# REPUBLIC OF KOREA

# RAPID TRANSIT PROJECT

## SEOUL METROPOLITAN AREA

## FEASIBILITY REPORT

FEBRUARY 1971

OVERSEAS TECHNICAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

REPUBLIC OF KOREA

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# Preface

In accordance with the provisions of paragraph 26, No. 2 of the joint communique issued following the conclusion of the Fourth Japan-Korea Regular Ministerial Conference held in Seoul in July 1970, the Government of Japan decided to extend assistance in the survey for the urban transport project aimed at improving traffic situation in the Seoul Metropolitan Area, Republic of Korea, and delegated the responsibility for the implementation of the survey to the Overseas Technical Cooperation Agency.

The Overseas Technical Cooperation Agency organized a survey team comprising 10 specialists in the fields covering city planning, transport economy, railroad technology and subway construction, headed by Mr. Ryohei Kakumoto, Doctor of Economics, and the Representative Director of the Japan Transport Economic Research Center and sent the team to the Republic of Korea over a period of one month from September 17, 1970.

With the cooperation of the government agencies including the Ministry of Transportation, Seoul Municipal Government and the Korean National Railroad, the survey team conducted field surveys, collected necessary data and materials and held discussions with officials concerned.

After returning to Japan, the team reviewed the results of the survey with the cooperation of various institutions and obtained a satisfactory conclusion on the rapid mass transit system required for the Seoul Metropolitan Area. This report is a summary of the conclusion reached on the said project.

It must be pointed out that the report was completed within a month after the return to Japan of the survey team and that the emphasis was placed on the First Phase Project which was considered to be of immediate need, in view of the urgency of the planning the Seoul Metropolitan Area Urban Transport Project.

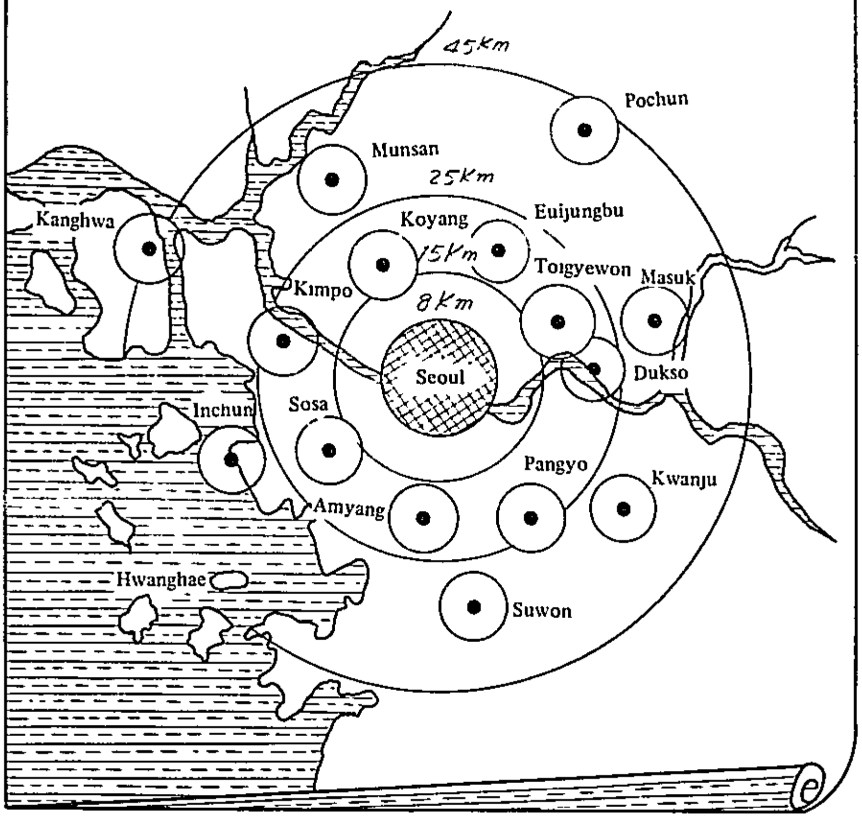
Finally, I would like to extend my heartfelt thanks to officials of both Government and Authorities concerned for their kind cooperation and assistance.

February 1971

Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency

## Map of Seoul Metropolitan Area

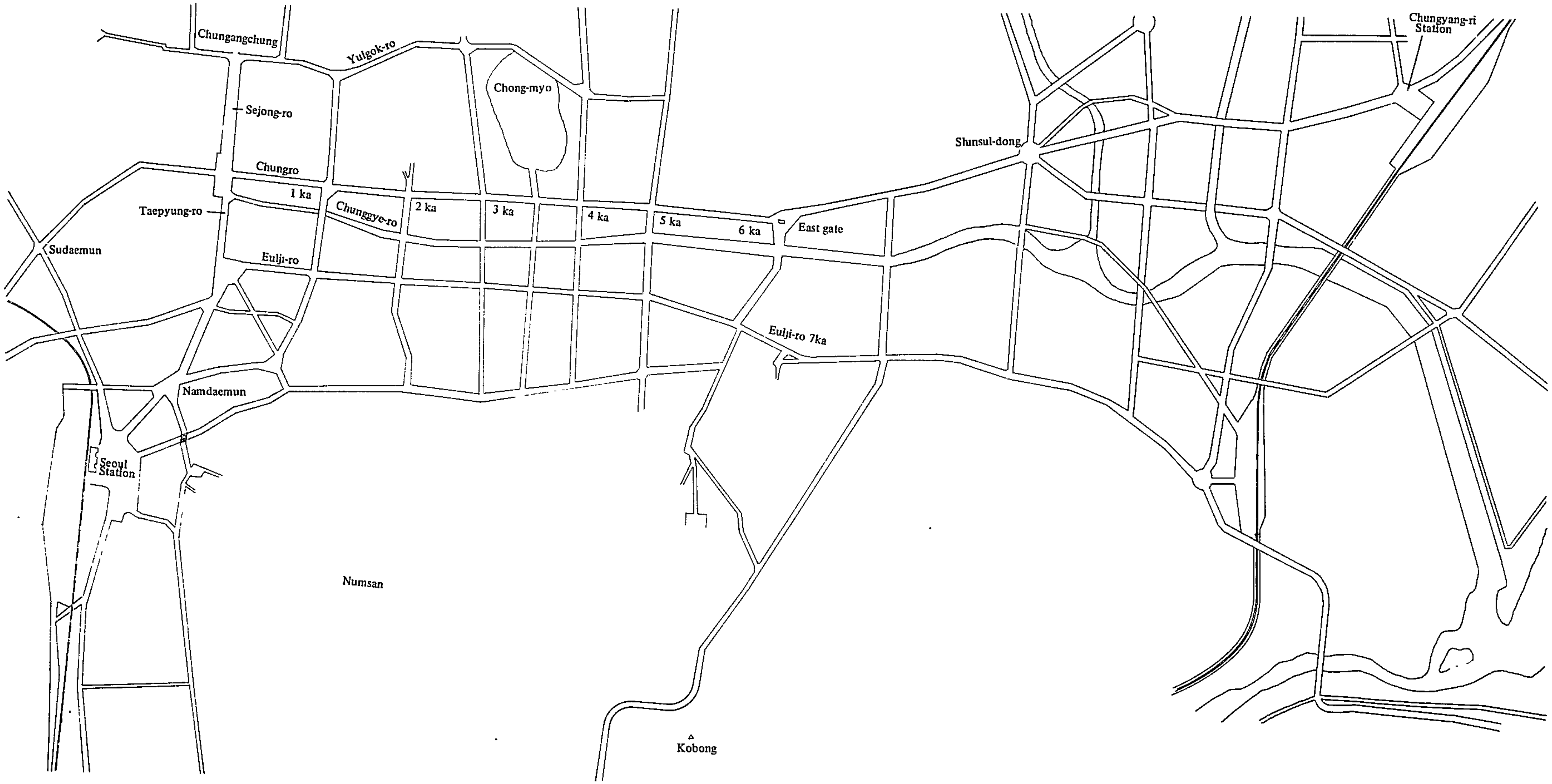
(The 45 km radius)



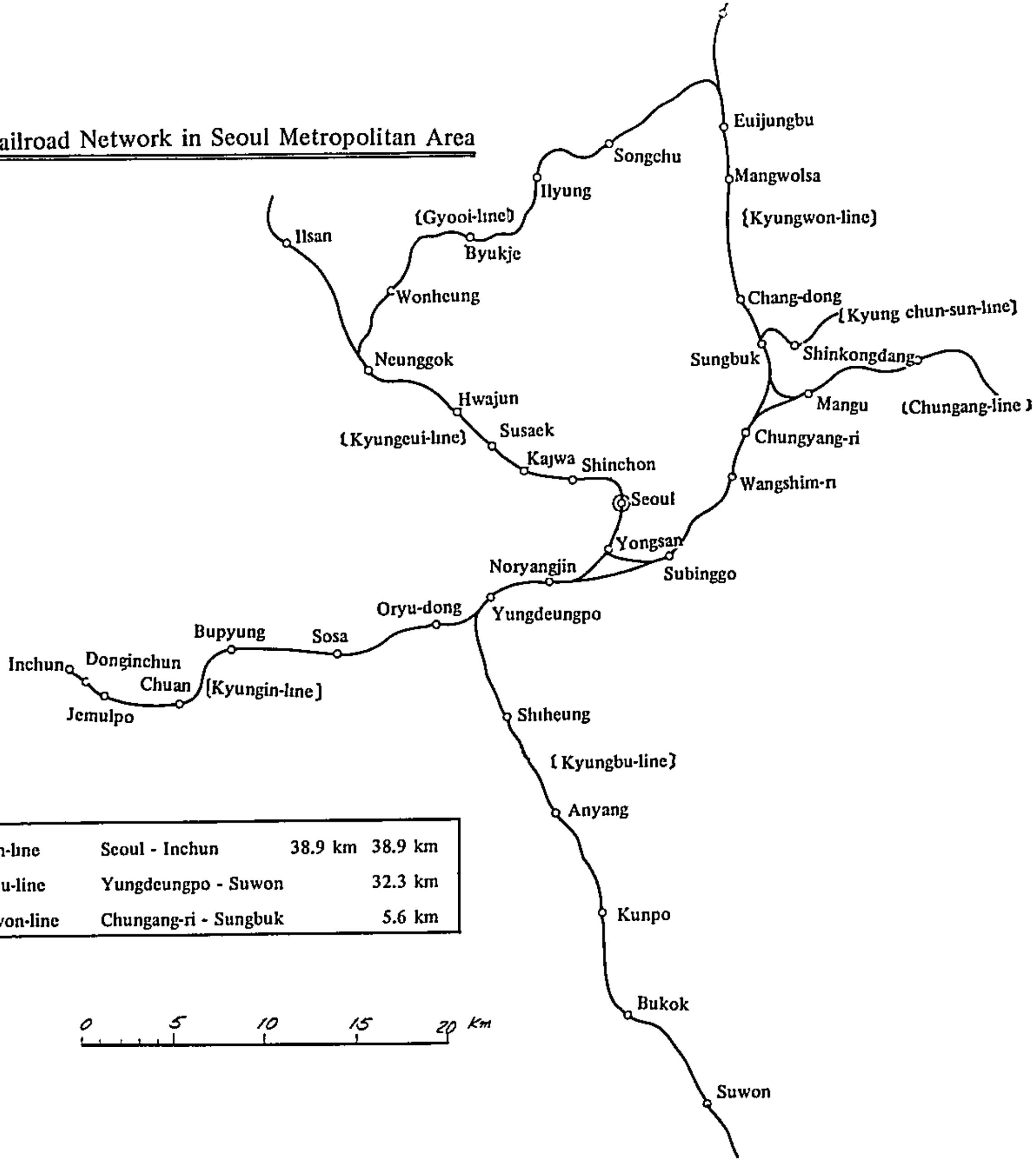

| | | Area (km²) | | Population (10,000) 1970 | 1981 (Estimated) |
|---|---|---|---|---|---|
| Seoul Metropolitan Area | | 5,760 | | 833 | 1,300 |
| | Area under city planning · | | 721 | | |
| Seoul Special City | Area inhabitable : | | 366 | 518 | 750 |
| | Total area of city in 1970 . | | 119 | | |

Map of Seoul City Area

Map of CBD, Seoul Special City



## Railroad Network in Seoul Metropolitan Area




| | | | |
|---|---|---|---|
| Kyungin-line | Seoul - Inchun | 38.9 km | 38.9 km |
| Kyungbu-line | Yungdeungpo - Suwon | | 32.3 km |
| Kyungwon-line | Chungang-ri - Sungbuk | | 5.6 km |

SUMMARY

1. Necessity of Urban Rapid Transit Railroad

The astonishing rapid growth of the economy in the Republic of Korea has brought about major changes in the industrial structure of the country and prompted the rapid shift of the population into the urban area.

The City of Seoul with a population of five million is expected to have a population of 7.5 million in 1981 and the population of the Metropolitan Area within a radius of 45 km is expected to reach the level of 13 million in the same year.

The present transport system in the City of Seoul comprises mainly the bus and taxi transport, accounting for 95% of city's total traffic volume and 70% of city's traffic concentrate in the core of Central Business District covering an area of 5.5 $km^2$. The traffic congestion has already reached its limit and awaits immediate measures for the alleviation of the worsening traffic situation.

The number of persons traveling to CBD in a day exceeds the one million level, of which 600,000 are commuters going to the place of work or school. The number of persons traveling to CBD in a day is expected to be 1.7 million in 1981, of which commuters are estimated at one million. The flow of passengers into CBD from Kyungbu Line and Kyungin Line districts and from Chungyangri and Kyungwŏn Line districts, which has already reached high level, is expected to increase further in the future.

Meanwhile, for the Metropolitan Area as a whole, a sub-city center plan and a comprehensive land use plan have been worked out in an attempt to decentralize city functions and a promising residential district has been planned for the area south of the Han River. Under the circumstances, the emergence of a means of transport to link these areas with CBD of Seoul Special City has become an urgent need.

It is impossible to satisfy transport demands in the Metropolitan Area by bus transport system alone. As a means to ease the present traffic paralysis and improve functions of the city in the future and promote the development of outlying areas at the same time, it is obvious that a rapid mass transit railroad of some type will become an urgent need in the future. Traffic volume of automobiles in the city center has already exceeded the capacity of the road. Even when expansion and improvement of road network are to be planned in the future, it will not be possible to provide road network having a sufficient capacity to satisfy ever increasing transport demands.

As a rapid mass transit system for the Seoul Metropolitan Area with a population exceeding the 10 million mark, the survey team concludes that there could not be any means other than rapid transit that runs in the sub-surface in the city center and on the elevated or surface track in the outlying area.

Operation of the present type of railroad on the elevated structures in the city center is not advisable from a viewpoint of preserving appearance of the city and preventing noises. Also, in view of the large transport demand and the need for through operation with the existing railroad lines, adoption of monorail system is not advisable.

As for timing of construction, there might be opinions that the system like subways which requires an enormous investment should be considered only at the stage when the economy of the country has progressed further. However, when the present road traffic situation and the anticipated growth of transport demands in the future are taken into consideration, improvement of transport facilities must be accelerated and smooth traffic must be attempted for the very goal of economic growth. To attain this goal, the subways are considered to be the only means.

2. Selection of Route

For the alleviation of the present traffic paralysis in the city center, and for further expansion of the city function and the development of the outlying area at the same time, the survey team considered it necessary to construct five rapid transit railroad lines (No. 1 Line through No. 5 Line) by 1981. These five lines extend from the city center to the growing sub-city centers and the residential districts in the outlying area in 10 radial routes. These routes form a dense transport network in the city center, split apart in the outlying area almost at the equal spacing and reach densely populated residential districts in the various parts of the Metropolitan Area. Of the five proposed lines, three lines cut through the city center from east to west and then extend radially to the outlying area. The remaining two lines approach the city center from north and south respectively and make a U-turn after reaching the city center and head for north and south again. This pattern is very close to the typical railroad network.

As a pattern of urban rapid transit railroad, the type which links the loop line of the city with the suburban railroads is also conceivable. With this pattern, however, the congestion at the junction stations and unbalance in the transport volume among stations, which are the result of a shortage of transport capacity of the loop line because of an increase in the transport volume of the suburban railroads, must be anticipated. For this reason, the pattern was not considered appropriate for adoption.

The total length of the five proposed lines, including 76 km of the existing lines is 209 km, of which approximately 61 km is sub-surface structure.

The maximum transport capacity of these lines is expected to be 800,000 persons an hour (On the assumption that the riding efficiency is 200% of the capacity) in the direction toward the city center and the transport capacity as a whole is expected to have a considerable reserve capacity after satisfying demands in 1981.

3. No. 1 Line Project

Of the five proposed lines, No. 1 Line was chosen as the first project to be constructed. Under this project, a subway line is to be constructed between Seoul and Chungyangri via Chongno for a total distance of about 8 km (length of line is to be 9 km) and connected to Kyungin Line, Kyungbu Line and Kyungwon Line of the Korean National Railroad at the above-mentioned two stations to make through operations on these lines. For this purpose, it is necessary to electrify Seoul—Inchun, Yungdeungpo—Suwon and Chungyangri—Sungbuk sections of the Korean National Railroad in conjunction with the completion of the subways. As No. 1 Line connects with the existing K.N.R. lines, the economic benefit derived from this line is expected to be much greater than that derived from other proposed lines. In consideration of the convenience of passengers, the number of stations will be increased to almost twice the present number on the existing K.N.R. lines, but the running time between Inchun and Seoul will be reduced substantially to 50 minutes. The running time between Seoul and Chungyangri will be 18 minutes. In 1974 when the line is expected to be completed, a train of six-car formation will be running every five minutes in the city center. The transport capacity for one way is estimated at 20,000 persons per hour.

Since all the proposed routes of sub-surface portions run along the existing roads, construction of subways is expected to be relatively easy with the adoption of the cut and cover method. Also, in view of satisfactory soil conditions in the project area, construction is expected to be completed in about 3 years.

As for standards of track, the track gauge of 1,435 mm, the same gauge of track as used by the Korean National Railroad, is to be used and other standards are to be the same as those generally used for the urban rapid transit system.

As for electric system, 25 KV, 60 Hz alternating current system is to be adopted in consideration of the operation of trains through the Korean National Rialroad lines. This system has never been tried for the subways in city area, but it is the system which was adopted for the New Tokaido Line of the Japanese National Railways and therefore may be called the system of the new age.

As for electric system for train operation, underground substations are not to be provided but only the sub-sectioning posts are to be provided. For overhead contact wires, the rigid suspension system is to be adopted. With regard to the signal system, automatic blocking system utilizing ground signals is to be adopted and the five aspect color light signals are to be used.

4. Electrification Plan for the Korean National Railroad

As stated previously, electrification of Seoul—Inchun section of Kyungin Line, Yungdeungpo—Suwon section of Kyungbu Line, and Chungyangri—Sungbuk section of Kyungwon Line by the completion of No. 1 Line will establish a key traffic axis in the Seoul Metropolitan Area. Electrification of these lines by the time of the completion of No. 1 Line, which is expected in 1974, will be easily accomplished.

For the time being, operation of trains of 6-car formation on Kyungin Line with a 10 minutes headway and trains of 6-car formation on Kyungbu Line and Kyungwon Line with an average headway of 15 minutes during the rush hours will be sufficient to meet transport demands but an increase in the transport volume is expected for each line in the future. However, for long distance passenger trains and freight trains, the present diesel locomotive system is to be adopted.

As for electrical system, 25 KV, 60 Hz alternating current system, which has been adopted for Chungang Line now being electrified, is to be used. This system is considered to be the most appropriate system from both economical and technical points of view when the electrification of all the railroad lines in Korea is taken into consideration.

With regard to the ground electric facility, one railroad substation is sufficient but in consideration of the importance of sub-surface section, two substations are to be provided.

Except the adoption of the auto-transformer system, which is economical and is electrically stable, the feeder system almost similar to that adopted for the electrification of Chungang Line will be satisfactory.

With the progress of electrification of lines, new stations will be provided for the sections having a long distance between stations on each line. The line alignment is to be modified so that the trains of Kyungbu Line may be operated through Kyungin Line near Yungdeungpo.

5. Other Project Lines

For other project lines, namely No. 2 Line through No. 5 Line, the order of construction is to be determined by taking into account transport demands following the completion of No. 1 Line and they are to be completed one at a time at one or two year intervals so that all the project lines are to be completed by 1981. Construction of each line is expected to require 3 or 4 years.

As the number of passengers traveling one way on each line during the rush hours in the CBD in 1981 is estimated at 30,000 to 50,000 per hour, trains of 6—8 car formation are to be operated with a 3—4 minute headway. In the suburban area, operationwith a 6—12 minute headway will be sufficient. Schedule speed is expected to be around 36 km/h.

As No. 2 Line is scheduled to run through Chongno in the city center like No. 1 Line and operates on one double-track along No. 1 Line, the track gauge of 1,435 mm and 25 KV, 60 Hz alternating current overhead contact line system, the same standard as No. 1 Line, are to be adopted. For No. 3, 4 and 5 Lines, which are not scheduled for through operation with No. 1 and 2 Lines or the Korean National Railroad consideration was given to the fact that the surface section has a total length of 51 km compared with the sub-surface section having a total length of 40.5 km and that there is every possibility of extending the surface section in the future, the 1,500 V direct current overhead contact line system, which is economical and dependable as an urban mass transit system, has been selected. The gauge of track is to be 1,435 mm, the same as for No. 1 and 2 Lines.

For the section covered by direct current system, silicon rectifier substations are to be provided at intervals of 5—6 km and the feeder system is to be the parallel arrangement of substations. Adoption of the remote control system for the operation of substation from the power control center and the use of the rigid suspension system for overhead contact line in the tunnel are to remain the same as in the section covered by the alternating current.

For station facilities and electric facilities, consideration is to be given to the arrangement so that these facilities may be able to meet the requirements when the number of cars forming a train is increased and the operating headway is shortened in the future.

6. Rolling Stocks and Maintenance Facilities

As for the type of rolling stocks, A.C. electric cars are required for No. 1 and No. 2 Lines and D.C. electric cars are required for No. 3, 4 and 5 Lines. However, efforts were made to standardize car body, truck and as many parts as possible so that they may be adaptable to all the project lines. As a result, operation of trains and services to passengers will be the same on all the lines and the benefits with respect to the maintenance will also be great.

As for the formation of a train, 4-car formation (2 motor cars plus two trailers with controller) is the basic formation, but a 6-car, 8-car or 10-car formation is also possible. Two motor cars are to be made into one unit and

8 motors on these cars are to be controlled by a single control device.

The car body is to be 20 m in length between coupling faces and is to be made of steel and to be of fire proof construction. As stainless steel is to be used for exterior board and light metal sheet for interior walls, painting is not required. All seats are to be long seats and four double doors are to be provided on each side of the car. Although the design capacity of a train of 6-car formation is 848, the train is able to accommodate up to 250% of the design capacity during the rush hours.

With regard to the performance of trains, selection was made on the type of cars so that the minimum running time may be obtained for the operation in various sections of an 1—3 km distance on the Korean National Rialroad lines and subway lines. The maximum speed adopted is 110 km/h.

The number of cars required in 1981, including those operating on the Korean National Railroad lines, is estimated to be 820 A.C. electric cars and 632 D.C. electric cars.

As for car maintenance facilities, a car shed is to be provided for each of No. 1 and 2 Lines, where routine and monthly inspections and minor repairs will be performed. Intermediate inspection and general inspection are to be performed at Seoul Work Shop of the Korean National Railroad.

For the D.C. electric cars on No. 3, 4 and 5 Lines, a car-shed and workshop is to be provided at an appropriate location along the line to be constructed first of the three lines.

7. Management and Operation of the Line and Passenger Fare

As the construction of the proposed urban rapid transit network including No. 1 through No. 5 lines is aimed for the solution of traffic problems in Seoul City and the majority of the proposed route is within the city limit, it is considered appropriate for Seoul City to bear the responsibility for the management of these project lines. In such a case, however, it is advisable that a special account is provided for the management of these lines in the same manner as in the case of the present bus enterprise which is being operated under the Local Public Enterprises Law.

Accordingly, the operation of the lines will also be the responsibility of the city in principle. However, in the case of No. 1 Line which is expected to operate through the Korean National Railroad line and has a short operating distance of its own, delegation of responsibility for the operation and maintenance of trains to the Korean National Railroad will result in more effective management and the reduction of expenses. However, the responsibility for providing services to passengers at stations is to remain in the hand of the city.

As for passenger fare for No. 1 Line (Seoul Station — Chungyangri Station), the flat fare system of 20₩ for adult and 10₩ for child is recommended. For commuters traveling to the place of work and school, commuter tickets should be discounted by 20% and 50% respectively. For the passengers traveling through the Korean National Railroad the total of the fare for a short distance on both lines will amount to an unreasonably high rate. It is recommended, therefore, that 10₩ is deducted from the total fare. The present minimum fare of 30₩ on the Korean National Railroad is also to be reduced to 20₩ up to the distance of 8 km. Under this system, the fare for the section between Noryangjin and the city center will be 30 ₩, which is reasonable to attract passengers. For the commuters' tickets, similar consideration should be given.

8. Required Investments and Operating Revenue

(1) No. 1 Line

The total investment required by the time of completion of the proposed line expected in 1974 is estimated at 25,960 million ₩, of which 23,560 million ₩ will be required for construction of facilities and 2,400 million ₩ for the purchase of rolling stocks (60 cars). As the number of rolling stocks will be increased to 170 by 1981, the total investment at the final stage will amount to 30,190 million ₩ (interest during construction is not included).

The operating revenue in 1974 is estimated at 2,219 million ₩ for transportation of about 150 million passengers and the expenditure excluding depreciation cost is estimated at 2,591 million ₩, leaving about 370 million ₩ in deficit. The deficit after depreciation is estimated at 1,021 million ₩. After 1975, however, the profit before depreciation will be realized. In 1981 the revenue will be 5,171 million ₩ and the expenditures including depreciation cost will be 3,766 million ₩, leaving 1,405 million ₩ in the black.

(2) Electrified Section of the Korean National Railroad

Electrification of Kyungin Line, Kyungbu Line and Kyungwon Line and required rolling stocks.

The total investment required by the time of the completion of the project is estimated at 13,011 million ₩, of which 6,271 million ₩ will be required for construction work, 5,040 million ₩ for the purchase of rolling stocks (126 cars) and 1,700 million ₩ for the construction of car maintenance facilities.

As the number of rolling stocks will be increased by 244 to a total of 370 and the number of rolling stocks for No. 1 Line will also be increased by 1981, investment for ground electric facilities and car maintenance facilities will also have to be increased. As a result, the total investment by 1981 is expected to reach 23,681 million ₩ (Interest during construction not included).

The increase in the revenue upon completion of electrification of the lines and after realization of through operation with No. 1 Line in 1974 is estimated at 1,735 million ₩ and the increase in the expenditure including depreciation cost is estimated at 2,519 million ₩. After 1976, however, the business will show a profit and in 1981, for example, the revenue will amount to 5,919 million ₩ and the expenditure including depreciation cost will be 4,300 million ₩, realizing such a large profit as 1,619 million ₩. This profit will undoubtedly benefit the financial position of the Korean National Railroad .

(3) No. 2—No. 5 Lines

The total investment required for the construction of No. 2—No. 5 Lines by 1981 is estimated at 261,700 million ₩ (Interest during construction not included), of which 31,600 million ₩ will be required for the purchase of rolling stocks and 230,100 million ₩ will be needed for construction work.

The number of passengers transported by these lines in 1981 is estimated at 27,400 million/day and the operating revenue is expected to amount to 21,515 million ₩. The expenditures will be 28,473 million ₩ and the business will show a deficit of 6,958 million ₩ before depreciation. With the inclusion of depreciation cost amounting to 6,701 million ₩, the total deficit will be 13,659 million ₩.

It will be necessary for the Government or Seoul Special City, therefore, to defray part of construction costs and subsidize to cover deficits in the operating revenue.

9. Benefits Derived from Urban Rapid Transit Railroads

Among the many social and national benefits derived from urban rapid transit railroads, main benefits will be: (1) saving of time by those utilizing transport facilities, (2) saving of investment for the purchase of automobiles and the saving of operating expense on automobiles, (3) saving of investment for construction of roads, (4) saving of road maintenance cost, (5) saving of expenses by the city for handling car accidents, (6) effect on the prevention of air pollution, (7) increased efficiency of land use and (8) a decrease in the number of the unemployed. As it was almost impossible to show all of these benefits by figures, calculations were made only on items (1) and (2) and the results were compared with the cost of urban rapid transit system.

The benefit derived from No. 1 Line in 1976 will amount to 4,054 million ₩, comprising 3,062 million ₩ in the saving of time described in item (1) and 992 million ₩ in the saving of expenses on automobiles described in item (2). This figure exceeds 3,148 million ₩, the cost of urban rapid transit system. The comparison of the balance of cost and benefit in 1981, when No. 1-5 Lines will have been completed, shows remarkable benefit amounting to 2.4 billion ₩ for No. 1 Line and that amounting to 6.5 billion ₩ for No. 2—5 Lines.

CONTENTS

## APPENDIX

Tables

# I INTRODUCTION

# I INTRODUCTION

## 1-1 Purposes of Survey

The purposes of the survey are to investigate the present traffic situation of Seoul Metropolitan Area, point out problems for the formulation of a transport plan for the Metropolitan Area, particularly the mass rapid transit construction project and the electrification project for the existing lines and make studies on the transport demands, selection of routes, operation plans, construction and improvement method, provide calculations of required costs and review the feasibility of the above-mentioned projects from an economic point of view and recommend measures for improvement of traffic situation of Seoul Metropolitan Area.

## 1-2 Scope of Survey

The scope of the survey was limited geographically to the Seoul Metropolitan Area within a radius of 45 km and the target of the project was set for 1981 by forecasting the next 10 years. Emphasis of the survey was placed on the construction of a rapid mass transit system and electrification of the Korean National Railroad and only a preliminary survey was conducted for road transport.

## 1-3 Organization of Survey Team

Chief of the team:
Ryohei KAKUMOTO — Doctor of Economics, Representative Director, Japan Transport Economics Research Center

Assistant Chief of the team:
Rolling stock planning
Naoharu FUKUZAKI — Executive Director, Japan Railway Technical Service

Transport demands:
Shigeo MORI — Director, Railway Division, Fukuoka District Land Transport Bureau, Ministry of Transport

City planning:
Akio NAMIKI — Chief Engineer, City Planning Division, City Bureau, Ministry of Construction

Electrification planning:
Tatsuya ISHIHARA — Director, Electrification Division, Electrical Engineering Department, Japanese National Railways

Economic analysis,
Operation planning:
Hisomu KATASE — Deputy Director General, Corporate Planning Department, Japanese National Railways

New line planning:
Masato ANDO — Deputy Director, Planning Department, New Line Construction Bureau, Teito Rapid Transit Authority

Organization and management:

| | |
|---|---|
| Minoru ENDO | Deputy Director, Finance Division, National Railway Dept., Railway Supervision Bureau, Ministry of Transport |

Engineering and construction:

| | |
|---|---|
| Shu ICHIKAWA | Assistant Chief, 3rd Engineering Division, New Line Construction Bureau, Teito Rapid Transit Authority |

Coordination:

| | |
|---|---|
| Kenji IWAGUCHI | Development Survey Division, Overseas Technical Cooperation Agency |

## 1-4 Activities of Survey Team

| | |
|---|---|
| Sep. 17 (Thu) | Arrived in Seoul at 10:50 A.M. (JAL Flight 951).<br><br>Held discussions with Korean counterparts on schedule of survey team. |
| Sep. 18 (Fri) | Made a courtesy call to the Ministry of Transportation, Seoul Metropolitan Government, Korean National Railroad and Economic Planning Board.<br><br>Received answers to questionnaires sent previously. |
| Sep. 19 (Sat) | Briefed by Seoul Metropolitan Government and KNR on City Planning and Railroad Five-Year Plan, respectively. |
| Sep. 21 (Mon)<br>Sep. 26 (Sat) | Made surveys on the state of road and railroad transport by use of automobiles, trains and helicopters. |
| Sep. 28 (Mon)<br>Oct. 2 (Fri) | Each specific group made field surveys, collected data and materials and heard explanations with the cooperation of officials of the Transportation Ministry, Seoul Metropolitan Government and KNR. |
| Oct. 3 (Sat)<br>Oct. 4 (Sun) | Made surveys of Seoul-Pusan Expressway, National Railroads Kyungbu Line, on the progress of City Planning of Ulsan Industrial City and traffic conditions of Pusan City. |
| Oct. 5 (Mon)<br>Oct. 10 (Sat) | Each specific group made field surveys, collected data and heard explanations with the cooperation of the Transportation Ministry, Seoul Metropolitan Government and KNR. |
| Oct. 12 (Mon)<br>Oct. 15 (Thu) | Summarized results of field surveys and made a follow-up survey. |
| Oct. 16 (Fri) | Departed Seoul at 02:00 P.M. and arrived in Tokyo at 07:40 P.M. (KAL 701). |

## 1-5 Acknowledgements

In the course of this survey, kind cooperation and support was extended to the survey team by the Government of the Republic of Korea, particularly the Ministry of Transportation, Ministry of the Construction, Seoul Metropolitan

Government and the Korean National Railroad, the Japanese Embassy in Seoul and other Authorities concerned. The survey team expresses its profound appreciation and gratitude to the officials of these agencies, listed below.

(Prefixes left out from the names and no particular order is observed.)

| | |
|---|---|
| Kim, Hak Yol | Minister, Economic Planning Board |
| Hwang, Byung Tae | Assistant Vice-Minister for Operation, E.P.B. |
| Paik, Sun Yup | Minister, Ministry of Transportation |
| Lee, Yong | Vice-Minister, M.O.T. |
| Suh, In Soo | Director, General Transportation Planning, M.O.T. |
| Park, Byung Sun | Director, Economic Cooperation, M.O.T. |
| Shin, Jin Woo | Director, Housing and Urban Bureau, Ministry of Construction |
| Kim, Sun Won | Chief, Urban Planning Section, M.O.C. |
| Yang, Taek Sik | Mayor, Seoul Special City |
| Kim, Chung Oh | First Deputy Mayor, Seoul Special City |
| Cha, Il Suk | Second Deputy Mayor, Seoul Special City |
| Son, Jung Mok | Director, Office of Planning and Management, S.S.C. |
| Yoon, Jin Woo | Director, Urban Planning Bureau, S.S.C. |
| Kim, Ung Kyun | Director, Tourism Bureau, S.S.C. |
| Kim, Myung Nyun | Director, Seoul Metropolitan Transit Construction Office |
| Kim, Kwang Soo | Chief, Management Section, O.S.M.T.C. |
| Sung, Wook Ho | Chief, Planning & Research Section, O.S.M.T.C. |
| Kim, Byung Lin | Chief, Construction Section, O.S.M.T.C. |
| Kim, Joon Bae | Director General, Office of Railroads |
| Kim, Dong Hyuk | Deputy Director General, Office of Railraods |
| Hong, Myun Hoo | Director, Finance Accounting Bureau, O.R. |
| Kwon, Young Joon | Director, Machinery & Electricity Bureau, O.R. |
| Lee, Yong Shik | Director for General Administration, Office of Railroads |
| Han, Mong Sook | Chief, Electrification Section, Machinery & Electricity Bureau, O.R. |

| | |
|---|---|
| Lee, Han Choon | Chief, Economic Cooperation Section, Finance Accounting Bureau, O.R. |
| Yoon, Jong Hyuk | Director, Office of Planning & Management, O.R. |
| Lee, Duk Sun | Business Promotion Office, O.R. |
| Kang, Ki Won | Planner, Office of Planning & Management |
| Kang, Jung Tae | Official, Third Section, Transport Bureau, Office of Railroads |
| Park, Dae Sun | Official, Track Maintenence Section, Facilities Bureau, O.R. |
| Kim, Jae Keun | Electrification Section, Machinery and Electricity Bureau, O.R. |
| Lee, Chong Man | Station Master, Suwon Railroad Station |

The Japanese Embassy

| | |
|---|---|
| Masahide Kanayama | Ambassador Plenipotentiary |
| Hiroshi Kamikawa | Minister |
| Kuniyoshi Date | Counselor |
| Moritaka Fukuda | First Secretary |

# II EXPANSION OF METROPOLITAN AREA AND NECESSITY OF NEW TRANSPORT SYSTEM

# II EXPANSION OF METROPOLITAN AREA AND New Transport System NECESSITY OF NEW TRANSPORT SYSTEM

## 2-1 Expansion of Metropolitan Area

### 2-1-1 Growth of economy and progress of urbanization

The economy of the Republic of Korea has made a remarkable growth in the last few years and the average annual growth rate of her GNP for the period from 1960 to 1968 was close to 10%. The per capita GNP has also increased by 1.5 times during the same period (See Table 2-1-1).

Table 2-1-1 Changes in Gross National Product

| Year | GNP (billion won) | Growth rate over previous year (%) | Total population (thousand persons) | Per capita GNP (won) |
|---|---|---|---|---|
| 1960 | 580.07 | | 24,989 | 23,600 |
| 61 | 613.61 | 4.2 | 25,700 | 26,900 |
| 62 | 634.97 | 3.5 | 26,432 | 24,000 |
| 63 | 693.03 | 9.1 | 27,184 | 25,500 |
| 64 | 750.31 | 8.3 | 27,958 | 26,800 |
| 65 | 805.85 | 7.4 | 28,754 | 28,300 |
| 66 | 913.82 | 13.4 | 29,193 | 31,300 |
| 67 | 995.16 | 8.9 | 30,293 | 32,900 |
| 68 | 1,127.32 | 13.3 | 31,093 | 36,300 |
| Average growth rate for the 1960—1968 period was 9.7% | | | | |

Notes: (1) Korea Statistical Year Book 1969 (EPB) P.P. 16, 88, 89
(2) At 1965 constant market prices.

Such a high rate of economic growth is attributable mainly to the high growth of the secondary industry. The average annual growth rate for mining and manufacturing industries during a period from 1960 to 1968 was as high as 16%. In contrast, the growth rate of primary industry was comparatively low and the average annual growth rate during the same period was 3.9% (See Table 2-1-2).

Table 2-1-2 Gross Domestic Product by Industry

| Year | Primary Industry (billion won) | Growth rate (%) | Secondary industry (billion won) | Growth rate (%) | Tertiary industry (billion won) | Growth rate (%) |
|---|---|---|---|---|---|---|
| 1960 | 242.90 | | 95.16 | | 210.58 | |
| 61 | 267.35 | 10.1 | 99.38 | 4.4 | 208.13 | △ 1.2 |
| 62 | 251.25 | △ 6.0 | 114.78 | 15.5 | 225.13 | 8.2 |
| 63 | 269.37 | 7.2 | 133.08 | 16.0 | 242.95 | 7.9 |
| 64 | 312.93 | △16.2 | 140.34 | 5.5 | 248.75 | 2 4 |
| 65 | 310.26 | 0.9 | 170.96 | 21.8 | 269 92 | 8.5 |
| 66 | 344.39 | 11.0 | 199.74 | 16.8 | 302.32 | 12.0 |
| 67 | 325.46 | △ 5.5 | 240.26 | 20.3 | 343.83 | 13.7 |
| 68 | 329.39 | 1.2 | 307.33 | 27.9 | 291.34 | 13.8 |
| Average growth rate for 1960~68 period | | 3.9 | | 16.0 | | 8.0 |

*Notes:* (1) *Korea Statistical* Year Book 1969 (E.P.B.) P.P. 80, 91.
(2) At 1965 constant market prices.

As a result of such high economic growth, the industrial structure of Korea underwent major changes, as a matter of course. That is, while the share of the primary industry in the gross national product dropped from 41.4% in 1960 to 29.4% in 1968, that of the secondary industry increased from 15.1% to 24.8% in the same period (See Table 2-1-3).

Table 2-1-3 Share of Industries in Gross National Product (%)

| | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 |
|---|---|---|---|---|---|---|---|---|---|
| Gross National Product | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Agriculture, forestry and fishery | 41.5 | 43.8 | 39.7 | 39.1 | 41.9 | 38.7 | 37.9 | 32.8 | 29.4 |
| Mining and manufacturing | 15.1 | 14.9 | 16.7 | 17.8 | 17.3 | 19.5 | 19.8 | 22.3 | 24.8 |
| Social overhead capital and other services | 43.5 | 41.3 | 43.6 | 43.1 | 40.8 | 41.8 | 42.3 | 44.9 | 45.8 |

Notes: (1) Korea Statistical Year Book 1969 (E.P.B.) P.P. 100, 101

(2) At 1965 constant market prices

Following the changes in the industrial structure, there was also a major change in the composition of employed population. The employed population in the primary industry has decreased gradually and the employed population in the secondary and tertiary industry, which may be called the urban type population, has been increasing gradually (See Table 2-1-4).

Table 2-1-4 . Employed Population by Industry

(Unit: 1,000 persons)

| | Total | | Agriculture, forestry, hunting & fishery | | Mining and manufacturing | | Social overhead capital and other services | |
|---|---|---|---|---|---|---|---|---|
| 1963 | 7,947 | 100% | 5,021 | 62.5% | 690 | 8.6% | 2,236 | 27.9% |
| 64 | 8,210 | 100 | 5,084 | 61.9 | 725 | 8.8 | 2,401 | 29.3 |
| 65 | 8,522 | 100 | 5,000 | 58.7 | 880 | 10.3 | 2,642 | 31.0 |
| 66 | 8,659 | 100 | 5,013 | 57.9 | 940 | 10.9 | 2,706 | 31.2 |
| 67 | 8,914 | 100 | 4,924 | 55.2 | 1,138 | 12.8 | 2,852 | 32.0 |
| 68 | 9,261 | 100 | 4,851 | 52.4 | 1,186 | 12.8 | 3,126 | 33.8 |
| 69 | 9,347 | 100 | 4,798 | 51.3 | 1,335 | 14.3 | 3,214 | 34.4 |

Note: Monthly statistics of Korea (E.P.B.) 1970, No. 1, 2, P 258

In the process of increase in such urban-type population, intensive shift of the employed population to the city area, particularly the rapid concentration of the population in the greater metropolitan area is more common.

According to "Guideline for National Physical Plan, June 1969", Korea's GNP in 1986 is expected to amount to 6,300 billion won, 8 times larger than that in 1965 and the ratio of urban population and rural population then is expected to be 64:36.

2-1-2 Present state of Metropolitan Area

Following the rapid progress of urbanization, concentration of the population in the Metropolitan Area has become more conspicuous in recent years. While the rate of annual increase in the population of the whole nation and of the cities other than Seoul during a period from 1960 to 1967 was 2.8% and 3.9% respectively, that of Seoul City was such an extremely high rate as 7.2%, which is a clear indication of the intensified concentration of population in the Metropolitan Area (See Table 2-1-5).

Table 2-1-5 Changes in City Population (Unit: 1,000 persons)

| | Nation | | All cities | | Seoul City | | Other cities | |
|---|---|---|---|---|---|---|---|---|
| | Population | growth rate | Population | growth rate | Population | growth rate | Population | growth rate |
| 1960 | 24,989 | | 7,193 | | 2,445 | | 4,748 | |
| 67 | 30,293 | Average annual 2.8% | 10,158 | Average annual 5.5% | 3,936 | Average annual 7.2% | 6,188 | Average annual 3.9% |

Note: Municipal Yearbook of Korea 1969, P.P. 40, 43.

The main reason of such intensified concentration of population is that the city of Seoul, as the capital of Korea, is the center of politics, economy and culture of Korea accommodating central management functions of all the government agencies and private industries.

The position of Seoul City as an industrial district is also high and shares 33% of the total industrial shipment of the nation (Guideline for National Physical Plan 1968, P. 85). Besides, the concentration of scuh tertiary industries as commerce and service industries in Seoul City is also remarkable with corresponding increase in the employed population.

The weight of Seoul City in the whole nation is indicated by various barometers in Table 2-1-6, from which it is evident that Seoul is the center of politics, economy and culture of the nation, both in name and reality.

Concentration of functions is particularly conspicuous with economic, education and cultural activities and the share of Seoul City in some fields accounts for more than half of the total activities of the nation.

Table 2-1-6 Weight of Seoul City in the Nation

| | Nation (1,000) | Seoul city (1,000) | Comparison with nation (%) | Year of comparison |
|---|---|---|---|---|
| Population | 31,093 | 4,335 | 13.9% | 1968 |
| Employed population in all industries | 9,347 | 1,026 | 11.0 | 68 |
| Employed population in primary industry | 4,924 | 37 | 0.7 | 67 |
| Employed population in secondary industry | 1,138 | 261 | 23.1 | 67 |
| Employed population in tertiary population | 2,852 | 609 | 21.3 | 67 |
| Number of registered automobiles | 80,951 | 35,135 | 43.5 | 68 |
| Number of telephone subscribers | 384,514 | 166,833 | 43.6 | 68 |
| Number of colleges | 68 | 36 | 57.3 | 67 |
| Number of manufacturing industries | 22,718 | 4,905 | 21.6 | 69 |
| Amount of industrial shipment | 408,036 mln won | 136,401 mln won | 33.4 | 63 |

Notes: (1) Korea Statistical Yearbook 1969

(2) Statistical Yearbook of Seoul 1969

Following such intensified concentration of population and industries in the Seoul Metropolitan Area, various problems stemming from the lag of social overhead capital have become more conspicuous.

The rate of housing shortage in Korea is 25.3% on the average but the rate in Seoul City is as high as 47.9%, which is a clear indication of a housing shortage for nearly half of the population of the city (Guideline for National Physical Plan 1968, P. 28).

The bus transport system, the only means of mass transportation in the city, has reached its limit in handling passengers at bus stops and its function as a means of mass transport is approaching to the state of paralysis.

Concentration of population and industries in the city area may also bring various environmental disruptions to the life of the city, which should be healthy and civilized originally.

2-1-3 Future plans for Seoul Metropolitan Area

As stated previously, concentration of population and industries in the Metropolitan Area has been progressing at an astonishing tempo. As a result, investment in social overhead capital is unable to catch up with the trend. Consequently, various bottlenecks such as housing shortage, sprawling of city area or lag of transport facility are becoming more conspicuous.

To guide this explosive energy to proper direction, effective measures, worked out from a long-range point of view and on the understanding of the reality, must be implemented vigorously.

"Guideline for National Physical Plan" proposed by the Ministry of Construction set 1986 as the target year and established the following guidelines.

(1) Population

In the target year the population of the country will reach 42 million, of which about 30% will concentrate in the Seoul Metropolitan Area.

(2) Assignment of industries

Seaside heavy industries will be located in Inchun district and light industries will be assigned along Kyungin Line and Kyungbu Line. In consideration of water resources for Seoul City, industries of the type which may cause water pollution will not be located upstream of the point of water intake.

(3) Development of land for housing construction

To cope with the increase of the city population, housing lots of low price and good environment will be supplied amply. Public investment and loans for housing construction will also be increased to reduce housing shortage to 2% ultimately. For this purpose, land readjustment work will be accelerated for the area south of the Han River in Seoul City and at the same time, establishment of housing complexes in relation with industrial districts along Kyungbu Line and Kyungin Line will be promoted vigorously to bring the housing close to the place of work.

(4) Creation of sub-city centers

To improve the present nucleous city pattern and plan for the dispersion of functions of the city center, creation of sub-city centers including Yungdeungpo will be contemplated and extensive deployment of the city will be attempted.

(5) Redevelopment of city center (CBD)

Among various establishments comprising the present city center, those that have already lost the ground for being located in the city center will be dispersed to the outlying area as much as possible. The city center will be reorganized to a structure consisting of mainly the business establishments with appropriately arranged consumers' establishments. In the implementation of the city center redevelopment plan, efforts must be made for effective land use and multiplication of building story must be planned while maintaining a balance with public facilities.

(6) Construction of urban transit system

To realize extensive deployment of the city and secure a means of transport within the Metropolitan Area, construction of mass transit systems such as subways must be contemplated vigorously.

In 1986 when the above-mentioned plans become a reality, the gross national product will have made a rapid growth. Per capita national income will have increased by about two-fold and the citizens will be able to enjoy modern and civilized life.

## 2-2 Land Use Plan and Population Assignment Plan

In planning an urban transit system, the pattern of land use and assignment of population, the source of traffic generation, must always be clarified. On this point, the current transport plan forecasts up to 1990 but sets 1981 as the target year.

Therefore, the forecast was made for three stages, 1981 and 1973 and 1976, the half-points to the target year, while keeping in mind the previously stated "Concept of Metropolitan Area" proposed by the Ministry of Construction.

Although it is extremely difficult to make a prediction of the future and the forecasts may differ considerably depending on the method used, an estimate of the future value was made on the following assumptions. In making the estimate the city area of Seoul was divided into 21 zones and the outlying area into seven districts for the convenience of calculation and several assumptions were also made.

Division of the city area into zones is shown in Chart 2-2-1.

(1) The population of the whole Metropolitan Area in 1981 will be 13 million, of which 7.5 million will be in Seoul City and 5.5 million will be in the outlying area.

(2) In CBD of Seoul City the present doughnut phenomenon of the resident population will continue to exist and the range of such phenomenon will be expanded. Dispersion of population will be accelerated in the districts where population density is extremely high.

The range of CBD will expand toward south of Seoul Railroads Station.

(3) In the area south of the Han River the population will increase at such a high rate as 11.5% per year until 1975 following the development of housing area and the progress of industrial establishment along Kyungbu Line and Kyungin Line and an increase of about 7.5% is also expected after 1975.

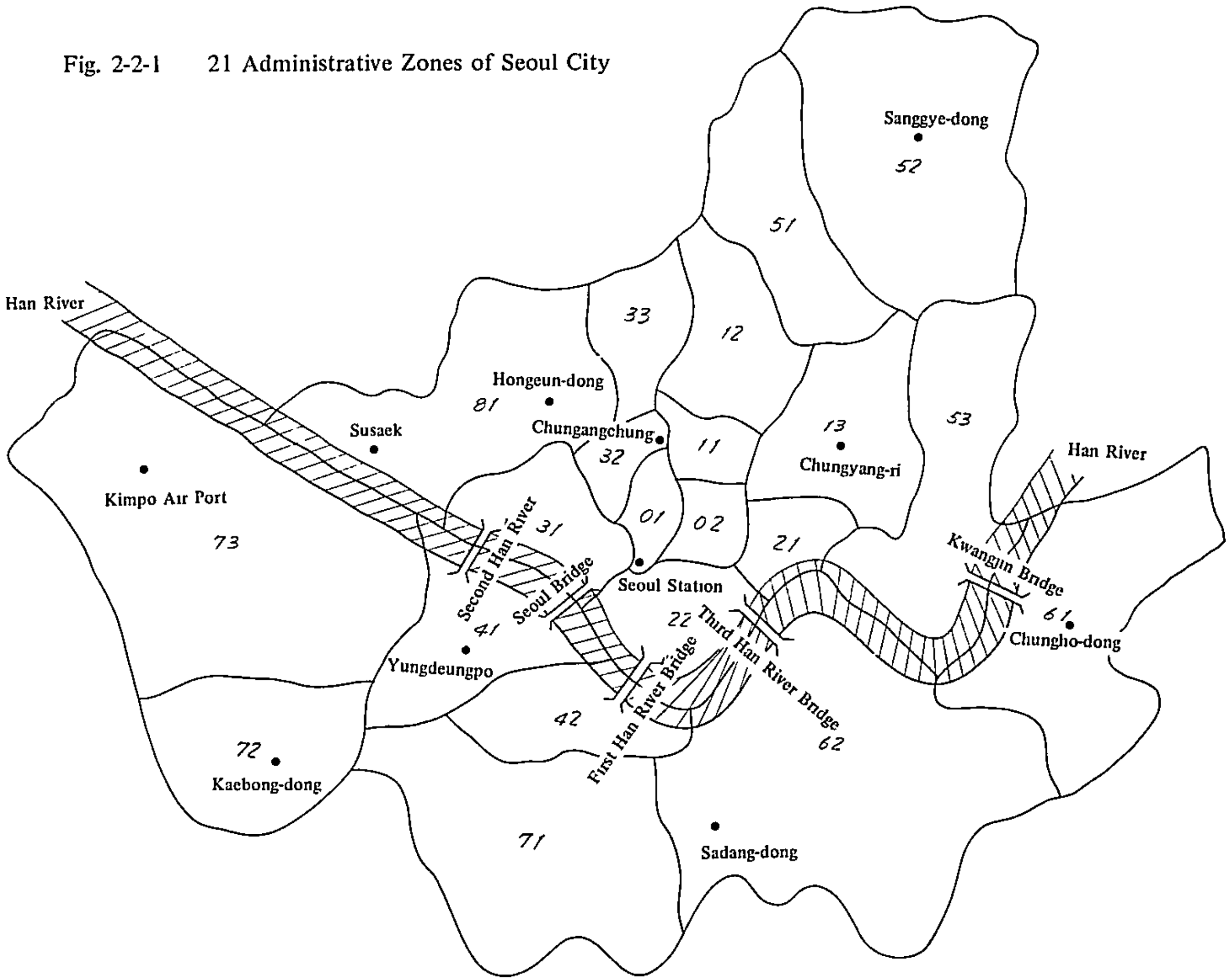
(4) In the newly developed areas south of the Han River, an excellent environment for housing districts of the population density of 10,000/$km^2$ will be secured.

(5) In the north of the Han River, where no major changes are expected in land use except for the city center, there will be few changes in the population and the increase is expected to continue leveling off until 1981.

(6) Zone 01 and Zone 02 will be designated as Central Business Districts (CBD) and the area of the two zones is estimated to be about 10 $km^2$.

(7) Populations of the outlying areas of Seoul City will be increased at an annual rate of 5.5%, centering around the nuclear cities.

Fig. 2-2-1 21 Administrative Zones of Seoul City



(8) The nuclear cities will include four satellite cities with a population of over 500,000. Among them will be Inchun with a population of one million, Suwon with a population of 600,000 and Anyang and Sosa, each having a population of 500,000. For Kwangju industrial (housing) complex, it was assumed that a city with a population of 300,000 would be created, by taking into consideration the policies of the city.

Based on the above assumption, the population of each zone of Seoul City and each of the seven outlying areas were estimated for each year as shown in Tables 2-2-1 and 2-2-2.

Table 2-2-1 Population of Seoul City by Zone and Year

(Unit: 1,000)

| | | Zone | 1969 | 1973 | 1976 | 1981 |
|---|---|---|---|---|---|---|
| North of the Han River | Central Zone | 01 | 91 | 85 | 76 | 45 |
| | | 02 | 144 | 125 | 106 | 58 |
| | | 11 | 89 | 88 | 82 | 57 |
| | | 12 | 225 | 219 | 213 | 202 |
| | | 13 | 668 | 630 | 596 | 522 |
| | | 21 | 465 | 429 | 401 | 351 |
| | | 22 | 297 | 291 | 286 | 278 |
| | | 31 | 713 | 710 | 690 | 591 |
| | | 32 | 47 | 45 | 43 | 36 |
| | Sub-total | | 2,739 | 2,622 | 2,493 | 2,140 |
| | Outlying Zone | 33 | 21 | 28 | 39 | 80 |
| | | 51 | 361 | 413 | 439 | 439 |
| | | 52 | 116 | 231 | 337 | 578 |
| | | 53 | 190 | 244 | 316 | 541 |
| | | 81 | 319 | 344 | 359 | 372 |
| | Sub-total | | 1,007 | 1,260 | 1,490 | 2,010 |
| Total, north of the Han River | | | 3,746 | 3,882 | 3,983 | 4,150 |
| South of the Han River | | 41 | 171 | 228 | 268 | 320 |
| | | 42 | 429 | 432 | 433 | 433 |
| | | 61 | 103 | 221 | 327 | 561 |
| | | 62 | 65 | 300 | 488 | 837 |
| | | 71 | 227 | 303 | 355 | 426 |
| | | 72 | 42 | 107 | 159 | 261 |
| | | 73 | 94 | 232 | 336 | 512 |
| Total, south of the Han River | | | 1,131 | 1,823 | 2,366 | 3,350 |
| Grand Total | | | 4,877 | 5,705 | 6,349 | 7,500 |

Table 2-2-2 Population of Seven Outlying Areas by Year

(Unit : 1,000)

| | 1969 | 1973 | 1976 | 1981 | |
|---|---|---|---|---|---|
| Suwon Area | 635 | 976 | 1,267 | 1,730 | |
| Anyang | 72 | 214 | 321 | 500 | |
| Suwon | 153 | 301 | 414 | 600 | |
| Osan | 27 | 51 | 69 | 100 | |
| Yongin-gun | 106 | 113 | 150 | 190 | |
| Shiheung-gun | 83 | 88 | 92 | 100 | Anyang excluded |
| Hwasung-gun | 194 | 209 | 221 | 240 | |
| Kwangju Area | 249 | 355 | 435 | 570 | |
| Kwangju-gun | 99 | 105 | 111 | 120 | |
| Kwangju complex | 30 | 120 | 187 | 300 | |
| Ichun-gun | 120 | 130 | 137 | 150 | In part |
| Inchun Area | 748 | 1,038 | 1,256 | 1,620 | |
| Sosa | 50 | 200 | 312 | 500 | |
| Inchun | 600 | 733 | 833 | 1,000 | |
| Buchun-gun | 98 | 105 | 111 | 120 | Sosa excluded |
| Kimpo Area | 209 | 226 | 238 | 260 | |
| Kangha-gun | 122 | 131 | 138 | 150 | |
| Kimpo-gun | 87 | 95 | 100 | 110 | |
| Euijungbu Area | 328 | 389 | 435 | 510 | |
| Euijungbu A | 87 | 125 | 153 | 200 | |
| Dongduchun | 66 | 77 | 86 | 100 | |
| Yangju-gun | 57 | 61 | 65 | 70 | In part |
| Pochun-gun | 86 | 91 | 94 | 100 | |
| Kapyung-gun | 82 | 35 | 37 | 40 | |
| Kyungeui Line Area | 308 | 383 | 438 | 540 | |
| Neunggok | 31 | 87 | 130 | 200 | |
| Keumchon | 36 | 41 | 44 | 50 | |
| Munsan | 36 | 41 | 44 | 50 | |
| Kayang-gun | 72 | 75 | 77 | 90 | Neunggok excluded |
| Paju-gun | 133 | 139 | 143 | 150 | In part |
| Chungang Line Area | 177 | 208 | 231 | 270 | |
| Yangju-gun | 123 | 149 | 168 | 200 | |
| Yangpyung-gun | 54 | 59 | 63 | 70 | In part |
| Total | 2,654 | 3,576 | 4,300 | 5,500 | |

## 2-3 Present State and Future Prospects of Urban Traffic

### 2-3-1 Present state of urban traffic

The city of Seoul is now in the process of a rapid expansion into a mammoth city. In order to maintain its function as a city and make a further growth with limited investment in social overhead capital, it is necessary for the city to solve various problems. One of the most serious problems that confront the city today is the urban traffic.

The present traffic in Seoul City depends mainly on buses, passenger cars and taxis. The share of railroads in the city transport is extremely small and about 97% of the city traffic depend on buses and taxis.

| Total traffic (1,000) | Bus (1,000) | Taxi (1,000) | Privately owned commuting bus (1,000) | Others (1,000) |
|---|---|---|---|---|
| 5,260 | 3,903 | 1,107 | 120 | 130 |
| 100% | 74.2% | 21.0% | 2.3% | 2.5% |

(Present state of traffic in Metropolitan Area and countermeasures, Seoul City)

Moreover, because of the nuclear city pattern of Seoul City, the majority of these traffic concentrate in CBD. CBD of Seoul City includes part of Chongno-ku and part of Chung-ku and has a total area of about 10 $km^2$ and about 70% of the total traffic of Seoul City concentrates in the nuclear part of the CBD, covering an area of 5.5 $km^2$.

Because of the topography and historical background of Seoul City, traffic in this district is specially heavy in the east-west direction but the capacity of road is the lowest in this direction. As a result, the capacity of road has already reached the saturation point on Chongno, Chunggyechon and Euljiro, all of which run in the east-west direction. To alleviate this situation, improvement of traffic facilities including grade separation of intersections and construction of elevated roadways is being progressed. Besides, various traffic control measures are being enforced, but they are still short of satisfying ever increasing traffic demands by automobiles and as a result, road traffic is delayed considerably depending on time and places. For this reason, there have been increasing signs of environmental disruptions caused by traffic such as gas emission, noises and vibrations caused by automobiles.

The City of Seoul is now in the process of a rapid growth and the income of the citizens is also expected to grow rapidly. Despite the present government measures to curb the purchase of automobiles, further progress of motorization will be unavoidable, whether one likes it or not, with the rise of income level of the people in the future.

From the examples of other countries, the number of registered passenger cars in Seoul City in 1975, when the average per capita income in Seoul City is expected to exceed the $600 level (on present price level), is expected to increase to 120,000.

Under the circumstances, the transport system of Seoul City must undergo a drastic change. Otherwise, sound growth of the city will not be materialized and moreover, deterioration and paralysis of city function will be unavoidable.

2-3-2 Concept of new transport system

The City of Seoul, now requiring a new transport system urgently, may be said to be in the most opportune stage for working out an urban transport project from the following two reasons.

That is, in the stage when there is no definite prospect for the growth of the city into a mammoth city, the administrators often adopt a small scale project in fear of the burden of investment and suffer consequences after experiencing shortages of transport capacity caused by increased transport demands thereafter. Or when the city administrators have little experience in automobile traffic, they often place too much hope on the future capacity of road network and neglect the need of an urban rapid transit system. It must be said most appropriate, therefore, to plan a transport system which will be required and which will be sufficient for the future mammoth city at the time when all the opportunities are matured with the support of citizens. The year of 1970 is indeed an opportune time for the City of Seoul for planning such a transport system.

Generally, as the size of a city expands, its transport system also changes accordingly, as a matter of course. In most cases, the city with a population of hundreds of thousands may well depend on automobile transport, but the city with a population of a million or so is usually provided with a rapid transit system within the existing city area (subways or elevated railroads having its own track). The city with a population of several million is provided with a rapid transit network covering its suburbs or the entire Metropolitan Area. When the transport system such as mentioned above is not provided adequately keeping with the expansion of the city, traffic paralysis will be unavoidable and the functions of the city will be hampered considerably. In the City of Seoul bus transport has been playing an important role in mass transport of passengers. As previously stated, however, the vehicular traffic on the majority of major roads in the city center has already reached the capacity of the roads. Even with the expansion of these roads or improvements of intersections, it will be almost impossible to expect a substantial increase in the road capacity to fully satisfy the future transport demands. If more automobiles are put on the street with the expansion of transport demands in CBD of Seoul City, the consequence will be the intensified traffic jam on the road and as a result, the running speed of automobiles will be reduced considerably.

After all, the increase in the number of automobiles will not contribute to the expansion of transport capacity of the city area. It is considered inevitable, therefore, to solve traffic problems of Seoul City by providing such an urban rapid transit system which offers the maximum transport capacity and the highest efficiency as a means of urban transportation.

The bus transport system which has long been playing its role as a means of urban transportation in Seoul City will not terminate its role upon completion of the new rapid transit system. Transportation of passengers from the area not covered by railroad network will also remain as a role of bus transport in the future. In the area covered by rapid transit railroad network, a new traffic system must be established with organic combination of bus transport system and railroad network. In other words, there must be a reorganization of traffic system to the so-called "Bus and Ride" transport system.

With the growth of the Metropolitan Area and the expansion of commuting range and also with the intensification of traffic congestion on the road in the city area as a result of increased popularity of automobiles, the dependency of commuters going to the place of work or school in CBD on rapid transit system will also be increased. If bus transport system is used for transportation of these commuters to a railroads station, the people residing in the area within a radius of several km will be greatly benefited. Without this "Bus and Ride" transport system, a combination of railroad and bus transport, development of the outlying area of major cities will not be expected. It is necessary, therefore, to establish a bus transport network which extends in all directions from a railroads station in conjunction with the construction of a rapid transit system. There will also be changes in the existing bus routes and the shifting of bus routes to this direction will be inevitable following the changes in the trends of passengers.

# III PLANNING OF URBAN RAPID TRANSIT RAILROAD PROJECT

# III PLANNING OF URBAN RAPID TRANSIT RAILROAD PROJECT

## 3-1 Basic Concept of Rapid Transit Railroad Network

### 3-1-1 Policy

As stated in the previous chapter, the city of Seoul is now growing to one of the leading cities of the world with the population in its metropolitan area exceeding 10 million. As a rapid transit railroad network for this growing metropolis, it was concluded that the city would need by 1981 five railroad lines which pass through CBD of the city and extend to the outlying area.

In the case of Seoul city, the urban rapid transit system must fulfill the following two objectives.

(1) Improvement of present urban traffic conditions -------- Solution of today's traffic problems and prevention of traffic paralysis.

(2) Expansion of city functions and development of outlying areas to new city areas -------- Redevelopment of CBD, prevention of over-population and development of sub city centers and satellite cities.

For this purpose, it must be a fundamental policy that the proposed rapid transit railroad network possess the highest economic value and provides a social benefit. In planning the network, therefore, consideration was given to the effective use of the existing railroad lines, and the existing road network in the city area and also to the design of the railroad network so that some reserve capacity may be provided to meet an increase in transport demands in the 1980's.

### 3-1-2 Selection of type of railroad system

As a rapid transit railroad system, adoption of both the conventional type of railroad by constructing elevated structures in the city area and the monorail system is conceivable. In this case, however, the subway system was adopted for the city area from the following reasons.

(1) In the present city area elevated railroad system is not advisable from the standpoint of the appearance of the city and the prevention of noises.

(2) The railroad system to be selected must possess the highest transport capacity and the possibility of through operation with the existing K.N.R. lines must also be taken into consideration.

In the outlying area, however, the railroad system under consideration will naturally come out to the surface and run over the elevated structures, semi-underground structures or embankment. Particularly, in the area where new city districts are planned, it is essential to provide elevated structures or semi-underground structures in coordination with the road project.

### 3-1-3 Railroad network centering on CBD

All of the above-mentioned five lines were planned to route through CBD of Seoul City. Each of world's mammoth cities including Tokyo, New York and London has a dense network of rapid transit system in its CBD.

Although the future Seoul City is expected to expand toward the outlying area, particularly toward south of the Han River, the function of the present CBD as the nerve center of the nation will still continue to exist and the centralization of functions will result in higher efficiency in handling city activities. As the future possibility, the increase of the population to the maximum limit of accommodating capacity of CBD must be taken into consideration. As for employed population, it is estimated that CBD is able to accommodate up to twice the number of the present employed population. It is necessary, therefore, to anticipate a large number of commuters from the outlying area, particularly from the south of the city. To cope with such an increase in the employed population, the proposed five lines are considered adequate for the time being but there must be room left for the future addition of lines depending on the increase in employed population in some area.

3-1-4 Scope and pattern of rapid transit railroad network

As for the scope of railroad network, consideration was given to the alignment of a rapid transit railroad network so that it would cover the entire metropolitan area by through operation with the existing railroads or by extension of the line to the outlying area.

Generally, the alignment of rapid transit railroad network includes the following types:

(a) The type that links the loop line of the city area with the suburban railroads.

(b) The centralized radial type that terminates in the city center.

(c) The type which runs through the city center and extends directly to the outlying area.

With the growth of cities into mammoth cities the network of through type (paragraph (c)) is gaining the popularity as in the case of Tokyo. The main reason for this trend may be as follows:

(1) As the commuting distance increases, the desire of passengers to avoid transfers as much as possible becomes more conspicuous. Because of the increased value of time for each commuter, the time consumed in transferring trains is considered to be a great loss to the life of society.

(2) The greatest disadvantages of the loop line type is that the congestion at the junction stations with the suburban railroads is unavoidable, thus causing confusions in the train operation. With the loop line type network, there is often an extreme unbalance in the traffic volume depending on the sections of the line and the increase of passengers from the suburban railroads often causes a shortage of transport capacity of the loop line itself.

(3) The commuters' trains are operated on dense operating schedule and as a result, require many cars and crew members. Addition of one turn-back point to the line makes it necessary to provide one extra train of complete set for each direction and extra crew members. It is also necessary to provide special platforms or lead track for turn-back operation.

The same situation is also conceivable for Seoul City. For this reason, the type of network for Seoul City should be the through operation type mentioned in paragraph (c).

As for the existing railroad, there is a line along the north bank of the Han River, which links Chungyangri and Yongsan (part of Kyungwon Line). It is conceivable, therefore, that this line is utilized for loop line operation. However, judging from the area through which the line is laid, the contribution of this line to the urban transport is not considered significant and besides, the line for Seoul area. It is important, therefore, to consider the use of this line mainly for the transportation of freight in order to meet the future increase in the volume of freight transport.

### 3-2 Macroscopic Forecast of Transport Demands

The hours in which the maximum capacity of the mass transport facilities is required is the morning rush-hours when 20 to 30% of the total passengers entering CBD through the day converge upon. More than 80% of the passengers during this hour are commuters going to the place of work or school. As these passengers concentrate on CBD in a limited duration, the comprehension of the true state of commuters during such hours will provide an overall picture of transport demands for mass transport facilities.

Consequently, it is advisable to make a macroscopic forecast of the number of present and future commuters concentrating on CBD before starting a detailed analysis of transport demands. In this macroscopic forecast the commuters were divided into two groups, the workers going to the place of work and the students going to school and then the forecast was made for the present (1970) and for the target year (1981).

#### 3-2-1 Number of commuting workers and students entering CBD

According to the bus traffic flow chart prepared by Seoul City for main roads in the city area, the number of persons passing the Cordon Line surrounding CBD during a two hour period in the rush-hours is as follows:

| Type of bus | Number of buses passing Cordon Line | Number of passengers per bus | Number of passengers passing Cordon Line |
|---|---|---|---|
| Ordinary | 3,273 | 126 | 412,398 |
| Seat-type and express | 5,339 | 70 | 373,730 |
| Total | | | 786,128 |

Of the above number, passengers entering CBD are assumed to account for 70%, or 786,000 x 0.7 = 550,000.

The number of persons entering CBD by automobile during a two hour period of the rush-hours is estimated to be the following.

| 1967 | | | |
|---|---|---|---|
| Number of automobiles with final destination in CBD (All day) | Rate of concentration during a two hour period | Number of auto mobiles entering CBD during a two hour period | Correction coefficient for 1970 |
| 213,653 | 12% | 26,638 | 1.55 |

| 1970 | | |
|---|---|---|
| Number of automobiles entering CBD during a two hour period | Average number of passengers (Drivers excluded) per car | Number of persons entering CBD by car during a two hour period |
| 39,739 | 2 | 79,478 ≒ 79,000 |

Notes: (1) The above is in acoordance with OD survey for automobiles conducted by Seoul City Office (1967).

(2) Correction coefficient for 1970 was determined by the ratio of traffic on major roads of Seoul City in 1970 to that in 1967.

Therefore, the number of persons entering CBD by bus and car during a two hour period of the rush hours will be:

550,000 + 79,000 = 629,000

Of this, 15% are the passengers other than commuters (Those going to the place of work or to school). Meanwhile, 87% of the total commuters concentrate on a 2 hour period of the rush-hours (According to data on metropolitan traffic, Seoul City) and the number of commuters (workers and students) is estimated to be:

629,000 x 0.85 ÷ 0.87 = 615,000 ≒ 600,000

The number of highschool and college students in Chongno district and Chung district is estimated at approximately 72,000 and that in Sungdong district Sungbuk district is estimated to be 70,000. Assuming that all the students in Chongno district and Chung district enter or pass through CBD and that 1/2 of the total students in Sungdong district and Sungbuk district pass through CBD, the number of students concentrating on CBD during the rush-hours is estimated at 107,000. Although the school district system is enforced for junior highschool, each school district is comparatively large and therefore, about the same number of junior highschool students is assumed to enters or passes through CBD. Therefore, the total number of students commuting is estimated at 200,000.

From the above calculations, we shall not greately err if we assume the number of commuters (workers and students) now entering CBD as follows:

| | |
|---|---|
| Number of commuting workers | 400,000 |
| Number of commuting students | 200,000 |
| Total | 600,000 |

3-2-2 Estimated number of commuters entering CBD in Target Year (1981)

When the future land use is taken into consideration, it is assumed that the number of schools in CBD will not increase and that the demands for new school will be satisfied in the outlying area. Therefore, the number of commuting students is expected to remain the same.

The number of commuting workers, however, is expected to increase further with the increase of the population in the Seoul Metropolitan Area.

The person trip then is expected to show almost the same pattern as in the case of the present Tokyo Metropolitan Area. The following is the result of a person trip survey conducted in Tokyo Metropolitan Area (1968).

| Population of 5 years of age or over in Tokyo Metropolis | Number of trips made by persons 5 years of age or over A | Number of trips to place of work, out of A B | Number of trips to CBD out of B C | Average number of trips per person a day |
|---|---|---|---|---|
| | | 6,400,000 | 1,321,000 | |
| 19,460,000 | 48,297,000 | B/A = 13.3% | C/B = 20.6% | 2.5 |

Note: CBD of Tokyo Metropolis covers Chiyoda, Chuo and Minato Wards in the heart of Tokyo.

On the assumption that the population of 5 years of age or over in the Seoul Metropolitan Area in 1981 is about 90% of the already estimated total population of 13 million (Korea Statistical Yearbook 1969), the following may be obtained with the use of the same basic unit as that used for Tokyo.

| Total population of Seoul Metropolitan Area | Population of 5 years of age or over | Average Number of trips per person a day | Total number of trips in Seoul Metropolitan Area | Number of trips to place of work | Number of trips to place of work in CBD |
|---|---|---|---|---|---|
| 13,000,000 | 11,700,000 | 2.5 | 29,250,000 | 3,890,000 13.3% of the figure in the column at left | 801 000 = 800,000 20.6% of the figure in the column at left |

The number of commuters (workers and students) entering CBD in the target year will be as follows

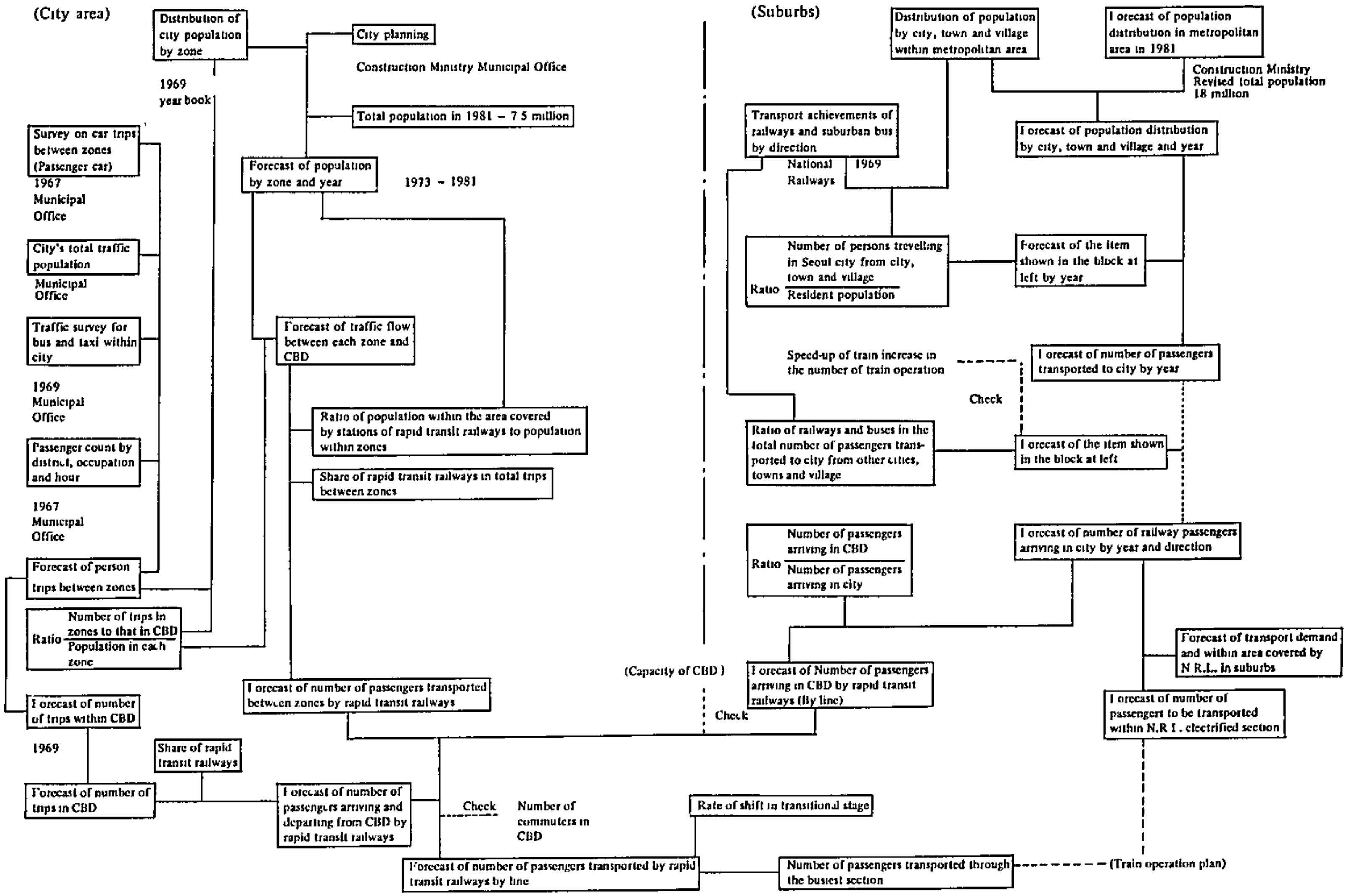
| | |
|---|---|
| Number of commuting workers | 800,000 |
| Number of commuting students | 200,000 |
| Total | 1,000,000 |

## 3-3 Forecast of Transport Demands for Urban Rapid Transit Railroad

### 3-3-1 Method of forecasting transport demands

For such various reasons as the necessity of preventing concentration of the population in city area, redevelopment of the over-populated area and establishment of housing areas and satellite cities in the outlying area, the special city of Seoul is expected to undergo major changes in the population distribution in the city area and also in the city traffic system. In forecasting transport demands, therefore, reliance on the propensity value based on the traffic survey data of the past alone is not adequate. Therefore, in forecasting future transport demands, prospects of futuee changes in environments were taken into consideration

Fig 3-3-1 Transport Demand Forecast Flow Chart, Seoul Special City Rapid Transit Railways



as much as possible and at the same time, the reorganization of public transport facilities of Seoul Special City were established with completion of the urban rapid transit system, that is bus routes will be rearranged so that the emphasis of bus transport may be placed on the supplemental role to the urban rapid transit system or the distribution role and "Bus and Ride System" will be adopted positively. The method of forecasting transport demand is shown in Chart 3-3-1.

3-3-2 Estimated transport volume in 1981

(1) Estimated population entering CBD by transport facilities

The estimate on transport demands by area was made from the present population distribution by zone within Seoul Special City, estimated population distribution in Metropolitan Area by city, town and county (see 2-2) and the ratio of the population entering CBD by transport facility to the total population in each zone, city and town. The results of estimate are shown in the following table.

Table 3-3-1 Estimated Population Entering CBD By Transport Facility (Daily)

| | 1969 (1,000) | 1981 (1,000) | Rate % |
|---|---|---|---|
| Area along Kyungbu Line and Kyungin Line | 221 | 376 | 170 |
| Direction to Mapo and Kinpo | 121 | 200 | 165 |
| Direction to Shinchon and Neunggok | 100 | 98 | 98 |
| Direction to Bulgwang-dong | 107 | 105 | 98 |
| Direction to Mia-dong and Suyu | 122 | 131 | 107 |
| Chungyangri, area along Kyungwon Line and Chungang Line | 220 | 299 | 136 |
| Direction to Chunho-dong and Kwangju | 100 | 226 | 226 |
| Direction to Yungdong (Third Han River Bridge) | 74 | 252 | 341 |
| Total | 1065 | 1687 | 157 |

At present, the number of persons entering CBD of Seoul City in week days by means of transport facilities is estimated to be about one million. This figure may be broken down into 400,000 for commuting workers, 200,000 for commuting students and about 400,000 for shoppers and others, as described in the previous section.

In 1981 the number of persons entering CBD by means of transport facilities is estimated to be about 1.7 million. This figure may be further broken down into 800,000 for commuting workers, 200,000 for students and about 700,000 for shoppers and others.

(2) Forecast of transport volume for urban rapid transit system

On the basis of the population distribution in each zone of Seoul City and in the outlying cities, towns and counties, the sphere of railroad stations on the five lines of the urban rapid transit system was assumed by taking into consideration the geography and road conditions.

and also from the population distribution in each zone, the previously mentioned number of persons entering CBD was divided into two groups, one group which utilizes urban rapid transit system and the other utilizes other means of trans transportation. To these, the number of person trips between zones through CBD, Number of person trips between zones other than CBD and the number of person trips between CBD by means of urban rapid transit system were added.

In determining relationship between the population of each region and the number of commuting workers and students entering CBD, the ratio of person trips arriving and originating in CBD to the passengers passing through CBD and the relationship between the number of persons arriving and originating in CBD and the number of passengers arriving and originating in the area other than CBD, reference was made to the 1967 car trip (passenger cars) OD Table compiled by Seoul Special City, 1969 survey on the number of person trips by area and hour and other traffic data of Seoul, and returns of census taken in Tokyo and Osaka, results of person trip surveys in Tokyo and the records of subways in Tokyo (The basis of calculation is shown in Table 3-3-3).

The total number of passengers for each area thus estimated is given in Table 3-3-2.

Table 3-3-2 Number of passengers transported by Urban Rapid Transit System in 1981 by direction (Daily)

| Direction | Number of passengers arriving and originating within Seoul (person) | Number of passengers arriving and originating in both Seoul and outlying area (person) | Total (person) |
|---|---|---|---|
| Mia-dong | 250,230 | | 250,230 |
| Chungyangri | 227,810 | 56,400 | 284,210 |
| Chunho-dong | 490,650 | 48,000 | 538,650 |
| Kyngmajang | 303,070 | | 303,070 |
| Bogwang-dong | 271,410 | | 271,410 |
| Yongsan | 379,160 | | 379,160 |
| Seoul Station | 358,720 | 217,700 | 576,420 |
| Mapo | 408,380 | | 408,380 |
| Shinchon | 201,000 | | 201,000 |
| Naengchun | 109,950 | | 109,950 |
| Inside CBD | 345,000 | | 345,000 |
| Total | 3,345,380 | 322,100 | 3,667,480 |

3-3-3 Basis for estimation of transport demands

a. For the estimation of transport demands, the commuting workers and students (season-ticket holders) were taken as the basis and the total number of passengers was obtained by assuming the ratio of season ticket holders to non-season ticket holders.

The ratio of season ticket holders to non-season ticket holders in 1969 was assumed to be 58:42 on the basis of the past records of Seoul City and that in 1981 was assumed to be 60:40.

b. The number of commuting workers and students entering CBD from various areas was considered to be in proportion to the population of each area for all years. The percentage of persons entering CBD by zone was determined as follows by taking into account the distance between each zone and CBD and with reference to person trip surveys conducted in Tokyo.

| Zone | Ratio of commuting workers and students arriving at CBD to the total population of zone | Zone | Ratio of commuting workers and students arriving at CBD to the total population of zone | Zone | Ratio of commuting workers and students arriving at CBD to the total population of zone |
|---|---|---|---|---|---|
| 11 | 14% | 32 | 14% | 53 | 10% |
| 12 | 14 | 33 | 12 | 61 | 10 |
| 13 | 14 | 41 | 12 | 62 | 14 |
| 21 | 14 | 42 | 12 | 71 | 10 |
| 22 | 14 | 51 | 10 | 72 | 10 |
| 31 | 14 | 52 | 10 | 73 | 10 |
| | | | | 81 | 12 |

c. The ratio of commuting workers and students utilizing subways to the total number of commuting workers and students entering CBD from each zone was estimated as follows by taking into consideration the distance between CBD and each zone.

| Zone | Percentage of passengers utilizing subways (%) | Zone | Percentage of passengers utilizing subways (%) |
|---|---|---|---|
| 11 | 25 | 51 | 75 |
| 12 | 50 | 52 | 90 |
| 13 | 50 | 53 | 75 |
| 21 | 50 | 61 | 90 |
| 22 | 50 | 62 | 75 |
| 31 | 50 | 71 | 90 |
| 32 | 25 | 72 | 90 |
| 33 | 50 | 73 | 90 |
| 41 | 75 | 81 | 75 |
| 42 | 75 | | |

d. The ratio of passengers entering CBD from various areas to the passengers passing through CBD and heading for opposite direction was estimated to be 9% on the basis of the results of traffic surveys conducted by Seoul Special City and with reference to the records of movement of the population revealed by a census taken in Tokyo and Osaka.

e. The ratio of passengers entering CBD from various areas to the passengers arriving and departing from the area other than CBD was estimated as follows with the use of 25% as a standard with reference to the examples of Tokyo Subways and also by taking into consideration the length of each line from CBD.

| | | |
|---|---|---|
| 1) | Direction of Mia-dong | 25% |
| 2) | Direction of Chungyangri | 25% |
| 3) | Direction of Chunho-dong | 80% |
| 4) | Direction of Kyngmajang | 45% |
| 5) | Direction of Bogwang-dong | 45% |
| 6) | Direction of Yongsan | 60% |
| 7) | Direction of Seoul Station | 60% |
| 8) | Direction of Mapo | 75% |
| 9) | Direction of Shinchon | 25% |
| 10) | Direction of Naengchun | 25% |

f. The number of passengers using subways in CBD was estimated at 15,000/km daily on the average for each line, on the basis of 1967 Car Trip (passenger cars) OD Table and 1969 Survey on the Number of Passengers by area and hour, conducted by Seoul Special City and the past records of subways in Tokyo. The distribution of passengers to each line was estimated as follows by taking into consideration the area of CBD where the line passes through and the length of each line.

| | |
|---|---|
| No. 1 Line | 20% |
| No. 2 Line | 20% |
| No. 3 Line | 25% |
| No. 4 Line | 20% |
| No. 5 Line | 15% |

## 3-4 Selection of Routes for Urban Transit Network

### 3-4-1 Requirements of urban transit network

Since the urban rapid transit system constitutes a cardinal axis of city traffic, selection of its route requires most careful consideration. As the system, when completed, has a direct or indirect effect on the city as a whole or or exerts such a great influences as to make a great change in the appearance of the city, the most appropriate route network must be selected by judging the existing conditions of the city from a broad point of view.

In the past, the type of urban rapid transit network or the typical network of urban transit has been discussed on many occasions. Figure 3-4-1 shows typical networks of urban transit. All of them have merits and demerits but figures (a) (b) and (c) are not prictical. Figure (d) is called Peterson System, (e) Cauer System, (f) Schimpf System and (g) Turner System.

The proposed network of urban transit for Seoul Special City is, after all, a combination of (d) and (g).

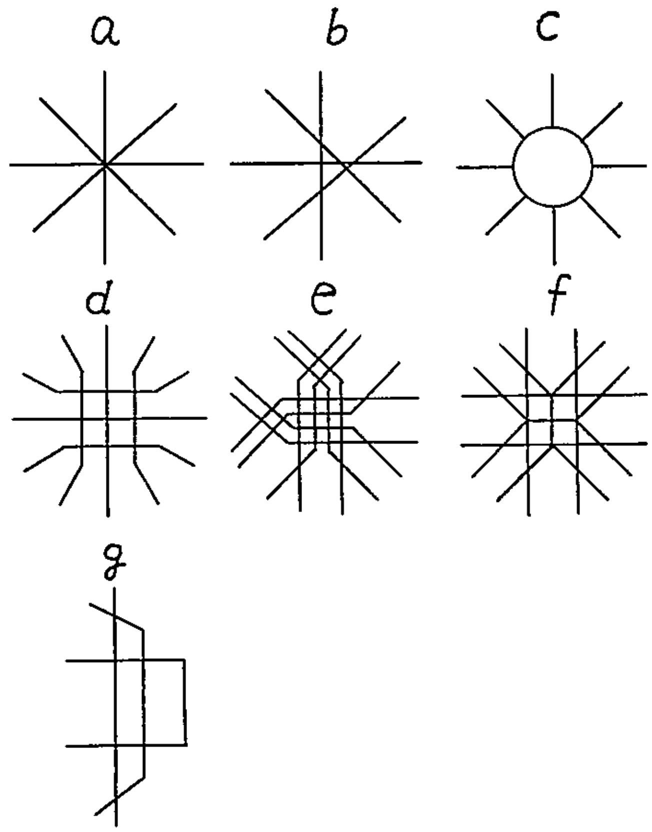
The present network of urban rapid transit system in Tokyo may be considered as a modification of (g). In the city that has been formed with historcal backgrounds, it is difficult to standardize line alignment into one specific type. Grade separation of more than two stories as shown in (a) increases technical difficulty by geometrical progression and therefore, should not be used. With the loop line type shown in (c), passengers from radial lines concentrate on the loop line and cause excess congestions. Therefore, this system should never be adopted.

With the consideration given to the above-mentioned factors, the survey team made a study for the selection of network with a first object of finding route which might satisfy transport and technical requirements. The essential points that the survey mission attached importance in selecting a network are as follows.

(1) The line alignment should be such that extends straight from the suburbs to the center of the city and further extends to the suburbs.

Since the primary purpose of the urban transit system is to share the larger part of traffic flow during the rush hours, the turn of the line in the center of the city may be unavoidable. However, the section between the city center and the suburbs should be made as a straight line as much as possible with due consideration given to transport demands along the proposed route. The route thus selected will help to reduce commuting time and construction cost and at the same time, will accelerate the development of the outlying area. There should also be due consideration given to the future extension of the line. The radius network that turns back in the city center requires a shuttle facility in the city center and moreover it operates near empty trains of poor utilization efficiency of passengers. Such operation loses the significance of capital investment. It is advisable, therefore, to plan another line that extends to the suburbs for the effective use of the line. There may be the time when it is required to divide the line into sections and construct only a certain section for the operation of trains only in that section. Even in such a case, the shuttle facilities (cross-over and related facilities such as signals,

Fig. 3-4-1 Typical Network of Urban Transit



etc.) will still be required. Therefore, if a station is designated for the installation of emergency cross-over where trains may be shuttled in case of accidents and other emergencies, in the initial planning of network, the waste of capital investment can be avoided.

(2) Network should be routed in the densely populated area to the extent that will not deviate from the requirements described in the previous paragraph.

When the line that extends straight to the city center is proposed, it often conflicts with the wish of passengers. It is natural, therefore, that the route should have some curved portions in consideration of present state of city, future plan and other factors. However, the route having an S-shape as a result of overemphasis of this point must be avoided by all means as a route of urban transit system. If such a route is required, bus or other transport facilities should be used as an alternative or an additional line should be planned. The point is that the selection of route must be based on the primary purpose of providing speedy transport of commuters.

The use of branch line is also conceivable. With this system, however, if the trains on this line are to run through on to the city center, the train density on the line outside the junction station will be reduced to half even on the main line. It is important, therefore, to give a careful study on transport demands before considering adoption of this system. The system of transferring passengers from the branch line at the junction station is not advisable when the transport volume is large.

(3) Selection of network should be made so to make the burden of transport even among the lines of the network.

Though it is understandable that the line which is constructed first is given the highest expectation in the city, it must be remembered that the line is only a part of the future network of the urban transit system. In planning a network, therefore, it is most important to give priority to the study of the entire network and then individual routes should be determined by giving full consideration to the spacing of routes, density of population, topography and other factors so that the burden of transport on each line may not be excessively heavy and unbalanced. Only after these considerations, construction should begin with the line having the highest priority.

Although the survey team set the target for 1981, expansion of the city is expected to continue beyond that target year and construction of additional lines will be required in the future. It is hoped, therefore, that your government will make constant studies and prepare not to be past cure.

(4) Selection of route should be made so as to provide connection to all directions with one transfer.

Depending on the way the lines are arranged the network sometimes requires more than one transfers and may become an inefficient network. Therefore, utmost attention must be paid to the combination of lines. There are also cases in which the construction of an underground railway station is difficult or impossible technically even when the combination of two crossing lines or two adjoining lines is planned. In selecting route, therefore, probe to the technical aspect must also be made as a matter of course.

The arrangement of a transfer station in such a case includes the shape of T. L. + . = and etc. The type most suitable to practical use should be selected by taking into consideration the walking distance of passengers and the simplicity of the structure of the station. However, if the convenience of passengers alone is over-emphasized, the design often results in the concentration of passengers on the stairways of the station with possible confusions at the station. It is necessary, therefore, to provide a certain walking distance to ensure belt-shape flow of passengers. In any event, the success or failure of the design of transfer station has the most influential effect on the evaluation of the transit by the passengers.

It must be stressed, therefore, that this point should be given utmost attention in designing transfer stations.

(5) Selection of route should be made so as to avoid duplication of the station area with the adjoining stations even in the city center.

The factors taken into consideration in determining the spacing of stations are the station area, trsnsport demands, train running speed, signal system, length of train (or the length of platforms) and construction cost of station facilities. These factors plus the conditions for locating stations should be taken into consideration in determining the spacing of stations. The standard distances are as follows:

| | |
|---|---|
| Undeveloped district | 2.0 ~ 3.0 km |
| Residential district | 0.8 ~ 1.5 km |
| City center | 0.6 ~ 1.2 km |

It may be unavoidable that the distance between stations in the city center is somewhat less than the above standard because of the distribution of passengers, but it is important to consider the distance by deducting the length of the station from the distance between the centers of two stations. It is advisable, therefore, to provide entrances to the subway on the surface at both ends of the platform as practically as possible for the convenience of passengers. For additional information, the present state of each line of the Teito Rapid Transit Authority in Tokyo shown in Table 3-4-1.

Table 3-4-1 Outlines of Teito Rapid Transit Authority By Line

| Line | Ginza | Marunouchi | Hibiya | Tozai | Chiyoda | Remarks |
|---|---|---|---|---|---|---|
| Operating Kilometerage | 14.3 km | 27.4 km | 20.3 km | 30.8 km | 9.9 km | As of end of June 1970 |
| Number of stations | 18 | 27 | 21 | 20 | 8 | " |
| Maximum distance between stations | 1.5 km Akasakamitsuke Toranomon | 1.9 km Nakanosakaue Shinjuku | 2.1 km Kitasenju Minamisenju | 3.9 km Minamisunamachi Kasai | 2.6 km Kitasenju Machiya | " |
| Minimum distance between stations | 0.5 km Uenohirokoji Ueno | 0.3 km Shinjuku Shinjukusanchome | 0.4 km Higashiginza Ginza Ginza Hibiya | 0.5 km Nihonbashi Kayabacho | 0.9 km Nishinippori Sendagi | " |
| Average distance between stations | 0.8 km | 1.1 km | 1.0 km | 1.6 km | 1.4 km | " |
| Number of passengers transported (1,000/day) | 975 | 1,268 | 880 | 782 | 90 | Total· 3,995 for June 1970 |

| The station handling the largest pssengers | The station handling the smallest passengers | Remarks |
|---|---|---|
| Ikebukuro (Terminal station of Marunouchi Line) 371,416 persons/day | Barakinakayama (Undeveloped area of Tozai Line) 3,279 persons/day | Last half of 1969 |

(6) Selection of route should be made after fully investigating the state of buildings in the surrounding area, topography and geology of the proposed route and also by keeping in mind the construction method that is practical with the present civil engineering technology.

In selecting the route for the proposed transit network, an estimate of transport demands is essential as a matter of course, but the relative difficulty of construction work should also be given consideration at all times. In the city like Seoul where streets cross one another almost attright angles, it is sometimes difficult to determine where to make a curve of the line. With the rapid transit system, as a rule, the use of an excessively small radius of curve will bring about adverse effect on the operating speed of train, power consumption and the track maintenance cost. It also makes the line longer with the resultant increase in the construction cost. However, in consideration of the event when the cost of compensation for private land and buildings amounts to a considerable sum, the route should be determined after making a full study of the route from an economical point of view. It is also conceivable that the fund is spent generously to avoid a small radius of curve so that the sources of future difficulty may be eliminated at time of initial construction.

Next, the topography and geology of the proposed route must also be fully comprehended. In the city like Seoul where the terrain is rugged and granite layers are found near surface or deep in the ground in a complicated composition, it is very risky to determine the route after making only a plane survey. For the network surveyed by the team, little data was available on the geology of the proposed route and as a result, the network was determined on the assumptions of the conditions in the proposed route. It is strongly recommended, therefore, that a longitudinal study of the route be provided by initiating a geological survey on these routes as early as possible. Particularly with the lines which will cross No. 1 Line to be constructed as the first phase of the urban transit project, at least the survey on the portions which are considered to be related with No. 1 Line should be accelerated and the construction of No. 1 Line should begin only after an assurance has been obtained for the crossing of No. 1 Line with other proposed lines. In the future, there will be a need for the adoption of the tunnel construction method for the section under road or buildings.

It is recommended, therefore, that a detailed construction method for the ordinary mining tunnel under road or building be worked out and that the route be determined with confidence.

(7) Relations with urban planning, road traffic and other railroad traffic should be taken into consideration.

It is needless to say that the urban transit project is an integral part of urban planning. Locating the route of the urban transit system along the road planned under the urban planning project will benefit passengers considerably upon completion of the system. However, as the route of the road under the urban planning does not always conform to the proposed route of the urban transit system, an effort should be made to bring both routes to the same line as much as possible by holding consultations between the two parties. As a means to save construction costs, the team recommends the adoption of the concept of co-existence with roads in the area outside a radius of 5 km by avoiding the adoption of the tunnel system and instead constructing elevated structures or employing the open-cut system in the center of the road.

It is natural that the connection with the existing roads or railroad lines must be taken into consideration. However, since the junction point of the urban transit system and the bus route must have a separate facility for the terminal of bus, there must be positive cooperation of the officials responsible for urban planning.

(8) Utilization of road for the route not only help promote the understanding of passengers and makes the facility more convenient but greatly contribute to the reduction of construction cost.

As stated in the previous paragraph, utilization of road for the route of the transit system will greatly contribute to the reduction of construction cost. From the standpoint of passengers, meanwhile, they can use subways without being confused in using surface transport system. Advisability of this state is evident from the examples of subways in other cities.

The people, after going down the ground and passing through bending stairways and walkways, often loses orientation before reaching the platform. At the out station the people often loses his confidence for orientation and is in doubt which way to go for the exit. The majority of inquires made to station clerks by passengers are this type. To eliminate this drawback, therefore, it is most advisable to locate the route to conform with the flow of surface traffic. For the selection of the route in the city center in particular, attention should always be given to this point.

It is also important to show originality such as distinguishing the identy of lines and stations by using different colors for trains and station premises for the convenience of passengers.

(9) Remodeling of the route of the urban transit system, especially the underground portion, is almost impossible or extremely difficult.

Remodeling of the route of the urban transit system, particularly the subway, after its completion is not easily accomplished. Therefore construction should begin only after giving a thorough study on the line alignment. Future alteration, if possible, will have to sacrifice a part of the completed line alignment or structures. Examples of other countries show that while the need of remodeling the old line is recognized, the authorities would not initiate the work and instead compensate the defect of the old line by constructing a new line or take a daring decision to invest a large amount of money to alter the line or leave the line as it is. In selecting the route for the network, therefore, the future transport demands, direction of city expansion, trends of population shift, trends of business district and other factors must be given a thorough study from all angles. The size of the location of a station must also be determined only after an accurate estimate on the future development has been obtained.

(10) Establishment of underground shopping center or underpass direct to multi-story buildings as a means of saving construction cost.

In the sub-surface section of the transit system the full width of the road is cut open for the construction of subway line and stations with a mezzanine and entrances to the subways are provided on the sidewalks on both sides of the road. Therefore, a considerably large space is available for various purposes.

Moreover, where there is a river of a sewage conduit between stations, the tunnel must be constructed deep in the ground.

In that case, if the space thus provided is used for the construction of underground shopping center or other purposes without being given back-filling, it will greatly contribute to the reduction of construction cost.

In the use of underground space, however, priority must be given to the facilities related to railroad transport or to the benefit of passengers, and the planning of underground arcade must be considered as a secondary step. Failure to observe this principle will result in the congestion or confusion in the mezzanine near the station. Locating eating establishments in the underground arcade will bring adverse effect with respect to drainage, ventilation, fire prevention and other reasons and therefore is not recommended.

There should also be a thorough study on the measures of safety and fire protection of the underground section.

Generally, multi-story buildings accommodate many employers and visitors and the underpass from the mezzanine of the station direct to the first basement of the building is advantageous also for the building owner. It is advisable, therefore, to plan such a underpass after consultations with the building owner on the cost and other aspects.

The existing underground cross walkways may also be utilized as the entrance to the station and at the same time, where there is a difference in the elevation between the mezzanine and the walkway, removal of useless stairways may be contemplated.

(11) In the suburbs measures should be provided so as to allow buses and private cars to stop or park at each station as a supplement to the urban transit system.

The range of distance the passengers can walk to the station has a limit as a matter of course. For the development of residential district, the range of railroad utilization must be expanded through adoption of such means as the previously mentioned "Bus and Ride" system. For this purpose, land space should be secured and necessary facilities should be provided for each station in advance for handling stopping and parking of buses and private cars. This will eliminate the necessity of bringing buses and private cars from the suburbs to the city center and as a result, the roads in CBD may be diverted for other new purposes.

As discussed in the foregoing 11 paragraphs, construction of an urban transit system requires an enormous capital investment. It is of prime importance, therefore, to make an utmost effort to maintain construction cost at the lowest level as much as possible and make a fair and correct judgement from a broad point of view for the selection of the most efficient route which will serve as a means of transit for the citizens and contribute to the further growth of the city.

3-4-2 Urban transit network in 1981

As the urban transit network required for Seoul City in 1981, the following directions extending radially from city center to the suburbs in 10 different directions have been determined by taking into consideration the area already developed and the area that is expected to be developed in the future, which were known from the previously mentioned survey results, and the sections covered by the Korean National Railroads Electrification Project.

- o Mia-dong area
- o Chunho-dong area
- o Bogwang-dong area
- o Seoul Station area
- o Sinchon area
- o Chungyangri area
- o Kyngmajang area
- o Yongsan area
- o Mapo area
- o Naengchun area

The above 10 directions were determined after an assurance was obtained from the survey that there would be large transport demands in these areas in the future and therefore, the selection is considered to be justified unless there are changes in the present urban planning. As the growth of a city often exceeds the forecast as a result of an unexpectedly growth of national economy, it is essential to make a constant study on the advisability of adding new lines.

On the basis of the above-mentioned 10 directions, a total of 5 routes were planned by joining two directions together in the city center. It is needless to say that the linkage was based on the typical network shown in Figure 3-4-1.

Of the 5 routes, the one most urgently needed is No. 1 Line which links Seoul, Chongno and Chungyangri and provides through operation with K.N.R.'s Kyungin Line, Kyungbu Line and Kyungeui Line.

Through operation of the existing K.N.R. lines with No. 1 Line will be possible through electrification of these lines. As there is a great transport demand for these lines, the benefit of electrification will be great compared with the total investment including the investment for electrification of the Korean National Railroads and the contribution of the lines to the alleviation of traffic congestion in the city center such as Chongno and etc. will also be great.

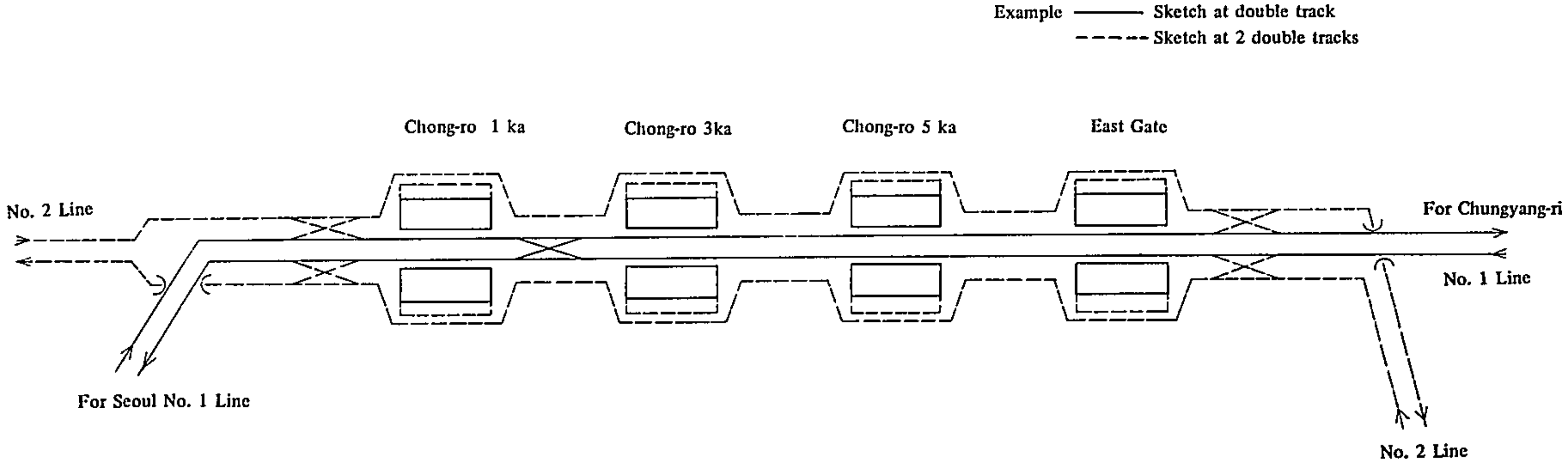
Moreover, this route may be said to be the most suitable route to demonstrate the convenience, excellent ability and the necessity of urban transit system for Seoul citizens. For this reason, early construction of No. 1 Line is recommended first of all.

The total constructed kilometerage of the proposed 5 lines is approximately 133 km, of which about 61 km is for underground section. The underground section was limited only to the densely populated city area in principle and the design of the line in the outlying area was determined to be of non-tunnel type to save construction cost and in consideration of other various projects from a synthetically view.

Also in due consideration of special circumstances in the city center of Seoul, an attempt was made to provide the following features.

(1) The existing roads and the proposed road under the urban planning were utilized as the route of the network to the extent possible.

Fig. 3-4-2 Rough Sketch of 2 Double Tracks Section at Chong-ro



When the saving of construction cost and the convenience of passengers are taken into consideration, the line alignment with excessively many curves linking major districts should be avoided.

Utilization of sidewalks for construction of the tunnel related facilities (entrances and ventilation openings) is very effective and convenient.

It is needless to say that the selection of route along the road is advantageous in every respect even in the surface section of the line. In this way, the increase of workload for obtaining right of way and the increase in the cost of purchasing right of way resulting from the rise in land prices may be avoided and the construction period may also be shortened.

(2) Consideration was given to avoid a triple crossing in the underground section.

The height of a tunnel is about 7 m and the triple crossing requires a depth of well over 20 m. The triple crossing is disadvantageous in that the bottom line requires extra excavations on both sides of the crossing point. Besides, the bottom line will require a depth which reaches the granite layer of Seoul City with resultant difficulty in the construction work. On the other hand, complicated facilities are required for transfer of passengers and such disadvantages as an increase in the number of stair steps are unavoidable. For these reasons, only a dual crossing was adopted for the crossing in the underground section.

(3) Line alignment of the 5 lines is close to the typical network of transit system.

The three proposed lines after crossing the center of the city from east to west, extend radially toward the outskirts of the city and the remaining 2 lines start from north and south toward the city and after hitting the center of the city, make a U-turn and extend to south and north respectively. This network is considered to be ideal in the light of typical transit network. When additional lines are planned in the future, it will be most advisable to advance the above-mentioned idealaccording to the progress of urbanization and the state of road network in Seoul City.

(4) Lines were arranged to run through the proposed southern sub-city centers, which are yet to be developed, and to have an almost equal spacing between the lines.

The necessity of the proposed lines to run through the proposed sub-city centers is need not be repeated. As the duplication of the station areas resulting from excessively close alignment of radial lines is not advisable, an effort was made in line alignment to provide an equal spacing between each line to the extent possible so that the transport demands may be equally distributed to each line.

(5) As the future expansion of the city center is expected to direct toward Seoul City Office, Namdaemon and Seoul Station, a dense network was planned for these districts.

As the above-mentioned districts, where commuters are now concentrating, have good foundations for construction of multi-story buildings and moreover, are expected to see further concentration of passengers, a network of high density was planned for these districts.

(6) Benefit created from No. 1 Line that operates to run through on Korean National Railroads.

Completion of No. 1 Line of the urban transit system, which has a total length of 85 km originating in Inchun and Suwon and reaching Sungbuk and the the center of Seoul City, will benefit the Metropolitan Area immensely. This line will not only play an important role in easing traffic congestion in the city center but will also display a concrete example of the necessity of constructing other proposed lines for Seoul City. This line, therefore, will provide valuable data for accomplishing a great objective, the early completion of the urban transit network.

(7) Importance was attached to the communication with inter-urban transport facilities (Railroads, bus and airlines).

People can expect satisfactory transport services only when there is a good connection between the urban and inter-urban transport. The inter-urban transport facilities which fail to provide good connections to urban transport can not expect efficient utilization of their facilities no matter how good they are.

In selecting routes for the transit network special consideration was given to the connection between major railroad stations and bus routes and to the feasibility of establishing bus terminals and the connection to the airport.

(8) For the two lines planned for Chongno, option for the direction was given by providing a cross-over on the lines (See Figure 3-4-2).

The two lines planned for Chongno extend to four areas. As a considerable unbalance in the transport demand could develop in each area in the future, installation of a cross over was contemplated so that the connection at both ends of each line may be changed according to the requirement for efficient and economic operation of the lines.

Also by arranging the platform for use by the two lines for the same direction, convenience of passengers was aimed. It was also contemplated to operate all trains on one line during the hour other than rush hours to enable maintenance work on other line even during the daytime.

It is also conceivable that one line is used for the operation of express trains and the other for the operation of local trains (stopping at every station), if necessary.

This system should be given an advance study to apply for No. 6 Line and the subsequent lines which may be planned additionally at time of planning in Euljiro and other road.

(9) Centralization of car shed and workshops and other facilities

It is natural that the car shed located close to the residential area affords more convenience to passengers. The car shed should be planned mainly for both ends of the line and the stations in-between should be provided with only auxiliary storage tracks. For this purpose, the use of turn-back line is also conceivable.

With regard to the car workshop, construction of independent workshop for each line will result in the increase of cost and therefore, a plan should be worked out for the construction of a workshop for joint use by all the lines.

For this purpose, it will be necessary to provide a single track line at an appropriate point between each line to link the lines one another. It is recommended that a preliminary study be initiated for such arrangement. It will be unavoidable, however, that the 2 lines running through Chongno are separated from the other 3 lines which employ a different electric system.

The above-mentioned are the points which were given special consideration in the planning of an urban transit network for Seoul City and which should be given a further study in the future.

As stated previously, alteration of the route after its completion is extremely difficult. It is important, therefore, that the planning of network be not limited only to the study on urban transit system but include a comprehensive and detailed study of urban planning and other projects to fully understand the significance of these project and develop an ideal network plan.

The point which should be given special attention besides the 5 pro proposed lines is the fact that the population of the area south of the Han River is expected to reach 3.35 million in 1981.

As a result, it will be necessary to provide measures to cope with the increase in the number of passengers traveling form east to west and vice versa between the lines of the urban transit system extending to the south.

On this point, a separate forecast of transport demands will be required in the future. If it is predicted that the transport demands will exceed the capacity of bus transport facilities and that the dependency on mass transport facilities will be unavoidable, it will be necessary to incorporate a plan for this area in the network plan at an appropriate time. In the east-west direction, in particular, there are many hilly districts and for this reason, it is recommended that a study be made also on the feasibility of monorail system which is more suitable for the construction in the area of steep grade.

3-4-3 Relationship between the growth of city and urbanization of outlying area and urban transit network

The following is a detailed explanation of the content in the preceding two paragraphs from a different angle.

When the city is viewed as a whole there is a CBD which is the center of the city activity and within the CBD there is a core of the city where all the activities are concentrating. When one specific district of the city is taken up, for example, there is variation in the density of employed population and the distribution of passengers, which in turn, is appeared as the size of traffic volume in each district. It is important in working out a traffic plan to grasp the concentrated district or the concentrated point as the core of the project area and provide corresponding measures.

Both the city as a whole and the CBD of the city have their own courses for future growth and these courses are destined by the topography, relative difficulty of land procurement and availability of transport facilities.

The most prominent course of the expansion is grasped as the axis. The existence of such axis is desirable also from the standpoint of the efficiency of the investment for public facilities of the city. In the case of transport facilities, particularly, the route provided along the axis of the city will satisfy transport demands in the area and contribute to the effective use of the facilities.

Also in the transport system, the establishment of a line having a large transport capacity, particularly the line which forms the main artery in combination with transit and road network is considered as the axis of transport system.

Two double-tracks lines or multi-track lines running in parallel to each other also constitute a typical axis. Moreover, the point where traffic axis comes in contact with or cross other traffic lines constitutes a core of traffic network as the node.

Thus, the core and axis exist both in the course of expansion of the city and in the development of transport network. Moreover, since they develop from the same foundation by interacting each other, they should match and they must be made to match each other geographically also in the future projects. Otherwise, both the city and the transport network will never be able to benefit by one another.

As the CBD expand centering around these cores and axes in keeping with the plane growth of the city to a mammoth city, the traffic routes in these districts will have to form a dense network.

In the selection of a network for the urban transit system for Seoul City, attention of the survey team was always given to the above points. Concerning these points a few detailed comments will be given below as a supplemennt.

(1) As the largest transversal axis of CBD, the street of Chongno was considered and 2 double-tracks were planned along this axis. As the longitudinal axis which connects to the transversal axis, a belt-shaped district linking Chungangchung, Municipal Government, Namdaemun and Seoul Railroad Station was considered and three lines were planned along this axis. However, since CBD is expanding centering around these axes, arrangement of the route was made in such a manner so that 5 lines will run in parallel in the east-west direction in the eastern sector of CBD they will cross one another in the western sector of CBD, thus providing a dense network.

(2) Even when the five lines are arranged in parallel, the distance between the lines is relatively short and therefore all the lines may be linked one another by underpasses.

Such arrangement will not only make the transport system in CBD more convenient and contribute to the development of CBD but will help accelerate the specialization of each city functions to each district.

(3) In the case of Seoul City, a plan to distribute part of CBD functions to Yoido Island and the area on the south bank of the Han River is being worked out. For the growth of these new CBDs, it is necessary to maintain a short distance between the existing CBD and the proposed CBDs in terms of time requirement. When the congestion of road traffic in the future is taken into

consideration, there can be no other means but the urban transit system.

(4) To provide a complete transport system in the area where many buildings stand close together, grade separation of the route from the existing buildings and transport facilities will be unavoidable. Fortunately, however, the progress of technology has made such grade separation possible and examples of successful grade separation are seen in many cities of the world. In Tokyo also, subway stations constructed under major railroad stations of the Japanese National Railways are providing convenience to passengers and contributing to the prosperity of the area. The necessity of similar nature will also be felt in Seoul in the future.

When the future progress of technology is taken into consideration in the planning of a transport system, the idea which is considered impossible today may be possible in the future when construction begins. It is important, therefore, to give flexible thought to the future planning instead of taking a fixed posture.

# IV NO. 1 LINE ( SEOUL - CHUNGYANGRI ) PROJECT

## IV NO. 1 LINE ( SEOUL-CHUNGYANGRI ) PROJECT

### 4-1 Transport Demands and Transport Plans

#### 4-1-1 Forecast of transport demands

Of the 5 proposed subway lines, the one which should be given the top priority for construction is the No. 1 Line (Seoul St.— Chungyangri St.).

If construction of this line starts immediately, the line will be ready for operation in the beginning of 1974.

Transport demands for No. 1 Line in 1974, the initial year of the operation and in 1981, estimated with the use of the method described in paragraph 3-3, are shown in the following table.

Table 4-1-1 Transport Demands for No. 1 Line (Seoul St.—Chungyangri St.)

(Daily average of week days)

| Arrival and Departure Points | | Total number of persons transported | |
|---|---|---|---|
| | | 1974 | 1981 |
| Outside of Seoul | Seoul City area: Yongsan, Yungdeungpo area | 161,930 | 227,810 |
| | Outskirts of Seoul City, area along Kyungbu and Kyungin lines | 112,100 | 217,700 |
| Outside of Chungyangri Station | Seoul City area: Sungbuk and Sungdong area | 54,470 | 225,180 |
| | Outskirts of Seoul City, area along Kyungwon & Chungang lines | 35,000 | 56,400 |
| Areas along the line between Seoul Station and Chungyangri Station | | 201,150 | 202,540 |
| Total | | 564,650 | 929,630 |

As shown in the above table, transport demands in the first year of operation is eatimated at about 560,000 and that in 1981 is expected to reach about 930,000.

It must be kept in mind, however, that the above-mentioned transport demand will not generate for No. 1 Line at one time. From the examples of the subways in other countries, it is generally known that the passengers of the subways after its inauguration gradually shift or attracted from other means of transportation and that it takes about a year or two before all the transport demands are actualized. As the proposed line is the first of the urban rapid transit system in Seoul City, a considerably lengthy period will be required before the people become familiarized with the subways, station employees become proficient in handling passengers and the passengers shift from bus transport. Therefore, the transport volume in the initial year of operation was presumed to be 400,000 or about 70% of the estimated transport demand and the attainment of 100% of the estimated transport demands was estimated to be after two years.

The estimated number of passengers transported hourly through the section which is considered to have the largest transport volume on No. 1 Line is shown in the following table.

Table 4-1-2 Estimated Transport Volume for No. 1 Line (Weekdays)

| Section | 1974 | | 1981 | |
|---|---|---|---|---|
| | All day | Per hour during rush hrs. | All day | Per hour during rush hrs. |
| Seoul—Chungyangri direction Between Seoul Station & City Office | 108,560 | 21,700 | 228,500 | 68,500 |
| Chungyangri—Seoul direction: Between Dongdaemun & Chongno 5 Ku | 101,670 | 20,300 | 192,800 | 57,800 |

(Note) The ratio of transport volume in one hour during the rush hours to the transport volume in all day was estimated at 20% for 1974 and 30% for 1981.

4-1-2 Determination of transport capacity and train operation plan

(1) Determination of transport capacity

Operation of trains in 1974 is expected to be as follows.

Rush hours : Six-car formation in 5 min. headway

Rest of the day : Six-car formation in 7-1/2 min. headway

The above is the standard headway and therefore may be changed according to the time zone of the day.

The design of hourly transport capacity during the rush hours is as follows:

(60 min÷5 min.) x 6 car x 140 person = 10,080 person

Therefore, the riding efficiency in the most congested section or between Seoul Station and Seoul Metropolitan Office will be 217%. (In the section between Yongsan and Seoul Station the Korean National Railroads line, the riding efficiency will be 240%. Refer to paragraph 5-1).

For 1981, the standard operating headway will be:

Rush hours : 10-car formation in 2-1/2 min. headway

Rest of the day: 10-car formation in 5 min. headway

The hourly transport capacity during the rush hours will be:

(60 min ÷ 2.5 min.) x 10 car x 140 person = 33,600 person

Therefore, the riding efficiency in the most congested section will be 204% (In the section between Yongsan and Seoul Station on the K.N.R. line, the riding efficiency will be 220%. Refer to paragraph 5 1).

For in-between years, the transport capacity may be increased in stages by operating 8-car set trains with 4 or 3 minutes headway.

(2) Running time

The running time between Seoul Station and Chungyangri Station, including stopping time and extra (reserve) time, will be 18 minutes.

The running time between stations is shown in the following table.

Table 4-1-3 Running Time for No. 1 Line

(Min. Sec)

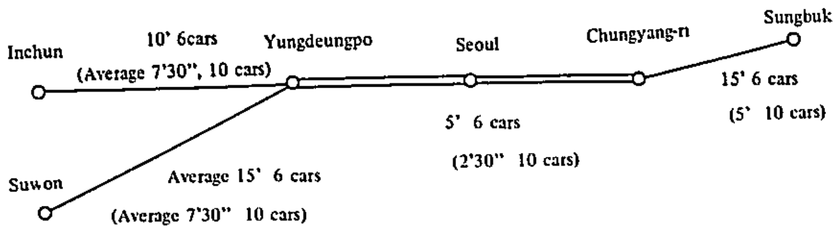
| Down Train: Stopping time | Down Train: Running time | Stations | Distance between stations (km) | Up Train: Running | Up Train: Stopping |
|---|---|---|---|---|---|
| (0.30) | | Seoul | | | (0.30) |
| | 2.00 | | 1.08 | 2.00 | |
| 0.30 | | City Office | | | 0.30 |
| | 2.40 | | 0.90 | 2.40 | |
| 0.30 | | Chongno-1 ku | | | 0.30 |
| | 1.30 | | 0.93 | 1.30 | |
| 0.20 | | Chongno-3 ku | | | 0.20 |
| | 1.30 | | 0.86 | 1.30 | |
| 0.20 | | Chongno-5 ku | | | 0.20 |
| | 1.40 | | 0.84 | 1.40 | |
| 0.30 | | Dongdaemun | | | 0.30 |
| | 1.30 | | 1.20 | 1.30 | |
| 0.20 | | Shinsuldong | | | 0.20 |
| | 1.50 | | 1.11 | 1.50 | |
| 0.20 | | Jekidong | | | 0.20 |
| | 1.40 | | 0.99 | 1.50 | |
| (0.30) | | Chungyangri | | | (0.30) |
| 2.50 | 14.20 | Total | 8.01 | 14.30 | 2.50 |
| 17.10 + 0.50 (extra) = 18.00 | | | | 17.20 + 0.40 (extra) = 18.00 | |

(3) Through operation on the Korean National Railroads and Turn-back Point

As shown in Table 4-1-1 which will appear later, transport demand for No. 1 Line consists of mainly the passengers from areas along such existing lines as Kyungin Line, Kyungbu Line, Kyungwon Line and Chungang Line of K.N.R. Therefore, No. 1 Line will be connected to the Korean National Railroads at both ends of the line, at Seoul Station and Chungyangri Station, for through operation. Forecast of transport demand shows the largest demand in the section between Yungdeungpo and Chungyangri. For the section between Yungdeungpo and Chungyangri, therefore, the operation of trains will be based on the previously mentioned operating headway and in the section beyond these stations, trains will be put on through operation with the headway two or three times longer than that required for the section between the above-mentioned two stations. This operation is illustrated in the following Chart 4-1-1.

Fig. 4-1-1 Train Operation Pattern for No. 1 Line

Headway, Car-numbers of each train, at 1974 and 1981 in ( ) car




For Kyungin Line and Kyungbu Line, operation of semi-express trains will be contemplated in the future in addition to local trains. Train schedules on the basis of the above concept are shown in Charts 4-1-2 and 4-1-3.

(4) Related facilities

To implement the above-mentioned operation schedules, turn-back facilities will be provided at Yungdeungpo Station and Chungyangri Station. Also, as a precautionary measure against emergencies, a lead track will be provided at Seoul Station (tunnel) to make the shuttling for the sub-surface section possible. It will also be necessary to provide a cross over at the point south of Yungdeungpo Station to enable the shunting of trains from Kyungbu Line to Kyungin Line. Grade separation of these lines should be planned in the future. Though the through operation to Kyungwon Line will be made at Chungyangri Station for the time being, it is advisable to plan a shunting line by means of a cross over or grade separation so that the through operation of Chungang Line (completion of electrification is expected in near future) to this line may be realized in the future.

In the compound of Yungdeungpo Station, shunting of freight trains and freight cars is being accomplished by crossing the tracks of Kyungin Line and Kyungbu Line and this operation is now the stumbling block of train operation.

As the frequency of train operation is expected to increase sharply upon completion of No. 1 Line and the electrification of the Korean National Railroads, departure and arrival of freight trains and shunting of freight cars on siding west of the station will have to be suspended during the rush hours. It is also conceivable that such operation will be almost impossible even during the day time with the further increase in the frequency of train operation. It is necessary, therefore, to plan construction of elevated structures for Kyungin Line in the compound of Yungdeungpo Station at the earliest possible time. (This plan and its construction cost are not contained in this report.)

## 4-2 Selection of Electric Traction System

For electric traction system, adoption of single phase 60 Hz 25 KV A.C. system (Overhead contact line system—hereinafter referred to as AC system) is recommended.

### 4-2-1 Reasons for recommending AC system

Line No. 1 of the rapid transit system has been planned on the condition

Fig. 4-1-2 Example of Train Diagram in Rush-hour (1974)

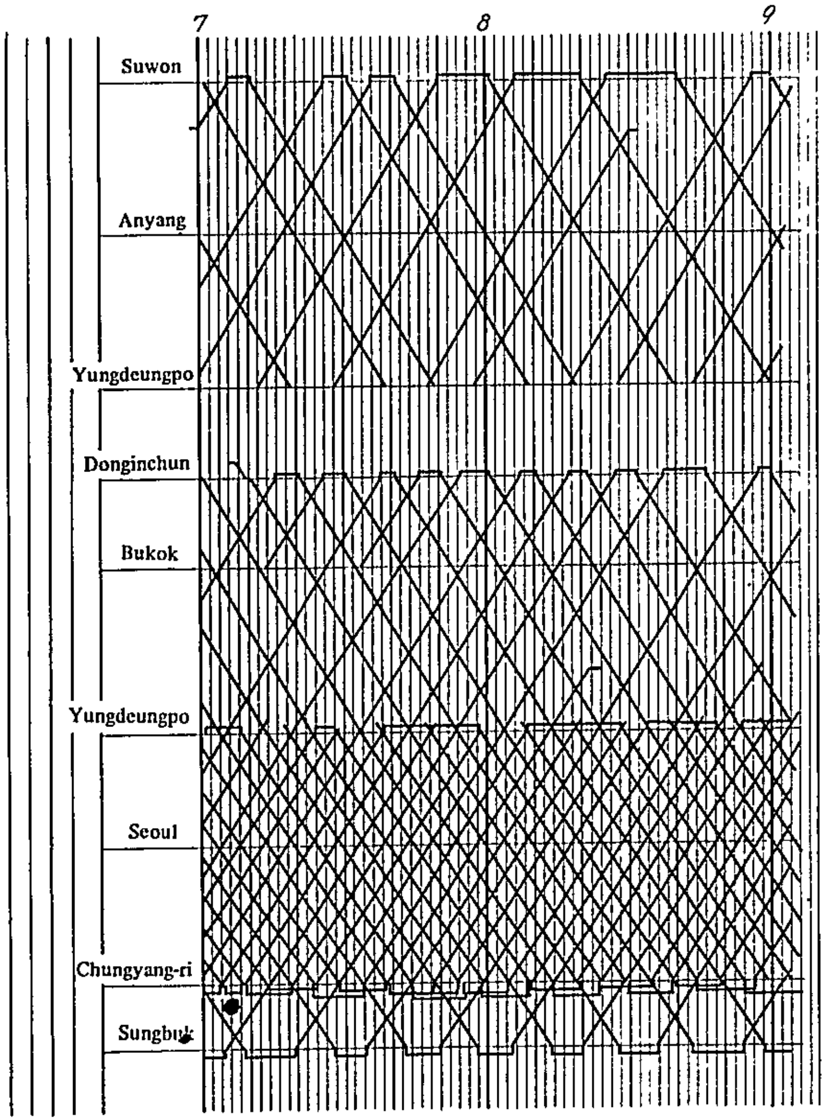
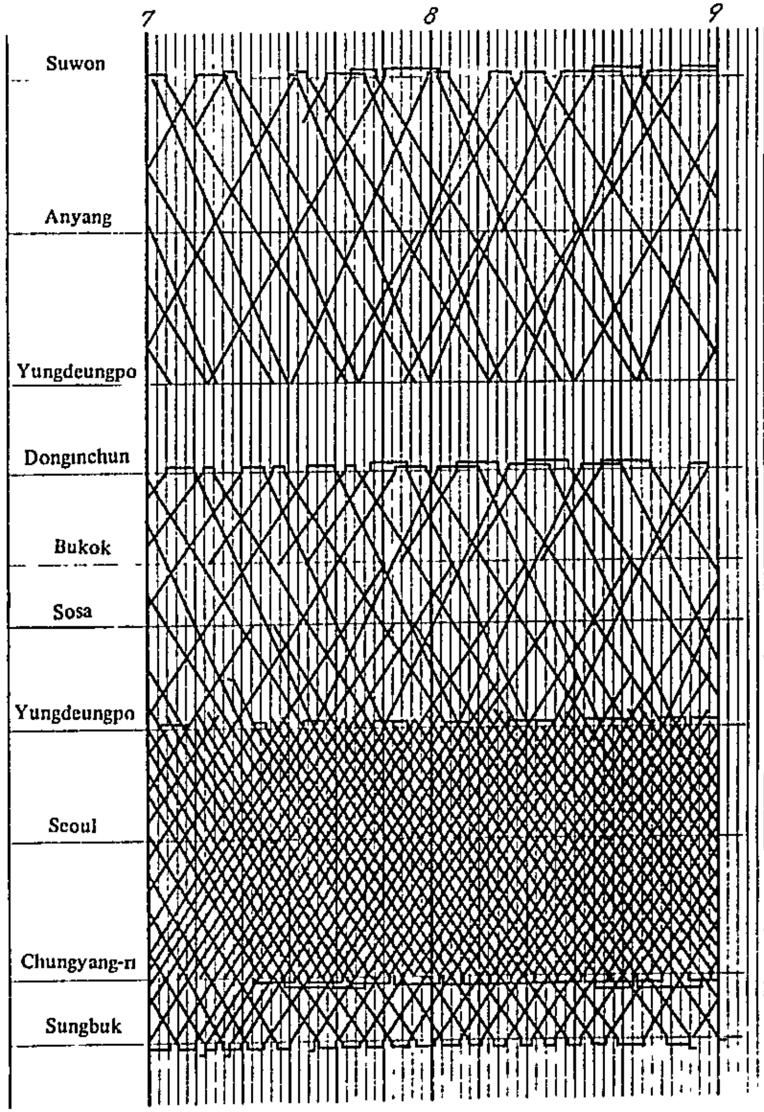



Fig. 4-1-3 Example of Train Diagram in Rush-hour (1981)



that it will provide through operation to the existing lines of the Korean National Railroads.

Though the sections of the existing lines planned for through operation have not been electrified yet, the Railroad Board, the Korean Government, has decided to adopt the AC System for electrification of Chungang Line and has a policy of expanding the electrification with this system also in the future.

After making a comparative study on the use of AC—DC dual current cars in consideration of possible adoption of DC 1,500 V system for underground section, no justifications could be found for the use of different electric traction system for underground section.

The AC System is a proved and dependable system, and the selection of this system will prove the rightness of judgement for the future in view of the anticipated wide use of the system in Korea.

4-2-2 Supplemental data

For the application of AC System to the subways, it is considered advisable to add a few comments.

(1) As the distance of the subway section is short, there is no need to provide underground traction substations. However, more precautions must be taken for the subways than the surface railroads to maintain uninterrupted supply of traction power.

(2) It is advisable to employ the auto-transformer (AT) system instead of booster transformer (BT) system to minimize the number of split sections of overhead contact wire.

(3) It is necessary to make the ceiling of the tunnel about 20 cm higher than that required when the dual current cars are used.

(4) Though the induction impediment for communication lines and others may be unavoidable, it is not too great compared with that of the surface railroads since the shielding effect of the tunnel, etc. can be expected.

As mentioned above, the AC system can be adopted for subways without any difficulty both technically and economically.

Judging from the past records of the existing long tunnels and the example of trunk lines extending to the subway lines in New York, there is not a specific reason for rejecting this system. In Japan plans are being worked out to adopt the underground system for the extension of super-high speed railroads of the Japanese National Railways into the Tokyo Metropolis.

## 4-3 Construction Project

### 4-3-1 Outlines of facilities

(1) Track structures

Sub-surface section....... Box-type reinforced concrete rigid frame structure -------- 8.8 km

Surface section .......... Surface track and half-cut U-shape reinforced concrete retaining wall structure ------ 0.7 km

(2) Station (See Figures 4-3-1, 4-3-2, 4-3-3 and Table 4-3-1).

Number of stations: 9

Length of platform: 220 m (Sufficient for accommodating a train of 10-car formation)

Note: While the total length of platform may be obtained by adding 5—6 m to the train length, it is appropriate to determine extra length for the future facilities on the basis of unit length of the car.

(3) Electric system: AC 25 KV, 60 Hz, Overhead contact wire system

(4) Signal and safety system: Five aspect color light signal, automatic train stop system (ATS)

(5) Electric railcar: Length between coupling faces 20 m. For details, refer to Chapter 6.

Table 4-3-1 List of Stations on No. 1 Line

| Station | Distance between stations | Type of platform | Mezzanine | Width of platform |
|---|---|---|---|---|
| Seoul | 1,080 m | Island type | Yes | 10 m |
| City Office | 900 m | " | Yes | 10 m |
| Chongno-1 ku | 930 m | " | Yes | 10 m |
| Chongno-3 ku | 860 m | " | Yes | 9 m |
| Chongno-5 ku | 840 m | " | Yes | 9 m |
| Dongdaemun | 1,200 m | " | Yes | 9 m |
| Shinsuldong | 1,110 m | Separate type | No | 5 m x 2 |
| Jekidong | 990 m | " | Yes | 6 m x 2 |
| Chungyangri | | Island type | Yes | 10 m |
| Total operating kilometerage | 8,010 m | | | |

Fig. 4-3-1 Outline of Island Platform Station

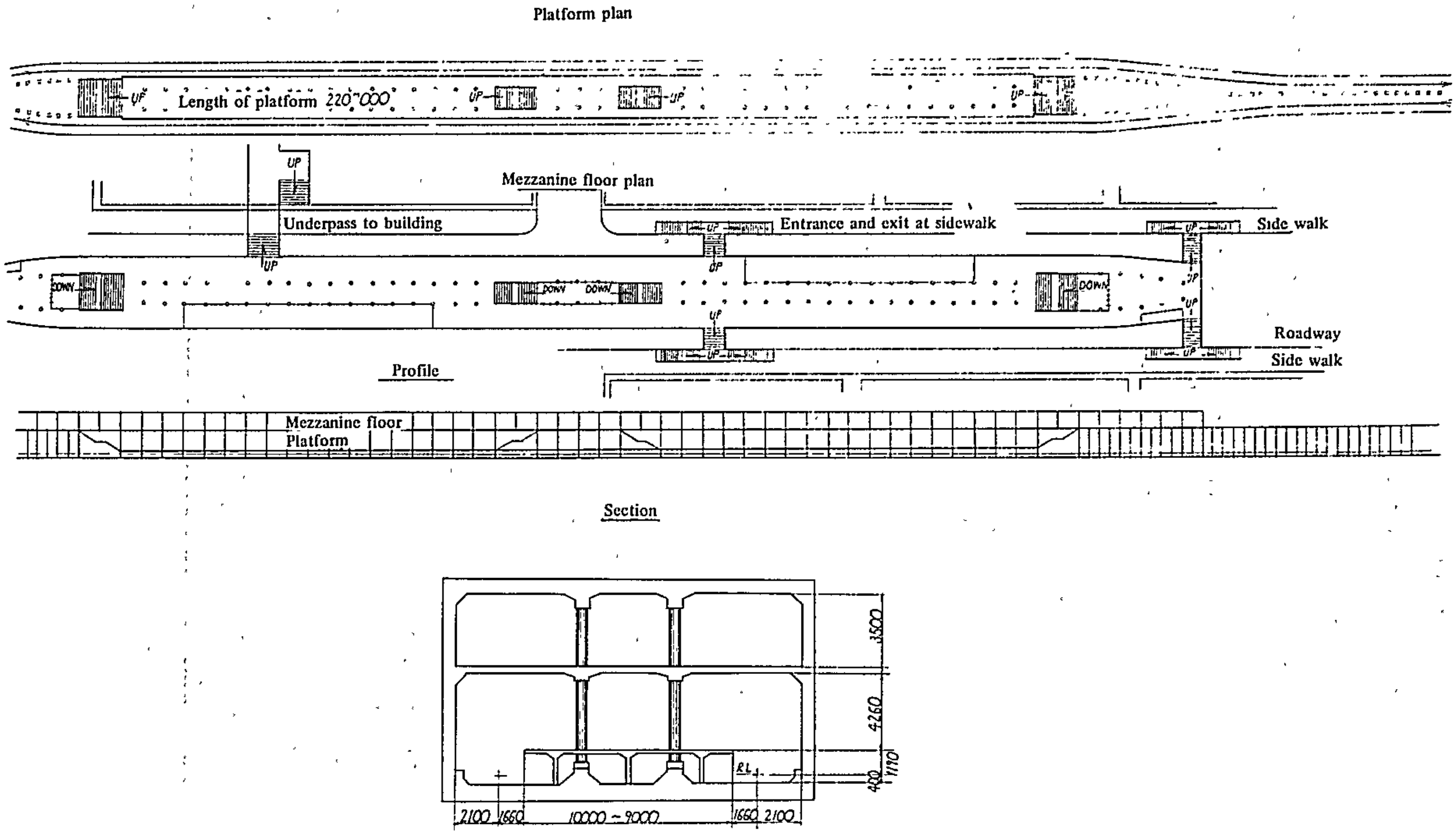


Fig. 4-3-2 Outline of Station in 2 Double Tracks Section

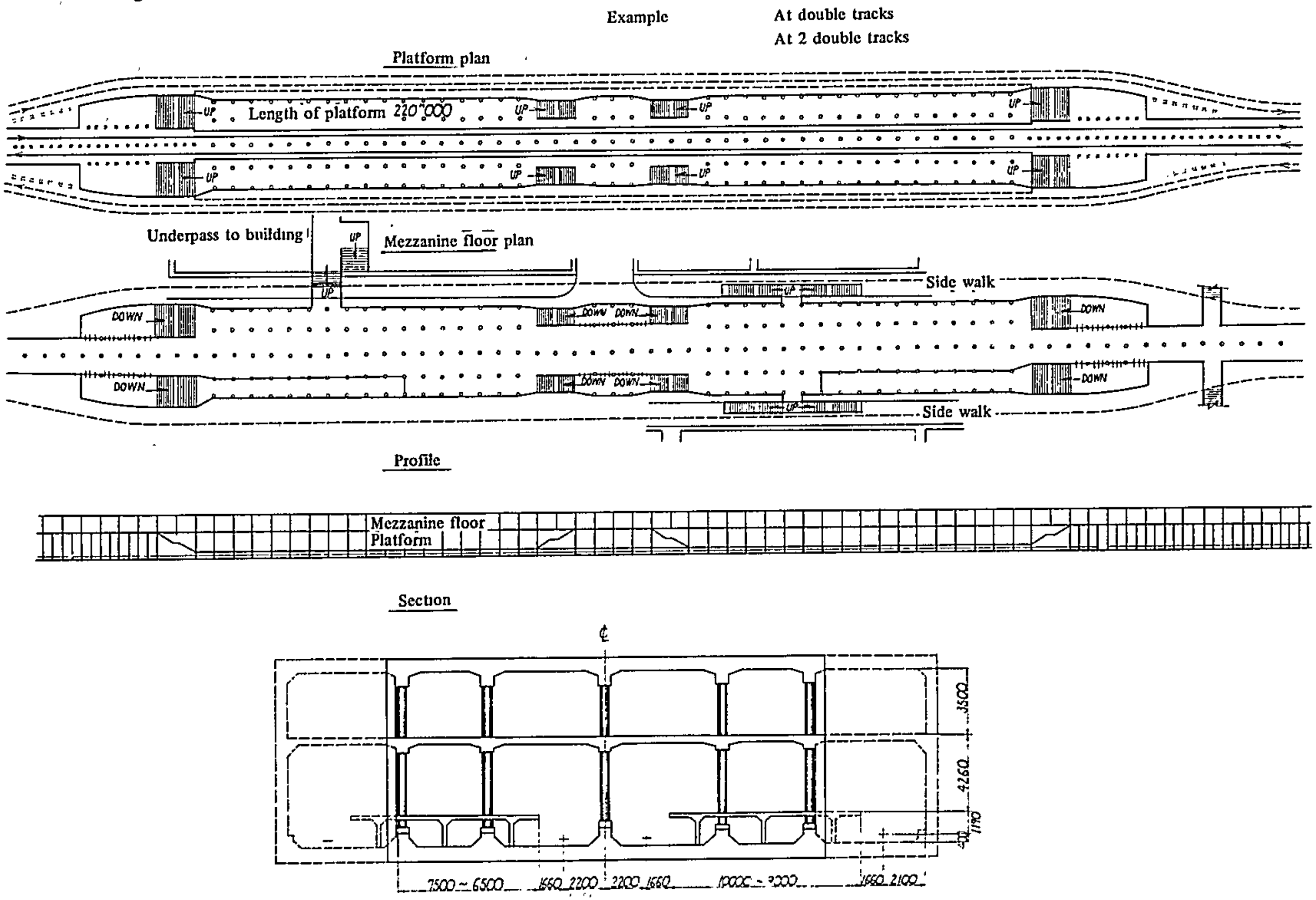
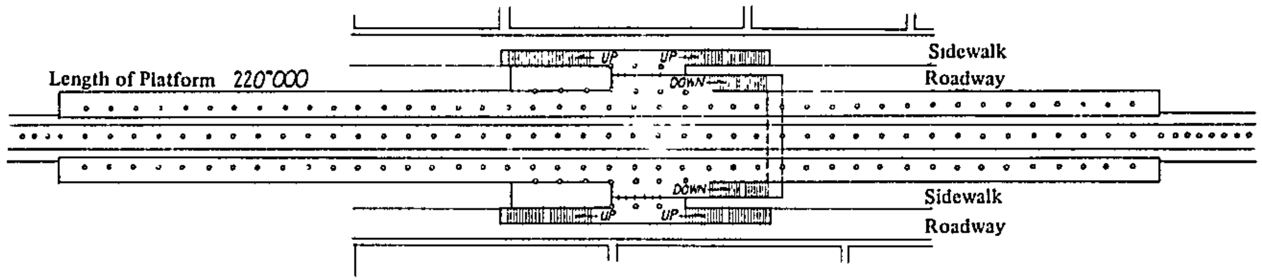
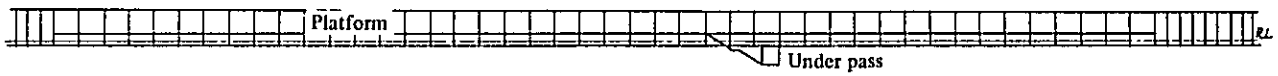


Fig. 4-3-3 Outline of Separate-side Platform Station

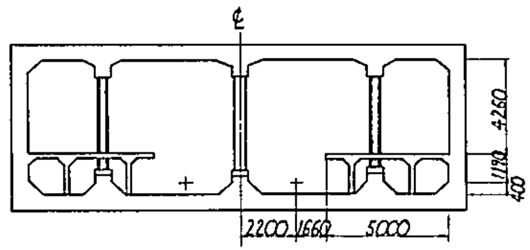
Plan




Profile




Section



4-3-2 Construction standard for sub-surface section (See Figure 4-3-4 and Table 4-3-2)

The gauge of tracks, electric system and maximum loading gauge were determined by taking into account the through operation to the Korean National Railroads. The height of construction and maximum loading gauge were determined on condition that the rigid overhead contact wire and the 25 KV system would be used in the tunnel. The width of construction gauge was reduced to save construction cost by restricting the opening height of windows of the train. A minimum allowable space was also provided between the rolling stock gauge and the construction gauge to provide room for inclination of electric railcar caused by rolling of car body, spring action and other forces. The thickness of trackbed is as shown in the table. As a rule, concrete bed should be used to save construction cost and maintenance cost. When the ballast is used, a base concrete 150 mm thick must be provided at the bottom as a drainage and as a result, the distance between R.L. and the upper surface of the tunnel bottom floor will be 700 mm. Use of ballast should be restricted to the section other than right of way, where prevention of vibration is required (See Figure 4-3-5).

For inside dimensions of the tunnel, the width was determined by adding to the construction gauge a 300 mm clearance for the side wall to allow installation of signals and a 200 mm clearance for the center column to allow installation of compressed air pipes and communication cables. With the width of center column determined to be 400 mm, the minimum distance between track centers was set at 4,400 mm.

The minimum radius of curve for the main line was determined to be 150 m. This was determined after taking into account the wheel base, gauge of track, line alignment and the topography. However, the minimum radius of curve of at least 200 mm should be maintained near the station and that of 400 m between stations as a rule to increase the speed of trains and save track maintenance cost. The minimum radius of curve for the section along the platform was determined to be 500 m by giving due consideration to the topography of individual districts. The determining factors are the clearance between platform and the end of the car entrance and the distance of watching passengers on platform.

The length of transition curve, cant and the radius of vertical curve were determined so as to ensure the maximum speed of 80 km/h in the tunnel section. The maximum grade and the radius of vertical curve were determined with the aim of saving construction cost and minimizing the restriction on the topography in consideration of the future necessity of grade separation in the tunnel section. The minimum grade was determined by taking into account the drainage of water, but it will be necessary to provide special safety devices for the detention of cars. Enlargement of construction gauge by means of curve and slack were determined according to the maximum loading gauge.

Fig. 4-3-4

No. 1 and 2 Line Construction and Car Gauge

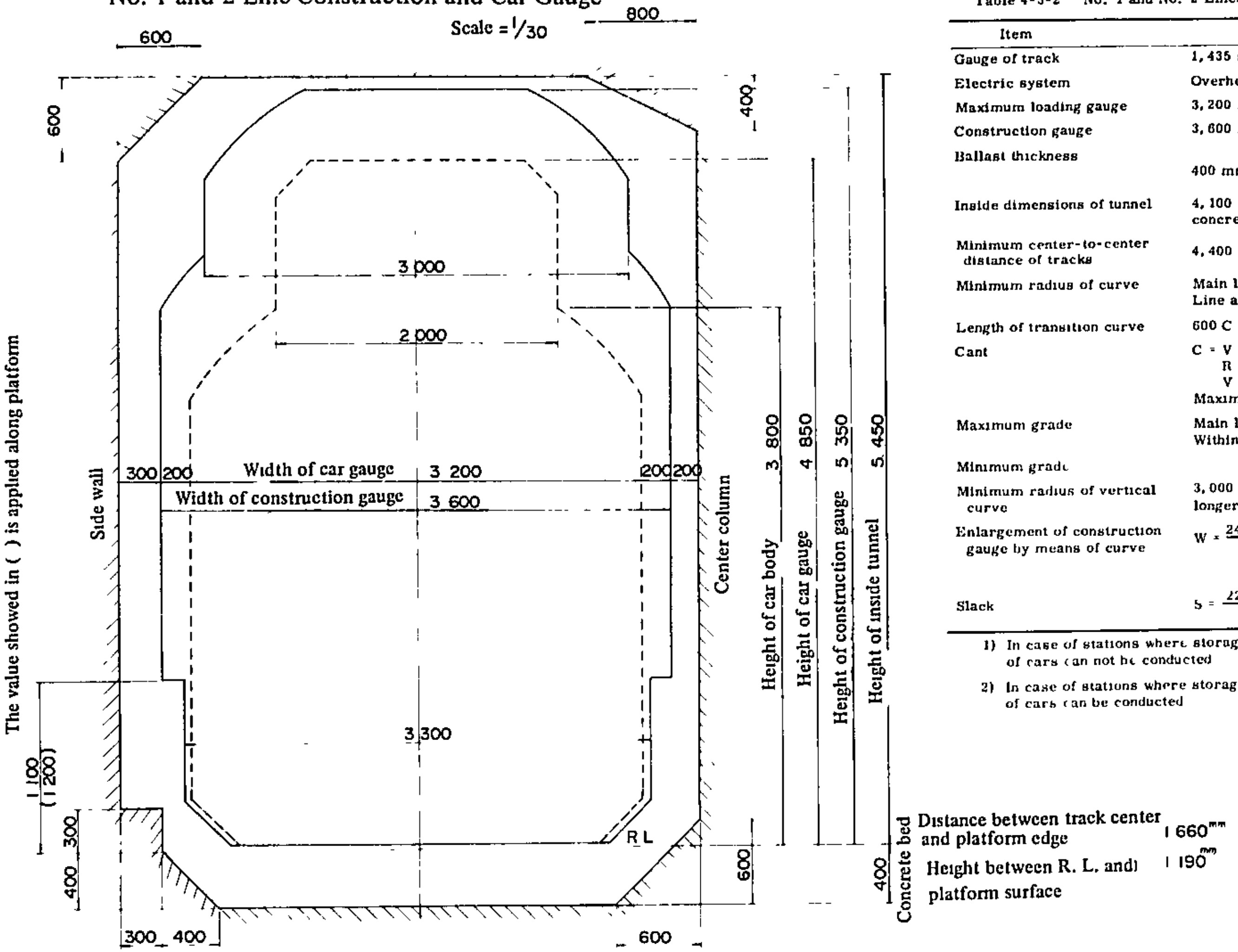


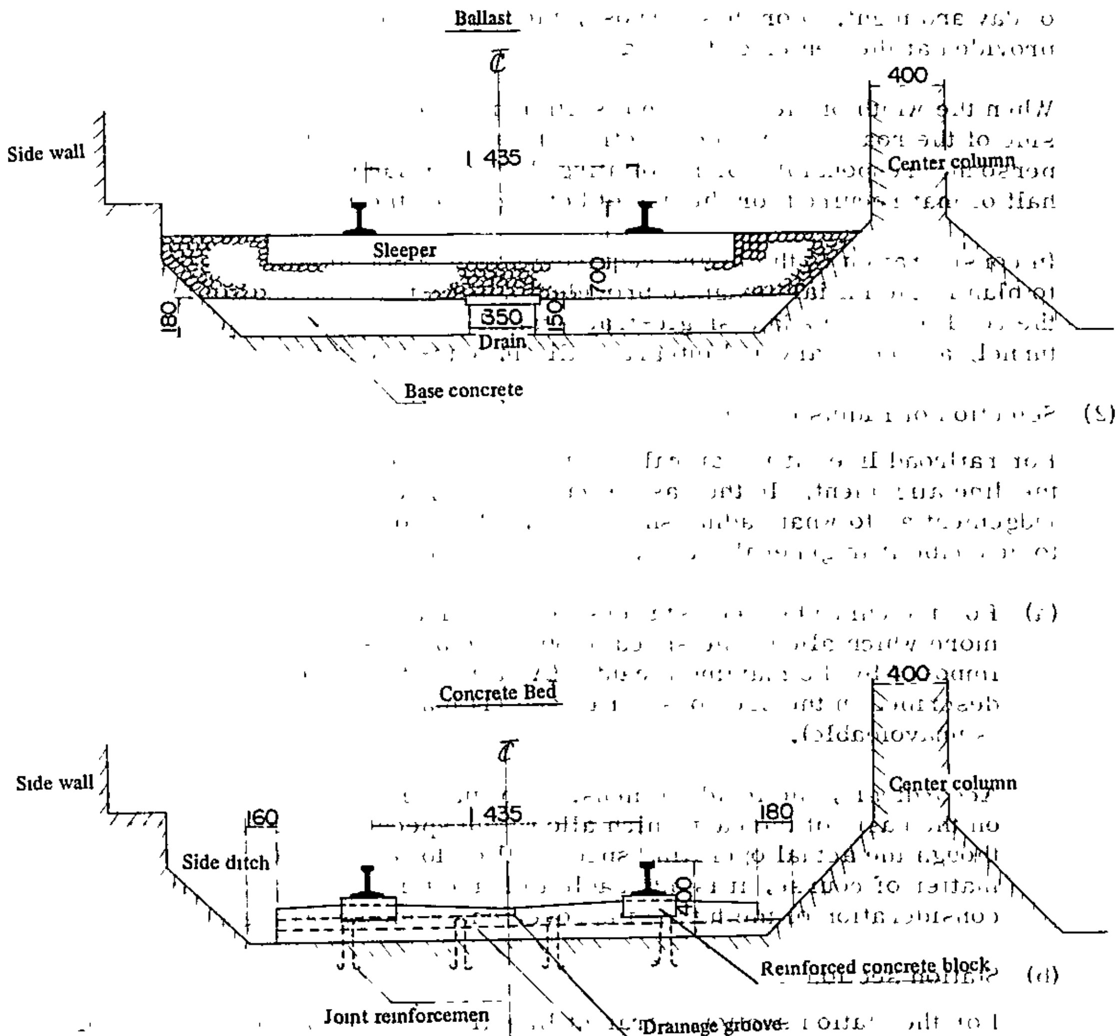

Table 4-3-2 No. 1 and No. 2 Lines Design Standards of Sub-surface Section

| Item | Standards |
|---|---|
| Gauge of track | 1,435 mm |
| Electric system | Overhead contact wire system, 25,000 V, AC |
| Maximum loading gauge | 3,200 mm in width, 4,850 mm in height from R.L. |
| Construction gauge | 3,600 mm in width, 5,350 mm in height from R.L. |
| Ballast thickness | 400 mm concrete bed, 700 ballast |
| Inside dimensions of tunnel | 4,100 mm in width, 5,850 mm in height with concrete bed |
| Minimum center-to-center distance of tracks | 4,400 mm |
| Minimum radius of curve | Main line 150 m<br>Line along platform 500 m |
| Length of transition curve | 600 C |
| Cant | $C = \frac{V}{R}$ C Cant (mm), R Radius of curve (m), V Velocity of train (K/h)<br>Maximum cant 150 mm |
| Maximum grade | Main line 35/1000<br>Within station 10/1000 *1, 5/1000 *2 |
| Minimum grade | 2/1000 |
| Minimum radius of vertical curve | 3,000 m (only when the plane curve radius is longer 300 m, it can be made 2,500 m) |
| Enlargement of construction gauge by means of curve | $W = \frac{2400}{R}$ W Length to extended on both sides (mm), R Radius of curve (m) |
| Slack | $S = \frac{2250}{R}$ S Slack (mm), R Radius of curve (m) |

1) In case of stations where storage, coupling and uncoupling, or shunting of cars can not be conducted

2) In case of stations where storage, coupling and uncoupling or shunting of cars can be conducted

Fig. 4-3-5 Section of Track Bed



## 4-4 Precautions to be Taken in the Design of Line Alignment

### 4-4-1 Plane line alignment

(1) Location of tunnel in the road

When there is sufficient room in the width of road, it is natural that the tunnel is located in the center of the road. Construction of tunnel in the center of the road not only minimizes the effect on the residents along the road and pedestrians but also prevents the increase and the number of cases of disposing aerial wires and underground utilities. More important is that the construction of the tunnel in the center of the road makes it possible to provide mucking facilities, which has a major effect on construction cost and construction period, at many points and continue muck transportation of day and night. For this purpose, the hoppers for muck are generally provided at the center of the road.

When the width of the road is not sufficient, it is advisable to use only one side of the road for the construction of tunnel because the number of personnel responsible for negotiating the use of land may be reduced to half of that required for the use of both sides of the road.

In consideration of the future requirement for 2 double-tracks, it is necessary to plan in the initial design to provide a double-track tunnel in the center of the road first and add a single-track tunnel to both sides of the double-track tunnel, as necessary and integrate all the four-tracks into one tunnel.

(2) Selection of radius of curve

For railroad line, it is natural that the straight line is selected mainly as the line alignment. In the case of curved line, however, it often requires judgement as to what radius should be used. Though it is extremely difficult to describe it in general terms, a few comments will be made below.

(a) For the curve between stations, it is desirable to use R = 450 m or more which allows the speed of 80 km/h because of the restriction imposed by the maximum cant. (As a result, the requirements described in the previous paragraph (1) may not be satisfied, but it is unavoidable).

Accordingly, the inside dimensions of tunnel must always be designed on the basis of the cant which allows the speed of 80 km/h. Even though the actual operating speed will be lower than 80 km/h as a matter of course, it is advisable to leave this much margin in consideration of the future improvement of the operating system.

(b) Station section

For the station section, straight line alignment is of course desirable. This is required for the safety of operation including the surveillance on the movement of passengers and the clearance between the train entrance and the platform edge.. The conflicting demand is made on the ground that the station should be located at the most convenient place for passengers and that the cross over, front and rear, should be provided in the straight portion of the line.

If a curved alignment is adopted along the platform by attaching importance to the latter, installation of a television facility is conceivable to save the manpower required for watch duty at the stage of future manpower curtailment.

(c) Construction of transit lines in privately owned land

When the line makes a curve along the corner of city street, the determination of the radius of curve to be employed is a difficult problem. In this case, understanding and cooperation of the public for the subway project becomes a precondition to construction work before a study can be made from an economical point of view. When the public reaction is not favorable, a small radius of curve will have to be used to minimize the requirement for the right of way and to avoid frictions with the public. Special cautions must be taken when the owner of the said land happened to be a school, religeous institute, or newspaper company.

In making an economic comparison of line alignments, a study must be made to determine how the curve to be employed will affect the cost of right of way, construction cost and cost of electric railcars as a result of increased operating hours. Then a study should be made on the operating cost and track maintenance cost against the initial capital investment before final decision is made on the line alignment.

(3) Sections under intersections of roads.

At the intersection of the road there often are structures of grade separation on the surface and a pile of utilities buried underground. Besides, there are many cases in which an underpass for pedestrians crossing is already completed or under plan. On the other hand, however, there are also many cases in which a subway station is constructed under the right below the intersection. In such a case, however, the station should be built across the intersection and a continuous mezzanine floor should be provided. Such a design of the station, however, will inevitably require construction of structures deep in the ground with the resultant increase in the construction cost. In such a case, therefore, it will be necessary to cut the cost in other aspect. With this type of the design, it is advisable to remove the existing underpass and others and absorb them in the mezzanine of the station. The underground utilities should be consolidated into a common utility conduit and made part of the structure of the subways. Efforts should be made to reduce the depth of required excavation even by the thickness of a slab.

(4) Crossing rivers and city facilities

For construction of a bridge over a river and structures for grade separation, a tunnel must be constructed under the bridge girder, pier and abutment while maintaining smooth flow of surface traffic. It is also necessary to provide a temporary conduit to allow the required flow of river water.

Details of the construction method for this type of structures have to be determined on the result of a detailed survey, but it is important to make an effort to minimize the width of the structure for economy and safety of crossing construction work.

The reason for adopting the separate type platform for Shinsul-dong and

Jeki-dong stations on No. 1 Line was to prevent the increase in the width of tunnel in the section crossing the river.

4-4-2 Longitudinal line alignment

(1) Management and design policy

No. 1 Line is one of few examples of the subways which are expected to attain balanced budget in a relatively short period of time. However, with the addition of new lines one after another, spending a large portion of operating revenue for the payment of interest is expected to last for a long period of time as in the case of subways in Tokyo,

If the design policy for the construction of the subways follows management policy faithfully, the reduction of the initial capital investment will be given priority over the reduction of operating expense and the depth of all the tunnels will be lessened.

Consequently, the longitudinal line alignment between stations should not be a concave shape but should be a convex shape instead.

In the design of longitudinal line alignment, the survey team carried through a policy for the curtailment of the initial capital investment. Though the performance of the train may compensate part of the fault, the existence of shortcomings in this method can not be denied.

(2) Crossing under other underground facilities

Planning should be made while paying attention to the points mentioned in paragraph (3) for crossing under intersections.

(3) River bottom and crossing other city facilities.

Besides the precautions described in paragraph (4), it is necessary to provide extra spaces longitudinally at the crossing in anticipation of constructing temporary support such as a conduit for river water and bridge foundation. In the section before and after crossing the river, there are places where there is a greater space between the surface and the tunnel. It is advisable to provide a mezzanine in these places for utilization as the site of a substation in the future or as a station mezzanine floor when constructing a station in the neighborhood. The example of this layout is Jeki-dong Station.

(4) Advisability of providing mezzanines in the station

The mezzanine is not indispensable for the station but it is convenient to have one at the busy stations. Reasons are given below.

(a) Such operating facilities as booking, ticket excavation and ticket collection may be provided at one centralized place and the facilities for ceasing operation at the slack time during the daytime and night time may also be provided.

(b) Sufficient space is available for station facilities.

(c) Advantageous for providing additional entrances and exits or underpasses to the adjoining buildings with the increase of passengers.

(d) Establishment of underground arcade on the mezzanine linking the adjoining two stations will encourage shoppers to use subways. The linkage by the mazzanine is also useful for the connection to the future new line. It is also advantageous because it enables communication with department stores, arcade in the adjacent building and parking lots.

The Ginza Integrated Station in Tokyo links three stations, each on Ginza Line (No. 3 Line), Marunouchi Line (No. 4 Line) and Hibiya Line (No. 2 Line), with a mezzanine. While the number of passengers using these three stations was 288,000 on June 6, 1967, the number of persons using the mezzanine totaled 402,000 the same day. The number of persons utilizing only the mezzanine totaled 114,000, accounting for 40% of the total passengers using this station. Judging from a large number of pedestrians in Seoul Special City, the utilization of the mezzanine by a large number of people, similar to that in the Ginza, is also anticipated and thus, the benefit derived from underground arcade can be fully appreciated.

### 4-4-3 Ventilation facilities

Since there is not much snowfall in Seoul during winter, the natural ventilation by the piston action of the train through ventilation openings, provided at sidewalk will be sufficient to remove carbon dioxide in the tunnel. The greatest disadvantage of this method is that it is not possible to let cool air into the tunnel at night, when the temperature drops, to cool down the air in the tunnel.

Recently, the subways in Tokyo and Osaka have suffered from extreme rises of the temperature in the tunnel and various studies have been made to work out measures to counter this situation.

The studies revealed that the most economical way is to provide continuous ventilation with the use of ventilation fans even in non-operating hours and also in winter from the beginning of the operation of the line to cool down the tunnel and prevent the rise of temperature in the tunnel. This method may increase the discomfort of passengers during winter, but it serves the purpose only by installing ventilation facilities at each station. If the coolness has to be sought during summer, there is no alternative but to provide an airconditioning system. In such a case, it will be necessary to incorporate in the initial design the plan to provide a space at each station for the installation of airconditioners and secure spaces at the surface section for the installation of heat exchangers. It may be difficult to secure spaces for heat exchangers in the city center, but the use of roofs of adjacent buildings may be one way to solve the problem and construction of facilities for joint use with building owners is also conceivable. If the supply of cooling water for district airconditioning is available this problem will be solved instantly.

## 4-5 Construction Method

### 4-5-1 Outline of geological conditions

Although an accurate judgement can not be made until the result of a detailed geological survey is available, the geological conditions in the project area are presumed to be as follows on the basis of brief data available and the observation of a part of construction site.

The stratum consists of surface soil, sandy layer, weathered granite, soft granite and hard granite in that order from the surface. The depth of the hard rock varies with the location but it is generally found in the range of 18 m to 34 m.

The ground-water level is not known yet. However, judging from the fact that some wells are being used in the city area, the city area is surrounded by mountains in north and south, and that some rivers or open conduits have been converted to culvert, gushing of groundwater to some extent is expected at time of construction.

In any event, construction of subways is considered possible by means of open-cut and cover method and the condition for construction work is considered quite favorable compared to Tokyo and Osaka. However, in the section where the depth of hard rock varies greatly, it may be necessary to make a follow-up survey depending on the result of geological survey. Attention must be paid to the fact that the depth of anchorage and penetrated depth of soldier piles and drilling method vary greatly depending on the depth of hard rock.

It must also be kept in mind that where there is a gush of groundwater in the sandy soil, there is always a danger of instability of lagging and the bottom face of excavation because of quick sand irrespective of the stiffness of soil formation. It is important, therefore, to be on alart at all times so that necessary steps may be taken according to the changes made before and during the construction work.

4-5-2 Adoption of open-cut and cover method and precautions to be taken

Compared with the subways of tube type which has its tunnel deep in the ground, the subway constructed by the open-cut and cover method affords more convenience to passengers. Examples of the advantages of the subways constructed by such method are that the time required to go from the surface entrance to the platform is very short and that the subways constructed along the city road network gives passengers clear understanding as to the orientation and the location of transfer, thus showing directly the effectiveness of the subways in absorbing crowd from the surface traffic (See Figures 4-5-1 and 4-5-2).

Geological conditions in Seoul Special City are favorable for adoption of this advantageous open-cut and cover method.

On the other hand, the tube-type tunnel uses the ordinary tunnel mining method and therefore is not always expensive.

However, as this method requires blasting of rocks with the use of dynamite, impact on the existing facilities and the residents is unavoidable. The tunnel constructed by this method has a depth of about 40 m from the surface of ground and much longer time is required by passengers to go from the entrance to the platform. For this reason, the open-cut and cover method should be adopted extensively and the use of ordinary tunnel mining method, when necessary, should be restricted only to the part of section other than stations.

Even though it has been previously stated that the geological conditions are favorable for the adoption of open-cut and cover method, it does not necessarily mean the simplicity of construction work.

Fig. 4.5-1 **Open Cut and Cover Construction**

**Construction order**

1. Soldier pile driving
2. Road Decking
3. Hanging and protecting of under ground utilities
4. Excavating, lagging and shoring
5. Water proofing and reinforce concrete placing
6. Back filling
7. Removing road deck
8. Extracting soldier pile
9. Reconstructing surface pavement

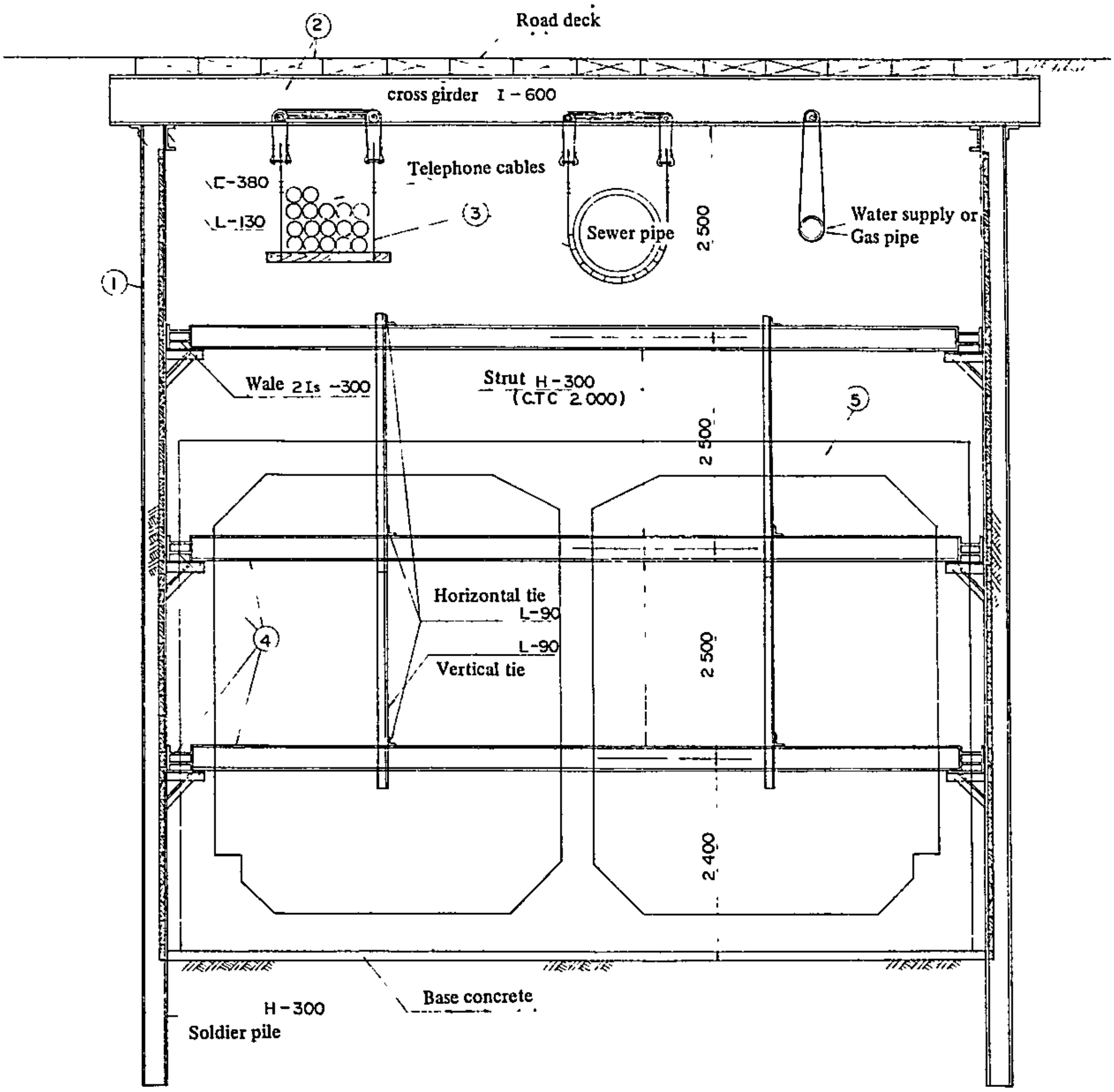
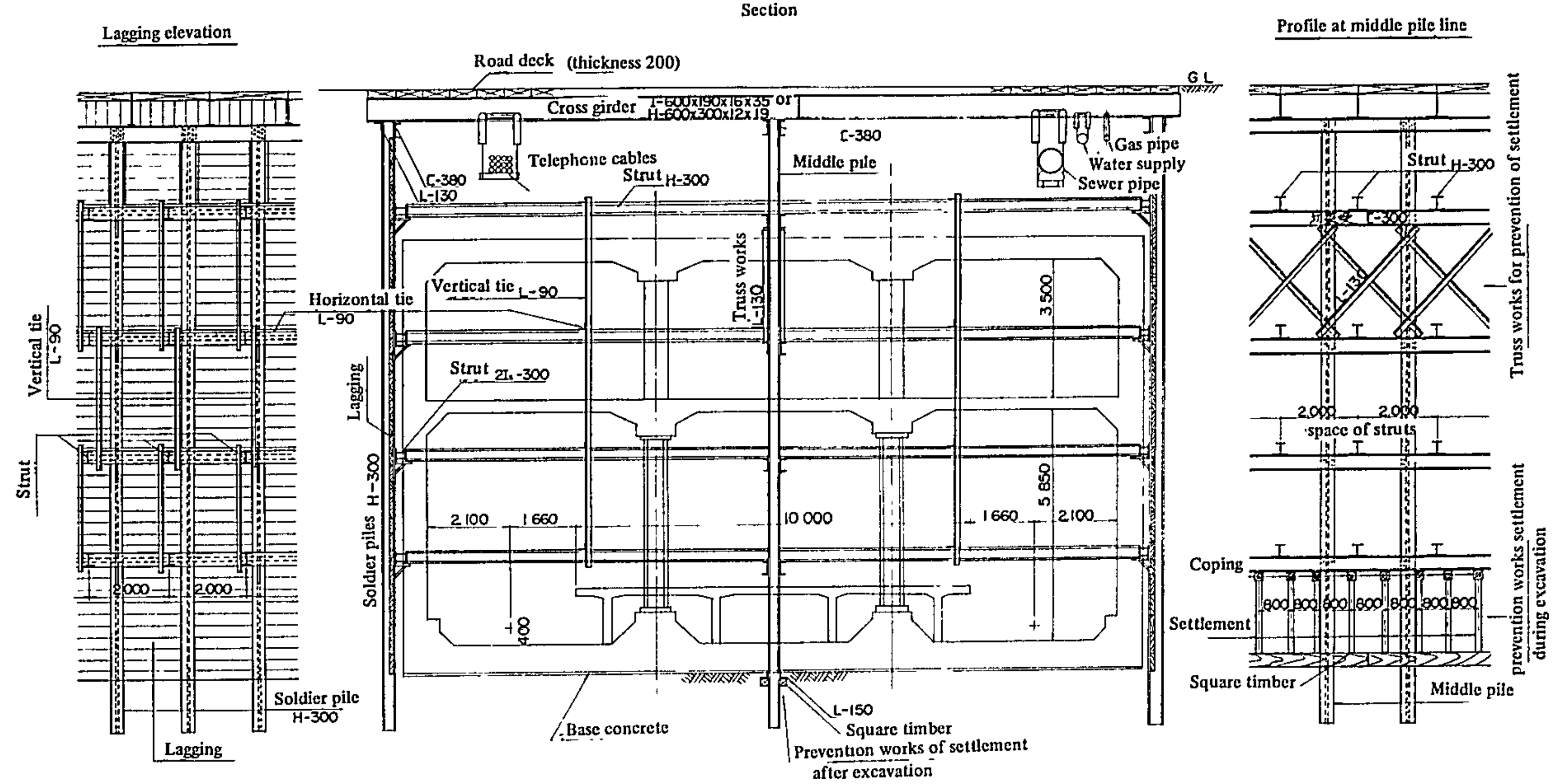


Fig. 4-5-2 Open Cut and Cover Construction at Station



As the work must be performed in the present city area, an accurate design and well planned construction procedure must be provided for the entire process of the work when a large scale construction work is planned with the use of open-cut and cover method.

The followings are the points to be given special attention in the engineering and construction work.

(1) Driving or built in soldier piles driving

Driving of steel piles in the dense sandy layer is comparatively difficult and in some cases it is almost impossible. Use of thick H-shape steel instead of I-iron for pile is also conceivable. However, where there is an impenetrable soil layer in the depth, it will be necessary to use a driving or boring machine and build soldier piles in the hole. This method is advisable also from the standpoint of minimizing noize problems.

For the anchorage of penetrated part of the pile after it hit the hard rock, special care must be exercised.

(2) Lagging and shoring

The section between the soldier piles must be provided with lagging and to protect the wall and must be given shoring. However, this procedure was not being strictly observed on many occasions at the construction site in the city area at time of the visit by the survey team. When the work is done in the road, the lagging face is subject to the constant dynamic impact exerted by the already saturated surface traffic. Since this condition is completely different from the static and stable condition of secluded private land, the lagging that is required by geologically and load condition must always be provided (See Figures 4-5-1 and 4-5-2).

It must be kept in mind that the carefully prepared lagging, together with road deck, is not only essential for maintaining surface traffic but also indispensable for ensuring protection of hanging underground utilities.

(3) Measures against the gush of groundwater

Though the amount of the gush of ground-water at time of excavation may be predicted in advance through a survey, the accuracy of the method used for the survey is not dependable.

The problems during the construction work are that the locations of water gush are not similar but the occurrence of the gush concentrates on a certain locality and that it is extremely difficult to predict the location of the gush.

Moreover, the gush of water occurs all of sudden at a certain depth and causes immediate failure of soil formation by reducing the shearing force of the soil to zero.

At time of geological survey for Seoul Special City, it is not only necessary to conduct surveys on the fluctuation of ground-water level, coefficient of permeability, pore water pressure and grade of sand but also provide a pumping test or make observations of actual state of soils by lowering the excavating shaft when deemed necessary depending on the results of the foregoing surveys.

Though various soil stabilizing methods such as ground water level lowering method or chemical grouting are conceivable depending on the distance or depth from the adjacent structures, it is advisable to select a method best suited to the sandy layer of Seoul City and to make a final decision after conducting a field experiment.

(4) Road decking

One of the outstanding features of the subway construction in Japan since the pre-war days was that the work is accomplished without interfering surface traffic by means of road decking.

The steel road deck and other materials now in use in Japan are capable to endure severe conditions imposed by heavy traffic and the present products placed on the market are the fruit of continued researches by the staff of the Teito Rapid Transit Authority over a long period of time, taking the lead in the development of such materials in the world.

When the traffic volume of Seoul Special City, almost equaling to that of Tokyo, and the large number of buses and additionally the participation of heavy duty trucks with the start of construction work are taken into consideration, adoption of the same kind of Japanese road decking method is strongly recommended.

Concerning heavy military vehicles (tanks, etc.), measures should be taken for the restriction of traffic by these vehicles to ensure safety of traffic by consulting with parties concerned.

(5) Protection of underground utilities

Another outstanding feature of the subway construction in Japan is that the work is continued by hanging and protecting underground utilities exposed during excavation without relocating them to the place out of excavation work. Though this method is very effective in saving construction cost and preventing disruption of city functions, it requires constant and very close supervision at time of the work. It is strongly hoped that both the contractors and construction supervisors realize the importance of this point.

The importance of construction supervision will be discussed in the separate section.

(6) Measures against the cold

The necessity of measures against the cold is beginning to be realized in Japan after having experienced construction of subways in Sapporo, situated at a higher latitude than Seoul City. In performing the work in the city area, efforts must always be made to shorten construction period as much as possible even when the work is being performed while maintaining the city functions. When the strong demand for the subways is taken into consideration, the importance of this point must be recognized.

For this reason, the winter season must be fully utilized for the construction work.. Among various measures to be taken against the cold in the work during the winter season, most important ones will be against the slippage of road deck and for curing of concrete and exposed underground utilities being protected.

(7) Water proofing of tunnel

The city of Seoul is favored by relatively abundant ground water resorces and use of well in the city area represents a familiar life similar to that seen in the Japanese cities. In view of the lengthy tunnel to be constructed, unfavorable conditions for construction work and limited construction period, the water proofing work must be complete and perfect to ensure safety against 25 KV power line and other hazards.

Unfavorable conditions for construction work include the possibility of the gush of ground water, as well as the disadvantages for the placement of concrete compared with the surface work, thus easily causing defects locally in tunnel body concrete. It is suggested, therefore, that the parties concerned realize the need of compensating this defect.

When providing water proofing sheet at first, the material which can resist physical impact must be selected. Then, the need for water proofing materials, which are resistive against impact, capable to meet the expansion and shrinkage of concrete body and which have strong bonding and are available for use even for the location of high moisture content, is strongly felt. However, such an ideal material can not be expected and therefore the result of the work varies greatly depending on way the water proofing work is performed. It is for this reason that the water proofing contractors for the subway construction in Japan are all designated contractors without exception. It is hoped that careful selection of materials is made and elaborated water proofing works are performed also in Seoul Special City.

(8) Work close to the existing structures

Generally, subways are constructed close to multi-story buildings or important structures or under these structures. In such cases, analysis of stress state in ground, planning and implementation of required protection works must be carried out carefully and accurately to ensure maximum safety of the work.

To add a word, the analysis of stress state in ground may be effective for the engineering of the work but it is more appropriate to consider that this analysis does not have any direct effect on the forecast of the intensity of deformation adjacent to open cuts, which change constantly during the process of construction work. It is recommended, therefore, that an automatic recorder of deformation or inclination and an interlocking automatic warning device be provided for the facilities to be protected as a routine procedure.

4-5-3 Importance of construction supervision

Though the availability of informations on engineering and construction records is increasing internationally, an adequate construction supervision can not be provided through mere reading of these information.

Precautions to be taken as a general rule will be discussed below.

Generally, the working drawing shows a certain stage of the process of the stationary state. In the case of open-cut and cover method, the state of ground changes with the progress of excavation. And the lagging and shoring works are generally given one step behind the excavation. The state of apparent stability of the shored face in spite of this lag is partly due to the fact that the failure of soil takes time because of rheology phenomenon but is chiefly due to such appropriate measures as the sufficient strength provided to the shoring work at the previous stage to withstand transitional force or the constant awareness of the change in the state of soil.

In many cases, the theory of engineering, not limited to civil engineering alone, presupposes the maintenance of stationary state, but in actuality, it should be considered that the theory is applicable only to a limited duration.

The importance of construction supervision lies in the attitude that foresees the change in the actual state and prepare to take necessary steps in advance to cope with such changes.

It should also be pointed out that the design and specifications give separate description for individual items and that these items have complicated relations between them with regard to timing and dimensions.

As for the protection of underground utilities, standard work drawings are available and the eager Korean authorities have probably made necessary studies of the drawings. However, the work performed in comformity with the drawings can not always be safe. There are too many conditions to be attached to the work and it will be known that there are also many problems which can not be discussed on the basis of general term in actuality.

An example of the past discussion will be given below.

The section of an underground pipe, that changes from natural ground to hanging position or connects to a valve or manhole, has a discontinuous point of change and therefore requires a care for handling. For the protection of bend pipes, standard drawings are available, but for the section involving a complicated continuation of bend pipes, care must be exercised by taking into account the physical action, instead of mere formal application of the content of the standard drawing.

The underground utilities being protected by hanging are not provided with preconditions that the road decking or lagging and shoring may be placed in the state of instability temporarily in the process of construction work. Even when these works are in a perfect condition, the cross girder may deflect due to the load of surface traffic and the utilities hanging from the girder may vibrate constantly lengthwise and crosswise. It is also necessary to take measures for minimizing the amplitude of vibration. The sudden change in the pressure inside of the utility pipe may also be the cause of an accident.

The point to be given special attention in the case of open-cut and cover method is that the soil surrounding a excavation becomes deformed with the progress of excavation and the underground utilities in the natural ground outside of the shored wall have been strained. Where the section being protected by hanging and the section in the natural ground are in continuation, the negligence of proper supervision and appropriate measures will be a direct cause of an accident.

From the above explanation it is readily known that the construction of tunnels in accordance with the engineering drawings involves difficulties of various degrees depending on the work performed at the place where no restrictions are imposed and in the city area where the work has to be performed over a long period of time and in much longer section.

For this reason, in the training of construction supervisors a particular emphasis must be placed on the importance of their responsibility and provides the trainees with engineering and empirical backgrounds.

### 4-6 Construction Materials for Civil Work

(1) Concrete

The design strength of concrete against the strength after 28 days is set lower for concrete in the tunnel than for the surface structures. This is due to the fact that the construction of tunnel must be performed under adverse conditions and that the subsequent repair work is almost impossible in the case of tunnel.

In Korea the cement is produced domestically and concrete aggregates are available in abundance. It is necessary, however, to pay attention to the following points.

To promote the workability under the above-mentioned circumstances, selection of concrete admixture must be made and a study must be made on whether the high-early-strength cement is available immediately when required and whether quality control of cement, gravel, sand and concrete is adequately provided. An example of qualities of ready-mixed concrete used by Teito Rapid Transit Authority in Tokyo is shown in Table 4-6-1.

(2) Water proofing materials

Since the asphalt and other water proofing materials are laid outside of the tunnel body concrete, replacement of these materials is almost impossible. As stated in the section for the construction method, the defect only in the part of the work often nullifies the effectiveness of the water proofing layer of other flawless sections. For this reason, only dependable materials should be used for water proofing works.

(3) Round steel

Though the deformed bar is being produced domestically, it is advisable to make a study to ascertain whether the uniformity in the quality and dimensions of materials are guaranteed, whether the discontinuity of deformed shape causes the concentration of stress and decreases the durability of structures. Besides, as the materials having a high strength may be required for portion of structures, such point should also be clarified.

(4) Shape steel

Shape steel and similar materials are used for the construction of temporary structures and the importance of these materials has been discussed previously. The merit of the shape steel lease system adopted by the Teito Rapid Transit Authority in Tokyo is that the contractors are able to perform the work safely with the leased materials without missing an opportunity by spending time for seeking new steel materials when confronted with a sudden change during the works.

Table 4-6-1 Results of Test on Ready-Mixed Concrete (For delivery from Apr. 21, 1970 to July 20, 1970)

| Item | Type | Prescribed value | Ube | Onoda | Osaka | Joyo | Sumitomo | Tokyo | Nihon | Hitachi | Mitsubishi | Places where concrete is mainly used | Analysis of the results |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quantity delivered ($m^3$) | | | 3,852 | 10,178 | 2,098 | 4,632 | 10,755 | 2,455 | 18,881 | 9,317 | 2,770 | | |
| Total number of test pieces (set) | | | 40 | 105 | 22 | 47 | 146 | 38 | 193 | 105 | 30 | | |
| Compressive strength ($kg/cm^2$) | Special A-360 | Standard design strength $\sigma_{28}$ = 240 | 355 | - | 343 | - | - | 343 | - | - | 379 | tipe side wall | Products of all firms meet the prescribed value |
| | A-345 | " | - | 346 | - | - | 346 | 333 | - | 355 | - | Wall & column | " |
| | A-320 | $\sigma_{28}$ = 210 | 293 | 313 | 311 | 312 | 286 | - | 301 | 293 | 302 | Wall, column, ventilation openings, vertical pump room (Slabs included) | |
| | A-310 | " | 305 | 308 | 299 | 320 | 314 | - | 296 | 297 | 301 | Slab | " |
| | High-early strength A-320 | $\sigma_7$ = 210 | - | - | - | - | 293 | - | 288 | 286 | 283 | Wall, column, ventilation opening, vertical pump room (Slabs included) | " |
| | B-210 | $\sigma_{28}$ = 120 | - | - | 167 | 164 | 146 | 223 | - | 172 | - | Base concrete | " |
| Coefficient of variation (%) | A | Less than 15% | 4.2 | 4.9 | 5.5 | 6.5 | 4.2 | 5.8 | 3.4 | 4.0 | 5.5 | | |
| Slump (%) | Special A-360, A-340 A-320, Early A-320 | 16 ± 2.5 | 16.8 | 16.5 | 16.9 | 16.1 | 16.2 | 15.6 | 16.7 | 16.3 | 16.3 | | |
| | A-310, B-210 | 13 ± 2.5 | 14.0 | 13.8 | 13.8 | 13.5 | 13.3 | 14.1 | 13.9 | 13.7 | 14.1 | | |
| Amount of air (%) | All types (except special A-360) | 3 4 | 3.4 | 3.5 | 3.2 | 3.4 | 3.5 | 3.4 | 3.4 | 3.5 | 3.4 | | |

It is hoped that the present practice in Japan where the use of steel materials is determined not from an economical point of view alone but also from the standpoint of safety of the work be well recognized by parties concerned.

It is recommended that the import of required materials be handled in such a manner that the required materials arrive on time for construction work, while paying attention to the above points.

An example of the box-type reinforced concrete tunnel adopted by the Teito Rapid Transit Authority is shown in Reference Drawings 1 and 2.

## 4-7 Electric System

### 4-7-1 Electric traction facilities

- o Supply of energy for traction

  The energy required for the electric traction will be normally supplied by the Korean National Railroad through overhead equipment. In consideration of the importance of subway, an emergency sub-station of a small capacity will be provided in Chungyangri (See Chart 5-3-1).

- o Sub-sectioning posts

  They will be provided at two locations in the tunnel and near both portals of the tunnel.

- o Feeder system

  Auto-transformers (two sets) will be provided at the sub-sectioning posts.

- o Overhead equipment (See Chart 4-7-1)

  Rigid system, contact wire of 110 $mm^2$ attached to aluminium T-bars.

- o Feeder: 95 $mm^2$ aluminium stranded cable

- o Distance between live parts and earth: more than 30 cm
  Distance between the contact wire and feeder: more than 50 cm
  Distance between the folding pantograph and the contact wire: more than 35 cm

As the rigid suspension system is adopted for the tunnel section, devices for the connection with the simple catenary system will be provided at both ends of the tunnel section.

### 4-7-2 Signal and safety appliances

- o Automatic block system by means of wayside signals

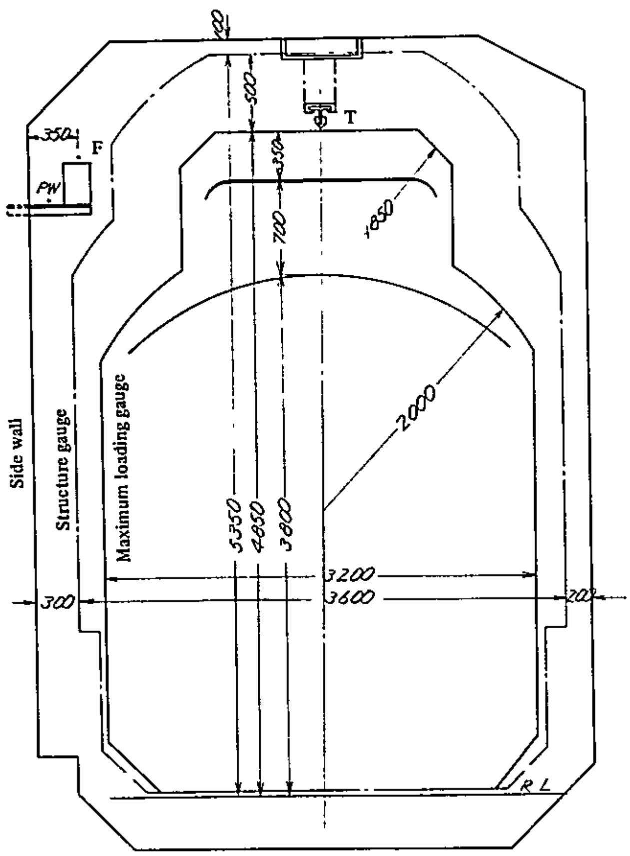
- o Standard length of block section: Approximately 400 m

- o Signals: Colored light type, five aspect system with warning and speed-reduce indications

- o Power switch: First class power relay interlocking system

Fig. 4-7-1 Standard Structure of Overhead Contact Line

25 KV A.C. A.T. feeding system
in tunnel




F : Feeder
PW : Protective wire
T : Contact wire

- o Signal track circuit: frequency divider double rail system
- o Automatic trains stop device: S-type ground inductor system
- o Return circuit: Impedance bond and rail bond

4-7-3 Power transmission lines and other power facilities

- o Transmission line: Two circuits of 22 KV cables

Links between the Korean National Railroad substation, electric company's substations and power room at each station. Layed in a trough in the tunnel.

4-7-4 Communication facilities

- o Communication cable: Includes dispatcher circuits and railway subscriber lines. Accommodated by a trough in the tunnel.
- o Telephone system for specific use for train dispatchers and power dispatchers.
- o Service telephones along the track and an emergency telephone circuit will be provided in the tunnel.

4-7-5 Others

- o Substation supervisory and remote control device: One set (Control center is to be located in the Korean National Railroads' Control Center).
- o Centralized Traffic Control System: One set
- o Improvement of communication lines belonging to other establishments.

## 4-8 Construction Costs and Construction Period

### 4-8-1 Construction costs

Though it was extremely difficult to make an accurate estimate on the construction cost during the survey conducted within a brief period of time, the following rough estimate was made on several conditions.

The conditions surrounding Seoul City may be said to be favorable for construction of subways in several respects. A few examples of the advantages are that an abundant and excellent labor force is readily available, cement is being produced domestically, the ready-mixed concrete is being used widely and finally, that the deformed bar of various sizes are readily available on the market.

On the other hand, the sub-surface construction work ever undertaken in this city was only the construction of underpasses of pedestrians' crossing and therefore, lack of experience in the work of this type can not be denied. However, the advantages are that this country has a wide experience in large scale civil works in various fields and that subway construction is being progressed in her neighbor country Japan and therefore is in a better position to obtain experiences of subway construction.

An estimate on the construction costs was made on the basis of the result of the survey on labor cost, material cost and others and on conditions described below.

(1) Construction work is to be done by employing the open-cut and cover method with road decking and lagging. Shape steels not domestically produced are to be imported and the rent of such materils is also to be calculated.

(2) Excavation and transportation of muck for a short distance are to be done by manpower and transportation of muck from the construction site is to be done by hopper and dump truck through day and night.

(3) Mixer trucks for ready-mixed concrete, wreckers for hoisting materils, pile drivers, and boring machine are available at the cost of rent only.

(4) The estimated construction period is three years or 30 months, from 1971 to 1973.

(5) The prices and labor wages used in the estimate were those prevailing in September 1970.

Breakdown list of the estimated construction cost are shown in Table 4-8-1.

Table 4-8-1 Breakdown list of Construction Cost for No. 1 Line

(In million won)

| Items | Amount | Cost per km | Percentage (%) |
|---|---|---|---|
| Cost of right-of-way | 366 | 39 | 1.6 |
| Cost of civil work | 17,863 | 1,880 | 75.8 |
| Cost of structures | 1,804 | 190 | 7.7 |
| Cost of track | 596 | 63 | 2.5 |
| Cost of electrification | 2,931 | 309 | 12.4 |
| Total | 23,560 | 2,480 | 100 |

Total construction kilometerages: 9.5 km

4-8-2 Construction period and financial plan

Annual requirement for construction fund estimated up to 1981 on the basis of the total construction cost described in the previous section will be as shown in Table 4-8-2.

Table 4-8-2 Construction Schedule and Annual Requirement for Construction Fund

(In billion won)

| Items \ Year | | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Const. Schedule | | Start | | | | Opening | | | | | | | | |
| Investment | Electric Railcar | | | | (60 cars) 2.4 | | (24 cars) 0.96 | (44 cars) 1.44 | (10 cars) 0.44 | (10 cars) 0.44 | (10 cars) 0.44 | (12 cars) 0.51 | | (170 cars) 6.63 |
| | Const. Cost | | 5.6 | 7.4 | 9.51 | 1.05 | | | | | | | | 23.56 |
| | Total | | 5.6 | 7.4 | 11.91 | 1.05 | 0.96 | 1.44 | 0.44 | 0.44 | 0.44 | 0.51 | | 30.19 |
| Remarks | | Escalation of prices and wages are not taken into consideration. Interest during construction is not included. | | | | | | | | | | | | |

The total investment before completion of the line amounts to 24.913 billion ₩ and the interest during construction amounts to 2.322 billion ₩.

## 4-9 Forecast of Operating Revenue and Expenditure

Forecast of operating revenue and expenditure was made for the year up to 1981 on the assumption that the initial operation would begin in 1974. As it is extremely difficult to forecast fluctuation of wages and prices, the estimate was based on the prevailing wages and prices in 1970.

The expenditure was divided into the operating expenses, interest paid and depreciation cost. The operating expenses were further broken down into personnel expense, power cost, repair and maintenance cost and others.

The profit and loss were calculated before and after depreciation.

By the above-mentioned classification and with the use of the following calculation basis, the forecast of profit and loss was made as shown in Table 4-9-3 carried at the end of this section.

### 4-9-1 Operating revenue

(1) Revenue from passenger fare

(a) Average number of passengers per day

The estimate on the number of passengers in 1974 and 1981 was made on the basis of transport demands and transport plan described in Section 4-1 and that for the years in-between was made by drawing a line between the two period (Table 4-9-1).

Table 4-9-1 Estimated Number of Passengers for No. 1 Line (Daily)

| Description \ Year | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 |
|---|---|---|---|---|---|---|---|---|
| From south of Yongsan | 191, 821 | 253, 676 | 322, 951 | 347, 463 | 371, 974 | 396, 485 | 420, 996 | 445, 510 |
| Ordinary passengers | 76, 728 | 101, 451 | 129, 208 | 139, 009 | 148, 808 | 158, 607 | 168, 406 | 178, 204 |
| Commuting workers | 75, 893 | 104, 625 | 137, 743 | 152, 454 | 167, 166 | 181, 878 | 196, 590 | 211, 306 |
| Commuting students | 39, 000 | 47, 600 | 56, 000 | 56, 000 | 56, 000 | 56, 000 | 56, 000 | 56, 000 |
| From north of Sungbuk | 62, 629 | 199, 449 | 144, 431 | 171, 860 | 199, 290 | 226, 710 | 254, 151 | 281, 580 |
| Ordinary passengers | 25, 052 | 39, 712 | 57, 744 | 68, 722 | 79, 700 | 90, 678 | 101, 656 | 112, 632 |
| Commuting workers | 23, 927 | 43, 162 | 67, 187 | 83, 636 | 100, 090 | 116, 542 | 132, 995 | 149, 448 |
| Commuting students | 13, 650 | 16, 575 | 19, 500 | 19, 500 | 19, 500 | 19, 500 | 19, 500 | 19, 500 |
| Within the line | 140, 805 | 171, 146 | 201, 546 | 201, 744 | 201, 942 | 202, 140 | 202, 338 | 202, 540 |
| Ordinary passengers | 56, 322 | 68, 458 | 80, 618 | 80, 697 | 80, 776 | 80, 855 | 80, 934 | 81, 016 |
| Commuting workers | 46, 683 | 56, 788 | 66, 928 | 67, 047 | 67, 166 | 67, 285 | 67, 404 | 67, 524 |
| Commuting students | 37, 800 | 45, 900 | 54, 000 | 54, 000 | 54, 000 | 54, 000 | 54, 000 | 54, 000 |
| Total | 395, 255 | 524, 271 | 668, 928 | 721, 067 | 773, 206 | 825, 345 | 877, 485 | 929, 630 |
| Ordinary passengers | 158, 102 | 209, 621 | 267, 570 | 288, 428 | 309, 284 | 330, 140 | 350, 996 | 371, 852 |
| Commuting workers | 146, 643 | 204, 575 | 271, 858 | 303, 139 | 334, 422 | 365, 705 | 396, 989 | 428, 278 |
| Commuting students | 90, 650 | 110, 075 | 129, 500 | 129, 500 | 129, 500 | 129, 500 | 129, 500 | 129, 500 |

(Note) "From south of Yongsan" indicate the through passengers arriving and departing from the area south of Yongsan. "From north of Sungbuk" indicate the through passengers arriving and departing from the area north of Sungbuk.

(b) Average fare per person

This was calculated on the basis of the fare system and the rate of fare described in paragraph 8-3.

(2) Miscellaneous incomes related to transportation

These were estimated to be 6.8% of the total revenue from the transportation of passengers on the basis of actual records for the subways in Japan.

4-9-2 Expenditure

(1) Personnel expense

(a) Number of personnel required

On the basis of examples of the Japanese subways, the number of personnel required in the initial year of 1974 was estimated as follows.

As the function of motorman and conductor for the No. 1 Line is to be performed by the employees of the Korean National Railroads, charges will be paid to the Korean National Railroads in actuality. For the convenience of calculation, however, these personnel were also counted for in the personnel expense. Therefore, these personnel are not carried in Table 5-11-2.

| Item | Average of subways in Japan | | Subways in Seoul | |
|---|---|---|---|---|
| | Basis of calculation | Personnel required | Requirement | Personnel required |
| Track maintenance personnel | per km of track | 6 | 8 km | 48 |
| Power line maintenance personnel | " | 8 | 8 km | 64 |
| Operating personnel | per Train at rush hours | 8.9 | 11 trains | 98 |
| Transport personnel | per Station | 35 | 9 stations | 315 |
| Maintenance and transport administrative personnel | per 100 field personnel | 3.4 | 525 | 18 |
| General administrative personnel | per 100 field personnel | 7.3 | 543 | 40 |

(b) Average wage per employee

The average wage per employee was estimated as shown in the following table with reference to the wage level for the employees of Seoul Municipal Government and the Korean National Railroads.

| Job classification | Wage in Won |
|---|---|
| Track maintenance personnel | 35,000 |
| Power line maintenance personnel | 35,000 |
| Rolling stock maintenance personnel | 35,000 |
| Motorman | 40,000 |
| Transport personnel | 35,000 |
| Administrative personnel | 35,000 |

(2) Power cost

The power cost was estimated as follows on the basis of the power rate in Korea, 2.35 w/KWH and on the assumption that the required power energy is 70 KWH per 1,000 ton km.

(In 1,000 ₩)

| Year | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 |
|---|---|---|---|---|---|---|---|---|
| Rate | 102,951 | 117,903 | 209,751 | 230,043 | 250,335 | 270,627 | 290,919 | 311,292 |

(3) Repair and maintenance costs

On the basis of the examples of the subways in Japan, the ratio of repair cost for the personnel expense in the maintenance expense of the track and power line was estimated as follows. Responsibility of repair and maintenance of rolling stocks is to be delegated to the Korean National Railroads. The repair and maintenance cost shown in Table 4-3-3 includes the rent of the Korean National Railroad car sheds.

| Description | Percentage |
|---|---|
| Track maintenance cost | 73 |
| Power line maintenance cost | 27 |

(4) Others

Other expenses were estimated on the basis of 37%, which is the ratio of other expenses (Expenses other than personnel expenses minus power cost and repair and maintenance cost) to the personnel expenses in the case of subways in Japan.

(5) Interest paid

All the funds required were presumed to be provided by loan. The loan was presumed to carry a 7% interest and to be paid on equal basis over 20 years after 3 years deferment, with reference to the conditions set forth for providing loans to the Korean National Railroad in the past three years.

(6) Depreciation cost

Depreciation cost was calculated on the assumptions shown in the following table by taking into account the service life of facilities in the case of the subways in Japan and that of the National Railroads in Korea.

Table 4-9-2 Service Life of Facilities

| Facilities | Service life | |
|---|---|---|
| Buildings | 60 year | |
| Track | Replacement method<br>15 | (1/2 is to be replacement property and 1/2 is to be depreciated in 15 years.) |
| Tunnel | 60 | |
| Station facilities | 30 | |
| Communication equipment | 30 | |
| Electric safety equipment | 30 | |
| Power line facilities | 40 | |
| Machinery | 15 | |
| Rolling stock | 15 | |

Table 4-9-3 Operating Revenue and Redemption Plan for No. 1 Line

(In million ₩)

| | | Description / Year | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 |
|---|---|---|---|---|---|---|---|---|---|---|
| Result of transport business | | Average number of passengers transported daily (person) | 395,255 | 524,271 | 668,928 | 721,067 | 773,206 | 825,345 | 877,485 | 929,630 |
| | | Total number of passengers transported annually (1,000) | 144,268 | 191,359 | 244,159 | 263,189 | 282,220 | 301,251 | 320,282 | 339,315 |
| | | Average fare per person (₩) | 14.40 | 14.37 | 14.35 | 14.33 | 14.31 | 14.29 | 14.28 | 14.27 |
| Revenue | | Revenue from transportation of passengers | 2,078 | 2,751 | 3,504 | 3,771 | 4,039 | 4,306 | 4,574 | 4,842 |
| | | Miscellaneous incomes from transport business | 141 | 187 | 238 | 256 | 275 | 293 | 311 | 329 |
| | | Total | 2,219 | 2,938 | 3,742 | 4,027 | 4,314 | 4,599 | 4,885 | 5,171 |
| Expenditure | | Operating expenses | 639 | 695 | 831 | 892 | 954 | 1,014 | 1,080 | 1,141 |
| | | Personnel expenses | 249 | 253 | 260 | 264 | 269 | 272 | 280 | 285 |
| | | Power cost | 103 | 118 | 210 | 230 | 250 | 271 | 291 | 311 |
| | | Repair & maintenance cost | 195 | 230 | 265 | 300 | 335 | 370 | 405 | 440 |
| | | Others | 92 | 94 | 96 | 98 | 100 | 101 | 104 | 105 |
| | | Interest paid | 1,952 | 2,027 | 2,074 | 2,073 | 2,020 | 1,947 | 1,855 | 1,723 |
| | | Total | 2,591 | 2,722 | 2,905 | 2,965 | 2,974 | 2,961 | 2,936 | 2,863 |
| Profit & loss | | Pre-depreciation profit & loss | △ 372 | 216 | 837 | 1,062 | 1,340 | 1,638 | 1,949 | 2,308 |
| | | Cumulative total | △ 372 | △ 156 | 681 | 1,743 | 3,083 | 4,721 | 6,670 | 8,978 |
| | | Depreciation cost | 649 | 707 | 793 | 819 | 846 | 872 | 903 | 903 |
| | | Total of expenditures | 3,240 | 3,429 | 3,698 | 3,784 | 3,820 | 3,833 | 3,839 | 3,766 |
| | | Profit and loss after depreciation | △ 1,021 | △ 491 | △ 44 | 243 | 494 | 766 | 1,046 | 1,405 |
| | | Cumulative total | △ 1,021 | △ 1,512 | △ 1,556 | △ 1,313 | △ 819 | △ 53 | 993 | 2,398 |
| Balance of capital account | Revenue | Carried over from profit & loss a/c | △ 372 | 216 | 837 | 1,062 | 1,340 | 1,638 | 1,949 | 2,308 |
| | | Loans payable | 1,709 | 1,438 | 1,965 | 825 | 620 | 419 | 220 | - |
| | | Transfer of surplus capital | - | - | - | - | - | - | - | - |
| | | Total | 1,337 | 1,654 | 2,802 | 1,887 | 1,960 | 2,057 | 2,169 | 2,281 |
| | Expenditure | Redemption of loans | 290 | 694 | 1,362 | 1,447 | 1,520 | 1,617 | 1,659 | 1,690 |
| | | Transfer to construction account | 1,047 | 960 | 1,440 | 440 | 440 | 440 | 510 | - |
| | | Transfer to surplus capital | - | - | - | - | - | - | - | 618 |
| | | Total | 1,337 | 1,654 | 2,802 | 1,887 | 1,960 | 2,057 | 2,169 | 2,308 |
| Balance of debt | | | 28,654 | 29,398 | 30,001 | 29,379 | 28,479 | 27,281 | 25,842 | 24,152 |

(Note) The debt at the beginning of the initial year of operation amounts to 27,235 million ₩.

4-10 Division of Properties and Assignment of Responsibility

As No. 1 Line is to connect and operate through Kyungin Line and Kyungwon Line of the Korean National Railroads, it is necessary to draw a clear-cut line between Seoul Municipal Government and the Korean National Railroad Office on the ownership of properties and the assignment of responsibility.

As for the ownership of properties, all the properties located in the area from the clearance of the switch branching off from Kyungin Line and Kyungwon-Line toward the center of the city are to belong to Seoul City. As for the ownership of properties located between the two parties such as passageways leading from the existing station of the Korean National Railroads to the subway station, overhead contact lines, feeder and communication lines, consultations should be made between the two parties.

As for the rolling stocks, they are to be placed under mixed ownership. In this report, however, allocation of rolling stocks was made by taking into account the number of rolling stocks required by each party at the peak hour, as an interim measure.

The assignment of responsibility, in principle, is to be made in accordance with the division of properties. However, in view of the fact that in the case of No. 1 Line, all the trains are to be operated through the Korean National Railroads, which has a longer operating line than the subway and also for the purpose of ensuring smooth management of train operation, it is considered appropriate to delegate the responsibility of train operation and operational control to the Korean National Railroads. Accordingly, the operation of trains on subway line is to be carried out under the instructions of the operation director of the National Railroads. When the No. 2 Line is completed in the future, the city operation director will give instructions on the operation of No. 2 Line from the same place as the National Railroads operating director.

As the supply of power is provided by the National Railroads substations, such functions as providing instructions for the supply of power and suspension of power supply are also to be handled accordingly.

All the responsibilities for the maintenance of rolling stocks are to be delegated to the Korean National Railroads.

Passenger services at the subway stations are to be the responsibility of Seoul City, but it will be necessary to delegate part of the passenger services to the National Railroads at the terminal stations of Seoul and Chungyangri Stations.

# V ELECTRIFICATION OF THE KOREAN NATIONAL RAILROAD

# V ELECTRIFICATION OF THE KOREAN NATIONAL RAILROAD

## 5-1 Electrification Project Lines

Sections of the National Railroads to be covered by the present electrification plan have been selected as shown in Table 5-1-1 below in conjunction with the subway construction project for Seoul Metropolitan Special City. The total length of the line proposed for electrification is 76.8 km.

Table 5-1-1 Electrification Project Lines

| Line | Section | Single or double | Route length |
|---|---|---|---|
| Kyungbu-line<br>Kyungin-line | Seoul - Inchun | Double track | 38.9 km |
| Kyungbu-line | Yungdeungpo - Suwon | " | 32.3 |
| Kyungwon-line | Chungyangri - Sungbuk | " | 5.6 |

Lines covered by the electrification plan are shown in Chart 5-1-1.

The range of electrification of lines as a means of mass transport in the suburban area will be expanded further in the future with the growth of the metropolis.

Though the transport demands and transport plans for each of the project lines have already been given in Section 4-1, those for the National Railroads will be described below as a supplement.

### 5-1-1 Transport demands for project lines

Electrification of the previously mentioned three lines of the Korean National Railroads and through operation with the subway which runs through CBD of Seoul Metropolitan City will substantially cut down the time required for travelling to the city area. As a result, the districts along these lines are expected to grow rapidly as a residential and industrial district.

Transport requirements for each of the lines in the first year (1974) and 1981, estimated by the method described in Section 3-3, will be as shown in Table 5-1-2. From this table it is known that the transport requirements for each of the lines will increase sharply after electrification. The increase in the transport requirements between Seoul Station and Yungdeungpo Station is particularly noteworthy.

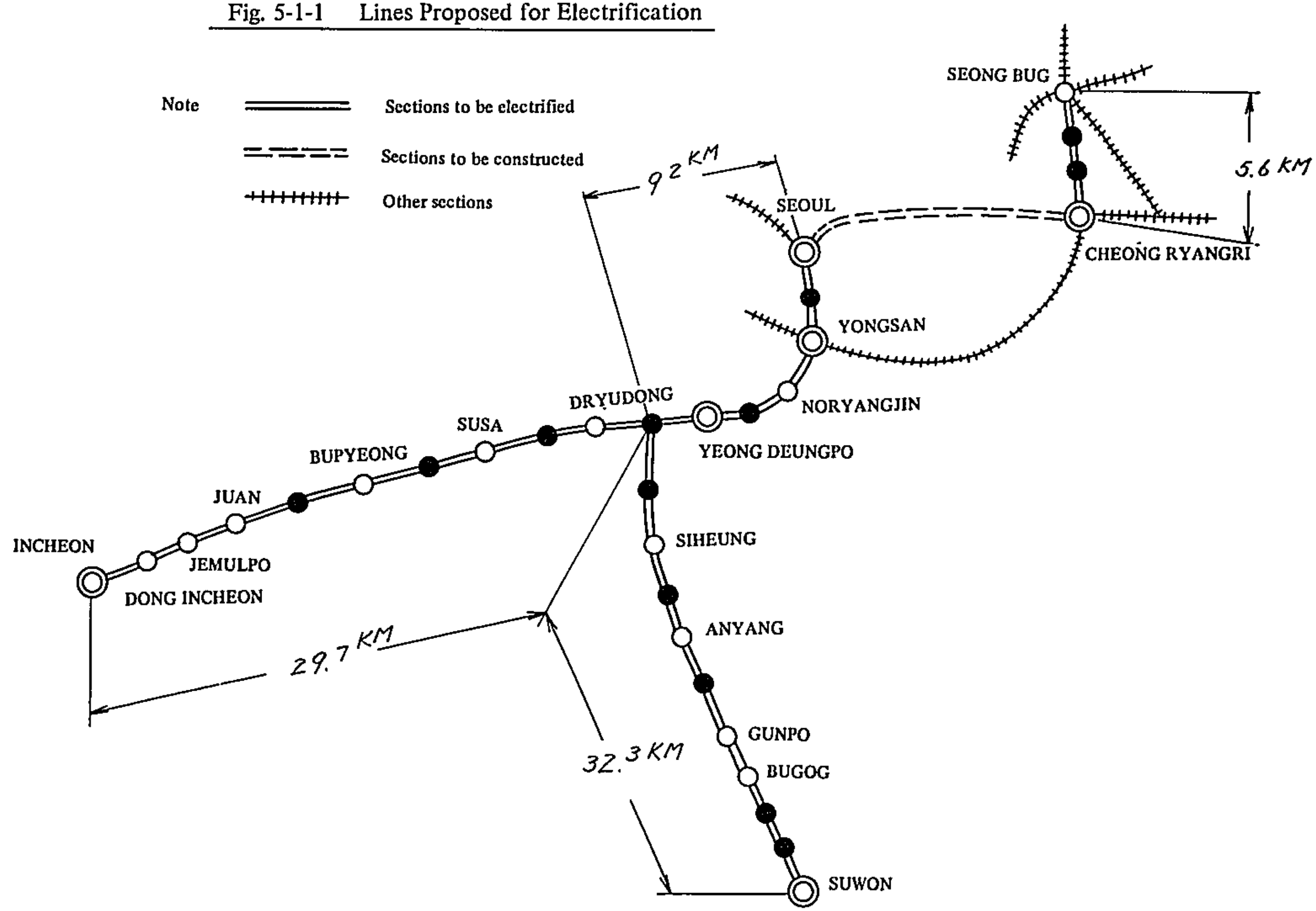
### 5-1-2 Transport plan for project lines

In establishing a transport plan to satisfy transport demand, special consideration was given to the following points.

(1) Operation of trains is to be made in such a manner as to connect Inchun and Suwon with CBD of Seoul Metropolitan City in about 50 minutes respectively.

(2) Operating headway and train formation are to be established so as to make the riding efficiency in one peak hour at the most congested section 240% in 1974 and 220% in 1981.

Fig. 5-1-1 Lines Proposed for Electrification



(3) Additional stations are to be constructed at time of electrification of the lines so that the distance between stations will be 2—3 km in order to fully demonstrate the ability of the suburban railways.

For realization of this transport plan, not only the electrification of the lines but all phases of railroad modernization program such as improvements of signal and safety systems must be implemented.

5-1-3 Operation plan for the project lines

On the basis of the above-mentioned transport demand and transport plan, a train operation plan has been established as follows:

(1) All trains are to be operated through the subway. Trains are to originate in Inchun, Suwon and Yungdeungpo and to terminate in Chungyangri and Sungbuk.

(2) For the operation between Yungdeungpo and Seoul, the existing track of Kyungin Line is to be used. For this purpose, remodeling of track layout is to be made at the south portal of Yungdeungpo Station (Refer to Section 4-1-2).

(3) The number of cars to form a train is to be 6 (4M2T) at the initial year and to be increased to 8 (4M4T), and then to 10 (6M4T) at the final stage.

Table 5-1-2 Transport Requirements Through National Railroad Lines (In the most congested section)

| Year / Section | 1969 | 1974 | | 1981 | |
|---|---|---|---|---|---|
| | All day | All day | One peak hour in the most congested section | All day | One peak hour in the most congested section |
| Yungdeungpo→Seoul | 25,964 | 121,848 | 24,370 | 246,400 | 73,920 |
| Inchun→Yungdeungpo | 23,904 | 39,430 | 7,886 | 99,625 | 29,888 |
| Suwon→Yungdeungpo | 10,073 | 28,925 | 5,785 | 87,001 | 26,100 |
| Sungbuk→Chungyangri | 4,615 | 27,810 | 5,562 | 100,264 | 30,079 |

Notes: 1. The ratio of through transport requirements during one peak hour to these of the all day was estimated to be 20% for 1974 and 30% for 1981.

2. Long distance travelers are not included.

(4) Operating headways during the rush hours for each section of the National Railroads are as follows:

| Section | 1974 | 1981 |
|---|---|---|
| Seoul Yungdeungpo | 5 min. | 2/ 2-1/2 min. |
| Yungdeungpo Inchun | 10 min. | Average 7-1/2 min. |
| Yungdeungpo Suwon | Average 15 min. | Average 7-1/2 min. |
| Chungyangri Sungbuk | 15 min. | 5 min. |

(5) Classes of trains are to be local trains and express trains. The express trains are to make only one stop (Bupyung or Anyang) between Yungdeungpo and Donginchun and between Yungdeungpo and Suwon. The running time between stations is shown in Table 5-1-3.

Table 5-1-3 Train Operating Time for National Railroads

(1) Kyungin Line (Seoul—Yungdeungpo)

| Down bound | | Stations | Distance | Up bound | |
|---|---|---|---|---|---|
| Local | | | | Local | |
| Stopping time | Running time | | | Running time | Stopping time |
| (0.30) | | Seoul | km | | — |
| | 2.40 | | 1.6 | 2.50 | |
| 0.20 | | (　　) | | | 0.20 |
| | 2.50 | | 1.6 | 2.50 | |
| 0.20 | | Yongsan | | | 0.20 |
| | 2.50 | | 2.6 | 3.00 | |
| 0.20 | | Noryangjin | | | 0.20 |
| | 2.00 | | 1.7 | 2.10 | |
| 0.20 | | (　　) | | | 0.20 |
| | 2.10 | | 1.6 | 2.10 | |
| — | | Yungdeungpo | | | (0.30) |
| 1.20 | 12.30 | Total | | 13.00 | 1.20 |
| 13.50 + 1.10 (margin) = 15.00 | | | | 14.20 + 1.40 (margin) = 16.00 | |

(2) Kyungbu Line (Yungdeungpo—Suwon)

| Down bound | | | | Stations | Distance | Up bound | | | |
|---|---|---|---|---|---|---|---|---|---|
| Express | | Local | | | | Local | | Express | |
| Stopping time | Running time | Stopping time | Running time | | | Running time | Stopping time | Running time | Stopping time |
| (0,30) | | (0,30) | | Yungdeungpo | Km | | - | | - |
| | | | 2,50 | | 2,4 | 2,40 | | | |
| | | 0,20 | | ( ) | | | 0,20 | | |
| | | | 2,30 | | 2 5 | 2,40 | | | |
| | | 0,20 | | ( ) | | | 0,20 | | |
| | 11,15 | | 3,00 | | 3,2 | 3,00 | | 11,15 | |
| | | 0,20 | | Shiheung | | | 0,20 | | |
| | | | 3,00 | | 3,0 | 3,00 | | | |
| | | 0,20 | | ( ) | | | 0,20 | | |
| | | | 3,20 | | 3,6 | 3,20 | | | |
| 0,30 | | 0,30 | | Anyang | | | 0,30 | | 0,30 |
| | | | 2,30 | | 2,3 | 2,30 | | | |
| | | 0,20 | | ( ) | | | 0,20 | | |
| | | | 3,20 | | 3,5 | 3,10 | | | |
| | | 0,20 | | Kunpo | | | 0,20 | | |
| | | | 3,20 | | 3,7 | 3 20 | | | |
| | | 0,20 | | Bukok | | | 0,20 | | |
| | 12,45 | | 2,30 | | 2,3 | 2,30 | | 13,15 | |
| | | 0,20 | | ( ) | | | 0,20 | | |
| | | | 2,50 | | 2,9 | 3,00 | | | |
| | | 0,20 | | ( ) | | | 0,20 | | |
| | | | 2,50 | | 2,8 | 2,50 | | | |
| - | | - | | Suwon | | | - | | - |
| 0,30 | 24,00 | 3 30 | 32,00 | Total | 32,4 | 32,00 | 3,30 | 24,30 | 0,30 |
| (margin) 24,30 + 2,30 = 27,00 | | (margin) 35,20 + 2,30 = 38,00 | | | | (margin) 35,30 + 2,30 = 38,00 | | (margin) 25,00 + 2,00 = 27 00 | |

(3) Kyungin Line (Yungdeungpo—Inchun)

| Down bound | | | | Stations | Distance | Up bound | | | |
|---|---|---|---|---|---|---|---|---|---|
| Express | | Local | | | | Local | | Express | |
| Stopping time | Running time | Stopping time | Running time | | | Running time | Stopping time | Running time | Stopping time |
| (0,30) | | (0,30) | | Yungdeungpo | km | | - | | - |
| | | | 2,50 | | 2,4 | 2,40 | | | |
| | | 0,20 | | ( ) | | | 0,20 | | |
| | | | 3,40 | | 3,9 | 3,40 | | | |
| | | 0,20 | | Oryudong | | | 0,20 | | |
| | | | 3,30 | | 2,7 | 3,10 | | | |
| | 14,15 | 0,20 | | ( ) | | | 0,20 | 13,00 | |
| | | | 2,30 | | 2,3 | 2,30 | | | |
| | | 0,20 | | Sosa | | | 0,20 | | |
| | | | 2,30 | | 2,7 | 2,40 | | | |
| | | 0,20 | | ( ) | | | 0,20 | | |
| | | | 2,30 | | 2,6 | 2,40 | | | |
| 0,20 | | 0,20 | | Bupyung | | | 0,20 | | 0,20 |
| | | | 2,50 | | 2,9 | 2,50 | | | |
| | | 0,20 | | ( ) | | | 0,20 | | |
| | | | 2,40 | | 2,7 | 2,50 | | | |
| | 8,55 | 0,20 | | Chuan | | | 0,20 | 8,30 | |
| | | | 2,20 | | 2,2 | 2,20 | | | |
| | | 0,20 | | Jemulbo | | | 0,20 | | |
| | | | 2,40 | | 2,5 | 2,40 | | | |
| | | 0,30 | | Donginchun | | | 0,30 | | |
| | | | 2,30 | | 2,0 | 2,30 | | | |
| | | - | | Inchun | | | - | | |
| 0,20 | 23,10 | 3,30 | 30,30 | Total | 28,9 | 30,30 | 3,30 | 21,30 | 0,20 |
| (margin) 23,30 + 2,30 = 26,00 | | (margin) 34,00 + 2,00 = 36,00 | | | | (margin) 34,00 + 2,00 = 36,00 | | (margin) 21,50 + 2,10 = 24,00 | |

(4) Kyungwon Line (Chungyangri— Sungbuk)

| Down bound | | Stations | Up bound | | |
|---|---|---|---|---|---|
| Local | | | Distance | Local | |
| Stopping time | Running time | | | Running time | Stopping time |
| (0.20) | | Chungyangri | km | | — |
| | 2.50 | | 2.6 | 2.50 | |
| 0.20 | | ( ) | | | 0.20 |
| | 1.40 | | 1.1 | 1.40 | |
| 0.20 | | ( ) | | | 0.20 |
| | 2.20 | | 1.9 | 2.10 | |
| - | | Sungbuk | | | |
| 0.40 | 6.50 | Total | 5.6 | 6.40 | 0.40 |
| (margin) 7.30 + 1.30 = 9.00 | | | | (margin) 7.20 + 1.40 = 9.00 | |

5-2 Preconditions of Electrification Plan

Train formation and operating headways during the rush hours as a precondition to the planning of electric traction facilities have been set as follows with reference to the previously mentioned operating plan.

| Line | Section | Route length | Train formation | Operating headway during the rush hours |
|---|---|---|---|---|
| Kyungin Line | Seoul— Yungdeungpo | 9.2 km | 10 cars | 2-1/2 min. |
| Kyungin Line | Yungdeungpo—Inchum | 29.7 | 10 | 5 min. |
| Kyungbu Line | Yungdeungpo— Suwon | 32.3 | 10 | 5 |
| Kyungwon Line | Chungyangri — Sungbuk | 5.6 | 10 | 5 |

However, it is advisable to postpone the installation of facilities which may be added in the future without requiring major modification and to limit the facilities to those which are essential for the initial operation. In the case of substations and car shed, for example, a land space should be secured at first so that facilities may be added later.

For the facilities in the section between Seoul and Suwon, consideration must be given to the arrangement so that considerable alterations may be avoided at time of trunk-line electrification to the south in the future.

## 5-3 Feeder System and Voltage Drop in Overhead Equipment

Since the Korean National Railroads has adopted the 60 Hz single-phase 25 KV AC system for the electrification of its Chungan Line, it is proposed to adopt the same system on the current electrification project.

It is also recommended in Section 4-2 that the electric traction system be the same for the subway, where the trains run through to and from the lines of the National Railroads.

### 5-3-1 Feeder system

The auto-transformer feeder system, which was adopted by the Japanese National Railways after an extensive research and experiment and is now being installed for the New Sanyo Line, has many advantages over many of the past systems. This system, therefore, has been adopted for the current project (Chart 5-3-1).

### 5-3-2 Voltage drop in overhead equipment

When this feeder system is adopted, the impedance of the circuit depends on such factors as the earth conductivity, its variation being small ranging from 0.215 to 0.239 Ω/km.

The voltage drops of the circuit calculated for the operating headway and train load simplified with the use of the previously mentioned operating conditions and schedule speed of train are shown in Chart 5-3-2.

That is, at 27.5 KV no-load feeding voltage at the substation and 20 KV minimum allowable voltage at the load end, the possible feeding distance with the operating headway of 2-1/2 min. is about 20 to 30 km and that with the operating headway of 5 min. is about 40 to 50 km.

Compared with the past booster transformer system, the auto-transformer system can extend the feeding distance considerably. This may be clear when the facts that the voltage of the circuit in this system is essentially in-

Fig. 5-3-1 Power Receiving, Feeding and Distribution System of Seoul Suburb Electrification

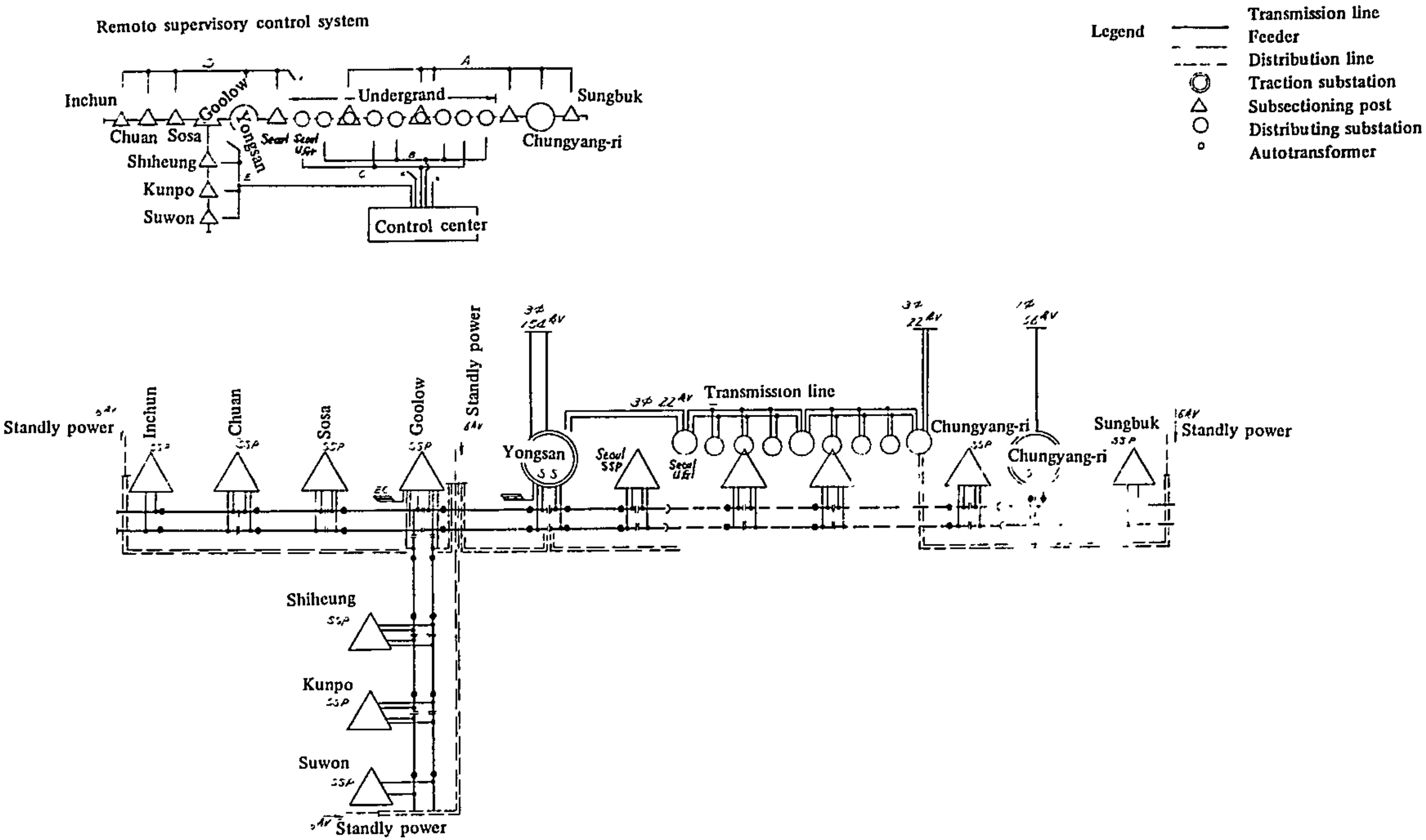
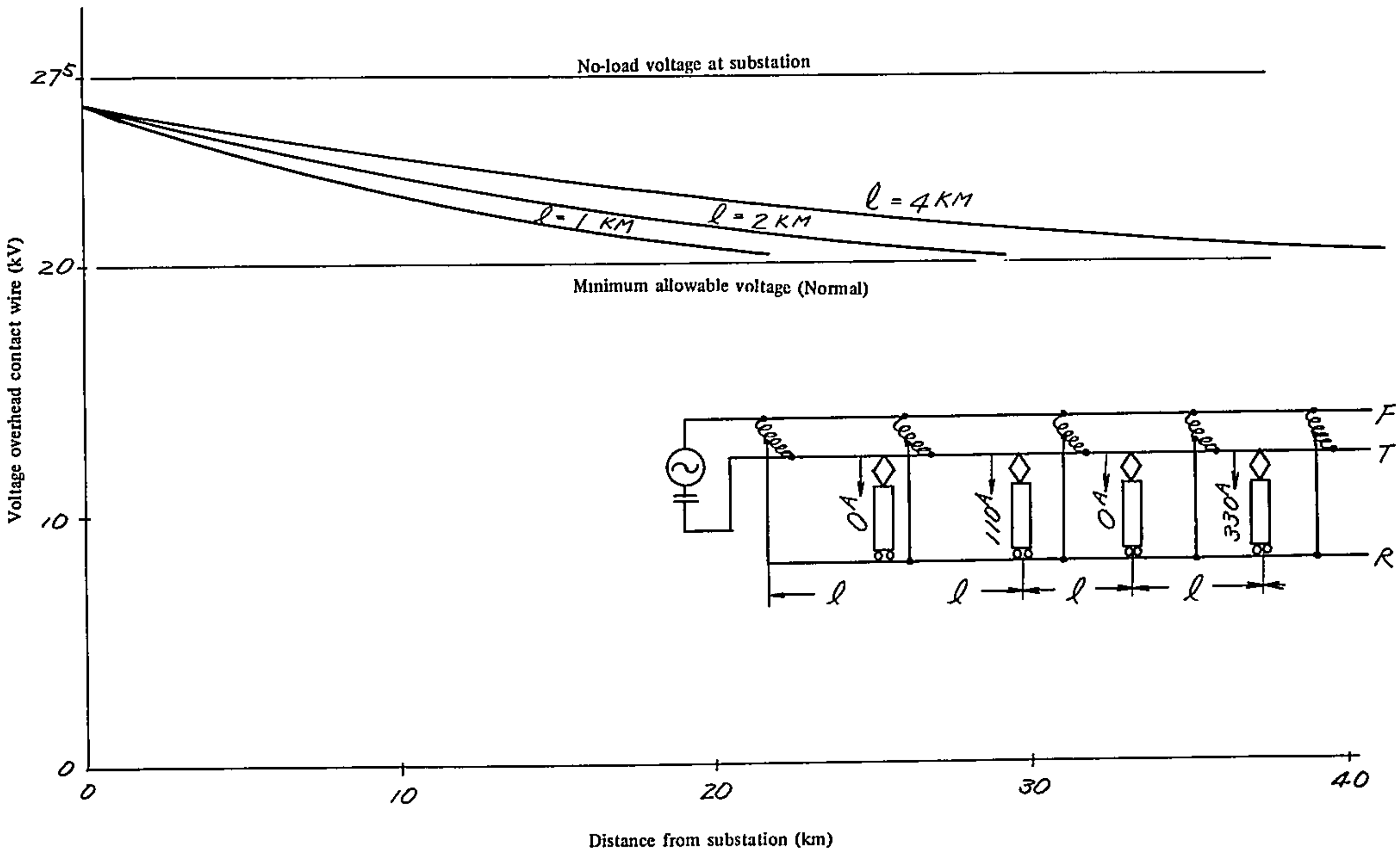


Fig. 5-3-2 Calculated Voltage at Overhead Contact Wire



creased to two-folds is taken into consideration Chart 5-3-1 shows an outline of the feeder system.

## 5-4 Train Load and Capacity of Substation

One-hour maximum demand during the rush hours estimated for each of the sections under the electrification project is shown in Chart 5-4-1.

In this chart, figures not parenthesized represent the value for 1981 carried by Table 5-1-3 and those parenthesized represent the value for the initial operation.

### 5-4-1 Location of substations

When the auto-transformer system is adopted, only one substation provided at the center of loads will be sufficient. In this case, the substation is required to be of the absolutely no power stoppage type. In view of the present power supply situation and the state of power transmission network in Korea and also in consideration of the future expansion program, it was considered advisable to provide a traction substation of the National Railroads in Yongsan.

In view of the importance of the underground section, it is advisable to provide the other traction substation for emergency use around Chungyangri.

As a counter proposal, the use of Tonong substation to be constructed at time of electrification of Chungang Line is conceivable. However, the feeder system to be adopted is different from that under the current project and therefore, the method which will be described later (Refer to Section 5-5-3) is recommended.

### 5-4-2 Capacity of substation

The initial capacity of the Yongsan substation is to be 20 MVA x 2. Although the actual load in one peak hour is only about 20 MVA, installation of a standby unit is indespensable for substation of this nature. It is also advisable to secure land space for additional installation of units up to 60 MVA in capacity in the future. The capacity of the transformer to be installed at Chungyangri will be 10 MVA, because of its use being limited in emergencies.

When the frequency of train operation increases and the electrification sections expand in the future, it will be necessary to provide a full-fledged substation in this neighborhood.

A substation will also be needed along the Kyungbu Line. In such a case, however, it will be appropriate to provide a traction substation in the neighborhood of Cheonan, with a sectioning post at Goolow, in conjunction with the extension of trunk-line electrification.

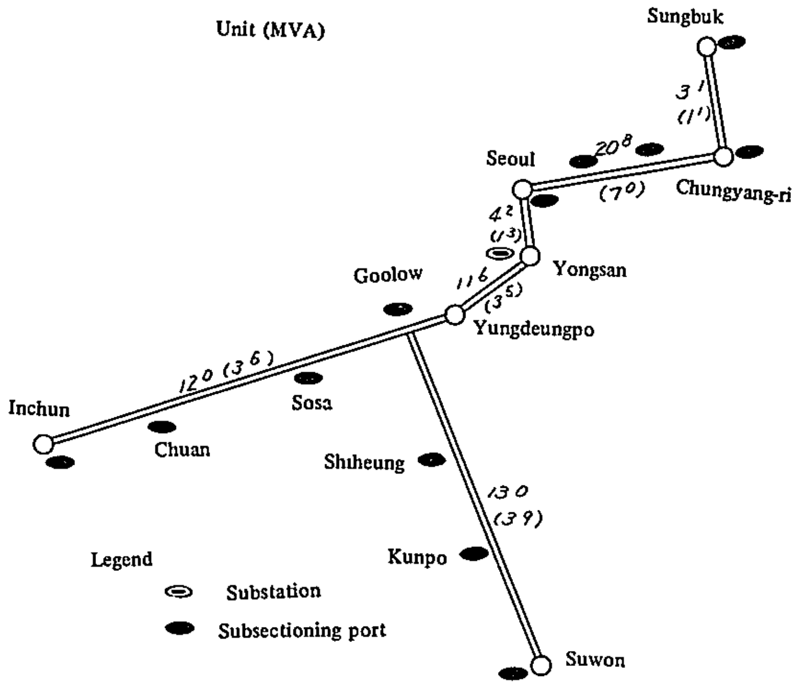
## 5-5 Power Receiving Transmission Lines and Substation Facilities

On the basis of the above-mentioned basic requirements, the following facilities are to be provided.

### 5-5-1 Yongsan Substation

Power is to be received from Yongsan Substation of the Korea Electric Company by two exclusive circuits of 154 KV overhead transmission

Fig. 5-4-1 Train Load by Section



lines (one circuit for spare purpose to be provided by the Korea Electric Company).

Major equipment at the substation are to be as follows (See Charts 5-5-1 and 5-5-2):

| | |
|---|---|
| AC circuit breaker for receiving | 2 sets |
| 2/3-phase transformer (20 MVA) | 2 sets |
| AC circuit breaker for feeder | 4 sets |
| Auto-transformer | 4 sets |
| Step-down transformer 154 → 22 KV | 1 set |
| High-tension distributing facilities | 1 set |

5-5-2 Sub-sectioning posts

Sub-sectioning posts are to be provided in the following locations for localizing power stoppages for maintenance and for isolating the faulty section in an emergency.

| | |
|---|---|
| Kyungwon Line: | Sungbuk, Chungyangri |
| Subway Line: | 2 places |
| Kyungin Line: | Seoul, Goolow, Sosa, Chuan, Inchun |
| Kyungbu Line: | Shiheung, Kunpo, Suwon |

The standard equipment of the sub-sectioning post are to be as follows: (See Chart 5-5-3).

| | |
|---|---|
| AC circuit breaker | 3 sets |
| Auto-transformer | 2 sets |

Facilities located at the ends of electrified section, at Goolow and at the car shed are to have special wiring connections.

High-tension distribution facilities are to be provided in about 1/3 of the sub-sectioning posts for receiving power from the Korea Electric Company.

5-5-3 Emergency substation

For the emergency substation described in Section 5-4-1, the following equipment is to be provided for the time being.

The Chungyangri sub-sectioning post is to have the following equipment:

| | |
|---|---|
| Transformer for feeder (10 MVA) | 1 set |
| AC circuit breaker for feeder | 2 sets |

This substation is to receive power from the Wangshimni Substation of the Korea Electric Company with one exclusive circuit of transmission line (To be provided by the Korea Electric Company).

Fig. 5-5-1 Connection Diagram of Yongsan Substation

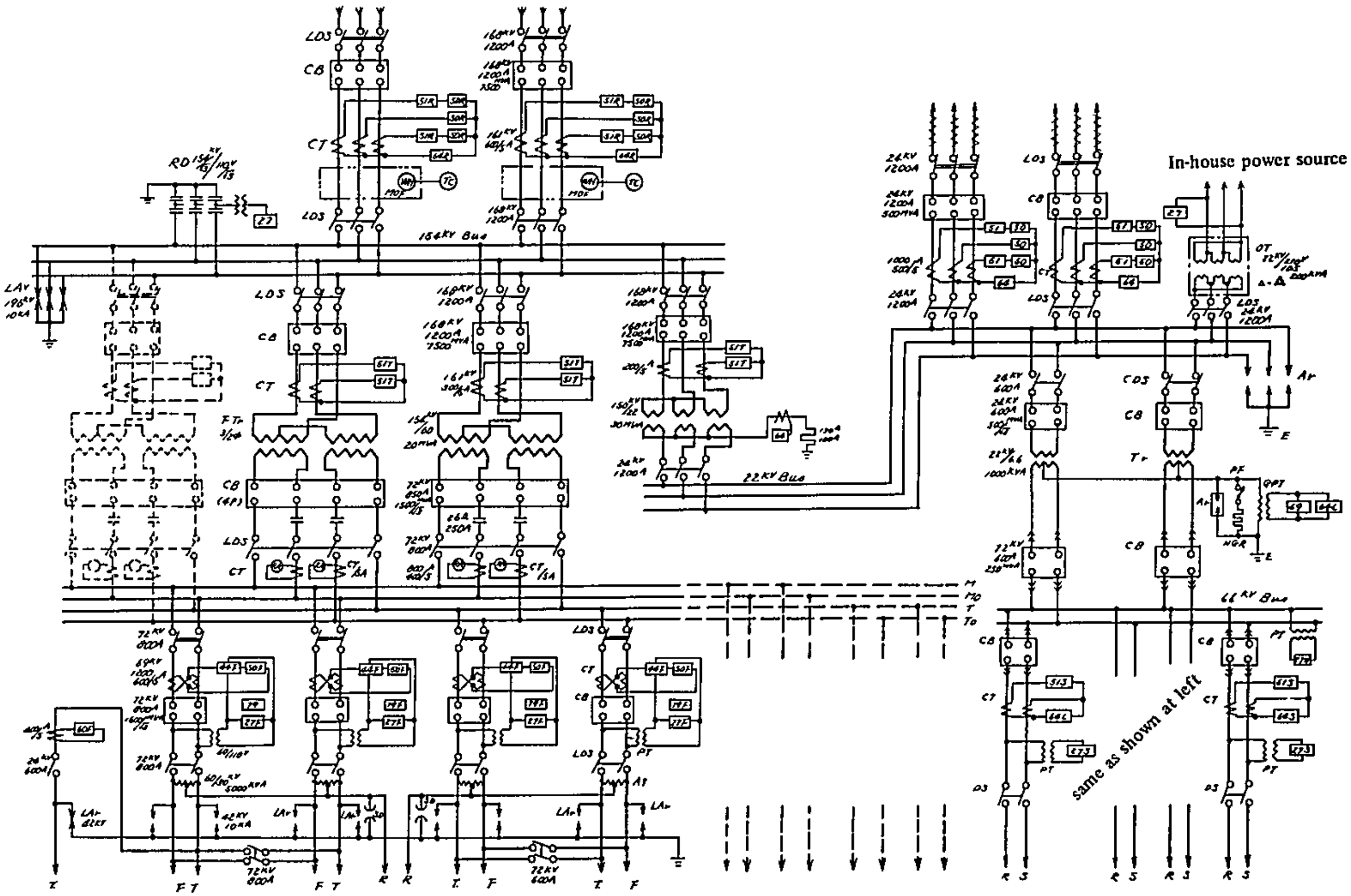
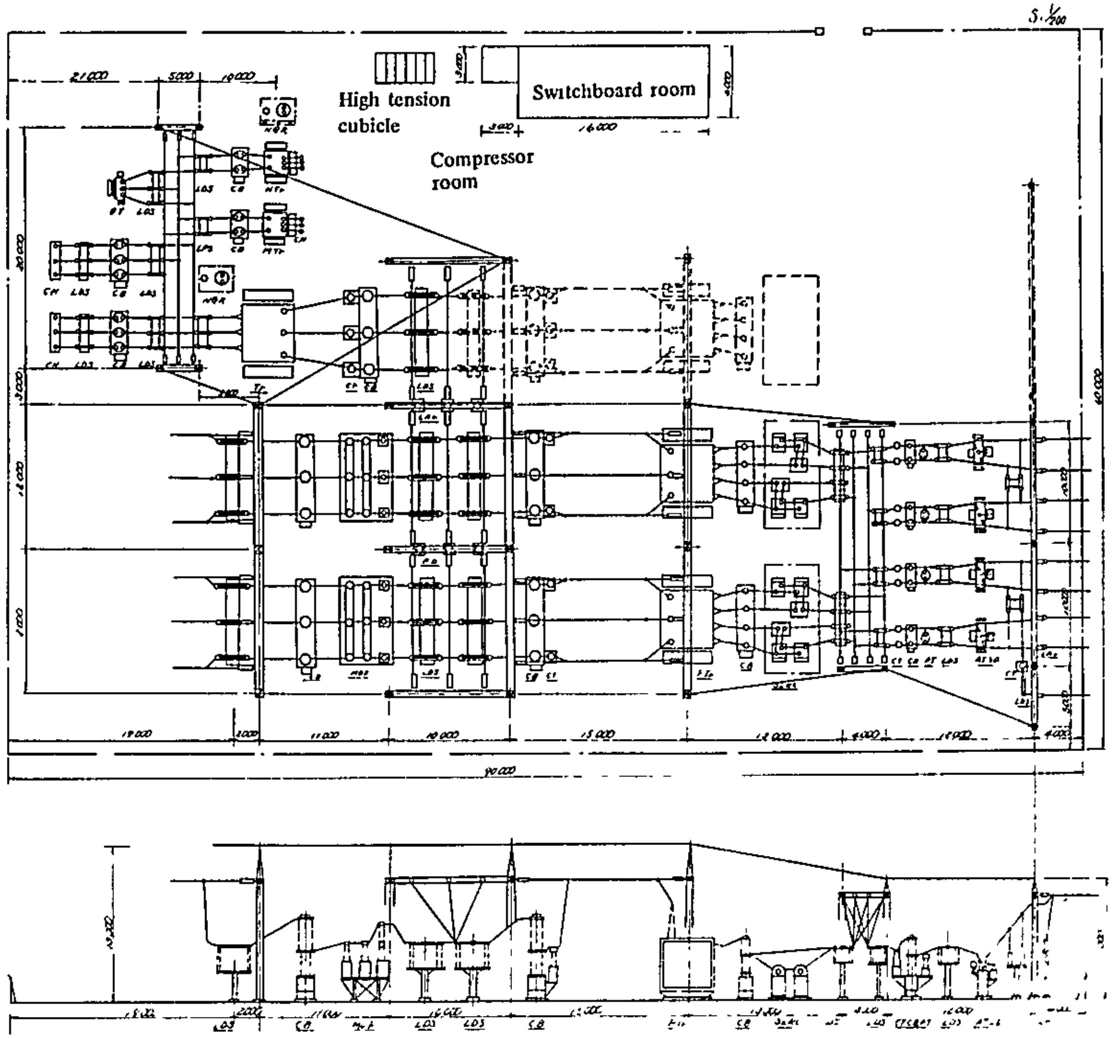
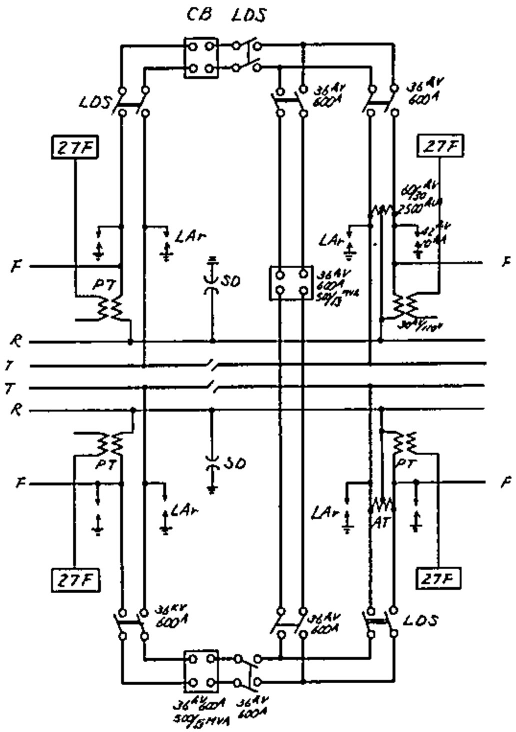


Fig. 5-5-2 Yongsan Substation Equipment Arrangement Plan



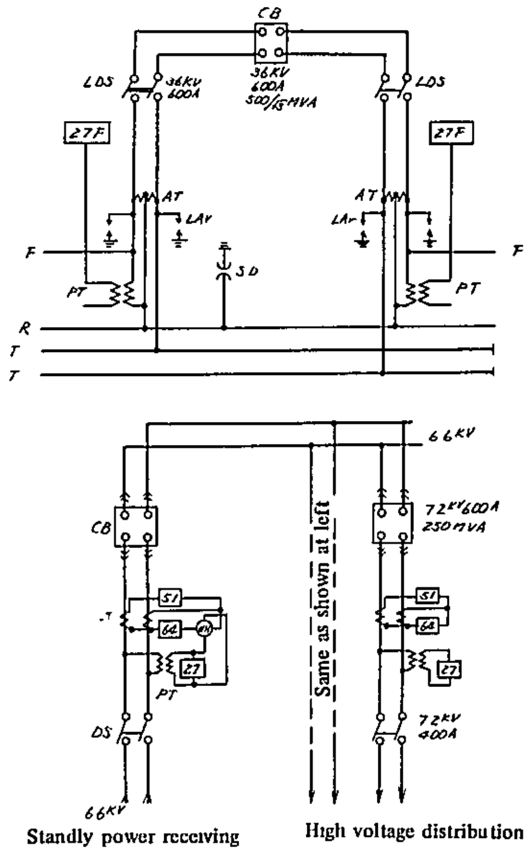
## Fig. 5-5-3 Connection Diagram of Sub-sectioning Posts

S.S.P. (Type A)




S.S.P. (Type C)

(End of feeder) circuit



5-5-4 Power control center

All equipment in these substations and sub-sectioning posts (tunnel sections included) are to be supervised and controled from the power control center through remote supervisory and control system.

It is convenient to have the power control center in the same location as the train dispatcher center. The feeder circuit is to be equipped with a fault locating device.

## 5-6 Overhead Equipment and High Voltage Distribution Lines

Wind-pressure load and the range of the temperature as the basis of the design are to be in accordance with the Korean National Rialroads standards.

### 5-6-1 Overhead equipment

Main components of the overhead equipment are to be the following.

Concrete pole (Steel pole in part)
Flexible bracket
Feeder (Al) 95 $mm^2$
Contact wire (Cu) 110 $mm^2$
Messenger cable (St) 90 $mm^2$
Protective cable (ACSR) 40 $mm^2$

Overhead contact wire is to be suspended by the simple catenary method and equipped with an automatic tensioning device (See Charts 5-6-1 and 5-6-2).

For Kyungbu Line which is said to be contemplating operation of trains at a speed of 130 km/h in the future, the high-tension heavy catenary system, which has been developed by the Japanese National Railways recently, is to be adopted.

In front of Yongsan substation, phase-break section is to be provided. For the sections along Kyungin Line where the salt contamination is likely to occur, it is necessary to strengthen insulators.

Installation of overhead equipment is to be limited to the range required for the operation of electric m.u. trains and the erection of supporting structures is to be planned for the main tracks between Seoul and Goolow and for the station yards so that little alternations may be needed at time of complete electrification in the future (See Chart 5-6-3).

### 5-6-2 High tension distribution lines

The existing high tension distribution lines are only remodeled when they hinder the electrification works.

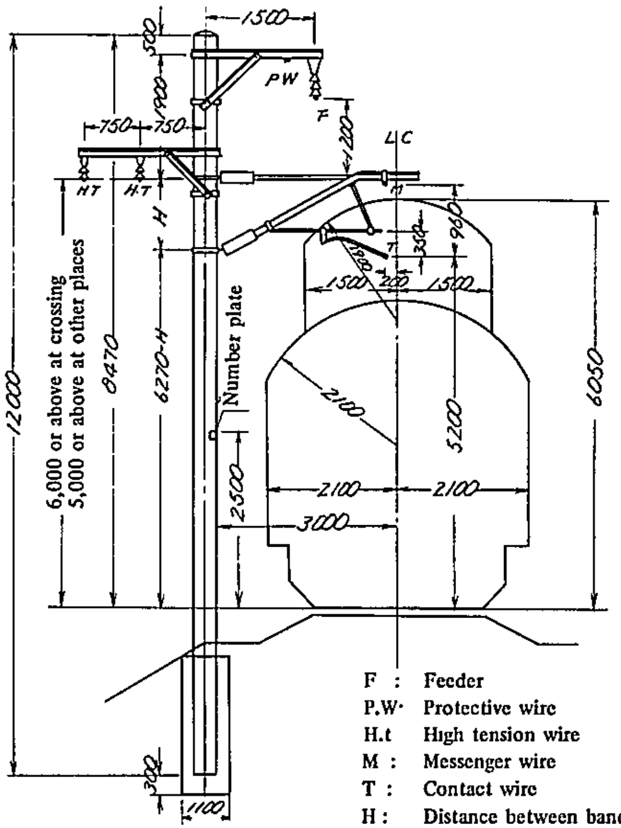
For the electrified sections, high tension distribution lines for signal are to be installed newly or added to form two circuits.

| | |
|---|---|
| Working voltage | 6.6 KV |
| Type of cable | 22 $mm^2$ x 2 |
| Supporting structures | Jointly suspended overhead equipment |
| Oil switchgear | At each station |

Fig. 5-6-1 Standard Structure of Overhead Contact Line

25 KV A.C. A.T. feeding system

Between stations – Straight line (Unit: mm)

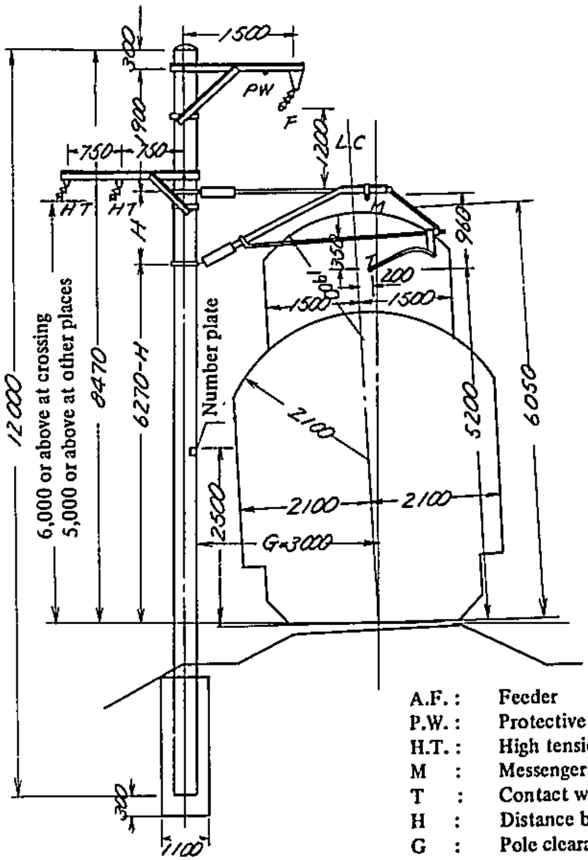


F : Feeder
P.W: Protective wire
H.t : High tension wire
M : Messenger wire
T : Contact wire
H : Distance between bands

Fig. 5-6-2 Standard Structure of Overhead Contact Line

25 KV A.C. A.T. feeding system

Between stations (Curve) (Unit : mm)

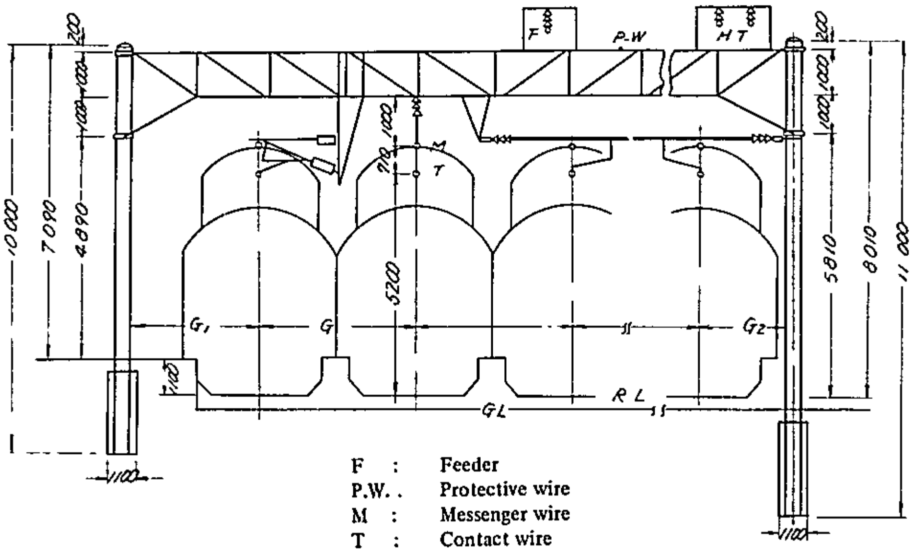


A.F. : Feeder
P.W. : Protective wire
H.T. : High tension wire
M : Messenger wire
T : Contact wire
H : Distance between bands
G : Pole clearance

## Fig. 5-6-3 Standard Structure of Overhead Contact Line

25 KV A.C. A.T. feeding system

In station




F : Feeder
P.W. . Protective wire
M : Messenger wire
T : Contact wire
G : Distance between track centers
$G_1,G_2$: Pole clearance
H.T. : High tension wire

## 5-7 Signal and Safety System

Efforts are to be made for the increase of the capacity of the line and for the promotion of the efficiency of the safety system by adopting modern equipment following the electrification of the line.

### 5-7-1 Automatic signal system and relay interlocking device

For the existing automatic block sections, additional block signals are to be provided. Sections between Yungdeungpo and Inchun on Kyungin Line and between Chungyangri and Sungbuk on Kyungwon Line are to be provided with automatic block system. Relay interlocking devices at Seoul, Yongsan, Yungdeungpo, Shiheung and Chungyangri stations are to be modified in part following the alternation of track layout in the station yards.

For other existing stations, the first class interlocking devices are to be newly provided. Along with this change, the main switches in the station yard are to be converted to power switches.

Signals are to be of the multi-color light, 3-5 aspect system.

Track circuit system for large stations is to be of the centralized frequency divider system. The main tracks are to be of the double rail system and the sidings are to be of the single rail system.

For sections between stations, frequency divider system of the double rail is to be adopted.

To cope with the increase in the operating frequency, ATS is to be provided for all home and starting signals in the station as well as block signals. The type is to be ATS-S in conformity with the existing system.

### 5-7-2 Electrification related facilities

Track circuits at the crossing are to be improved to employ ground inductor system. Impedance bonds and welded bonds are to be newly provided.

Also in conjunction with this improvement, it is hoped that efforts be made to replace the existing rails with long rails before electrification of the lines while paying attention to the location of track circuits.

### 5-7-3 Centralized traffic control system

In order to provide a constant and accurate supervision over the operation of trains, the centralized traffic control system is to be employed for the entire section of electrification. Display panel and control panel of the system are to be located in the train dispatcher center.

## 5-8 Communication and Public Address System

### 5-8-1 Electrification related facilities

Such circuits as the substation remote control circuit, power dispatcher circuit, and TB circuit for maintenance of electric traction facilities are to be additionally provided.

As a means to prevent inductive interference resulting from AC electrification, the bare conductors of railway telecommunication are to be made to a polyethylene insulated alumina-sheathed tape-armored cable and laid underground along the track. Determination of the number of core wires whould be made appropriately by giving due consideration to the future increase in traffic. For improvements of the lead-covered cables in the section between Seoul and Yungdeungpo and in the vicinity of Inchun, measures should be made by taking into account the shielding effects afforded by such factors as multi-tracks, elevated structures and urban districts.

Improvements are to be made to the communication lines which belong to other establishments. Since the scope of alternation varies greatly depending on the value of earth conductivity, it is advised that the value of earth conductivity be measured at the earliest opportunity.

The Japanese National Railways is utilizing Neutral coils for its subscriber circuits of automatic exchange in an effort to reduce the cost required for countermeasures.

5-8-2 Improvements of other facilities

In relation to the establishment of new stations and the increase in the number of passengers, additional subscriber circuits are to be provided. Also, to meet the increase of telephone subscribers, the switchboards at Yungdeungpo, Bupyung, Inchun and Suwon are to be replaced by the cross-bar type or the capacity of the existing automatic switchboard is to be boosted.

Loud speaker public address systems and interphones are to be provided at major stations.

5-8-3 Train radio communication system

A study should be initiated to determine the feasibility of providing trains with a radio communication system and of joint use of the system by the National Railroads and subways.

Telephone system for train dispatchers is to be replaced by a more efficient system.

5-9 Civil Works and Structures

In relation to the electrification of the line, the following requirements must be taken into consideration. Construction of car sheds and improvements of the railway workshop will be discussed in Chapter 6.

5-9-1 Construction of stations

Along with the electrification of lines, six stations are to be newly constructed on Kyungin Line, five stations on Kyungbu Line and two stations on Kyungwon Line.

These stations are not to be equipped with switches in principle. The existing stations are to be provided with new ticket gates which enable passengers to access directly from back side of the railway compounds.

The platform is to be elevated for the length of about 230 m to correspond to the train length.

An overbridge or an underpass for passengers' use is to be provided at the station where necessary.

Grade separation of crossing is to be planned separately and not included in this project.

5-9-2 Train detention tracks

Train detention plans for 31 trains (each formed by 6 cars) for the initial operation are shown in the following table.

Table 5-9-1 Train Detention Plan

| Station | Number of trains |
|---|---|
| Inchun | 4 |
| Bupyung | 6 |
| Bukok | 5 |
| Seoul | 3 |
| Chungyangri (Underground) | 2 |
| Sungbuk | 5 |
| Car shed | 6 |
| Total | 31 |

Except for the track totaling 900 m to be provided newly at Bukok for 4 trains and additional tracks to be provided at the car shed, all the detention points are to use the existing tracks.

5-9-3 Alternation of track layout

One additional lead track for turn-back operation of trains is to be provided at Yungdeungpo between the up and down tracks of Kyungin Line.

As the stations are provided under the ground at Seoul and Chungyangri, lines are to be branched off at the entrance of both stations on Kyungin Line and Kyungwon Line.

Tracks are to be modified so as to allow electric m.u. trains to proceed to the tracks of Kyungin Line at level between the junction of Kyungbu Line and Kyungin Line and Yungdeungpo.

However, when the operating headway on both lines shortens to about 5 minutes in the future, crossing of trains on both lines at level will be difficult and such improvement plan as the grade separation at Yungdeungpo will have to be considered.

5-10 Required Construction Cost and Construction Period

Estimated construction cost required by the time of completion of the project is shown in Table 5-10-1. This estimate, however, does not include the cost of additional facilities (Additional installation of main equipment at the substation, construction of additional detention tracks, etc. resulting from increase after inauguration).

Since the detailed engineering and test operation of electric traction system involve such up-to-date technologies as AT feeder system, high-tension heavy catenary system, rigid suspension system and frequency divider system, it is considered appropriate to adopt the technology of Japan that has a wide experience in these fields.

Table 5-10-1 Estimated Cost for Electrification of the National Railroads

(In million won)

| | Kyungin Line | Kyungbu Line | Kyungwon Line | Total Cost for N. R. |
|---|---|---|---|---|
| Total | 3,570 | 1,977 | 724 | 6,271 |
| Transmission line | - | - | - | - |
| Substation | 1,074 | 180 | 128 | 1,382 |
| Overhead equipment | 405 | 353 | 93 | 851 |
| Lighting & utility | 90 | 34 | 13 | 137 |
| Signal & safety | 1,200 | 450 | 340 | 1,990 |
| Telecommunication | 490 | 540 | 50 | 1,080 |
| Related civil works | 311 | 420 | 100 | 831 |

In consideration of the followings, the construction period including the time required for tests after completion of the work is estimated to be approximately 3 years.

(1) Many works have to be accomplished in the area close to the existing tracks.

(2) Complicated change-over works such as the change in signal and safety systems have to be accomplished.

(3) Diversified works have to be accomplished simultaneously.

(4) Experiences are not deemed sufficient to such types of work.

(5) Fabrication and erection of equipments must be given careful attention to ensure dependability of facilities.

It is considered possible, however, to work out a construction schedule which enables the selection of a section where work may be progressed comparatively easily and the completion of that section about half an year a head of other sections to provide a place for on-the-job training on operation of train and maintenance.

## 5-11 Forecast of Revenue and Expenditure upon Completion of Electrification of Lines

### 5-11-1 Capital investment plan

As shown in Table 5-11-1, the capital investment required by the time of the completion of the electrification program is estimated at 13,010 million ₩ which may be broken down into 6,270 million ₩ for ground facilities, 5,040 million ₩ for 126 electric cars, and 1,700 million ₩ for workshop and car shed. An additional investment of 10,670 million ₩, including 9,390 million ₩ for 244 electric cars and enlargement of facilities at workshop, car shed and substations will also be required by 1981 after inauguration.

5-11-2 Revenue and expenditure and redemption plan

Forecast of revenue and expenditure and redemption plan up to 1981 upon completion of electrification of the Korean National Railroads are shown in Table 5-11-2. Calculation method used for this estimate is almost identical to that used in Section 4-9, except the following points.

(1) Revenue

In the calculation of the passenger revenue, new fare rates were adopted in consideration of the change in the fare system as described in Section 8-3. For the revenue from the transportation of passengers and miscellaneous transport revenues, only the increased portion of revenue as a result of electrification is taken into consideration.

Receipt from subways includes charges for energy conversion and supply from the National Railroads Yongsan substation to the subways, cost of repair and maintenance of subway cars and the rent of car shed.

(2) Expenditure

Operating expenses shown includes only the increased portion as a result of electrification of the line. However, the management expense and operating expenses were considered to be offset by rationalization of the business structure as a result of the electrification.

As it is evident from the table, the business in the initial year of operation will have a deficit of about 270 million ₩ before depreciation and about 780 million ₩ after depreciation, but thereafter, the profit will increase sharply and the cumulative deficits before depreciation will disappear in the third year of operation. In the fifth year, the cumulative deficits after depreciation will completely disappear. In 1981, the last year of the revenue and expenditure planning period, the business is expected to show a cumulative profit amounting to about 3,870 million ₩ after depreciation.

(3) Loans

Required loans during the construction period from 1971 to 1973 are estimated at about 13,990 million ₩ including interest amounting to 980 million ₩. As the additional borrowings required for the redemption of debt and for the subsequent investment during a period from 1974, the initial year of operation, to 1981 are expected to amount to 8,390 million ₩, the total borrowings are expected to reach 22,380 million ₩ at the final stage.

As the redemption of debt during the same period is expected to amount to 5,980 million ₩, the balance of borrowings at the end of 1981 will be about 16,400 million ₩.

The conditions set for the loan are a 7% interest rate and redemption of principal equally divided over 20 years with 3 year deferment.

Table 5–11–1

Construction Schedule for Electrification of the Korean National Railroads and Requirement for Construction Fund

(In million ₩)

| Items | Year | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground facilities | Schedule | — | — | — | | | | — | | | | | |
| | Fund | 700 | 3,700 | 1,871 | | | | 166 | | | | | 6,437 |
| Electric Railcars | Number of railcars | | | 126 | 54 | 60 | 20 | 30 | 30 | 20 | 30 | | (370cars) |
| | Fund | | | 5,040 | 2,160 | 1,800 | 900 | 1,230 | 1,350 | 780 | 1,170 | | 14,430 |
| Workshop and car shed | Schedule | — | — | — | | — | | | | — | | | |
| | Fund | 250 | 1,150 | 300 | | 800 | | | | 314 | | | 2,814 |
| Total | | 950 | 4,850 | 7,211 | 2,160 | 2,600 | 900 | 1,396 | 1,350 | 1,094 | 1,170 | | 23,681 |
| Remrks | Escalation of prices and wages are not taken into consideration. | | | | | | | | | | | | |

Table 5–11–2

## Revenue and Expenditure upon Completion of Electrification of the Korea National Railroads and Redemption Plan

(In million ₩)

| Description | | Year | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Result of transport business | | Average number of passengers transported daily (person) | 228,716 | 329,165 | 429,614 | 479,367 | 529,120 | 578,878 | 628,626 | 678,380 | The debt at the bigining of 1974 amounts to 13,989 million ₩. |
| | | Total number of passengers transported annually (1,000) | 83,481 | 120,145 | 156,809 | 174,969 | 193,129 | 211,289 | 229,448 | 247,609 | |
| | | Average fare per person (₩) | 17.14 | 18.17 | 18.72 | 19.19 | 19.58 | 19.90 | 20.17 | 20.41 | |
| Revenue | | Revenue from transportation of passengers | 1,431 | 2,188 | 2,935 | 3,358 | 3,781 | 4,204 | 4,627 | 5,053 | |
| | | Miscellaneous incomes from transport business | 97 | 148 | 200 | 228 | 257 | 286 | 315 | 344 | |
| | | Revenue from Subway | 207 | 252 | 297 | 342 | 387 | 482 | 477 | 522 | |
| | | Total | 1,735 | 2,588 | 3,432 | 3,928 | 4,425 | 4,922 | 5,419 | 5,919 | |
| Expenditure | | Operating expenses | 947 | 1,127 | 1,307 | 1,487 | 1,666 | 1,875 | 2,025 | 2,207 | |
| | | Personnel expenses | 398 | 429 | 465 | 501 | 586 | 571 | 607 | 643 | |
| | | Power cost | 104 | 150 | 196 | 242 | 288 | 334 | 380 | 425 | |
| | | Repair & maintenance cost | 450 | 548 | 646 | 744 | 842 | 970 | 1,038 | 1,139 | |
| | | Interest paid | 1,061 | 1,230 | 1,317 | 1,330 | 1,337 | 1,312 | 1,256 | 1,182 | |
| | | Total | 2,008 | 2,357 | 2,624 | 2,817 | 3,003 | 3,187 | 3,281 | 3,339 | |
| Profit and loss | | Pre-depreciation profit & loss | △ 273 | 226 | 808 | 1,111 | 1,422 | 1,735 | 2,138 | 2,580 | |
| | | Cumulative total | △ 273 | △ 47 | 761 | 1,872 | 3,294 | 5,029 | 7,167 | 9,747 | |
| | | Depreciation cost | 511 | 575 | 639 | 703 | 767 | 831 | 895 | 961 | |
| | | Total of expenditures | 2,519 | 2,932 | 3,263 | 3,520 | 3,770 | 4,018 | 4,176 | 4,300 | |
| | | Profit and loss after depreciation | △ 784 | △ 349 | 169 | 408 | 655 | 904 | 1,243 | 1,619 | |
| | | Cumulative total | △ 784 | △ 1,133 | △ 964 | △ 556 | 99 | 1,003 | 2,246 | 3,865 | |
| Balance of capital account | Revenue | Carried over from profit & loss a/c | △ 273 | 226 | 808 | 1,111 | 1,422 | 1,735 | 2,138 | 2,580 | |
| | | Loans payable | 2,482 | 2,678 | 792 | 1,109 | 886 | 356 | 85 | — | |
| | | Transfer of surplus capital | | | | | | | | | |
| | | Total | 2,209 | 2,904 | 1,600 | 2,220 | 2,308 | 2,091 | 2,223 | 2,580 | |
| | Expenditure | Redemption of loans | 49 | 304 | 700 | 824 | 958 | 997 | 1,053 | 1,097 | |
| | | Transfer to construction account | 2,160 | 2,600 | 900 | 1,396 | 1,350 | 1,094 | 1,170 | — | |
| | | Transfer to surplus capital | | | | | | | | 1,483 | |
| | | Total | 2,209 | 2,904 | 1,600 | 2,220 | 2,308 | 2,091 | 2,223 | 2,580 | |
| Balance of debt | | | 16,422 | 18,796 | 18,888 | 19,173 | 19,101 | 18,460 | 17,492 | 16,395 | |

# VI ELECTRIC RAILCARS AND THEIR INSPECTION AND MAINTENANCE

# VI ELECTRIC RAILCARS AND THEIR INSPECTION AND MAINTENANCE

## 6-1 Design Criteria for Electric Railcars

### 6-1-1 Type of electric railcars

For operation at AC 25 KV on No. 1 and 2 lines and at DC 1,500 V on No. 3, 4 and 5 lines, cars serving on respective lines are planned to be equipped with the compatible AC or DC electric system. In designing these two types of cars, maximum efforts were made for standardization of parts. The car body, truck and many equipment with the exception of AC electrical devices were designed for common use by both types to assure equal operating conditions and passengers services on all lines and at once serve for a substantial reduction of maintenance cost and labour.

### 6-1-2 Car dimensions

To cope with the heavy traffic expected on all the proposed lines, cars should preferably have dimensions that allow for the maximum capacity. However, considering the through service on the underground and KNR lines, the car length was set at 19,500 mm which is shorter than the standard value adopted by KNR.

The car width, on the other hand, was set at 3,180 mm in consideration of the platform dimensions of KNR line, and the car height was determined to be 3,800 mm to provide the commuting passengers with good riding comfort (See Fig. 6-1-1).

### 6-1-3 Design capacity and maximum capacity

To increase the capacity, long seat accommodation was adopted with hand traps furnished for standing passengers.

Both types of cars were designed to have the following capacities.

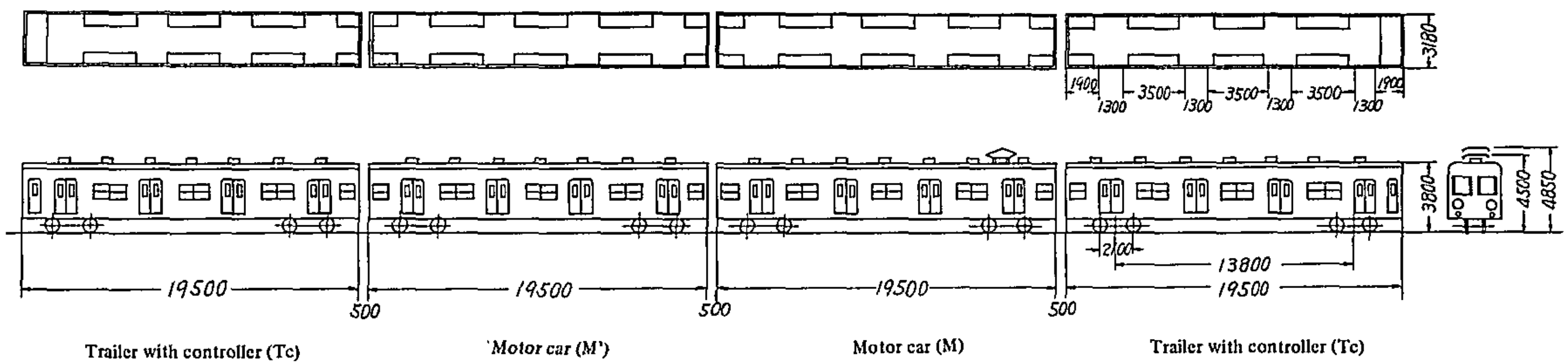
| | |
|---|---|
| Electric motor car: | 54 (seat capacity) + 90 (standing capacity) = 144 |
| Trailer with controller | 48 (seat capacity) + 88 (standing capacity) = 136 |

During rush hours, all cars would be capable of accommodating 250% of their design capacity.

### 6-1-4 Train formation

Since varying numbers of cars (four cars, six cars, eight cars and ten cars) are expected to be coupled to a train according to the transport demand, the four-car train formation consisting of two motor cars and two trailers with controller was adopted as the basis for the train composition. Further, the basic operation unit of motor cars was set at two cars, with one rectifier and one control device provided for the eight motors of each unit.

Fig. 6-1-1 Train Set of A.C. Railcars



Accordingly, the train formation would be as follows:

| | | (Capacity) |
|---|---|---|
| 4 cars to each train | Tc M M' Tc | 560 passengers |
| 6 " | Tc M M M M' Tc | 848 " |
| 8 " | Tc M M' Tc·Tc M M' Tc | 1,120 " |
| 10 " | Tc M M' M M' Tc · Tc M M' Tc | 1,408 " |

Note: Tc = Trailer with controller M M' = Electric motor car

6-1-5 Car performance

Each motor car was designed to be equipped with four 120 KW DC motor so that commuter trains may cover the station spacing of 1 to 3 km within the shortest running time. Rated speed and maximum speed were set at 44 km/h and 110 km/h, respectively. A four-car train would have an acceleration of 2.2 km/h/s and a deceleration of 3.0 km/h/s. With these ratings, it would be possible to cover the Inchun - Seoul section and Seoul - Chungyanri section on No. 1 Line in 50 min. and 18 min., respectively.

6-1-6 Car construction

Light-weight steel construction was adopted for car body, with stainless steel used for outer plates and light alloy sheets for interior panel to dispense with painting work. Car was designed to be constructed with non-combustible materials, and consideration was given to noise absorption and heat insulation. Side doors to be provided at four places on either side were planned to be of the two-leaved type having a parting width of 1,300 mm. Electric heaters would be employed for heating and blowers on the ceiling for ventilation. Since the maximum operating time is expected to be about an hour, installation of toilet was not considered. Truck was designed to be of a simple construction using coil springs and oil dampers for easy maintenance.

6-1-7 Electrical equipment

For use with both AC and DC electric systems, motor, control equipment and other major DC equipment were planned to be of the same type. Parts of electrical equipment were selected with consideration given to the non-combustibility, fault-free operation and easy maintenance. Contactless system was largely to be introduced in the control circuit and auxiliary circuit.

6-2 Main Particulars

| Item | | Unit | AC Cars | DC Cars |
|---|---|---|---|---|
| Gauge | | mm | 1,435 | |
| Electric system | | | AC, 25 KV, 60 Hz | DC, 1500 V |
| Performance of 1 unit of motor cars (2 motor cars) | | | | |
| One-hour ratings | Output | KW | 960 | |
| | Voltage | V | 1,500 | |
| | Current | A | 720 | |
| | Speed (80% F) | km/h | 44 | |
| Tractive effort | ( " ) | kg | 7,980 | |

| Item | Unit | AC Cars | DC Cars |
|---|---|---|---|
| Maximum allowable speed | km/h | 110 | |
| Unloaded weight | | | |
| Electric motor car | t | 45 (average) | 42 (average) |
| Trailer with controller | " | 35 | 35 |
| Car body | | | |
| Length between coupling faces | mm | 20,000 | |
| Maximum length | " | 19,500 | |
| Maximum width | " | 3,180 | |
| Height above rail level | " | 3,800 | |
| Height of folded pantograph | " | 4,500 | 4,150 |
| Distance between center plates | " | 13,800 | |
| Floor height | " | 1,200 | |
| No. of side doors on either side | | 4 | |
| Truck | | | |
| Type | | Swing bolster type bogie truck | |
| Rigid wheel base | " | 2,100 | |
| Wheel diameter (new) | " | 860 | |
| Foundation brake rigging | | Truck rigging type | |
| Power transmission | | Parallel axled cardan drive using hollow shafts | |
| Gear ratio | | 5.60 | |
| Control system and control equipment | | | |
| Control system | | Rheostatic control, series-parallel control, & weak field control | |
| Control equipment | | Motor-driven cam shaft contactor | |
| No. of steps powering | | 28 | |
| braking | | 24 | |
| No. of positions of master controller | | 4 | |
| Voltage of control circuit | V | 100 | |
| Brake | | Dynamic brake, & electro-magnetic straight air brake | |
| Main motor | | | |
| No. per Unit of 2 cars | | 8 | |
| Type | | DC series-wound motor with interpole | |
| One-hour rating (80% F) | | 375 V, 120 KW, 360 A, 1600 pm | |

| Item | Unit | AC Cars | DC Cars |
|---|---|---|---|
| Main transformer | | | |
| Type | | Oil immersed forced, oil/air cooled, shell type transformer | |
| Continuous rating | | Primary - 25 KV, 1150 KVA; Secondary - 1850 V, 1050 KVA; Tertiary - 440 V, 100 KVA | |
| Main rectifier | | | |
| Type | | Oil cooled silicon rectifier, bridge connection | |
| Continuous rating | | 1500 V, 720 A<br>Flat type element (800 2500 V)<br>4S x 1 P x 4A | |
| Motor-generator | | | |
| Type | | Single phase squi-rrel-cage motor; two-phase three-wire generator | Direct-coupled type with regulator |
| Rating | | 20 KVA, AC 220 V (motor), AC 100 V (generator) | 20 KVA, DC 1500 V - AC 100 V |
| Motor-driven air compressor | | | |
| Type | | Reciprocating compressor | Reciprocating compressor |
| Rating | | 2000 lit. capacity 12 KW, 220 V | 2000 lit. capacity 12 KW, 1500 V |
| Motor-driven blower | | For use with main transformer | |
| Auxiliary air compressor | | DC 80 V, 450 W | |

## 6-3 Details of Car Components

### 6-3-1 Car body

With the exception of the motorman's cab, pantograph fitting part and few other portions, body of both motor cars and trailers with controller was designed to have an identical gable construction so as to facilitate its manufacture. Excluding the use of channel steel for the underframe side sill and buffer beam as well as for the center sill for coupler installation, car body was designed to have a totally welded construction using pressed steel sheets so as to reduce its tare. End framing, side framing and roof framing are to be assembled after separately fabricating them in advance.

The mission did not employ aluminum materials because they incur a higher cost and more maintenance work, though they are used to build car bodies of light weight construction in recent years. Application of stainless steel for outer plates and light alloy sheets for interior panels was intended to eliminate the need for painting.

Passageways connecting cars, even through motorman's cabs, were planned to be provided with an overall hood and apron to allow the passengers to take refugee in case of emergency.

Tight lock couplers, adopted for good riding comfort, were designed to be engaged or released in time with air pipe couplings and electric couplings by the control action in the motorman's cabin.

Two-leaved side doors having a parting width of 1,300 mm are to be simultaneously opened or closed when the conductor turns on the pertinent switch. Side windows were designed to be of the vertical two-leaved unit type, with the opening of the lower leaf limited to 75 mm.

Long seat adopted for all cars was planned to have a cushion height of 430 mm and a depth of 550 mm to assure good riding comfort.

Interior facilities were planned to include hand straps and luggage racks. It was intended that the ventilator would have a large draft capacity and could be switched over from forced draft to suction and vice versa, and that it would be used for suction in winter. Immediately below the ventilator would be installed the semi-flush type blower. 15 to 16 fluorescent lamps for interior illumination would be arranged in-two rows, and speakers for announcement broadcasting would also be installed.

6-3-2 Truck

To ensure satisfactory riding comfort and easy inspection and maintenance, the truck was designed to be supported by coil springs and have cylindrical roller bearings and solid wheels. Electromagnetic straight air braking system employed is planned to incorporate truck rigging brakes for motor cars and disc brakes for trailer cars with controller. Driving system was planned to be of the double axled parallel Cardan drive type using hollow shaft, with motors mounted on the axle spring.

Truck frame was designed to be H-shaped with no end beam, with its side sill and cross beam planned to have welding construction. Swing bolster was also designed to be welded. Weight of car body is to be sustained at three places by the center plates and side bearing. Axle spring was planned to be a wing type spring using rubber cushion, and combined use of oil damper and coil spring was planned for swing bolster spring. Brake cylinder is to be fitted to cross beam. Helical gear was so arranged that the gear wheel is press fitted to that axle and the pinion of special steel supported by the roller bearing.

6-3-3 Electrical equipment of AC motor car

Control system employed for AC cars involves the rheostatic and series-parallel control after rectification from AC to DC. Rectifier system AC cars is in wide use the world over since it permits the use of highly efficient DC motors. Although tap or phase control system is practicable for voltage regulation, the rheostatic and series-parallel control systems were employed to assure the common use of parts by AC cars and DC cars for one thing, and to utilize the powering rheostat for the dynamic braking that facilitates the control of power running for another.

Phase control by means of thyrister is also in actual use at present, but the mission did not consider it practicable because of the higher cost it would incur and the possible development of higher harmonics which leads to heavier inductive disturbance. Therefore, regenerative brake resorting to this method was not employed.

Main motor was designed to be workable up to 40% weak field because of the wide range of expected speed variation, and its rating was set at a 80% field.

It is assumed that weak field operation would be employed in a large measure when the train runs between stations spaced at a long interval.

Insulation was planned to be class F(armature) and class H(field).

Main control equipment was designed to be of the motor-driven cam shaft type having a simple construction that demands the least maintenance work, and efforts were made to incorporate as many contactless parts as possible in the control circuit. Since acceleration was set at 2.2 km/h/sec., number of steps for powering control need not be so many. Control steps of dynamic braking, however, were set at 24 since it must be applied from the high operating speed.

Main rehostat was designed to be of the natural ventialtion type to eliminate noise.

Current collector was designed to be of the spring lift type to provide the rigid overhead wiring with sufficient follow-after disposition.

Auxiliary equipment required are the motor-generator (2 phase 3 wire type on output side), motor-driven air compressor, etc. which are supplied with power from the transformer tertiary winding (See Figs. 6-3-1 & 6-3-2).

6-3-4 Electrical equipment of DC motor car

As described in the preceding paragraph, most electrical equipment of of AC cars can be used in common by DC cars. Control equipment can be used in common by effecting only a partial modification to the low-tension circuit. Main circuit breaker was planned to be combined with high speed current reducer to display a high efficiency. Main circuit was designed to be identical to that of ordinary DC cars, and master controller was designed to have four positions involving series control, series-parallel control, parallel control, and weak field control.

Generator of the motor-generator was planned to be of the two phase three wire system with its rating at AC 100 V, 60 Hz.

## 6-4 Cost of Railcars

It was assumed that the cost of an AC and DC four-car train comprising two motor cars and two trailers with controller would be as follows:

AC Train: ₩150,000,000.-

DC Train: ₩132,000,000.-

## 6-5 Car Inspection and Repair, and Car Depot

Fig. 6-3-1 Characteristic of Traction Motor

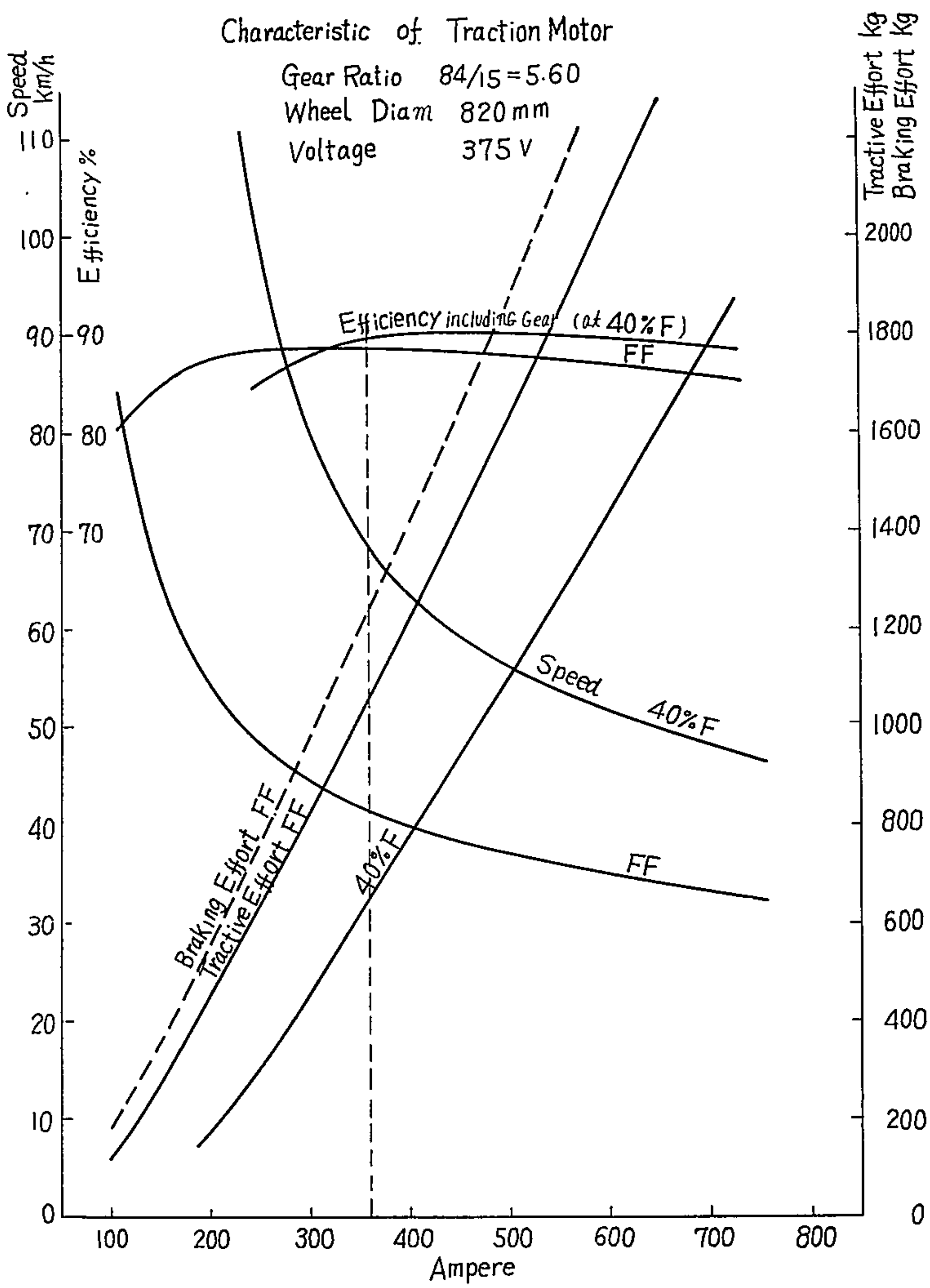
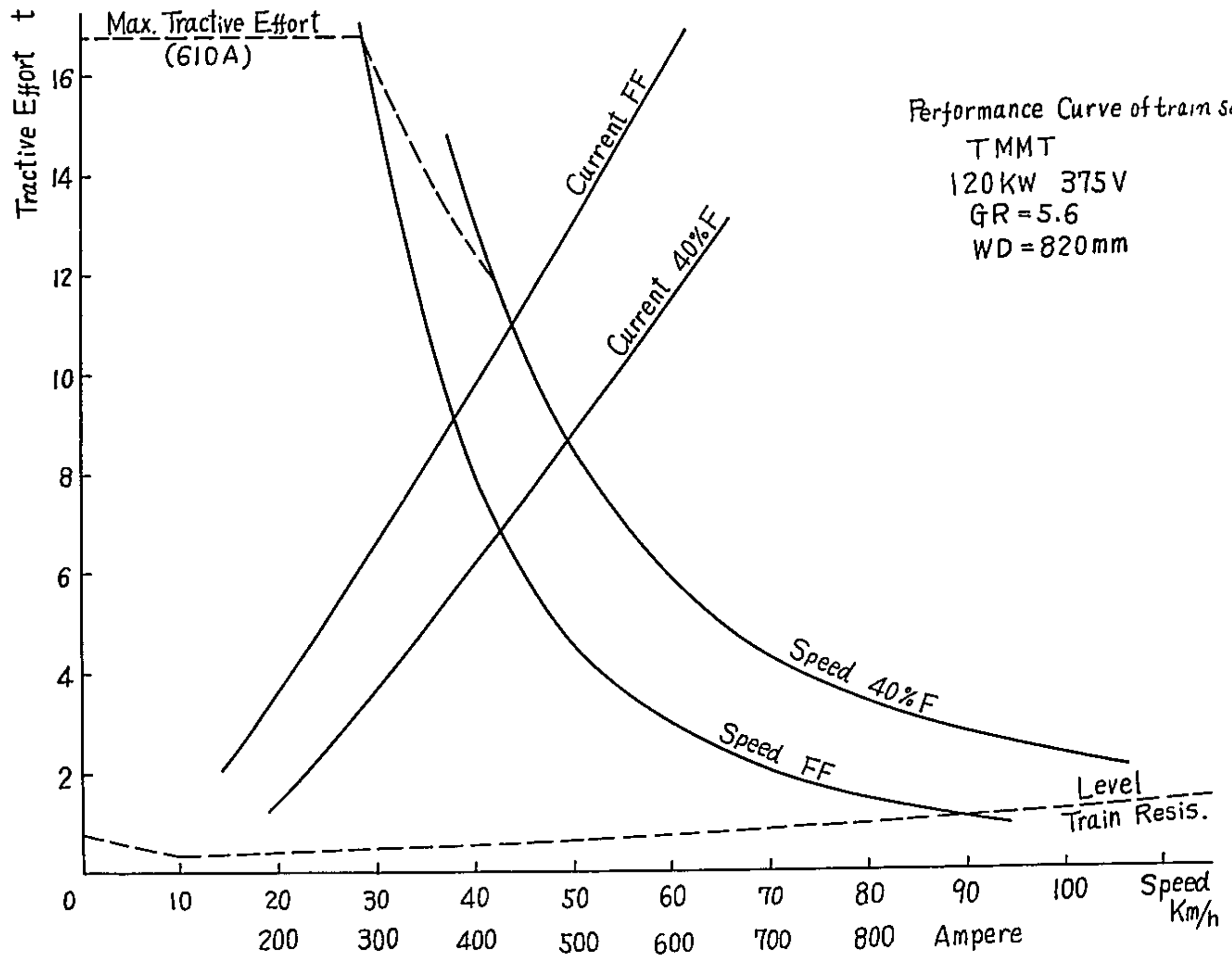


Fig. 6-3-2 Performance Curve of Train Set



6-5-1 Car inspection and repair

Like other types of railway cars, both AC and DC cars are planned to be put to inspection and repair service according to the following schedule.

| Type of Work | Car Kilometerage | Work Recurrence |
|---|---|---|
| Routine Inspection | | Every or every other day |
| Monthly Inspection | 10,000 km | Every 30 days |
| Intermediate Repair | 150,000 km | Every one and a half years |
| Overhaul | 300,000 km | Every three years |

Routine and monthly inspections are the periodical inspections similar to those conducted for other types of railways cars. In the intermediate repair which is intended mainly to cover running gear, the truck, braking device, current collector, and coupling devices are to be removed from car body for inspection, with repair work effected if necessary, and main motor is to be also detached from the truck for cleaning and inspection, but need not be overhauled unless abnormalities are detected. Other electrical equipment are to be cleaned and examined without removing them.

In the overhaul work, all components are to be removed to restore them to satisfactory working conditions by partial dismantling. However, reactor and transformer need not be detached each time.

Since the trains would carry mostly commuting passengers, their daily operating kilometerage is expected to be small. Frequency of overhaul work would therefore be determined not by the running kilometerage but by the operating period.

Periodical inspection and maintenance should preferably be conducted for each train unit consisting of four or six cars.

6-5-2 Car depot and workshop

For routine and monthly inspection as well as for minor repair of AC cars serving on No. 1 and 2 lines, a car depot is to be established at a suitable point along the KNR line.

For intermediate and overall repair work, facilities of Seoul Backshop are planned to be used. If a new shop is established and testing equipment of electrical apparatus procured for cars operating on No. 1 line, servicing of about 200 cars would be possible.

There will occur the need for establishing new repair facilities for servicing AC cars which would increase to 870 in 1981. Hence it is proposed to construct a new workshop by utilizing the structure and site of Seoul Workshop which is expected to be demolished upon completion of Taejong Workshop in 1976. The new workshop, proposed to be designed solely for electric railcars, would have an area of 130 thousand $m^2$ and would be capable of servicing about 1,000 cars in turn.

For servicing of cars operating on No. 3, 4 and 5 lines, it was planned that a car shed with simple inspection and maintenance facilities would be established along each line, with a car depot to be constructed along the line commissioned earliest to cover all three lines (See Reference Drawing 4).

Capital investment required for the aforementioned facilities would be as given below.

| | |
|---|---|
| Car depot along KNR line :<br>(Cost of land, buildings, machines and quipment, tracks, etc.) | 900 million Won |
| Expansion of Seoul Backshop :<br>(Cost of buildings, machines and equipment, tracks, etc.) | 800 million Won |
| Car workshop for No. 1 & 2 lines : | 4,000 million Won |
| Car workshop for No. 3, 4 & 5 lines : | 6,360 million Won |

It was assumed that the number of days required for a car to be retained in the workshop for overhaul and intermediate repair work would be as follows :

| | | |
|---|---|---|
| Overhaul | 12 days | (7 days in main workshop) |
| Intermediate Repair | 9 days | (4 " ) |

# VII PLANS PERTAINING TO OTHER PROPOSED LINES

# VII PLANS PERTAINING TO OTHER PROPOSED LINES

## 7-1 Outline of Construction Plan

### 7-1-1 Selection of standards

Since No. 1 and 2 lines run on the two double tracks at Chongno, No. 2 line was planned to have the same standards as No. 1 line, with its gauge set at 1,435 mm for operation at AC 25 KV supplied through the overhead contact wire system.

For the remaining three lines, No. 3, 4 and 5, gauge was set at 1,435 mm for operation at DC 1500 V to be supplied through the overhead contact wire system.

The gauge of 1,435 mm was selected for standardization and common use of track materials and car parts by all five lines. There are a number of electric systems that can be employed in an urban transport system such as the third rail system of DC 600 V or 750 V, overhead contact wire system of 1,500 V or 3,000 V, and overhead wire system of AC 25 KV 60 Hz which was adopted for No. 1 and 2 lines. Of these different systems, overhead contact wire system of DC 1,500 V was selected for No. 3, 4 and 5 lines for reasons given below.

(1) Comparison with DC low tension third rail system

All of the three lines are expected to demand a large power supply since 10-car trains will be serving on them at a headway of 2 min. and 30 sec. This means that one train will weigh as much as 600 tons, and that more than 8,500 A will be required to start it in a low tension system of DC 750 V or less. In this case, conductors of electrical equipment must be made larger in size, and the possible large voltage drop in the feeder circuit necessitates the substation spacing of about 3.5 km and further incurs a higher cost of rectifiers to be installed at substations. ' Worse still is the fact that the increase of direct current causes the breaking operation to become abruptly difficult and inaccurate and once an arc flame develops, the resultant damage is very heavy. For these reasons, low tension DC system of less than 750 V is not suited for the three lines on which trains composed of many cars will be serving.
When considered in terms of construction cost, the low tension system using the third rail cuts down the cost of civil engineering work in subsurface sections by a few per cent since it allows for a shallower excavation depth, but it invites some 30% increase in the cost of electrical work due to additional construction of substations and yet promises virtually no reduction in the cost of cars. Therefore, saving of the overall construction cost by the third rail system of 600 V or 750 V is limited to a very small amount. The system causes a higher overall cost because it produces a saving only in the subsurface sections, while incurring a higher cost of electrical work and practically the same construction work in surface sections. Of a total construction kilometerage of 91.5 km of all three lines combined, subsurface sections occupy only 40.5 km, and it is rather likely that surface sections will be extended in future. Hence, the low tension system is more costly than the overhead contact wire system.

From the viewpoint of track maintenance, overhead contact wire system is more advantageous and safer.

(2) Comparison with DC 3,000 V system

In the DC 3,000 V system, a large insulation distance must be secured. If circuit breaker and other main circuit equipment are to be installed beneath the car floor for this reason, the floor height would have been made larger than is necessary. In ordinary cases, therefore, these equipment must be placed on the floor to the poor economy of floor space.

(3) Diffusion of DC 1,500 V system

DC 1,500 V system is in wide use in urban mass transport systems. Equipment of this system are available in diversified kinds and produced on a large scale, and their application is supported by the established practical techniques. Increasing adoption of this system is noted among private railway companies in Japan in their effort to cope with the growing transport demand.

(4) Comparison with AC 25 KV system

Comparison of this system with DC 1,500 V system revealed that the cost increment of civil engineering work in subsurface sections and of cars cannot be offset by the cost reduction of electrical facilities, indicating that the system is not economically justifiable.

7-1-2 Outline of transport plan

Transport plan for four lines (No. 2 to No. 5) was worked out as outlined in Table 7-1-1 on the basis of the results given in Paragraph 3-3.

7-1-3 Outline of facilities

(1) Construction of structures

Subsurface sections: 51.5 km - Box-type reinforced concrete rigid frame structure. Construction of ordinary mining tunnel to be considered for sections rich in undulation.

Surface sections: 72.0 km - To be composed of open-cut sections, elevated sections and embankments.

Kilometerages given indicate the total subsurface and surface sections of all four lines combined (123.5 km).

(2) Station

Overall platform length: 220 m on No. 2, 3 and 4 lines to allow the operation of 10-car trains.

180 m on No. 5 line to allow the operation of 8-car trains.

(3) Electric system

No. 2 Line: AC 25 KV, 60 Hz, Overhead contact wire system.

No. 3, 4 & 5 Lines: DC 1,500 V, Overhead contact wire system.

(4) Signalling and safety device

Three- to five-aspect colour light signals and automatic train stop device (ATS).

(5) Electric railcar

Length between coupling faces: 20 m

For other details, refer to Chapter 6.

Table 7-1-1 Transport Plan for No. 2 - 5 Lines

| Line No. | Total daily in 1981 (persons) | One-way daily in 1981 in sections with heaviest traffic (persons) | One-way *during one hour* of peak traffic (persons) | (Transport plan for 1981) Train formation | Head-way (min) | No. of cars[2] required (cars) | (Transport plan for the time of opening) Time of opening | Train formation | Head-way (min) | No. of cars[2] required (cars) |
|---|---|---|---|---|---|---|---|---|---|---|
| No. 2 | 808,650 | Shinchon district - 91,380<br>Chunhodong district -167,920 | 50,400 | 8-car | 3[3] | 280 | Jan. '80 | 8-car | 4 | 208 |
| No. 3 | 797,700 | Mapo district -132,970<br>*Kyongmajang district* -114,020 | 39,800 | 8-car | 3[3] | 248 | Jul. '76 | 8-car | 4 | 144 |
| No. 4 | 719,570 | Yongsan district -131,270<br>Bogwangdong district -102,810 | 39,400 | 8-car | 3[3] | 240 | Jan. '81 | 8-car | 3 | 240 |
| No. 5 | 411,930 | Miadong district -111,410<br>Yongchon district - 54,350 | 33,400 | 6-car | 3[3] | 144 | Jan. '78 | 6-car | 4 | 108 |

Notes (1) The volume of passengers during of peak *traffic is estimated* at 30% of daily passenger.

(2) No. of cars required was calculated by the application of the following equation.

$$M = \frac{P}{N. \frac{60\,\ell}{N.\ 2\left(\frac{60}{v} + 8\right)}} \cdot (1 + d) \cdot K$$

Where M No. of cars required

P. One-way

N· Number of passengers - 280 persons/car

$\ell$. Route length

v: Scheduled speed - 36 km/h (27 km/h in subsurface sections and 40 km/h in surface section)

t. time required for shuttling ........ 4 min.

d: rate of extra ..................... 0.1

K: rate of *section fluctuation* ........ 0.75 on No. 2, 3 & 4 lines; 0.83 on No. 5 line

(3) To be extended to 6 to 12 minutes in suburban districts.

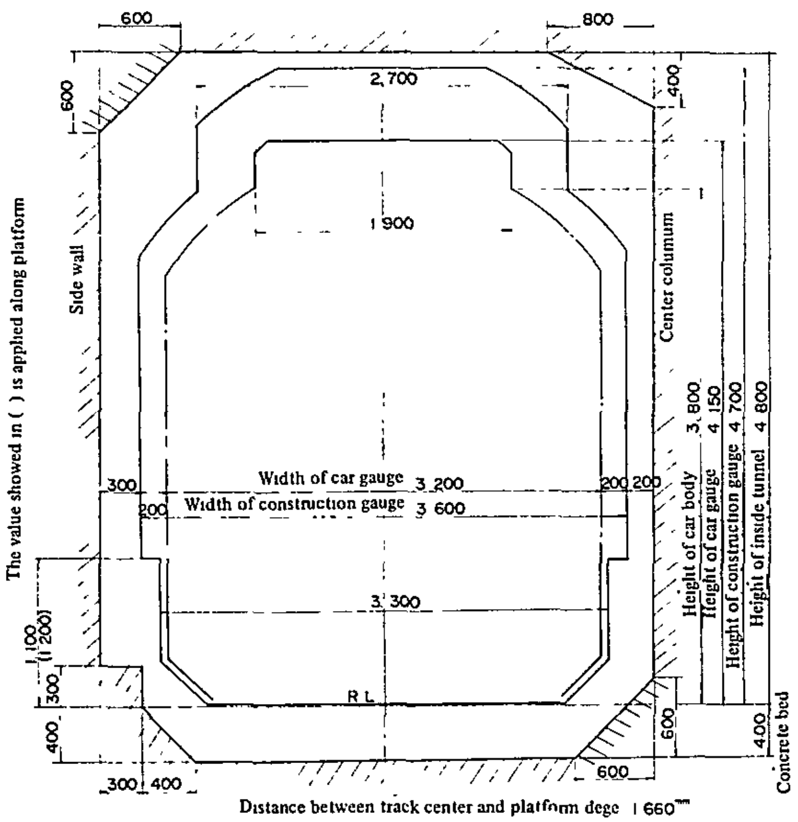
7-2 Design Standards of Subsurfaces Sections

In view of the possibility of diversified reciprocal interchange services of No. 1 and 2 lines on the quadruple track in Chongno, standards of No. 2 line should preferably the same as those of No. 1 line.

As for No. 3, 4 and 5 lines, the width of rolling stock gauges should be set at 3,200 mm. Adoption of this value is imperative even if no regard is given to the through service with KNR line, because the track gauge is 1,435 mm. Trains serving on Tokyo's underground railway lines No. 2, 5, 6, 8 and 9 have a car width of 2,800 mm against the gauge of 1,067 mm. A smaller car width aggravates the passengers' discomfort during rush hours, reduces the upper limit of transport capacity, and further deters the future improvement of riding comfort. For these reasons, the width should be set at 3,200 mm to make best use of the wide track gauge of 1,435 mm.

The height of maximum loading was set at a value compatible with the electric system of DC 1,500 V, and is therefore smaller than that of No. 1 and 2 lines. As a consequence, the height of construction gauge is smaller than that of No. 1 and 2 lines. For other design standards which are identical to those of No. 1 and 2 lines, refer to Paragraph 4-3 (See Fig. 7-2-1 and Table 7-2-1).

Fig. 7-2-1 No. 3, 4 and 5 Line Construction and Car Gauge




Distance between track center and platform dege 1 660mm
Height between R L. and platform surface 1 190mm

Table 7-2-1 Design Standards of Subsurface Sections of No. 3 - 5 Lines

| Item | Standards |
|---|---|
| Track gauge | : 1,435 mm |
| Electric system | : Overhead contact wire system, DC 1,500 V |
| Maximum loading gauge | : 3,200 mm (width) x 4,150 mm (height from RL) |
| Construction gauge | : 3,600 mm (width) x 4,700 mm (height from RL) |
| Ballast thickness | : Concrete bed - 400 mm Ballast 700 mm |
| Inside dimensions of tunnel cross section | : 4,100 mm (width) x 5,200 mm (height) with concrete |
| Minimum centre-to-center distance of tracks | : 4,400 mm |
| Minimum radius of curvature | : Main line - 150 m |
| | Line along platform - 500 m |
| Length of transition curve | : 600 C (C = Cant) |
| Cant (C) | : $C = 10\frac{V^2}{R}$ where, R = Radius (m) |
| | V = Speed (km/h) |
| | Maximum value of cant - 150 mm |
| Maximum grade | : Main line - 35/1000 |
| | Line in station premises - 10/1000*1, 5/1000*2 |
| Minimum gauge | : 2/1000 |
| Radius of vertical curve | : 3,000 m (reducible to 2,500 mm in case plane curve exceeds 300 m) |
| Enlargement of construction gauge by means of curve | : $W = \frac{2,400}{R}$ W (mm) R (m) |
| Slack | : $S = \frac{2,250}{R}$ S (mm) R (m) |

*1 In case of stations where storage, coupling and uncoupling, or shunting of cars can not be conducted.

*2 In case of stations where storage, coupling and uncoupling, or shunting of cars can be conducted.

Distance between track center and platform edge: 1,660 mm

Height of platform surface: 1,190 mm (from RL)

## 7-3 Structures of Surface Sections

### 7-3-1 Merits and demerits of different types of surface section structures

Subsurface tunnels are constructed in routing an urban transit through the built-up urban area where no surface space is available. In suburban areas where the necessary right-of-way can secured, studies must be made to select a construction that incurs the least cost. This holds true particularly when the road construction under a city planning project envisages the service of urban transit.

Three types can be conceived of for construction of surface sections, i.e., open-cut type, embankment type and elevated type. Table 7-3-1 shows the merits and demerits of these three types, with the proviso that each of them would be so employed that tracks and the ground surface can be perfectly grade-separated with ample vertical distance between them (See Fig. 7-3-1).

Table 7-3-1 Comparison of Open-cut Structure, Embankment, and Elevated Structure

(1) Comparison of Construction

| Type | Level | Width of Right-of-Way | Construction Cost | Vibration and Noise, and Countermeasure |
|---|---|---|---|---|
| Open-cut Type | Below ground surface | Medium with index standing at 170 (with normal plane ratio set at 1:0.3): Reducible to the value of elevated structure if turned into a tunnel or provided with retaining walls. | Medium | Small, reducible to the noise and vibration level of subsurface tunnels if ceiling is provided. |
| Embankment | Ground surface | Large with index standing 310 (with normal plane ratio set at 1 : 1.5); reducible to about 150 if provided with retaining walls on either side. | Small | Large, but may be alleviated by means of green belt. |
| Elevated structure | Ground surface | Small with index standing at 100 which is approximately equal to the value of underground tunnels, and does not increase much in curved sections. | Large | Large, sheltering is effective but accompanies electric wave disturbance. |

(2) Comparison from the Viewpoint of City Planning —

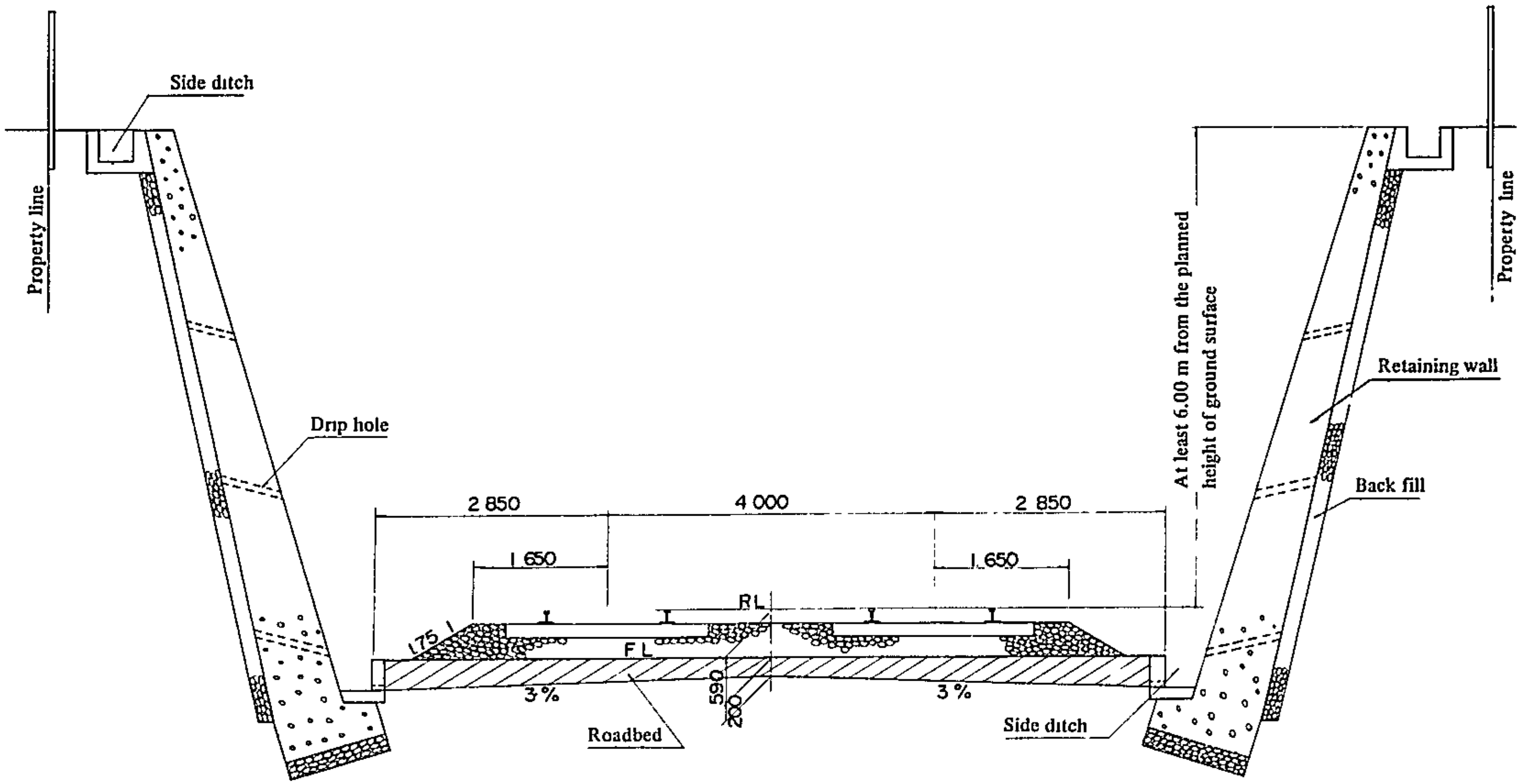
| Type | Influence on City's Appearance and Beauty, and Countermeasure | Cutting Effect on the Formation of Urban Area | Passengers' Comfort in Enjoying Outside Views |
|---|---|---|---|
| Open-cut Type | Influence is small | No cutting effect. Convertible to subsurface tunnel in future. | Poor |
| Embankment | Gives influence. Embankment can be turned into green belts by afforestation and provision of flower gardens. | Effect is large. Embankment can be grade-separated from streets if its height is over 7 m. | Good |
| Elevated Type | Given influence, but the selected type of girders and piers can be harmonized with the surroundings. | Effect is large. Grade separation of streets is possible. | Good |

(3) Comparison from the Viewpoint of Utilization and Improvement of Structures

| Type | Utilization of Structures | Improvement of Structures | Need for Additional Right-of-Way for Track Addition |
|---|---|---|---|
| Open-cut Type | Space on the roofed structures provides the source of income. | Improvement into subsurface tunnel is feasible. | Track addition is structually possible, if a small additional right-of-way is secured. |
| Embankment | Embankment can be turned into green belt, but provides no source of income. | Improvement into elevated bridge is possible. | No need for securing right-of-way. |
| Elevated Type | Space under the girder provides the source of income by accommodating buildings. | Span can be widened by remodelling it into a bridge. | Right-of-way must be secured for each track addition. |

It may be added that the noise and vibration incidental to the elevated type can be reduced in future through a comprehensive improvement of parepet, ballast, and truck.

Fig. 7-3-1 Section in Cut



7-3-2 Selection of type of surface section structures

Since Seoul's development is likely to transform the existing suburban areas into city areas with a fairly high population density, the mission hopes that the open-cut type will be given special consideration since it can be converted into the subsurface tunnel.

It is advisable that open-cut type be adopted specifically in those area where urbanization is anticipated to progress at a rapid tempo or changes are expected in the pattern of development.

Elevated structure allows the utilization of the space below the girder for various purposes including warehouses in industrial zones. In the initial stage, however, such space utilization should preferably be refrained from since it often spoils the beauty of city.

Embankment is to be adopted for effective reduction of earthwork cost in sections where the topography demands cutting work. Its adoption should be decided on with due account taken of the scenic slopes of nearby mountains and hills.

7-3-3 Elevated structure

Elevated sections are believed to occupy a considerably large portion of the proposed lines. Type of their structures, though quite diversified, can be broadly classified into two: the one in which simple girders and piers are continuously connected, and the other in which superstructure and substructure are integrated into a rigid frame which is connected one after another to cover a number of spans.

The former type has many different kinds, the cheapest of which is the elevated reinforced concrete construction of both pier and girder. But the reinforced concrete rigid frame structure is usually less costly than the simple girder structure. Where the soil formation is poor and foundation work incurs a large cost, however, continuous simple girder is more economical. Cost of simple girder structure increases, up to a span of about 30 m, in the order of reinforced concrete girder, PC girder, composite girder and steel girder. If the span is in excess of 30 m, employment of reinforced concrete girder involves difficulties, and setting up of timbering to support the span is often prohibitive at street intersections because of the restrictions on work execution.

Elevated reinforced concrete rigid frame bridge was studied by the Japanese National Railways during the construction of its New Tokaido Line. Fig. 7-3-2 shows the standard type of this bridge adopted as a result of the said study. There are many other types but none can be considered economically superior to the standard type.

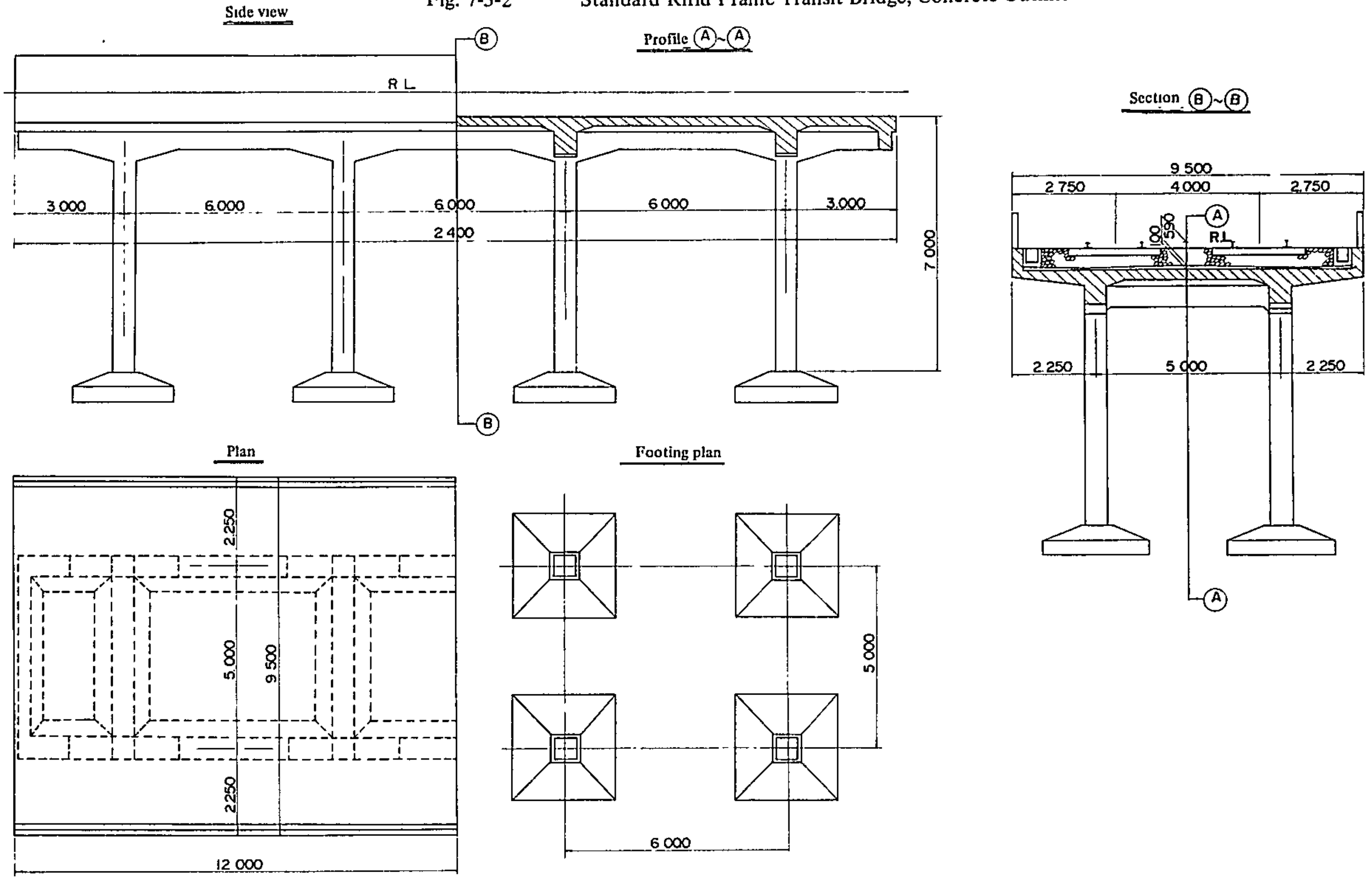
Reference: Michiyuki Kono

On the Economical Design of Reinforced Concrete Structures for Elevated Railway Tracks, Railway Technical Research Report No. 310, July 1962.

Michiyuki Kono and Toshiji Matsumoto

Design of the Standard Rigid Frame Railway Bridge in New Tokaido Line, Transactions of the Japan Society of Civil Engineers, No. 115, March 1965.

Fig. 7-3-2 Standard Rifid Frame Transit Bridge, Concrete Outline



### 7-3-4 Construction method across the Han River

Selection of construction method for crossing the Han River must be preceded by the choice between the bridge construction and tunnel construction. The choice must be made with consideration given to economic preferability, alighment on either bank which involves the choice between the surface station and subsurface station, and harmony with the scenery on either bank.

A point which merits attention with respect to the choice between the bridge construction and tunnel construction is that the unit cost for bridge construction rises sharply with the increase in spans, whereas that for open-cut tunnel construction remains the same irrespective of the extension of tunnel length. It also deserves attention that the unit construction cost of ordinary mining tunnel or shield tunnel decreases with the extension of tunnel length.

It is possible that the conditions for executing bridge construction and open-cut tunnel construction across the Han River will create only a small gap of cost; and nothing definite can be said at the present stage about the economic preferability of the two methods. The team is of the opinion, however, that open-cut square type tunnel can be constructed without resorting to the sinking caisson method or pneumatic caisson method by making good use of the small width of low-water channel. Construction cost will be saved largely by implementing a construction plan in which due consideration is given to counterplan against flood during the construction period and by avoiding the flood season in executing the construction of important structure.

Construction by the above-method will be made successful by giving sufficient weight to all structures to counteract their buoyancy, providing temporary waterproofing walls for embankment portions after completing structures outside the embankment, and dividing the structure in the river into sections for consecutive block by block construction with waterproofing walls provided to divert the location of low-water channel suitably.

For the possible bridge construction across the Han River, Reference Fig. 3 shows, by way of example, the design of a simple Warren truss bridge which is often employed by Tokyo's rapid transit.

## 7-4 Plan for Electrical Facilities

The technical standards for DC . 1, 500 V system are as briefed below:

(1) Power from Korea Electric Company is to be received through an exclusive transmission line, and an exclusive transmission system to connect the traction substations and electricity room of each station is to be constructed. Each substation and electricity room should be designed so that power can be received from two circuits.

(2) Under no load conditions, the substation feeding voltage is to be maintained at 1, 750 V. Voltage at load terminal is to exceed 1, 000 V under normal condition. Thus to satisfy the expected standard load, substation spacing should be held at 5 - 7 km.

(3) As for the feeding system the substations should in principle be in prallel, with feeders installed separately for up and down tracks and a high-speed circuit breaker provided for each circuit.

(4) The substations are to be standardized, equipped in principle with two units of silicon rectifiers having a rated capacity of 6,000 KW. Maximum one hour demand of a substation is estimated to be about 10,000 KW (See Fig. 7-4-1).

(5) As in the case of a.c. electrification system, substations are to be remote controlled from a control center. For the protection of feeder circuit, feeder line fault selective device (Δ I device) and interlinked circuit breaking device are to be installed.

(6) Rigid suspension contact system is to be employed in tunnels. In view of the current capacity, double contact wire system must be employed in principle (See Fig. 7-4-2).

(7) Specifications for elevated sections are as follows:

| | | |
|---|---|---|
| Support | : | Concrete post, trussed beam |
| Overhead contact system | : | Double simple catenary with automatic tensioning |
| Feeder | : | Standed aluminum wire |

Facilities for duplication-track and side-tracks are to be simplified.

(8) Signalling system and facilities are to be identical to those of a.c. electrification system, except that impedance bond and welding bond are heavier Divided Commercial Frequency Track-Circuit System is to be adopted on the entire line.

(9) Telecommunication system is to be the same as that of a.c. electrification system where no special cables nor countermeasures against inductive disturbances are required.

The above has been planned based on the existing conditions of the facilities being used in the rapid transit railways in major cities of Japan. In formulating these plans, due consideration was given to the assurance of safe and fault-free operation.

## 7-5 Cost and Period of Construction

Lack of topographic data did not allow the team to make a detailed study for the selection of the construction method and type of structures. Table 7-5-1, showing the work schedule and cost up to 1981, was prepared on the basis of field survey, cost data of No. 1 line and other materials.

Cost of materials and labour shown in the table is expressed with September 1970 taken as the base month.

Fig. 7-4-1 Block Diagram of D C. Traction Substation

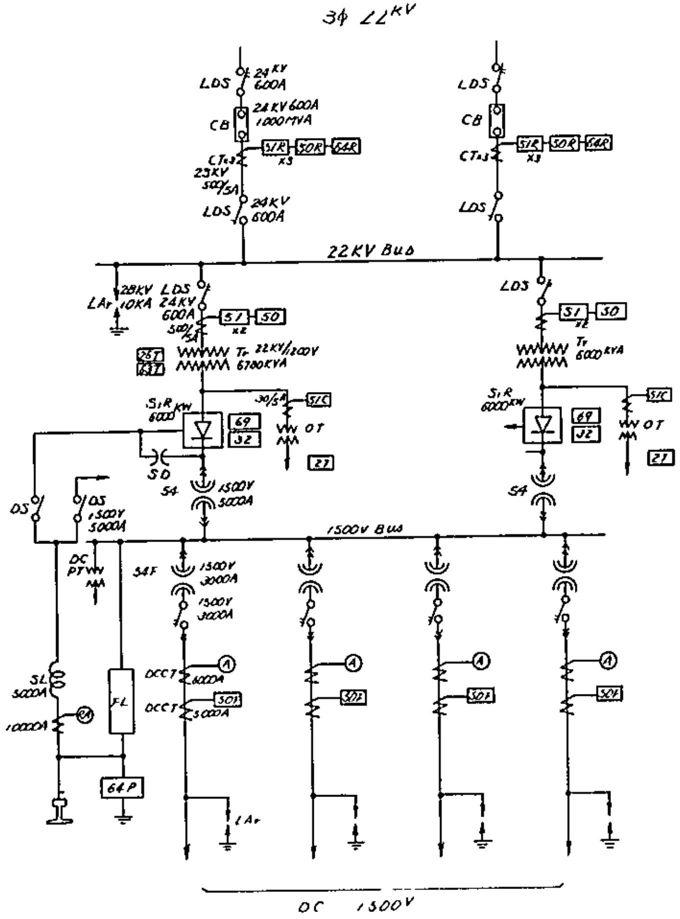



Fig. 7-4-2 Standard Structure of Overhead Contact Line

1,500 V D.C in tunnel

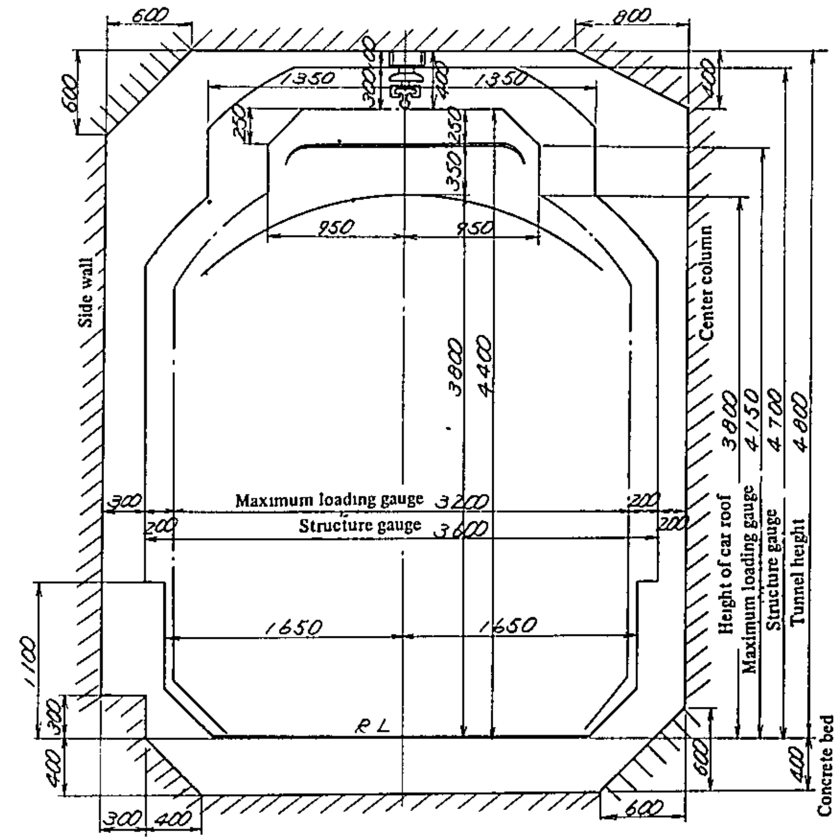


Table 7-5-1 Construction Schedule and Annual Funds Required for Lines No. 2—5

Unit: 100 million Won

| Item \ Year | | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Construction Schedule | | | | Start of construction of No. 3 line | Start of construction of No. 5 line | | | Opening of No. 3 line<br>Start of construction of No. 2 line | Opening of No. 5 line<br>Start of construction of No. 4 line | | Opening of No. 2 line | Opening of No. 4 line | | |
| Investment | Electric Railcar | | | | | | | (144 cars) 47.5 | | (180 cars) 61.2 | | (258 cars) 94.8 | (330 cars) 112.5 | (912 cars) 316.0 |
| | Construction | | | | 154 | 239 | 311 | 247.3 | 357 | 294.2 | 398 | 272.2 | 28.3 | 2,301 |
| Total | | | | | 154 | 239 | 311 | 294.8 | 357 | 355.4 | 398 | 367 | 120.8 | 2,617 |

Remarks

1. Rise of the commodity price and labour cost during the scheduled construction period is disregarded.
2. Interest during the construction period is not included.

## 7-6 Estimated Profit and Loss

Profit and loss in 1981 when all the proposed lines will be opened to traffic is as tabulated below. Figures shown in the following table were obtained by following the method employed for calculation of profit and loss of No. 1 line operation.

Table 7-6-1 Estimated Profit and Loss of Lines No. 2—5 in 1981

Unit: Million Won

| Item | Amount |
|---|---|
| Revenue | |
| Railway Operating Revenue | 20, 145 |
| Miscellaneous Operating Revenue | 1, 370 |
| Sub-total | 21, 515 |
| Expenditure | |
| Railway Operating Expenses | 7, 719 |
| Personnel Expenses | 3, 748 |
| Power Cost | 1, 835 |
| Repair Expenses | 816 |
| Others | 1, 320 |
| Interest Payable | 20, 754 |
| Sub-total | 28, 473 |
| Excess of Loss | |
| Loss before Depreciation | △ 6, 958 |
| Depreciation | 6, 701 |
| Loss after Depreciation | △13, 659 |

In estimating the above profit and loss, it was assumed that the loss prior to depreciation incurred after each line is opened would be borne by the Government or Seoul City, and that the amortization of loan would be made by conversion. It is to be noted that these subsidiary measures do not change the fact that lines excepting No. 1 line produce a loss prior to depreciation and their construction demands a huge amount of capital investment. This is the reason why the Government or local organizations concerned bear the whole or part of the construction cost of underground railways in many countries of the world and further provide grant-in-aid to cover the deficit in their accounts. Japan is no exception to this practice as evidenced in its policy enforced as from 1970 for saddling both the Government and the local autonomous body concerned with one-fourth of the net construction cost of underground railways.

# VIII MANAGEMENT

# VIII MANAGEMENT OF UNDERGROUND RAILWAYS

## 8-1 Organization Undertaking Management

It is the common practice established by many years of experience in major cities of the world that the management of rapid transit railways serving within a city area or a city and its environs is undertaken by the city or respective railway enterprise acting in behalf of the city, whereas the management of railways whose service area extends beyond the said city areas is left to respective inter-urban railway enterprises or other railway enterprises whose routes run near urban areas.

Reason for this is that the former is intended primarily for transport service within the city area and resort largely to the city's budget, and their construction is closely interrelated with the city planning, while the latter's urban transportation service is essentially divergent from their intrinsic mission for which they are constructed, i.e., inter-urban passenger and freight transportation and other similar services. Even if a portion of an inter-urban railway line is constructed to connect the city center with suburbs, it would be advisable, from the viewpoint of the standards and distance of that line and the network of lines in which it is included, to place its operation under the management of the railway enterprise operating the whole network.

The above-mentioned world-wide practice is expedient in Seoul, too. The term, therefore, recommends that Seoul City undertake the management of railway lines serving within the city area and its peripheries, and KNR manage the operation of lines serving outside the city.

## 8-2 Organization for Municipal Management of Railways

Operation by a special account which is currently employed for management of bus and water supply enterprises in accordance with the Local Public Enterprise Law is recommendable. For this type of management, establishment of the following internal organization under officers responsible for construction and operation would be advisable.

- Construction Division
    - Administration Section
    - Design Section
    - Construction Section
    - Mechanical and Electric Section
    - Construction Office
- Operation Division
    - General Affairs Section
    - Transport Section
    - Maintenance Section
    - Mechanical and Electric Section

## 8-3 Fare System and Tariff

### 8-3-1 No. 1 Line

(1) Fundamental approach

In determining the fare system and tariff, those of other traffic means must be referred to so as to obtain the understanding of passengers. Particularly, the tariff must be so determined that fares are limited to the extent that allows passengers utilizing other surface traffic media can readily shift to underground railways. However, fares may be set slightly higher than those of buses since underground railway service surpasses bus services in speed, punctuality, boarding and alighting safety, and other benefits.

With respect to fares of regular passengers no discount system is to be considered because the existing city bus service provides no such system and the construction of the proposed lines is intended primarily for regular passengers. However, to save the ticket issuing and punching labour in the morning and evening rush hours and induce passengers to underground railways, it would be advisable to provide some discount. If season tickets are to be issued, account must be taken of the number of monthly holidays on which season ticket passengers do not commute to and from their offices and schools. (Number of commuting days is assumed to be 24 days per month in this report.)

In view of the Government policy which gives a high priority to education and of the current income level, employment of the season ticket system for school commuting must be planned with its tariff established on the basis of the current bus tariff. However, differently from the case of but service, no discount is to be admitted to single trips.

The discount rate for students should be revised with the future ascent of income level.

With respect to children's fares, it would be reasonable to adopt a system similar to and balanced with the fare system of KNR in which children are charged half the rate for adults.

(2) Classification and calculation of passenger fare

(a) Ordinary passenger fare

Division of passengers by age:

Adult - Passengers of more than 12 years of age.
Children - Passengers from six years of age up to 12 years of age.

Ordinary passenger fare for adults: ₩20 for the entire length of each line.

Ordinary passenger fare for children: Half the fare for adult passengers.

(b) Season ticket fare for office commuting:

₩960 per month (80% of the fare for 30 return trips).

(c) Season ticket fare for school commuting :

₩600 per month (50% of the fare for 30 return trips).

(Fare for season-ticket school commuters may be set at 60% of 30 return trips per month.)

(d) Season ticket fare for children

Half the fare for season ticket office commuting given in item (b) above.

The flat rate system adopted for each of the above items is considered a adequate for a route length of about 8 km. With the increase in the service distance in future, however, adoption of the district rate system or distance scale rate system would have to be considered.

8-3-2 Fares for reciprocal interline through service between KNR and No. 1 Line

(1) Fundamental approach

Fare for interline through service between KNR and No. 1 line should in principle be the sum total of fares for respective lines since they are managed by different enterprises. However, it would be logically justified to make some adjustment to such sum total because the simple addition of two fares could invite, particularly if the distance travelled is short, an unreasonably high rate which is not desirable for inducement of passengers, and also because the through service saves more labour than in the interchange service at the station of origin or destination. A noteworthy fact that justifies the above-mentioned adjustment is that KNR charges a higher minimum fare than the city bus for both ordinary and office commuting passengers. This can be accepted as reasonable while KNR attaches importance to inter-urban service, but not in those sections where it positively partakes in the city traffic.

For these reasons, adjusted fares given below are to be adopted.

(2) Classification and calculation of passenger fares

(a) Ordinary passenger fare

For passengers using the through service between the electrified section of KNR line and the underground railway line, ₩10 is to be deducted from the added fare for the two lines. The deducted amount of ₩10 is to be borne equally by respective enterprises.

Minimum fare adopted by KNR for the section which is equivalent in extension to No. 1 line is ₩30. This amount is to be reduced to ₩20 because the said 8 km section should essentially be included in the service area of the urban transport system. For passengers using the through service covering the 8 km section, therefore, ₩10 should be deducted from the added fare of ₩40.

This arrangement will enable passengers to reach the city center from a station not farther than Noryangjin by direct through service at the current minimum fare of ₩30 of KNR.

Ordinary fare for children: Half the above-mentioned passenger fare for adults.

(b) Season ticket fare for office commuting

KNR offers an average of 44% discount for office commuters on the basis of 30 returns trips a month. However, a minimum fare of ₩1,210 is set for office commuters whose travelling distance is less than 20 km. The monthly season ticket fare of KNR, when compared with the short distance bus fare for 24 return trips, is much higher.

For this reason, KNR's 8 km extension from the city center is treated as an urban transport route identical in nature to underground railway lines, and a season ticket fare of ₩960 was set for the said distance. For office commuters using through service, sum total of season ticket fares for two lines, each set at ₩960, is to be discounted by a quarter. The amount of discount is to be equally borne by the two enterprises.

(₩960 + ₩960) x (1 — 1/4) = ₩1,440

Discount amount - ₩480

Discount amount to be borne by each enterprise - ₩240

The season ticket fare given above is twice as much as the bus fare of ₩720 for 24 return trips at the current rate of ₩15 per trip. The team considers it highly probable, however, that when the through service over the entire 8 km section is opened, passengers will take to railways rather than buses despite the fare differential of ₩720 because the former can cover the entire section in about 16 minutes with punctual service, whereas the latter requires more than 30 minutes and is less dependable in service punctuality.

For a through service involving more than 16 km of KNR line, simple addition of the two fares is considered to present no problems because of the large discount rate offered by KNR.

For the intermediate section between 8 km and 16 km in distance, gradual increase in discount rate is made by considering the fare of aforementioned two sections and made some adjustments (See Table 8-3-1).

Table 8-3-1 Season Ticket Tariff for Office Commuters Using Through Service between KNR and No. 1 Line (per month)

Unit : ₩

| Operating Kilometer-age of KNR | Bus Fare for 24 Return Trips a Month | | Amount by Simple Addition without Revision of KNR Fares | | | Amount by Simpe Addition with Revision of KNR Fares | | | Amount after Adjustment of Fares of Both Lines |
|---|---|---|---|---|---|---|---|---|---|
| | City Bus | Suburban Bus | No. 1 line | KNR line | Total | No. 1 line | KNR line | Total | |
| 0 8 | 720 | 720 | 960 | 1,210 | 2,170 | 960 | 960 | 1,920 | 1,440 |
| 9 | 720 | 960 | 960 | 1,210 | 2,170 | 960 | 1,040 | 2,000 | 1,580 |
| 10 | 720 | (960) 1,200 | 960 | 1,210 | 2,170 | 960 | 1,040 | 2,000 | 1,580 |
| 11 | 720 | (960) 1,400 | 960 | 1,210 | 2,170 | 960 | 1,040 | 2,000 | 1,720 |
| 12 | 720 | (960) 1,400 | 960 | 1,210 | 2,170 | 960 | 1,040 | 2,000 | 1,720 |
| 13 | 720 | (1,200) 1,680 | 960 | 1,210 | 2,170 | 960 | 1,120 | 2,080 | 1,860 |
| 14 | 720 | (1,200) 1,680 | 960 | 1,210 | 2,170 | 960 | 1,120 | 2,080 | 1,860 |
| 15 | 720 | (1,440) 1,920 | 960 | 1,210 | 2,170 | 960 | 1,120 | 2,080 | 2,000 |
| 16 | | (1,440) 2,160 | 960 | 1,210 | 2,170 | 960 | 1,120 | 2,080 | 2,000 |
| 17 | | (1,680) 2,160 | 960 | 1,210 | 2,170 | 960 | 1,210 | 2,170 | |
| 18 | | (1,680) 2,400 | 960 | 1,210 | 2,170 | 960 | 1,210 | 2,170 | |
| 19 | | (1,680) 2,400 | 960 | 1,210 | 2,170 | 960 | 1,210 | 2,170 | |
| 20 | | (1,920) 2,640 | 960 | 1,210 | 2,170 | 960 | 1,210 | 2,170 | |
| 21 | | (1,920) 2,640 | 960 | 1,460 | 2,420 | 960 | 1,460 | 2,420 | |
| 22 | | (2,160) 2,880 | 960 | 1,460 | 2,420 | 960 | 1,460 | 2,420 | |
| 23 | | (2,160) 2,880 | 960 | 1,460 | 2,420 | 960 | 1,460 | 2,420 | |
| 24 | | (2,160) 3,120 | 960 | 1,460 | 2,420 | 960 | 1,460 | 2,420 | |
| 25 | | (2,400) 3,360 | 960 | 1,460 | 2,420 | 960 | 1,460 | 2,420 | |
| 26 | | (2,400) 3,600 | 960 | 1,600 | 2,560 | 960 | 1,600 | 2,560 | |
| 27 | | (2,400) 3,600 | 960 | 1,600 | 2,560 | 960 | 1,600 | 2,560 | |
| 28 | | (2,640) 3,600 | 960 | 1,600 | 2,560 | 960 | 1,600 | 2,560 | |
| 29 | | (2,640) 3,840 | 960 | 1,600 | 2,560 | 960 | 1,600 | 2,560 | |
| 30 | | (2,880) 3,840 | 960 | 1,600 | 2,560 | 960 | 1,600 | 2,560 | |
| 31 | | (2,880) 4,080 | 960 | 1,760 | 2,720 | 960 | 1,760 | 2,720 | |
| 32 | | (2,880) 4,080 | 960 | 1,760 | 2,720 | 960 | 1,760 | 2,720 | |
| 33 | | (3,120) 4,320 | 960 | 1,760 | 2,720 | 960 | 1,760 | 2,720 | |
| 34 | | (3,120) 4,560 | 960 | 1,760 | 2,720 | 960 | 1,760 | 2,720 | |
| 35 | | (3,360) 4,560 | 960 | 1,760 | 2,720 | 960 | 1,760 | 2,720 | |
| 36 | | (3,360) 4,800 | 960 | 1,880 | 2,840 | 960 | 1,880 | 2,840 | |
| 37 | | (3,360) 4,800 | 960 | 1,880 | 2,840 | 960 | 1,880 | 2,840 | |
| 38 | | (3,600) 5,040 | 960 | 1,880 | 2,840 | 960 | 1,880 | 2,840 | |
| 39 | | (3,600) 5,040 | 960 | 1,880 | 2,840 | 960 | 1,880 | 2,840 | |
| 40 | | (3,840) 5,040 | 960 | 1,880 | 2,840 | 960 | 1,980 | 2,840 | |
| 41 | | (3,840) 5,240 | 960 | 2,010 | 2,970 | 960 | 2,010 | 2,970 | |
| 42 | | (3,840) 5,520 | 960 | 2,010 | 2,970 | 960 | 2,010 | 2,970 | |

Note. Figures in parentheses in the column for suburban bus fare indicate the special rates employed for buses operating between Seoul and Inchun.

(c) Season ticket fare for school commuting

Simple addition of fares of the two lines is practicable, because a high discount rate is given to commuting students by KNR lines.

8-3-3 Special tariff of KNR line

As described in the preceding section, the electrified section of KNR is intended not only for inter-urban passenger service but also for the city transport route, should therefore be established without adhering too closely to the tariff adopted for other sections. Accordingly, a special tariff for passengers using KNR line is planned as tabulated below.

Table 8-3-2 Special Tariff for KNR Line

| Operating Kilometer= age | Ordinary Passenger Fare | | Season Ticket Fare for Office Commuters (per month) | |
|---|---|---|---|---|
| | Current Fare | Special Fare | Current Fare | Special Fare |
| 0 8 | 30 ₩ | 20 ₩ | 1,210 ₩ | 960 ₩ |
| 9 | 30 | | 1,210 | 1,040 |
| 10 | 30 | | 1,210 | 1,040 |
| 11 | 30 | | 1,210 | 1,040 |
| 12 | 30 | | 1,210 | 1,040 |
| 13 | 30 | | 1,210 | 1,120 |
| 14 | 30 | | 1,210 | 1,120 |
| 15 | 30 | | 1,210 | 1,120 |
| 16 | 30 | | 1,210 | 1,120 |
| 17 | 30 | | 1,210 | 1,120 |
| 18 | 30 | | 1,210 | 1,120 |
| 19 | 30 | | 1,210 | 1,120 |

# IX BENEFITS DERIVED FROM URBAN RAPID TRANSIT SYSTEM IN SEOUL SPECIAL CITY

# IX BENEFITS DERIVED FROM URBAN RAPID TRANSIT SYSTEM IN SEOUL SPECIAL CITY

## 9-1 Benefits of Rapid Transit Urban Railway Service

Rapid transit urban railway service brings about diversified social as well as national benefits to the city and its environs it serves. Construction of the proposed underground railway line is believed to produce immense benefits which may be considered under the following categories.

(1) Saving of travelling time of passengers resorting to transport means

Rapid transit urban railway service generally covers the distance between the origin and destination in a shorter time than is required by bus service. Passengers who have shifted from buses to rapid transit railways can appropriate the time thus saved for production activities. While the average running speed of motor cars will naturally decline with the congestion of surface traffic, that of railways is virtually free from slow-down.

(2) Saving of capital input and operation cost for bus service

As the users of transport means prefer railways to others, capital input as well as operation cost for bus service, such as personnel expenses, fuel cost, repair expenses, etc. can be saved. In addition, buses now in service can be used for more effective and important purposes.

(3) Saving of capital input for road construction and improvement

Traffic congestion on major roads running through the central district of the city is in the state of saturation. To cope with the future increase in the volume of surface traffic, capital investment in roads is mandatory. Construction of railways serves to cut down the required capital investment for road construction and improvement.

Further, as buses come to appropriate for purposes other than passenger service in the central district of the city, existing roads will offer more space for passenger cars and trucks.

(4) Saving of cost for road maintenance and traffic control

Use of buses for purposes divergent from the central district of the city will reduce the cost for road maintenance and traffic control, and make it possible to appropriate the cost so saved for other purposes.

(5) Saving of cost incurred by traffic accidents

Since the rate of accidents of surface traffic is generally higher than that of rapid transit urban railways, diverted use from buses is expected to cut down the cost incurred by traffic accidents.

(6) Mitigation of air pollution

Air pollution by exhaust gas of motor cars, which is now posed as a serious problem, can be alleviated by the construction of electrified rapid transit railways.

(7) Increase of land value

Extension of rapid transit railway lines into suburban areas coupled by the linked service of railways and buses will largely cut down the time required to reach the city center from suburban areas. This will serve for the development of wide areas extending along the city peripheries and for the increase of land value (which is not necessarily expressed by land price).

(8) Decrease of unemployment rate

Construction of railway lines extends the commuting distance between the city center and residential districts in suburbs. This contributes to balanced supply and demand of labour, and serves for decreasing the number of jobless workers.

## 9-2 Trial Calculation of Benefits of Rapid Transit Railway Service in Seoul Special City

It is most preferable to obtain the overall effect of rapid transit railway service by converting all the aforementioned benefits into tangible values. In this report, however, trial calculation is made for such benefits as saving of travelling time (item (1) of the preceding section) and saving of capital input and operation cost for bus service (item (2) of the preceding section), and the benefit calculated is compared with the cost of rapid transit railway service.

Results of the trial calculation is shown in Table 9-2-1.

As shown in Table 9-2-1, No. 1 line alone will yield a benefit worth about ₩900 million in 1976. In 1981, No. 1 line is expected to produce a benefit of ₩2,400 million and No. 2—5 lines ₩6,500 million. Thus, five lines combined are estimated to bring about a social benefit of almost ₩9,000 million in value.

Table 9-2-1 Benefit and Cost of Lines No. 1 — 5

Value expressed in ₩1 million with 1970 taken as the base year.

| Section | | No. 1 Line | | Lines No. 2—5 |
|---|---|---|---|---|
| Year | | 1976 | 1981 | 1981 |
| Benefit derivable by rapid transit urban railway service | Saving of travelling time | 2,564 | 3,762 | 25,272 |
| | Saving of time for interchange | 498 | 840 | - |
| | Saving of bus operation cost | 673 | 939 | 6,693 |
| | Saving of capital input in buses | 319 | 513 | 3,093 |
| | Total | 4,054 | 6,054 | 35,058 |
| Cost of rapid transit urban railway service | Personnel expenses | 260 | 285 | 3,748 |
| | Cost for fuel, repair, etc. | 571 | 856 | 3,971 |
| | Capital input in rolling stock | 569 | 786 | 3,745 |
| | Capital input in facilities | 1,748 | 1,748 | 17,128 |
| | Total | 3,148 | 3,675 | 28,592 |
| | Excess of benefit over cost | 906 | 2,379 | 6,466 |

## 9-3 Method and Basic Values for Trial Benefit Calculation

(1) Work hour value

Average work hour value within the normal working hours in 1970 was obtained on the basis of the national income (net national product) and number of employed workers in Seoul, average per capita annual income of public service personnel, wages of ordinary workers, as well as fares for limited express trains of K.N.R. (excluding seat reservation charge) and saving of travelling time by such trains. The work hour value outside the normal working hours was set at 70% of that within the normal working hours.

Work hour value per hour

₩129 within the normal working hours

₩90 outside the normal working hours

(2) Time saved

Average passenger-kilometers on ordinary days was obtained from the number of passengers carried between stations on ordinary days and the station spacings, which was applied to 300 days of the year. 75% of this average passenger-kilometers was applied to 65 holidays throughout the year.

Average operating speed to carry the above number of passengers was assumed to be 15 km/h in the city and 25 km/h in the suburban area for buses and 27 km/h in subsurface sections and 40 km/h in surface sections for underground railways.

Number of passengers carried within the normal working hours was assumed to be 13.5% of the total number of passengers carried on an ordinary day.

Saving of time for interchange between No. 1 line and KNR lines reciprocal interline through service between them was assumed to be 7.5 minutes for rush hours during which 25% of total number of passengers on an ordinary day was assumed to be carried.

(3) Operation cost of buses

Operation cost was obtained on the basis of the operating kilometrage of buses which were assumed to carry the total number of passengers given in the preceding item.

| | | |
|---|---|---|
| Fuel cost | ₩3.50/bus/km | |
| Cost of oil & grease | ₩0.64/bus/km | ₩41.20/bus/km with 10% overhead cost added. |
| Cost of tyre & tube | ₩2.30/bus/km | |
| Cost for repair | ₩5.91/bus/km | |
| Personnel expenses | ₩26.00/bus/km | |

(4) Capital input in buses

| | |
|---|---|
| Unit cost of buses | ₩3.05 million |
| Repayment period | 5 years; residual value after depreciation - 10% |
| Extra car ratio | 10% |

# APPENDIX

# APPENDIX

List of Reference Data

1. 統 計 資 料

(1) KOREA STATISTICAL YEARBOOK 1969

ECONOMIC PLANNING BOARD REPUBLIC OF KOREA

(2) STATISTICAL YEAR BOOK OF SEOUL 1969

SEOUL METROPOLITAN GOVERNMENT

(3) STATISTICAL YEAR BOOK OF TRANSPORTATION 1970

MINISTRY OF TRANSPORTATION

(4) REPORT ON MINING AND MANUFACTURING CENSUS '68

ECONOMIC PLANNING BOARD

THE KOREA DEVELOPMENT BANK

(5) MONTHLY STATISTICS OF KOREA 1. 2, 1970

ECONOMIC PLANNING BOARD

(6) SEOUL市調査統計資料　VOL 11 №2 1970　　SEOUL特別市

(7) 統 計 表 1970－9　　韓国電力

2. 国土計画, 都市計画関係資料

(1) 国土計画基本構想 1968　　建 設 部

(2) KOREA PHYSICAL PLAN 1970

MINISTRY OF CONSTRUCTION, REPUBLIC OF KOREA

(3) GUIDELINES FOR NATIONAL PHYSICAL PLAN JUNE, 1969

MINISTRY OF CONSTRUCTION, REPUBLIC OF KOREA

(4) 都市計画一覧表 1970. 9.　　都 市 局

(5) 建 設 白 書 1969　　建 設 部

(6) 人口配分と土地利用計画, 交通施設計画　　建 設 部

3 交通関係資料

(1) 首都圏交通の現状と対策 1970. 7　　SEOUL特別市

(2) 首都圏交通調査資料　　SEOUL特別市

(3) SEOUL 特別市街路交通状態調査報告書（起終点及び交叉路調査）

SEOUL特別市

(4) SEOUL 特別市道路混雑度及び走行速度調査分析報告書　　SEOUL特別市

(5) SEOUL 市内の一般道路及び高速道路整備計画　　SEOUL特別市

(6) 道路の管理体制　　SEOUL特別市

(7) SEOUL 市 ZONE 別常住人口状況及び将来予測　　SEOUL特別市

| | | |
|---|---|---|
| (8) | SEOUL 市 各区別学生数（高校以上） | |
| | SEOUL 市 各区別就業者数 | SEOUL特別市 |
| (9) | SEOUL 市 ZONE 別学生数（高校以上），就業者数 | |
| | 現況及び将来予測 | SEOUL特別市 |
| (10) | SEOUL 市 ZOME 別流出入交通量（全日） | |
| | 〃 （昼間） | SEOUL特別市 |
| (11) | SEOUL 市 BUS 路線通過台数現況 | SEOUL特別市 |
| (12) | 石 油 類 税 | SEOUL特別市 |
| (13) | SEOUL 中心市外バス路線別運行回数表 | 京畿道バス組合 |

4 鉄道関係資料

| | | |
|---|---|---|
| (1) | KOREAN RAIROAD TODAY | 鉄 道 庁 |
| (2) | 首都圏交通調査資料 1及び2 | 鉄 道 庁 |
| (3) | 鉄道時刻表 1970．9月号 | 市 販 |
| (4) | 鉄道時刻表 1970．4．1 | 鉄 道 庁 |
| (5) | 列車ダイヤ | 鉄 道 庁 |
| (6) | 列車運転施行手続 | 鉄 道 庁 |
| (7) | 首都圏電化計画 | 鉄 道 庁 |
| (8) | 産業線電鉄化概況 | 鉄 道 庁 |
| (9) | 電鉄化施設基準 | 鉄 道 庁 |
| (10) | 線路統計現況表 | 鉄 道 庁 |
| (11) | 駅新設改良，ホーム扛上計画一覧表 | 鉄 道 庁 |
| (12) | 電鉄変電設備施行標準 | 鉄 道 庁 |
| (13) | 信号保安設備数量現況表 | 鉄 道 庁 |
| (14) | 通信回線現況表 | 鉄 道 庁 |
| (15) | SEOUL 工作廠概況 | 鉄 道 庁 |
| (16) | 電気供給規程同細則 | 鉄 道 庁 |
| (17) | LONG RANGE LOAD FORECAST 1969.11 | 韓国電力 |
| (18) | SEOUL 中心貨物流動状況 | 鉄 道 庁 |
| (19) | 貨物 TERMINAL の概略 | 鉄 道 庁 |
| (20) | 速度制限表 | 鉄 道 庁 |

5 施工関係資料

| | | |
|---|---|---|
| (1) | コンクリート標準示方書解説 | 大韓土木学会 1969年 |
| (2) | 鋼道路橋設計標準示方書解説 | 大韓土木学会 1964年 |

6. 図 面

| | | |
|---|---|---|
| (1) | SEOUL 首都圏図 | { 1/250,000<br>1/50,000 |

| | | |
|---|---|---|
| (2) | 街路現況図 | 1/50,000 |
| (3) | 街路網計画図 | 1/25,000<br>1/50,000 |
| (4) | 土地利用計画図 | 1/50,000 |
| (5) | 道路計画，住宅計画 | 1/50,000 |
| (6) | 人口密度図 | 1/50,000 |
| (7) | 道路構造物現況図 | 1/25,000 |
| (8) | SEOUL 駅平面図 | 1/1,000 |
| (9) | 清涼里駅平面図 | 1/1,000 |
| (10) | SEOUL 市内平面図 | 1/3,000 |
| (11) | SEOUL 特別市行政区域図 | 1/25,000 |
| (12) | 新編 SEOUL 特別市全図 | 1/5,000 |
| (13) | SEOUL 市地下埋設物現況図 | |
| | 下水<br>上水 | 1/25,000 |
| | ガス<br>電気 | 1/9,000 |
| | 通信 | 1/25,000 |
| (14) | 高架，高速道路計画，現況図 | 1/50,000 |
| (15) | 線路一覧略図（関係区間） | |
| (16) | 線路縦断面図（〃） | |
| (17) | 線路平面図（〃） | |
| (18) | 停車場平面図（〃） | |
| (19) | 京仁地区送電系統図（概要） | 1/150,000 |
| (20) | 京仁地区送電系統図（詳細） | 1/150,000 |
| (21) | 信号機建植位置図 | |
| (22) | 市外通信線距離隔図 | |
| (23) | 車輛検修設備配置及平面図 | |
| (24) | 全国送電系統図 | |
| (25) | SEOUL 市変電所位置図 | |
| (26) | SEOUL 市中心部通信線路位置図 | |
| (27) | SEOUL 市中心市外バス路線網図 | 京畿道バス組合 |

7 日本の参考資料

(1) 東京人の生活行動（中間報告）

—昭和43年度パーソントリップ調査結果より—

1969 東京都首都整備局

(2) 都市交通年報　　　　　　　　　　　　　運 輸 省

(3) 鉄筋コンクリート鉄道高架橋の経済的設計に関する研究

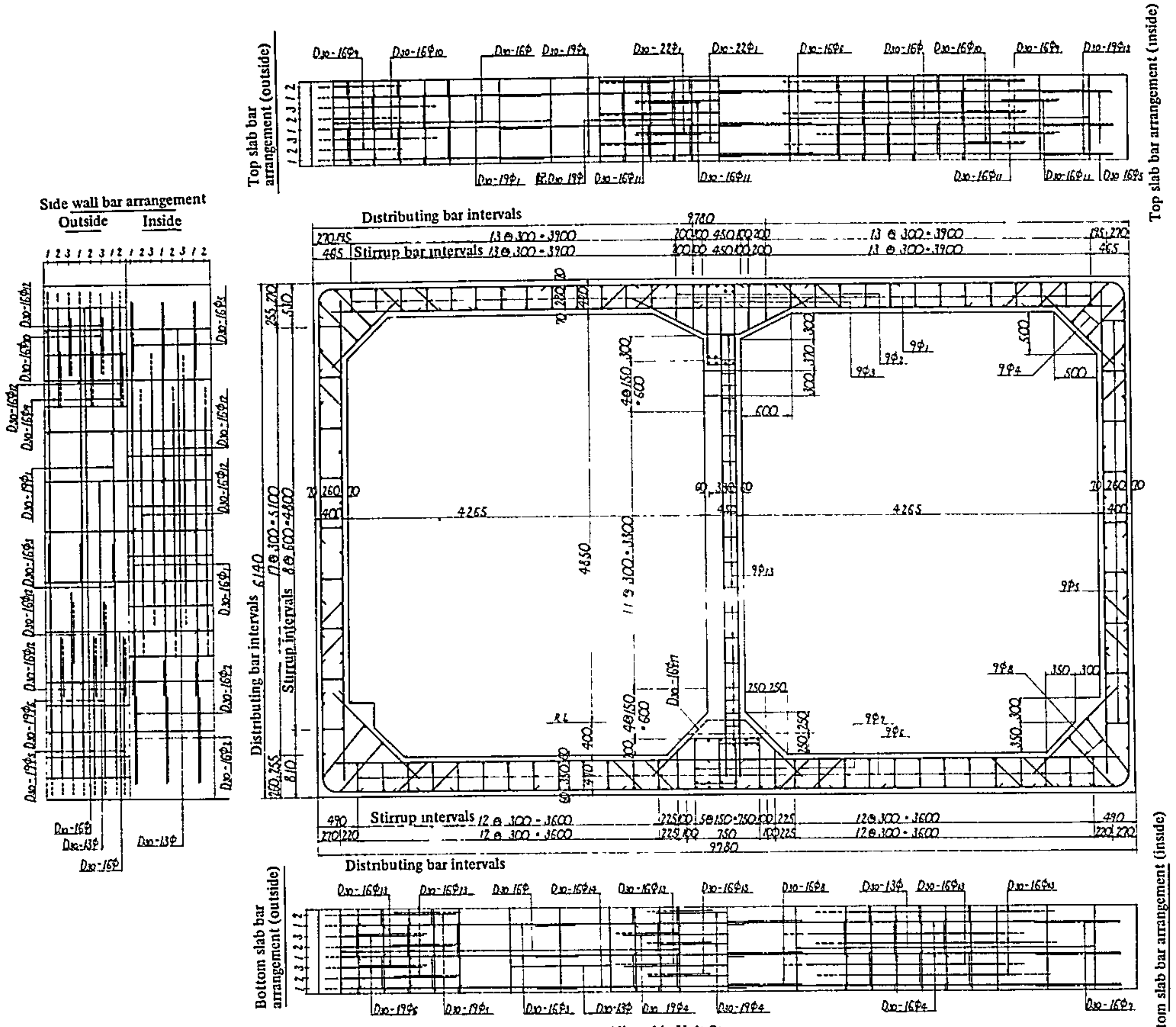
鉄道技術研究報告 №30 July 1962

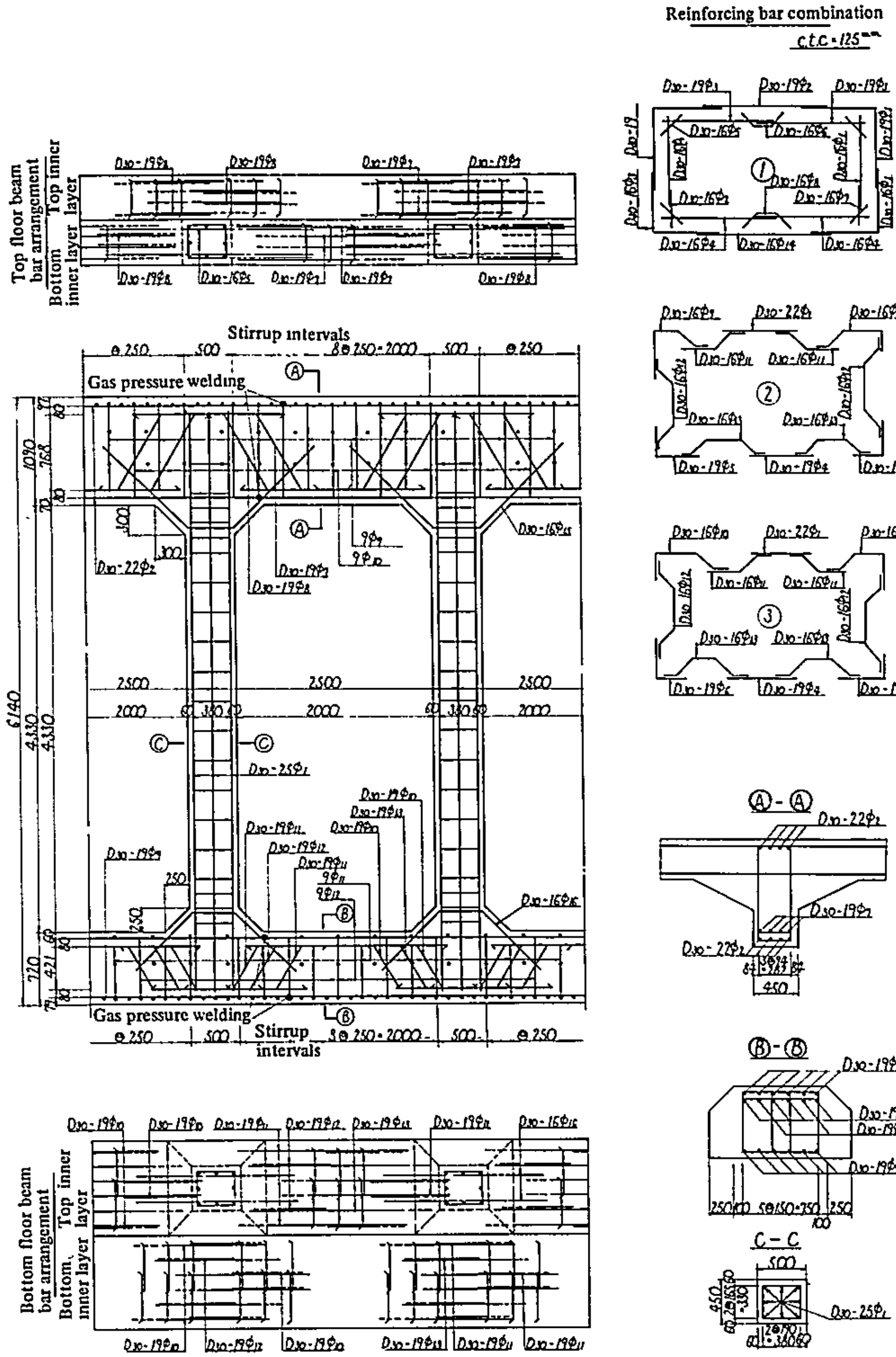
河 野 通 久

(4) 新幹線標準ラーメン高架橋の設計について

土木学会論文集 №15 March 1965

河 野 通 久 , 松 本 嘉 司

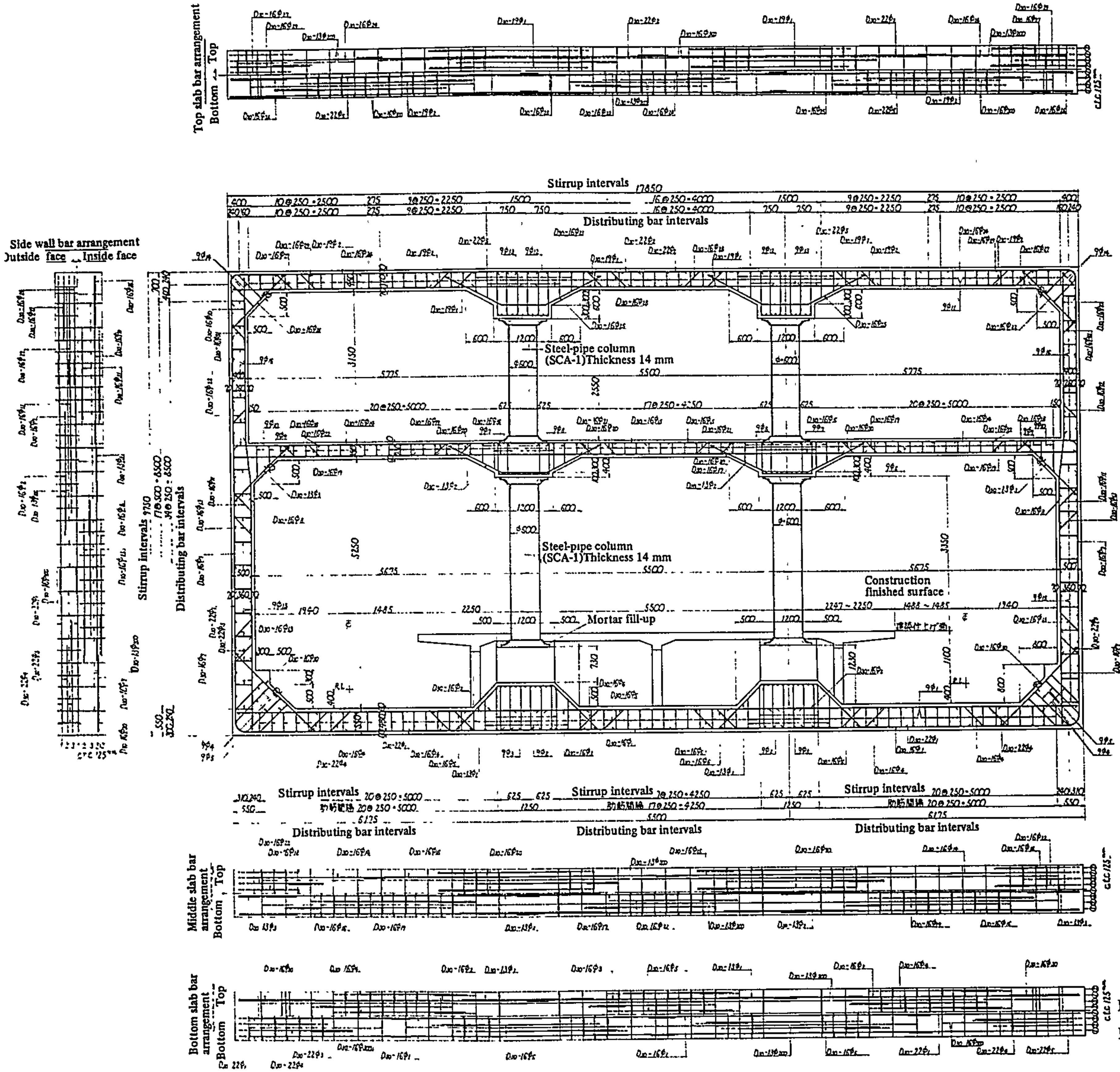


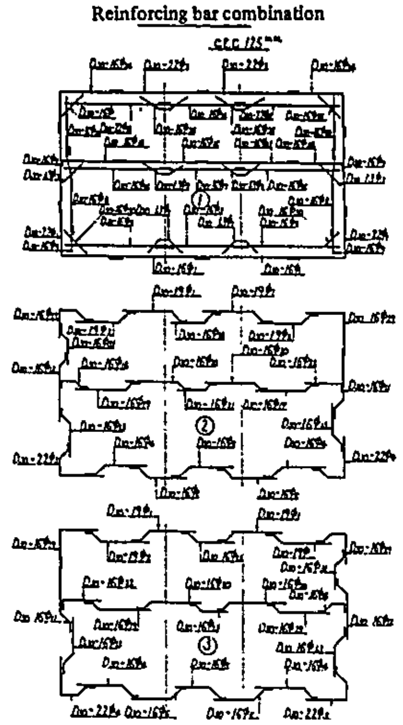




**Allowable Unit Stress**

| | | $\sigma_{CK}$= 210 kg/cm² | | | Allowable unit stress |
|---|---|---|---|---|---|
| Concrete | Bending compressive stress | | | | 70 kg/cm² |
| Concrete | Shearing stress | When diagonal reinforcement is not calculated | | Slab | 8.5 kg/cm² |
| Concrete | Shearing stress | When diagonal reinforcement is not calculated | | Girder | 6.5 kg/cm² |
| Concrete | Shearing stress | When diagonal reinforcement is calculated | | Girder | 18.5 kg/cm² |
| Concrete | Adhesive stress | Ordinary round steel | | | 7.5 kg/cm² |
| Concrete | Adhesive stress | Deformed round steel | | | 15 kg/cm² |
| Concrete | Supported stress | | | | 63 kg/cm² |
| Steel bar | Tensile stress and compressive stress | | | SR 24 | 1400 kg/cm² |
| Steel bar | Tensile stress and compressive stress | | | SD 30 | 1600 kg/cm² |

Reference Drawing 1 Bar Arrangement for Double Track Portion



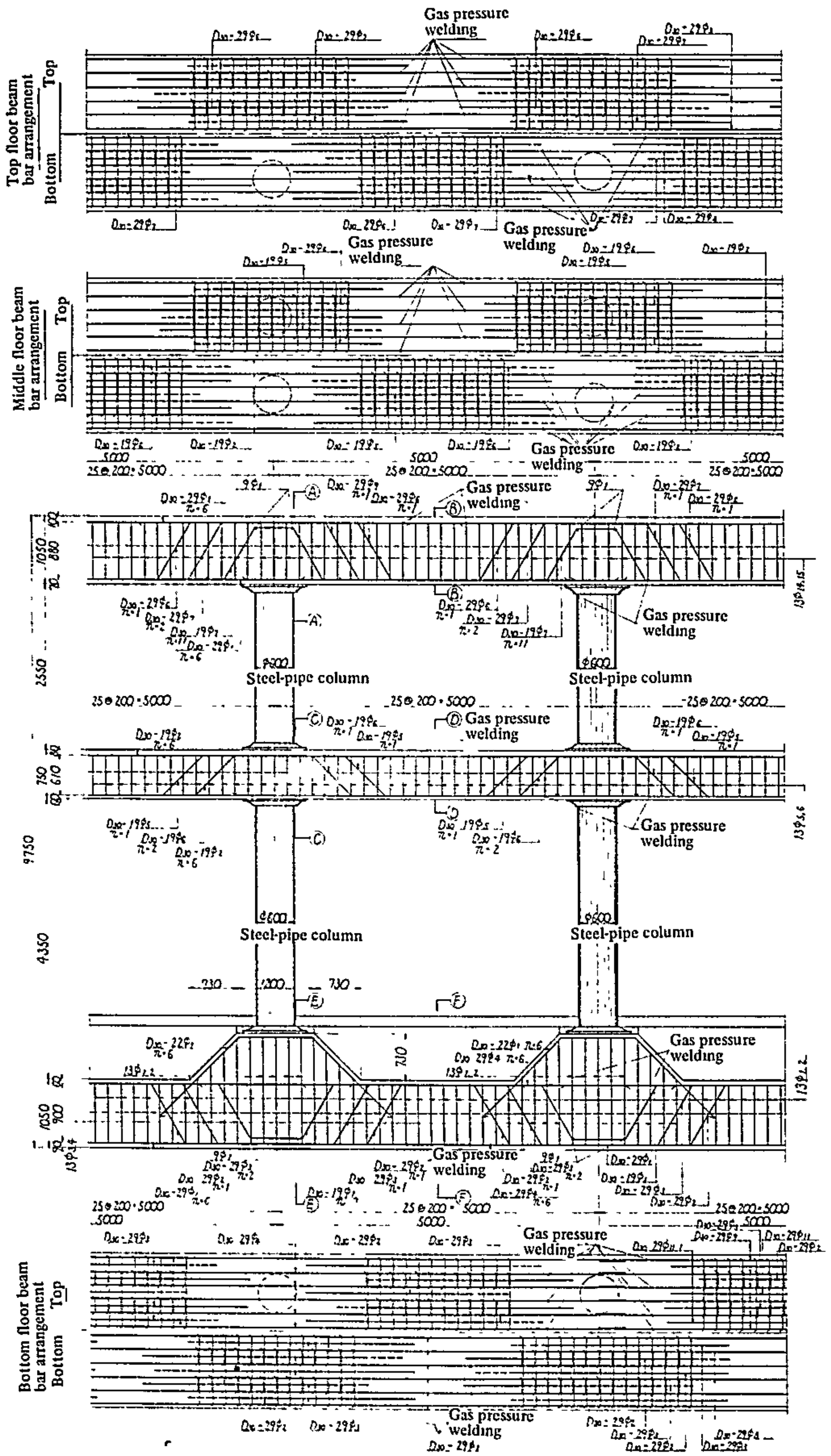




Allowable Unit Stress

| | | $\sigma_{CK}$= 210 kg/cm2 | | Allowable unit stress |
|---|---|---|---|---|
| Concrete | | Bending compressive stress | | 70 kg/cm2 |
| | Shearing stress | When diagonal reinforcement is not calculated | Slab | 8.5 kg/cm2 |
| | | | Girder | 6.5 kg/cm2 |
| | | When diagonal reinforcemnt is is calculated | Girder | 18.5 kg/cm2 |
| | Adhesive stress | Ordinary round steel | | 7.5 kg/cm2 |
| | | Deformed round steel | | 15 kg/cm2 |
| | Supported stress | | | 63 kg/cm2 |
| Steel bar | Tensile stress and compress stress | | SR 24 | 1400 kg/cm2 |
| | | | SD 30 | 1600 kg/cm2 |

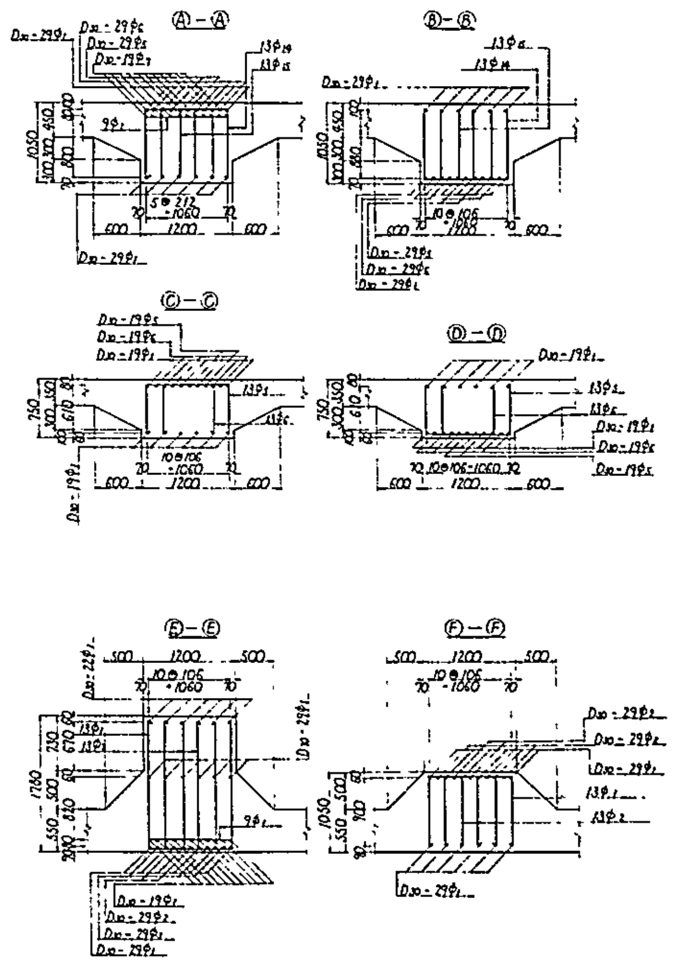
Reference Drawing 2

Example 1 of Bar Arrangement for Island Platform Station




### Allowable Unit Stress

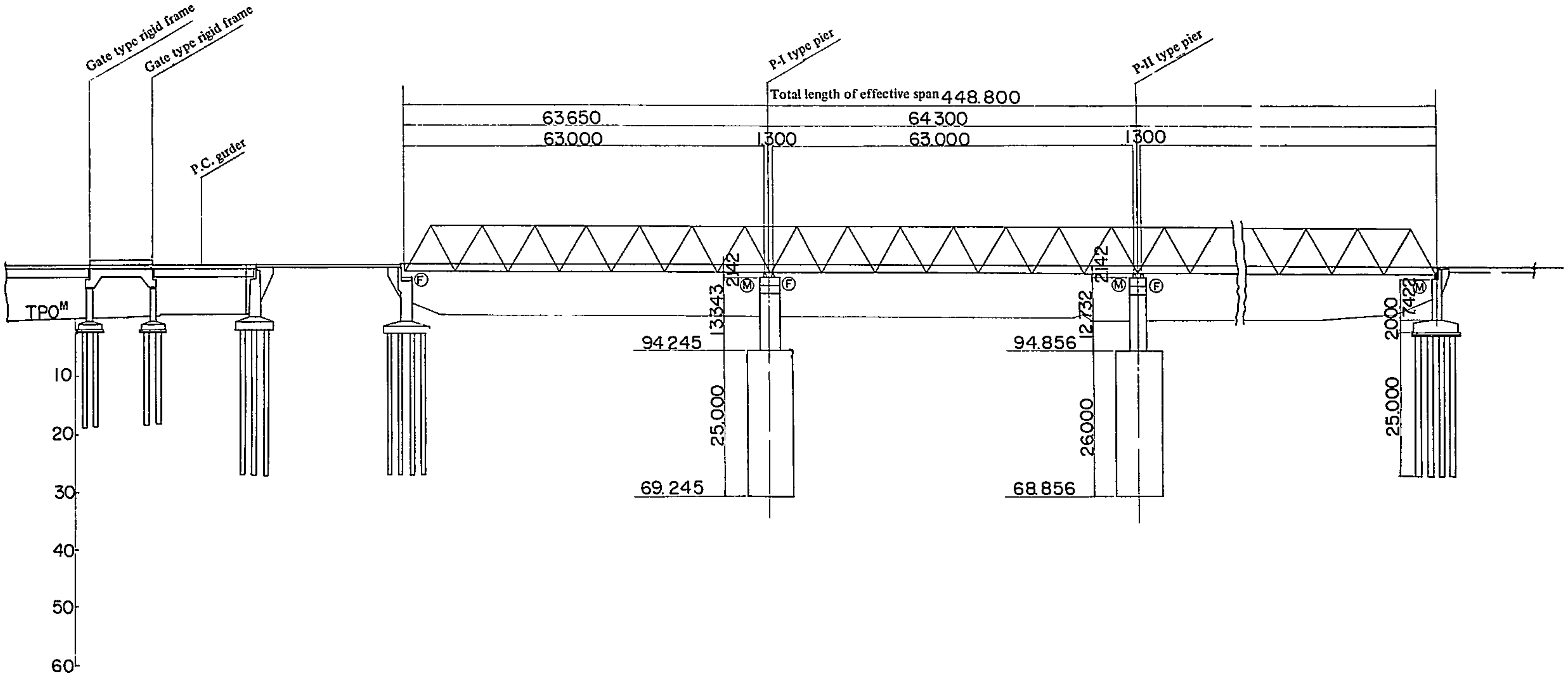
| | | | | |
|---|---|---|---|---|
| $\sigma_{CK}$= 210 kg/cm² | | | | Allowable unit stress |
| Concrete | Bending compressive stress | | | 70 kg/cm² |
| | Shearing stress | When diagoanl reinforcement is not calculated | Slab | 8.5 kg/cm² |
| | | | Girder | 6.5 kg/cm² |
| | | When diagonal reinforcement is calculated | Girder | 18.5 kg/cm² |
| | Adhesive stress | Ordinary round steel | | 7.5 kg/cm² |
| | | Deformed round steel | | 15 kg/cm² |
| | Supported stress | | | 63 kg/cm² |
| Steel bar | Tensile stress and compress stress | | SR 24 | 1400 kg/cm² |
| | | | SD 30 | 1600 kg/cm² |




Reference Drawing 2 Example 2 of Bar Arrangement for Island Plarform Station

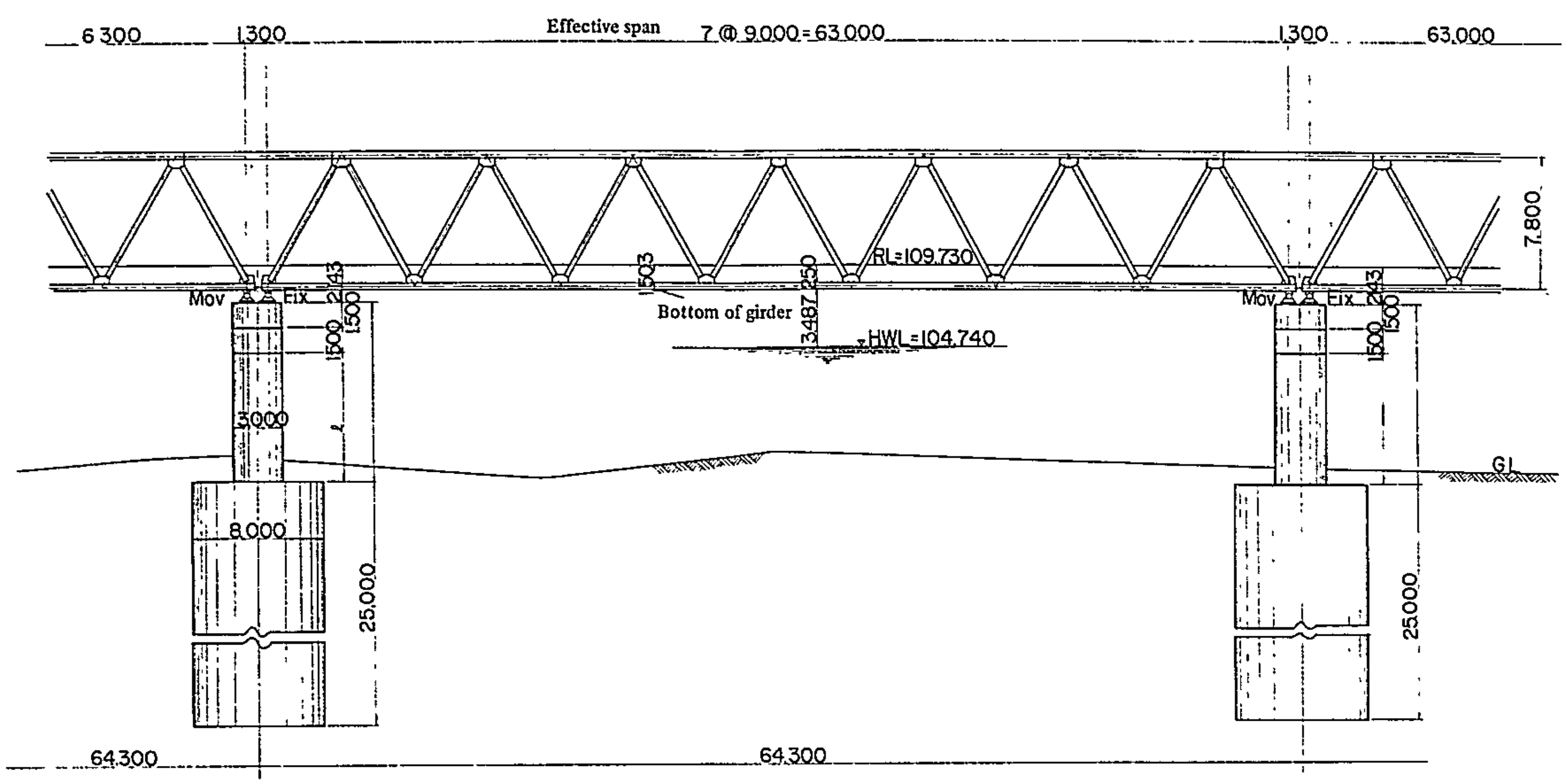
## Reference Drawing 3  Example 1 of Bridge Design

Longitudinal Section

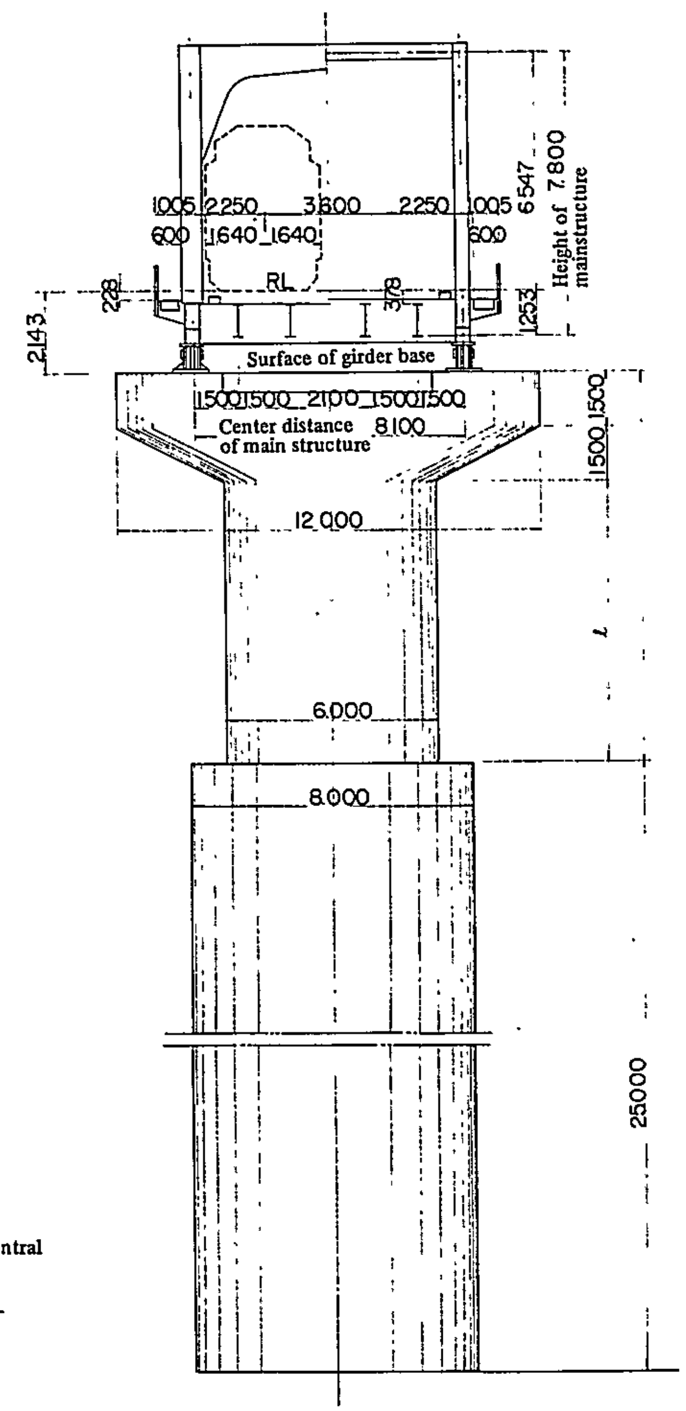


## Reference Drawing 3　Example 2 of Bridge Design

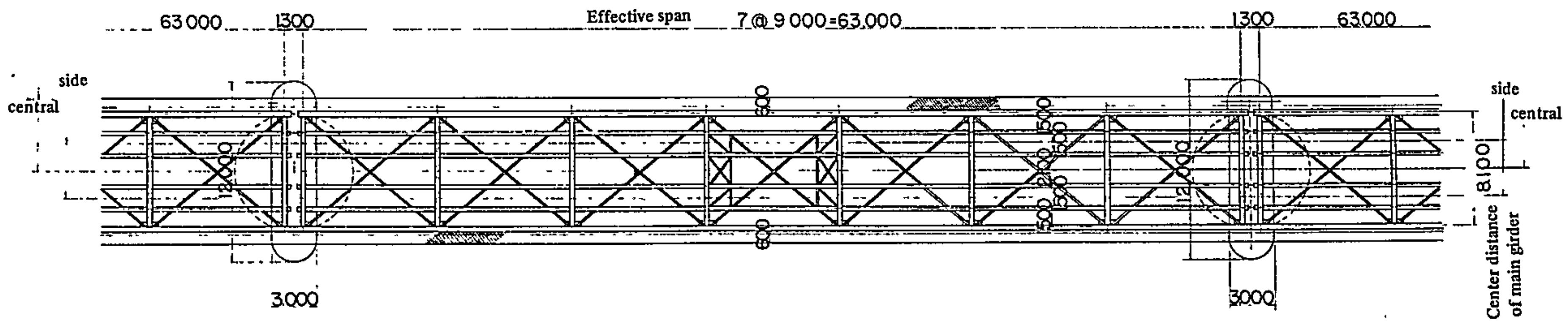
Side Elevation



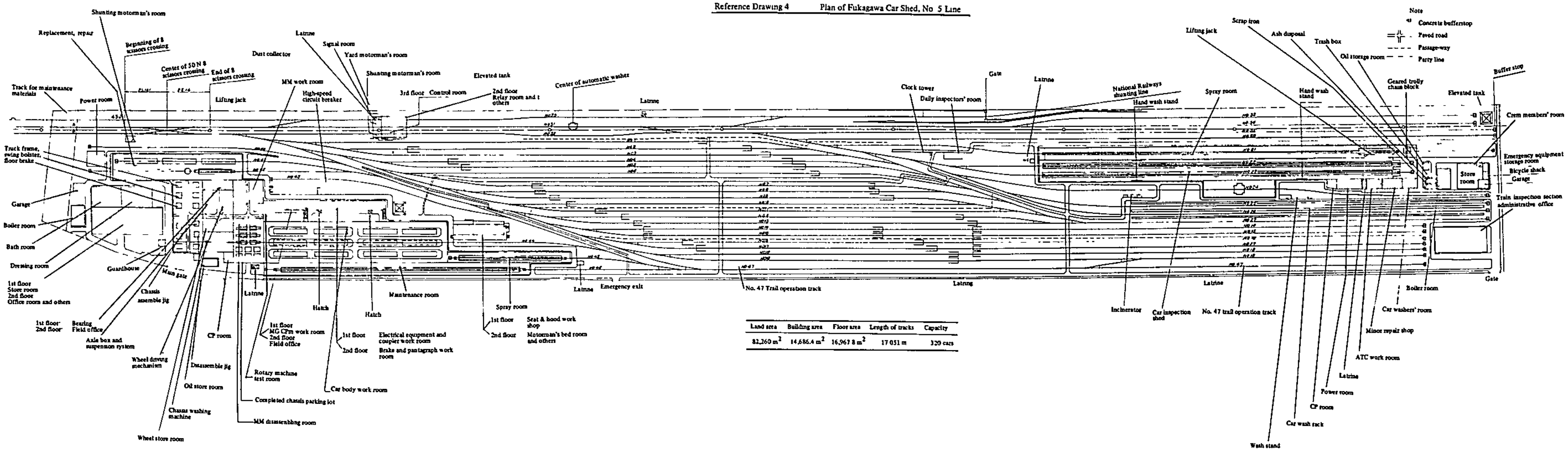

Section




Plan



Reference Drawing 4 Plan of Fukagawa Car Shed, No 5 Line




| Land area | Building area | Floor area | Length of tracks | Capacity |
|---|---|---|---|---|
| 82,260 $m^2$ | 14,686.4 $m^2$ | 16,967 8 $m^2$ | 17 051 m | 320 cars |