 percent of the cost borne by Line No. 1, as shown in Table 13-2, is added, the total construction cost becomes 189.8 billion Won.

The materials and equipment procured domestically and the labor input are evaluated at the going market prices and wage rates respectively in the beginning of May 1977, when the field investigation was carried out. The imported materials and equipment are converted into Won at the following foreign exchange rate prevailing during the same period.

US$ 1 = ¥280 = 480 Won

The major foreign exchange components of the construction cost are for railcars, rails and fastenings, a part of signal systems, machinery of workshops, major portions of transformer facilities, etc., which are evaluated at CIF prices. Import duties and excise taxes, which are assumed to be 20 percent of CIF prices in total, are added to the domestic currency portion.

The domestic currency components are assumed to include on the average three percent excise tax in their prices.

The cost item of engineering fee and overhead consists of costs for detailed design, construction supervision, training before operation, test run, etc., which are summed up in the domstic currency portion. Should there be any engineering services to be intrusted to the overseas consultants, some additional foreign exchange would be required.

Incidentally, the construction cost used in the economic analysis of the project does not necessarily coincide with the figures in Table 13-1, because in economic analysis import duties and excise taxes are excluded from cost items as transfer items that do not mean the consumption of real resources.

## 13.2 Operation Cost

The estimated operation cost of the Line No. 2 shown in Table 13-3 is based upon operating staff, train operation and transport planning. As for the operation cost of the car depot, the above cost includes only the amount to be borne by the Line No. 2. The foreign exchange portion in the maintenance cost is primarily appropriated for the spare parts of railcars. Twenty percent tariff and excise tax on them are added to the domestic currency portion. In economic analysis, taxes are excluded from the calculation for the reasons aforementioned.

Table 13-1 Construction Cost

Unit: million Won

| | Main Line | | | Car Depot | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|
| | D.C. | F.C. | Total | D.C. | F.C. | Total | D.C. | F.C. | Total |
| Right-of-Way | 2,328 | 0 | 2,328 | 0 | 0 | 0 | 2,328 | 0 | 2,328 |
| Civil work | 86,889 | 924 | 87,813 | 908 | 0 | 908 | 87,797 | 924 | 88,721 |
| Building | 8,131 | 0 | 8,131 | 1,840 | 0 | 1,840 | 9,971 | 0 | 9,971 |
| Track | 3,682 | 2,452 | 6,134 | 560 | 640 | 1,200 | 4,242 | 3,092 | 7,334 |
| Electric and Mechanical Work | 10,277 | 8,728 | 19,005 | 1,412 | 1,768 | 3,180 | 11,689 | 10,496 | 22,185 |
| Total | 111,307 | 12,104 | 123,411 | 4,720 | 2,408 | 7,128 | 116,027 | 14,512 | 130,539 |
| Engineering and Overhead | 4,533 | 0 | 4,533 | Included in Main Line | | | 4,533 | 0 | 4,533 |
| Railcar | 8,527 | 41,401 | 49,928 | 0 | 0 | 0 | 8,527 | 41,401 | 49,928 |
| Grand Total | 124,367 | 53,505 | 177,872 | 4,720 | 2,408 | 7,128 | 129,087 | 55,913 | 185,000 |

Note: D.C. denotes domestic currency.
F.C. denotes foreign currency.

Table 13-2 Car Depot Construction Cost to be borne with the Line No. 1

Unit: million Won

| | |
|---|---|
| Domestic Currency Portion | 3,147 |
| Foreign Currency Portion | 1,605 |
| Total | 4,752 |

Table 13-3 Operation Cost

Unit: million Won

| Item \ Year | | 1982 | 1983 | 1984 | --- | 2011 |
|---|---|---|---|---|---|---|
| Personnel Cost | D.C. | 2,530 | 2,530 | 3,430 | 3,430 | 3,430 |
| Maintenance Cost | D.C. | 300 | 300 | 450 | 450 | 450 |
| | F.C. | 450 | 450 | 750 | 750 | 750 |
| Power Cost | D.C. | 700 | 700 | 1,300 | 1,300 | 1,300 |
| Overhead | D.C. | 440 | 440 | 600 | 600 | 600 |
| Total | D.C. | 3,880 | 3,880 | 5,630 | 5,630 | 5,630 |
| | F.C. | 540 | 540 | 900 | 900 | 900 |
| Grand Total | Grand Total | 4,420 | 4,420 | 6,530 | 6,530 | 6,530 |

Note: Interest on loan and bond as well as depreciation cost is not included.

## 14. Financial Analysis

### 14.1 Basis and Assumptions for Analysis

The financial analysis of the Rapid Transit Line No. 2 Project is based on the following assumptions.

#### 14.1.1 Assumptions for Cost Estimation

The construction and operating costs discussed in Chapter 13 are not dealt with under the same headings in the calculations for financial analysis. One account differs in amount from the other to some extent by reason of the computer program used, but the assumption is made that such differences will not significantly affect the results of financial analysis.

##### 14.1.1.1 Construction Costs and Service Life of Assets

The total construction cost is estimated to be 185 billion Won, as shown in Table 14-2, about 70 percent (129.1 billion Won) of which is accounted for by the domestic currency portion and about 30 percent or 55.9 billion Won by the foreign currency portion.

The domestic currency portion of the total construction cost will be met with the governmental and municipal funds and the proceeds from the issue of municipal bonds (subway bonds), and the foreign currency portion will be met with loans from other countries.

The service life of the fixed assets is estimated according to the "Official Service Life Chart of Fixed Assets of the Republic of Korea", as shown in Table 14-1.

Table 14-1 Service Life of Fixed Assets

| Inauguration | Track (Main Line) | Track (Depot) | Station Facilities | Buildings | Electric Feeding System | Signal & Safety Devices | Traction Substations | Machinery | Rolling Stock |
|---|---|---|---|---|---|---|---|---|---|
| 5 | 60 | 60 | 45 | 40 | 30 | 30 | 40 | 12 | 15 |

Table 14-2 Breakdown of Total Construction Cost

DC: Million Won
FC: Thousand US dollars
(1 dollar ~ 480 Won)

| Item | Year | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | Total |
|---|---|---|---|---|---|---|---|---|
| Right-of-way | DC | 1,498 | 606 | 224 | | | | 2,328 |
| | FC | | | | | | | |
| Track | DC | 8,319 | 20,798 | 34,349 | 14,228 | 7,561 | 6,874 | 92,039 |
| | FC | 681 | 1,244 | 5,360 | | 1,081 | | 8,366 |
| Station facilities | DC | | | 590 | 5,314 | 222 | 2,005 | 8,131 |
| | FC | | | | | | | |
| Buildings | DC | | | | 1,558 | | 282 | 1,840 |
| | FC | | | | | | | |
| Electrical equipment and Machinery | DC | | 111 | 4,637 | 4,348 | 1,084 | 1,509 | 11,689 |
| | FC | | 21 | 12,028 | 7,656 | 662 | 1,500 | 21,867 |
| Rolling stock | DC | | | | 5,116 | | 3,411 | 8,527 |
| | FC | | | | 51,752 | | 34,500 | 86,252 |
| Initial expenses | DC | 352 | 768 | 1,739 | 945 | 337 | 392 | 4,533 |
| | FC | | | | | | | |
| Total | DC | 10,169 | 22,283 | 41,539 | 31,509 | 9,204 | 14,383 | 129,087 |
| | FC | 681 | 1,265 | 17,388 | 59,408 | 1,743 | 36,000 | 116,485 |
| Grand Total | | 10,496 | 22,890 | 49,885 | 60,025 | 10,041 | 31,663 | 185,000 |

Remarks: DC: Domestic Currency Portion
FC: Foreign Currency Portion

14.1.1.2 Fund Raising

The total construction cost estimated at 185 billion Won will be met with the governmental and municipal subsidies, and the proceeds from the issue of municipal bonds (subway bonds), as shown in Table 14-3.

This fund raising program is based on the assumption that the governmental and municipal subsidies will be free of interest and that the municipal bonds will be issued, and foreign loans will be made, subject to conditions shown in Table 14-4.

14.1.1.3 Train Operation Schedule

(1) The car-kilometer is placed at 42,400 per day for the period from 1982 to 1983 during which services will be provided between City Hall and Dae Un Dong Jang, and that for 1984 onward after the route is extended from the City Hall to Seo Gyo Dong is placed at 77,600 per day.

(2) The car repair cost is placed at 42.4 Won per car per km.

(3) Electric power consumption is placed at 2.3 kWh per km, and the cost of electric power is estimated to be 19.96 Won per kWh.

14.1.1.4 Personnel Plan

(1) The number of personnel required for the Line No. 2 is placed at 1,760 persons for the period from 1982 to 1983 during which services will be provided between City Hall and Dae Un Dong Jang, and is increased to 2,380 for the years following 1983.

(2) The personnel expenses are placed at 1,436,000 Won per employee per year and the general administrative expenses, 250,000 Won per employee per year on the basis of the operating results of the Line No. 1.

Table 14-3 Fund Raising Program

(Unit: Million Won)

| Item \ Year | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | Total |
|---|---|---|---|---|---|---|---|
| Governmental subsidy | 3,603 | 6,851 | 13,381 | 10,150 | 2,965 | 4,632 | 41,582 |
| Municipal subsidy | 6,893 | 3,385 | 13,156 | 9,980 | 2,915 | 4,556 | 40,885 |
| Municipal bonds | - | 11,720 | 15,002 | 11,379 | 3,324 | 5,195 | 46,620 |
| Foreign bonds | - | 934 | 8,346 | 28,516 | 837 | 17,280 | 55,913 |
| Total | 10,496 | 22,890 | 49,885 | 60,025 | 10,041 | 31,663 | 185,000 |

Table 14-4 Borrowing Conditions

| Fund Source | Percent (%) | Interest rate | Deferment period | Payment method |
|---|---|---|---|---|
| Governmental subsidy | 22.477 | - | - | - |
| Municipal bonds | 22.1 | | - | - |
| Municipal bonds | 25.2 | 14 | 5 | Total redemption in the 6th year after issue |
| Foreign loans | 30.223 | 5 | 5 | Repayment in equalized installments over 15 years |

### 14.1.2 Assumptions for Revenue Estimation

The following assumptions are made in the revenue estimation for the Line No. 2.

#### 14.1.2.1 Demand Forecast

The yearly passenger volume of the Line No. 2 is estimated, using the results shown in Table 14-6. The proportion of ordinary passengers, commuters and students who will use the Line No. 2 is estimated according to the rush hour passenger traffic survey for the Line No. 1 taken in March 1977, as shown in Table 14-5.

Table 14-5 Passenger Classification

| Classification | Percentage |
|---|---|
| Ordinary passengers | 83.8 |
| Commuters | 6.3 |
| Students | 9.9 |

The rates of fare reduction are assumed to be 30 percent for commuters and 50 percent for students.

#### 14.1.2.2 Fare Structure

The fare for the Line No. 2 is assumed to be the same as that for the Line No. 1. The current fare structure for the latter is the minimum at 40 Won up to 8 km travelled and increases by 3.6 Won for every additional kilometer travelled. Each 10 Won or the fraction thereof is raised to the whole number.

Table 14-6 Estimated Passenger Traffic Volume

(Passengers per Day)

| Classification \ Year | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ordinary Passengers | 398,976 | 511,590 | 624,206 | 638,774 | 653,344 | 667,914 | 682,482 | 697,054 | 711,622 | 726,192 | 740,762 | 755,332 |
| Commuters | 30,122 | 38,622 | 47,124 | 48,224 | 49,324 | 50,424 | 51,524 | 52,624 | 53,724 | 54,824 | 55,924 | 57,024 |
| Students | 46,964 | 60,220 | 73,476 | 75,190 | 76,906 | 78,620 | 80,336 | 82,050 | 83,766 | 85,480 | 87,196 | 88,910 |
| Total | 476,062 | 610,432 | 744,806 | 762,188 | 779,574 | 796,958 | 814,342 | 831,728 | 849,112 | 866,496 | 883,882 | 901,266 |

| Classification \ Year | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 |
|---|---|---|---|---|---|---|---|---|---|---|
| Ordinary Passengers | 769,902 | 同 左 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 |
| Commuters | 58,124 | 同 左 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 |
| Students | 90,626 | 同 左 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 |
| Total | 918,652 | 同 左 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 |

14.1.2.3 Miscellaneous Revenue (Advertising Revenue)

The miscellaneous revenue is estimated at 3 percent of the fare revenue.

14.1.3 Simulation Cases

Several simulation cases of Line No. 2 in financing and managing procedures are formulated after due consideration of the results of operation of Line No. 1:

(1) Effect of the minimum fare level on the financing standing of the proposed line (effect of changes in fare);

(2) Effect of the interest rate of the municipal bond on the financing standing of the proposed subway (effect of changes in interest rate); and

(3) Effect of subsidies on the financial standing of the proposed subway (effect of the difference in the amount of governmental and municipal subsidies).

All those simulation cases are presented in tabulated form in Table 14-7. Furthermore, the simulation cases are expanded to consider the increases in fares and personnel and other expenses as well as renewal costs in order to be in accord with reality. Such variants on the simulation cases are discussed in detail in Section 14.3 later.

Table 14-7 Simulation Cases

| Proportion of Subsidies (from Government and Municipality) \ Interest on Municipal Bond \ Minimum Fare Level | | 40 Won | 60 Won | 80 Won |
|---|---|---|---|---|
| 45% | 14%* | (Basic case) 1 | 2 | 3 |
| | 6%** | 4 | | |
| 60% | 14% | 5 | | |
| | 6% | | | |

Remarks: * In case of the Line No. 1.

** In case of the interest rate of national housing bond.

## 14.2 Financial Program

### 14.2.1 Analysis of Simulation Results

#### 14.2.1.1 Repayment Plan

Table 14-8 shows that the year-end debts outstanding at peak level, peak principal repayment and total amount of interest payable. The table does not reveal the trend in obligations over the years of repayment, but furnishes the following information:

(1) If 55 percent of the total construction cost is met with borrowings (municipal bonds plus foreign loans), the year-end amount of borrowed funds at the peak level will be about 102.5 billion Won, and if 40 percent is met with borrowed funds, the year-end amount of borrowed funds at the peak level will be about 74.4 billion Won.

(2) The peak principal payments will be about 18.7 billion Won and about 9.7 billion Won, respectively, if the same assumptions as in paragraph (1) above are made.

(3) If 55 percent of the total construction cost is met with borrowings and the municipal bond draws interest at 14 percent, the interest payments will amount to 60.7 billion Won, the largest amount of all cases. If only the interest rate of the muncipal bond is changed to 6 percent, the interest payments will decrease to 42.1 billion Won. If 40 percent of the total construction cost is met with borrowings and the municipal bond draws interest at 14 percent, the interest payments will be 41 billion Won.

(4) From the standpoint of repayment, therefore, it will be the most desirable of all cases considered if 40 percent of the total construction cost is met with borrowings and the municipal bond carries 14-percent interest.

Incidentally, the estimates presented in Table 14-8 are made on the assumptions that construction costs accrued in the first year will be met with the subsidies from the Government and Municipality.

Table 14-8 Plan of Repayment (Rough Plan)

(Billions of Won)

| Indices / Interest Rate of Municipal Bond / Percentage of Bonds and Foreign Loans in Total Construction Cost | Peak Term-end Debts out-standing | | Peak Princi-pal Payments | | Total Interest Payments | |
|---|---|---|---|---|---|---|
| | 14% | 6% | 14% | 6% | 14% | 6% |
| 55% | 102.5 | 102.5 | 18.7 | 18.7 | 60.7 | 42.1 |
| 40% | 74.4 | | 9.7 | | 41.0 | |

### 14.2.1.2 Estimated Revenue and Expenditure and Funds Flow Program

Table 14-9 summarizes the estimated revenue and expenditure and funds flow program in each case. The table does not reveal the trend in the financial condition of the proposed line over the years of repayment, but clarifies the following points.

(1) Assuming that the minimum fare is 40 Won, the accumulated operation subsidy cannot be repaid within 20 years even if the governmental and municipal construction subsidies are increased from 45 percent to 60 percent of the total construction cost and the interest rate of the municipal bond is lowered from 14 percent to 6 percent.

(2) Assuming that the minimum fare is 40 Won, the Line No. 2 will not be able to wipe out the accumulated deficits within 20 years of service inauguration, even if the conditions of borrowing are as favorable as in case (1) above.

(3) As can be known from the foregoing, there seems little hope that the proposed line will be operated in a financially sound condition at the same minimum fare as that of the Line No. 1. Other conditions being equal, it will be impossible to keep the line No. 2 financially sound unless the minimum fare is 60 Won or more.

(4) Since there are limits to the effects of an increase in subsidies and a reduction of interest rate of the municipal bond, efforts are to be made in other areas: the minimum fare would be revised upward every three years to increase the fare revenue and the subway operations are to be rationalized to cut expenses instead of merely relying on the subsidies of the government and municipality.

Table 14-9 Funds Flow Program and Estimated Revenue and Expenditure

(Years)

| Indices: Percentage of Governmental and Municipal Subsidies in Total Construction Cost | Interest Rate of Municipal Bond / Minimum Fare | (Funds Flow Program) First Break-even Year --- Time of Complete Repayment of Accumulated Operation Subsidies | | | (In Revenue Expenditure Program) First Break-even Year --- Time of Elimination of Accumulated Deficits | | |
|---|---|---|---|---|---|---|---|
| | | 40 Won | 60 Won | 80 Won | 40 Won | 60 Won | 80 Won |
| 45% | 14% | 11 - * | 8 - 18 | 6 - 11 | 16 - * | 7 - 15 | 5 - 1 |
| | 6% | 11 - * | | | 16 - * | | |
| 60% | 14% | 11 - * | | | 16 - * | | |
| | 6% | | | | | | |

Remarks: 1. Figures without units indicates the year after inauguration.
2. * mark indicates a period longer than 20 years.

14.2.1.3 Effects of Minimum Fare Level

Assumed Cases

Minimum Fare: 40 Won (Case 1)
60 Won (Case 2)
80 Won (Case 3)

(1) On a yearly basis, the Line No. 2 will not go into the black until the 11th year of service in Case 1, whereas it will earn a surplus in the 8th year of service in Case 2, and in the 6th year of service in Case 3. (See Fig. 14-1)

On a cumulative basis, the operation will not be so profitable in Case 1 that the operation subsidies can be repaid within 20 years of service, while the subsidies can be repaid in 18 years in Case 2, and in 11 years in Case 3, after service inauguration. (See Fig. 14-2)

(2) The increases in the minimum fare also favorably affect the estimated revenue and expenditure program for the Line No. 2. On a yearly basis the first break-even year will fall on the 16th year of service in Case 1, while the Line will break even for the first time in the 7th year of service in Case 2 and in the 5th year of service in Case 3. (See Fig. 14-3)

In Case 1 the operation will not be so profitable that the cumulative deficits can be made up within 20 years of service, whereas the cumulative defecits will be eliminated in the 15th year of service in case 2 and in the 7th year of service in Case 3. (See Fig. 14-4)

(3) As the plan of repayment is the same in each case, it will not be influenced by the minimum fare level.

In short, the minimum fare has an important bearing on the performance of the proposed line, and the fare revision upward provides an effective means to improve its revenue.

Effect on Minimum Fare Level

(1) Funds Flow Program

Fig. 14-1 Trend in Yearly Balance of Fund

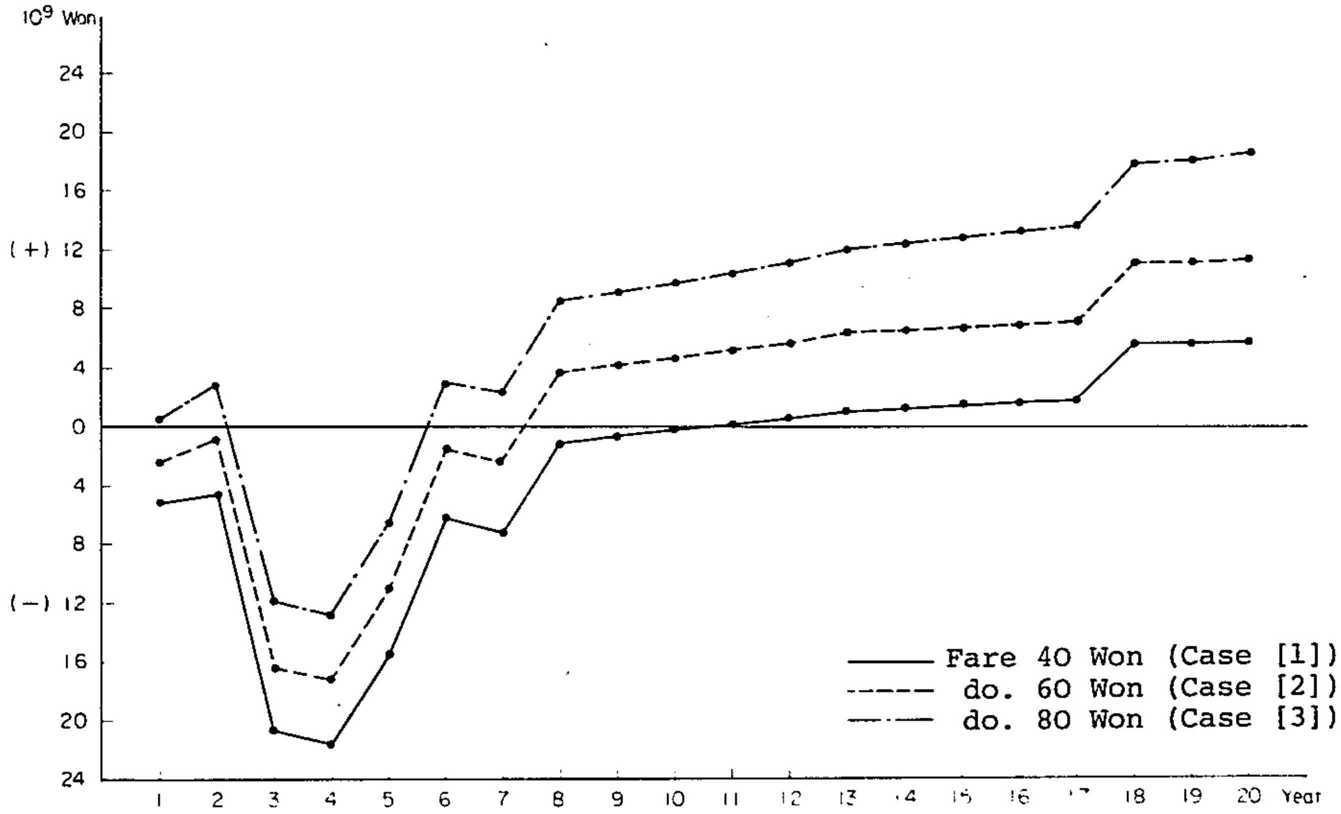
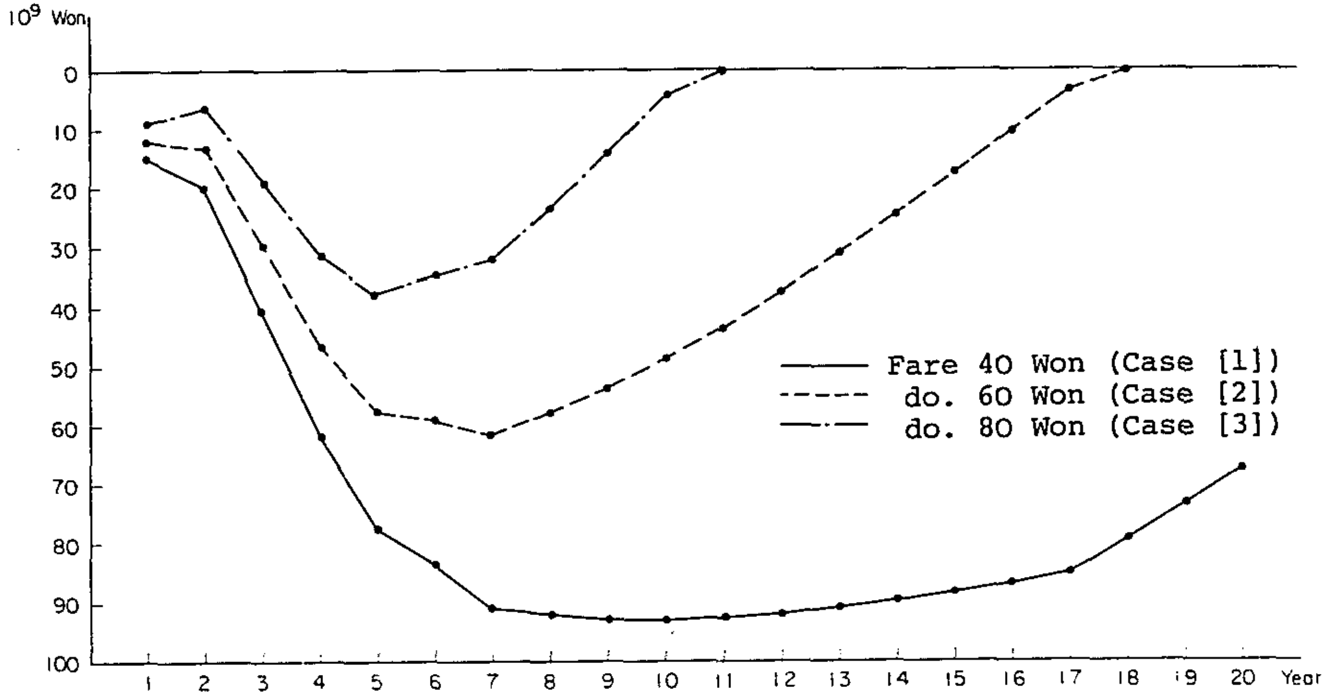


Fig. 14-2 Trends in Cumulative Balance of Operation Subsidy .



(2) Estimated Revenue and Expenditure

Fig. 14-3 Trend in Yearly Profit after Depreciation

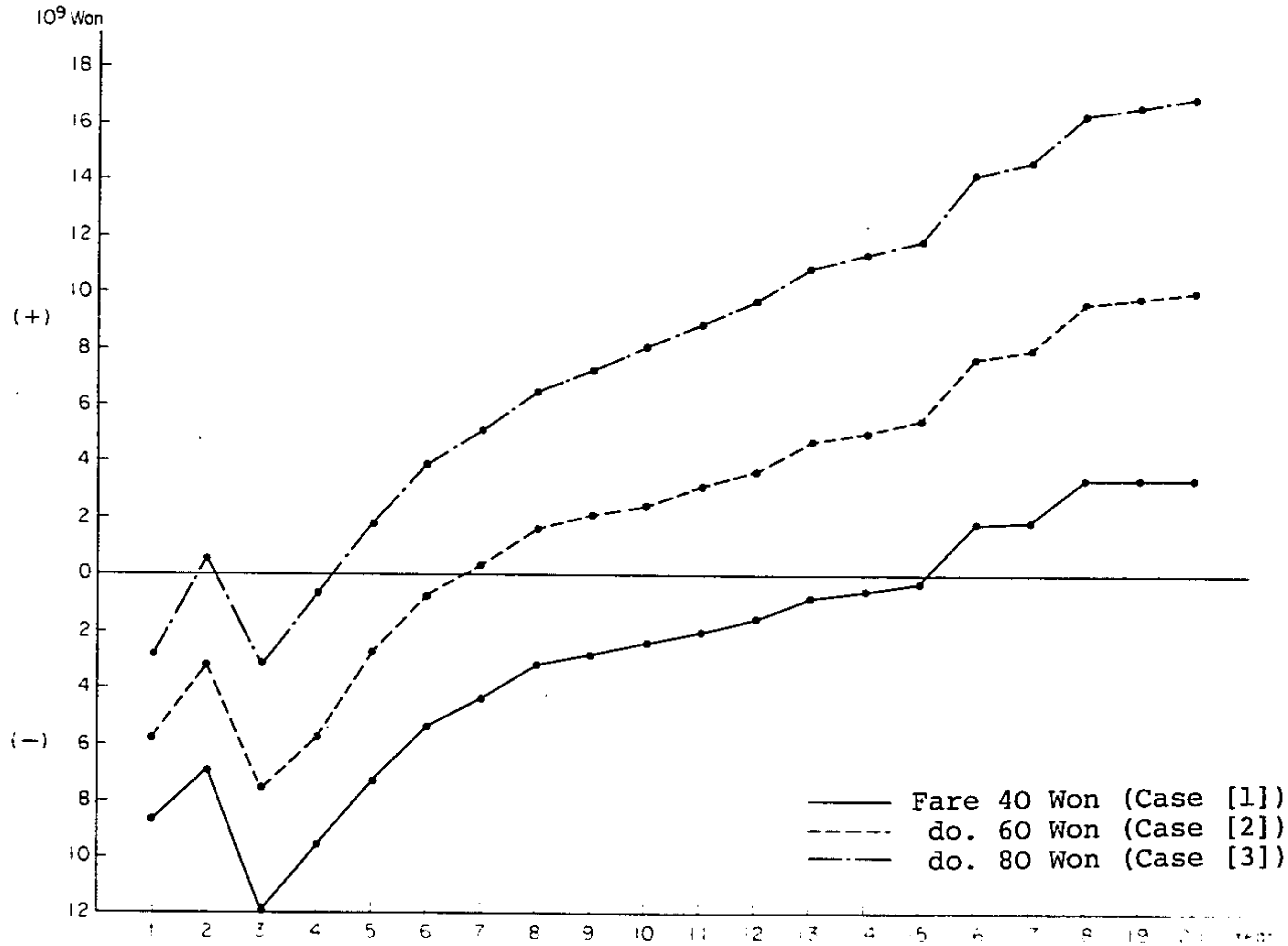
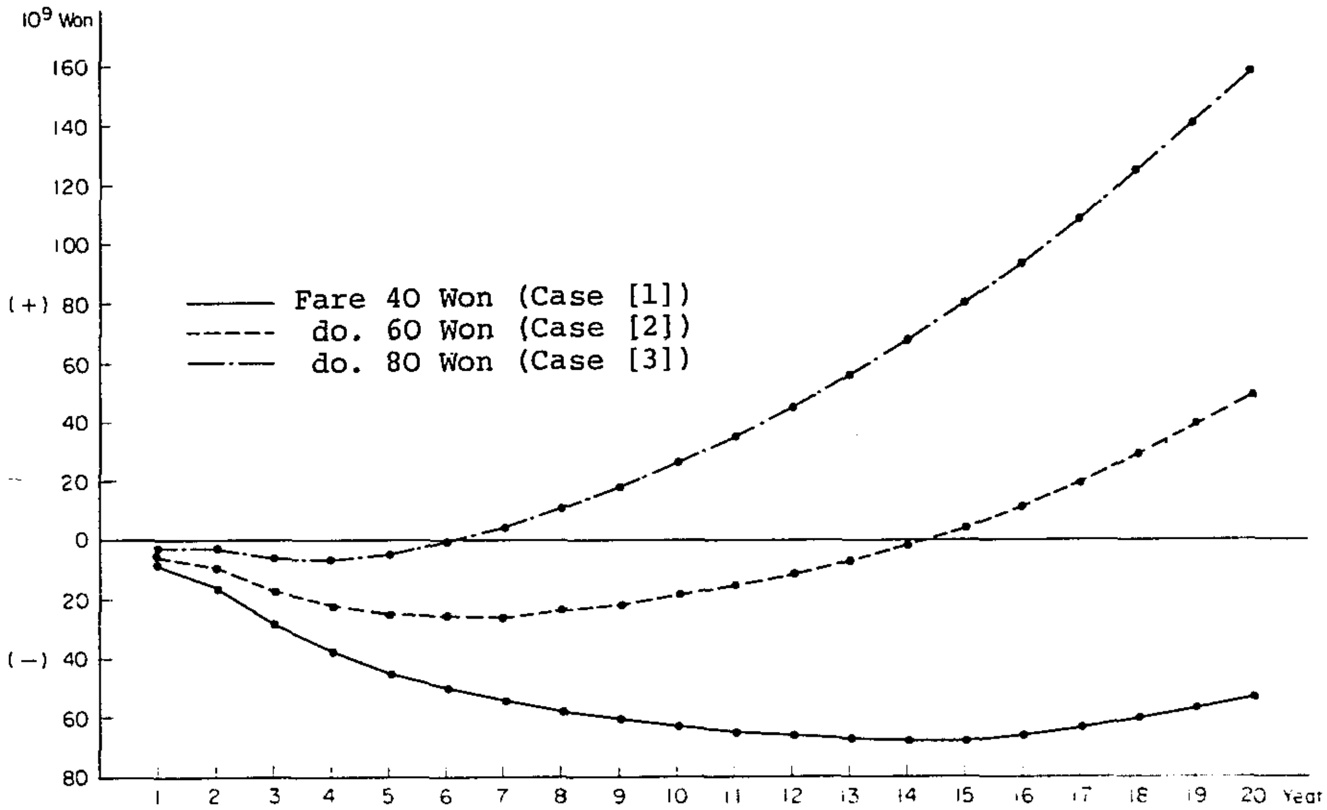


Fig. 14-4 Trend in Accumulated Profit Brought Foward



The plans of repayment, funds flow program, and the estimated revenue and expenditure for the three assumed cases are presented in Tables 14-10 through -18.

14.2.1.4 Effects of Interest Rates of Municipa Bond

Assumed cases

Interest on the Municipal Bond: 14% p.a. (Case 1)

6% p.a. (Case 4)

(1) The bonds and loans outstanding at the year-end will reach the peak level of about 102.5 billion Won in the last year of the construction period and the principal repayments will reach the peak level of about 18.7 billion Won in the second year of service in both cases, while the interest repayments will differ by about 3.5 billion Won maximum from Case 1 to Case 4 in the last year of the construction period. (See Fig. 14-5)

(2) On a yearly basis the line will go into the black in terms of the fund flow program in the eleventh year of service in both cases. (See Fig. 14-6)

On a cumulative basis, the operation will not be so profitable in either case that the operation subsidies can not be repaid within 20 years of service. (See Fig. 14-7)

(3) According to the estimated revenue and expenditure, the Line No. 2 will break even for the first time in the 15th year of service in both Cases 1 and 4 (see Fig. 14-8), whereas the cumulative deficits cannot be eliminated within 20 years of service in either case. (See Fig. 14-9)

In short, the interest payable can naturally be reduced if the bond is issued at a lower interest rate, but its interest rate itself causes little effect on the funds flow program and the estimated revenue and expenditure. An effort should therefore be made to find a most effective means to

# Table 14-10 Repayment Plan (Case 1)

Unit: Millions Wo

| Item | Year | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Municipal bond | Bonds outstanding, beginning of year | 0 | 0 | 11720 | 26722 | 38101 | 41425 | 46620 | 34900 | 19898 | 8518 | 5194 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Bonds issued | 0 | 11720 | 15002 | 11379 | 3324 | 5194 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Principal repayment | 0 | 0 | 0 | 0 | 0 | 0 | 11720 | 15002 | 11379 | 3324 | 5194 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Interest repayment | 0 | 820 | 2691 | 4538 | 5567 | 6163 | 5706 | 3836 | 1989 | 960 | 364 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Bonds outstanding, end of year | 0 | 11720 | 26722 | 38101 | 41425 | 46620 | 34900 | 19898 | 8518 | 5194 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Loans | Loans outstanding, beginning of year | 0 | 0 | 934 | 9280 | 37796 | 38633 | 55913 | 52185 | 48458 | 44730 | 41003 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 |
| | Loans disbursed | 0 | 934 | 8346 | 28516 | 837 | 17280 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Principal repayment | 0 | 0 | 0 | 0 | 0 | 0 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 |
| | Interest repayment | 0 | 23 | 255 | 1177 | 1911 | 2364 | 2796 | 2609 | 2423 | 2237 | 2050 | 1864 | 1677 | 1491 | 1305 | 1118 | 932 | 746 | 559 | 373 | 186 |
| | Loan outstanding end of year | 0 | 934 | 9280 | 37796 | 38633 | 55913 | 52185 | 48458 | 44730 | 41003 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 | 0 |
| Loans (US$1000) | Loan, beginning of year | 0 | 0 | 1946 | 19333 | 78742 | 80485 | 116485 | 108720 | 100954 | 93188 | 85423 | 77657 | 69891 | 62126 | 54360 | 46594 | 38828 | 31063 | 23297 | 15531 | 7766 |
| | Loan disbursed | 0 | 1946 | 17387 | 59408 | 1744 | 36000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Principal repayment | 0 | 0 | 0 | 0 | 0 | 0 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 |
| | Interest repayment | 0 | 49 | 532 | 2452 | 3981 | 4924 | 5824 | 5436 | 5048 | 4659 | 4271 | 3883 | 3495 | 3106 | 2718 | 2330 | 1941 | 1553 | 1165 | 777 | 388 |
| | Loan, end of year | 0 | 1946 | 19333 | 78742 | 80485 | 116485 | 108720 | 100954 | 93188 | 85423 | 77657 | 69891 | 62126 | 54360 | 46594 | 38828 | 31063 | 23297 | 15531 | 7766 | 0 |
| Municipal bond and loans | Debt outstanding, beginning of year | 0 | 0 | 12654 | 36002 | 75897 | 80058 | 102533 | 87085 | 68356 | 53249 | 46197 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 |
| | Increase in debt | 0 | 12654 | 23348 | 39895 | 4161 | 22474 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Principal repayment | 0 | 0 | 0 | 0 | 0 | 0 | 15448 | 18729 | 15107 | 7052 | 8922 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 |
| | Interest repayment | 0 | 841 | 2946 | 5715 | 7478 | 8527 | 8502 | 6445 | 4112 | 3196 | 2414 | 1864 | 1677 | 1491 | 1305 | 1118 | 932 | 746 | 559 | 373 | 186 |
| | Debt outstanding, end of year | 0 | 12654 | 36002 | 75897 | 80058 | 102533 | 87085 | 68356 | 53249 | 46197 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 | 0 |
| Governmental Construction Subsidy | | 3603 | 6851 | 13381 | 10150 | 2965 | 4633 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Municipal Construction Subsidy | | 6893 | 3385 | 13156 | 9980 | 2915 | 4555 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Construction Subsidies | | 10496 | 10236 | 26537 | 20130 | 5880 | 9189 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## Table 14-11 Funds Flow Program (Case 1)

Unit: Million Won

| Item / Year | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Expenditure** | | | | | | | | | | | | | | | | | | | | |
| Personnel expenses | 2527 | 2527 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 |
| Other expenses in total | 1807 | 1807 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 |
| Administrative | 440 | 440 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 |
| Electricity | 710 | 710 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 |
| Repairs and maintenance | 656 | 656 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 |
| Capital investment | 10041 | 31663 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Interest repayment | 7478 | 8527 | 8502 | 6445 | 4112 | 3196 | 2414 | 1864 | 1677 | 1491 | 1305 | 1118 | 932 | 746 | 559 | 373 | 186 | 0 | 0 | 0 |
| Repayment of bonds and loans | 0 | 0 | 15448 | 18729 | 15107 | 7052 | 8922 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 0 | 0 | 0 |
| Total | 21853 | 44524 | 30464 | 31688 | 26033 | 16762 | 17850 | 12105 | 11919 | 11732 | 11546 | 11360 | 11173 | 10987 | 10801 | 10614 | 10428 | 6514 | 6514 | 6514 |
| **Revenue** | | | | | | | | | | | | | | | | | | | | |
| Fare revenue in total | 6217 | 7972 | 9477 | 9699 | 9920 | 10141 | 10362 | 10583 | 10805 | 11026 | 11247 | 11468 | 11768 | 11768 | 11768 | 11768 | 11768 | 11768 | 11768 | 11768 |
| Ordinary passengers | 5592 | 7171 | 8525 | 8724 | 8923 | 9122 | 9321 | 9520 | 9719 | 9918 | 10117 | 10316 | 10586 | 10586 | 10586 | 10586 | 10586 | 10586 | 10586 | 10586 |
| Commuters | 296 | 379 | 451 | 461 | 472 | 482 | 493 | 503 | 514 | 524 | 535 | 545 | 559 | 559 | 559 | 559 | 559 | 559 | 559 | 559 |
| Students | 329 | 422 | 502 | 513 | 525 | 537 | 549 | 560 | 572 | 584 | 595 | 607 | 623 | 623 | 623 | 623 | 623 | 623 | 623 | 623 |
| Misc. income | 187 | 239 | 284 | 291 | 298 | 301 | 311 | 318 | 324 | 331 | 337 | 344 | 353 | 353 | 353 | 353 | 353 | 353 | 353 | 353 |
| Interest received | 58 | 74 | 88 | 90 | 92 | 94 | 96 | 98 | 100 | 102 | 104 | 106 | 109 | 109 | 109 | 109 | 109 | 109 | 109 | 109 |
| Construction subsidies | 5880 | 9189 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bonds and loans | 4161 | 22474 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Proceeds from fund carried forward | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 16502 | 39948 | 9850 | 10079 | 10309 | 10539 | 10769 | 10999 | 11229 | 11459 | 11689 | 11919 | 12230 | 12230 | 12230 | 12230 | 12230 | 12230 | 12230 | 12230 |
| Balance | -5350 | -4576 | -20614 | -21609 | -15724 | -6223 | -7080 | -1106 | -690 | -274 | 143 | 559 | 1057 | 1243 | 1430 | 1616 | 1802 | 5716 | 5716 | 5716 |
| Operation subsidies or repayment | 5350 | 4576 | 20614 | 21609 | 15724 | 6223 | 7080 | 1106 | 690 | 274 | -143 | -559 | -1057 | -1243 | -1430 | -1616 | -1802 | -5716 | -5716 | -5716 |
| Total subsidies | 14855 | 19431 | 40045 | 61654 | 77377 | 83600 | 90680 | 91787 | 92476 | 92750 | 92607 | 92048 | 90992 | 89749 | 88319 | 86703 | 84901 | 79185 | 73469 | 67752 |
| Bonds and loans outstanding | 80058 | 102533 | 87085 | 68356 | 53249 | 46197 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 | 0 | 0 | 0 | 0 |
| Surplus brought forward | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Accumulated surplus brought forward | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## Table 14-12 Estimated Revenue and Expenditure (Case 1)

Unit: Million Won

| | Item \ Year | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Revenue | Fare revenue in total | 6217 | 7972 | 9477 | 9699 | 9920 | 10141 | 10362 | 10583 | 10805 | 11026 | 11247 | 11468 | 11768 | 11768 | 11768 | 11768 | 11768 | 11768 | 11768 | 11768 |
| | Ordinary passengers | 5592 | 7171 | 8525 | 8724 | 8923 | 9122 | 9321 | 9520 | 9719 | 9918 | 10117 | 10316 | 10586 | 10586 | 10586 | 10586 | 10586 | 10586 | 10586 | 10586 |
| | Commuters | 296 | 379 | 451 | 461 | 472 | 482 | 493 | 503 | 514 | 524 | 535 | 545 | 559 | 559 | 559 | 559 | 559 | 559 | 559 | 559 |
| | Students | 329 | 422 | 502 | 513 | 525 | 537 | 549 | 560 | 572 | 584 | 595 | 607 | 623 | 623 | 623 | 623 | 623 | 623 | 623 | 623 |
| | Misc. income | 187 | 239 | 284 | 291 | 298 | 304 | 311 | 318 | 324 | 331 | 337 | 344 | 353 | 353 | 353 | 353 | 353 | 353 | 353 | 353 |
| | Interest received | 58 | 74 | 88 | 90 | 92 | 94 | 96 | 98 | 100 | 102 | 104 | 106 | 109 | 109 | 109 | 109 | 109 | 109 | 109 | 109 |
| | Proceeds from fund carried forward | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Total | 6461 | 8285 | 9850 | 10079 | 10309 | 10539 | 10769 | 10993 | 11229 | 11459 | 11689 | 11919 | 12230 | 12230 | 12230 | 12230 | 12230 | 12230 | 12230 | 12230 |
| Expenditure | Personnel expenses | 2527 | 2527 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 |
| | Other expenses in total | 1807 | 1807 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 |
| | Administrative | 440 | 440 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 |
| | Electricity | 710 | 710 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 |
| | Repairs and maintenance | 656 | 656 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 |
| | Depreciation | 4361 | 4361 | 6707 | 6707 | 6707 | 6205 | 6205 | 5836 | 5836 | 5836 | 5836 | 5836 | 5582 | 5582 | 5481 | 3558 | 3558 | 2281 | 2281 | 2281 |
| | Interest expense | 6485 | 6485 | 8502 | 6445 | 4412 | 3196 | 2414 | 1864 | 1677 | 1491 | 1305 | 1118 | 932 | 746 | 559 | 373 | 186 | 0 | 0 | 0 |
| | Total | 15180 | 15180 | 21723 | 19666 | 17633 | 15916 | 15133 | 14213 | 14027 | 13841 | 13654 | 13468 | 13028 | 12842 | 12554 | 10445 | 10258 | 8795 | 8795 | 8795 |
| | Profit before depreciation | -4358 | -2534 | -5166 | -2880 | -617 | 829 | 1841 | 2621 | 3038 | 3454 | 3870 | 4286 | 4784 | 4971 | 5157 | 5343 | 5530 | 5716 | 5716 | 5716 |
| | Profit after depreciation | -8719 | -6895 | -11874 | -9587 | -7324 | -5377 | -4364 | -3214 | -2798 | -2382 | -1965 | -1549 | -798 | -612 | -324 | 1785 | 1972 | 3435 | 3435 | 3435 |
| | Profit brought forward | -8719 | -15613 | -27487 | -37074 | -44398 | -49774 | -54138 | -57352 | -60150 | -62532 | -64498 | -66047 | -66845 | -67456 | -67781 | -65995 | -64024 | -60589 | -57154 | -53719 |

## Table 14-13 Repayment Plan (Case 2)

Unit: Million Won

| Item | Year | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1996 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Municipal bond | Bonds outstanding, beginning of year | 0 | 0 | 11720 | 26722 | 38101 | 41425 | 46620 | 34900 | 19898 | 8518 | 5194 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Bonds issued | 0 | 11720 | 15002 | 11379 | 3324 | 5194 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Principal repayment | 0 | 0 | 0 | 0 | 0 | 0 | 11720 | 15002 | 11379 | 3324 | 5194 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Interest repayment | 0 | 820 | 2691 | 4538 | 5567 | 6163 | 5706 | 3836 | 1989 | 960 | 364 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Bonds outstanding, end of year | 0 | 11720 | 26722 | 38101 | 41425 | 46620 | 34900 | 19898 | 8518 | 5194 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Loans | Loans outstanding, beginning of year | 0 | 0 | 934 | 9280 | 37796 | 38633 | 55913 | 52185 | 48458 | 44730 | 41003 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 |
| | Loans disbursed | 0 | 934 | 8346 | 28516 | 837 | 17280 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Principal repayment | 0 | 0 | 0 | 0 | 0 | 0 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 |
| | Interest repayment | 0 | 23 | 255 | 1177 | 1911 | 2364 | 2796 | 2609 | 2423 | 2237 | 2050 | 1864 | 1677 | 1491 | 1305 | 1118 | 932 | 746 | 559 | 373 | 186 |
| | Loan outstanding end of year | 0 | 934 | 9280 | 37796 | 38633 | 55913 | 52185 | 48458 | 44730 | 41003 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 | 0 |
| Loans (US$1000) | Loan, beginning of year | 0 | 0 | 1946 | 19333 | 78742 | 80485 | 116485 | 108720 | 100954 | 93188 | 85423 | 77657 | 69891 | 62126 | 54360 | 46594 | 38828 | 31063 | 23297 | 15531 | 7766 |
| | Loan disbursed | 0 | 1946 | 17387 | 59408 | 1744 | 36000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Principal repayment | 0 | 0 | 0 | 0 | 0 | 0 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 |
| | Interest repayment | 0 | 49 | 532 | 2452 | 3981 | 4924 | 5824 | 5436 | 5048 | 4659 | 4271 | 3883 | 3495 | 3106 | 2718 | 2330 | 1941 | 1553 | 1165 | 777 | 388 |
| | Loan, end of year | 0 | 1946 | 19333 | 78742 | 80485 | 116485 | 108720 | 100954 | 93188 | 85423 | 77657 | 69891 | 62126 | 54360 | 46594 | 38828 | 31063 | 23297 | 15531 | 7765 | 0 |
| Municipal bond and loans | Debt outstanding, beginning of year | 0 | 0 | 12654 | 36002 | 75897 | 80058 | 102533 | 87085 | 68356 | 53249 | 46197 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 |
| | Increase in debt | 0 | 12654 | 23348 | 39895 | 4161 | 22474 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Principal repayment | 0 | 0 | 0 | 0 | 0 | 0 | 15448 | 18729 | 15107 | 7052 | 8922 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 |
| | Interest repayment | 0 | 844 | 2946 | 5715 | 7478 | 8527 | 8502 | 6445 | 4412 | 3196 | 2414 | 1864 | 1677 | 1491 | 1305 | 1118 | 932 | 746 | 559 | 373 | 186 |
| | Debt outstanding, end of year | 0 | 12654 | 36002 | 75897 | 80058 | 102533 | 87085 | 68356 | 53249 | 46197 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 | 0 |
| Governmental Construction Subsidy | | 3603 | 6851 | 13381 | 10150 | 2965 | 4633 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Municipal Construction Subsidy | | 6893 | 3385 | 13156 | 9980 | 2915 | 4555 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Construction Subsidies | | 10496 | 10236 | 26537 | 20130 | 5880 | 9189 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 14-14 Funds Flow Program (Case 2)

Unit: Million Won

| | Item / Year | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Expenditure | *Personnel expenses* | 2527 | 2527 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 |
| | Other expenses in total | 1807 | 1807 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 |
| | Administrative | 440 | 440 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 |
| | Electricity | 710 | 710 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 |
| | Repair and maintenance | 656 | 656 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 |
| | Capital investment | 10041 | 31663 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Interest repayment | 7478 | 8527 | 8502 | 6445 | 4412 | 3196 | 2414 | 1864 | 1677 | 1491 |
| | Repayment of bonds and loans | 0 | 0 | 15448 | 18729 | 15107 | 7052 | 8922 | 3728 | 3728 | 3728 |
| | Total | 21853 | 44524 | 30464 | 31688 | 26033 | 16762 | 17850 | 12105 | 11919 | 11732 |
| Revenue | Fare revenue in total | 9009 | 11552 | 13652 | 13971 | 14290 | 14608 | 14927 | 15246 | 15564 | 15883 |
| | Ordinary passengers | 8104 | 10391 | 12281 | 12567 | 12854 | 13140 | 13427 | 13714 | 14000 | 14287 |
| | Commuters | 428 | 549 | 649 | 664 | 679 | 694 | 710 | 725 | 740 | 755 |
| | Students | 477 | 612 | 723 | 740 | 757 | 773 | 790 | 807 | 824 | 841 |
| | Misc. income | 270 | 347 | 410 | 419 | 429 | 438 | 448 | 457 | 467 | 476 |
| | Interest received | 84 | 107 | 127 | 130 | 132 | 135 | 138 | 141 | 144 | 147 |
| | Construction subsidies | 5880 | 9189 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Bonds and loans | 4161 | 22474 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | *Proceeds from fund carried forward* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Total | 19404 | 43668 | 14188 | 14520 | 14851 | 15182 | 15513 | 15844 | 16175 | 16507 |
| Balance | | -2449 | -856 | -16275 | -17169 | -11182 | -1580 | -2337 | 3739 | 4257 | 4774 |
| *Operation subsidies or repayment* | | 2449 | 856 | 16275 | 17169 | 11182 | 1580 | 2337 | -3739 | -4257 | -4774 |
| Total subsidies | | 11954 | 12809 | 29084 | 46253 | 57435 | 59015 | 61352 | 57613 | 53356 | 48582 |
| Bonds and loans outstanding | | 80058 | 102533 | 87085 | 68356 | 53249 | 46197 | 37275 | 33548 | 29820 | 26093 |
| *Surplus brought forward* | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Accumulated surplus brought forward | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | Item / Year | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Expenditure | *Personnel expenses* | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 |
| | Other expenses in total | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 |
| | Administrative | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 |
| | Electricity | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 |
| | Repair and maintenance | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 |
| | Capital investment | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Interest repayment | 1305 | 1118 | 932 | 746 | 559 | 373 | 186 | 0 | 0 | 0 |
| | Repayment of bonds and loans | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 0 | 0 | 0 |
| | Total | 11546 | 11360 | 11173 | 10987 | 10801 | 10614 | 10428 | 6514 | 6514 | 6514 |
| Revenue | Fare revenue in total | 16202 | 16520 | 16964 | 16964 | 16964 | 16964 | 16915 | 16915 | 16915 | 16915 |
| | Ordinary passengers | 14574 | 14860 | 15260 | 15260 | 15260 | 15260 | 15216 | 15216 | 15216 | 15216 |
| | Commuters | 770 | 785 | 806 | 806 | 806 | 806 | 804 | 804 | 804 | 804 |
| | Students | 858 | 875 | 898 | 898 | 898 | 898 | 896 | 896 | 896 | 896 |
| | Misc. income | 486 | 496 | 509 | 509 | 509 | 509 | 507 | 507 | 507 | 507 |
| | Interest received | 150 | 153 | 157 | 157 | 157 | 157 | 157 | 157 | 157 | 157 |
| | Construction subsidies | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Bonds and loans | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | *Proceeds from fund carried forward* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 138 | 340 |
| | Total | 16838 | 17169 | 17630 | 17630 | 17630 | 17630 | 17580 | 17580 | 17716 | 17920 |
| Balance | | 5292 | 5809 | 6457 | 6644 | 6830 | 7016 | 7152 | 11066 | 11204 | 11406 |
| *Operation subsidies or repayment* | | -5292 | -5809 | -6457 | -6644 | -6830 | -7016 | -7152 | -3382 | 0 | 0 |
| Total subsidies | | 43290 | 37481 | 31024 | 24380 | 17550 | 10534 | 3382 | 0 | 0 | 0 |
| Bonds and loans outstanding | | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 | 0 | 0 | 0 | 0 |
| *Surplus brought forward* | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7683 | 11204 | 11406 |
| Accumulated surplus brought forward | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7683 | 18887 | 30293 |

## Table 14-15 Estimated Revenue and Expenditure (Case 2)

Unit: Million Won

| | Item \ Year | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Revenue | Fare revenue in total | 9009 | 11552 | 13652 | 13971 | 14290 | 14608 | 14927 | 15246 | 15564 | 15883 | 16202 | 16520 | 16964 | 16964 | 16964 | 16964 | 16915 | 16915 | 16915 | 16915 |
| | Ordinary passengers | 8104 | 10391 | 12281 | 12567 | 12854 | 13140 | 13427 | 13714 | 14000 | 14287 | 14574 | 14860 | 15260 | 15260 | 15260 | 15260 | 15216 | 15216 | 15216 | 15216 |
| | Commuters | 428 | 549 | 649 | 664 | 679 | 694 | 710 | 725 | 740 | 755 | 770 | 785 | 806 | 806 | 806 | 806 | 804 | 804 | 804 | 804 |
| | Students | 477 | 612 | 723 | 740 | 757 | 773 | 790 | 807 | 824 | 841 | 858 | 875 | 898 | 898 | 898 | 898 | 896 | 896 | 896 | 896 |
| | Misc. income | 270 | 347 | 410 | 419 | 428 | 438 | 448 | 457 | 467 | 476 | 486 | 496 | 509 | 509 | 509 | 509 | 507 | 507 | 507 | 507 |
| | Interest received | 84 | 107 | 127 | 130 | 132 | 135 | 138 | 141 | 144 | 147 | 150 | 153 | 157 | 157 | 157 | 157 | 157 | 157 | 157 | 157 |
| | Proceeds from fund carried forward | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 138 | 340 |
| | Total | 9363 | 12005 | 14188 | 14520 | 14851 | 15182 | 15513 | 15844 | 16175 | 16507 | 16838 | 17169 | 17766 | 17907 | 18053 | 18204 | 18309 | 18469 | 18673 | 18880 |
| Expenditure | Personnel expenses | 2527 | 2527 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 |
| | Other expenses in total | 1807 | 1807 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 |
| | Administrative | 440 | 440 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 |
| | Electricity | 710 | 710 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 |
| | Repairs and maintenance | 656 | 656 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 |
| | Depreciation | 4361 | 4361 | 6707 | 6707 | 6707 | 6205 | 6205 | 5836 | 5836 | 5836 | 5836 | 5836 | 5582 | 5582 | 5481 | 3558 | 3558 | 2281 | 2281 | 2281 |
| | Interest expense | 6485 | 6485 | 6502 | 6445 | 4412 | 2196 | 2414 | 1864 | 1677 | 1491 | 1305 | 1118 | 932 | 746 | 559 | 373 | 186 | 0 | 0 | 0 |
| | Total | 15180 | 15180 | 21723 | 19666 | 17633 | 15916 | 15133 | 14213 | 14027 | 13841 | 13654 | 13468 | 13028 | 12842 | 12554 | 10445 | 10258 | 8795 | 8795 | 8795 |
| | Profit before depreciation | -1457 | 1186 | -828 | 1561 | 3925 | 5472 | 6585 | 7467 | 7984 | 8502 | 9019 | 9537 | 10320 | 10648 | 10980 | 11318 | 11609 | 11955 | 12159 | 12366 |
| | Profit after depreciation | -5817 | -3175 | -7535 | -5147 | -2782 | -734 | 380 | 1631 | 2148 | 2666 | 3184 | 3701 | 4738 | 5066 | 5499 | 7760 | 8051 | 9674 | 9877 | 10085 |
| | Profit brought forward | -5817 | -2992 | -16526 | -21673 | -24455 | -25189 | -24809 | -23179 | -21030 | -18364 | -15181 | -11480 | -6742 | -1676 | 3823 | 11582 | 19633 | 29306 | 39184 | 49269 |

## Table 14-16 Repayment Plan (Case 3)

Unit: Million Won

| Item | Year | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Municipal bond | Bonds outstanding, beginning of year | 0 | 0 | 11720 | 26722 | 38101 | 41425 | 46620 | 34900 | 19898 | 8518 | 5194 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Bonds issued | 0 | 11720 | 15002 | 11379 | 3324 | 5194 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Principal repayment | 0 | 0 | 0 | 0 | 0 | 0 | 11720 | 15002 | 11379 | 3324 | 5194 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Interest repayment | 0 | 820 | 2691 | 4538 | 5567 | 6163 | 5706 | 3836 | 1989 | 960 | 364 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Bonds outstanding, end of year | 0 | 11720 | 26722 | 38101 | 41425 | 46620 | 34900 | 19898 | 8518 | 5194 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Loans | Loans outstanding, beginning of year | 0 | 0 | 934 | 9280 | 37796 | 38633 | 55913 | 52185 | 48458 | 44730 | 41003 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 |
| | Loans disbursed | 0 | 934 | 8346 | 28516 | 837 | 17280 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Principal repayment | 0 | 0 | 0 | 0 | 0 | 0 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 |
| | Interest repayment | 0 | 23 | 255 | 1177 | 1911 | 2364 | 2796 | 2609 | 2423 | 2237 | 2050 | 1864 | 1677 | 1491 | 1305 | 1118 | 932 | 746 | 559 | 373 | 186 |
| | Loan outstanding end of year | 0 | 934 | 9280 | 37796 | 38633 | 55913 | 52185 | 48458 | 44730 | 41003 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 | 0 |
| Loans (US$1000) | Loan, beginning of year | 0 | 0 | 1946 | 19333 | 78742 | 80485 | 116485 | 108720 | 100954 | 93188 | 85423 | 77657 | 69891 | 62126 | 54360 | 46594 | 38828 | 31063 | 23297 | 15531 | 7766 |
| | Loan disbursed | 0 | 1946 | 17387 | 59408 | 1744 | 36000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Principal repayment | 0 | 0 | 0 | 0 | 0 | 0 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 |
| | Interest repayment | 0 | 49 | 532 | 2452 | 3981 | 4924 | 5824 | 5436 | 5048 | 4659 | 4271 | 3883 | 3495 | 3106 | 2718 | 2330 | 1941 | 1553 | 1165 | 777 | 388 |
| | Loan, end of year | 0 | 1946 | 19333 | 78742 | 80485 | 116485 | 108720 | 100954 | 93188 | 85423 | 77657 | 69891 | 62126 | 54360 | 46594 | 38828 | 31063 | 23297 | 15531 | 7766 | 0 |
| Municipal bond | Debt outstanding, beginning of year | 0 | 0 | 12654 | 36002 | 75897 | 80058 | 102533 | 87085 | 68356 | 53249 | 46197 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 |
| | Increase in debt | 0 | 12654 | 23348 | 39895 | 4161 | 22474 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Principal repayment | 0 | 0 | 0 | 0 | 0 | 0 | 15448 | 18729 | 15107 | 7052 | 8922 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 |
| | Interest repayment | 0 | 844 | 2946 | 5715 | 7478 | 8527 | 8502 | 6445 | 4412 | 3196 | 2414 | 1864 | 1677 | 1491 | 1305 | 1118 | 932 | 746 | 559 | 373 | 186 |
| | Debt outstanding, end of year | 0 | 12654 | 36002 | 75897 | 80058 | 102533 | 87085 | 68356 | 53249 | 46197 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 | 0 |
| Governmental Construction Subsidy | | 3603 | 6851 | 13381 | 10150 | 2965 | 4633 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Municipal Construction Subsidy | | 6893 | 3385 | 13156 | 9980 | 2915 | 4555 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Construction Subsidies | | 10496 | 10236 | 26537 | 20130 | 5880 | 9189 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## Table 14-17 Funds Flow Program (Case 3)

Unit: Million Won

| | Item \ Year | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Expenditure | Personnel expenses | 2527 | 2527 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 |
| | Other expenses in total | 1807 | 1807 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 |
| | Administrative | 440 | 440 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 |
| | Electricity | 710 | 710 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 |
| | Repairs and maintenance | 656 | 656 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 |
| | Capital investment | 10041 | 31663 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Interest repayment | 7478 | 8527 | 8502 | 6445 | 4412 | 3196 | 2414 | 1864 | 1677 | 1491 | 1305 | 1118 | 932 | 746 | 559 | 373 | 186 | 0 | 0 | 0 |
| | Repayment of bonds and loans | 0 | 0 | 15448 | 18729 | 15107 | 7052 | 8922 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 0 | 0 | 0 |
| | Total | 21853 | 44524 | 30464 | 31688 | 26033 | 16762 | 17850 | 12105 | 11919 | 11732 | 11546 | 11360 | 11173 | 10987 | 10801 | 10614 | 10428 | 6514 | 6514 | 6514 |
| Revenue | Fare revenue in total | 11808 | 15141 | 17827 | 18243 | 18659 | 19075 | 19492 | 19908 | 20324 | 20740 | 21156 | 21572 | 22063 | 22063 | 22063 | 22063 | 22063 | 22063 | 22063 | 22063 |
| | Ordinary passengers | 10621 | 13619 | 16036 | 16410 | 16785 | 17159 | 17533 | 17907 | 18282 | 18656 | 19030 | 19405 | 19846 | 19846 | 19846 | 19846 | 19846 | 19846 | 19846 | 19846 |
| | Commuters | 561 | 720 | 847 | 867 | 887 | 907 | 927 | 946 | 966 | 986 | 1006 | 1025 | 1049 | 1049 | 1049 | 1049 | 1049 | 1049 | 1049 | 1049 |
| | Students | 625 | 802 | 944 | 966 | 988 | 1010 | 1032 | 1054 | 1076 | 1098 | 1120 | 1142 | 1168 | 1168 | 1168 | 1168 | 1168 | 1168 | 1168 | 1168 |
| | Misc. income | 354 | 454 | 535 | 547 | 560 | 572 | 585 | 597 | 610 | 622 | 635 | 647 | 662 | 662 | 662 | 662 | 662 | 662 | 662 | 662 |
| | Interest received | 109 | 140 | 165 | 169 | 173 | 177 | 181 | 185 | 188 | 192 | 196 | 200 | 205 | 205 | 205 | 205 | 205 | 205 | 205 | 205 |
| | Construction subsidies | 5880 | 9189 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Bonds and loans | 4161 | 22474 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Proceeds from fund carried forward | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 109 | 310 | 527 | 751 | 983 | 1223 | 1470 | 1792 | 2119 |
| | Total | 22313 | 47398 | 18527 | 18960 | 19392 | 19825 | 20257 | 20689 | 21122 | 21554 | 21987 | 22528 | 23239 | 23456 | 23681 | 23912 | 24152 | 24399 | 24721 | 25049 |
| | Balance | 460 | 2875 | -11936 | -12729 | -6641 | 3063 | 2407 | 8584 | 9203 | 9822 | 10441 | 11168 | 12066 | 12469 | 12880 | 13298 | 13724 | 17885 | 18207 | 18535 |
| | Operation subsidies or repayment | -460 | -2875 | 11936 | 12729 | 6641 | -3063 | -2407 | -8584 | -9203 | -9822 | -4397 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Total subsidies | 9045 | 6170 | 18106 | 30835 | 37476 | 34413 | 32006 | 23421 | 14218 | 4397 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Bonds and loans outstanding | 80058 | 102533 | 87085 | 68356 | 53249 | 46197 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 | 0 | 0 | 0 | 0 |
| | Surplus brought forward | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6044 | 11168 | 12066 | 12469 | 12880 | 13298 | 13724 | 17885 | 18207 | 18535 |
| | Accumulated surplus brought forward | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6044 | 17213 | 29278 | 41748 | 54628 | 67926 | 81650 | 99535 | 117742 | 136276 |

## Table 14-18 Estimated Revenue and Expenditure (Case 3)

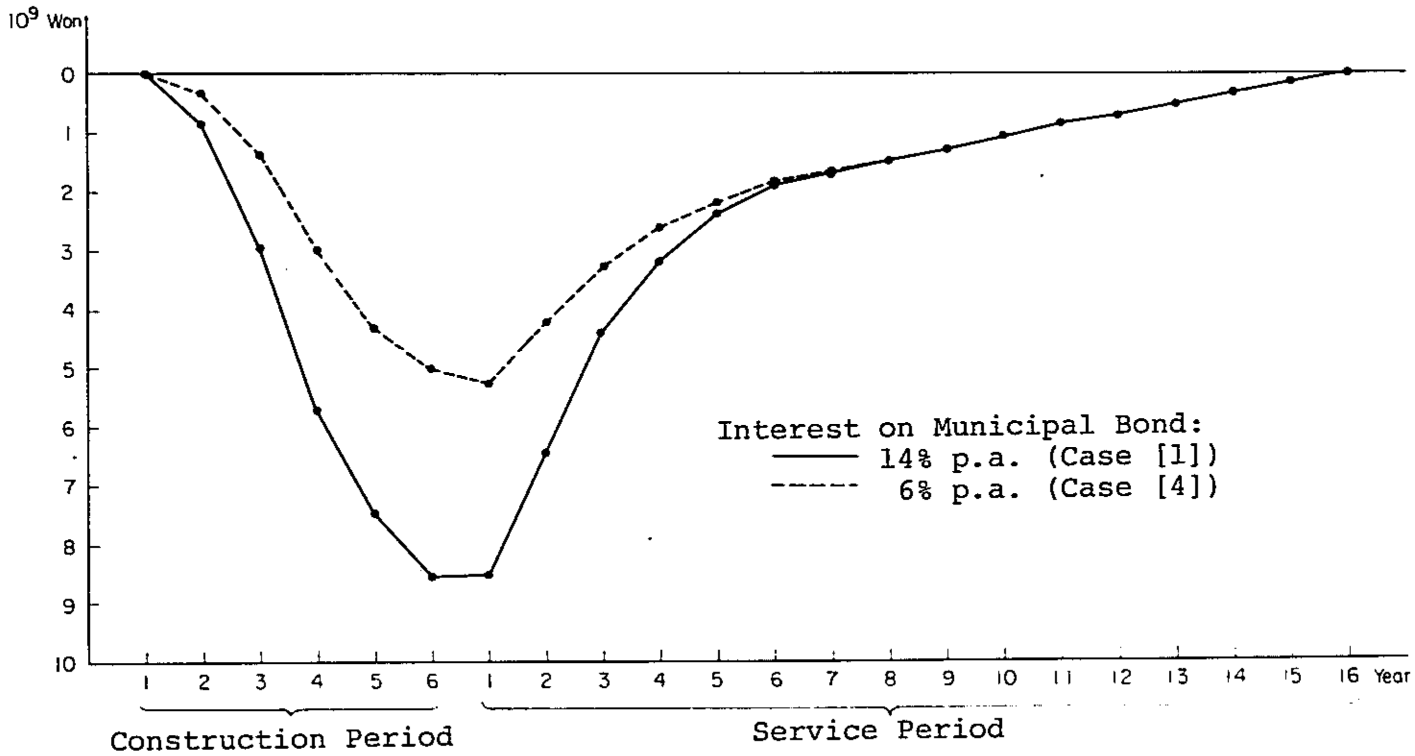
Unit: Million Won

| | Item \ Year | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Revenue | Fare revenue in total | 15141 | 17827 | 18243 | 18659 | 19075 | 19492 | 19908 | 20324 | 20740 | 21156 | 21572 | 22063 | 22063 | 22063 | 22063 | 22063 | 22063 | 22063 | 22063 |
| | Ordinary passengers | 13619 | 16036 | 16410 | 16785 | 17159 | 17533 | 17907 | 18282 | 18656 | 19030 | 19405 | 19846 | 19846 | 19846 | 19846 | 19846 | 19846 | 19846 | 19846 |
| | Commuters | 720 | 847 | 867 | 887 | 907 | 927 | 946 | 966 | 986 | 1006 | 1025 | 1049 | 1049 | 1049 | 1049 | 1049 | 1049 | 1049 | 1049 |
| | Students | 802 | 941 | 966 | 988 | 1010 | 1032 | 1054 | 1076 | 1098 | 1120 | 1142 | 1168 | 1168 | 1168 | 1168 | 1168 | 1168 | 1168 | 1168 |
| | Misc. income | 454 | 535 | 547 | 560 | 572 | 585 | 597 | 610 | 622 | 635 | 647 | 662 | 662 | 662 | 662 | 662 | 662 | 662 | 662 |
| | Interest received | 140 | 165 | 169 | 173 | 177 | 181 | 185 | 188 | 192 | 196 | 200 | 205 | 205 | 205 | 205 | 205 | 205 | 205 | 205 |
| | Proceeds from fund carried forward | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 109 | 310 | 527 | 751 | 983 | 1223 | 1470 | 1792 | 2119 |
| | Total | 15735 | 18527 | 18960 | 19392 | 19825 | 20257 | 20689 | 21296 | 21924 | 22564 | 23217 | 23959 | 24198 | 24443 | 24694 | 24952 | 25216 | 25526 | 25841 |
| Expenditure | Personnel expenses | 2527 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 |
| | Other expenses in total | 1807 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 |
| | Administrative | 440 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 |
| | Electricity | 710 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 |
| | Repairs and maintenance | 656 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 |
| | Depreciation | 4361 | 6707 | 6707 | 6707 | 6205 | 6205 | 5836 | 5836 | 5836 | 5836 | 5836 | 5582 | 5582 | 5481 | 3558 | 3558 | 2281 | 2281 | 2281 |
| | Interest expense | 6485 | 8502 | 6445 | 4412 | 3196 | 2414 | 1864 | 1677 | 1491 | 1305 | 1118 | 932 | 746 | 559 | 373 | 186 | 0 | 0 | 0 |
| | Total | 15180 | 21723 | 19666 | 17633 | 15916 | 15133 | 14213 | 14027 | 13841 | 13654 | 13468 | 13028 | 12842 | 12554 | 10445 | 10258 | 8795 | 8795 | 8795 |
| | Profit before depreciation | 4916 | 3511 | 6001 | 8466 | 10114 | 11329 | 12312 | 13105 | 13919 | 14746 | 15585 | 16513 | 16938 | 17370 | 17807 | 18251 | 18702 | 19012 | 19327 |
| | Profit after depreciation | 556 | -3196 | -707 | 1759 | 3909 | 5124 | 6476 | 7269 | 8084 | 8910 | 9749 | 10931 | 11356 | 11888 | 14249 | 14693 | 16421 | 16730 | 17046 |
| | Profit brought forward | -2352 | -5548 | -6255 | -4496 | -587 | 4537 | 11013 | 18282 | 26366 | 35276 | 45025 | 55956 | 67312 | 79201 | 93450 | 108143 | 124564 | 141294 | 158340 |

Effect on Interest Rate of Municipal Bond

(1) Repayment Plan

Fig. 14-5 Trend in Interest Repayment



(2) Funds Flow Program

Fig. 14-6 Trend in Yearly Balance of Funds

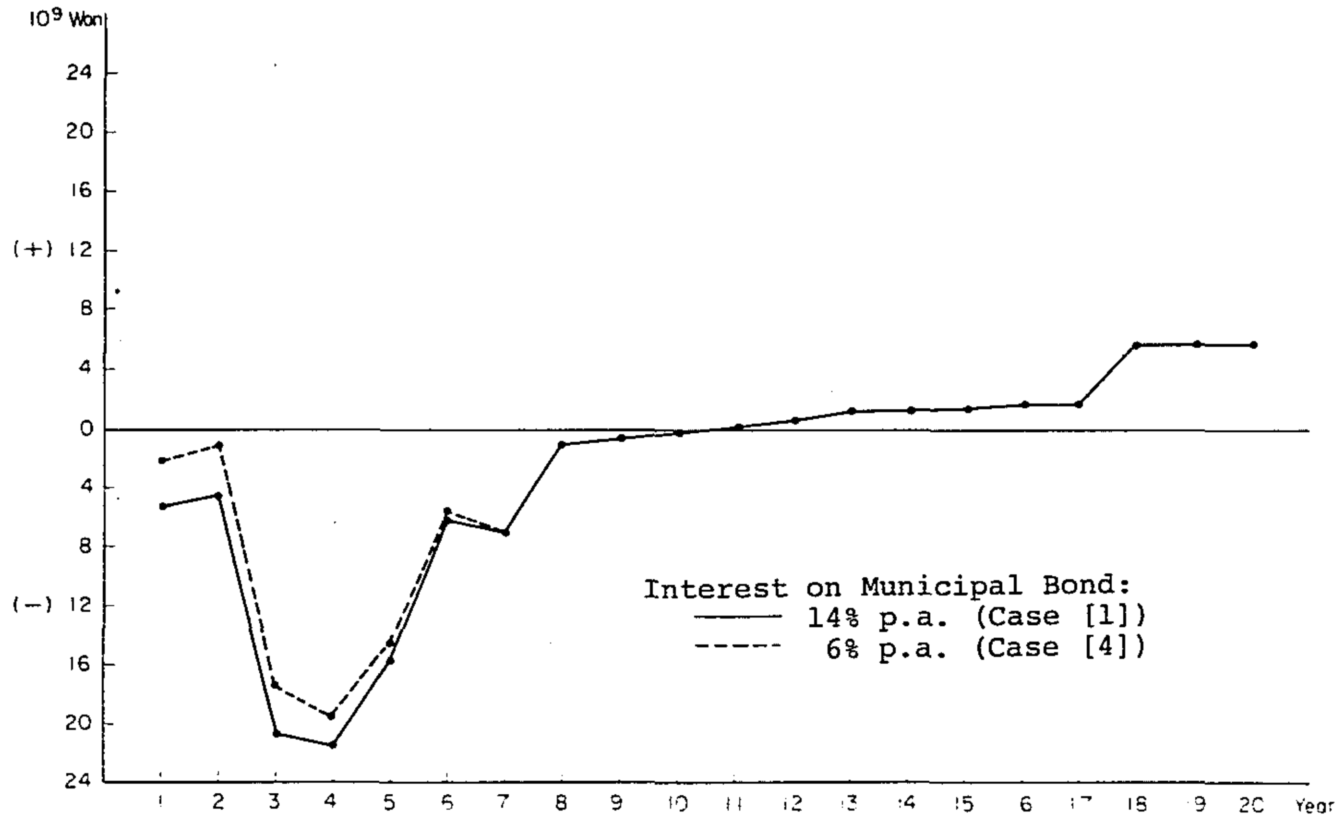
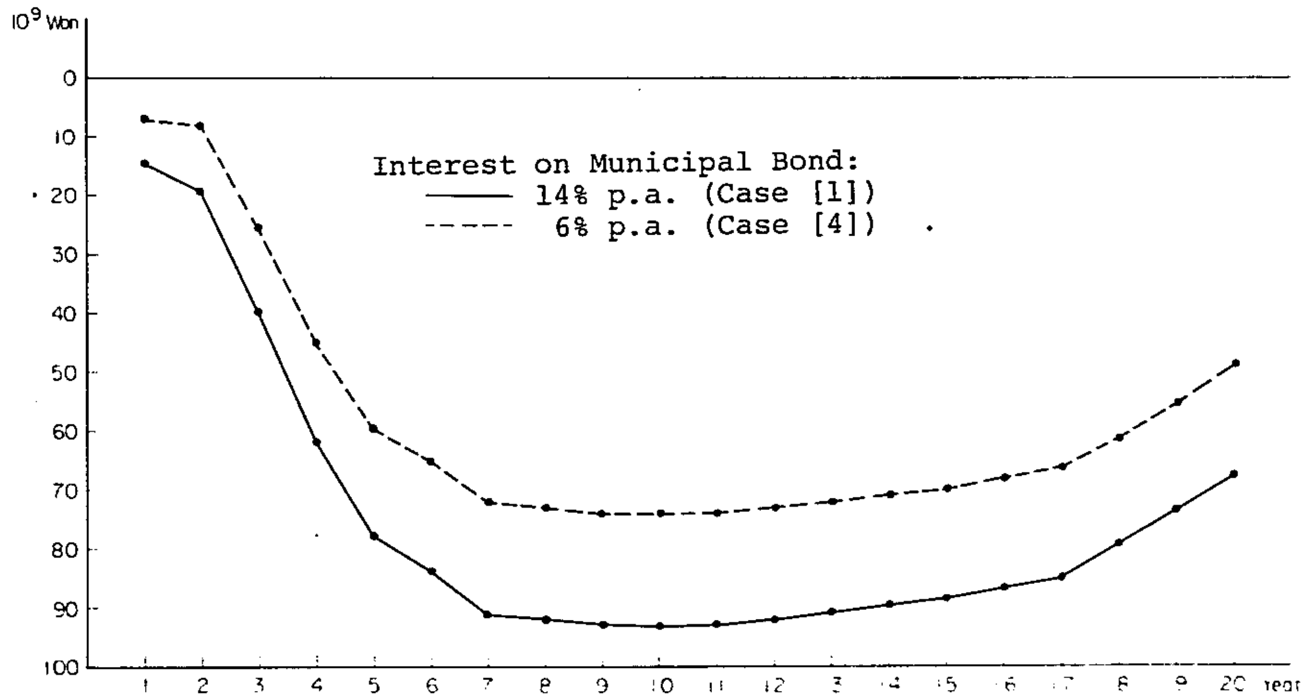


Fig. 14-7 Trend in Cumulative Balance of Operation Subsidy



(3) Estimated Revenue and Expondituere

Fig. 14-8 Trend in Yearly Profit after Depreciation

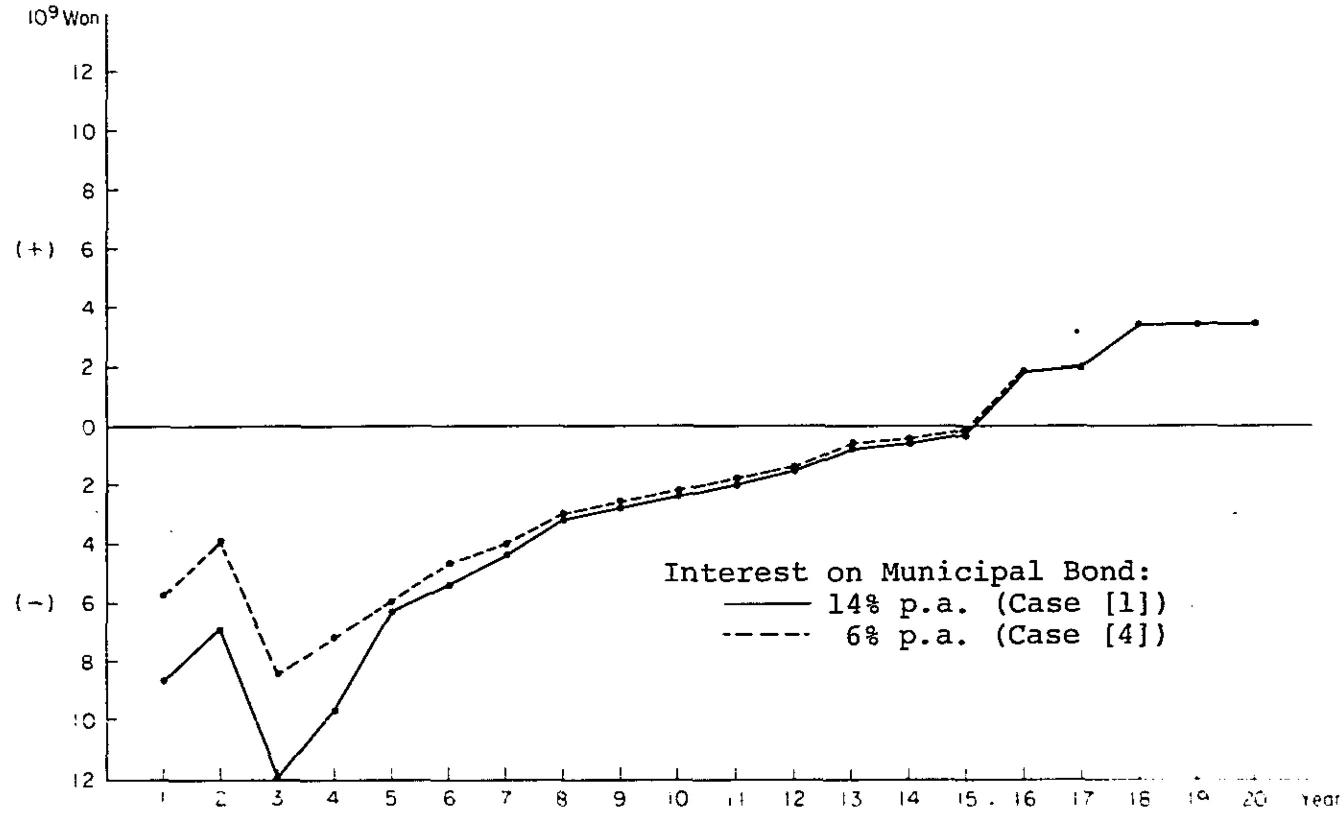
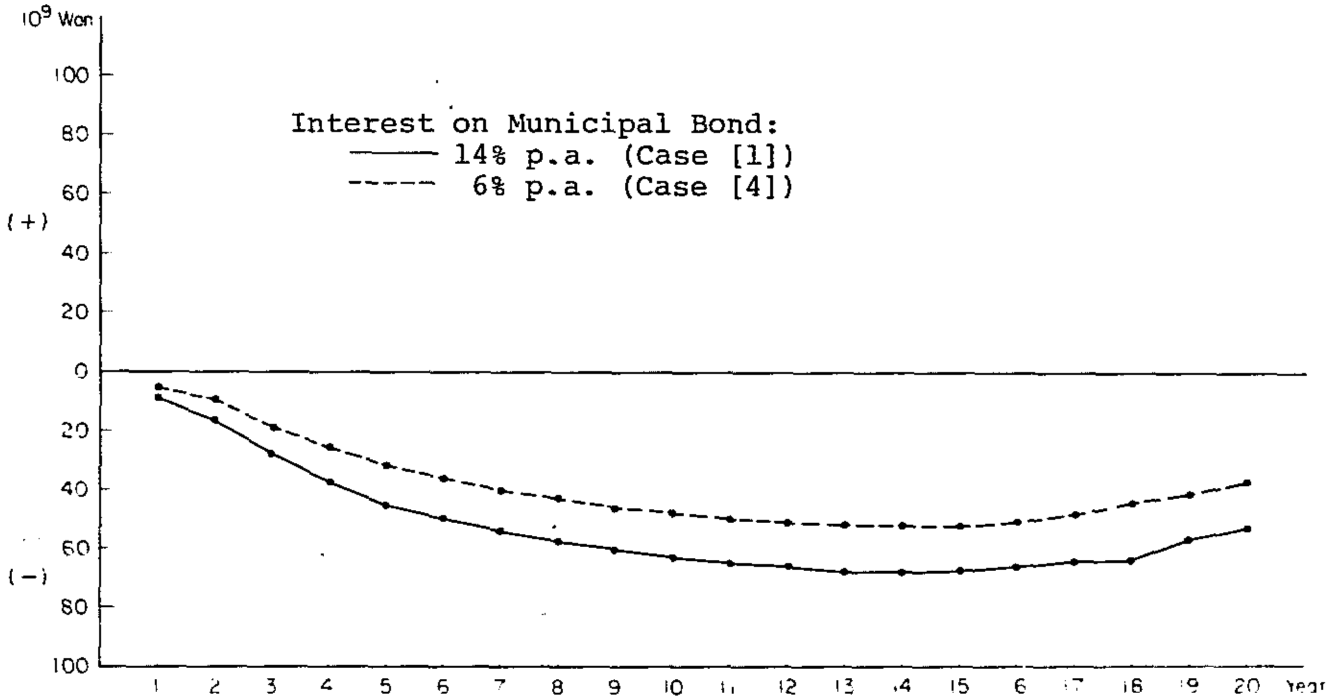


Fig. 14-9 Trend in Accumulated Profit



revise the minimum fare upward from time to time in order to improve the proposed line financially as early as possible.

The repayment plan, funds flow program, and estimated revenue and expenditure for Case 4 are presented in Tables 14-19 through -21.

14.2.1.5 Effects of Subsidies

Assumed Cases:

Proportion of Construction Subsidies

Case 1: About 45% of the total construction cost or about 82.5 billion Won

Case 5: About 60% of the total construction cost or about 110.6 billion Won

(1) The year-end total operation subsidy outstanding will reach the peak level in the last year of the construction period in both Cases 1 and 5, and will differ by about 28 billion Won from Case 1 to Case 5.

The principal repayment starting in the first year of service will differ by about 8.5 billion Won from Case 1 to Case 5 when the principal payments reaches the peak level. (See Fig. 14-10)

The interest payments will be at the peak level in the first year of service and will differ by about 3.5 billion Won from Case 1 to Case 5. (See Fig. 14-11)

(2) On a yearly basis the line will go into the black in terms of the funds flow programs in the eleventh year of service in both Cases 1 and 5, but the deficits covered till the ninth year of service will differ from Case 1 to Case 5. The difference in deficit which will be covered with operation subsidy will reach the peak level of about 11.4 billion Won in the fourth year of service. (See Fig. 14-12)

# Table 14-19 Repayment Plan (Case 4)

Unit: Million Won

| Item | Year | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Municipal bond | Bonds outstanding, beginning of year | 0 | 0 | 11720 | 26722 | 38101 | 41425 | 46620 | 34900 | 19898 | 8518 | 5194 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Bonds issued | 0 | 11720 | 15002 | 11379 | 3324 | 5194 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Principal repayment | 0 | 0 | 0 | 0 | 0 | 0 | 11720 | 15002 | 11379 | 3324 | 5194 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Interest repayment | 0 | 352 | 1153 | 1945 | 2386 | 2641 | 2446 | 1644 | 852 | 411 | 156 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Bonds outstanding, end of year | 0 | 11720 | 26722 | 38101 | 41425 | 46620 | 34900 | 19898 | 8518 | 5194 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Loans | Loans outstanding, beginning of year | 0 | 0 | 934 | 9280 | 37796 | 38633 | 55913 | 52185 | 48458 | 44730 | 41003 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 |
| | Loan disbursed | 0 | 934 | 8346 | 28516 | 837 | 17280 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Principal repayment | 0 | 0 | 0 | 0 | 0 | 0 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 |
| | Interest repayment | 0 | 23 | 255 | 1177 | 1911 | 2364 | 2796 | 2609 | 2423 | 2237 | 2050 | 1864 | 1677 | 1491 | 1305 | 1118 | 932 | 746 | 559 | 373 | 186 |
| | Loan outstanding end of year | 0 | 934 | 9280 | 37796 | 38633 | 55913 | 52185 | 48458 | 44730 | 41003 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 | 0 |
| Loans (US$100) | Loan, beginning of year | 0 | 0 | 1946 | 19333 | 78742 | 80485 | 116485 | 108720 | 100954 | 93188 | 85423 | 77657 | 69891 | 62126 | 54360 | 46594 | 38828 | 31063 | 23297 | 15531 | 7766 |
| | Loan disbursed | 0 | 1946 | 17387 | 59408 | 1744 | 36000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Principal repayment | 0 | 0 | 0 | 0 | 0 | 0 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 |
| | Interest repayment | 0 | 49 | 532 | 2452 | 3981 | 4924 | 5824 | 5436 | 5048 | 4659 | 4271 | 3883 | 3495 | 3106 | 2718 | 2330 | 1941 | 1553 | 1165 | 777 | 388 |
| | Loan, end of year | 0 | 1946 | 19333 | 78742 | 80485 | 116485 | 108720 | 100954 | 93188 | 85423 | 77657 | 69891 | 62126 | 54360 | 46594 | 38828 | 31063 | 23297 | 15531 | 7766 | 0 |
| Municipal bond and loans | Debt outstanding, beginning of year | 0 | 0 | 12654 | 36002 | 75897 | 80058 | 102533 | 87085 | 68356 | 53249 | 46197 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 |
| | Increase in debt | 0 | 12654 | 23348 | 39895 | 4161 | 22474 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Principal repayment | 0 | 0 | 0 | 0 | 0 | 0 | 15448 | 18729 | 15107 | 7052 | 8922 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 |
| | Interest repayment | 0 | 375 | 1409 | 3122 | 4297 | 5005 | 5241 | 4253 | 3275 | 2648 | 2206 | 1864 | 1677 | 1491 | 1305 | 1118 | 932 | 746 | 559 | 373 | 186 |
| | Debt outstanding, end of year | 0 | 12654 | 36002 | 75897 | 80058 | 102533 | 87085 | 68356 | 53249 | 46197 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 | 0 |
| Governmental Construction Subsidy | | 3603 | 6851 | 13381 | 10150 | 2965 | 4633 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Municipal Construction Subsidy | | 6893 | 3385 | 13156 | 9980 | 2915 | 4555 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Construction Subsidies | | 10496 | 10236 | 26537 | 20130 | 5880 | 9189 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## Table 14-20 Funds Flow Program (Case 4)

Unit: Million Won

| | Item \ Year | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Expenditure | Personnel expenses | 2527 | 2527 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 |
| | Other expenses in total | 1807 | 1807 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 |
| | Administrative | 440 | 440 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 |
| | Electricity | 710 | 710 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 |
| | Repairs and maintenance | 656 | 656 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 |
| | Capital investment | 10041 | 31663 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Interest repayment | 4297 | 5005 | 5241 | 4253 | 3275 | 2648 | 2206 | 1864 | 1677 | 1491 | 1305 | 1118 | 932 | 746 | 559 | 373 | 186 | 0 | 0 | 0 |
| | Repayment of bonds and loans | 0 | 0 | 15448 | 18729 | 15107 | 7052 | 8922 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 0 | 0 | 0 |
| | Total | 18672 | 41002 | 27203 | 29496 | 24896 | 16213 | 17642 | 12105 | 11919 | 11732 | 11546 | 11360 | 11173 | 10987 | 10801 | 10614 | 10428 | 6514 | 6514 | 6514 |
| Revenue | Fare revenue in total | 6217 | 7972 | 9477 | 9699 | 9920 | 10141 | 10362 | 10583 | 10805 | 11026 | 11247 | 11468 | 11768 | 11768 | 11768 | 11768 | 11768 | 11768 | 11768 | 11768 |
| | Ordinary passengers | 5592 | 7171 | 8525 | 8724 | 8923 | 9122 | 9321 | 9520 | 9719 | 9918 | 10117 | 10316 | 10586 | 10586 | 10586 | 10586 | 10586 | 10586 | 10586 | 10586 |
| | Commuters | 296 | 379 | 451 | 461 | 472 | 482 | 493 | 503 | 514 | 524 | 535 | 545 | 559 | 559 | 559 | 559 | 559 | 559 | 559 | 559 |
| | Students | 329 | 422 | 502 | 513 | 525 | 537 | 549 | 560 | 572 | 584 | 595 | 607 | 623 | 623 | 623 | 623 | 623 | 623 | 623 | 623 |
| | Misc. income | 187 | 239 | 284 | 291 | 298 | 304 | 311 | 318 | 324 | 331 | 337 | 344 | 353 | 353 | 353 | 353 | 353 | 353 | 353 | 353 |
| | Interest received | 58 | 74 | 88 | 90 | 92 | 94 | 96 | 98 | 100 | 102 | 104 | 106 | 109 | 109 | 109 | 109 | 109 | 109 | 109 | 109 |
| | Construction subsidies | 5880 | 9189 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Bonds and loans | 4161 | 22474 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Proceeds from fund carried forward | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Total | 16502 | 39948 | 9850 | 10079 | 10309 | 10539 | 10769 | 10999 | 11229 | 11459 | 11689 | 11919 | 12230 | 12230 | 12230 | 12230 | 12230 | 12230 | 12230 | 12230 |
| | Balance | -2169 | -1054 | -17353 | -19417 | -14587 | -5674 | -6873 | -1106 | -690 | -274 | 143 | 559 | 1057 | 1243 | 1430 | 1616 | 1802 | 5716 | 5716 | 5716 |
| | Operation subsidies or repayment | 2169 | 1054 | 17353 | 19417 | 14587 | 5674 | 6873 | 1106 | 690 | 274 | -143 | -559 | -1057 | -1243 | -1430 | -1616 | -1802 | -5716 | -5716 | -5716 |
| | Total subsidies | 7075 | 8129 | 25482 | 44899 | 59486 | 65160 | 72033 | 73139 | 73829 | 74102 | 73959 | 73401 | 72344 | 71101 | 69671 | 68055 | 66253 | 60537 | 54821 | 49105 |
| | Bonds and loans outstanding | 80058 | 102533 | 87085 | 68356 | 53249 | 46197 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 | 0 | 0 | 0 | 0 |
| | Surplus brought forward | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Accumulated surplus brought forward | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## Table 14-21 Estimated Revenue and Expenditure (Case 4)

Unit: Million Won

| | Item \ Year | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Revenue | Fare revenue in total | 6217 | 7972 | 9477 | 9699 | 9920 | 10141 | 10362 | 10583 | 10805 | 11026 | 11247 | 11468 | 11768 | 11768 | 11768 | 11768 | 11768 | 11768 | 11768 | 11768 |
| | Ordinary passengers | 5592 | 7171 | 8525 | 8724 | 8923 | 9122 | 9321 | 9520 | 9719 | 9918 | 10117 | 10316 | 10586 | 10586 | 10586 | 10586 | 10586 | 10586 | 10586 | 10586 |
| | Commuters | 296 | 379 | 451 | 461 | 472 | 482 | 493 | 503 | 514 | 524 | 535 | 545 | 559 | 559 | 559 | 559 | 559 | 559 | 559 | 559 |
| | Students | 329 | 422 | 502 | 513 | 525 | 537 | 549 | 560 | 572 | 584 | 595 | 607 | 623 | 623 | 623 | 623 | 623 | 623 | 623 | 623 |
| | Misc. income | 187 | 239 | 284 | 291 | 298 | 304 | 311 | 318 | 324 | 331 | 337 | 344 | 353 | 353 | 353 | 353 | 353 | 353 | 353 | 353 |
| | Interest received | 58 | 74 | 88 | 90 | 92 | 94 | 96 | 98 | 100 | 102 | 104 | 106 | 109 | 109 | 109 | 109 | 109 | 109 | 109 | 109 |
| | Proceeds from fund carried forward | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Total | 6461 | 8285 | 9850 | 10079 | 10309 | 10539 | 10769 | 10999 | 11229 | 11459 | 11689 | 11919 | 12230 | 12230 | 12230 | 12230 | 12230 | 12230 | 12230 | 12281 |
| Expenditure | Personnel expenses | 2527 | 2527 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 |
| | Other expenses in total | 1807 | 1807 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 |
| | Administrative | 440 | 440 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 |
| | Electricity | 710 | 710 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 |
| | Repairs and maintenance | 656 | 656 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 |
| | Depreciation | 4221 | 4221 | 6513 | 6513 | 6513 | 6027 | 6027 | 5666 | 5666 | 5666 | 5666 | 5666 | 5421 | 5421 | 5322 | 3460 | 3460 | 2213 | 2213 | 2213 |
| | Interest expense | 3700 | 3700 | 5241 | 4253 | 3275 | 2648 | 2206 | 1864 | 1677 | 1491 | 1305 | 1118 | 932 | 746 | 559 | 373 | 186 | 0 | 0 | 0 |
| | Total | 12255 | 12255 | 18268 | 17280 | 16302 | 15189 | 14747 | 14044 | 13857 | 13671 | 13485 | 13298 | 12866 | 12680 | 12395 | 10347 | 10161 | 8727 | 8727 | 8727 |
| | Profit before depreciation | -1573 | 251 | -1906 | -688 | 520 | 1377 | 2049 | 2621 | 3038 | 3454 | 3870 | 4286 | 4784 | 4971 | 5157 | 5343 | 5530 | 5716 | 5716 | 5767 |
| | Profit after depreciation | -5794 | -3970 | -8418 | -7201 | -5993 | -4650 | -3978 | -3045 | -2628 | -2212 | -1796 | -1380 | -636 | -450 | -165 | 1883 | 2069 | 3503 | 3503 | 3554 |
| | Profit brought forward | -5794 | -9764 | -18183 | -25383 | -31376 | -36026 | -40004 | -43049 | -45677 | -47889 | -49685 | -51065 | -51701 | -52151 | -52316 | -50433 | -48363 | -44861 | -41358 | -37804 |

Effects on Construction Subsidies

(1) Repayment Plan of Bonds and Loans

Fig. 14-10 Trend in Year-End Debt Outstanding and Principal Repayment

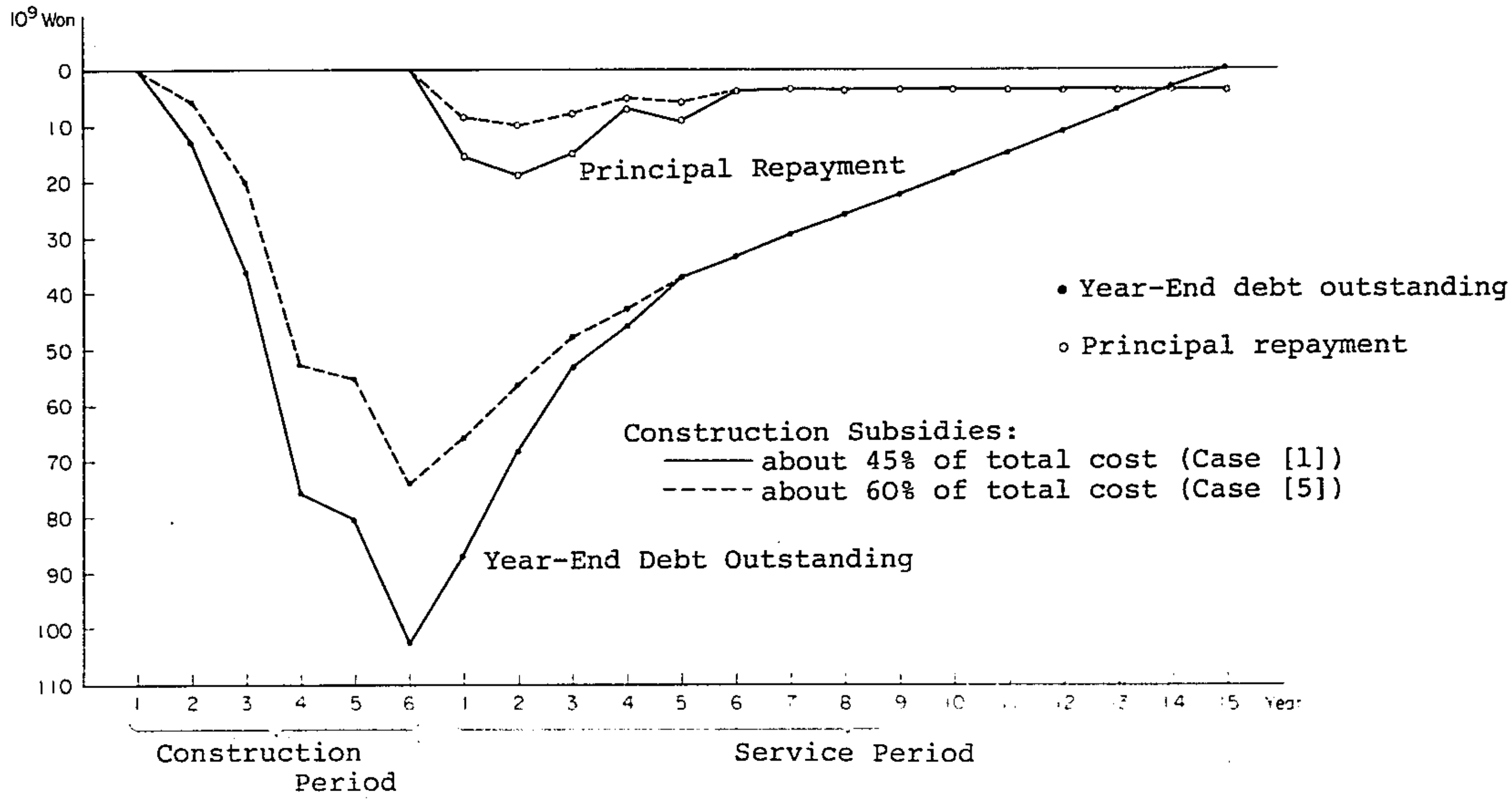
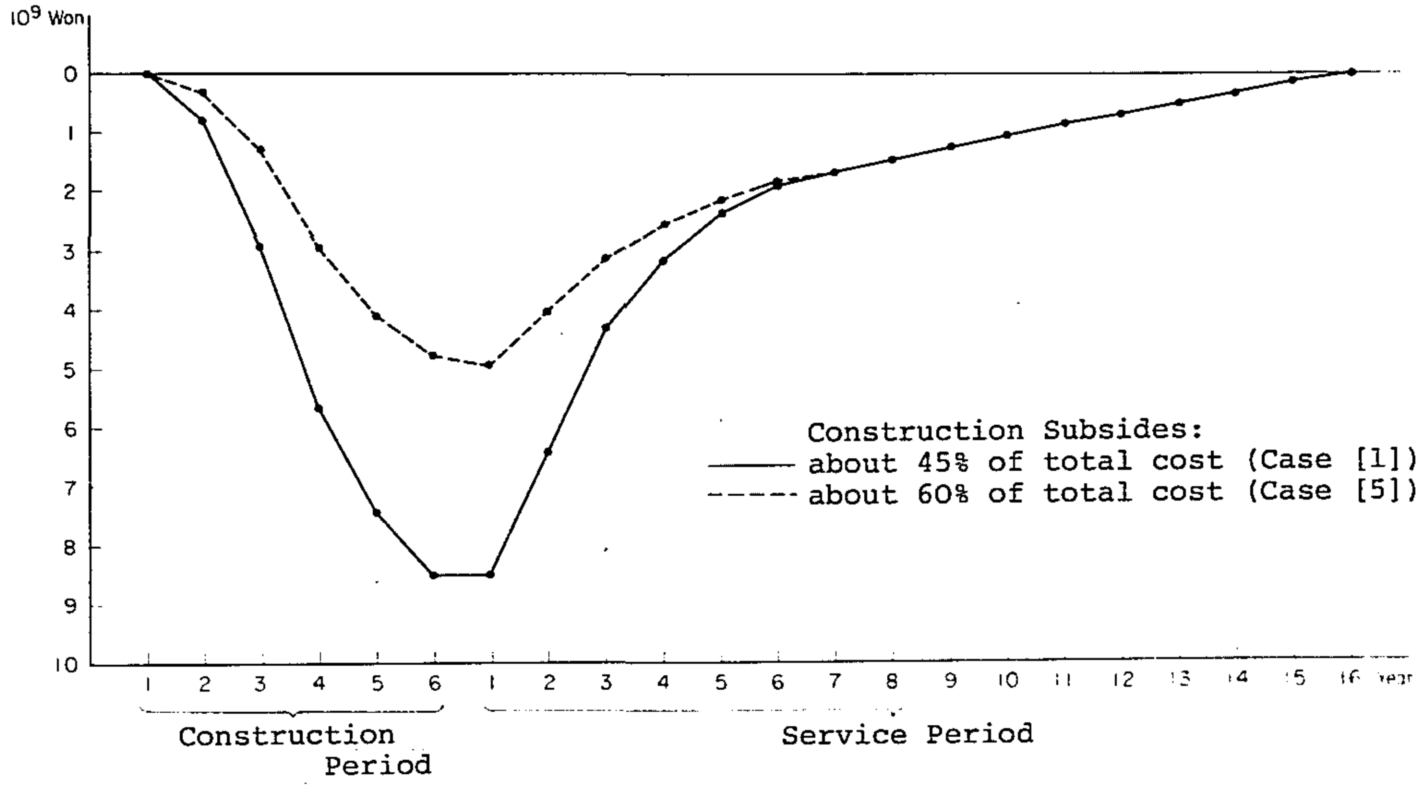
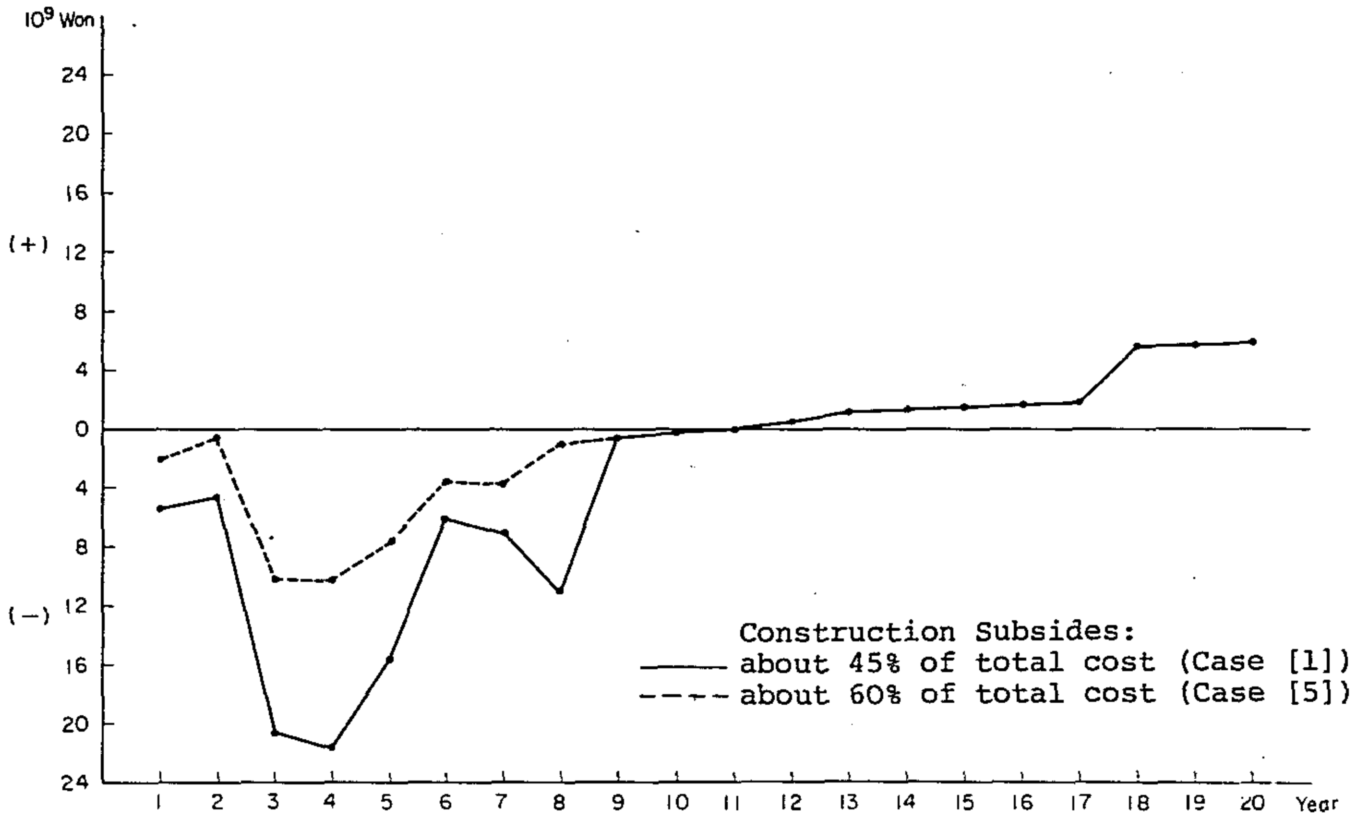


Fig. 14-11 Trend in Interest Repayment



## (2) Funds Flow Program

Fig. 14-12 Trend in Yearly Balance of Funds



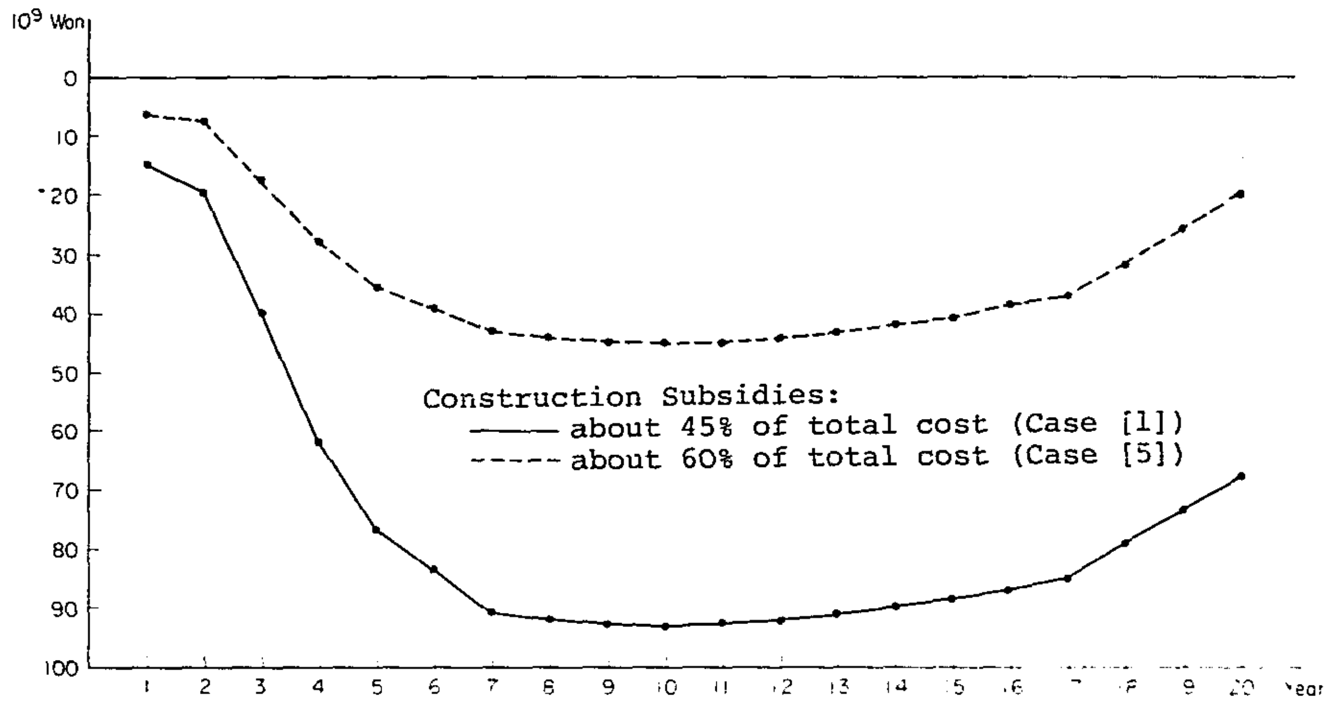
On the cumulative basis, the operation will not be so profitable in either case that the subsidies cannot be repaid within 20 years of service. (See Fig. 14-13)

(3) According to the estimated revenue and expenditure, the line will not go into the black until the sixteenth year of service in either case. (See Fig. 14-14) The performance on the cumulative basis will be such that the cumulative deficits cannot be eliminated within 20 years of service in either case. (See Fig. 14-15)

In short, the percentage of the construction subsidies to the total cost has an important bearing on the repayment plan. It is therefore necessary to work out an elaborate financing program.

The repayment plan, funds flow program, and estimated revenue and expenditure for Case 5 are presented in Tables 14-22 through -24.

Fig. 14-13 Trend in Cumulative Balance of Operation Subsidy



(3) Estimated Revenew and Expenditure

Fig. 14-14 Trend in Yearly Profit after Depreciation

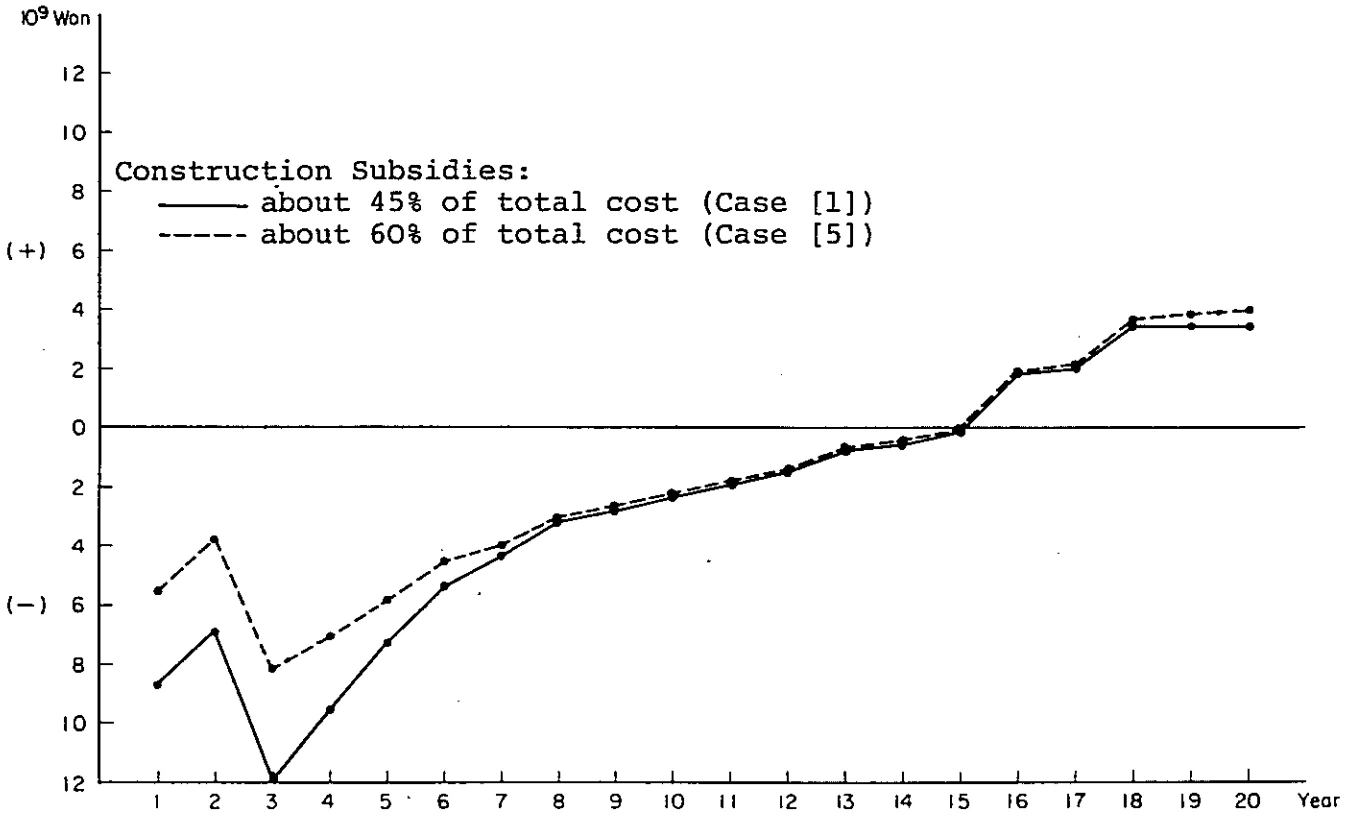
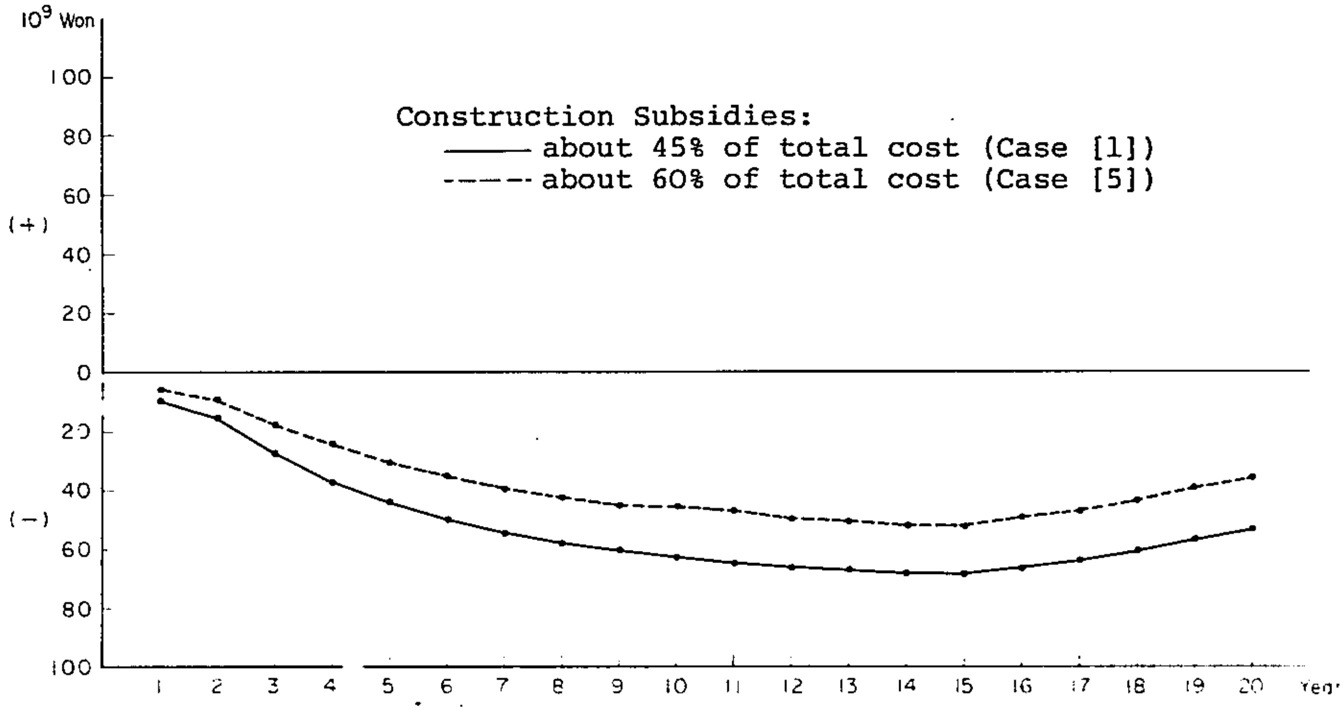


Fig. 14-15 Trend in Accumulated Profit



## Table 14-22 Repayment Plan (Case 5)

Unit: Million Won

| Item | Year | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Municipal bond | Bonds outstanding, beginning of year | 0 | 0 | 4651 | 10604 | 15120 | 16439 | 18501 | 13850 | 7896 | 3380 | 2061 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Bonds issued | 0 | 4651 | 5953 | 4516 | 1319 | 2061 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Principal repayment | 0 | 0 | 0 | 0 | 0 | 0 | 4651 | 5953 | 4516 | 1319 | 2061 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Interest repayment | 0 | 326 | 1068 | 1801 | 2209 | 2446 | 2265 | 1522 | 789 | 381 | 144 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Bonds outstanding, end of year | 0 | 4651 | 10604 | 15120 | 16439 | 18501 | 13850 | 7896 | 3380 | 2061 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Loans | Loans outstanding, beginning of year | 0 | 0 | 934 | 9280 | 37796 | 38633 | 55913 | 52185 | 48458 | 44730 | 41003 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 |
| | Loans disbursed | 0 | 934 | 8346 | 28516 | 837 | 17280 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Principal repayment | 0 | 0 | 0 | 0 | 0 | 0 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 |
| | Interest repayment | 0 | 23 | 255 | 1177 | 1911 | 2364 | 2796 | 2609 | 2423 | 2237 | 2050 | 1864 | 1677 | 1491 | 1305 | 1118 | 932 | 746 | 559 | ·373 | 186 |
| | Loan outstanding end of year | 0 | 934 | 9280 | 37796 | 38633 | 55913 | 52185 | 48458 | 44730 | 41003 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 | 0 |
| Loans (US$1000) | Loan, beginning of year | 0 | 0 | 1946 | 19333 | 78742 | 80485 | 116485 | 108720 | 100954 | 93188 | 85423 | 77657 | 69891 | 62126 | 54360 | 46594 | 38828 | 31063 | 23297 | 15531 | 7766 |
| | Loan disbursed | 0 | 1946 | 17387 | 59408 | 1744 | 36000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Principal repayment | 0 | 0 | 0 | 0 | 0 | 0 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 |
| | Interest repayment | 0 | 49 | 532 | 2452 | 3981 | 4924 | 5824 | 5436 | 5048 | 4659 | 4271 | 3883 | 3495 | 3106 | 2718 | 2330 | 1941 | 1553 | 1165 | 777 | 388 |
| | Loan, end of year | 0 | 1946 | 19333 | 78742 | 80485 | 116485 | 108720 | 100954 | 93188 | 85423 | 77657 | 69891 | 62126 | 54360 | 46594 | 38828 | 31063 | 23297 | 15531 | 7766 | 0 |
| Municipal bond and loans | Debt outstanding, beginning of year | 0 | 0 | 5585 | 19884 | 52916 | 55072 | 74414 | 66035 | 56354 | 48111 | 43064 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 |
| | Increase in debt | 0 | 5585 | 14299 | 33032 | 2156 | 19341 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Principal repayment | 0 | 0 | 0 | 0 | 0 | 0 | 8379 | 9681 | 8243 | 5047 | 5789 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 |
| | Interest repayment | 0 | 349 | 1323 | 2978 | 4120 | 4809 | 5060 | 4131 | 3212 | 2617 | 2194 | 1864 | 1677 | 1491 | 1305 | 1118 | 932 | 746 | 559 | 373 | 186 |
| | Debt outstanding, end of year | 0 | 5585 | 19884 | 52916 | 55072 | 74414 | 66035 | 56354 | 48111 | 43064 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 | 0 |
| Governmental Construction Subsidy | | 4699 | 9253 | 17859 | 13547 | 3957 | 6184 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Municipal Construction Subsidy | | 5797 | 8052 | 17726 | 13446 | 3928 | 6138 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Construction Subsidies | | 10496 | 17305 | 35586 | 26993 | 7885 | 12322 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 14-23 Funds Flow Program (Case 5)

Unit: Million Won

| | Item / Year | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Expenditure | Personnel expenses | 2527 | 2527 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 |
| | Other expenses in total | 1807 | 1807 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 |
| | Administrative | 440 | 440 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 |
| | Electricity | 710 | 710 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 |
| | Repair and maintenance | 656 | 656 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 |
| | Capital investment | 10041 | 31663 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Interest repayment | 4120 | 4809 | 5060 | 4131 | 3212 | 2617 | 2194 | 1864 | 1677 | 1491 | 1305 | 1118 | 932 | 746 | 559 | 373 | 186 | 0 | 0 | 0 |
| | Repayment of bonds and loans | 0 | 0 | 8379 | 9681 | 8243 | 5047 | 5789 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 0 | 0 | 0 |
| | Total | 18495 | 40806 | 19953 | 20326 | 17970 | 14178 | 14497 | 12105 | 11919 | 11732 | 11546 | 11360 | 11173 | 10987 | 10801 | 10614 | 10428 | 6514 | 6514 | 6514 |
| Revenue | Fare revenue in total | 6217 | 7972 | 9477 | 9699 | 9920 | 10144 | 10362 | 10583 | 10805 | 11026 | 11247 | 11468 | 11768 | 11768 | 11768 | 11768 | 11768 | 11768 | 11768 | 11768 |
| | Ordinary passengers | 5592 | 7171 | 8525 | 8724 | 8923 | 9122 | 9321 | 9520 | 9719 | 9918 | 10117 | 10316 | 10586 | 10586 | 10586 | 10586 | 10586 | 10586 | 10586 | 10586 |
| | Commuters | 296 | 379 | 451 | 461 | 472 | 482 | 493 | 503 | 514 | 524 | 535 | 545 | 559 | 559 | 559 | 559 | 559 | 559 | 559 | 559 |
| | Students | 329 | 422 | 502 | 513 | 525 | 537 | 549 | 560 | 572 | 584 | 595 | 607 | 623 | 623 | 623 | 623 | 623 | 623 | 623 | 623 |
| | Misc. income | 187 | 239 | 284 | 291 | 298 | 304 | 311 | 318 | 324 | 331 | 337 | 344 | 353 | 353 | 353 | 353 | 353 | 353 | 353 | 353 |
| | Interest received | 58 | 74 | 88 | 90 | 92 | 94 | 96 | 98 | 100 | 102 | 104 | 106 | 109 | 109 | 109 | 109 | 109 | 109 | 109 | 109 |
| | Construction subsidies | 7885 | 12322 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Bonds and loans | 2156 | 19341 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Proceeds from fund carried forward | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Total | 16502 | 39948 | 9850 | 10079 | 10309 | 10539 | 10769 | 10999 | 11229 | 11459 | 11689 | 11919 | 12230 | 12230 | 12230 | 12230 | 12230 | 12230 | 12230 | 12230 |
| | Balance | -1993 | -859 | -10103 | -10247 | -7660 | -3639 | -3728 | -1106 | -690 | -274 | 143 | 559 | 1057 | 1243 | 1430 | 1616 | 1802 | 5716 | 5716 | 5716 |
| | Operation subsidies or repayment | 1993 | 859 | 10103 | 10247 | 7660 | 3639 | 3728 | 1106 | 690 | 274 | -143 | -559 | -1057 | -1243 | -1430 | -1616 | -1802 | -5716 | -5716 | -5716 |
| | Total subsidies | 6543 | 7501 | 17604 | 27851 | 35511 | 39150 | 42878 | 43984 | 44674 | 44948 | 44805 | 44246 | 43189 | 41946 | 40517 | 38901 | 37099 | 31382 | 25666 | 19950 |
| | Bonds and loans outstanding | 55072 | 74414 | 66035 | 56354 | 48111 | 43064 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 | 0 | 0 | 0 | 0 |
| | Surplus brought forward | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Accumulated surplus brought forward | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

# Table 14-24 Estimated Revenue and Expenditure (Case 5)

Unit: Million Won

| | Item \ Year | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Revenue | Fare revenue in total | 6217 | 7972 | 9477 | 9699 | 9920 | 10147 | 10362 | 10583 | 10805 | 11026 | 11247 | 11468 | 11768 | 11768 | 11768 | 11768 | 11768 | 11768 | 11768 | 11768 |
| | Ordinary passengers | 5592 | 7171 | 8525 | 8724 | 8923 | 9122 | 9321 | 9520 | 9719 | 9918 | 10117 | 10316 | 10586 | 10586 | 10586 | 10586 | 10586 | 10586 | 10586 | 10586 |
| | Commuters | 296 | 379 | 451 | 461 | 472 | 482 | 493 | 503 | 514 | 524 | 535 | 545 | 559 | 559 | 559 | 559 | 559 | 559 | 559 | 559 |
| | Students | 329 | 422 | 502 | 513 | 525 | 537 | 549 | 560 | 572 | 584 | 595 | 607 | 623 | 623 | 623 | 623 | 623 | 623 | 623 | 623 |
| | Misc. income | 187 | 239 | 284 | 291 | 298 | 304 | 311 | 318 | 324 | 331 | 337 | 344 | 353 | 353 | 353 | 353 | 353 | 353 | 353 | 353 |
| | Interest received | 58 | 74 | 88 | 90 | 92 | 94 | 96 | 98 | 100 | 102 | 104 | 106 | 109 | 109 | 109 | 109 | 109 | 109 | 109 | 109 |
| | Proceeds from fund carried forward | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Total | 6461 | 8285 | 9850 | 10079 | 10309 | 10539 | 10769 | 10999 | 11229 | 11459 | 11689 | 11919 | 12230 | 12230 | 12266 | 12329 | 12395 | 12465 | 12576 | 12689 |
| Expenditure | Personnel expenses | 2527 | 2527 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 | 3418 |
| | Other expenses in total | 1807 | 1807 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 | 3096 |
| | Administrative | 440 | 440 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 595 |
| | Electricity | 710 | 710 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 | 1300 |
| | Repairs and maintenance | 656 | 656 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 | 1201 |
| | Depreciation | 4213 | 4213 | 6502 | 6502 | 6502 | 6017 | 6017 | 5657 | 5657 | 5657 | 5657 | 5657 | 5412 | 5412 | 5313 | 3455 | 3455 | 2210 | 2210 | 2210 |
| | Interest expense | 3545 | 3545 | 5060 | 4131 | 3212 | 2617 | 2194 | 1864 | 1677 | 1491 | 1305 | 1118 | 932 | 746 | 559 | 373 | 186 | 0 | 0 | 0 |
| | Total | 12093 | 12093 | 18076 | 17148 | 16228 | 15149 | 14726 | 14034 | 13848 | 13662 | 13475 | 13289 | 12857 | 12671 | 12386 | 10342 | 10155 | 8724 | 8724 | 8724 |
| | Profit before depreciation | -1418 | 405 | -1725 | -566 | 583 | 1408 | 2061 | 2621 | 3038 | 3454 | 3870 | 4286 | 4784 | 4971 | 5193 | 5443 | 5695 | 5951 | 6062 | 6175 |
| | Profit after depreciation | -5632 | -3808 | -8227 | -7068 | -5919 | -4609 | -3956 | -3035 | -2619 | -2203 | -1786 | -1370 | -627 | -441 | -120 | 1988 | 2240 | 3741 | 3852 | 3965 |
| | Profit brought forward | -5632 | -9440 | -17666 | -24734 | -30653 | -35263 | -39219 | -42254 | -44873 | -47076 | -48862 | -50233 | -50860 | -51301 | -51421 | -49433 | -47193 | -43452 | -39600 | -35635 |

### 14.2.2 Measures for Sound Management of Line No. 2

It is quite difficult to keep the proposed line financially sound if its minimum fare will not be higher than that of the Line No. 1. Even if the proportion of construction subsidies from the central government and municipality is increased and the interest rate of municipal bonds is lowered, there will be few cases where the proposed line can be operated any better than break-even basis.

Therefore, efforts are to be made to increase incomings as by raising the minimum fare at proper intervals on the one hand and to cut outgoings as by promoting the rationalized operations on the other.

Mention will now be made of some of the measures that will be conducive to the sound management of the proposed line.

#### 14.2.2.1 Increase in Incomings

Minimum Fare

As has already been pointed out, the revision of the minimum fare upward is an effective means to better the financial condition of the proposed line. However, too high fares will result in a decline in traffic demand so that the passenger volume estimated in 14.1.2.1 cannot be realized. From the practical point of view, therefore, it is desirable to maintain the fare level currently in force for a few initial years of service and to increase the minimum fare by about 30 percent every three years or so.

#### 14.2.2.2 Saving of Outgoing

(1) Rationalized Operation

Measures are to be taken to introduce the unattended ticket vending machine and gate operation, to mechanize the administrative and accounting procedures and to increase the overall efficiency of management.

(2) It will be necessary to increase construction subsidies, decreasing the interest repayment. It is also required to eliminate wasteful expenses through rigid inventory control.

## 14.3 Financial Programs by Different Assumption

The financial programs for the two different cases are mentioned below:

Case 6:

Assumptions:

- The minimum fare for the first year service is 40 Won 40 Won and is increased by 30 percent every three years.
- The personnel expenses increase by ten percent a year.
- The other expenses increase by four percent a year.
- The equipment and facilities are renewed or reconstructed after their useful life.

Case 7:

Assumptions:

- The base fare for the first year of service is 40 Won and is increased by 30 percent every three years.
- The personnel expenses increase by 9.2 percent a year.
- The prices increase by 7.8 percent a year.
- The equipment and facilities are renewed or reconstructed after their useful life.

The above two cases will be discussed in comparison with Case 1, the basic case. In practice, only Case 6 will be compared with Case 1, since the repayment plan funds flow program, and estimated revenue and expenditure are not different entirely between Case 6 and Case 7.

(1) On the yearly basis the line No. 2 will not go into the black in terms of the funds flow program until the

eleventh year of service, whereas in Case 6 a surplus is assured in the sixth year of service as in Case 3 where the minimum fare is assumed to be 80 Won. (See Fig. 14-16)

On the cumulative basis, the subsidies can be repaid within nine years of service in Case 6. (See Fig. 14-17.)

(2) According to the estimated revenue and expenditure, the line will break even in the sixteenth year of service on the yearly basis in Case 1, whereas in Case 6 it will earn a surplus in the fifth year of service. (See Fig. 14-18.)

Cumulative deficits can be eliminated within eight years after service inauguration, and a profit will be carried forward to the next year. (See Fig. 14-19.)

(3) The repayment plan does not differ in each case regardless of the modification of assumptions.

The most important factor of all, through which the proposed system has been much improved in Case 6 rather than in Case 1 is the assumption that the minimum fare is to be increased by 30 percent every three years. At this increased fare the revenue will outbalance the undesirable effects of labor and material costs.

In a word, absolutely from the financial viewpoint, Case 6, therefore, represents the most favorable assumption of all thus far made for the sound management of the proposed line.

The repayment plan, funds flow program, and estimated revenue and expenditure for Case 6 are presented in Tables 14-25 through 14-27, and those for Case 7, in Tables 14-28 through -30.

Financial Condition by Different Assumption

(1) Fund flow Program

Fig. 14-16 Trend in Yearly Balance of Funds

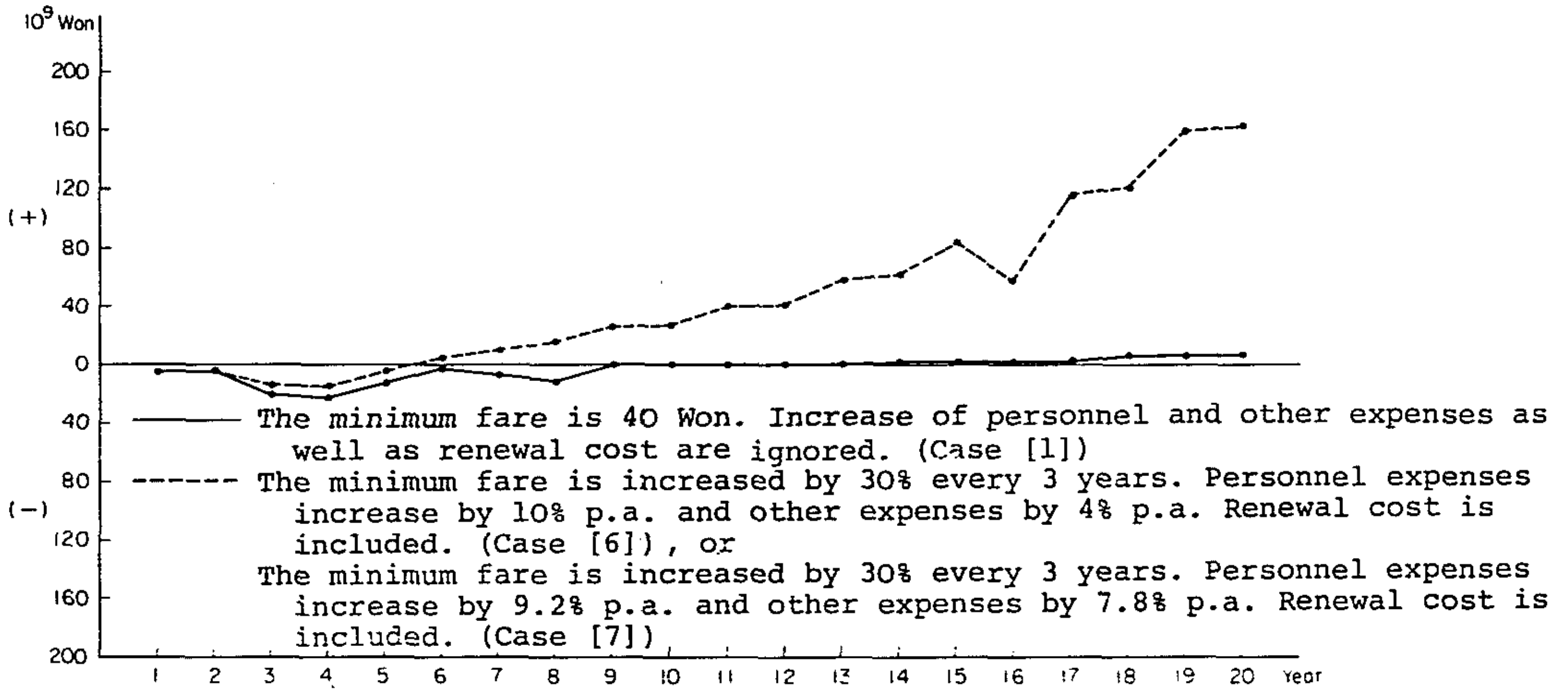
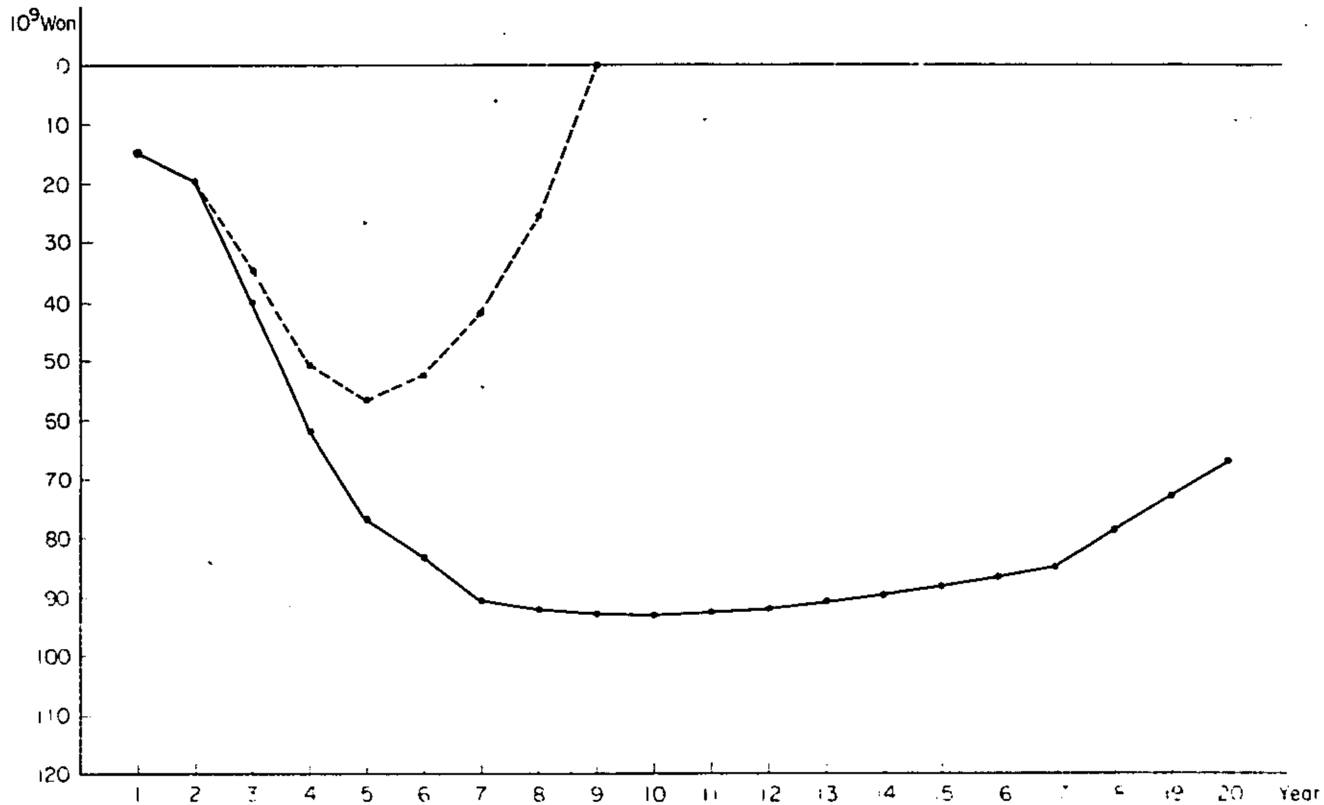


Fig. 14-17 Trend in Cumulative Balance of Operation Subsidy




——— The minimum fare is 40 Won. Increase of personnel and other expenses as well as renewal cost are ignored. (Case [1])

------ The minimum fare is increased by 30% every 3 years. Personnel expenses increase by 10% p.a. and other expenses by 4% p.a. Renewal cost is included. (Case [6]), or
The minimum fare is increased by 30% every 3 years. Personnel expenses increase by 9.2% p.a. and other expenses by 7.8% p.a. Renewal cost is included. (Case [7])

(2) Estimated Revenew and Expenditure

Fig. 14-18 Trend in Yearly Profit after Depreciation

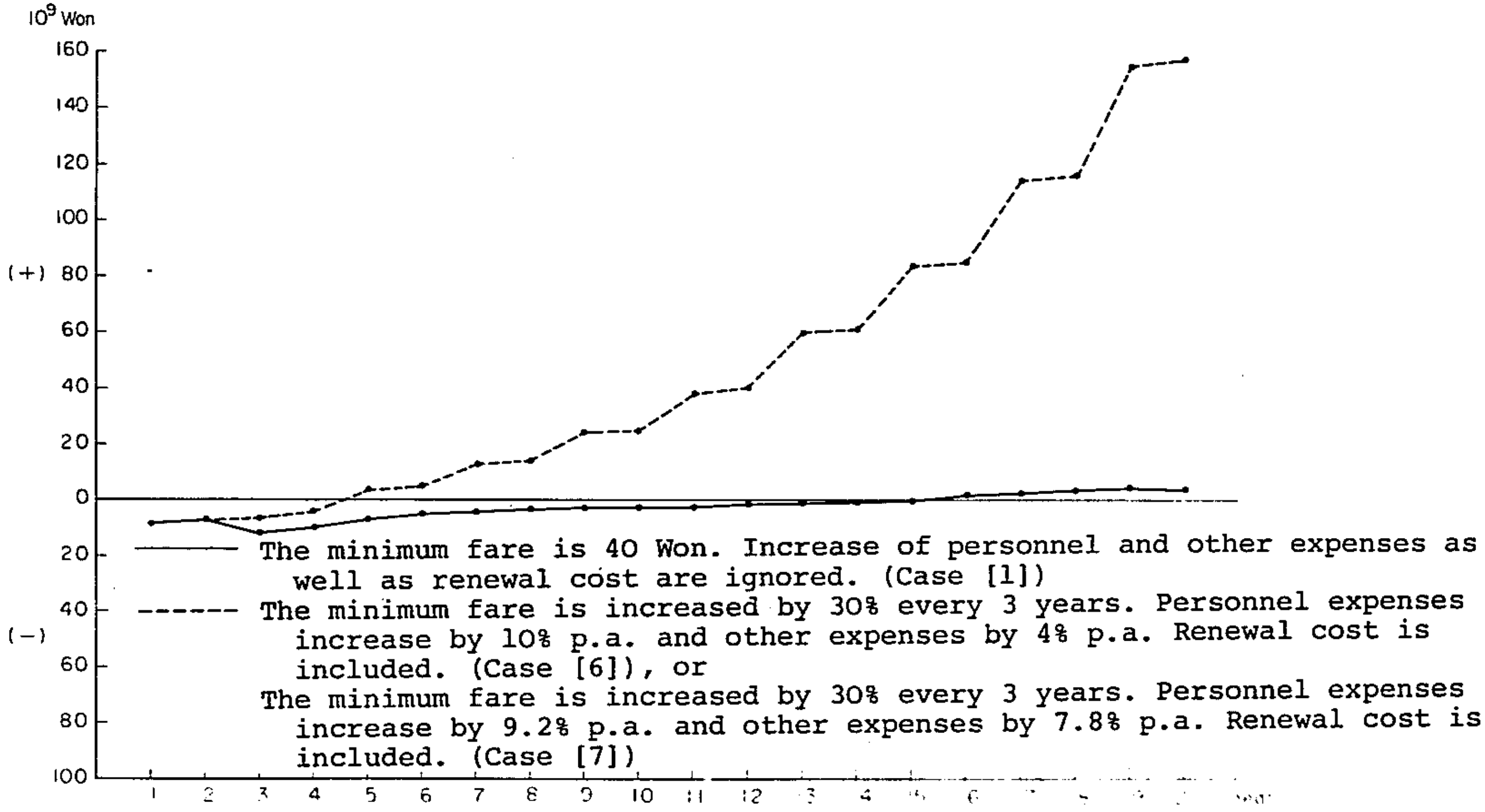


Fig. 14-19 Trend in Accumulated Profit

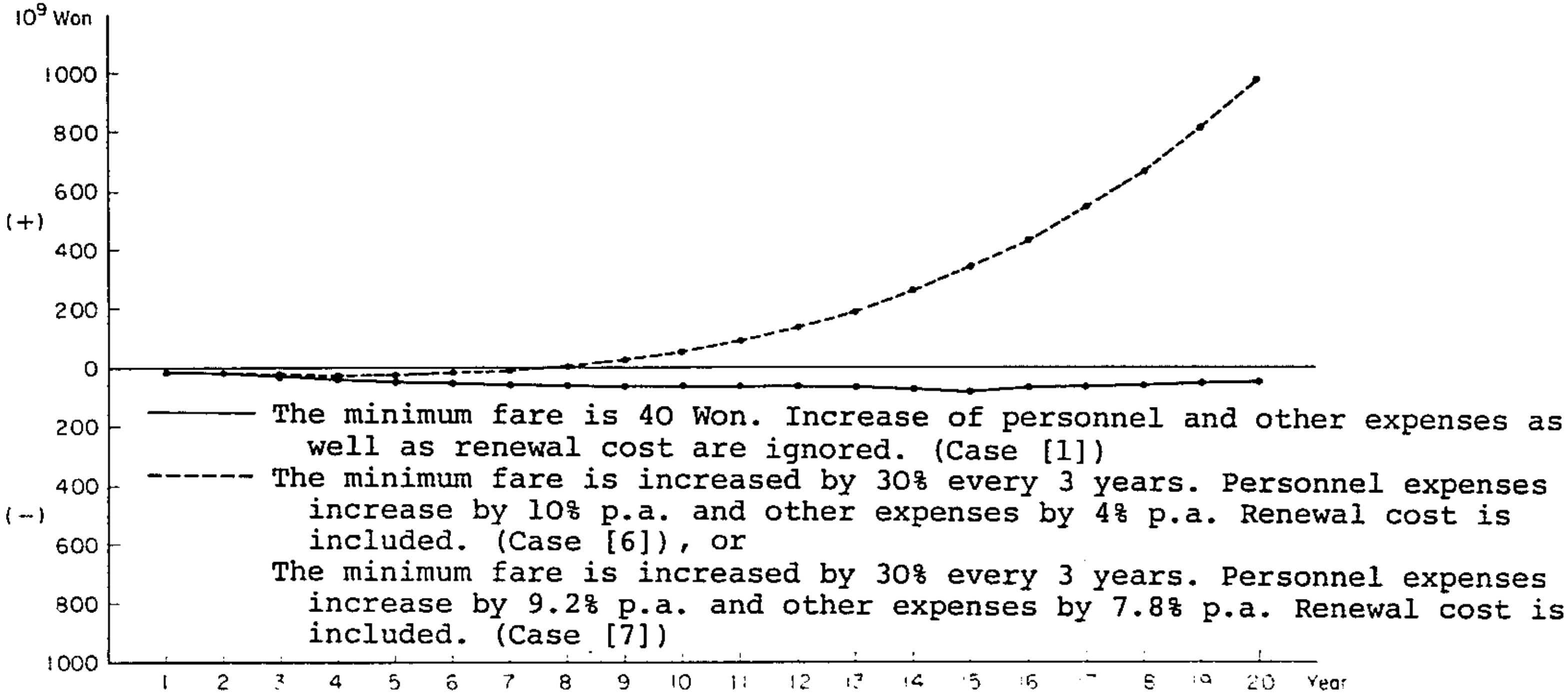


Table 14-25 Repayment Plan (Case 6)

Unit: Million Won

| Item | Year | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Municipal bond | Bonds outstanding, beginning of year | 0 | 0 | 11720 | 26722 | 38101 | 41425 | 46620 | 34900 | 19898 | 8518 | 5194 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Bonds issued | 0 | 11720 | 15002 | 11379 | 3324 | 5194 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Principal repayment | 0 | 0 | 0 | 0 | 0 | 0 | 11720 | 15002 | 11379 | 3324 | 5194 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Interest repayment | 0 | 820 | 2691 | 4538 | 5567 | 6163 | 5706 | 3836 | 1989 | 960 | 364 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Bonds outstanding, end of year | 0 | 11720 | 26722 | 38101 | 41425 | 46620 | 34900 | 19898 | 8518 | 5194 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Loans | Loans outstanding, beginning of year | 0 | 0 | 934 | 9280 | 37796 | 38633 | 55913 | 52185 | 48458 | 44730 | 41003 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 |
| | Loans disbursed | 0 | 934 | 8346 | 28516 | 837 | 17280 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Principal repayment | 0 | 0 | 0 | 0 | 0 | 0 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 |
| | Interest repayment | 0 | 23 | 255 | 1177 | 1911 | 2364 | 2796 | 2609 | 2423 | 2237 | 2050 | 1864 | 1677 | 1491 | 1305 | 1118 | 932 | 746 | 559 | 373 | 186 |
| | Loan outstanding end of year | 0 | 934 | 9280 | 37796 | 38633 | 55913 | 52185 | 48458 | 44730 | 41003 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 | 0 |
| Loans (US$1000) | Loan, beginning of year | 0 | 0 | 1946 | 19333 | 78742 | 80485 | 116485 | 108720 | 100954 | 93188 | 85423 | 77657 | 69891 | 62126 | 54360 | 46594 | 38828 | 31063 | 23297 | 15531 | 7766 |
| | Loan disbursed | 0 | 1946 | 17387 | 59408 | 1744 | 36000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Principal repayment | 0 | 0 | 0 | 0 | 0 | 0 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 |
| | Interest repayment | 0 | 49 | 532 | 2452 | 3981 | 4924 | 5824 | 5436 | 5048 | 4659 | 4271 | 3883 | 3495 | 3106 | 2718 | 2330 | 1941 | 1553 | 1165 | 777 | 388 |
| | Loan, end of year | 0 | 1946 | 19333 | 78742 | 80485 | 116485 | 108720 | 100954 | 93188 | 85423 | 77657 | 69891 | 62126 | 54360 | 46594 | 38828 | 31063 | 23297 | 15531 | 7766 | 0 |
| Municipal bond and loans | Debt outstanding, beginning of year | 0 | 0 | 12654 | 36002 | 75897 | 80058 | 102533 | 87085 | 68356 | 53249 | 46197 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 |
| | Increase in debt | 0 | 12654 | 23348 | 39895 | 4161 | 22474 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Principal repayment | 0 | 0 | 0 | 0 | 0 | 0 | 15448 | 18729 | 15107 | 7052 | 8922 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 |
| | Interest repayment | 0 | 844 | 2946 | 5715 | 7478 | 8527 | 8502 | 6445 | 4412 | 3196 | 2414 | 1864 | 1677 | 1491 | 1305 | 1118 | 932 | 746 | 559 | 373 | 186 |
| | Debt outstanding, end of year | 0 | 12654 | 36002 | 75897 | 80058 | 102533 | 87085 | 68356 | 53249 | 46197 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 | 0 |
| Governmental Construction Subsidy | | 3603 | 6851 | 13381 | 10150 | 2965 | 4633 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Municipal Construction Subsidy | | 6893 | 3385 | 13156 | 9980 | 2915 | 4555 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Construction Subsidies | | 10496 | 10236 | 26537 | 20130 | 5880 | 9189 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## Table 14-26 Funds Flow Program (Case 6)

Unit: Million Won

| | Item \ Year | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Expenditure | Personnel expenses | 2527 | 2555 | 3474 | 3512 | 3550 | 3589 | 3629 | 3669 | 3709 | 3750 | 3791 | 3833 | 3875 | 3918 | 3961 | 4004 | 4049 | 4093 | 4138 | 4184 |
| | *Other expenses in total* | 1807 | 1825 | 3134 | 3167 | 3200 | 3233 | 3266 | 3300 | 3335 | 3369 | 3404 | 3440 | 3476 | 3512 | 3548 | 3585 | 3622 | 3660 | 3698 | 3737 |
| | Administrative | 440 | 445 | 604 | 610 | 617 | 623 | 630 | 636 | 643 | 650 | 656 | 663 | 670 | 677 | 684 | 691 | 698 | 706 | 713 | 720 |
| | Electricity | 710 | 718 | 1315 | 1329 | 1343 | 1357 | 1371 | 1385 | 1399 | 1414 | 1429 | 1443 | 1459 | 1474 | 1489 | 1504 | 1520 | 1536 | 1552 | 1568 |
| | Repairs and maintenance | 656 | 663 | 1215 | 1227 | 1240 | 1253 | 1266 | 1279 | 1292 | 1306 | 1319 | 1333 | 1347 | 1361 | 1375 | 1390 | 1404 | 1419 | 1433 | 1448 |
| | Capital investment | 10041 | 31663 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3159 | 0 | 1263 | 29957 | 0 | 19971 | 0 | 0 |
| | Interest repayment | 7478 | 8527 | 8502 | 6445 | 4412 | 3196 | 2414 | 1864 | 1677 | 1491 | 1305 | 1118 | 932 | 746 | 559 | 373 | 186 | 0 | 0 | 0 |
| | Repayment of bonds and loans | 0 | 0 | 15448 | 18729 | 15107 | 7052 | 8922 | 3726 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 0 | 0 | 0 |
| | Total | 21853 | 44570 | 30557 | 31853 | 26269 | 17070 | 18231 | 12561 | 12449 | 12336 | 12228 | 12119 | 15169 | 11903 | 13059 | 41647 | 11585 | 27724 | 7836 | 7920 |
| Revenue | Fare revenue in total | 6217 | 7972 | 14726 | 15070 | 20036 | 20483 | 27212 | 27793 | 36883 | 37638 | 49911 | 50893 | 68965 | 68965 | 89657 | 89657 | 116562 | 116562 | 151527 | 151527 |
| | Ordinary passengers | 5592 | 7171 | 13247 | 13556 | 18023 | 18425 | 24478 | 25000 | 33177 | 33856 | 44896 | 45779 | 62036 | 62036 | 80648 | 80648 | 104850 | 104850 | 136302 | 136302 |
| | Commuters | 296 | 379 | 700 | 716 | 952 | 974 | 1294 | 1321 | 1753 | 1789 | 2373 | 2419 | 3278 | 3278 | 4262 | 4262 | 5541 | 5541 | 7203 | 7203 |
| | Students | 329 | 422 | 780 | 798 | 1061 | 1084 | 1441 | 1471 | 1953 | 1993 | 2642 | 2694 | 3651 | 3651 | 4747 | 4747 | 6171 | 6171 | 8022 | 8022 |
| | Misc. income | 187 | 239 | 442 | 452 | 601 | 614 | 816 | 834 | 1106 | 1129 | 1497 | 1527 | 2069 | 2069 | 2690 | 2690 | 3497 | 3497 | 4546 | 4546 |
| | Interest received | 58 | 74 | 137 | 140 | 186 | 190 | 252 | 258 | 342 | 349 | 463 | 472 | 639 | 639 | 831 | 831 | 1081 | 1081 | 1405 | 1405 |
| | Construction subsidies | 5880 | 9189 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Bonds and loans | 4161 | 22474 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Proceeds from fund carried forward | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 484 | 1206 | 1962 | 3014 | 4144 | 5661 | 6691 | 8783 | 10623 | 13507 |
| | Total | 16502 | 39948 | 15305 | 15662 | 20823 | 21288 | 28280 | 28884 | 38331 | 39118 | 52355 | 54097 | 73635 | 74688 | 97322 | 98838 | 127830 | 129922 | 163100 | 170985 |
| | Balance | -5350 | -4623 | -15253 | -16191 | -5446 | 4217 | 10049 | 16324 | 25882 | 26780 | 40127 | 41979 | 58466 | 62785 | 84263 | 57192 | 116245 | 102198 | 160264 | 163065 |
| | Operation subsidies or repayment | 5350 | 4623 | 15253 | 16191 | 5446 | -4217 | -10049 | -16324 | -25777 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Total subsidies | 14855 | 19478 | 34730 | 50921 | 56367 | 52150 | 42101 | 25777 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Bonds and loans outstanding | 80058 | 102533 | 87085 | 68356 | 53249 | 46197 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 | 0 | 0 | 0 | 0 |
| | Surplus brought forward | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 105 | 26780 | 40127 | 41979 | 58466 | 62785 | 84263 | 57192 | 116245 | 102198 | 168264 | 163065 |
| | Accumulated surplus brought forward | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 105 | 26885 | 67012 | 108991 | 167457 | 230242 | 314505 | 371697 | 487942 | 590140 | 750404 | 913469 |

## Table 14-27 Estimated Revenue and Expenditure (Case 6)

Unit: Million Won

| | Item \ Year | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Revenue | Fare revenue in total | 6217 | 7972 | 14726 | 15070 | 20036 | 20483 | 27212 | 27793 | 36883 | 37638 | 49911 | 50893 | 68965 | 68965 | 89657 | 89657 | 116562 | 116562 | 151527 | 151527 |
| | Ordinary passengers | 5592 | 7171 | 13247 | 13556 | 18023 | 18425 | 24478 | 25000 | 33177 | 33856 | 44896 | 45779 | 62036 | 62036 | 80648 | 80648 | 104850 | 104850 | 136302 | 136302 |
| | Commuters | 296 | 379 | 700 | 716 | 952 | 974 | 1294 | 1321 | 1753 | 1789 | 2373 | 2419 | 3278 | 3278 | 4262 | 4262 | 5541 | 5541 | 7203 | 7203 |
| | Students | 329 | 422 | 780 | 798 | 1061 | 1084 | 1441 | 1471 | 1953 | 1993 | 2642 | 2694 | 3651 | 3651 | 4747 | 4747 | 6171 | 6171 | 8022 | 8022 |
| | Misc. income | 187 | 239 | 442 | 452 | 601 | 614 | 816 | 834 | 1106 | 1129 | 1497 | 1527 | 2069 | 2069 | 2690 | 2690 | 3497 | 3497 | 4546 | 4546 |
| | Interest received | 58 | 74 | 137 | 140 | 186 | 190 | 252 | 258 | 342 | 349 | 463 | 472 | 639 | 639 | 831 | 831 | 1081 | 1081 | 1405 | 1405 |
| | Proceeds from fund carried forward | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 484 | 1206 | 1962 | 3014 | 4144 | 5661 | 6691 | 8783 | 10623 | 13507 |
| | Total | 6461 | 8285 | 15305 | 15662 | 20823 | 21288 | 28280 | 28884 | 38438 | 39676 | 52905 | 54606 | 74099 | 75032 | 97543 | 98894 | 127880 | 129974 | 168153 | 171038 |
| Expenditure | Personnel expenses | 2527 | 2555 | 3474 | 3512 | 3550 | 3589 | 3629 | 3669 | 3709 | 3750 | 3791 | 3833 | 3875 | 3918 | 3961 | 4004 | 4049 | 4093 | 4138 | 4184 |
| | Other expenses in total | 1807 | 1825 | 3134 | 3167 | 3200 | 3233 | 3266 | 3300 | 3335 | 3369 | 3404 | 3440 | 3476 | 3512 | 3548 | 3585 | 3622 | 3660 | 3698 | 3737 |
| | Administrative | 440 | 445 | 604 | 610 | 617 | 623 | 630 | 636 | 643 | 650 | 656 | 663 | 670 | 677 | 684 | 691 | 698 | 706 | 713 | 720 |
| | Electricity | 710 | 718 | 1315 | 1329 | 1343 | 1357 | 1371 | 1385 | 1399 | 1414 | 1429 | 1443 | 1459 | 1474 | 1489 | 1504 | 1520 | 1536 | 1552 | 1568 |
| | Repairs and maintenance | 656 | 663 | 1215 | 1227 | 1240 | 1253 | 1266 | 1279 | 1292 | 1306 | 1319 | 1333 | 1347 | 1361 | 1375 | 1390 | 1404 | 1419 | 1433 | 1448 |
| | Depreciation | 4361 | 4361 | 6707 | 6707 | 6707 | 6205 | 6205 | 5836 | 5836 | 5836 | 5836 | 5836 | 5819 | 5819 | 5813 | 5687 | 5687 | 5609 | 5609 | 5609 |
| | Interest reexpense | 6485 | 6485 | 8502 | 6445 | 4412 | 3196 | 2414 | 1864 | 1677 | 1491 | 1305 | 1118 | 932 | 746 | 559 | 373 | 186 | 0 | 0 | 0 |
| | Total | 15180 | 15226 | 21817 | 19831 | 17869 | 16224 | 15515 | 14669 | 14557 | 14446 | 14336 | 14227 | 14102 | 13994 | 13881 | 13649 | 13544 | 13362 | 13445 | 13529 |
| | Profit before depreciation | -4358 | -2581 | 195 | 2538 | 9661 | 11269 | 18971 | 20051 | 29716 | 31065 | 44405 | 46215 | 65816 | 66857 | 89475 | 90932 | 120023 | 122221 | 160316 | 163118 |
| | Profit after depreciation | -8719 | -6941 | -6512 | -4169 | 2954 | 5063 | 12766 | 14215 | 23880 | 25229 | 38569 | 40360 | 59997 | 61038 | 83662 | 85245 | 114336 | 116612 | 154708 | 157509 |
| | Profit brought forward | -8719 | -15660 | -22172 | -26341 | -23387 | -18324 | -5558 | 8657 | 32538 | 57767 | 96336 | 136716 | 196713 | 257750 | 341412 | 426657 | 540993 | 657605 | 812313 | 969822 |

## Table 14-28 Repayment Plan (Case 7)

Unit: Million Won

| Item | Year | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Municipal bond | Bonds outstanding, beginning of year | 0 | 0 | 11720 | 26722 | 38101 | 41425 | 46620 | 34900 | 19898 | 8518 | 5194 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Bonds issued | 0 | 11720 | 15002 | 11379 | 3324 | 5194 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Principal repayment | 0 | 0 | 0 | 0 | 0 | 0 | 11720 | 15002 | 11379 | 3324 | 5194 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Interest repayment | 0 | 820 | 2691 | 4538 | 5567 | 6163 | 5706 | 3836 | 1989 | 960 | 364 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Bonds outstanding, end of year | 0 | 11720 | 26722 | 38101 | 41425 | 46620 | 34900 | 19898 | 8518 | 5194 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Loans | Loans outstanding, beginning of year | 0 | 0 | 934 | 9280 | 37796 | 38633 | 55913 | 52185 | 48458 | 44730 | 41003 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 |
| | Loans disbursed | 0 | 934 | 8346 | 28516 | 837 | 17280 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Principal repayment | 0 | 0 | 0 | 0 | 0 | 0 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 |
| | Interest repayment | 0 | 23 | 255 | 1177 | 1911 | 2364 | 2796 | 2609 | 2423 | 2237 | 2050 | 1864 | 1677 | 1491 | 1305 | 1118 | 932 | 746 | 559 | 373 | 186 |
| | Loan outstanding end of year | 0 | 934 | 9280 | 37796 | 38633 | 55913 | 52185 | 48458 | 44730 | 41003 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 | 0 |
| Loans (US$1000) | Loan, beginning of year | 0 | 0 | 1946 | 19333 | 78742 | 80485 | 116485 | 108720 | 100954 | 93188 | 85423 | 77657 | 69891 | 62126 | 54360 | 46594 | 38828 | 31063 | 23297 | 15531 | 7766 |
| | Loan disbursed | 0 | 1946 | 17387 | 59408 | 1744 | 36000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Principal repayment | 0 | 0 | 0 | 0 | 0 | 0 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 | 7766 |
| | Interest repayment | 0 | 49 | 532 | 2452 | 3981 | 4924 | 5824 | 5436 | 5048 | 4659 | 4271 | 3883 | 3495 | 3106 | 2718 | 2330 | 1941 | 1553 | 1165 | 777 | 388 |
| | Loan, end of year | 0 | 1946 | 19333 | 78742 | 80485 | 116485 | 108720 | 100954 | 93188 | 85423 | 77657 | 69891 | 62126 | 54360 | 46594 | 38828 | 31063 | 23297 | 15531 | 7766 | 0 |
| Municipal bond and loans | Debt outstanding, beginning of year | 0 | 0 | 12654 | 36002 | 75897 | 80058 | 102533 | 87085 | 68356 | 53249 | 46197 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 |
| | Increase in debt | 0 | 12654 | 23348 | 39895 | 4161 | 22474 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | *Principal repayment* | 0 | 0 | 0 | 0 | 0 | 0 | 15448 | 18729 | 15107 | 7052 | 8922 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 | 3728 |
| | Interest repayment | 0 | 844 | 2946 | 5715 | 7478 | 8527 | 8502 | 6445 | 4412 | 3196 | 2414 | 1864 | 1677 | 1491 | 1305 | 1118 | 932 | 746 | 559 | 373 | 186 |
| | Debt outstanding, end of year | 0 | 12654 | 36002 | 75897 | 80058 | 102533 | 87085 | 68356 | 53249 | 46197 | 37275 | 33548 | 29820 | 26093 | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 | 0 |
| Governmental Construction Subsidy | | 3603 | 6851 | 13381 | 10150 | 2965 | 4633 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Municipal Construction Subsidy | | 6893 | 3385 | 13156 | 9980 | 2915 | 4555 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Construction Subsidies* | | 10496 | 10236 | 26537 | 20130 | 5880 | 9189 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## Table 14-29 Funds Flow Program (Case 7)

Unit: Million Won

| | Item / Year | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Expenditure | Personnel expenses | 2527 | 2555 | 3473 | 3511 | 3549 | 3588 | 3627 | 3667 | 3707 | 3748 |
| | Other expenses in total | 1807 | 1826 | 3135 | 3169 | 3203 | 3238 | 3273 | 3308 | 3344 | 3380 |
| | Administrative | 440 | 445 | 605 | 611 | 618 | 624 | 631 | 638 | 645 | 652 |
| | Electricity | 710 | 718 | 1316 | 1330 | 1344 | 1359 | 1373 | 1388 | 1403 | 1418 |
| | Repairs and maintenance | 656 | 663 | 1215 | 1228 | 1242 | 1255 | 1268 | 1282 | 1296 | 1310 |
| | Capital investment | 10041 | 31663 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Interest repayment | 7478 | 8527 | 8502 | 6445 | 4412 | 3196 | 2414 | 1864 | 1677 | 1491 |
| | Repayment of bonds and loans | 0 | 0 | 15448 | 18729 | 15107 | 7052 | 8922 | 3728 | 3728 | 3728 |
| | Total | 21853 | 44571 | 30558 | 31855 | 26272 | 17074 | 18236 | 12566 | 12456 | 12846 |
| Revenue | Fare revenue in total | 6217 | 7972 | 14726 | 15070 | 20036 | 20483 | 27212 | 27793 | 36883 | 37638 |
| | Ordinary passengers | 5592 | 7171 | 13247 | 13556 | 18023 | 18425 | 24478 | 25000 | 33177 | 33856 |
| | Commuters | 296 | 379 | 700 | 716 | 952 | 974 | 1294 | 1321 | 1753 | 1789 |
| | Students | 329 | 422 | 780 | 798 | 1061 | 1084 | 1441 | 1471 | 1953 | 1993 |
| | Misc. income | 187 | 239 | 442 | 452 | 601 | 614 | 816 | 834 | 1106 | 1129 |
| | Interest received | 58 | 74 | 137 | 140 | 186 | 190 | 252 | 258 | 342 | 349 |
| | Construction subsidies | 5880 | 9189 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Bonds and loans | 4161 | 22474 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Proceeds from fund carried forward | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | Total | 16502 | 39948 | 15305 | 15662 | 20823 | 21288 | 28280 | 28884 | 38331 | 39117 |
| | Balance | -5350 | -4623 | -15254 | -16193 | -5449 | 4213 | 10045 | 16318 | 25875 | 26771 |
| | Operation subsidies or repayment | 5350 | 4623 | 15254 | 16193 | 5449 | -4213 | -10045 | -16318 | -25797 | 0 |
| | Total subsidies | 14855 | 19478 | 34732 | 50925 | 56373 | 52160 | 42115 | 25797 | 0 | 0 |
| | Bonds and loans outstanding | 80058 | 102533 | 87085 | 68356 | 53249 | 46197 | 37275 | 33548 | 29820 | 26093 |
| | Surplus brought forward | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 78 | 26771 |
| | Accumulated surplus brought forward | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 78 | 26849 |

| | Item / Year | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Expenditure | Personnel expenses | 3788 | 3830 | 3872 | 3914 | 3957 | 4000 | 4044 | 4088 | 4132 | 4177 |
| | Other expenses in total | 3416 | 3453 | 3490 | 3528 | 3566 | 3604 | 3643 | 3682 | 3722 | 3762 |
| | Administrative | 659 | 666 | 673 | 680 | 688 | 695 | 702 | 710 | 718 | 725 |
| | Electricity | 1434 | 1449 | 1465 | 1480 | 1496 | 1512 | 1529 | 1545 | 1562 | 1579 |
| | Repairs and maintenance | 1324 | 1338 | 1353 | 1367 | 1382 | 1397 | 1412 | 1427 | 1443 | 1458 |
| | Capital investment | 0 | 0 | 3159 | 0 | 1263 | 29957 | 0 | 19971 | 0 | 0 |
| | Interest repayment | 1305 | 1118 | 932 | 746 | 559 | 373 | 186 | 0 | 0 | 0 |
| | Repayment of bonds and loans | 3728 | 3728 | 3728 | 3728 | 3722 | 3728 | 3728 | 0 | 0 | 0 |
| | Total | 12237 | 12129 | 15180 | 11915 | 13072 | 41662 | 11601 | 27741 | 7855 | 7940 |
| Revenue | Fare revenue in total | 49911 | 50893 | 68965 | 68965 | 89657 | 89657 | 116562 | 116562 | 151527 | 151527 |
| | Ordinary passengers | 44896 | 45779 | 62036 | 62036 | 80648 | 80648 | 104850 | 104850 | 136302 | 136302 |
| | Commuters | 2373 | 2419 | 3278 | 3278 | 4262 | 4262 | 5541 | 5541 | 7203 | 7203 |
| | Students | 2642 | 2694 | 3651 | 3651 | 4747 | 4747 | 6171 | 6171 | 8022 | 8022 |
| | Misc. income | 1497 | 1527 | 2069 | 2069 | 2690 | 2690 | 3497 | 3497 | 4546 | 4546 |
| | Interest received | 463 | 472 | 639 | 639 | 831 | 831 | 1081 | 1081 | 1405 | 1405 |
| | Construction subsidies | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Bonds and loans | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Proceeds from fund carried forward | 483 | 1205 | 1961 | 3013 | 4143 | 5659 | 6689 | 8781 | 10620 | 13504 |
| | Total | 52354 | 54097 | 73634 | 74687 | 97320 | 98837 | 127828 | 129920 | 168097 | 170982 |
| | Balance | 40117 | 41968 | 58454 | 62772 | 84248 | 57175 | 116227 | 102179 | 160243 | 163042 |
| | Operation subsidies or repayment | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Total subsidies | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Bonds and loans outstanding | 22365 | 18638 | 14910 | 11183 | 7455 | 3728 | 0 | 0 | 0 | 0 |
| | Surplus brought forward | 40117 | 41968 | 58454 | 62772 | 84248 | 57175 | 116227 | 102179 | 160243 | 163042 |
| | Accumulated surplus brought forward | 66967 | 108935 | 167389 | 230161 | 314409 | 371584 | 487811 | 589990 | 750233 | 913275 |

## Table 14-30 Estimated Revenue and Expenditure (Case 7)

Unit: Million Won

| | Item \ Year | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Revenue | Fare revenue in total | 6217 | 7972 | 14726 | 15070 | 20036 | 20483 | 27212 | 27793 | 36883 | 37638 |
| | Ordinary passengers | 5592 | 7171 | 13247 | 13556 | 18023 | 18425 | 24478 | 25000 | 33177 | 33856 |
| | Commuters | 296 | 379 | 700 | 716 | 952 | 974 | 1294 | 1321 | 1753 | 1789 |
| | Students | 329 | 422 | 780 | 798 | 1061 | 1084 | 1441 | 1471 | 1953 | 1993 |
| | Misc. income | 187 | 239 | 442 | 452 | 601 | 614 | 816 | 834 | 1106 | 1129 |
| | Interest received | 58 | 74 | 137 | 140 | 186 | 190 | 252 | 258 | 342 | 349 |
| | Proceeds from fund carried forward | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | Total | 6461 | 8285 | 15305 | 15662 | 20823 | 21288 | 28280 | 28884 | 38437 | 39675 |
| Expenditure | Personnel expenses | 2527 | 2555 | 3473 | 3511 | 3549 | 3588 | 3627 | 3667 | 3707 | 3748 |
| | Other expenses in total | 1807 | 1826 | 3135 | 3169 | 3203 | 3238 | 3273 | 3308 | 3344 | 3380 |
| | Administrative | 440 | 445 | 605 | 611 | 618 | 624 | 631 | 636 | 645 | 652 |
| | Electricity | 710 | 718 | 1316 | 1330 | 1349 | 1344 | 1373 | 1388 | 1403 | 1418 |
| | Repairs and maintenance | 656 | 663 | 1215 | 1228 | 1242 | 1255 | 1268 | 1282 | 1296 | 1310 |
| | Depreciation | 4361 | 4361 | 6707 | 6707 | 6707 | 6205 | 6205 | 5636 | 5836 | 5836 |
| | Interest reexpense | 6485 | 6485 | 8502 | 6445 | 4412 | 3196 | 2414 | 1864 | 1677 | 1491 |
| | Total | 15180 | 15227 | 21818 | 19833 | 17872 | 16228 | 15519 | 14675 | 14564 | 14454 |
| | Profit before depreciation | -4358 | -2581 | 194 | 2536 | 9658 | 11265 | 18967 | 20045 | 29709 | 31057 |
| | Profit after depreciation | -8719 | -6942 | -6513 | -4171 | 2951 | 5060 | 12761 | 14210 | 23873 | 25221 |
| | Profit brought forward | -8718 | -15660 | -22174 | -26345 | -23394 | -18334 | -5573 | 8637 | 32510 | 57731 |

| | Item \ Year | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Revenue | Fare revenue in total | 49911 | 50893 | 68965 | 68965 | 89657 | 89657 | 116562 | 116562 | 151527 | 151527 |
| | Ordinary passengers | 44896 | 45779 | 62036 | 62036 | 80648 | 80648 | 104850 | 104850 | 136302 | 136302 |
| | Commuters | 2373 | 2419 | 3278 | 3278 | 4262 | 4262 | 5541 | 5541 | 7203 | 7203 |
| | Students | 2642 | 2694 | 3651 | 3651 | 4747 | 4747 | 6171 | 6171 | 8022 | 8022 |
| | Misc. income | 1497 | 1527 | 2069 | 2069 | 2690 | 2690 | 3497 | 3497 | 4546 | 4546 |
| | Interest received | 463 | 472 | 639 | 639 | 831 | 831 | 1081 | 1081 | 1405 | 1405 |
| | Proceeds from fund carried forward | 483 | 1205 | 1961 | 3013 | 4143 | 5659 | 6689 | 8781 | 10620 | 13504 |
| | Total | 52905 | 54606 | 74098 | 75031 | 97542 | 98893 | 127878 | 129971 | 168150 | 171035 |
| Expenditure | Personnel expenses | 3788 | 3830 | 3872 | 3914 | 3957 | 4000 | 4044 | 4088 | 4132 | 4177 |
| | Other expenses in total | 3416 | 3453 | 3490 | 3528 | 3566 | 3604 | 3643 | 3682 | 3722 | 3762 |
| | Administrative | 659 | 666 | 673 | 680 | 688 | 695 | 702 | 710 | 718 | 725 |
| | Electricity | 1434 | 1449 | 1465 | 1480 | 1496 | 1512 | 1529 | 1545 | 1562 | 1579 |
| | Repairs and maintenance | 1324 | 1338 | 1353 | 1367 | 1382 | 1397 | 1412 | 1427 | 1443 | 1458 |
| | Depreciation | 5836 | 5836 | 5819 | 5819 | 5813 | 5687 | 5687 | 5609 | 5609 | 5609 |
| | Interest reexpense | 1305 | 1118 | 932 | 746 | 559 | 373 | 186 | 0 | 0 | 0 |
| | Total | 14345 | 14237 | 14113 | 14006 | 13895 | 13664 | 13560 | 13379 | 13463 | 13548 |
| | Profit before depreciation | 41395 | 46205 | 65804 | 66844 | 89460 | 90916 | 120005 | 122201 | 160295 | 163095 |
| | Profit after depreciation | 38560 | 40369 | 59985 | 61025 | 83647 | 85229 | 114318 | 116593 | 154687 | 157487 |
| | Profit brought forward | 96291 | 136660 | 196645 | 257670 | 341317 | 426547 | 540865 | 657458 | 812144 | 969631 |

## 14.4 Financial Plan

### 14.4.1 Subsidies

#### 14.4.1.1 Total Amount

The subsidy is divided into a subsidy granted to aid the construction of a new rapid transit system and a subsidy granted to cover the initial operating deficit.

In many instances, as the urban transit railways contribute considerably to the improvement of the infrastructure with significant social and economic impacts, the total cost of construction has been subsidized by the central and local governments.

The operation subsidy which is closely related to the economic policy of the central government such as public utility charges, etc., the subsidy policies of major countries, which varies in each case, are summarized in Table 14-31.

In the case of the Line No. 2 the assumption is made from the example in the construction of the Line No. 1 as well as on the results of the field survey that the central and municipal governments will subsidize the construction costs and operation deficits as follows:

(1) Construction subsidy

The Korean Government and Seoul Municipal Government (SMG) will subsidize about 22.5 percent each of the construction cost totalling about 45 percent.

(2) Operation subsidy

SMG covers the operation deficits, before depreciation. The financing plan for the case where the Government and SMG are assumed to subsidize about 60 percent of the total construction cost is also worked out. In either case, it is necessary to frame a detailed yearly financing plan according to Tables 14-32 and -33.

Table 14-31 Subsidy Policies of Major Countries (1)

| Name of Enterprise | Nature of Enterprise | Financial Subsidy: Construction Subsidy | Financial Subsidy: Operation Subsidy | Sources of Funds |
|---|---|---|---|---|
| London Transport Executive (LTE)<br>(UK) | Public corporation | 100% of the total capital investment<br>Central government: 75%<br>Municipality : 25% | (1) No operation subsidy is in principle granted<br>(2) The operating deficit is covered by the central government and municipality. | Central government: General account budget<br>Municipality: Bond and tax |
| Régie Autonome des Transports Parisiens<br>(France) | Public corporation | (1) 100% of the total capital investment in the case of a suburban trunk railway<br>Central government: 50%<br>Municipality : 50%<br>(2) 60% of the total capital investment in the case of extension of an existing line or construction of a new branch line | The central government subsidizes 70% and Paris municipality 30% of the relevant cost when --<br>(1) Fare hike bill is rejected, or<br>(2) Compulsory fare discount is granted for social welfare purposes | Special taxes<br>Special facilities tax<br>Travelling tax |
| München U Bahn<br>(MUB)<br>(Germany) | Public enterprise | 100% of the total capital investment in the case of a new rapid transit railway<br>Central government: 60%<br>State : 20%<br>Municipality : 20% | The operating deficit is covered by the municipality. | Central government: Fuel tax<br>Municipality: Car registration tax |
| AB Storstockholms Lokaltraffik<br>(SL)<br>(Sweden) | Public enterprise | 100% of the total capital investment in the case of a new rapid transit railway<br>Central government: 50%<br>State (Loan) : 50% | Deficit is always recorded because of the discount rates granted for social welfare purposes. It is covered by the state government | Central government: General account budget<br>State government: Fund raised in the money market and income tax |
| New York City Transit Authority (NYCTA)<br>(USA) | Public enterprise | (1) 100% of the total capital investment in the case of a new rapid transit railway<br>Central government: 8/12<br>State government : 3/12<br>Municipality : 1/12<br>(2) The state and municipality also subsidize the extension and improvement of existing lines | The municipality is not legally required to cover the operating deficit, but subsidizes to cover --<br>(1) Fare discounts for social welfare purposes,<br>(2) Public order maintenance cost, and<br>(3) Cost of repairs and maintenance of station facilities | |
| San Francisco Bay Area Rapid Transit District (BART)<br>(USA) | Special corporation | (1) As the railway is a civic project, its construction cost is for the most part defrayed by the community<br>(2) The federal and state governments cover the deficit | (1) No operation subsidy is in principle granted<br>(2) The state government covers the operating deficit by increasing the fixed asset tax, if necessary | State: Fixed asset tax and sales tax |
| Teito Rapid Transit Authority<br>(Japan) | Special corporation | 90% of the direct construction cost of the total capital investment of the above:<br>Central government: 33%<br>Municipality : 33%<br>Transit authority : 34% | No operation subsidy is granted | Central government: General account budget<br>Municipality: General account budget |

Table 14-32 Financing Plan (Subsidy: About 45%)

Unit: Million Won

| Description \ Year | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | Total |
|---|---|---|---|---|---|---|---|
| Government subsidy | 3,603 | 6,851 | 13,381 | 10,150 | 2,965 | 4,632 | 41,582 |
| Municipality subsidy | 6,893 | 3,385 | 13,156 | 9,980 | 2,915 | 4,556 | 40,885 |
| Municipal bond | - | 11,720 | 15,002 | 11,379 | 3,324 | 5,195 | 46,620 |
| Loans | - | 934 | 8,346 | 28,516 | 837 | 17,280 | 55,913 |
| Total | 10,496 | 22,890 | 49,885 | 60,025 | 10,041 | 31,663 | 185,000 |

Table 14-33 Financing Plan (Subsidy: About 60%)

Unit: Million Won

| Description \ Year | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | Total |
|---|---|---|---|---|---|---|---|
| Government subsidy | 4,699 | 9,253 | 17,860 | 13,547 | 3,957 | 6,184 | 55,500 |
| Municipality subsidy | 5,797 | 8,052 | 17,726 | 13,446 | 3,928 | 6,138 | 55,087 |
| Municipal bond | - | 4,651 | 5,953 | 4,516 | 1,319 | 2,061 | 18,500 |
| Loans | - | 934 | 8,346 | 28,516 | 837 | 17,280 | 55,913 |
| Total | 10,496 | 22,890 | 49,885 | 60,025 | 10,041 | 31,663 | 185,000 |

Table 14-34 Total Amount and Subsidies

Unit: Million Won

| Description \ Case | Case 1 | Case 2 | Case 5 |
|---|---|---|---|
| Government (construction subsidy) | 41,583 | 41,583 | 55,499 |
| Municipality (construction subsidy) | 40,884 | 40,884 | 55,087 |
| (operation subsidy) | 92,750 | 61,352 | 44,948 |
| Subtotal | 133,634 | 102,236 | 100,035 |
| Total | 175,217 | 143,819 | 155,534 |

The total amounts of subsidies for Cases 1 and 2 where the subsidy percentage is 45 percent and Case 5 where the subsidy percentage is 60 percent are shown in Table 14-34.

14.4.1.2 Subsidy Repayment Period

Both the construction and operation subsidies differ from the viewpoint of financial analysis and are dealt with on the assumption that no definite date is set for repayment without carrying any interest.

In the foregoing simulation cases the interest on subsidies is not taken into account, but the assumption is made that their repayment begins when the traffic service becomes the black figure. For instance, the periods of subsidy repayment for simulation Cases 1, 2 and 5 can be estimated as shown in Table 14-35.

Table 14-35 Estimated Period of Subsidy Repayment

Unit: Years

| Case / Type of Subsidy | Case 1 | Case 2 | Case 3 |
|---|---|---|---|
| Operation subsidy | 32 | 18 | 24 |
| Construction subsidy | 48 | 26 | 45 |

In Case No. 2 where the minimum fare is assumed to be 60 Won, it will take about 18 years to repay the operating subsidy. It will be in about 26 years after service inauguration that the construction subsidy is repaid, since it will be repaid out of the profit earned after the operation subsidy repayment.

14.4.2 Fund Source

The total construction cost of the Line No. 2 was estimated to be 185 billion Won. As this amount nearly equals the general budget (annual) of the city of Seoul municipality, it is of course impossible for the municipality to meet the total construction cost with its general account budget. It would be recommendable that the municipality will plan to make loans from other countries with the aid of the central government to cover at least the imports from abroad.

Judging from the case of the Line No. 1, the municipality would plan the floatation of municipal bonds in the hope that citizens who are benefited from the proposed line, when constructed, will subscribe to them. When floating bonds, the yield and method of subscription is to be carefully studied in consideration of the experience with waterworks bonds and national housing bonds.

As about 55 percent of the total construction cost is assumed to be met with loans from abroad and the proceeds from the interest-bearing municipal bonds, the remaining 45 percent will be met with the passive funds from the Korean Government and the SMG. The subsidy policies of major countries are summarized in Table 14-31 with a view to suggesting some possibilities of fund raising in this area.

Needless to mention, the interest-bearing debts should be repaid out of the profit earned by this Line.

(1) Taxation upon Individual Road Users

As is clear from the results of economic analysis of this project, the greater part of the benefit of the Line would be enjoyed by the users of the existing roads in the alleviated road traffic. It therefore stands to reason to tax upon the road users in some way or other after the proposed line comes into regular service.

However, if citizens are willing to subscribe to the municipal bond in large measure, the kinds and levels of taxes are to be carefully decided, as both funds will come from one and the same source.

(a) Fuel tax

(b) Drivers' license tax

(c) Automobile registration tax

(2) Taxation upon Road Traffic Corporations

Passenger-carrying business like bus and taxi operating companies will also directly benefit from the proposed line, when it comes into operation. They have also a good reason for taxation, although it must be taken into consideration that these companies may suffer some loss in the number of passengers when the line starts its regular service.

(a) Corporation registration tax

(b) Corporate income tax

(3) The citizens who live along the route of the proposed line will also benefit not only directly but indirectly from this project. Their indirect benefits include a land price hike in the area served by the line and an increase in income resulting from the prosperous activities after the line comes into operation.

(4) Proceeds from Development of the Station Hinterland

The citizens who live in the neighborhood will indirectly benefit from the proposed line in the land price hike without investing in its construction. If they invest in the intensive utilization of their land, their returns would be the greater. On the other hand, if the Rapid Transit Bureau develops the hinterland, it can make earnings from the land utilization. In fact, there will be a time when the Bureau is called for to develop the hinterland by building shopping centers, station terminal buildings and hotels.

# 15. Economic Analysis

## 15.1 General

This chapter deals with the economic analysis of the Line No. 2 Project. In the foregoing chapters traffic volume in Seoul, construction cost and annual operating costs of the proposed line are estimated. This project is evaluated on the basis of the figures obtained in the preceding chapters.

## 15.2 Process of Economic Analysis

This project is evaluated according to the following criteria. In this study the proposed project is evaluated from the standpoint of the general public, in particular, or the nation as a whole.

### 15.2.1 Criteria for Economic Evaluation

Four basic methods are in general practice employed in the economic analysis of investments in transport facilities, i.e., annual cost method, benefit-cost ratio method, internal rate of return method, and net present value method. In this study this project is evaluated with the three criteria which have been adopted by IBRD, ADB, USAID and OECF.

1) Net present value
2) Benefit-cost ratio
3) Internal rate of return

### 15.2.2 Project Life for Economic Evaluation

The project life for the economic evaluation of this project is determined to be 30 years based on the useful life of civil structures, rolling stock, electric and communication facilities, and other assets. The project life of 20 and 40 years is also evaluated in this study, as the actual useful life of assets is variable from one cases to the other as the case may be.

### 15.2.3 Discount Rate

The discount rate is assumed to be 15 percent in consideration of the interest rates currently prevailing in Korea and the opportunity cost of capital.

Furthermore, the cases of discount rates of 10 and 20 percent will also be studied in anticipation of changes in the general economic situation of the country.

## 15.3 Construction and Operation Plans

### 15.3.1 Construction and Partial Operation

Line No. 2 is planned to be constructed and opened by stage.

1) First Stage

From City Hall to Han Dae Ap (underground section)
From Han Dae Ap to Dae Un Dong Jong (elevated section)

2) Second Stage

From City Hall to Seo Gyo Dong (underground section)

The sections built in the first stage are to be opened in 1982, and the section built in the second stage, in 1984.

### 15.3.2 Construction and Operating Cost

The annual construction and operating costs of the proposed line are shown in Table 15-1 and -2. In this case these costs represent economic ones without regard to taxes. Price fluctuations in the construction costs are taken into the account in the sensitivity analysis.

Table 15-1 Annual Economic Project Cost

[Million Won]

| | |
|---|---|
| 1978 | 8,693 |
| 1979 | 21,557 |
| 1980 | 46,886 |
| 1981 | 53,598 |
| 1982 | 9,620 |
| 1983 | 27,899 |
| Total | 168,253 |

Table 15-2 Annual Economic Operating Cost

[Million Won]

| 1982 | 1983 | 1984 | ----- | 2011 |
|---|---|---|---|---|
| 4,330 | 4,330 | 6,380 | 6,380 | 6,380 |

15.4 Unit Value in Benefit Estimation

The following unit values are used in the estimation of benefits of this project. All the unit values used in this study are those of 1977 and do not include any tax.

15.4.1 Time Benefit

The average time benefit of the nation is obtainable by dividing her GNP per capita of 1977 by the annual working hours. The information required to calculate the average time benefit is obtained from the "Fourth 5-Year Development Plan".

In fact, however, the time benefit considerably differs from one district to the other in Korea. In the light of this fact the average time benefit of the citizens of Seoul was corrected by the ratio (=1.57) between the average income per capita of the nation and that of the citizens of Seoul. The source of information is the Official Bulletin of Seoul, 1973.

(a) Time Benefit of Passengers of Mass Transit System

It is assumed that the same time benefit would apply to the passengers of all mass transit systems, e.g., but, rapid transit railway and KNR. In other words, the average time benefit of passengers of mass transit system with various trip purpose and age distribution can be estimated to be the same to that of Seoul citizen. The children of five years or under are excluded from the calculation of trip generation and GNP per capita.

Average time benefit of passengers of mass transit system is derived from the foregoing:

$$V^t_{P.M} = 4.75 \text{ Won/min}$$

(b) Time Benefit of Car Users

The majority of car users are assumed to make a trip for the purpose to directly contribute the production. The average time benefit of car users is to be 50 percent higher than that of passengers of mass transit systems. The obtained result is as follows:

$$V^t_{P.C} = 7.12 \text{ Won/min}$$

15.4.2 Vehicle Operating Costs

The vehicle operating costs are divided into distance-dependent and time-dependent costs.

(1) Distance-dependent Operating Cost

The distance-dependent trip cost mainly consists of such elements as fuel, lubricant, tire and tube, repairs, depreciation, and personnel cost. For information the operating costs by vehicle currently in use in Japan are shown in Table 15-3.

Table 15-3 Operating Costs by Vehicle in Japan

[Yen/km]

| Type \ Item | | Flat Paved Road | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Fuel | Lubricant | Tire & Tube | Repairs | Depreciation | Labor | Total |
| Medium size vehicle | Passenger car | 5.25 | 0.37 | 1.30 | 2.67 | 12.86 | 1.82 | 24.27 |
| | Truck | 9.10 | 0.64 | 3.00 | 3.16 | 6.43 | 3.05 | 25.38 |
| Compact vehicle | Passenger car | 3.50 | 0.35 | 1.18 | 2.00 | 5.13 | 1.66 | 13.82 |
| | Truck | 3.50 | 0.35 | 0.88 | 1.44 | 5.00 | 2.10 | 13.27 |
| Bus | Regular service | 9.10 | 0.64 | 3.60 | 4.76 | 14.84 | 2.15 | 35.09 |
| | Service Charter | 10.50 | 0.74 | 3.60 | 4.76 | 17.31 | 2.90 | 39.81 |
| Special vehicle | | 10.50 | 0.74 | 6.00 | 4.76 | 17.80 | 3.05 | 42.85 |
| Motorcycle | | 1.75 | 0.18 | 0.42 | 0.94 | 2.62 | 0.83 | 6.74 |
| Light vehicle | | 1.16 | 0.12 | 0.42 | 0.68 | 1.96 | 0.83 | 5.17 |
| Special light vehicle | | 3.02 | 0.30 | 0.15 | 1.50 | 2.36 | 0.83 | 8.16 |
| Small motor cycle | | 0.87 | 0.09 | 0.32 | 0.37 | 1.73 | 0.83 | 4.21 |
| Cart | | - | - | 1.00 | 0.48 | 0.71 | 1.05 | 3.24 |
| Bicycle | | - | - | 0.50 | 0.36 | 0.90 | 0.83 | 2.59 |

(a) Fuel Cost

The fuel cost is calculated by the following:

Fuel cost = UCF x FC

where,

UCF: fuel price (The fuel prices in Korea are shown in Table 15-4.)

CF: fuel consumption per km

The fuel consumption per km is determined from a survey taken in Japan. Refer to Table 15-5.

(b) Lubricant Cost

The lubricant prices that prevailed in Seoul in 1977 are shown in Table 15-7.

Table 15-4 Price in Seoul

[Won/liter]

| | |
|---|---|
| Ajtomotive Diesel Fuel | 50.0 |
| Regular Gasoline | 125.0 |
| High Octane Gasoline | 146.5 |

Table 15-6 Fuel Costs

[Won/km]

| | |
|---|---|
| Bus | 17.50 |
| Car | 11.80 |

(c) Tire and Tube Costs

The prices and useful life of tires of buses and cars are shown in Tables 15-8 and -9, respectively. The prices shown include the tubes.

Table 15-7 Lubricant Consumption

[Won/km]

| | |
|---|---|
| Bus | 0.48 |
| Car | 0.28 |

Table 15-8 Tire Price

[Won/piece]

| | |
|---|---|
| Bus | 38,700 |
| Car | 6,760 |

Table 15-9 Useful Life of Tires

[Won/piece]

| | |
|---|---|
| Bus | 300 (km/day) x 90 (days) |
| Car | 400 (km/day) x 120 (days) |

Table 15-10 Tire and Tube Costs

[Won/km]

| | |
|---|---|
| Bus | 5.73 |
| Car | 0.56 |

Table 15-5 Vehicle Speed and Fuel Consumption

[cc/km]

| Speed km/h \ Type | Light passenger car (360 cc) | Passenger car (1200 cc) | Passenger car (2000 cc) | Truck (2-4 ton) gasoline | Truck (6-8 ton) diesel | Bus (70-86 persons) diesel |
|---|---|---|---|---|---|---|
| 4 | 119 | 170 | 245 | 328 | 415 | 421 |
| 6 | 112 | 160 | 233 | 321 | 410 | 417 |
| 8 | 104 | 149 | 220 | 311 | 403 | 410 |
| 10 | 97 | 139 | 208 | 308 | 397 | 400 |
| 12 | 90 | 130 | 196 | 285 | 375 | 387 |
| 14 | 85 | 122 | 185 | 273 | 358 | 374 |
| 16 | 80 | 115 | 175 | 262 | 343 | 362 |
| 18 | 76 | 109 | 166 | 253 | 332 | 350 |
| 20 | 73 | 104 | 160 | 244 | 321 | 339 |
| 22 | 70 | 100 | 154 | 235 | 312 | 329 |
| 24 | 68 | 96 | 149 | 228 | 303 | 320 |
| 26 | 66 | 94 | 144 | 220 | 294 | 312 |
| 28 | 64 | 91 | 140 | 213 | 286 | 303 |
| 30 | 63 | 88 | 135 | 208 | 280 | 296 |
| 32 | 61 | 85 | 131 | 202 | 271 | 288 |
| 34 | 60 | 82 | 127 | 196 | 264 | 282 |
| 36 | 58 | 80 | 123 | 191 | 258 | 276 |
| 38 | 57 | 77 | 120 | 186 | 252 | 268 |
| 40 | 56 | 75 | 116 | 181 | 245 | 262 |
| 42 | 55 | 73 | 113 | 176 | 240 | 256 |
| 44 | 54 | 72 | 111 | 173 | 235 | 251 |
| 46 | 54 | 70 | 108 | 170 | 231 | 246 |
| 48 | 54 | 69 | 106 | 167 | 227 | 242 |
| 50 | 53 | 68 | 105 | 165 | 223 | 238 |
| 52 | 53 | 67 | 103 | 163 | 220 | 235 |
| 54 | 53 | 66 | 101 | 161 | 218 | 232 |
| 56 | 54 | 66 | 100 | 161 | 216 | 230 |
| 58 | 55 | 66 | 99 | 161 | 213 | 228 |
| 60 | 55 | 65 | 98 | 161 | 211 | 227 |
| 62 | 56 | 65 | 97 | 162 | 210 | 228 |
| 64 | 56 | 65 | 97 | 163 | 212 | 230 |
| 66 | 57 | 66 | 96 | 163 | 214 | 232 |
| 68 | 58 | 66 | 96 | 164 | 216 | 234 |
| 70 | 59 | 67 | 95 | 165 | 219 | 237 |
| 72 | 60 | 67 | 95 | 167 | 222 | 240 |
| 74 | 61 | 68 | 94 | 170 | 225 | 243 |
| 76 | 62 | 69 | 94 | 173 | 229 | 246 |
| 78 | 63 | 70 | 93 | 176 | 233 | 249 |
| 80 | 65 | 71 | 93 | 179 | 237 | 253 |

(d) Depreciation

The total durable kilometerage and depreciation expense of the bus and car are shown in Tables 15-12 and -13, respectively.

(e) The expenses of repairs and labor cost are shown in Table 15-14. The total distance-dependent trip costs by vehicle are shown in Table 15-15.

(2) Time-dependent Operating Cost

The time-dependent operating cost consists of such elements as labor, maintenance and administrative expenses. For information the time benefit, by vehicle according to the Report of the Expressway Survey Association of Japan are shown in Table 15-16.

(a) Labor Cost

The labor cost for bus operation consists of expenses incurred by the employment of drivers and conductors.

(b) Maintenance and Administrative Costs

The time-dependent operating costs are shown in Table 15-17.

Table 15-11 Vehicle Price

| | [Thousand Won] |
|---|---|
| Bus | 5,750 |
| Car | 1,320 |

Table 15-12 Total Kilometerage

| | [Thousand km] |
|---|---|
| Bus | 600 |
| Car | 150 |

Table 15-13 Depreciation Expense

| | [Won/km] |
|---|---|
| Bus | 9.58 |
| Car | 8.80 |

Table 15-14 Repair and Labor Cost

[Won/km]

| | Repair Expense | Labor Cost |
|---|---|---|
| Bus | 2.87 | 1.44 |
| Car | 1.76 | 1.32 |

Table 15-15 Distance-dependent Operating Cost

| | Fuel | Lubricant | Tire & Tube | Depreciation | Repair | Labor | Total |
|---|---|---|---|---|---|---|---|
| Bus | 17.50 | 0.48 | 5.73 | 9.58 | 2.87 | 1.44 | 37.60 |
| Car | 11.88 | 0.28 | 0.56 | 8.80 | 1.76 | 1.32 | 24.60 |

Table 15-16 Time Benefit by Vehicle in Japan

| Type of Vehicle | | Time Benefit Cost (Yen/min) |
|---|---|---|
| Passenger car | | 11.68 -- 14.69 |
| Bus | Regular service | 44.50 -- 82.13 |
| | Service on charter | 74.01 --125.21 |
| | Regular size | 40.49 |
| Truck | Small size | 15.39 -- 16.21 |

Table 15-17 Time-dependent Operating Cost

[Won/min]

| Type of Vehicle \ Cost Element | Labor | Maintenance and Administration | Total |
|---|---|---|---|
| Bus | 22.79 | 13.91 | 36.70 |
| Car | - | 1.83 | 1.83 |

## 15.5 Benefits of Line No. 2 Project

As noted before, this project is studied from the standpoint of the public interest and its benefits are evaluated on the national level. In other words, the benefits can be defined as the difference in socio-economic cost between the cases whether the Line No. 2 is constructed or not. Thus the difference is termed as that between the traffic system with Line No. 2 and the existing traffic system, which is operated with the present service level.

### 15.5.1 Benefits Estimated in this Study

The economic impact of the proposed project will spread over a wide area when implemented. In this study, however, its economic evaluation is limited in the direct benefit of traffic sector. Economic and diseconomic effects on the assets, development and such indirect effects as economic and diseconomic impacts for market are not be counted among the benefits of the proposed project because of two reasons. One is that quantification of these effects is difficult.

The other is that by leaving out such beneficial effects of the proposed project, this study can have an extra margin of safety in benefit analysis.

The traffic benefits derived from the proposed line can be classified as follows:

1) Benefits Accruing from Diverted Traffic

    (a) Benefit from diverted passengers

    (b) Benefit from transport facilities

2) Benefits Accruing from Undiverted Traffic

    (a) Benefit from undiverted passengers

    (b) Benefit from transport facilities

The benefits of the Line No. 2 is the difference in socio-economic cost that it would bring about and can be counted in terms of time saved by passengers and a reduction in operating, maintenance and administration costs of the public traffic facilities.

Passengers' benefit is the travelling time thus saved. The benefit of the public transport facilities is reduction in operating, maintenance and administration costs, that is, savings that are made in fuel cost, maintenance expense, labor cost, vehicles, and other expenses incurred in the operation of traffic facilities including buses and cars.

The benefits of the proposed line are analyzed on the diverted traffic and undiverted traffic separately, in order to take into consideration possible fluctuations of the estimated traffic volume for the proposed line.

In this study the accident cost is not taken up, because the hazards involved in transportation are assumed to be not so different among all public transport modes. In other words, only the diversion from the one public transport to the other will be considered. The assumption is also made in the traffic volume that the traffic diverted to the Line No. 2 consists of passengers of buses, the Line No. 1, and the KNR, and that the car users who are to be diverted to the Line No. 2 are negligible.

### 15.5.2 Benefits from Diverted Traffic

#### (1) Benefit to Diverted Passengers

When the Line No. 2 opens its regular service, the passengers who divert from the existing traffic systems including the Line No. 1 to the Line No. 2 will enjoy the time benefit calculated by the following equation:

$$B(D)_i = \Sigma P^D_{i,j} (T^{D'}_{i,j} - T^D_{i,j}) \cdot V^i_P$$

where,

$B(D)_i$ : Unit time benefit of diverted passengers

$P^D_{i,j}$ : Number of diverted passengers between zones i and j

$T^{D'}_{i,j}$ : Time required for a transit system to carry passengers between zones i and j when the Line No. 2 is not constructed

$T^D_{i,j}$ : Time required for a transit system to carry diverted passengers between zones i and j when the Line No. 2 is not constructed

$V'_P$ : Time benefit of diverted passengers

The letter with apostrophe indicates the figure for the cases where the Line No. 2 is not constructed.

The Line No. 2 is constructed, traffic diversion will occur among the following main public transport modes:

- Buses ⟶ Line No. 2
- Line No. 1 and KNR ⟶ Line No. 2

The diverted passenger means here the passenger who uses at least a part of the Line No. 2 on his way to office or home.

The time-saving benefit of diverted passengers can be calculated by the following equation:

$$B(D)_i = \Sigma \left( P^{D \cdot B'}_{i,j} \cdot T^{D \cdot B'}_{i,j} + P^{D \cdot R'}_{i,j} \cdot T^{D \cdot R'}_{i,j} - P^{D}_{i,j} \cdot T^{D}_{i,j} \right) \cdot V'_{P\,M}$$

$$\begin{cases} P^{D}_{i,j} = P^{D \cdot B'}_{i,j} + P^{D \cdot R'}_{i,j} \\ P^{D}_{i,j} \cdot T^{D'}_{i,j} = P^{D \cdot B'}_{i,j} \cdot T^{D \cdot B'}_{i,j} + P^{D \cdot R'}_{i,j} \cdot T^{D \cdot R'}_{i,j} \end{cases}$$

where,

$P^{D \cdot B'}_{i,j}$ : Number of trips made between the zones i and j by passengers who use buses as a main traffic system when the Line No. 2 is not constructed

$P^{D \cdot R'}_{i,j}$ : Number of trips made between the zones i and j by passengers who use the Line No. 1 and the KNR as main traffic systems when the Line No. 2 is not constructed

$T^{D \cdot B'}_{i,j}$ : Time required for a bus to carry passengers between zones i and j when the Line No. 2 is not constructed

$T^{D,R'}_{i,j}$ : Time required for the Line No. 1 or the KNR to carry passengers between zones i and j when the Line No. 2 is not constructed

$V^{t}_{P \cdot M}$ : Unit benefit of mass transit system users

From these equations, the time-saving benefit of diverted passengers can be computed as shown in Table 15-18.

Table 15-18 Benefit from Diverted Passengers

| | [Man.hr/Day] | |
|---|---|---|
| 1982 | 20,972 | At the Overall opening in 1984 |
| 1984 | 44,432 | ° Time saving per person per day 3 minutes and 35 seconds |
| 1994 | 55,655 | ° Annual total benefit 4,620 million Won |

(2) Benefit from Transport Facilities

When Line No. 2 opens its regular service, traffic diversion arises so that the operation, maintenance and administration costs of the existing transport systems are reduced. This benefit of a reduction in operating cost can be calculated as a function of time and distance.

1) Distance-dependent Benefit

When the Line No. 2 is constructed, bus passengers divert thereto to some extent so that a benefit accrues from the reduction in the travelling distance of buses. This distance-dependent benefit can be calculated by the following equation:

$$B(D)_2 = \sum_{i,j} (B^{D'}_{i,j} \cdot LB^{D'}_{i,j} - B^{D}_{i,j} \cdot LB^{D}_{i,j}) \cdot V^{L}_{B}$$

where,

$B^{D'}_{i,j}$ : Number of bus trips made by potential diverted passengers between zones i and j when the Line No. 2 is not constructed

$B^{D}_{i,j}$ : Number of bus trips made by diverted passengers between zones i and j when the Line No. 2 is constructed

$LB^{D'}_{i,j}$ : Distance travelled by buses carrying potential diverted passengers between zones i and j when the Line No. 2 is not constructed

$LB^{D}_{i,j}$ : Distance travelled by buses carrying diverted passengers between zones i and j when the Line No. 2 is constructed

$V^{L}_{B}$ : Bus operating cost (distance-dependent cost)

This calculation is made through comparison of the bus-kilometer $(B^{D'}_{i,j} \cdot LB^{D'}_{i,j}$ , $B^{D}_{i,j} \cdot LB^{D}_{i,j})$ as follows:

Table 15-19 Distance-dependent Benefit to Bus
[Bus-kilometer/Day]

| | | |
|---|---|---|
| 1982 | 103,933 | At the overall opening in 1984 |
| 1984 | 210,344 | ° Annual reduction in distance travelling distance 76,800,000 km |
| 1994 | 265,948 | ° Annual benefit 2,890 million Won |

2) Time-dependent Benefit

When Line No. 2 is constructed, some bus passengers are diverted thereto so that benefits accrue from time savings made by buses. This benefit can be calculated by the following equation:

$$B(D)_3 = \sum_{i,j} (B^{D'}_{i,j} \cdot TB^{D'}_{i,j} - B^{D}_{i,j} \cdot TB^{D}_{i,j}) \cdot V^{t}_{B}$$

where,

$TB^{D'}_{i,j}$ : Time required for buses to carry the potential diverted passengers between zones i and j when the Line No. 2 is not constructed

$TB^{D}_{i,j}$ : Time required for buses to carry the potential diverted passengers between zones i and j when the Line No. 2 is constructed

$V^{t}_{B}$ : Bus operating cost (time-dependent cost)

This calculation is made through comparison of the aggregate operating hours of buses $(B^{D'}_{i,j} \cdot TB^{D'}_{i,j}, \quad B^{D}_{i,j} \cdot TB^{D}_{i,j})$.

The saving in operating number of vehicles resulting from the reduction in bus operating time is calculated, based on obtained from the Bureau of Transportation of the Tokyo Metropolitan Government as follows:

° Saving in Bus Capital Cost ($S_C$)

$$S_C = S_n \cdot S_v / L_b$$

where,

$S_n$ : Number of buses saved
$S_v$ : Bus investment
$L_b$ : Useful life of buses

° $S_n$ is calculated by the following equation:

$$S_n = S_t / M_t \cdot (1.0 + S_r + R_t)$$

where,

$S_t$ : Saving in bus operating time
$M_t$ : Bus operating time per vehicle per day
$S_r$ : Reserve ratio
$R_t$ : Bus repair and inspection ratio

Table 15-20 Bus Operation Coefficient in Seoul

| | |
|---|---|
| Operating hours (4:00 -- 24.00) | 20 hr |
| Operating time per bus per day (95% of operating hr) | 19 hr |
| Repair and inspection ratio | 1/3 day/week |
| Reserve ratio | 5% |
| Useful life of buses | 5 yrs |

The time-dependent benefit to buses is finally computed as shown in Table 15-21.

Table 15-21 Time-dependent Benefit of Buses

| | (Bus.hr/Day) | |
|---|---|---|
| 1982 | 5,471 | At the Overall opening 1984 |
| 1984 | 11,100 | ° Number of buses saved 505 |
| 1994 | 14,027 | |
| | | ° Annual benefit 8,920 million Won |

The benefit of a reduction in the running cost of the Line No. 1 and the KNR is not included in the benefits accrued from the diverted traffic. The passengers of the Line No. 1 and the KNR are estimated to decrease by about 6 percent, when the Line No. 2 is constructed. In this study, however, the benefit of this benefit is not taken up in part because the effect on the operating cost of the Line No. 1 and the KNR cannot be accurately determined and in part because by leaving it out, this study can have an extra margin of safety in benefit analysis.

### 15.5.3 Benefit from Undiverted Traffic

#### (1) Benefit to Undiverted Passengers

The Line No. 2, when constructed, will alleviate road traffic congestion in Seoul with the result that the travelling time can be reduced accordingly.

The benefit of the reduction in travelling time can be calculated by the following equation:

$$B(U)_1 = \sum_{i \cdot j} P^U_{i,j} \; (T^{U'}_{i,j} - T^U_{i,j}) \cdot V^t_P$$

where,

$P^U_{i,j}$ : Number of undiverted passengers between zones i and j

$T^{U'}_{i,j}$ : Time required for a transport system to carry potential undiverted passengers between zones i and j when the Line No. 2 is not constructed

$T^U_{i,j}$ : Time required for a transport system to carry undiverted passengers between zones i and j when the Line No. 2 is constructed

$V^t_P$ : Unit time benefit of undiverted passengers

The main transport systems used by the potential undiverted passengers will be buses, the Line No. 1, the KNR, private cars, or pedestrainism. The assumption is made in this study that the service level of the Line No. 1 and the KNR will not change after the Line No. 2 is opened.

The time-saving benefit of undiverted passengers will be derived from the alleviation of road traffic congestion for the users of buses and cars.

This time-saving benefit can be calculated by the following equation:

$$B(U)_1 = B(U)_C + B(U)_B$$

where,

$B(U)_B$ : Time-saving benefit to bus passengers

$B(U)_C$ : Time-saving benefit to car users

The time-saving benefit of undiverted passengers by transport system can be calculated as follows:

1) Time-saving Benefit to Bus Passengers

$$B(U)_B = \sum_{i,j} P_{i,j}^{U.B'} (T_{i,j}^{U.B'} - T_{i,j}^{U.B}) \cdot V_{P.M}^{t}$$

where,

$P_{i,j}^{U.B}$ : Number of undiverted bus passengers between zones i and j

$T_{i,j}^{U.B'}$ : Time required for the bus passengers between zones i and j when the Line No. 2 is not constructed

$T_{i,j}^{U.B}$ : Time required for the bus passengers between zones i and j when the Line No. 2 is constructed

$V_{P.M}^{t}$ : Unit time benefit of mass transit system users

2) Time-saving Benefit to Car Users

$$B(U)_C = \sum_{i,j} P_{i,j}^{U.C} (T_{i,j}^{U.C'} - T_{i,j}^{U.C}) \cdot V_{P.C}^{t}$$

where,

$P_{i,j}^{U.C}$ : Number of undiverted car users between zones i and j

$T_{i,j}^{U.C'}$ : Time required for the car user to make a trip between zones i and j when the Line No. 2 is not constructed

$T_{i,j}^{U.C}$ : Time required for the car user to make a trip between zones i and j when the Line No. 2 is constructed

$V_{P.C}^{t}$ : Unit time benefit of car users

Table 15-23 Time-saving Benefit of Undiverted Bus Passengers

Time Saved by Undiverted Bus Passengers

| | [Man.hr/Day] |
|---|---|
| 1982 | 70,629 |
| 1984 | 109,115 |
| 1994 | 133,395 |

At the Overall Opening in 1984

° Time saving per person per day
57 seconds

° Annual total benefit
11,350 million Won

Table 15-24 Time-saving Benefit of Car Users

Time Saved by Car Users

| | [Man.hr/Day] |
|---|---|
| 1982 | 20,495 |
| 1984 | 33,057 |
| 1994 | 40,560 |

At the Overall Opening in 1984

° Time saving per person per day
1 minute

° Annual total benefit
5,150 million Won

(2) Benefit from Transport Facilities

When the Line No. 2 is opened for the regular service, traffic diversion will alleviate the road traffic congestion so that the operation, maintenance and administration costs of the existing transport systems used by undiverted passengers will be reduced. The benefit of a reduction in operating cost is calculated in terms of travelling time of bus and car.

The assumption is made that the car- and bus-kilometers are the same, whether the Line No. 2 is constructed or not.

$$B(U)_2 = B(U.B) + B(U.C)$$

where,

$B(U)_2$ : Benefit from the transport facilities for undiverted passengers

B(U.B) : Benefit from the bus service for undiverted passengers

B(U.C) : Benefit from the private cars

The reduction in the maintenance and operation costs of cars is included in the direct benefit of car users depending on the case, but in this study it is included in the benefit of reduction in operating cost to the traffic facilities.

1) Benefit from the Bus Service

The benefit of reduction in the travelling time of buses used undiverted passengers can be calculated by the following equation.

$$B(U.B) = \sum_{i,j} B^{U}_{i,j} (TB^{U'}_{i,j} - TB^{U}_{i,j}) \cdot V^{t}_{B}$$

where,

$B^{U}_{i,j}$ : Number of bus trips for undiverted passengers between zones i and j

$TB^{U'}_{i,j}$ : Travelling time of buses for the potential undiverted passengers between zones i and j when the Line No. 2 is not constructed

$TB^{U}_{i,j}$ : Travelling time of buses for the undiverted passengers between zones i and j when the Line No. 2 is constructed

$V^{t}_{B}$ : Bus operating cost (time-dependent cost)

This calculation is made through comparison of the aggregate operating hours ( $B^{U'}_{i,j} \cdot TB^{U'}_{i,j}$ , $B^{U}_{i,j} \cdot TB^{U}_{i,j}$ ). In other words, the benefit is expressed by the difference in aggregate operating hours that will result from the alleviated road traffic congestion.

Table 15-25 Benefit from Bus Service

| Time Saved Buses [Bus.hr/Day] | | At the Overall Opeerating in 1984 |
|---|---|---|
| 1982 | 4,668 | ° Number of buses saved 328 |
| 1984 | 7,204 | ° Annual benefit 5,790 million Won |
| 1994 | 8,736 | |

The average saving in bus travelling time resulting from the alleviated of road traffic congestion is 0.165 min/km.

2) Benefit from Private Car

The benefit of a reduction in the travelling time of cars used by undiverted persons can be calculated by the following equation:

$$B(U.C) = \sum_{i,j} C^{U}_{i,j} (TC^{U'}_{i,j} - TC^{U}_{i,j}) \cdot V^{t}_{C}$$

where,

$C^{U}_{i,j}$ : Number of car trips made by undiverted users between zones i and j

$TC^{U'}_{i,j}$ : Travelling time required for the potential undiverted car users between zones i and j when the Line No. 2 is not constructed

$TC^{U}_{i,j}$ : Travelling time required for undiverted car users between zones i and j when the Line No. 2 is constructed

$V^{t}_{C}$ : Car operating cost (time-dependent cost)

The benefit is calculated as shown in Table 15-26.

Table 15-26 Benefit from Transport Facilities

| Time Saved By Private Cars [Car.hr/Day] | | At the Overall Opening in 1984 |
|---|---|---|
| 1982 | 12,809 | ° Annual benefit 830 million Won |
| 1984 | 20,661 | |
| 1994 | 25,027 | |

The average saving in car travelling time resulting from the alleviated road traffic congestion is 0.086 min/km.

## 15.6 Economic Evaluation of Project

The Line No. 2 is planned to be constructed by stage, and the useful life of 30 years applied in this economic evaluation starts when the whole line is opened to traffic.

The figures shown in Table 15-27 are obtained by the economic analysis of the Line No. 2 project.

The economic analysis shows that all cases in the net present value, benefit-cost ratio and internal rate of return comply with the requirements previously discussed. As a result, it can be concluded that the Line No. 2 is economically feasible.

When the benefit of a partial service is omitted, the net present value (at the beginning of 1984) is estimated to be 2,357 million Won and the benefit-cost ratio is 1.01 based on the discount rate 15% per annum. These figures suggest how important a partial service will be, if the plan of construction is the same whether the line is opened partially or wholly.

## 15.7 Sensitivity Analysis

### 15.7.1 Parameters Used in Sensitivity Analysis

The following parameters are applied in the sensitivity analyses of the Line No. 2 project.

(1) Project Life and Discount Rate

The proposed project is basically evaluated with the useful life of 30 years, and the discount-rate of 15 percent. These figures are modified in the sensitivity analyses.

(2) Unit Time Benefit

The time benefit of passengers is hard to determine accurately whatever approach may be adopted. In the estimation of the unit time benefit of passengers, the children of five years or under are excluded for an extra margin of safety. However, this age limit may give the minimum average benefit of passengers, because the users of mass transit systems and car users are not evenly distributed in all generations over 5 years of age, but there is a tendency for concentration of the generations which can contribute to production.

In the light of such tendency the time benefit of passengers used in this study may be lower than actually is. Therefore, this study also includes a case where only the generations of 15 years or over, working generations, are considered.

(3) Economic Project Cost

The fluctuations in the economic project cost is analyzed in this study.

(4) Planned Population

The fluctuations in the planned population is analyzed in this study.

(5) Passengers on Line No. 2

The fluctuations in the estimated traffic volume on the Line No. 2 will be analyzed, assuming that there will be no change in undiverted traffic volume.

1977 Price

Unit: Billion Won

## Table 15-27 Economic Analysis

| No. | Year | Estimated Cost | Maintenance Cost | Total Cost | Benefit | | Total Benefit | Present Value | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Diverson | Undiversion | | 15.0% | | 17.6% | |
| | | | | | | | | Cost | Benefit | Cost | Benefit |
| -5 | 1978 | 8.693 | 0. | 8.693 | 0. | 0. | 0. | 17.485 | 0. | 19.582 | 0. |
| -4 | 1979 | 21.557 | 0. | 21.557 | 0. | 0. | 0. | 37.703 | 0. | 41.279 | 0. |
| -3 | 1980 | 46.886 | 0. | 46.886 | 0. | 0. | 0. | 71.308 | 0. | 76.322 | 0. |
| -2 | 1981 | 53.598 | 0. | 53.598 | 0. | 0. | 0. | 70.883 | 0. | 74.169 | 0. |
| -1 | 1982 | 9.620 | 4.330 | 13.950 | 8.013 | 14.808 | 22.821 | 16.042 | 26.244 | 16.410 | 26.845 |
| 0 | 1983 | 27.899 | 4.330 | 32.229 | 8.013 | 14.808 | 22.821 | 32.229 | 22.821 | 32.229 | 22.821 |
| 1 | 1984 | 0. | 6.380 | 6.380 | 16.430 | 23.123 | 39.553 | 5.548 | 34.394 | 5.424 | 33.624 |
| 2 | 1985 | 0. | 6.380 | 6.380 | 16.858 | 23.625 | 40.483 | 4.824 | 30.611 | 4.610 | 29.255 |
| 3 | 1986 | 0. | 6.380 | 6.380 | 17.287 | 24.127 | 41.414 | 4.195 | 27.230 | 3.919 | 25.441 |
| 4 | 1987 | 0. | 6.380 | 6.380 | 17.715 | 24.630 | 42.344 | 3.648 | 24.211 | 3.332 | 22.113 |
| 5 | 1988 | 0. | 6.380 | 6.380 | 18.143 | 25.132 | 43.275 | 3.172 | 21.515 | 2.832 | 19.211 |
| 6 | 1989 | 0. | 6.380 | 6.380 | 18.571 | 25.634 | 44.205 | 2.758 | 19.111 | 2.408 | 16.682 |
| 7 | 1990 | 0. | 6.380 | 6.380 | 19.000 | 26.136 | 45.136 | 2.398 | 16.968 | 2.047 | 14.480 |
| 8 | 1991 | 0. | 6.380 | 6.380 | 19.428 | 26.638 | 46.066 | 2.086 | 15.059 | 1.740 | 12.563 |
| 9 | 1992 | 0. | 6.380 | 6.380 | 19.856 | 27.141 | 46.997 | 1.814 | 13.359 | 1.479 | 10.895 |
| 10 | 1993 | 0. | 6.380 | 6.380 | 20.285 | 27.643 | 47.927 | 1.577 | 11.847 | 1.257 | 9.445 |
| 11 | 1994 | 0. | 6.380 | 6.380 | 20.713 | 28.145 | 48.858 | 1.371 | 10.502 | 1.069 | 8.185 |
| 12 | 1995 | 0. | 6.380 | 6.380 | 20.713 | 28.145 | 48.858 | 1.192 | 9.132 | 0.909 | 6.958 |
| 13 | 1996 | 0. | 6.380 | 6.380 | 20.713 | 28.145 | 48.858 | 1.037 | 7.941 | 0.772 | 5.915 |
| 14 | 1997 | 0. | 6.380 | 6.380 | 20.713 | 28.145 | 48.858 | 0.902 | 6.905 | 0.657 | 5.028 |
| 15 | 1998 | 0. | 6.380 | 6.380 | 20.713 | 28.145 | 48.858 | 0.784 | 6.004 | 0.558 | 4.275 |
| 16 | 1999 | 0. | 6.380 | 6.380 | 20.713 | 28.145 | 48.858 | 0.682 | 5.221 | 0.475 | 3.634 |
| 17 | 2000 | 0. | 6.380 | 6.380 | 20.713 | 28.145 | 48.858 | 0.593 | 4.540 | 0.403 | 3.089 |
| 18 | 2001 | 0. | 6.380 | 6.380 | 20.713 | 28.145 | 48.858 | 0.516 | 3.948 | 0.343 | 2.626 |
| 19 | 2002 | 0. | 6.380 | 6.380 | 20.713 | 28.145 | 48.858 | 0.448 | 3.433 | 0.291 | 2.232 |
| 20 | 2003 | 0. | 6.380 | 6.380 | 20.713 | 28.145 | 48.858 | 0.390 | 2.985 | 0.248 | 1.898 |
| 21 | 2004 | 0. | 6.380 | 6.380 | 20.713 | 28.145 | 48.858 | 0.339 | 2.596 | 0.211 | 1.613 |
| 22 | 2005 | 0. | 6.380 | 6.380 | 20.713 | 28.145 | 48.858 | 0.295 | 2.257 | 0.179 | 1.371 |
| 23 | 2006 | 0. | 6.380 | 6.380 | 20.713 | 28.145 | 48.858 | 0.256 | 1.963 | 0.152 | 1.166 |
| 24 | 2007 | 0. | 6.380 | 6.380 | 20.713 | 28.145 | 48.858 | 0.223 | 1.707 | 0.129 | 0.991 |
| 25 | 2008 | 0. | 6.380 | 6.380 | 20.713 | 28.145 | 48.858 | 0.194 | 1.484 | 0.110 | 0.842 |
| 26 | 2009 | 0. | 6.380 | 6.380 | 20.713 | 28.145 | 48.858 | 0.169 | 1.291 | 0.094 | 0.716 |
| 27 | 2010 | 0. | 6.380 | 6.380 | 20.713 | 28.145 | 48.858 | 0.147 | 1.122 | 0.079 | 0.609 |
| 28 | 2011 | 0. | 6.380 | 6.380 | 20.713 | 28.145 | 48.858 | 0.127 | 0.976 | 0.068 | 0.518 |
| 29 | 2012 | 0. | 6.380 | 6.380 | 20.713 | 28.145 | 48.858 | 0.111 | 0.849 | 0.057 | 0.440 |
| 30 | 2013 | 0. | 6.380 | 6.380 | 20.713 | 28.145 | 48.858 | 0.096 | 0.738 | 0.049 | 0.374 |
| Total | | 168.253 | 200.060 | 368.313 | 613.859 | 846.345 | 1,460.205 | 287.542 | 338.964 | 295.892 | 295.855 |
| | | | | | | | Net-Present Value | 51.422 | | -0.037 | |
| | | | | | | | B/C Ratio | 1.179 | | 1.000 | |

Internal Rate of Return : 17.63 %

15.7.2 Results of Analyses

(1) Project Life and Discount Rate

The results of sensitivity analyses of the project based on the project life and discount rate are represented in Table 15-28 and Fig. 15-1. The benefit-cost ratio of the project is quite sensitive to the change in discount rate. When the discount rate is lowered, the net present value of the project increases in a sharp curve. It can therefore be said that the project is well feasible even if the project life is changed, so long as the discount rate is not higher than 17 percent.

(2) Unit Time Benefit

When the generations of 15 years and over are considered as users of traffic facilities, unit time benefit rises by 40 percent so that the economic value of this project increases sharply. In this case the project is well feasible if the discount rate is not higher than 19 percent. As the actual time benefit of passengers seems to be in the neighborhood of this value, it may be implied that this study has an enough margin of safety in its economic analysis.

(3) Economic Project Cost

The results of sensitivity analyses of the project based on the economic project cost are represented in Table 15-30 and Fig. 15-3. The project is well feasible, even if the economic project cost is increased by 10 percent (I.R.R = 16.3%). Should the economic project cost be decreased by 3 to 4 percent, the project is feasible even if the discount rate is as high as 18 percent.

(4) Planned Population

The results of sensitivity analyses of the project based on the planned population are represented in Table 15-31 and Fig. 15-4. The project is still feasible even if the estimation of the planned population is in err by 10 percent. Although the project is more sensitive to the changes in the planned population than to the changes in the economic project cost or in the number of diverted passengers, the error in population estimation can generally be considered to be insignificant, judging from the method of estimation.

(5) Passengers of Line No. 2

The sensitivity of the project to the changes in the estimated number of diverted passengers is analyzed in Table 15-32 and Fig. 15-5. The project is less sensitive to the changes in the estimated number of diverted passengers than to the changes in the planned population or in the economic project cost.

The conclusion can therefore be drawn from the above results of economic analysis that the Line No. 2 project is feasible, unless the Korean economy undergoes an extraordinary change. It is also noted that an extra margin of safety is an important consideration throughout the benefit calculation stages in this study.

No alternative plan is considered in this study. If it can be called an alternative plan to maintain the present transport service in one way or another, the proposed project is recommendable to be promoted by all means in preference to the alternative plan.

Table 15-28 Sensitivity Analysis (1)
(Project Life and Discount Rate)

Unit of Net Present Value: Billion Won

| Discount Rate (%) | Project Life | | | | | |
|---|---|---|---|---|---|---|
| | 20 years | | 30 years | | 40 years | |
| | Benefit-Cost Ratio | Net Present Value | Benefit-Cost Ratio | Net Present Value | Benefit-Cost Ratio | Net Present Value |
| 8 | 1.79 | 2,152.8 | 1.98 | 2,764.3 | 2.06 | 3,047.5 |
| 10 | 1.56 | 1,552.9 | 1.69 | 1.920.9 | 1.73 | 2,070.5 |
| 12 | 1.37 | 1,017.4 | 1.45 | 1,266.2 | 1.48 | 1,346.3 |
| 15 | 1.13 | 384.0 | 1.18 | 514.2 | 1.19 | 546.4 |
| 18 | 0.96 | - 133.8 | 0.98 | - 64.1 | 0.98 | - 50.7 |
| 20 | 0.86 | - 434.7 | 0.87 | - 388.2 | 0.88 | - 380.7 |
| I.R.R. | 17.2% | | 17.6% | | 17.7% | |

Table 15-29 Sensitivity Analyses (2)
(Unit Time Benefit of Passengers)

Unit of Net Present Value: Billion Won

| Discount Rate (%) | Project Life | | | | | |
|---|---|---|---|---|---|---|
| | 20 years | | 30 years | | 40 years | |
| | Benefit-Cost Ratio | Net Present Value | Benefit-Cost Ratio | Net Present Value | Benefit-Cost Ratio | Net Present Value |
| 8 | 2.02 | 2,776.3 | 2.25 | 3,535.6 | 2.35 | 3,887.3 |
| 10 | 1.75 | 2,054.1 | 1.90 | 2,535.8 | 1.96 | 2,721.5 |
| 12 | 1.53 | 1,459.8 | 1.63 | 1,768.7 | 1.66 | 1,868.2 |
| 15 | 1.26 | 739.8 | 1.31 | 901.5 | 1.33 | 941.5 |
| 18 | 1.06 | 161.6 | 1.08 | 248.2 | 1.09 | 264.7 |
| 20 | 0.94 | - 189.4 | 0.96 | - 111.8 | 0.97 | - 102.4 |
| I.R.R. | 19.0% | | 19.4% | | 19.4% | |

Table 15-30 Sensitivity Analysis (3)
(Economic Project Cost)

Unit of Net Present Value: Billion Won

| Discount Rate | Economic Project Cost (90%) | | Economic Project Cost (95%) | | Economic Project Cost (100%) | | Economic Project Cost (105%) | | Economic Project Cost (110%) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Benefit-cost Ratio | Net Present Value | Benefit-cost Ratio | Net Present Value | Benefit-cost Ratio | Net Present Value | Benefit-cost Ratio | Net Present Value | Benefit-cost Ratio | Net Present Value |
| 8% | 2.13 | 296.63 | 2.05 | 286.53 | 1.98 | 276.43 | 1.91 | 226.33 | 1.85 | 256.23 |
| 10% | 1.82 | 213.22 | 1.75 | 202.65 | 1.69 | 192.09 | 1.62 | 181.52 | 1.57 | 170.96 |
| 12% | 1.57 | 148.72 | 1.51 | 137.67 | 1.45 | 126.62 | 1.40 | 115.57 | 1.34 | 104.52 |
| 15% | 1.28 | 75.06 | 1.23 | 63.24 | 1.18 | 51.42 | 1.13 | 39.60 | 1.09 | 27.79 |
| 18% | 1.07 | 18.85 | 1.02 | 6.23 | 0.98 | -6.42 | 0.94 | -19.04 | 0.90 | -31.67 |
| 20% | 0.96 | -12.42 | 0.91 | -25.62 | 0.87 | -38.82 | 0.84 | -52.02 | 0.80 | -65.22 |
| I.R.R. | 19.2% | | 18.4% | | 17.6% | | 17.0% | | 16.3% | |

Project life: 30 years

Table 15-31 Sensitibity Analysis (4)
(Planned Population)

Unit of Net Present Value: Billion Won

| Discount Rate (%) | Planned Population (90%) | | Planned Population (95%) | | Planned Population (100%) | | Planned Population (105%) | | Planned Population (110%) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Benefit-Cost Ratio | Net Present Value | Benefit-Cost Ratio | Net Present Value | Benefit-Cost Ratio | Net Present Value | Benefit-Cost Ratio | Net Present Value | Benefit-Cost Ratio | Net Present Value |
| 8 | 1.78 | 220.51 | 1.88 | 248,47 | 1.98 | 276.43 | 2.08 | 304.39 | 2.18 | 332.35 |
| 10 | 1.52 | 144.83 | 1.60 | 168.46 | 1.69 | 192.09 | 1.77 | 215.72 | 1.85 | 239.35 |
| 12 | 1.31 | 85.80 | 1.38 | 106.21 | 1.45 | 126.62 | 1.52 | 147.03 | 1.65 | 167.45 |
| 15 | 1.06 | 17.53 | 1.12 | 34.48 | 1.18 | 51.42 | 1.24 | 68.37 | 1.30 | 85.32 |
| 18 | 0.88 | -35.49 | 0.93 | -20.95 | 0.98 | - 6.41 | 1.03 | 8.14 | 1.08 | 22.68 |
| 20 | 0.79 | -65.47 | 0.83 | -52.14 | 0.87 | -38.82 | 0.92 | -25.50 | 0.96 | -12.18 |
| I.R.R. | 15.9% | | 16.8% | | 17.6% | | 18.5% | | 19.3% | |

Project Analysis Period: 30 years

Table 15-32 Sensitivity Analysis (5)
(Diverted Traffic Volume)

Unit of Net Present Value: Billion Won

| Discount Rate (%) | Diverted Traffic Volume (90%) | | Diverted Traffic Volume (95%) | | Diverted Traffic Volume (100%) | | Diverted Traffic Volume (105%) | | Diverted Traffic Volume (110%) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Benefit-Cost Ratio | Net Present Value | Benefit-Cost Ratio | Net Present Value | Benefit-Cost Ratio | Net Present Value | Benefit-Cost Ratio | Net Present Value | Benefit-Cost Ratio | Net Present Value |
| 8 | 1.90 | 253.21 | 1.94 | 264.82 | 1.98 | 276.43 | 2.02 | 288.05 | 2.06 | 299.66 |
| 10 | 1.62 | 172.54 | 1.65 | 182.31 | 1.69 | 192.09 | 1.72 | 201.87 | 1.75 | 211.65 |
| 12 | 1.39 | 109.79 | 1.42 | 118.21 | 1.45 | 126.62 | 1.48 | 135.04 | 1.51 | 143.46 |
| 15 | 1.13 | 37.53 | 1.56 | 44.47 | 1.18 | 51.42 | 1.20 | 58.38 | 1.23 | 65.32 |
| 18 | 0.94 | -18.27 | 0.96 | -12.34 | 0.98 | - 6.42 | 1.00 | - 0.47 | 1.02 | 5.46 |
| 20 | 0.84 | -49.65 | 0.86 | -44.24 | 0.87 | -38.82 | 0.89 | -33.40 | 0.91 | -27.99 |
| I.R.R. | 16.9% | | 17.3% | | 17.6% | | 18.0% | | 18.3% | |

Fig. 15-1 Sensitivity Analysis (1)

(Relationship among Benefit-Cost Ratio, Discount Rate and Project Life)

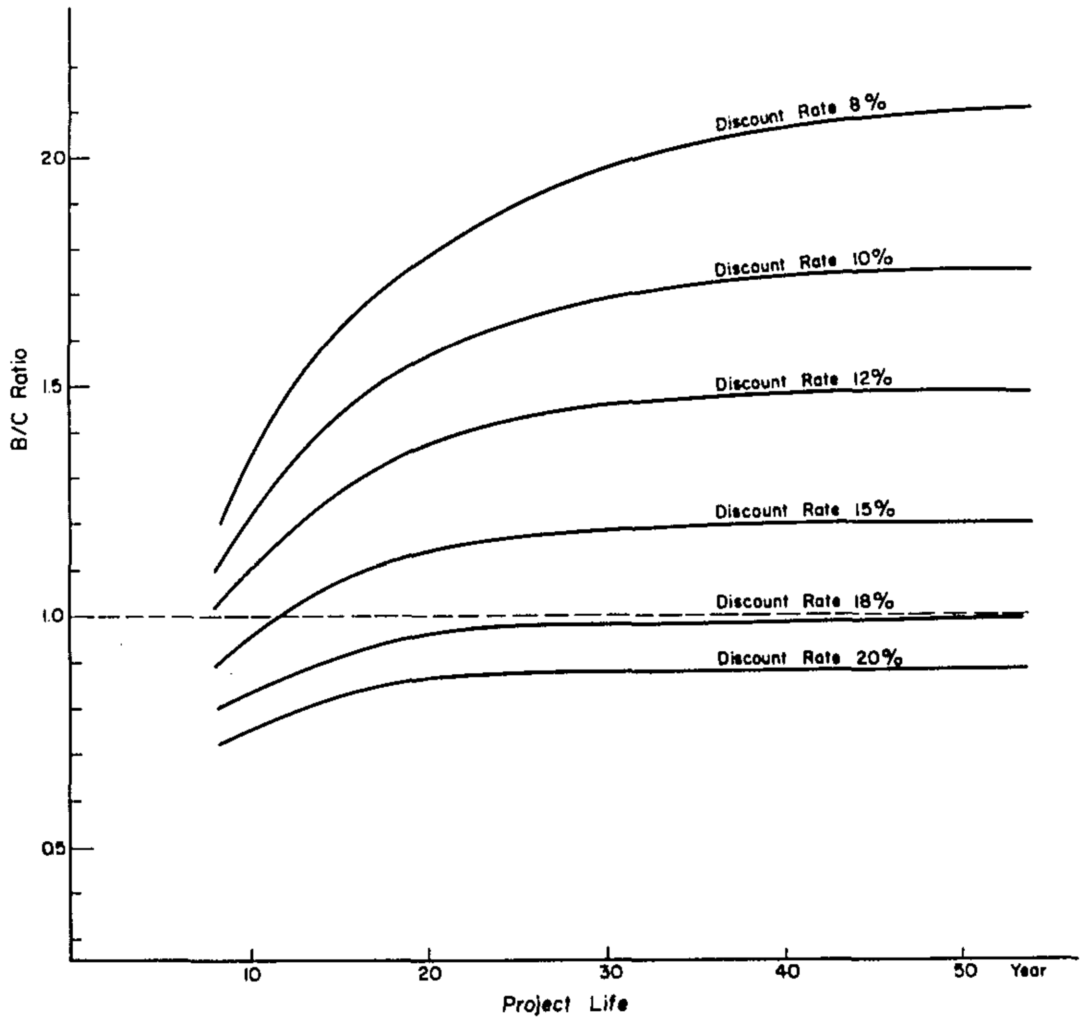


Fig. 15-2 Sensitivity Analysis (2)

(Relationship among Benefit-Cost Ratio, Discount Rate and Project Life with Modified Unit Time Benefit of Passengers)

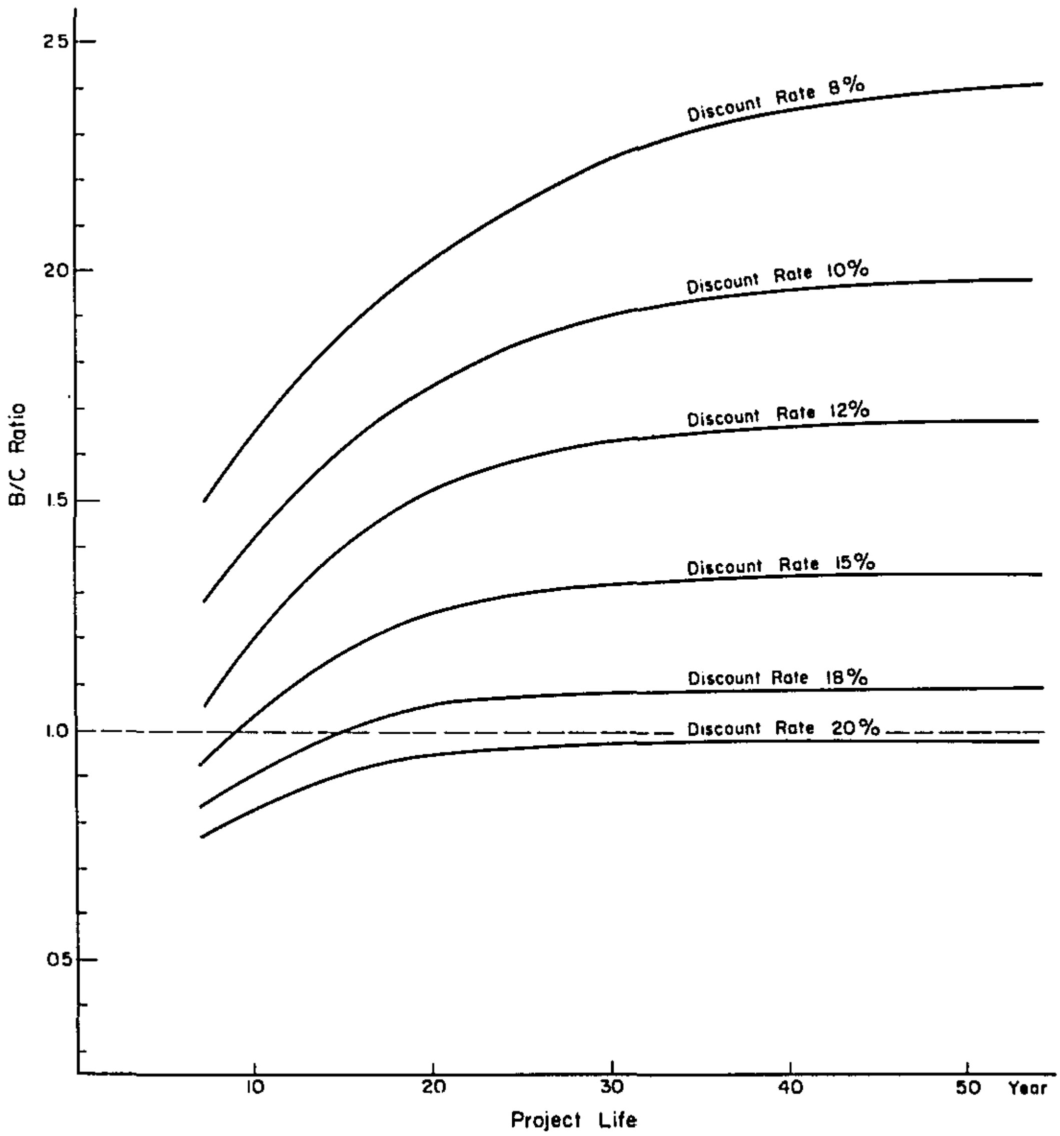


Fig. 15-3 Sensitivity Analysis

(Relationship between Discount Rate and Benefit-Cost Ratio with Modified Economic Project Cost)

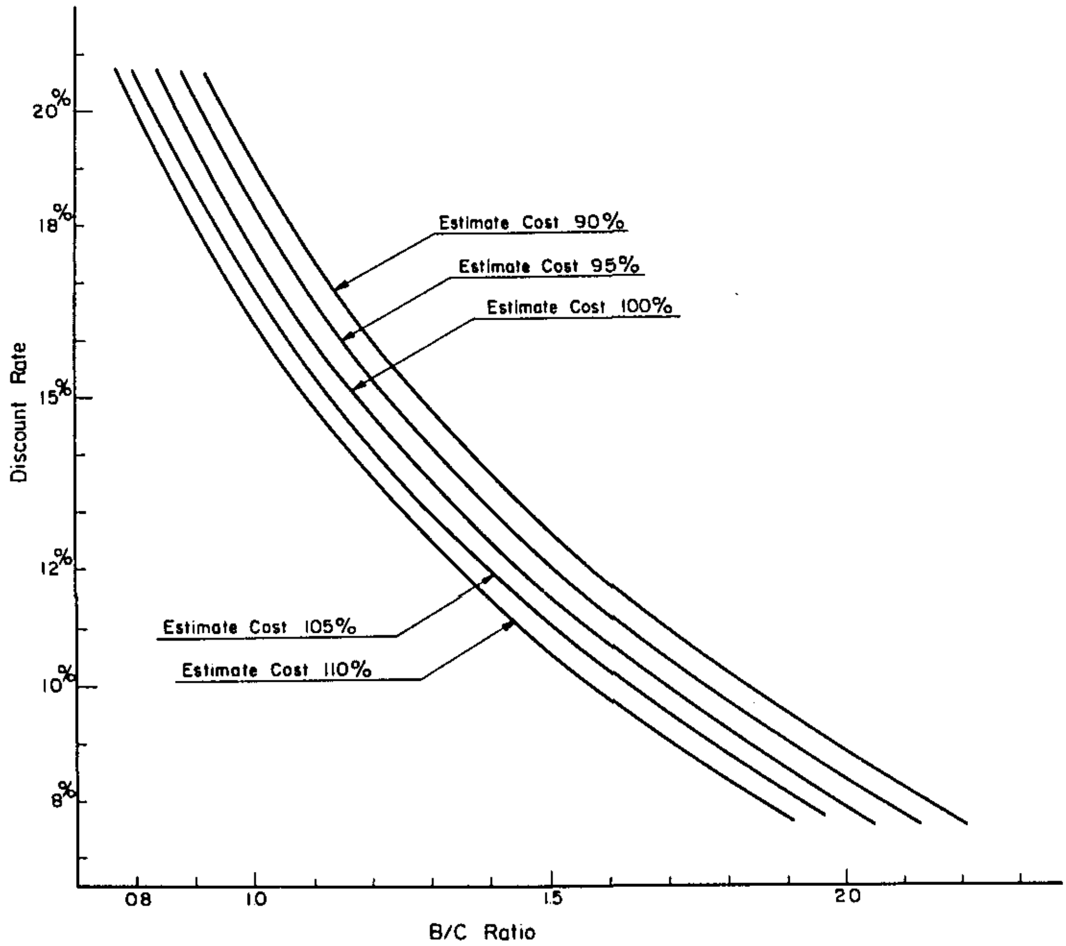


Fig. 15-4 Sensitivity Analysis (4)

(Relationship between Discount Rate and Benefit-Cost Ratio with Modified Planned Population)

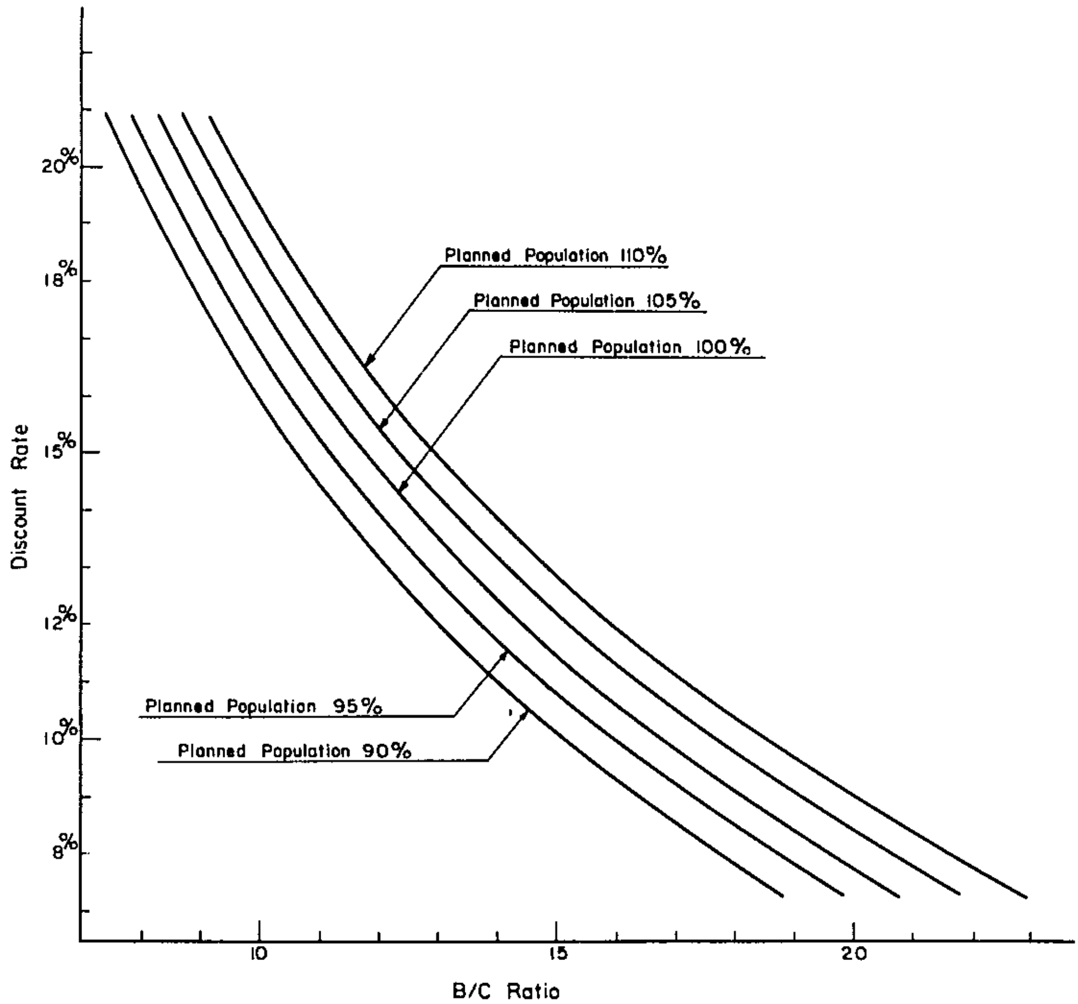


Fig. 15-5 Sensitivity Analysis (5)

(Relation between Discount Rate and Benefit-Cost Ratio with Modified Diverted Traffic Volume)