THE ISLAMIC REPUBLIC OF PAKISTAN

FEASIBILITY STUDY REPORT
ON
THE ELECTRIFICATION OF
KARACHI SUBURBAN RAILWAY
AND
PRELIMINARY FEASIBILITY STUDY REPORT
ON
RAPID TRANSIT SYSTEM

MARCH 1977

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of ESCAP and the Government of Pakistan, the Government of Japan decided to conduct a feasibility study for the Electrification Project of the Karachi Suburban Railway, and the Japan International Cooperation Agency (JICA) conducted the study.

In view of the importance of the Project, JICA organized a study team consisting of 9 experts headed by Mr. Hiroshi Yoshimura, Executive Director of the Japan Association of Signal Industries, and sent it to Pakistan for a period of 35 days from November 24 to December 28, 1974.

The team studied the improvement and electrification of the said suburban railway, and simultaneously conducted the preliminary study on the Rapid Transit System at the earnest request of the Pakistani side.

The draft feasibility study report, being prepared in Japan, was submitted to the Government of Pakistan in July 1975, while the comments on the draft report were received in June 1976 and the answers thereto were sent to the Government of Pakistan in December 1976.

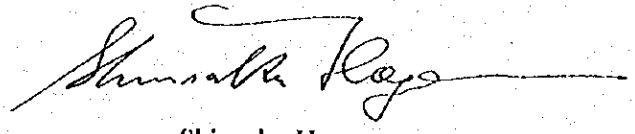
Thus, we have come to finalize the report with all the necessary amendments or modifications being completed.

This report has been prepared on the basis of the results of the study which had been conducted in accordance with the original purpose of exploring the technical and economical feasibilities of the improvement and electrification of the existing railway lines in Karachi and its vicinity. Therefore, this report may not fully meet the need of the Pakistani side that the priority should be given to the study on the Rapid Transit System, which was raised while the study was under way, but we are confident that the aforementioned Project will also play an important role as part of the Rapid Transit System Project.

I sincerely hope that this report will contribute to the development of the Integrated Mass/Rapid Transit System in the Karachi Metropolitan Area and serve to promote friendly relations between Pakistan and Japan.

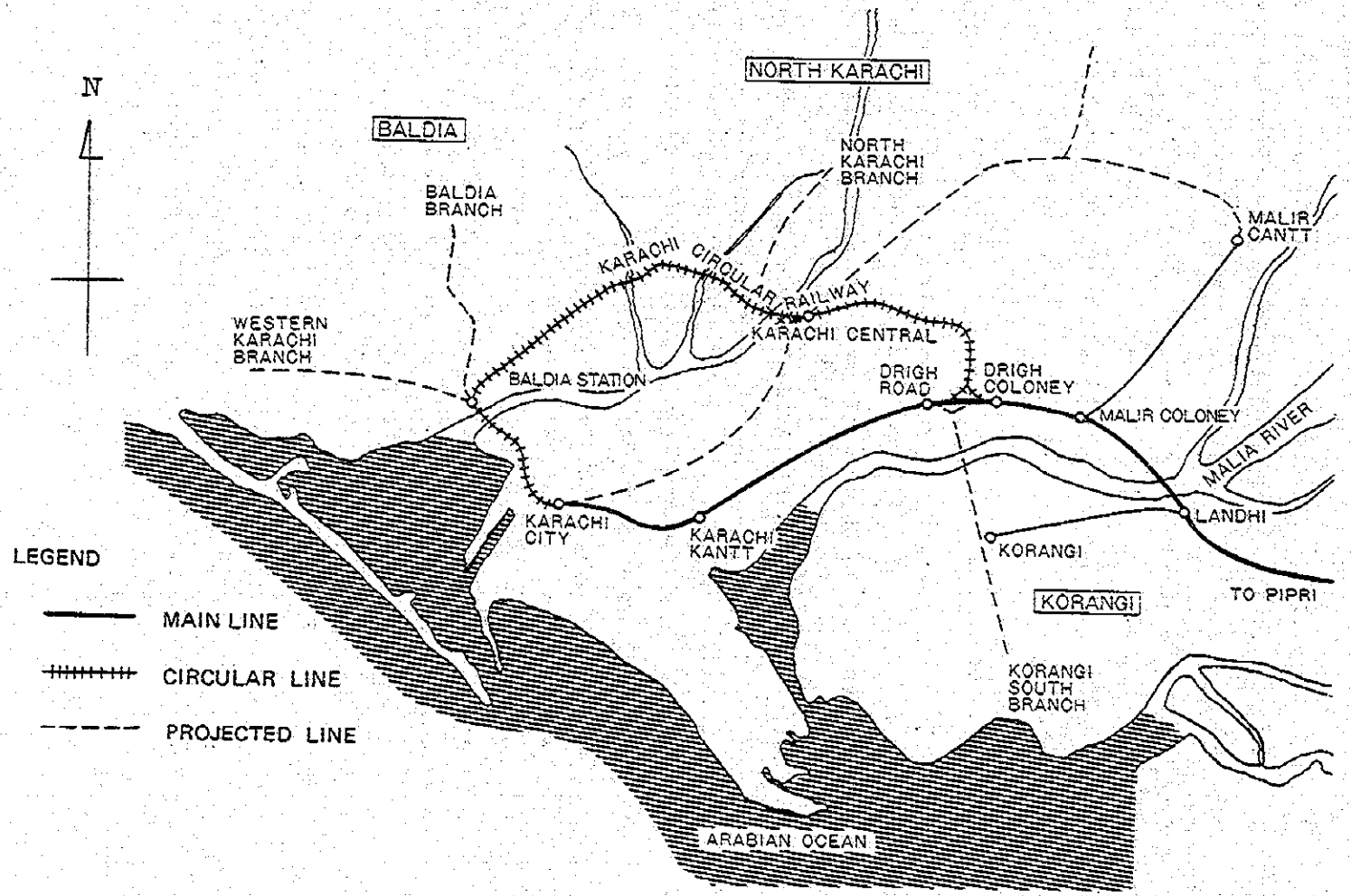
Finally, I would like to express my deep appreciation to all the staffs who participated in this study and to express my heartfelt gratitude to the authorities concerned of the Government of Pakistan for the cooperation extended to the team.

March 1977



Shinsaku Hogen
President
Japan International Cooperation Agency
Tokyo Japan

ROUTE MAP OF KARACHI SUBURBAN RAILWAY



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INTRODUCTION

1. DEVELOPMENTS OF THE STUDY

(1) This feasibility study was inaugurated in 1967 by the 15th meeting of the Transportation and Communications Committee of ECAFE as part of the so-called Trans-Asian Railway Network Project to form an international trunk line from Teheran to Bangkok by linking the railways of all countries concerned.

In the 21st meeting of the same committee in 1972 and the 29th general assembly of ECAFE held in Tokyo in April, 1973, delegates from Japan emphasized the pressing need for the modernization and improvement of the efficiency of existing railways rather than the construction of new lines to form this link. This opinion, accepted by member countries, was based on the results of studies so far conducted under the leadership of Japan on the present situation and the feasibility of linking existing railways. In the same general assembly of ECAFE, the Japanese delegation stated that it was willing to send a study team to carry out a comprehensive study and this was well received by member countries.

(2) In the 22nd meeting of the Transportation and Communications Committee held in January, 1974, the Japanese delegation stated, on the basis of the conclusion of (1), that it was willing to continue with at least one or two studies every year. As a result of this, Japan was requested to carry out studies on the improvement and modernization of Bangladesh Railways and the extension project of Thailand Railways as well as the study on railway electrification to ease commuter transport in the Karachi Metropolitan Area in Pakistan. Upon these requests, the Japanese delegation declared that it was willing to send study teams as soon as possible.

(3) In February, 1974, a formal request for the sending of a study team to Pakistan was made to the Japanese Government by the Pakistani Government. In this request, a study on transportation other than by railway was also requested because of the need to investigate passenger traffic flow in the light of the overall traffic system even if the study were to be restricted only to railways.

Though the request covered studies on the electrification and extension of the existing circular line, the utilization of existing transportation facilities in Karachi, the extension of the traffic network

by the construction of underground or elevated railways, the introduction of trolley buses or streetcars, etc., the Pakistani Government had no objection to the fact that the scope of studies conducted by the Japanese study team would be limited to railways under the agreement with ECAFE.

Under these circumstances, the survey team notified the Pakistani Government, for the purpose of defining the scope of study, its intention that the study was to be limited to (1) electrification of the existing circular line in Karachi and (2) development of railways within a 10-mile radius of Karachi. The Pakistani Government made no objection to this. As a result, the preliminary study was conducted mainly in and around Karachi for about three weeks from March 15, 1974.

(4) Before returning to Japan, the preliminary study team prepared an interim report and delivered it to the Pakistani Government, recommending (1) that existing facilities should first be fully utilized because the circular line (KCR) was a single line where both train frequency in rush hours and train running speed were low although the main line was a double line having a considerable utilization factor and also because the train operation system of KCR was not complete; (2) that level-crossings in KCR totaling 29 should be grade-separated with a view to speeding up train operation; and (3) that the electrification, which would be very effective in speeding up train operation and increase the traffic capacity, should necessarily be promoted positively, but modernization, such as signal automation, relay interlocking, the adoption of CTC, etc., in combination with electrification would be more effective, and that an DC electrification system would be more advisable. In addition to these major recommendations, the requirements of railway passenger facilities and coordination with railway freight transport for construction of three new lines as well as the problems of choosing between elevated and underground railways for the construction of a transit spine were pointed out in the interim report.

(5) In November, 1974, the present feasibility study team visited Pakistan to study the technical and economic feasibility of electrification and other improvements of the existing railway main line and the circular line in the Karachi Metropolitan Area (within a radius of about 10 miles) under the decision of the Japanese Government based on the aforementioned agreement of ECAFE and the present agreement. The study team explained the object of its study to the Pakistani Government.

(6) However, the Pakistani Government had already studied the rapid transit system (RTS) in the Karachi Metropolitan Area through an organization called "RTS Cell".

In this RTS plan, the construction of a spine between Karachi City and Liaqatabad City as well as of three new lines (North Karachi Branch, Baldia Branch and Koranghi Branch) with a view to connection with existing lines is contemplated in addition to electrification and other improvements of the existing main line and KCR. Some differences between the study team and the Pakistani Government were therefore inevitable.

Admittedly, the Pakistani Government fully understood that the proposal of the study team had been agreed to by ECAFE, but insisted that only electrification and improvement of the existing main line and KCR would be insufficient and that the construction of new lines should be performed first.

The study team insisted upon the study as originally planned; but the Pakistani Government stood firm.

(7) The study team asked the Japanese Government for instructions through the Japanese Embassy in Pakistan and obtained the reply indicating that in substance, the study on technical and economic feasibility of electrification and other improvements of the existing main line and KCR should be executed as originally planned, but that a preliminary feasibility study on the construction of the spine and three new lines could be undertaken with the intentions of the Pakistani Government taken into consideration. The study team notified the Pakistani Government to this effect.

As a result, mutual agreement between the study team and the Pakistani Government was reached.

The contents of this agreement were submitted in writing to the Pakistani Government by the Japanese Embassy in Pakistan to define the new scope of the work. In addition, to define the future plans relating to the RTS, a planned railway route map of the proposed rapid transit system in the Karachi Metropolitan Area was prepared and signed by both the leader of this study team and the responsible person from RTS Cell.

2. PURPOSE AND CONTENTS OF STUDY

2-1. Purpose of Study

The purpose of this study is to execute an economic and technical feasibility study on the establishment of a rapid transit system relating to existing railway main line and KCR in the Karachi Metropolitan Area (within a radius of 10 miles) and also to execute a preliminary feasibility study on the construction of a spine and three new lines included in the city development plan established in 1971 by Karachi Development Authority (KDA) in view of the increasing growth of the Karachi Metropolitan Area. Both studies are executed by the Japanese Government on request from the Pakistani Government.

2-2. Contents of Study

The contents of the study required for the aforementioned purpose are as follows:

(A) Spine and Karachi Circular line extensions:

(1) Review of the city development plan established by KDA for the period of 1969 to 1974.

(2) Site investigation of set routes.

(3) Considerations on method of construction of ideal permanentway structure, formation, etc., and electrification system.

(4) Examination of most suitable method of connection with existing railways.

(5) Examination of layout and capacity of rolling stock, repair shops and workshops.

(6) Investigation on elimination of troubles in telecommunication circuits.

(7) Survey of structural foundations and underground obstacles along set routes.

(8) Investigation of performance ability of construction equipment, laborers and local contractors.

(9) Examination of problems for acquisition of land.

(10) Investigation on the financial aid policy of the Pakistani Government.

(11) Review of data of forecast demand for railway traffic.

(B) Introduction of rapid transit system into existing railways (main line and KCR):

(1) Investigation of performance ability of construction equipment, laborers and local contractors.

(2) Investigation on supply and demand of electric power.

(3) Examination of the present situation of traffic and for the solution of problems:

(a) Organization and administration of the Karachi Regional Office of Pakistan Railways.

(b) Present situation of railway transport (passengers and freight and demand for railway traffic.

(c) Investigation on actual conditions of railways, such as operation facilities, rolling stock, etc.

(d) Investigation on the present situation of other means of traffic (buses, streetcars, taxis, etc.).

(4) Economic survey:

The following items should be examined on the basis of data furnished by the Pakistani Government:

(a) Effects of electrification and other improvements in the Karachi Metropolitan Area.

(b) Forecast of demand for railway traffic.

(c) Prospects of the railways amongst all means of traffic.

(5) Establishment of a railway traffic plan.

(6) Establishment of a plan for electrification and other improvements of railways.

(7) Coordination of the aforementioned plans with transport and development plans of the Pakistan Railway.

(8) Outline design and estimation of construction costs.

(9) Economic evaluation:

(a) Estimation of benefit.

(b) Cost-benefit analysis.

(c) Internal rate of return.

3. ORGANIZATION OF STUDY TEAM

Leader: Hiroshi Yoshimura ..... General
Non-regular staff member of JARTS
Executive director of Japan Associations of Signal Industries

Member: Hiroshi Kobayashi ..... Civil Engineer
Non-regular staff member of JARTS
Chief of Planning Sec.,Track & Structure Dept., Tokyo Minami Railway Operating Division, JNR

Member: Hachiro Shibata ..... Civil Engineer
Non-regular staff member of JARTS
Chief of Planning Sec. Track & Structure Dept. Tokyo Minami Railway Operating Division JNR

Member: Hachiro Shibata ..... Civil Engineer
Non-regular staff member of JARTS
Deputy director of 2nd Engineering Dept. of Fukuken Engineering Inc.

Member: Tetsuei Mochizuki ..... Electrical Engr.
Non-regular staff member of JARTS
Assistant Chief of Planning Division, Electrical Engineering Dept.,JNR

Member: Ryoichi Harada ..... Train Operation & Rolling Stock
Non-regular staff member of JARTS
Assistant Chief of Safety Division, Train Operation Dept.,JNR

Member: Hiroyuki Tsukamoto ..... Traffic Demand
Non-regular staff member of JARTS
Deputy Director of Corporate Planning Dept.,JNR

Member: Ryujiro Yamagishi ..... Economic Evaluation
Non-regular staff member of JARTS
Chief Researcher of Economic Dept., Institute of Transportation Economics

Member:	Akira Yasuzawa		Organization Management
	Deputy Director of JARTS		
Member:	Koh Mogi		Coordinator
	Technical councilor of Investigation and Research Dept., Japan International Cooperation Agency		

4. SCHEDULE OF STUDY TEAM (in 1974)

November:

24 (Sun.) - Departed from Tokyo and arrived at Karachi.

25 (Mon.) - Visited the Japanese Consulate-General at Karachi to pay courtesy and explain the contents of the study; discussed various matters with members of the RTS Cell, Pakistani Party.

26 (Tue.) - Departed from Karachi and arrived at Islamabad; visited the Japanese Embassy in Pakistan; made arrangements and deliberated on the contents of study with the Pakistani Government.

27 (Wed.) - Visited the Pakistani Ministry of Communication to deliberate on the basic scope of study.

28 (Thu.) - Visited the Ministry of Communication to discuss existing data.

29 (Fri.) - To prevent the waste of study time through prolonged negotiations, the team was divided into two gorups, and Kobayashi and other four members departed for Lahore as scheduled.

30 (Sat.) - (1) First group composed of Leader, Mochizuki, Yasuzawa and Mogi visited Japanese Embassy and Ministry of Communication.

(2) Second group composed of Kobayashi, Tsukamoto, Shibata, Harada and Yamagishi visited the Head Office of Pakistan Railways to pay their respects and made site investigation of the existing electrified section.

December:

1 (Sun.) - (1) First group deliberated on measures to be taken.

(2) Second group arranged data.

2 (Mon.) - (1) First group deliberated on measures in the Japanese Embassy.

(2) Second group departed from Lahore and arrived at Karachi.

3 (Tue.) - (1) First group prepared proposed scope of work in the Japanese Embassy.

(2) Second group visited sites of KCR and main line.

4 (Wed.) - (1) First group visited the Ministry of Communication to deliberate on the proposed scope of work and obtained outline agreement.

(2) Second group visited the proposed site of construction of new lines.

5 (Thu.) - (1) First group departed from Islamabahd and arrived at Karachi.

(2) Two groups were rejoined and details of the negotiations with the Ministry of Communication were reported to the second group. Scope of future study was examined.

6 (Fri.) - Discussed outline and relation to RTS of the master plan at KDA.

7 (Sat.) - Ascertained basic concepts for the railway with the RTS Cell at the Karachi Regional Office.

8 (Sun.) - Visited the proposed site of construction of the spine; discussed problems for the study with ESCAP.

9 (Mon.) - Ascertained contents of the KDA plan and basic concepts for the railway at KDA. Civil group conducted site investigation of KCR level crossings and discussed grade-separated crossings.

10 (Tue.) - Electrical, train operation and economic groups discussed the reply to the previously submitted questionnaire at KDA. Civil group made site investigation of KCR level crossings.

11 (Wed.) - Train operation group visited rolling stock repair facilities. Electrical group heard a talk about the current electric power situation at KESC. Economic group requested data from the Karachi Regional Office.

12 (Thu.) - Train operation, electrical and civil groups visited train operation control facilities, CTC facilities and proposed route of spine, respectively. Economic group discussed future situation of traffic at KDA.

13 (Fri.) - Discussed basic concepts with Cell members in conference room of RTS Cell.

14 (Sat.) - Discussed train operations, forecast of future transport, etc. in conference room of RTS Cell. Electrical group made site investigation of block systems and crossing facilities of KCR. Civil group visited three new line routes.

15 (Sun.) - Held a meeting of all team members. Each group posed problems and solutions were discussed by all members.

16 (Mon.) - Economic group examined data collected in Cell conference room. The other groups visited sites to investigate electric power sources train handling and main line crossings, respectively.

17 (Tue.) - Train operation and economic groups discussed track capacity and future demand for railway transport, respectively, with Cell members. Electrical group visited KESC to discuss electric power source problems and the civil group visited sites to investigate track maintenance.

18 (Wed.) - Electrical group visited the Karachi Regional Office to investigate CTC signalling system. The other groups checked collected data in Cell conference room.

19 (Thu.) - Discussed the results of study with Cell and ESCAP members.

20 (Fri.) - Arranged a draft interim report on the basis of results of study.

21 (Sat.) - Prepared interim report; expressed compliments to the authorities and bodies concerned prior to return to Japan.

22 (Sun.) - Leader, Kobayashi, Tsukamoto and Mochizuki went from Karachi to Lahore to visit the Head Office of Pakistan Railways.

23 (Mon.) - Reported the results of study at the Japanese Embassy; discussed treatment of interim report; visited the Ministry of Communication to express compliments.

24 (Tue.) - Departed from Islamabad and arrived at Karachi; explain details of negotiations held at the Japanese Embassy to the Japanese Consul-General in Karachi.

25 (Wed.) - Departed from Karachi and arrived at Bangkok.

26 (Thu.) - Reported details of negotiations with the Pakistani Government to the Japanese Embassy at Bangkok and JICA.

27 (Fri.) - Reported details of negotiations with the Pakistani Government to ESCAP members concerned with railways; deliberated on method of preparation of future reports, etc.

28 (Sat.) - Departed from Bangkok and arrived at Tokyo.

6. ACKNOWLEDGEMENT

To all persons concerned, in particular to the following, who gave immeasurable cooperation and assistance to the study team, we would like to express our deep sense of gratitude:

ESCAP

Mr. S. Masood Husain	Chief, Transport and Communications Division
Mr. Toyohiko Matsumoto	Chief, Railway Section, Transport and Communications Division
Mr. Shwe Shane	Coordinator-cum-Consultant, Trans-Asian Railway, Transport and Communications Division
Mr. Hans J. Niess	Regional Railway Expert, Trans-Asian Railway, Transport and Communications Division

Ministry of Communication

H. E. Mr. K.T. Kidwai	Secretary
Mr. Bashir Ibrahim	Joint Secretary
Mr. Shahio Hasan	Statistical Officer

Pakistan Railways

Mr. S. S. Hasan	Chief Electrical Engineer, RTS Cell
Mr. S. M. H. Rizvi	Chief Civil Engineer, RTS Cell
Mr. Jafar Wafa	Transportation Officer, RTS Cell

K. D. A.

Mr. Abbas Hussain	Director General
Mr. A. H. Zaidi	Additional Director, Master Plan Department
Mr. Saeed Manzoor	Deputy Director (Transportation), Master Plan Department
Mr. Favidudoin Ahmad	Deputy Director (Urban & Regional Planning), Master Plan Department

SUMMARY AND RECOMMENDATION

1. SUMMARY OF THE NECESSITY FOR ELECTRIFICATION AND MODERNIZATION OF THE RAILWAYS

1-1. Present Situation of the Demand for Railway Traffic and Traffic Capacity

The study of Karachi Development Authority (KDA) conducted in 1971 indicates that the average railway passenger traffic per day in the environs of Karachi was 75,000 passengers. This feasibility study, made as of 1973, also shows a similar figure of 76,000 passengers, which is not a marked increase from the previous figure. This may be considered to be liable to the fact that the existing railway facilities do not provide a sufficient traffic service.

Observing this from the relationship between the railway traffic capacity and the demand, railway traffic capacity on the main line is estimated to be 53,000 passengers and that on the circular line (KCR) 16,000 passengers, while the demand for transportation, according to the study carried out by a United Nations team, is 60,000 passengers on the main line and 15,000 on the circular line. The circular line is operating at nearly full capacity but it is obvious that the capacity of the main line needs to be increased.

The above figures are those obtained when observed from an overall point of view, and their relation in the rush hours differs greatly; namely, the United Nations team clarified that about 80 per cent of 75,000 passengers carried were commuters, which possibly consisted of 48,000 and 12,000 passengers in the morning and afternoon rush hours (6:00 - 10:00 and 14:00 - 16:00) on the main and circular lines when observed individually.

The present traffic capacity of the main line and the circular line is estimated at 37,000 passengers and 11,000 passengers, respectively. Accordingly and based on these figures, it has been ascertained that the lines would not be able to cope with carrying the increased number of passengers as mentioned above.

1-2 Forecast on Future Passenger Traffic Volume

With regard to estimating future passenger traffic volumem this feasibility study set up three targets (the years 1982, 1987 and 2002) as

guide-posts to perform forecasting in relationship with the increasing traffic volume which will be described later in this report.

Namely, this feasibility study on the RAilway Modernization Project divides its construction schedule into Phase I which consists mainly of electrification and improvement and Phase II which is mainly to alter the main line into a four-track line and the circular line into a double-track line. It is assumed that Phase I will be completed by 1981, and in 1982 the two lines will have a traffic capacity more than double their existing capacity through speed up and reduction in the head way of trains resulting from electrication. And as the service thus improved can be assumed to induce further traffic demand, the present traffic volume will also double.

The Phase II construction work will be completed by 1986. With the effects of the completion of Phase II assumed to emerge from 1987, this feasibility study has modified the passenger traffic volume of 1985 proposed by RTS Cell, with consideration given to rail mileage and traffic volume. With regard to the passenger traffic flow in the year 2002, this has been determined with change made in a portion of the estimate for the year 2000, and with regard to those in the intermediate periods between targets and beyond 2002, it has taken into consideration the rate of population increase and the rate at which passengers transfer to the modernization railways from other transportation modes.

As a result of these calculations, a spiraling increase in railway passengers and passenger-kilometers is expected, i.e., from 1974's 7,500 passengers and 1,287,000 passenger-kilometer to 150,000 passengers and 2,697,000 passenger-kilometer in 1982; from 1987's 314,000 passengers and 5,819,000 passenger-kilometer to 752,000 and 14,590,000 in 2002, to 1,346,000 in 2012, and 26,926,000 in 2012, respectively.

As such, the existing railway traffic capacity is insufficient to meet the potential demand under the present circumstances, as well as future demand which is predicted to increase at an accelerating rate. In order to solve these problems, the electrification and modernization of the existing railways to make them capable of providing mass transport safely, timely and rapidly is necessary and for this reason the necessity for early electrification and modernization of the railways is strongly recommended.

2. CONCRETE MEASURES FOR ELECTRIFICATION AND MODERNIZATION OF THE RAILWAYS

2-1. General Description of this Project

The need for the electrification and modernization of the existing railways has been referred to in the preceding paragraph. This feasibility study has established the concrete measures, which should be adopted for the promotion of these needs, as described hereunder. The traffic in the Karachi Metropolitan Area is a pressing problem which must be solved in view of the rapidly increasing population and the expanding Metropolitan area. The remodelling of the existing Pakistan Railway lines into the mass rapid transit system should be promoted under the recognition that mass rapid transit system based on railway is the only means to solve this problem. The extension of the R/T spine and three other lines must also be envisaged as part of the mass rapid transit system. Remodelling to the mass rapid transit system is aimed at passenger transport, particularly commuters, but sufficient consideration is additionally given to freight transport. What is more important and urgent is to make best use of and modernize the existing main line (Karachi City - Pipri) and KCR. Modernization of these lines is aimed at the construction of an electrified double-track line on KCR and electrified four-track line on the main line. The section where the main line and KCR run on the same track (between Karachi City and Drigh Road) will be remodelled to a four-track line as part of the main line. This plan is established with consideration given to the relationship between the construction of electric car depots and a future freight yard at Pipri and also to the transit system of local passenger trains. This electrification covers the distance up to Pipri.

In view of the scale of the sclae of the construction, a considerably long time will be required before completion of this Project. Therefore, this work should proceed step by step in two phases as described hereunder.

2-2. Phase I: Modernization of Existing Railways (Electrification, Improvement of Signal System and Crossings, and Strengthening of Tracks)

In principle, the existing railways should be electrified in their present state while automatic signal, grade separation of level crossings and installation of automatic gates and strengthening tracks should be promoted so as to increase the running speed of trains and track capacity. The employment of an automatic signal system and automatic gates at level

crossings is essential in increasing the speed and frequency of trains and is important with respect to safety. Grade separation of level crossings can be effected either by elevating the railway or the road, and these two methods are under consideration. The scheduled time for the completion of Phase I falls on 1981.

The final draft of this feasibility study concluded that modernization of the existing railways would increase the train frequency of the main line to at least double its present capacity and that of the KCR line to about 5 times, and the running time between Karachi City and Pipri could be reduced by approximately 30 per cent.

2-3. Phase II: Remodelling of KCR to Form a Loop Line

With the completion of Phase II aimed for 1986, the remodelling of KCR to a double track should be initated, then that of the main line (Karachi City and Drigh Road) to a four-track line started to provide a loop line by connecting the added double track of KCR. In consequence, KCR and the main line can be operated independently on separate tracks. KCR trains should stop at every station and the main line trains run without stopping in the section from Karachi-Cantt to Drigh Road. The time for one running cycle of a train on KCR will be reduced by approximately 30 minutes when compared with that at present and about 15 minutes on the main line (Karachi City to Pipri). The minimum headway in the rush hours will be reduced to about 10 minutes on KCR and 7.5 minutes on the main line (Karachi to Landhi).

When Phase II has been completed this way, the overall traffic network well coordinated with bus lines and taxicabs should be organized in parallel to the progress of the modernization, thus it is obvious that KCR will help relieve the central metropolitan area and the major roads of traffic congestion. This also will serve as a useful measure to control road traffic pollution and to use energy efficiently; these are now creating serious social problems. In order to deal with such problems, buses must be permitted to enter all KCR stations and all stations must be provided with a plaza for taxicab parking. The rationalization of bus routes should also be promoted.

3. R/T SPINE AND EXTENSIONS (3 lines)

The concept of the mass rapid transit system previously described naturally covers the R/T spine and the extension of the three lines. The addition of these four lines to the existing lines to be modernized will enable systematic transport by the mass rapid transit system. Although the R/T spine will constitute one of the favorable routes passing through the central area of the city, no more than a partial effect can be seen with respect to the relief of metropolitan areas from traffic congestion, but the R/T spine would rather show its true worth by the effects of modernizing the KCR. Hence the modernization of the KCR should be the first project to start.

With regard to the extension of the three lines, it is desirable that it proceed together with the detailed progress of the urban development plan, but this might create a bottleneck in railway traffic if modernization of the KCR should not be realized.

4. CONSTRUCTION SCALE AND COST

The scale of construction, the speed of development and the growth of demand therefor will affect the time for the completion of the construction work, and could require a long period. For this reason this feasibility study divides this Project into two Phases; Phase I to be completed by 1981 and Phase II by 1986. In Phase I, electrification of the existing lines should be, in principle, carried out with the lines in their original state; the civil engineering works consist mainly of grade separation of level crossings and strengthening of tracks; the electrical works consist mainly of electrification, the employment of automatic signalling and the construction of electric car depots. In Phase II, the remodelling of the KCR to a double track and of the main line (Karach- City to Drigh Road) to a four track should be carried out; the civil engineering works consist mainly of the provision of new tracks, the construction of runover bridges and elevated bridges; the electrical works consist of the installation of new overhead contact lines and signals on the KCR. The costs required to complete these works are as given below; Alternative 1 shows the cost if the railways are to be modernized in their existing condition and Alternative 2 if part of the railway section, including level crossings with major roads, is to be constructed to provide elevated tracks.

ALTERNATIVE 1

(In thousand rupees)

	KCR	Main line	Electric Car Depot, Malir Br. etc.	Total
Civil engineering	443,800	1,207,333	129,500	1,780,633
Electric	215,367	328,333	129,700	673,400
Total	659,167	1,535,666	259,200	2,454,033

ALTERNATIVE 2

Civil engineering	1,811,433	1,207,333	129,500	3,148,266
Electric	215,367	328,333	129,700	673,400
Total	2,026,800	1,535,666	259,200	3,821,666

An additional Rs. 1,600,000 will be required for the procurement of 600 electric cars by 2012.

5. ADMINISTRATION AND MANAGEMENT

As a result of this feasibility study, it is estimated that traffic demand of the Karachi City as previously described in paragraph 1-2 of this report, will, in 1987, result in a traffic volume of about 4.2 times that of 1971 and, in 2002, of about 10 times. However, as is proposed by this study team, the present traffic capacities of the KCR line and the main line would be greatly increased and the train headways particularly in the rush hours would be reduced markedly as described in Chapter 4 of this report, by carrying out a series of such modernization schemes as the electrification of the existing KCR line and the making of this and the main line into a double-track and a four-track line respectively. For this purpose, and keeping pace with the increase in traffic services, considerably many more train operating personnel and track and electrical maintenance personnel would be required as well as a reinforcement of the administration which should be carried out in order to assure the safe operation of trains. The following describes how individual divisions should be administrered and operated.

5-1. Transportation and Train Operating Sectors

In addition to the booking clerk to be greatly increased in number, in order that passengers be protected and safely conducted in the rush hours, additional platform clerk should be employed. And in order to check booked tickets to prevent fraudulent riding, ticket examiner clerk would be required. Furthermore, additions to the operating clerk to assure normal operation of trains could not be avoided. Because station masters alone are not sufficient to provide smooth services, an administrative organization to assist station master should be established whereby individual responsibilities should be clarified. It is also recommended that such an organization as is capable of interconnecting the Regional Office and the stations so as to permit the complete transmission of orders and information and cope with the changing situation should be established, particularly a new passenger control organization should be realized and the existing train control organization reinforced.

5-2. Facilities Sector

With regard specifically to the maintenance of tracks, the increase of the train speeds and frequency track damage is predicted to increase. Therefore, more heavy and longer rails should be used; manual maintenence should be shifted to mechanical maintenance; the operational organization to sub-divide assigned sections should be re-organized; a fixed pattern for watching trains so as to protect maintenence staff while working should be established and proper time intervals to permit maintenance staff to work before and after the passing of trains should be assured.

5-3. Electrical Sector

With regard to the maintenance of the electrical system, the maintenance of the substation facilities should preferably be consigned to KESC as has been practiced so far. In order to strengthen the functions of Karachi Regional Office, a few more personnel should be employed and trained so as to cope with the maintenance of signals and communication systems. Addition of several more engineers should be assigned to Karachi Regional Office and this will be sufficient to fulfill the administration service, while about two electric power and communication control centers should be manned to control power, signal and communication systems such as the transformation of electricity and the transmission of high voltages.

6. ANALYSIS OF COST BENEFIT AND FUND ANALYSIS

6-1. Analysis of Cost Benefit

The major benefit thought to accrue from this Project, if carried out, are as given hereunder.

(1) The passenger will benefit by using the improved railway service, so that travelling efficiency (the saving of time spent in travelling) will increase.

(2) Passengers will give up the utilization of buses, taxis or other means of transport and avail themselves of the improved railway services as well as in case of giving up the use or consumption of other goods or services and availing themselves of the railway will conduce to increased utility of facilities themself from the improved services.

(3) The increase of passengers utilizing the railways will make investment in roads unnecessary and may reduce road traffic, as well as imporve the inefficient operation of facilities, caused by road traffic congestion.

(4) The provision of grade separated crossings and automatic gates will relieve road traffic congestion, hence it will lead to more efficient traffic operation.

(5) The electrification of the railways and the modernization of signalling and communication systems with the increase of the operating efficiency of electric cars and the efficient use of energy, will conduce the overall transport efficiency, which will make possible the saving of resources (costs).

(6) The remodelling of the main line to a four-track line and of the KCR to a double-track line will bring about efficient operations not only for the benefit of commuters, but also for long-distance passengers and goods transport to and from the Karachi Metropolitan Area.

(7) In connection with Item (2), the spreading use of automobiles will be moderated. Environmental pollution resulting from automobile exhaust gases, which is attracting attention throughout the world, will therefore be reduced.

(8) The improvement of the existing lines will promote the construction of the R/T spine and the three extension lines projected as part of the metropolitan traffic plan.

(8) The figure of the improved metropolitan traffic expected from the introduction of modern electric cars and other improvements will contribute to the enhancement of Karachi's social and economic activities through the abovementioned benefits and will also be a status symbol of which Karachi's citizens will be proud.

6-2. Calculations of Costs and Benefit

The results of the judgement that was obtained by calculating the costs required for and the benefit occurring from the execution of this Project, and that made on the national, economic effects involved are given hereunder.

From the calculations for judgement, net benefit values of 1,072,308.1 and 390,543.5 thousand rupees were obtained at a discount rate of 6% for Alternatives 1 and 2, respectively. At a discount rate of 12%, both alternatives indicated negative net benefit value. For internal rate of return indicating the discount rate at which discounted net benefit for each year be zero as a total throughout the subject period, 7.66% and 6.55% were obtained for Alternatives 1 and 2, respectively. These percentages resulted from calculating only direct benefit (not in total) possible to be calculated of those benefit described in paragraph 6-1 above, and are well worth of evaluation. Meanwhile, the benefit from time saving and that from cost saving at a discount rate of 6% are thousand Rs. 2,972,267.0 and thousand Rs. 1,665,734.4 respectively.

6-3. Results of Fund Analysis

On the assumption that this Project is operated on a commercial basis by a single management organ similar to a private enterprise, this feasibility study analyzes what financial effects will be produced, as given hereunder.

(1) The modernization of traffic service will enable savings in operating costs and at the same time increase earnings in parallel to the increase of traffic volume, thus resulting in a largely improved operating revenue and expenditure. For this purpose, however, the current carriage charges for service by the Karachi Suburban Railway should be raised.

(2) Due to the vast construction cost, a capital fund that has to be repaid every year to recover the initial cost will be great when compared with the revenue from carriage charges and the operating expenses.

(3) In order to maintain the sound management of the railways

without impairing the benefit to passengers using the modernized railway service, part or most of the construction fund should be borne by and part of the interest thereof subsidized by the Government. Other public financial aid will also be required.

6-4. Economic Evaluation

Whether it is a road traffic project or any other traffic project, the sound management of a project which relates to metropolitan traffic as in the subject of this feasibility study will inevitably be difficult insofar as it is on a self-paying basis using fund on hand, because the construction of traffic facilities in metropolitan area require, whether railway or road facilities, a vast amount of funding. This Project aims at the modernization of the existing railway facilities. However, if the construction of raods as traffic facilities was undertaken in place of the railway facilities, the amount of funding required would exceed that required for the fixed facilities of this Project. Assuming that the capital costs in these two different projects were approximately equal to and that the amount of the cost saving produced under this Project were calculated in comparison to the case when passengers and goods are transported by road, it would amount to thousand Rs. 782,750,6 at a discount rate of 6%, The ratio of the amount of such saving to the capital cost (excluding the cost of rolling stock procured) is 30.8% in Alternative 1 and 24.5% in Alternative 2.

As described in paragraph 6-2 above, the national economic effect of this Project judged from analyzed costs and benefit are by no means small. Therefore, the economic effect of this Project resulting from such various analyses are considered to be worthy of thorough evaluation. In the execution of this Project, however, we would add that public financial aid is inevitably required.

7. RECOMMENDATION

Although there are many things to be executed in the future, the following particulars are specifically recommended to be put into practice in order to promote the electrification and modernization of the Karachi Suburban Railway.

7-1. Consolidation of Organizations

In order to solve the traffic problems in the Karachi metropolitan area, the establishment of MRTS centering on the railway is most necessary, and in order to promote this, close contact and cooperation between all the organs relating to the metropolitan development plan and roads must be

maintained. For this purpose, a powerful organization based mainly on the Pakistan Railways and composed of many experts selected from the related organs should be established with RTS Cell being at the helm.

7-2. Necessity for Electrification and Modernization of Malir Branch

The electrification and modernization of the railways envisaged by RTS Cell is limited to the cosntruction of a spine and the extension of other three lines beside KCR and Main line. However, in view of the KDA master plan and the metropolitan development plan, the Malir Branch should also be included for electrification and modernization.

7-3. Establishment of Measures to Increase Earnings

The assurance of revenue is a matter of primary concern for the railway management. Furthermore, as the transport service will be greatly improved by future electrification and modernization, which follow from a vast amount of investment, earnest efforts must be exerted to deal with increasing earnings also from the principle that such revenue must be shared by those who utilise the railways.

It is said that half the passengers utilizing the railways are ticketless. Therefore, the following countermeasures, including those to prevent free rides, should be studied.

(1) The Karachi Regional Office should be assigned with greater authority to administer earnings.

(2) In order to prevent free rides, efforts should be made to enhance the moral of passengers, and beside this, fencing should be installed and passengers more closely watched. Conductors' depots should be established. Inspection of tickets in the running trains should be done more strictly by the conductor.

7-4. Enhancement of Traffic Moral

Electrification and modernization of the railways will greatly accelerate the speed and reduce the headway of trains in future. From the standpoints of preventing danger and protecting the equipment installed, efforts should be made to enhance the traffic moral of inhabitants so that they will not enter the trackway nor run over level crossings when the gates are closed.

PART 1 GENERAL DESCRIPTION

CHAPTER 1
Present Situation of Pakistan Railways

1-1. General Description

Pakistan has an area of approximately 800,000 square kilometers (about twice that of Japan), with a plain stretching from south to north mostly along the Indus, a vast, broad desert stretching through the middle of the country, and mountains 2,000 to 3,000 meters high in the northeast and northwest boundary between the country and China, Soviet Union and India.

Due to this topography, traffic first developed in the densely populated area to the east of the Indus. In particular the first railway was laid in Karachi, which was the former capital of Pakistan and is now the only trading port of the country adjoining the Arabian Sea, then extended gradually along Indus to Lahore (the second largest city; population 2,150,000) and further to Rawalpindi (population 770,000). Specifically, since the capital of the country was transferred to Islamabad adjacent to Rawalpindi, this section of the railway has been playing an important role as the artery of the country carring passengers and freight. Apart from this, other railways developed a long time ago, running to Chaman, the boundary of Afghanistan, to Zahidan, the boundary of Iran, and to the Khyber Pass which is famous in history. These railways were laid chiefly to meet mili tary purpose

Recently the rapid growth of population around large cities has been forming a serious problem creating congested commuter traffic, particularly remarkable around Karachi.

The mission of Pakistan Railways is to serve the public in transportation, and it has practiced a low-rate fare policy. Meanwhile, it has been placing a great emphasis on the improvement of transportation, and has been executing the modernization of its existing facilities, the elimination of bottlenecks and the replacement of old rolling stock with new. As a result, due to the rapid growth of the economy from 1973 to 1974 and the resultant shortage of traffic capacity, the following plans are under preparation.

(1) Construction of a Freight Yard in Pipri

The big problem in the sphere of freight transportation is the shortage of handling capacity in the freight yards around Karachi. In order

to improve the quality of freight transportation and to meet the growth of the demand for transportation, the addition of the handling capacity of the freight yard in Karachi is most necessary. For this purpose, Pakistan Railways has been exerting efforts in addition to the improvement of existing facilities. However, as the present condition of the locations will not permit further expansion of freight yards, the construction of a new freight yard in Pipri is planned.

(2) Improvement of Transport around Islamabad

For the purposes of dealing with the marked growth of population around Islamabad and to increase traffic capacity to the industrial area, the construction of an Islamabad Branch of 5.6 route miles is planned to provide a loop line. Together with this, a plan to change the existing meter-gauge track to broad-gauge track is under consideration.

(3) Construction of Karachi Terminal Station

In parallel with the rapid growth of population and the rapid development of heavy industrialization around Karachi, the construction of a terminal station in Karachi Cantonment has become necessary. The estimated construction cost for this is Rs. 113 million. The terminal station will be a high-rise building designed in a modern style, provided with all facilities and equipment necessary for passenger operations to provide a comfortable service to passengers. The building planned will permit the simultaneous departure of nine passenger trains, including short-distnace passenger trains.

1-2. History

Pakistan Railways (hereinafter called "PR") was formerly called North Western Railway, and after a railway of 105 route miles between Karachi and Kotori was completed in 1861, the route mileage was gradually extended to 1,851 miles in 1886. Thereafter, despite the fact that the rate of progress in construction was obstructed by two World Wars, PR developed steadily to establish 6,890 route miles in 1947, out of which, however 1,891 miles situated in the territory which became Indian was transferred to India in the same year. Consequently the total of route mileage decreased to approximately 5,000 miles. Thereafter, however, PR merged the 318 miles of railway situated in the Province of Sind and previously managed by the Jodhpur Railway on behalf of the old Government of India, and the combined total of 5,317 route miles is in the possession of PR.

In February, 1961, North Western Railway was re-named Pakistan

Western Railway (PWR), which was further re-named Pakistan Railways in the latter half of 1974 because of the independence of East Pakistan (now called the People's Republic of Bangladesh) in 1974.

1-3. Organization

In PR, the Railway Boad, consisting of the Chairman, the Vice Chairman and two Members, is established as the top organ in charging of decision making. The Chairman is the chief executive officer of general railway affairs and the Board is responsible for arriving at decisions on technical matters and advising the Government in matters of railway policy.

The Board has a three-fold function to perform, that is;

(1) The usual secretaiat and policy-making functions of the Government in the sphere of control and regulation of the affairs of PR.

(2) The highest technical authority for the evaluation and determination of all technical problems connected with the working of PR.

(3) A board of management for administration, construction, operation and maintenance of PR.

Under the control of the Board, PR is staffed with technical superintendents, eight divisional superintendents for Mechanical and Electrical Engineering, Transportation, Commercial, Signalling, and Personnel Affairs Divisions, etc. In addition to the above, six regional offices have been established acting as subsidiaries of the PR headquarters at Karachi, Sukkur, Lahore, Rawalpindi, Quetta and Multan to supervise local sections. These offices are organized similarly to headquarters, but are under the overall control of the Vice-Chairman of the Railway Board.

1-4. Outline

At present, PR has 874 stations, about 133,000 employees and carries about 140 million passengers a year and 11 million tons of freight (fiscal 1973), the revenue consisting of about Rs. 340 million (about ¥1,020 million) in fiscal 1974 for passenger earnings, Rs. 65 million (about ¥200 million) for luggage, Rs. 560 million (¥1,680 million) in freight, totalling Rs. 970 million (¥2,180 million). As such, the percentage of expenditure to gross earnings is fairly freight at 78. However, when compared with the figures of the previous year, earnings from the transport of passengers and luggage registered a satisfactory growth while those from freight decreased markedly

due to the world-wide recession and inflation, consequently the percentage of expenditure to gross earnings dropped from the previous year's 72 to 78.

1-5. Passenger and Freight

1-5-1 Passenger Traffic

1-5-1-1 Passenger Fare System

The ratio of passenger earnings to the growth of revenue in fiscal 1973 accounted for 34.2%. There are four classes for passengers; Special Class (air-conditioned), First Class, Second Class and Third Class. About 95% of passengers use Third Class.

Passenger fare decrease according to distance, and there are different types of tickets available for air-conditioned car, reserved seats and sleeping berths. Passenger fare in excess of Rs. 3 (¥90) have traffic duty imposed on them.

1-5-1-2 Traffic Capacity and Improvement

Approximately 14 to 16 passenger trains per day run on the main line between Karachi and Lahore, but there are many branches with less than half the above figure. Each passenger train pulled by a steam locomotive has only 11.4 coaching vehicles, a mixed train 10.2 and that pulled by a diesel locomotive 18.4, indicating the marked lack of traffic capacity.

In this connection, in order to provide passengers with comfortable trips and decrease congestion, PR has taken steps to permit, on certain trains, passengers to change from Second Class Coaches to Third Class Sleeping Berths with nominal fare. In order to facilitate the purchase of tickets by the railway's clientele, 20 city booking agencies, 11 external agencies and automatic platform ticket machines at major stations are functioning. Services are being improved by having different ticket colours for different classes.

1-5-1-3 Number of Passengers Carried

Changes in the number of passengers carried are as described hereunder. In fiscal 1973, the number of passengers increased by 5.5 million over the previous year to 140 million passengers, the highest ever recorded. By class, the overwhelming increase of about 5 million passengers travelled Third Class. The average distance per passenger increased to 51.2 miles, and an increase in earnings of Rs. 2.35 per passenger was registered.

Table 1-5-1-3(a) Number of Passengers Carried by Class (1969 - 1974)

(in thousands)

Year \ Class	Air-Conditioned		First		Upper Class Railcar		Second		Third		Total
	No. of passengers	%	No. of passengers	%	No. of passengers	%	No. of passengers	%	No. of passengers	%	
1969 - 70	93	0.07	345	0.26	14	0.01	5,692	4.32	125,724	95.3	131,869
1970 - 71	86	0.07	305	0.24	25	0.02	5,214	4.14	120,407	95.5	126,037
1971 - 72	83	0.07	318	0.26	41	0.03	5,009	4,04	118,755	95.6	124,206
1972 - 73	90	0.07	368	0.27	54	0.04	5,766	4.27	128,897	95.4	135,175
1973 - 74	92	0.07	358	0.25	50	0.04	6,316	4.49	133,836	95.2	140,652

Table 1-5-1-3(b) Number of Passengers Carried and Passenger Mile (1969 - 1974)

Year \ Type	No. of passengers (In thousands)	Passenger Mile (In thousands)	Average distance per passenger (Miles)	Earnings per passenger (Rupees)
1969 - 70	131,869	6,117,219	46.4	2.09
1970 - 71	126,037	5,822,706	46.2	2.07
1971 - 72	124,206	5,914,923	47.6	2.11
1972 - 73	135,175	6,824,188	50.5	2.29
1973 - 74	140,652	7,208,431	51.2	2.35

1-5-2 Freight Traffic

1-5-2-1 Traffic Volume by Commodity

Nearly 60% of the operating earnings of PR is from freight transport. Freight transported mainly consists of exported and imported freight from Karachi Port, but imported freight are always in excess of exported freight. Most imported freight are hauled by the main line to factories and to up-country destinations as well as many to be transshipped to Afghanistan.

As such, the transport of freight moves with Karachi Port at the helm, but the lack of harbour and port facilities and the resticted freight yards in Karachi are making it difficult to switch to freight trains and are impeding the smooth transport of freight.

Over the past several years, traffic volume has been maintained at 12.3 to 12.6 million tons, but dipped to the level of 11 million tons in fiscal 1973 due to the effects of the world-wide recession and inflation. The shortage of freight cars, particularly waggons, cannot be overlooked. In addition to the above factors, changes from the use of railways to trucks must be considered as a result of the road network being rapidly developed and improved.

Major freight transported are as shown on Table 1-5-2-1, and mainly consist of wheat, cement, coal, coke, rice, chemical fertilizers, grains, and pulses. The freight normally rank high, particularly chemical fertilizers which in fiscal 1973 recorded over 1 million tons, the highest figure in the past five years.

1-5-2-2 Ton mile, Average Distance of Hual and Average Revenue per Ton

Although average distance of haul in fiscal 1973 decreased marginally from that in the preceding year, the average rate charged per ton per mile and the average revenue per ton of freight have been increasing every year. This may be attributed to the increased use of long-distance and high-class freight though the growth of freight transport facilities of same level.

1-5-2-3 Steps to Increase Revenue

In this situation, rigorous steps were taken by PR to increase its revenue. In fiscal 1967, PR started collection and delivery service for freight by itself. The combined total of freight handled in fiscal 1973 at Karachi, Lahore, Lyallpur and Multan amount to 77,000 tons and PR earned

Rs. 705,000 (¥210 million). Also, in the sphere of freight transportation, PR operated special trains for livestock, express trains for fruits and vegetables, and refrigerated fish vans and electro mechanically refrigerated vans on the section between Karachi and Peshawar, so as to improve the quality of transport.

Furthermore, in order to take advantage of covered waggons, the handling of small luggage has been done collectively at major stations from June, 1974. Also in April, that year an inland dry port was opened in Lahore, so as to permit custom clearance of exported and imported freight and other procedures. The dry port is a sub-organ of Karachi Port and is functioning to ease the overcrowding freight.

1-6. Operation of Trains

1-6-1 Train Frequency and Mileage

(1) Passenger Trains

The average number of trains operated per day in fiscal 1973 was 422 trains, up about 5% over the previous year. Of the 422 trains, 332 trains were ordinary trains and the other 90 were mixed trains. By locomotive, 234 ordinary and 16 mixed trains were pulled by diesel engines, accounting for nearly 60% of the total, 76 ordinary and 73 mixed steam engines, 73 mixed trains, almost equal, and 22 ordinary trains were electrically powered.

With regard to train-mileage, an average of about 53,718 miles per day was registered, a marginal decrease from fiscal 1974. The breakdown of 53,718 miles by types of locomotive is that diesel engines ran 33,950 miles, 63% of the total mileage operated, but dropping from the 95% of the previous year, while steam engines increased by approximately 1,600 miles to a total of 16,265 miles and electric engines remained at the same level.

(2) Freight Trains

The average number of freight trains operated per day in fiscal 1973 was 197, down 28 from the previous year, possibly due to the inactive loadings influenced by the world-wide recession and inflation. This decreased all freight train frequencies regardless of the type of locomotive used. In particular, trains pulled by steam engines dipped only 75, or 75% of the previous year, and trains pulled by diesel and electric engines decreased

Table 1-5-2-1 Tonnage of Major Freight Carried in 1969 to 1974

(In thousands)

Freights	1969 - 70	1970 - 71	1971 - 72	1972 - 73	1973 - 74	100%
Wheat	1,283	1,187	1,536	1,689	1,312	11.9
Cement	1,095	1,138	1,219	1,229	1,069	9.7
Coal & Coke	968	1,028	872	959	677	6.2
Rice	695	802	843	850	729	6.6
Chemical fertilizers	972	609	571	716	1,016	9.2
Grains & Pulses	998	1,125	1,062	710	434	3.9
Oils	371	444	588	652	583	5.3
Firewood	599	668	640	546	422	3.8
Sugar	98	108	137	264	250	2.2
Salt	247	256	240	230	215	2.0
Cotton	141	184	301	191	83	0.8
Total	12,323	12,342	12,597	12,317	11,009	100.0

Table 1-5-2-2 Ton-miles, Average Distance of Haul and Average Revenue Per Ton (1969 - 1974)

Year	Ton-miles (In thousands)	Average distance of haul (Miles)	Freightage per mile (Paisa)	Average revenue per ton (Rupee)
1969 - 70	4,672,217	381.7	8.14	30.9
1970 - 71	4,579,051	373.2	8.51	31.6
1971 - 72	4,722,749	376.5	9.37	35.1
1972 - 73	5,112,218	417.5	9.92	41.2
1973 - 74	4,490,876	409.9	12.1	49.4

Note: 1 rupee equals 30 yen and 1 paisa equals 0.3 yen.

to 111 and 11 respectively from the levels of the previous year.

With regard to the per train number of covered waggons which form the main form of freight car, an average of 70 waggons were pulled by steam locomotive, 51.7 by diesel, 59.5 by electric, or 49.7 on average. Of these waggons, an average of 17 covered waggons carrying goods were pulled by steam locomotives, 35.7 by diesel and 34.7 by electric, and it is noticeable that nearly 40% of these waggons are empty.

Due to the abovementioned situation, the average freight train mileage per day in fiscal 1973 dropped greatly for the first time in the past several years, except for that pulled by electric locomotives, and that by diesel engines was 16.693 miles (93% of the previous year) and steam engines 30.20 miles (71% of the previous year), totalling 21,210.20 miles (89% of the previous year).

1-6-2 Train Speed

With respect to the speed of trains, fast passenger trains on the main line are planned to run at the maximum speed of 65 miles per hour, rapid service trains at 50 miles per hour and local trains at 40 miles per hour. The set speeds are 60, 50 and 35 miles, each 10% less than the above figures. On KCR, the maximum speed is planned to be 45 miles per hour, with the set speed being 40 miles per hour. Maximum speeds on branches vary with railway divisions.

On freight trains, the maximum speed is 35 miles and that planned is set to 30 miles per hour. The actual speed of trains pulled by steam locomotive is 8.97 miles per hour, diesel 11.5 miles per hour and electric 11.8 miles per hour; the average being fairly low at 11.2 miles per hour. These figures show the combined total hours required by trains from their starting points to their destinations. In addition, when trains are delayed markedly, permission is granted so that the above speeds may be raised to their maximum.

1-6-3 Locomotives

The number of steam locomotives owned by PR as of June 30, 1973 is 562, diesel locomotives 401 and electric locomotives 29, totalling 992. Steam locomotives have been replaced step by step with diesel and electric locomotives and are now used mainly on broad-gauge lines, due to the fact that the supply of the coal used as fuel for steam locomotives was ceased by India since 1948 and only 31 out of 562 steam locomotives on hand are

Table 1-6-1-1 Numbers of Trains Operated (1969 - 1974)

Type of train and loco. \ Year		1969 - 70	1970 - 71	1971 - 72	1972 - 73	1973 - 74
Passenger train	Steam	68,558	72,012	55,990	57,396	54,779
	Diesel	80,062	75,322	82,614	80,482	91,189
	Electric	-	-	5,515	8,260	8,106
	Total	151,620	152,168	144,119	146,738	154,074
Freight train	Steam	55,903	41,751	34,563	34,692	27,563
	Diesel	35,400	31,849	46,830	43,033	40,671
	Electric	-	2,847	3,754	4,224	3,792
	Total	91,303	76,447	85,147	81,949	72,026
Total		242,923	228,615	229,266	228,687	226,100
Average per day		665	626	628	626	619

Table 1-6-1-2 Train-Miles (1969 - 1974)

(In thousands)

Type of train and loco. \ Year		1969 - 70	1970 - 71	1971 - 72	1972 - 73	1973 - 74
Passenger train	Steam	7,092	6,424	4,737	5,339	5,937
	Diesel	12,579	12,428	13,079	13,038	12,392
	Electric	-	727	899	1,279	1,278
	Total	19,671	19,579	18,715	19,656	19,607
Freight train	Steam	3,042	2,015	1,522	1,449	1,023
	Diesel	6,320	5,644	6,527	6,547	6,093
	Electric	-	459	589	671	626
	Total	9,362	8,118	8,638	8,667	7,742

using coal and the remain using a combination of diesel oil and coal. Diesel locomotives in fiscal 1973 accounted for 79.6% of the total ton-miles, but their rate of use was 43.7%, far from 50%. 29 electric locomotives were imported in 1970 and are now operated on the section between Lahore and Khanewal.

The average running miles of locomotives on broad-gauge lines (exclusive of rolling stock for repair and inspection) as actually registered in fiscal 1974 were 133 miles; 86 miles for steam locomotives, 171 miles for diesel and 202 miles for electric. The actual working hours per day of a steam locomotive were 9.06, diesel 14.3 and electric 14.8, the average being 11.6. The percentage of spare locomotives stands at 13.2% of steam locomotives, 13.4% diesel and 11.3% electric, the average being 13.2%.

Table 1-6-3-1 Number of Locomotives Owned and Average Running Miles Per Day (1969-1974)

Type of loco. / Gauge / Year	Steam				Diesel	Electric	Extension	Average Running Per Day			
	5'-6"	3'-3"	2'-6"	Total				Steam	Diesel	Electric	Extension
1969 – 70	623	46	41	710	337	–	1,076	82	200	–	127
1970 – 71	623	46	41	710	402	29	1,141	82	186	163	127
1971 – 72	508	36	41	585	401	29	1,015	86	180	226	138
1972 – 73	486	36	41	563	401	29	993	86	182	232	138
1974 – 74	485	36	41	562	401	29	992	87	171	220	133

1-6-4 Rolling Stock

1-6-4-1 Amount of Rolling Stock Owned

The amount of rolling stock owned by PR at the end of fiscal 1973 was 2,060 passenger cars and 1,116 freight cars, totalling 3,176 cars, indicating a marginal decrease over the past few years. A total of 37,339 freight cars are owned, consisting of 23,707 covered wagon cars, accounting for about 63%, 8,229 open wagon and other special type cars for explosives, ores, liquids, timber, etc. Similarly to passenger cars, the number of freight cars is also tending to decrease.

Table 1-6-4-1 Amounts of Passenger Cars and Freight Cars Owned (1969 - 1974)

		Year / Gauge	1969 - 70	1970 - 71	1971 - 72	1972 - 72	1973 - 74
Passenger Cars	Passenger Vehicles	Broad gauge (5' - 6")	1,905	1,914	1,814	1,819	1,822
		Meter gauge (3' - 3")	126	126	125	125	125
		Narrow gauge (2' - 6")	114	114	113	113	113
		Total	2,145	2,154	2,052	2,057	2,060
	Luggage Cars	Broad gauge (5' - 6")	1,098	1,074	1,029	1,004	1,038
		Meter gauge (3' - 3")	32	32	32	32	32
		Narrow gauge (2' - 6")	46	46	46	46	46
		Total	1,176	1,152	1,107	1,082	1,116
	Total		3,321	3,306	3,159	3,139	3,176
Freight Cars	Broad gauge (5' - 6")		35,893	35,700	35,987	35,803	35,721
	Meter gauge (3' - 3")		1,073	1,073	1,073	1,073	1,053
	Narrow gauge (2' - 6")		564	564	560	560	565
	Total		37,530	37,337	37,624	37,436	37,339

1-6-4-2 Inspection, Maintenance, Repairing and Construction of Railcar

The diesel locomotive workshop in Rawalpindi has an annual capacity of repairing about 300 locomotives. In addition, maintenance of diesel locomotives is done at Karachi Cantonment, Rawalpindi, etc. In Rawalpindi, Lahore and Rohri, maintenance of railcars is performed, and the construction of the various types of tank cars and covered wagon cars is carried out. Additions of new facilities and equipment are under progress to modernize

and strengthen the existing workshops.

1-7. Earnings and Expenditures

1-7-1 Outline of Earnings and Expenditures

In PR, the percentage of expenditure to gross earnings used to be well balanced at 67 to 73, but lowest figure of 78 was recorded in fiscal 1974, due to the fact that revenue from both passenger fare and luggage charges continued to grow steadily whereas great set-backs were observed in the revenue from goods loaded due to the world-wide recession and inflation.

Meanwhile, with regard to expenditure, the influence of the oil crisis caused fuel expenses to increase by about Rs. 10,000 or up 50% over the previous year. All maintenance costs, operating expenses and administration expenses increased remarkedly.

Table 1-7-1-1 Earnings and Expenditure (1969 - 1974)

(In thousand Rs.)

Category / Year	Earnings (A)	Expenditure (B)	Profit (A) - (B)	Percentage of Expenditure to Gross Earnings
1969 - 70	731,172	589,205	141,967	80
1970 - 71	716,272	523,894	192,378	73
1971 - 72	795,291	591,657	203,634	74
1972 - 73	943,684	637,751	305,933	67
1973 - 74	974,703	761,260	213,443	78

Table 1-7-1-2 Breakdown of Earnings (1969 - 1974)

(In thousand Rs.)

Category / Year	Passengers	Luggage	Freight	Others	Total
1969 - 70	281,912	40,526	389,232	19,502	731,172
1970 - 71	264,714	35,477	400,144	15,937	716,272
1971 - 72	271,548	39,649	458,154	16,040	785,391
1972 - 73	314,288	40,580	571,857	16,959	943,684
1973 - 74	333,701	64,786	559,408	16,806	974,703

Table 1-7-1-3 Breakdown of Expenditure (In thousand Re.)

Category / Year	Repairs & Maintenance	Fuel Expenses	Operating Expenses	Work Expenses, except fuel & operating expenses	Administration expenses	Others	Total
1969 - 70	236,365	142,254	83,136	19,715	81,858	25,877	589,205
1970 - 71	192,755	137,798	86,927	20,703	69,538	16,176	523,894
1971 - 72	218,509	158,162	90,102	22,467	83,234	19,183	591,657
1972 - 73	234,133	153,664	108,709	25,704	96,075	19,466	637,751
1973 - 74	261,706	212,501	129,852	27,844	109,490	19,867	761,260
%	34.4	27.9	17.1	3.6	14.4	2.6	100

1-7-2 Number of Employees and Personnel Expenses

The number of PR's employees at the end of fiscal 1974 was 133,043 almost no change being observed over the last several years. By division, the greater number of staff, 46,197 (34.7%) are engaged in operating services, vehicle repairs and maintenance, followed by 33,485 (25.2%) in facilities, the combined total of these divisions accounting for nearly 60%, but only 20% are employed in business division. The ratio of personnel expenses to the gross expenditure is at the favorable level of 50%, but this is gradually decreasing.

Table 1-7-2 Personnel Expenses and Gross Expenditure

Category / Year	Personnel Expenses (A)	Gross Expenditure (B)	(A)/ (B)
1969 - 70	258,493	589,205	44
1970 - 71	269,558	523,894	51
1971 - 72	300,394	591,657	51
1972 - 73	373,600	637,751	58
1973 - 74	398,473	761,260	52

CHAPTER 2

The Necessity for the Modernization of the Railways

2-1. Overall Forecast of the Passenger Demand by Transportation Mode

2-1-1 Outline of the Methods Used to Forecast the Passenger Demand

This feasibility study was made basically in accordance with the KDA's "Final Report on Transportation" 1), and data furnished by KDA and RTS-Cell of PR. The study on the basis of which this report was prepared was promoted by a project team consisting of experts from the United Nations, while KDA, acting as the cooperative agency of the Republic of Pakistan, cooperated in carrying out this study with this team (hereinafter called "the KDA study"). Several consultant corporations also participated in the United Nations team. The field survey by the United Nations team was conducted in October, 1971. All modes and conditions of transportation in the Karachi Metropolitan region area were subject to the KDA study, this being conducted using comprehensive data accumulated by the efforts of the Master-plan Department of KDA.

1) Data No. K-08: Master Plan for Karachi Metropolitan Region
Final Report on Transportation (MP-PR/94), January, 1974

The main subject of the present study was aimed at the remodelling to double-track and electrification of KCR, the remodelling to four-track and electrification of the main line and the implementation of other improvements relating thereto, to improve the present situation of commuter traffic in the Karachi Metropolitan Region Area, so as to examine their feasibility.

Accordingly, we take it for granted that the improvement of the railway facilities under consideration would lead to a quantitative improvement in urban transportation. In this context, the development plan worked out by KDA does not necessarily take preference over railway, but emphasizes the expansion of bus routes, etc.

The present feasibility study has estimated future railway traffic volume through forecasting the future train operating system and traffic flow patterns after the completion of the Railway Modernization Project under consideration.

The KDA study adopted the gravity model and modalsplit model, both simplified versions of conventional traffic demand forecasting models. With these models, several alternative strategies can be readily assessed.

One of the simplifications adopted by the KDA study was such that the detailed number of non-work trips was not estimated, but the number of total trips which is equal to the number of work trips plus the number of non-work trips would be estimated on the basis of the probable number of work trips. The number of work trips between zones was estimated by means of the work generation and attraction ratios to the population and employment totals for each zone. In this case, separate ratios were used for car-owning households and non-car-owning households. The proportion of car-owning households was determined according to the income distribution estimate from the types of dwelling houses in each zone.

The gravity model was calibrated with respect to the distribution of commuters transported in 1971. The modal split into modes of transportation was calculated using the ratio of car-ownership, income groups and trip lengths.

The number of railway trips was determined by subtracting the number of bus trips from the number using public transport. In determining this, trip lengths and the railway network were taken into account in respect to geographical distribution. Some of the calculations mentioned above were carried out manually and some by computer.

2-1-2 Conditions Taken Into Consideration

There are two alternatives adopted for this Development Plan; one is a distributive investment plan (known as "DIP") and the other is a concentrated investment plan (known as "CIP"). Each of these alternatives depends on separate type of the land use plan, of the population spread, of the income distribution and of the ratio of car-owning households. The values forecast by CIP are predominantly superior to those by DIP. Table 2-1 shows the values of population, etc. forecast by CIP.

Table 2-1 Characteristic Values of Population Statistics (Karachi Metropolitan Area)

	1969	1985	2000
Population (in millions)	3.3*	7.3	15.0
Low-income households (in thousands) (1)	302	467	411
Medium-income households (in thousands) (2)	176	612	1747
High-income households (in thousands) (3)	32	143	627
Total households (in thousands)	510	1222	2785
Number of Cars (in thousands)	36	138	539

Notes: (1) Rs. 300 or less a month.
(2) Rs. 300 to Rs. 1,000 a month.
(3) Rs. 1,000 or more a month.
* 1974 est.: 4.0 or more

The forecast of demand for transportation is based on two premises; one is the situation restrained in accordance with the latest tendency appearing as changes in transportation system patterns. Under this premise, the number of users of public transport would increase, but number of pedestrians or users of private modes of transport would decrease. Under such circumstances, it is considered that the restriction of parking areas in business center, the imposition of parking fees, rises in the selling prices of cars and, fuel, and increase in car registration taxes, would become problems.

The other is the unrestrained situation, in which public modes of transport would be improved according to the increase in population, while private modes of transport would also be more frequently used, and both the public and the private modes would be used at an almost identical rate with that in 1971.

This Development Plan was assessed on the basis of the restrained situation. Under the restrained situation, the ratio of selection in private mode of transport (such as privately owned cars, taxicabs and rickshaws) was estimated to decrease as shown in Table 2-2.

Table 2-2 Ratio of Use of Private Modes of Transport

Household Income	Trip Length (miles)							
	1971 [1]	2000	1971 [2]	2000	1971 [3]	2000	1971 [4]	2000
Non-car-owning								
Low-income households	8	8	2	2	2	0	0	0
Medium-income households	20	13	7	77	5	5	4	0
High-income households	75	60	70	33	60	25	50	0
Car-owning								
Medium-income households	92	85	82	75	70	60	55	40
High-income households	95	95	95	85	85	70	65	50

Table 2-3 Estimated Values in No. of Passengers Carried
(Passengers in Thousands/Day)

Modes of transport	1971	%	1985	%	2000	%	1985/1971	2000/1985
On foot and bicycle	4,064		8,133		16,727		2.00	2.06
Car and motorcycle	388	18.3	1,109	19.2	3,338	21.6	2.86	3.01
Taxicab and rickshaw	503	23.7	1,092	18.9	2,540	16.4	2.17	2.33
Bus and mini bus	1,160	54.5	3,093	53.5	7,819	50.5	2.67	2.53
Railway	75	3.5	487	8.4	1,786	11.5	6.49	3.67
Total	6,190		13,914		32,210		2.25	2.31
Sub-total (excluding on foot and bicycle)	2,126	100.0	5,781	100.0	15,483	100.0	2.72	2.68

Table 2-4 Estimated Values in No. of Passenger Mile
(Thousand Passenger Miles/Day)

Modes of transport	1971	%	1985	%	2000	%	1985/1971	2000/1985
On foot and bicycle	1,923		3,520		6,726		1.83	1.91
Car and motorcycle	2,479	22.8	7,175	21.8	21,179	23.7	2.89	2.95
Taxicab and rickshaw	1,987	18.2	3,863	11.7	7,037	7.9	1.94	1.82
Bus and mini bus	5,623	51.7	16,340	49.5	39,474	44.2	2.91	2.42
Railway	800	7.3	5,606	17.0	21,536	24.2	7.01	3.84
Total	12,812		36,504		95,951		2.85	2.63
Sub-total (excluding on foot and bicycle)	10,889	100.0	32,984	100.0	89,225	100.0	3.03	2.70

2-1-3 Estimated Traffic Volume

Table 2-3 and 2-4 show the information furnished by the RTS-Cell of PR for use in carrying out the present feasibility study. The information is that estimated under the restrained condition.

In Table 2-3, the ratio of the number of railway users is estimated to have a share of from 3.5% in 1971 of the total number of users of all modes of transport rising to 8.4% in 1985 and to 11.5% in 2000. The growth ratio of 1985 to 1971 is 6.5 times.

Table 2-4 shows that because trip lengths by railway are ralatively longer than those by other modes of transport, the passenger mile share in this Table is greater than that in Table 2-3. The growth ratio of 1985 to 1971 is seven times.

2-2. Required Traffic Capacity of Railway and Domand for Transportation

2-2-1 Present Situation of Traffic Volume and Capacity

As was mentioned previously in this report, the initial values based on which the KDA study started concerning the forecast of traffic volume were those of 1971, or 75,000 passengers per day. Under the present feasibility study, however, the traffic volume of 1973 was investigated, which resulted in approximately 76,000 passengers per day. Based on this traffic volume, the basic assumptions for the following two points were established; first, because of insufficient traffic service by the existing PR facilities, the traffic volume by PR in the environs of Karachi does not tend to increase; secondly, if investment in improvements were not to be realized after 1974 when this feasibility study was carried out, the traffic volume of 75,000 passengers per day would continue unchanged even after 1974. From the second assumption, therefore, the difference between the traffic volume after the realization of investment and that of the present time is deemed to vary with the effect of the investment.

The operating routes of shuttle trains of the main line around Karachi consist of the following three lines:

KL Line (Karachi City to Landhi). KLK Line (Landhi and Korangi) and DK Line (Drigh Road to Karachi City) form part of KL Line.

KM Line (Wazir Mansion to Karachi City to Malir Cantonment)

LK Line (Drigh Colony to Landhi)

KCR consists of one line running from Drigh Colony to Wazir Mansion to Karachi City. The main line and KCR are not linked to each other with a complete loop, but KCR and DK Line are linked at Drigh Road so as to permit interchange.

As of 1974, 36 shuttle trains were assigned to the KL Line, 32 to the KM Line, 8 to the LK Line and 23 to the KCR. One train consists of Third-class coach vehicles (85 passengers in each vehicle) and Second-class coach vehicles (42 passengers in each vehicle) to total 6 to 8 coach vehicles. The traffic capacity of one train is 88 x 6 + 42 x 2 = 612 passengers. However, taking into consideration the degree of traffic congestion, this feasibility study assumes that 700 passengers are the reasonable capacity of one train. The respective traffic capacities of the main line and KCR are 700 x 76 = 53,200 or about 53,000 passengers a day and 700 x 23 = 16,100 or about 16,000 passengers a day.

According to the study of the United Nations team, of the passengers using PR, KCR shares about 20% and the main line 80%, or the number of passengers carried by the respective lines is 15,000 and 60,000 passengers per day. These numbers account for a shortage in the traffic capacity of the main line and sufficiency in the case of KCR. This may be possible from an overall, average point of view, and a further definitive study must be made with respect to the traffic capacity of these lines in the rush-hour time periods.

As working hours in most businesses in Pakistan are from 8 in the morning to 2 in the afternoon, the commuting time periods are from 6 to 9 in the morning and 2 to 4 in the afternoon. Assuming that the time between 6 and 10 in the morning and 2 and 5 in the afternoon are taken as the rush-hour time periods, the number of trains to be provided on the main line is 41 and KCR 12. With the degree of congestion taken into account and the capacity of one train assumed to be 900 passengers, the traffic capacity of the main line is 900 x 41 = 36,900 ≒ 37,000 passengers and that of KCR is 900 x 12 = 10,800 ≒ 11,000 passengers. Meanwhile, of the passengers using PR, commuters constitute 80%. Therefore, the number of passengers carried by the main line and KCR in the rush hours is 48,000 and 12,000 respectively, and these numbers prove to be more than the traffic capacities. (The above figure of 900 passengers per train deems rather small).

2-2-2 Estimated Traffic Volume by This Feasibility Study

In forecasting the future traffic volume for individual years constituting the basis of the judgement to be made from this feasibility study, the three years (the years 1982, 1987 and 2002) were set as guides.

Forecasts were first made for each of the three years, then the intermediate periods between the individual years and the time beyond 2002 were forecasted by means of simple interpolation and exterpolation. The ratios of increase in traffic volume for these periods were determined with consideration given to the rate of population growth and the rate of conversion of passengers to the modernized railways from other modes of transport.

This Modernization Project is divided broadly into two phase; Phase 1 consisting of electrification and improvement of the existing railways and Phase 2 consisting of electrification and the remodelling of KCR to a double-track line and that of the main line to a four-track line. Phase 1 will be completed by 1981 and its effect will be felt since 1982. At this time a some simplified method of evaluation of such an effect will be employed. Namely, the speeding up and reduction in head way achieved by the adoption of electric cars will double the existing traffic capacities in 1982. This improved service will permit supply to create demand; which will lead to a doubling of the traffic volume at least.

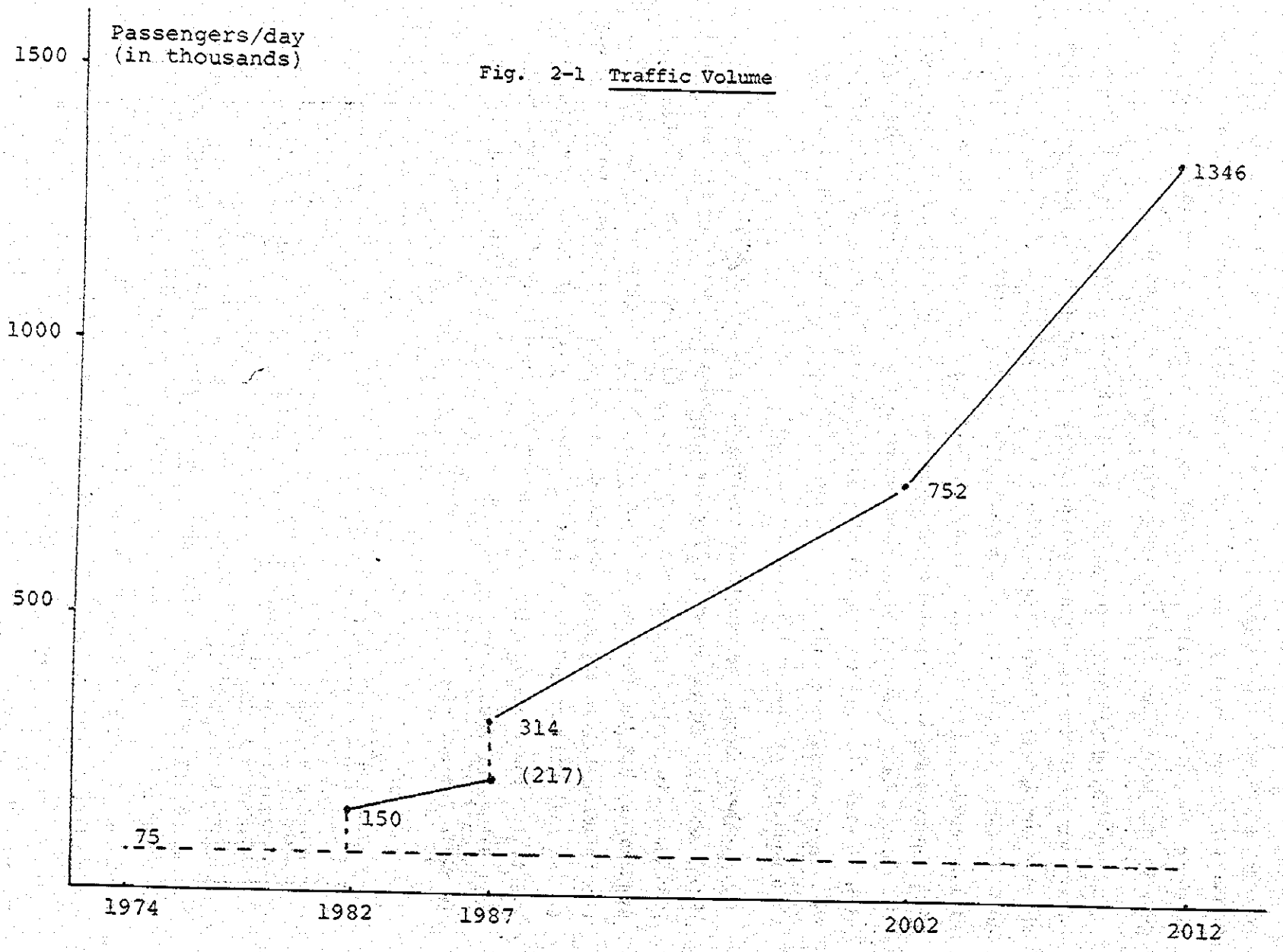
Phase 2 will be completed by 1986 and its effect will emerge since 1987. The traffic volume of 1987 was determined by modifying the values of 1985 shown in Tables 2-3 and 2-4 furnished by RTS-Cell. From the basic standpoint that the Development Plan of this feasibility study is to improve the existing lines, modifying calculations were made with consideration given to the rail mileage and the traffic flow presented in the plan provided by RTS-Cell. The traffic volume of 2002 was obtained by modifying the forecast values of 2000 shown in Table 2-3 and 2-4. The results are as given in Table 2-5 and Fig. 2-1.

Table 2-5 Traffic Volume

Year / Traffic Volume	1974	1982	1987	2002	2012
Passengers (in thousands)	75	150	314	752	1,346
Passenger-Kilometers (in thousands)	1,287	2,697	5,819	14,590	26,926

As was mentioned previously, the modernization of the existing railways in and around Greater Karachi Area is considered to be pressing need even from the view-point of traffic capacity alone. In addition, it goes without saying that the mission of a railway should be to provide safe, accurate and rapid mass transportation, thereby reducing running costs. Hence the modernization of the existing railways in and around Greater Karachi Area is necessary.

Fig. 2-1 Traffic Volume



CHAPTER 3
MRTS (Mass Rapid Transit System)

In this section, the MRTS (mass rapid transit system) by railway is proposed as a radical measure to improve passenger transport in the Karachi Metropolitan Area.

3-1. Present Situation of Railway Transport and the Suburban Transport Planning of KDA

At present, railway transport has a share of only 6.6% of commuter transport in the Karachi Metropolitan Area, possibly because of unimproved running speed, insufficient frequency of train service leading to a long waiting times, absence of planned commuter transport service and, in general, the lack of appeal of railways to the general public.

In view of these circumstances concerning the railway, KDA has three suburban transport plans under consideration for 1985 (some improvement of existing facilities seems to be considered in these plans). In brief, these plans are as follows:

Plan 1: Some improvement of the railway is planned, but no construction of a new tramway is contemplated. The system planned is entirely based on transportation by bus. With this system, the increase in bus transport capacity will necessarily result in an increased proportion of bus services in commuters transported by public facilities, which is expected to reach 80%.

Plan 2: In the transportation system planned, rapid transit (R/T) spine and tramways are to be combined organically. As feeders for this system, tramways are planned to transport passengers to the city center from the PR main line or principal stations of KCR.

Plan 3: The system planned is entirely based on tramways. Substitution of a tramway for the R/T spine is planned on the assumption that the tramway is to be supported by a bus network.

According to the results of an analysis of advantages and disadvantages of these three plans, the system entirely based on transportation by bus is reported to be better than the other plans.

3-2. MRTS Plans Based on Modernization of Railway

Urban traffic problems in the Karachi Metropolitan Area are considered to be urgent in view of the rapid increase in the population and development of city -planning. As mentioned above, the plans of KDA to solve this question are almost entirely based on bus or tramway services. In these plans, the actual state of the unimproved railway seems to have been imaged.

In this feasibility study, a solution of the urban traffic problems of the Karachi Metropolitan Area is suggested with the realization that it is the railway that can accomplish the mission of MRTS in a future ideal of transportation system. The subject under investigation is essentially passenger transport, in particularly, commuter traffic, but goods traffic is also taken into consideration.

3-3. Concrete Plans for Realization of MRTS

Concrete plans for the reconstruction of the existing lines of PR in the Karachi Metropolitan Area into the MRTS are proposed herein. In addition, plans for the construction of new R/T spine lines and extensions (three lines) are discussed considering that the R/T spine and extensions should form a part of the MRTS in the Karachi Metropolitan Area.

3-3-1 Utilization and Modernization of Existing Lines

Construction of new lines is naturally of importance, but the utilization of the main line (between Karachi City and Pipri) and KCR's existing lines is considered vital and urgent more than anything else. The fundamental target of modernization of existing lines is to complete the doubling of track and electrification of KCR's existing lines as well as the quadrupling of track and electrification of the main line.

In this modernization, the quadrupling of track in the overlapping section of the main line and KCR line (between Karachi City and Drigh Road) should be performed. At the same time, a new goods yard should be constructed. In addition, the electrification of the line to Pipri should be performed taking into account the connection with the future goods yard as well as local passenger transport. In view of its scale, the completion of this project will require a rather long period of time.

Consequently, the solution of immediate problems should be solved in stages.

(1) Phase 1: Modernization of existing lines (electrification, improvement of signaling system, improvement of crossings, track strengthening, etc.)

As a general rule, the speeding-up of operation and increase in track capacity can be achieved by carrying out the electrification with existing lines left intact and performing the introduction of an automatic signalling system, grade-separation and automation of level crossings, track strengthening, etc. According to approximate estimates, this modernization of existing lines will increase the number of trains by a factor of about two on the main line and by a factor of about five on KCR's lines. In addition, a shortening of about 30% in the arrival time will be made possible be ween Karachi City and Pipri.

Automation of signalling system and level crossing facilities will allow the speeding up of train operation and an increase in train frequency. The main purpose of this automation is to improve safety.

With these modernization plans, remarkable diversion and attraction of passengers to the railway can be expected.

For a plan of grade-separation of level crossings, two alternative systems are under study: On corresponding to the raising of the road level with the railway maintained on the level of the ground, and the other is the raising of the level of the railway with the road maintained on the ground.

(2) Phase 2: Conversion of KCR lines into a loop line.

In the first half of Phase 2, the doubling of track of the KCR existing lines and quardrupling of track of the main line section between Karachi City and Drigh Road should be completed. The double track added to the main line in this way should be conencted to the existing KCR lines to form a loop line. (This loop line is hereinafter called "the KCR"). As a result of the formation of this loop, the separated operation of KCR and main line will be made possible in terms of operation system. KCR trains may stop at every station and main line trains may run non-stop between Karachi-Cantt and Drigh Road. Once these conditions have been fully satisfied, the establishment of an MRTS utilizing existing lines can be considered to have been completed in general terms.

Upon completion of this MRTS, train operation will be speeded up greatly: as compared with the current operation, the running time is expected to he reduced by about 15 minutes for travel on the section between Karachi City and Pipri and by about 30 minutes for a round on the KCR.

During rush hours, trains will run with a 7.5 minute minimum headway between Karachi City and Landhi and with about 10 minute minimum headway on t the KCR. The trip time of passengers will also be reduced.

In particular, the realization of a well-coordinated traffic system in harmony with buses, taxis and other similar services will be possible. This means that the complete MRTS can be realized. Such a well-coordinated traffic system can be considered not only to contribute to the relief of traffic congestion in the whole city center within the KCR, but also to be the effective measure for the control of environmental pollution and the efficient use of energy.

For the realization of this system, the development of station fronts for the accommodation of buses should be planned at all stations of the KCR. In addition, the reorganization of bus services adapted to this development should be performed so that satisfactory coordination with the railway can be obtained. Phase 2 obviously constitutes the major prerequisite and foundation for the construction of the R/T spine and extensions (three lines) now under consideration. In addition, Phase 2 is considered to further augment the usefulness of the construction of the R/T spine.

3-3-2 R/T Spine and Extensions (3 Lines)

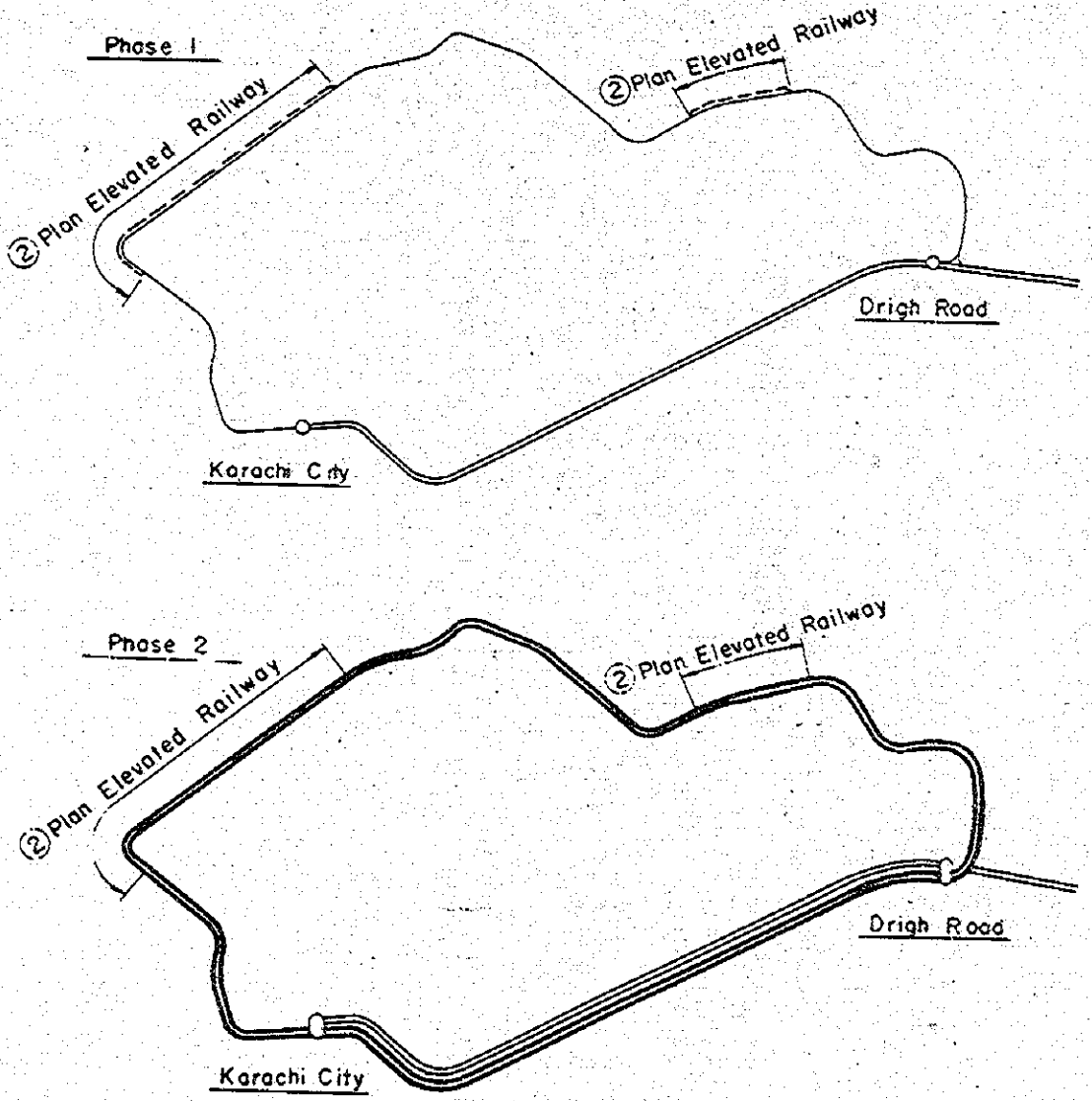
The concept of MRTS as described in the foregoing should be necessarily applied also to the R/T spine and extensions (3 lines). With these four lines incorporated, the MRTS should form a more substantial traffic system.

The R/T spine is one of the most desirable routes passing through the city center but is considered to have only partial effect on the elimination of traffic congestion in the urban area. In addition, the R/T spine is considered to be fully effective when coupled with the effect of the modernization of the KCR. Consequently, the modernization of the KCR should be completed prior to the construction of the R/T spine.

For extensions (3 lines), the progress of construction in keeping with the development of city planning is advisable.

In any case, the modernization of the KCR is admittedly a major prerequisite.

Fig. 3-1 Modernization Plan of the Existing Railways



PART 2 DETAILS

CHAPTER 4

Plan for Train Operation and Rolling Stock

4-1. Present Transport Situation and Measures for its Improvement

At present, the main line is a double line using the automatic block system. Around Karachi, this line is the most modernized principal trunk line, but the actual situation of transport on this line is such that the total number of passenger trains (hereinafter called "PC") and freight trains (hereinafter called "FC"), both pulled by diesel locomotives and running one way, is only about 60 per day (about 25% of which are PCs). At present, therefore, the track capacity of the main line is not fully utilized.

In the present project, the improvement of signal safety device and level crossing facilities should be executed along with electrification. The replacement of the present local service PC by electric railcars (hereinafter called "EC") will also require some modification of paltform application and track layout at principal stations including Karachi City Karachi Cantt and Landhi stations. For medium and long distance service PC and FC, the operations pulled by diesel locomotives as currently practiced will be advantageous in view of through operations into non-electrified sections. Accordingly, the adoption of electric locomotives (hereinafter called "EL") for these trains has not been considered even for the stage after the completion of the electrification project.

The present KCR is a single line of the tablet block system and the station track layout is mainly organized for freight trains. In Phase 1 (to be completed by 1982), electrification, signalling system automation and level crossing improvement should be executed. In addition, the doubling of track of the section between Site and Shah Abdul Latif, now causing a bottleneck obstruction for smooth transport, should be executed with a view to the full utilization of track capacity. All PC now in use should be replaced by EC. In Phase 2 (by 1987), the planned number of required trains in excess of the track capacity will require additional track.

In addition to the two sections mentioned above, the Malir Cantt Branch should be electrified with the present single line left intact. For this branch, the signalling system should be automated and all PC now in service replaced by EC.

For replacement of PC by EC, due regard has been paid to the

shortening of running time so that railway transport may fully show its advantage. At the same time, the minimization of the number of electric railcars required to increase the number of trains has been taken into consideration. Diesel locomotives (DL) saved by the replacement of PC with EC can reasonably be used for the operation of extra freight train and for the removal or diversion of steam locomotives (SL).

4-2. Train Operation Plan

4-2-1 Train Operation System

(1) Main Line

EC should run between Karachi City and Pipri. About one half of EC running between Karachi and Pipri should operate a shuttle service to and from Landhi where a lower level of passenger transport volume is estimated. As currently practiced, all medium and long distance service PC should depart from Karachi City Station or Karachi Cantt Station, provided that the starting station for all PC departing during the rush hour should be Karachi Cantt Station.

By 1987, doubling of track and completion of the loop line of KCR should be accomplished. This will result in a quadruple line between Karachi City and Drigh Road. Accordingly, the train schedule has been set on the basis of non-stop operation on the main line between Karachi City and Drigh Road.

(2) KCR

For KCR, trains are now operated mainly between Karachi City and Drigh Colony: 12 passenger trains are operated daily each way, two of which are for Karachi Cantt via Drigh Road. In view of the future traffic system in 1982, the shuttle service between Karachi City and Drigh Road has been considered as a major operation. For Drigh Colony, only a minor operation to Depot Hill has been taken into consideration.

In the daytime, the through operation of some EC's into the main line should be taken into consideration. The most recommended measure for 1987 is the completion of the KCR loop line so that the circulating operation within the KCR alone may be conducted.

(3) Malir Cantt Branch (M.C.B.)

At present, 16 passenger trains (one way) are scheduled, all for through operation into the main line. Upon completion of the electri-

Table 4-1 Present Situation of Train Operation (1974)

Main Line

Name of station	Length of section (km)	Block system	Non-inter-locked station	Real running time: Rapid service PC	Real running time: FC	Number of trains (one way)	Running speed (km/h)
Kiamari							
	4,923					Local PC 32	°Fast railcar
Karachi City							Max. speed 105
	3,701			6	10		planned speed (95)
Karachi Cantt						Rapid service PC 15	
	3,862						
Cansar Halt			○	6	10		°Rapid service PC:
	1,673					Long-distance PC 2	Max speed 95
Depature yard							planned speed (85)
	1,593						
Karsaz Halt			○			FC 15	°Local PC:
	1,834						
Air Force Halt			○	3	6		Max speed 65
	1,030					Total 64	planned speed (55)
Drigh Road							°FC
	1,770			2	3		
Drigh Colony							
	1,236					Max. number per hour: 5	Max speed 55
Air Port			○	2	3		planned speed (50)
	2,124						
Malir Colony							
	1,576			2	3		
Malir							
	3,669			3	5		

Double line, automatic

Main Line (Cont'd)

Name of station	Length of section (km)	Block system	Non-inter-locked	Real running time		Number of trains (one way)	Running speed (km/h)
				Rapid service PC	FC		
Landhi							
	5,953			6	8		
Jimma goth							
	6,919			5	8		
Pipri							
Total	41,833		10	35 (45)	56 (56)		

Malir Colony	7.6	Single line, non-automatic		PC (down) (21) (up) (17)	16	
Malir Cantt						

Note: Figures in parentheses in Column "Running time" indicate schedule values.

K. C. R.

Name of station	Length of section (km)	Block system	Station without accommodation for opposing train	Real running time	Number of trains (one way)	Track capacity	Running speed (km/h)
Drigh Colony							
	1,577			4.0	9	60	
Depot Hill							
	4,701			6.0		54	Max. 72
Karachi University							
	1,976			3.0			
Urdu College							
	1,142		○	3.0	11	50	Planned: 65
Karachi Central							
	2,848			5.0		59	
Liaqatabed							
	2,076			3.0		66	
North Nazimabad							
	1,834			3.0			
Orangi							
	2,140		○	3.0		50	
Manghopir							
	1,883			3.0		66	
Site							
	2,076			3.0		66	
Shah Abdul Latif							
	1,319			3.0	12		
Baldia			○				
	1,352		○	3.0		41	
Layari							
	1,545			3.0			

Single line, non-automatic (tablet)

K. C. R. (Cont'd)

Name of station	Length of section (km)	Block system	Station without accommodation for opposing train	Real running time	Number of trains (one way)	Track capacity	Running speed (km/h)
Wazir Mansion							
Karachi Port Trust	1,062		○	3.0	12	43	
Karachi City	1,432			6.0			
Total	28,962			54.0 (75.0)			
Drigh Road							
Depot Hill	1,769	Ditto		6.0	2	54	Ditto

fication project, local operation between Malir Colony and Malir Cantt should be adopted. In the daytime, however, the through operation of some EC's into the main line should also be taken into consideration.

4-2-2 Running Speed and Time

(1) Main Line

The main line section between Karachi City and Pipri has an average inter-station distance of 3.0 km. In addition, there are only few curve limitations in this section. Consequently, the maximum running speed can be raised to 110 km/h and the highest speed obtained from the performance of rolling stock. In view of the number of level crossing and the difference in speed between EC and PC or FC operated in combination, a running speed of 100 km/h has been planned for the time being. In this case, the running time planned for 1982 between Karachi City and Pipri is 46 minutes (for a schedule speed of 48.1 km/h) on the basis of a stopping time of 30 seconds at every station. This running time is the same as that of the current rapid service PC.

In 1987, the running time on the above section will be 40 minutes (at a schedule speed of 55.4 km/h) due to non-stop operation between Karachi Cantt and Drigh Road.

(2) KCR

KCR has many curve limitations and turnout limitations. In addition, the average inter-station distance of the KCR is as short as 2.0 km. The maximum planned speed has therefore been limited to 90 km/h. Turnouts of No. 12 are mainly used. Restricted speed on the reverse side of these turnouts has been planned to be 50 km/h. In planning the curve speed limit, the value of restricted speed currently adopted in Pakistan has been increased by 10 km/h for the EC. (See Table 4-6).

On these assumptions, the running time between Drigh Road and Karachi City will be 55 minutes (for a schedule speed of 31.8 km/h) in 1982 on the basis of an average stopping time of 1 minute at every station This running time is 20 minutes shorter than the current running time of PC. In 1987, this time will be further shortened by 9 minutes due to the elimination of turnout limitations and shorter stopping times at stations (30 seconds per station), both made possible by the doubling of track. As a result, the running time will be 46 minutes (for a schedule speed of 38.0 km/h) in 1987.

Fig. 4-1 Train Operation System After Electrification

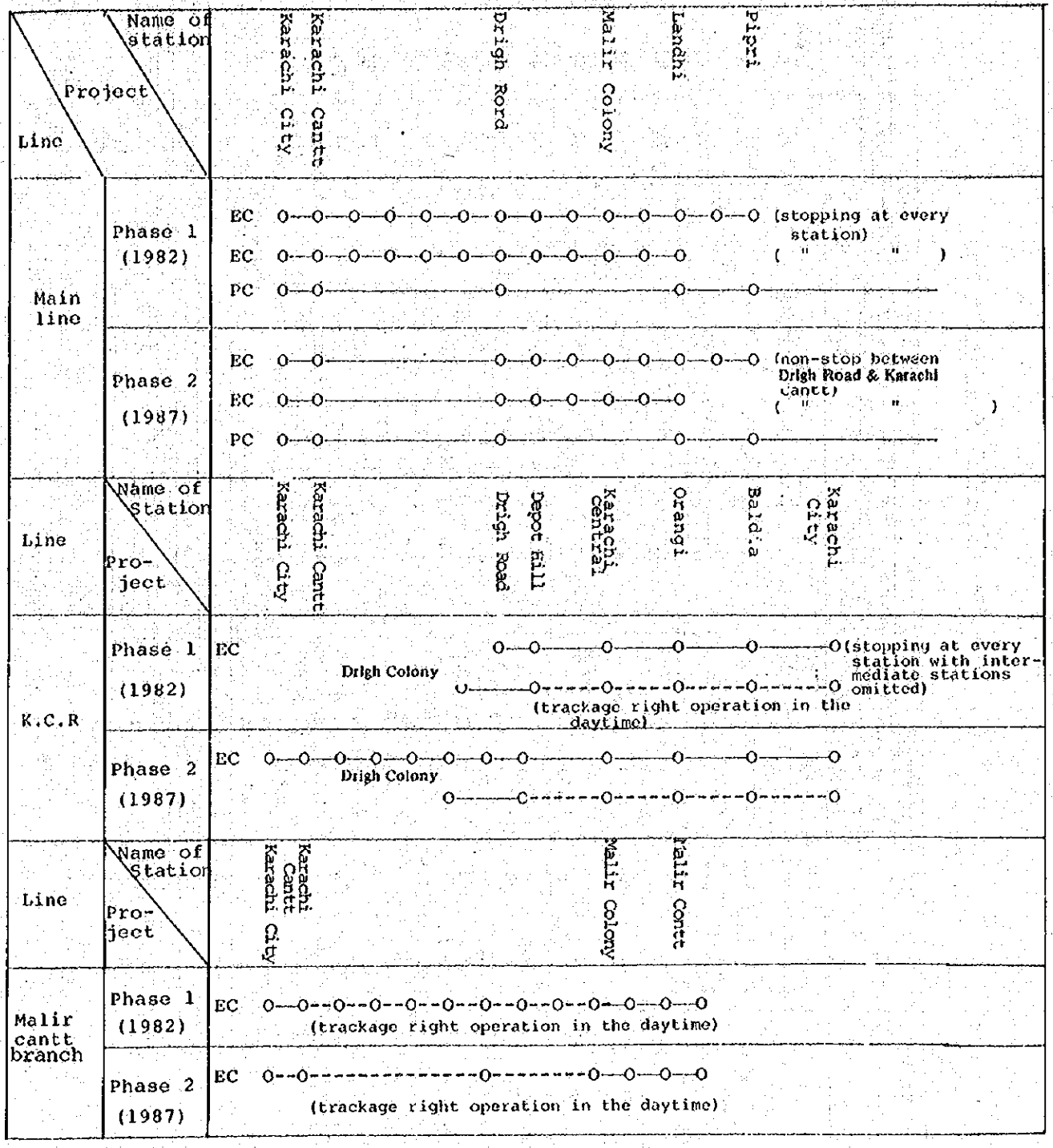


Table 4-2 Running time and speed

Main Line (Phase 1 - 1982)

Name of station	Length of section Miles	Km	Cumulative distance in Km (starting from Kianari)	Up Real running time	Up Stopping time	Up Max. speed	Up Average speed	Down Real running time	Down Stopping time	Down Max. speed	Down Average speed	Remarks
Karachi City			4,923			K/h	K/h			K/h	K/h	
	2.30	3,701		3'30"		98	63	3'30"		98	63	Karachi City-Pipri
Karachi Cantt			8,624		30"				30"			
	2.40	3,862		3'45"		98	62	3'45"		98	62	Schedule time
Chansar Halt			12,486		30				30			
	1.04	1,673		2'15"		82	45	2'15"		82	45	(Up) 46'00"
Depature yard			14,159		30				30			
	0.99	1,593		2'00"		84	48	2'00"		84	48	(down) 46'00"
Karsaz Halt			15,752		30				30			
	1.14	1,834		2'15"		87	49	2'15"		85	49	Schedule speed
Air Force Halt			17,586		30				30			
	0.64	1,030		1'45"		60	35	1'45"		62	35	(Up) 48.1 Km/h
Drigh Rord			18,616		30				30			
	1.10	1,770		2'15"		80	47	2'15		88	47	(down) 48.1 Km/h
Drigh Colony			20,386		30				30			
	0.75	1,236		1'45"		70	42	1'45"		70	42	
Air Port			21,539		30				30			
	1.32	2,124		2'30		90	51	2'30		88	51	
Malir Colony			23,716		30				30			
	0.98	1,576		2'00"		80	47	2'00"		80	47	
Malir			25,292		30				30			
	2.28	3,669		3'30"		98	63	3'30"		98	63	
Landhi			28,961		30				30			
	3.70	5,953		4'45"		98	75	5'00"		98	75	
Jimma Goth			34,914		30				30			
	4.30	6,919		5'30"		95	75	5'30"		98	75	
Pipri			41,833									
					(allowances 2'15")				(allowance 2'00")			
Total	22.94	36,910		37'45"	8'15"			38'00"	8'00"			
Malir Colony			0			K/h	K/h			K/h	K/h	Malir Colony - Malir Cannt
	1.70	2,816		3'00"		85	56	3'00"		85	56	
Model Colony			2,816		1'00"				1'00"			
	1.50	2,414		2'45"		80	53	2'45"		80	53	Schedule time (Up) 12'00"
Matpan			5,230		1'00"				1'00"			(Down) 12'00"
	1.50	2,414		2'45"		80	53	2'45"		80	53	Schedule speed
Malir Cantt			7,644									
					(allowances 1'30")				(allowance 1'30")			
	5.20	7,644		8'30"	3'30"			8'30"	3'30"			(Up) 38.2 Km/h) (Down 38.2 Km/h)

Table 4-3 Main Line (Phase 2 - 1987)

Name of station	Length of section		Cumulative distance in Km (starting from Kiamari)	Up				Down				Remarks
	Miles	Km		Real running time	Stopping time	Max. speed	Average speed	Real running time	Stopping time	Max. speed	Average speed	
						K/h	K/h			K/h	K/h	
Karachi City			4,923									
	2.30	3,701		3'30"		98	63	3'30"		98	63	Karachi City - Pipri
Karachi Cantt			8,624		30"				30"			
	2.40	3,862		3'15"		98	71	3'00"		98	77	Schedule time
Chansar Halt			12,486		-				-			
	1.04	1,673		1'15"		98	80	1'15"		98	80	(Up) 40'00"
Depature yard			14,159		-				-			
	0.99	1,593		1'00"		98	95	1'00"		98	95	(Down 40'00"
Karsaz Halt			15,752		-				-			
	1.14	1,834		1'15"		98	88	1'15"		98	88	-
Air Force Halt			17,586		-				-			Schedule speed
	0.64	1,030		1'00"		93	61	1'00"		90	61	
Drigh Road			18,616		30"				30"			(Up) 55.4 km/h
	1.10	1,770		2'15"		80	47	2'15"		88	47	
Drigh Colony			20,386		30				30			(Down) 55.4 km/h
	0.75	1,236		1'45"		70	42	1'45"		70	42	
Air Port			21,539		30				30			
	1.32	2,124		2'30"		92	51	2'30"		88	51	
Malir Colony			23,716		30				30			
	0.98	1,576		2'00"		80	47	2'00"		80	47	
Malir			25,292		30				30			
	2.28	3,669		3'30"		98	63	3'30"		98	63	
Landhi			28,961		30				30			
	3.70	5,953		4'45"		98	75	5'00"		98	75	
Jimma goth			34,914		30				30			
	4.30	6,919		5'30"		95	75	5'30"		98	75	
Pipri			41,833		(Allowances 2'30")				(Allowances 2'30")			
Total	22.94	36,910		33'30"	6'30"			33'30"	6'30"			

Table 4-4 K.C.R. (Phase 1 - 1982)

Name of station	Length of section		Cumulative distance in Km (starting from Drigh Colony)	Up				Down				Remarks
	Miles	Km		Real running time	Stopping time	Max. speed	Average speed	Real running time	Stopping time	Max. speed	Average speed	
						K/h	K/h			K/h	K/h	
Drigh Colony			0									Drigh Colony- Karachi city
	0.98	1,577		2'15'		65	42	2'15"		63	42	
Depot Hill			1,577		1'00"				1'00"			
	2.922	4,701		4'30"		83	63	4'45"		90	59	Schedule time (Up) 54"00"
Karachi University			6,278		1'00"				1'00"			(Down 54"00"
	1.228	1,976		2'15"		90	53	2'15"		80	53	
Urdu College			8,254		1'00"				1'00"			
	0.71	1,142		2'00"		48	34	1'45"		70	39	Schedule speed (Up) 32.2 km/h
Karachi Central			9,396		1'00"				1'00"			(Down) 32.2 km/h
	1.77	2,848		3'15"		85	53	3'00"		90	57	
Liaqatabad			12,244		1'00"				1'00"			
	1.29	2,076		3'00"		55	42	2'30"		85	50	
North Nazimabad			14,320		1'00"				1'00"			Drigh Road- Karachi City
	1.14	1,834		2'30"		70	44	2'30"		63	44	
Orangi			16,154		1'00"				1'00"			
	1.33	2,140		3'00"		70	43	3'00"		65	43	Schedule time (Up) 55"00"
Manghopir			18,294		1'00"				1'00"			(Down) 55"00"
	1.17	1,863		3'00"		55	38	2'15"		87	50	
Site			20,177		1'00"				1'00"			
	1.29	2,076		2'15"		85	55	2'15"		87	55	Schedule speed (Up) 31.8 km/h
Shah Abdul Latif			22,535		1'00"				1'00"			(Down) 31.8 km/h
	0.82	1,319		2'15"		58	35	2'00"		60	40	
Baldia			23,572		1'00"				1'00"			
	0.84	1,352		2'00"		75	41	2'00"		77	41	
Layari			24,923		1'00"				1'00"			
	0.96	1,545		2'15"		60	41	2'00"		80	46	
Wazir Mansion			26,468		1'00"				1'00"			
	0.66	1,062		2'00"		50	32	1'45"		67	36	
Karachi Port Trust			27,530		1'00"				1'00"			
	0.89	1,432		2'15"		58	38	2'15"		60	38	
Karachi City			28,962									
					(Allowances 1'15")				(Allowances 3'30")			
Total	18.00	28,962		38'45"	15'15"			36'30"	17'30"			
						K/h	K/h			K/h	K/h	
Drigh Road Depot Hill	1.10	1,769		3'00"		52	35	3'00"		52	35	

Table 4-5 K.C.R. (Phase 2 - 1987)

Name of station	Length of section		Cumulative distance in Km (starting from Kiamari)	Up				Down				Remarks
	Miles	Km		Real running time	Stopping time	Max. speed	Average speed	Real running time	Stopping time	Max. speed	Average speed	
Drigh Colony			0			K/h	K/h			K/h	K/h	Drigh colony - Karachi City
	0.98	1,577		2'15"		65	42	2'15"		63	42	
Depot Hill			1,577		30"				30"			
	2.922	4,701		4'15"		83	66	4'30"		90	63	Schedule time (Up) 45'00"
Karachi University			6,278		30				30			
	1.228	1,976		2'15"		90	53	2'00"		90	59	(Down) 45'00"
Urdu College			8,254		30				30			
	0.71	1,142		1'45"		66	39	1'45"		70	39	Schedule speed (Up) 38.6 Km/h
Karachi Central			9,396		30				30			
	1.77	2,848		3'00"		87	57	3'00"		90	57	(Down) 38.6 Km/h
Liaqatabad			12,244		30				30			
	1.29	2,076		2'30"		73	50	2'30"		85	50	
North Nazimabad			14,320		30				30			Drigh Road - Karachi City
	1.14	1,834		2'30"		70	44	2'30"		63	44	
Orangi			16,154		30				30			
	1.33	2,140		2'45"		70	47	3'00"		65	43	Schedule time (Up) 46'00"
Manghopir			18,294		30				30			
	1.17	1,883		2'15"		87	50	2'15"		87	50	(Down) 46'00"
Site			20,177		30				30			
	1.29	2,076		2'15"		85	55	2'15"		87	55	Schedule speed (Up) 38.0 Km/h
Shah Abdul Latif			22,535		30				30			
	0.82	1,319		2'00"		58	40	2'00"		60	40	(Down) 38.0 Km/h
Baldia			23,572		30				30			
	0.84	1,352		2'00"		75	41	2'00"		77	41	
Layari			24,923		30				30			
	0.96	1,545		2'00"		77	46	2'00"		80	46	
Wazir Mansion			26,468		30				30			
	0.66	1,062		1'45"		70	36	1'45"		67	36	
Karachi Port Trust			27,530		30				30			
	0.89	1,432		2'15"		58	38	2'15"		60	38	
Karachi City			28,962		(allowances 2'15")				(allowances 2'00")			
Total	18.00	28.962		35'45"	-'15"			36'00"	9'00"			
Drigh Road Depot Hill	1.10	1,767		3'00"			K/h 35	3'00"		52	K/h 35	

(3) Malir Cantt Branch

For a maximum planned speed of 90 km/h for 1982, the running time will be 12 minutes (for a shedule speed of 38.2 km/h) which is 5 to 10 minutes shorter than the current time.

Table 4-6 Curve Speed Limit

Type of Train \ Curve (m)	870	700	600	500	450	400	350	300	250	200
Electric rail-car train	105(km/h)	95	90	85	80	75	70	65	60	50
Passenger train (DL)	95(km/h)	85	80	75	70	65	60	55	50	45
Freight train (DL)	(km/h)						60	55	50	45

4-2-3 Train Planning

(1) Calculation of Number of rains

The required transport capacity has been estimated by adjusting the average section traffic flow of 40,000 passenger-kilometers/kilometer/day for 1982 in accordance with actual conditions of each railway division.

Main line: Karachi City - Landhi: 40,000 x 160% = 64,000
Landhi - Pipri: 40,000 x 90% = 36,000

KCR: Drigh Road - Karachi City: 40,000 x 110% = 44,000
Drigh Colony - Depot Hill: 40,000 x 70% = 28,000

M.C.B.: Malir Colony - Malir Cantt: 40,000 x 70% = 28,000

In 1987 when the KCR loop line is expected to be completed, the main line section between Karachi City and Drigh Road will be covered by the KCR. Accordingly, the required transport capacity has been underestimated for 1987.

Main Line: Karachi City - Landhi: 72,000 x 130% = 93,000
Landhi - Pipri: 72,000 x 70% = 50,000

KCR: Drigh Road - Karachi City: 72,000 x 100% = 72,000
Drigh Colony - Depot Hill: 72,000 x 50% = 36,000

M.C.B.: Malir Colony - Malir Cantt: 72,000 x 50% = 36,000

The number of trains has been calculated by dividing the required transport capacity of each railway division listed above by 150 (normal accommodation per car) x 6 (number of cars, making up a train).

The ratio of hourly transport capacity for rush hours to daily transport capacity has been taken as 15%. The load factor for rush hours

has been taken as 200% for the main line and KCR and 150% for other lines.

Train frequency and headway for rush hours and other times in each railway division are shown in Table 4-7. On the basis of this table, the headway is to be adjusted in accordance with different times.

For intermediate years between 1982 and 1987, the number of trains should be gradually increased.

(2) Future Measures

The increase in demand for railway transport should be met as follows:

(a) In view of currently available station length and platform length at each station, the train make-up unit should be limited to a maximum of 12 electric cars. In accordance with the headway, the train make-up should be augmented from 6 electric cars to 9 cars and then to 12 cars.

(b) From the viewpoint of facilities, a minimum headway of three minutes can be adopted. In view of the mixed operation of PC and FC on the main line in the futute, a minimum headway of about five minutes is recommendable. Full utilization of the main line. The number of trains planned for the main line should be minimized.

Table 4-7 Operation Planning for each Line

Name of line	Project	Section	Number of cars making up train	Headway in minutes		Electric railcar train frequency		Transport capacity	
				In rush hours	At other times	Per rush hour	Per day	Per rush hour	Per day
Main Line	Phase 1 (1982)	Karachi City - Landhi	6	10	15~20	6	80	300x6x6=10,800	*150x6x75=67,500
		Landhi - Pipri	6	20	30	3	40	300x6x3= 5,400	150x6x40=36,000
	Phase 2 (1987)	Karachi City - Landhi	6	7.5	15	8	100	300x6x8=14,400	150x6x100=90,000
		Landhi - Pipri	6	15	20	4	60	300x6x4= 7,200	150x6x60=54,000
K.C.R.	Phase 1 (1982)	Drigh Road - Karachi City	6	15	20	4	50	300x6x4= 7,200	150x6x50=45,000
		Drigh Colony - Depot Hill	6	15 30	30	3	30	225x6x3= 4,050	150x6x30=27,000
	Phase 2 (1987)	Karachi City - Drigh Raod - Karachi City City	6	10	15	6	80	300x6x6=10,000	150x6x80=72,000
		Drigh Colony - Depot Hill	6	15	20	4	40	225x6x4= 5,400	150x6x40=36,000
M.C.B.	Phase 1 (1982)	Malir Colony - Malir Cantt	6	20	30	3	30	225x6x3= 4,050	150x6x30=27,000
	Phase 2 (1987)		6	16	20	4	40	225x6x4= 5,400	150x6x40=36,000

Note: * = $\frac{\text{(Passengers carried)}}{300} \times \text{(Train make-up)} \times \frac{\text{(Number of trains)}}{6}$

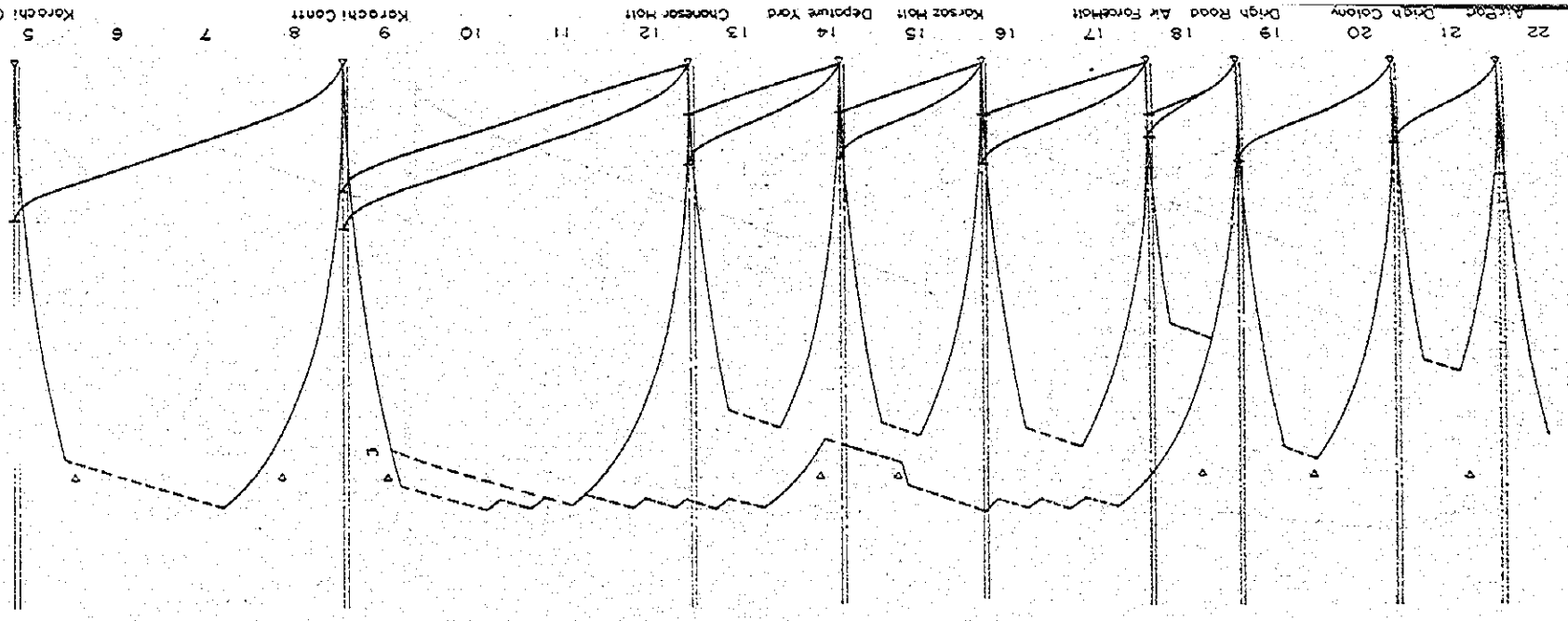
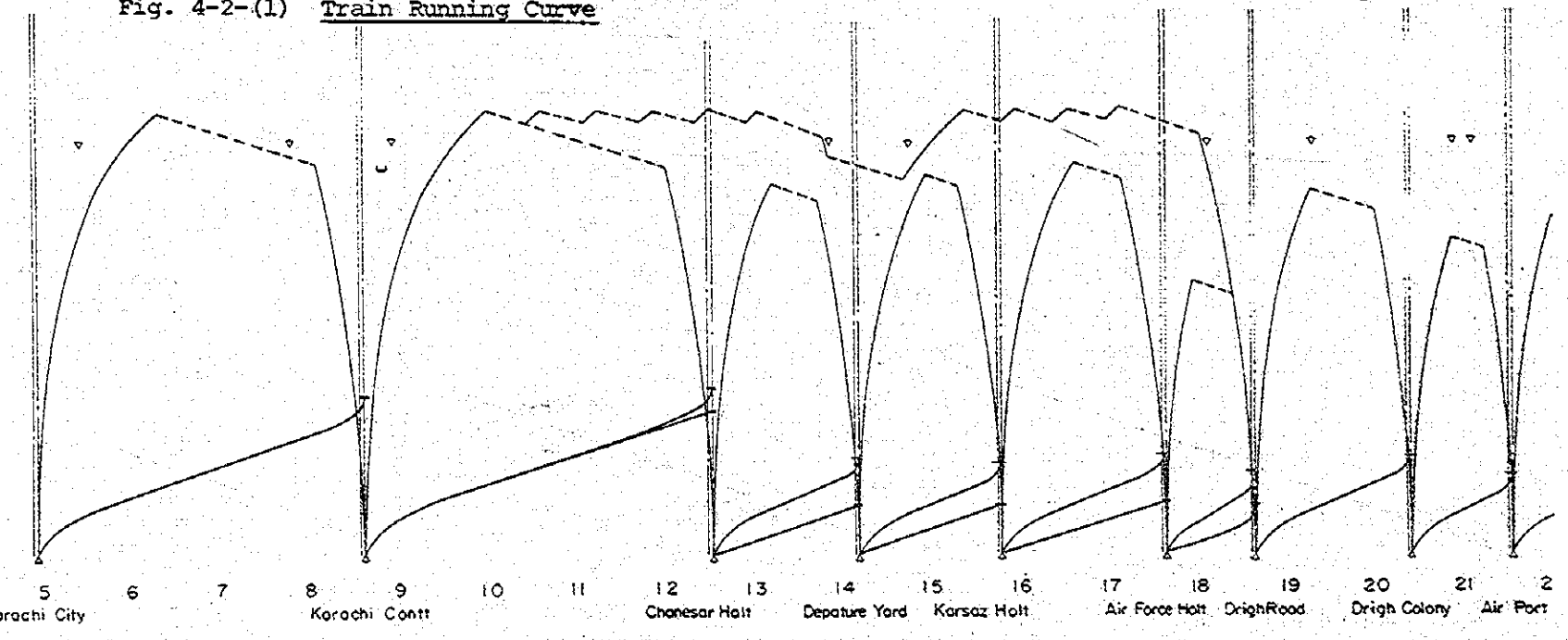


Fig. 4-2-(1) Train Running Curve

Main Linn

Vmax 100km/h
Point 90km/h
#12 50km/h
EC 4M2T
303t
MM 120kw
Gr 4.82
Dc 1500v
= 1.5km/h/s
= 2.0
= 1.75



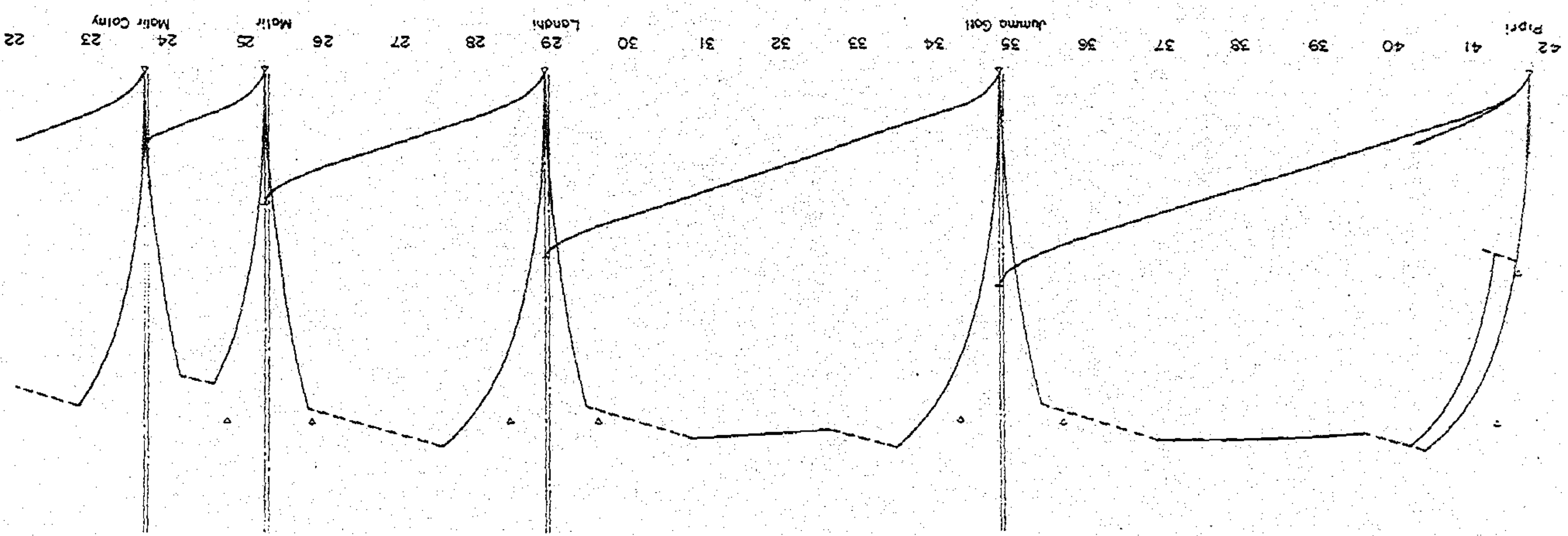
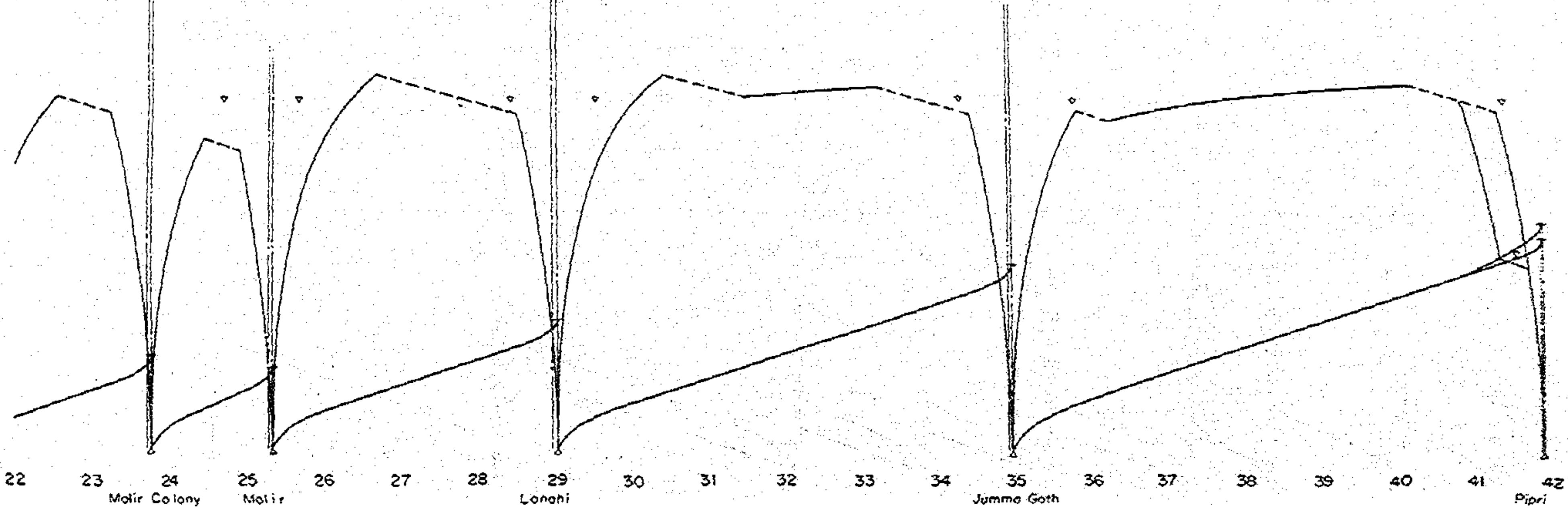


Fig. 4-2-(2) Train Running Curve



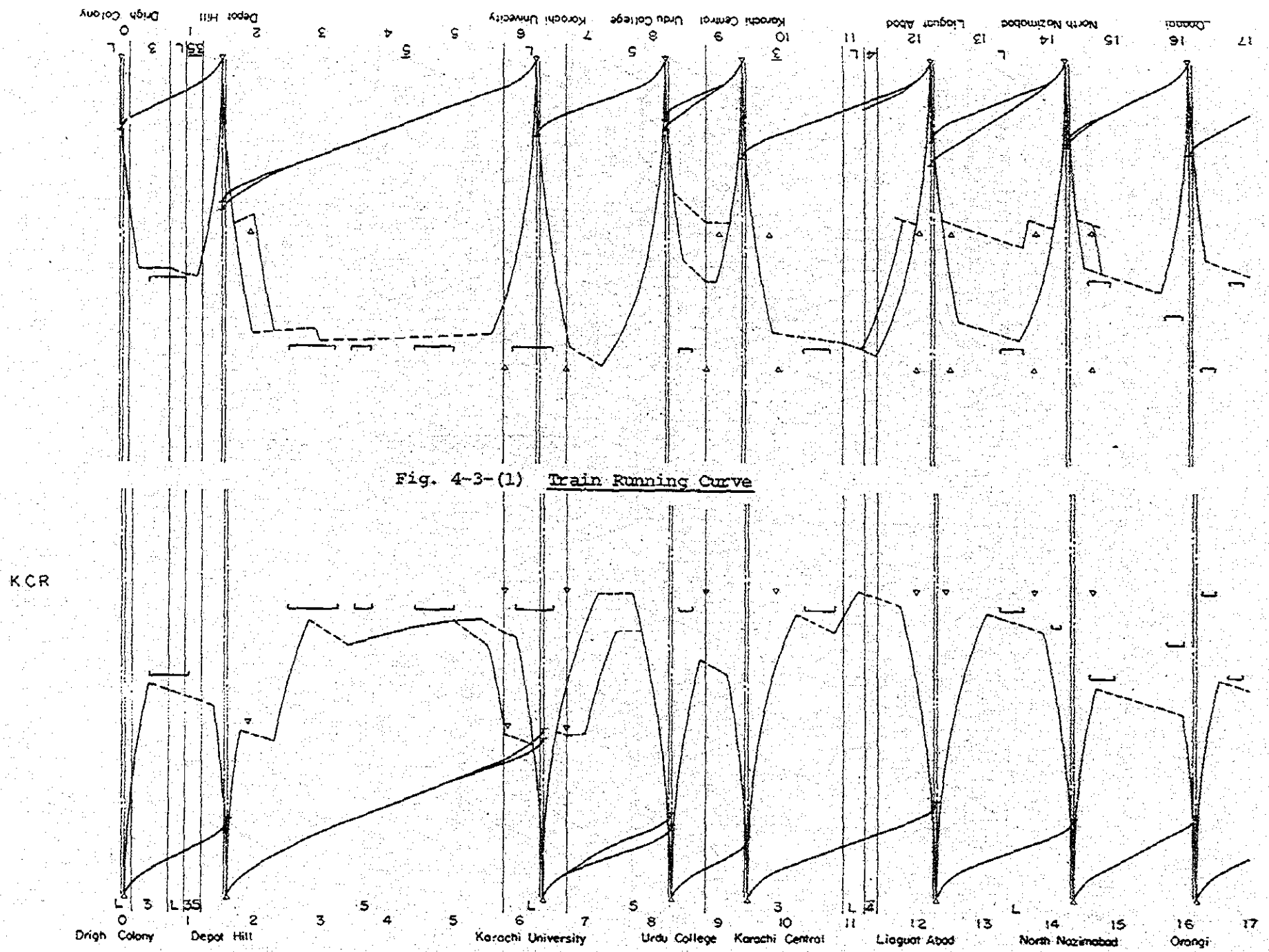


Fig. 4-3-(1) Train Running Curve

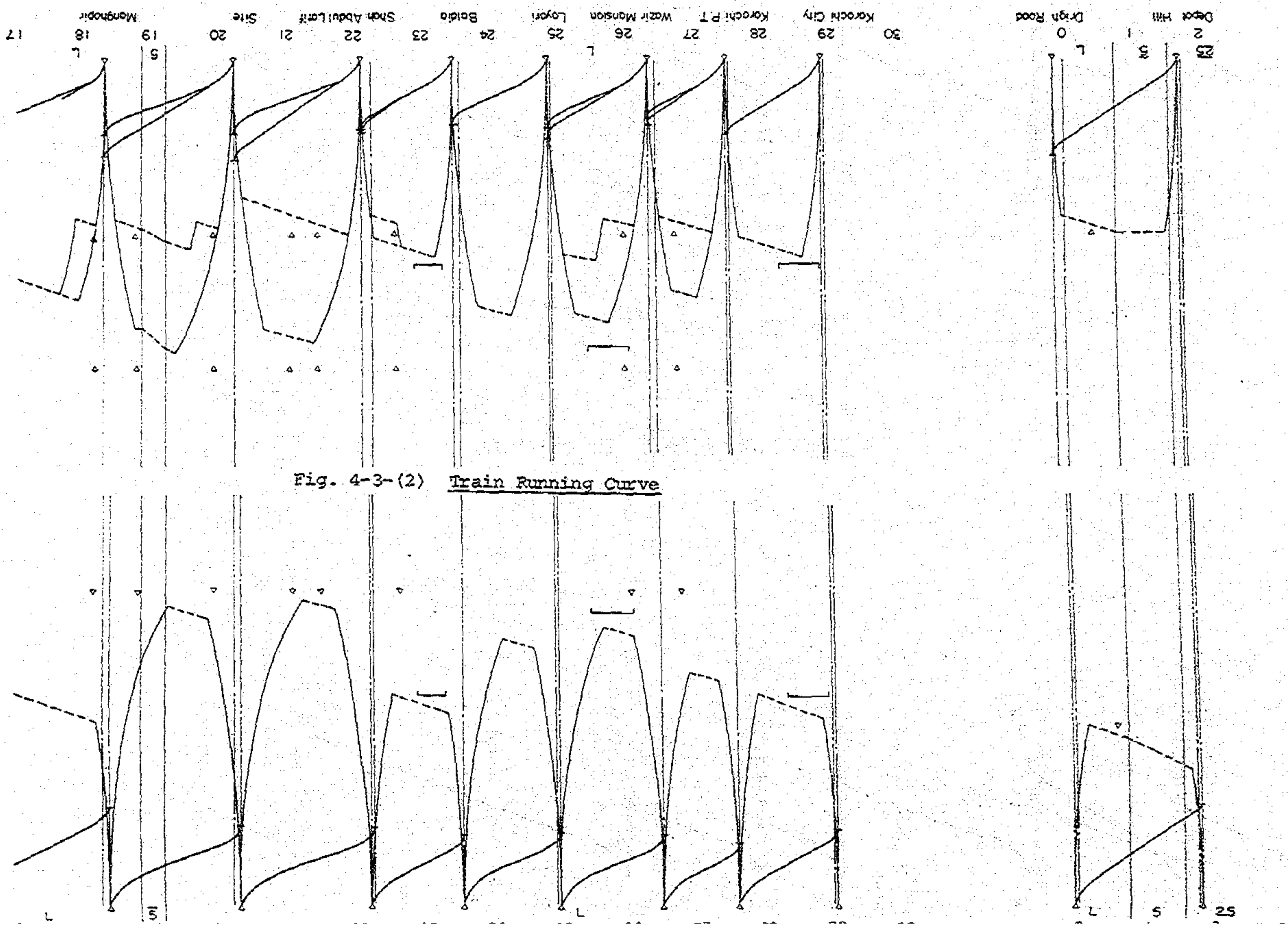


Fig. 4-3-(2) Train Running Curve

Fig4-4 Example of Rush-Hour Train Timetable on the Main Line (1982)

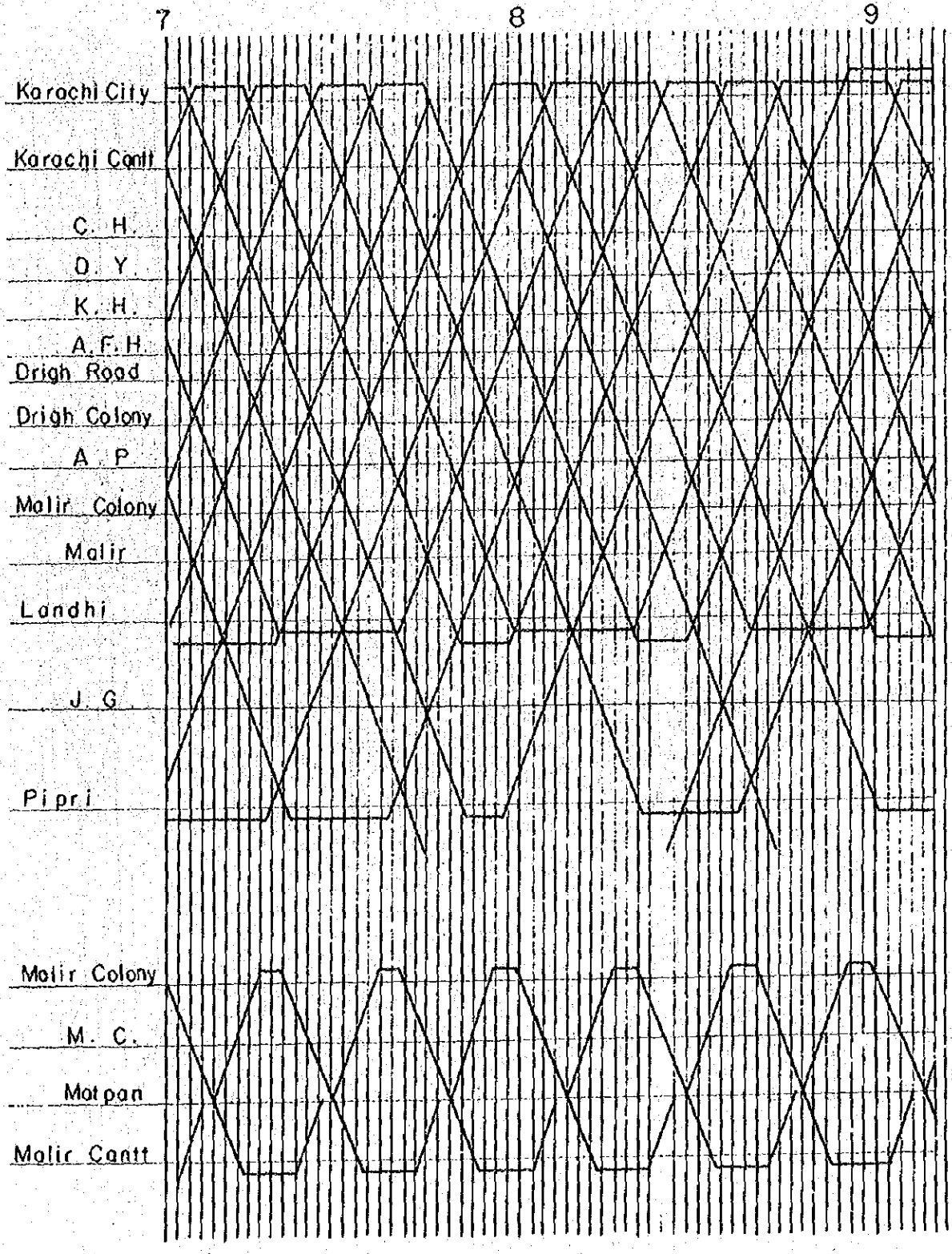


Fig. 4-5 Example of Rush-Hour Train Timetable on the Main Line (1987)

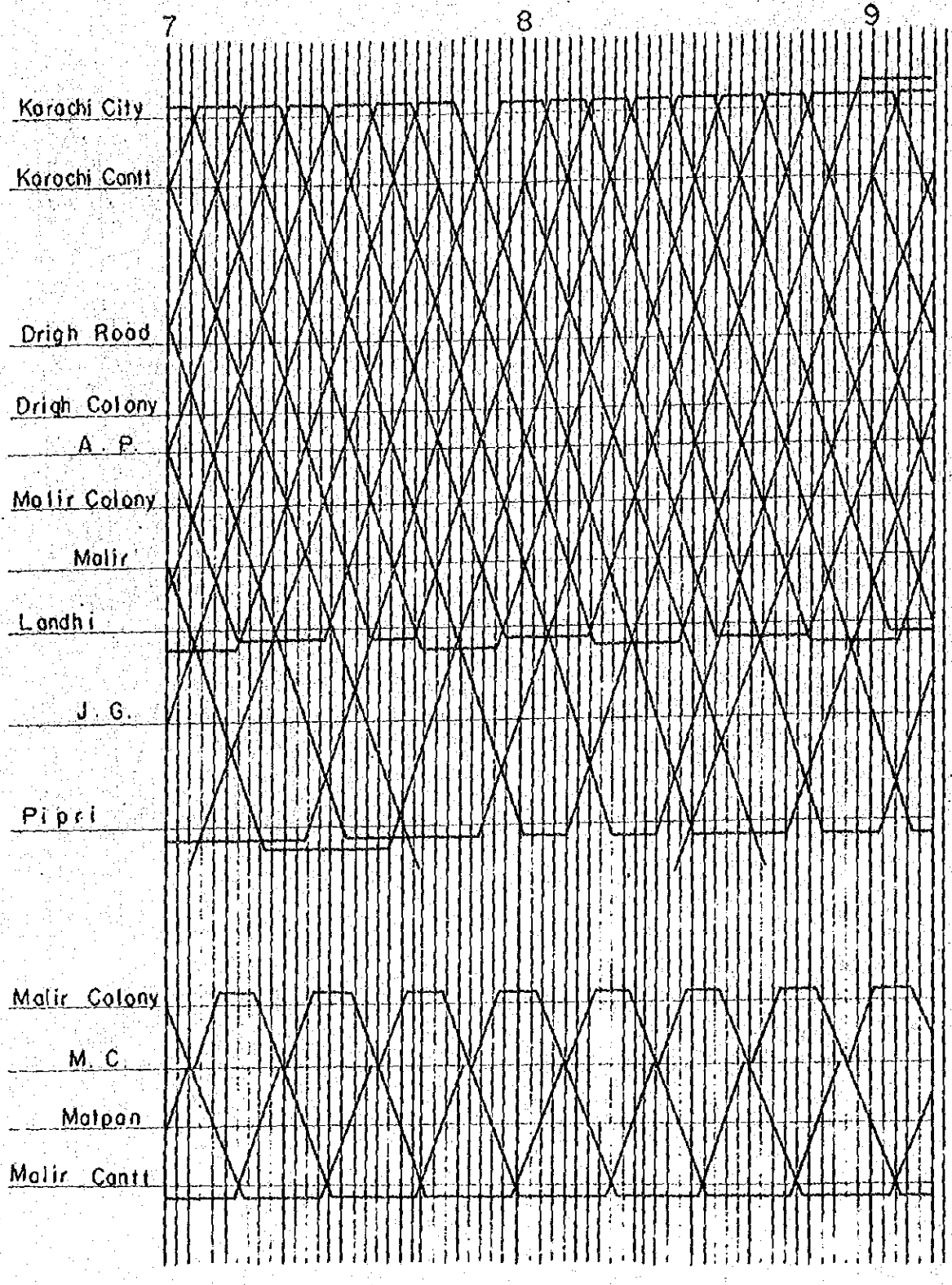


Fig. 4-6 Example Rush Hour Train Timetable (As Headways of Every 15 Minutes) (KCR Phase1-1982)

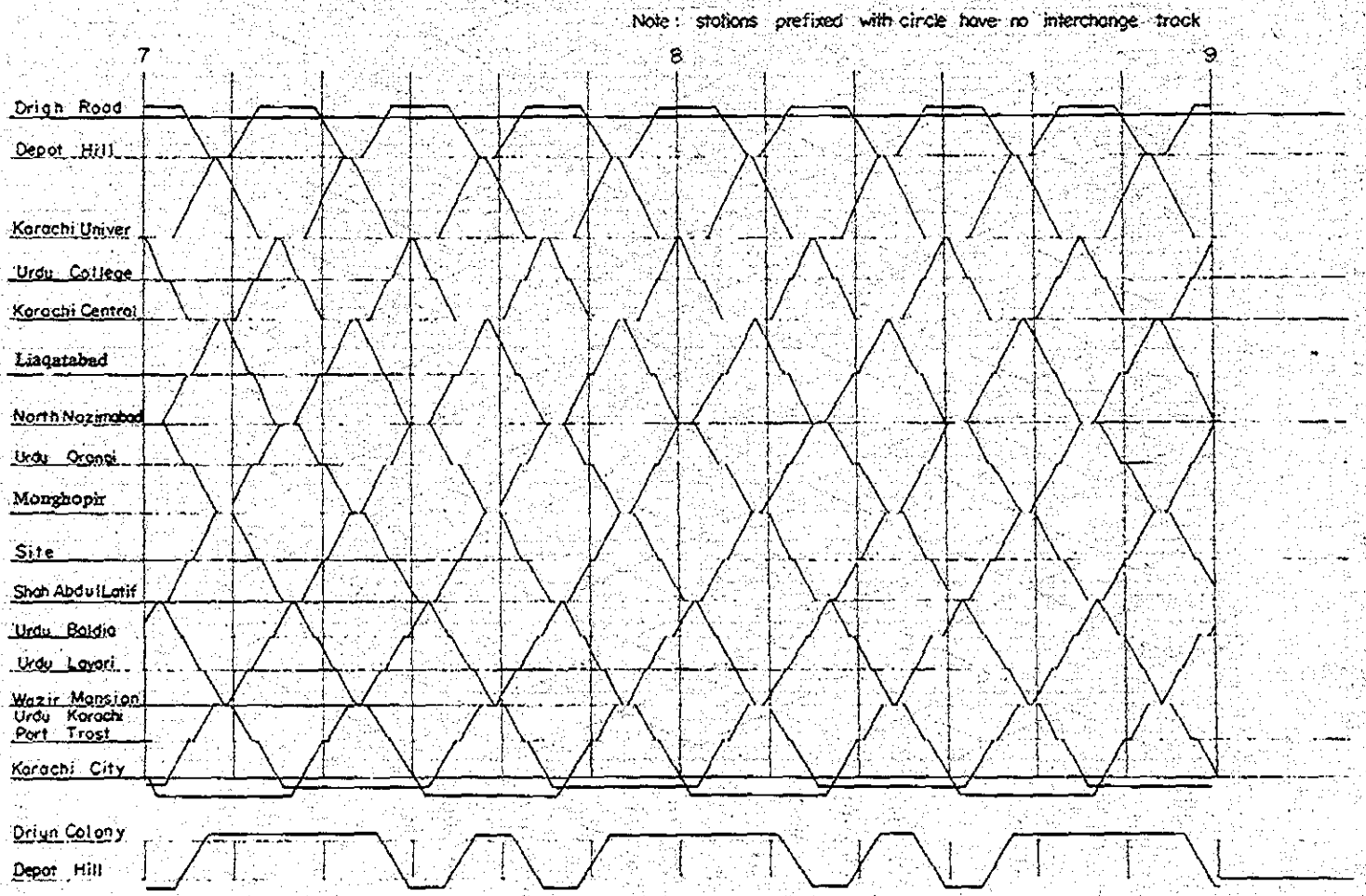
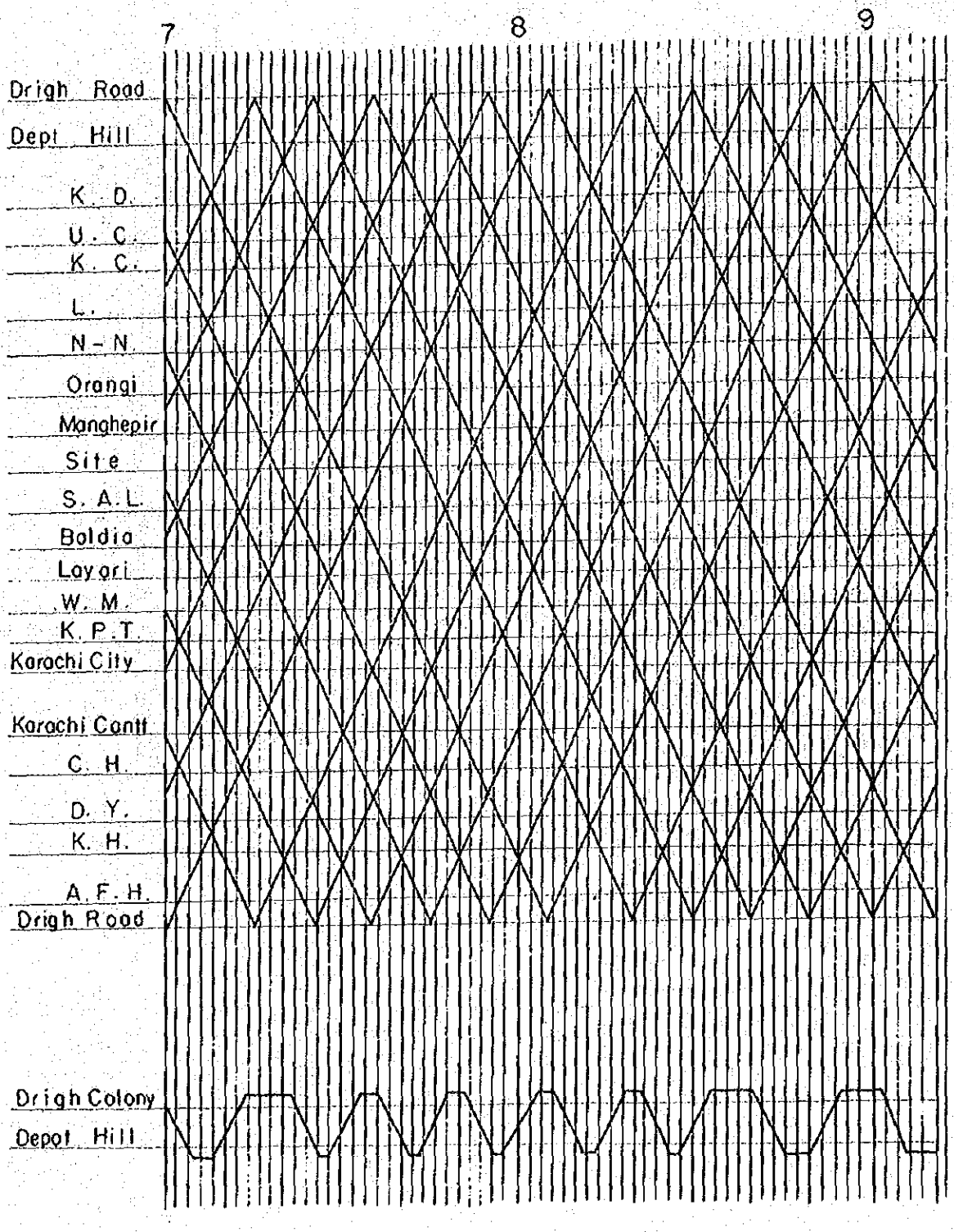


Fig. 4-7 Example of Rush-Hour Train Timetable on the KCR Line (1987)



4-3. Electric Cars

4-3-1 Type and Size of Electric Car

The electric cars adopted should be of the direct current, 1500 V, suburban type so that they may also be used spine and other underground routes planned to be constructed in future.

Th size of electric cars should be 19,500mm (length) x 3,250mm (width) so as to fit the dimensions of passenger coaches now is use by the Pakistan Railways.

4-3-2 Train Unit

Train units should be 6, 9 or 12 electric cars depending on the demand for railway transportation. The train make-up for each unit should be as follows:

6 electric car train - TcMM'MM'Tc
9 elertric car train - TcMM'TcMM'MM'Tc
12 electric car train - TcMM'MM'TcMM'MM'Tc

Note: Tc = Control Car
MM = Motor Car

4-3-3 Performance

Each motor car should be equipped with four 120 kW D.C. motors so that a minimum running time may be obtained for commuter electric cars for an inter-station distance of 1 to 5 km. The maximum speed should be 110 km/h. For a 6 electric car train, acceleration and deceleratio should be 2.0 km/h/sec and 3.0 km/h/sec, respectively.

With a view to operations in common with spine and other underground routes, all car bodies and electric parts should be of non-combustible construction. In addition, electric parts should be suitable for the ambient conditions (high temperature and dustry) around Karachi.

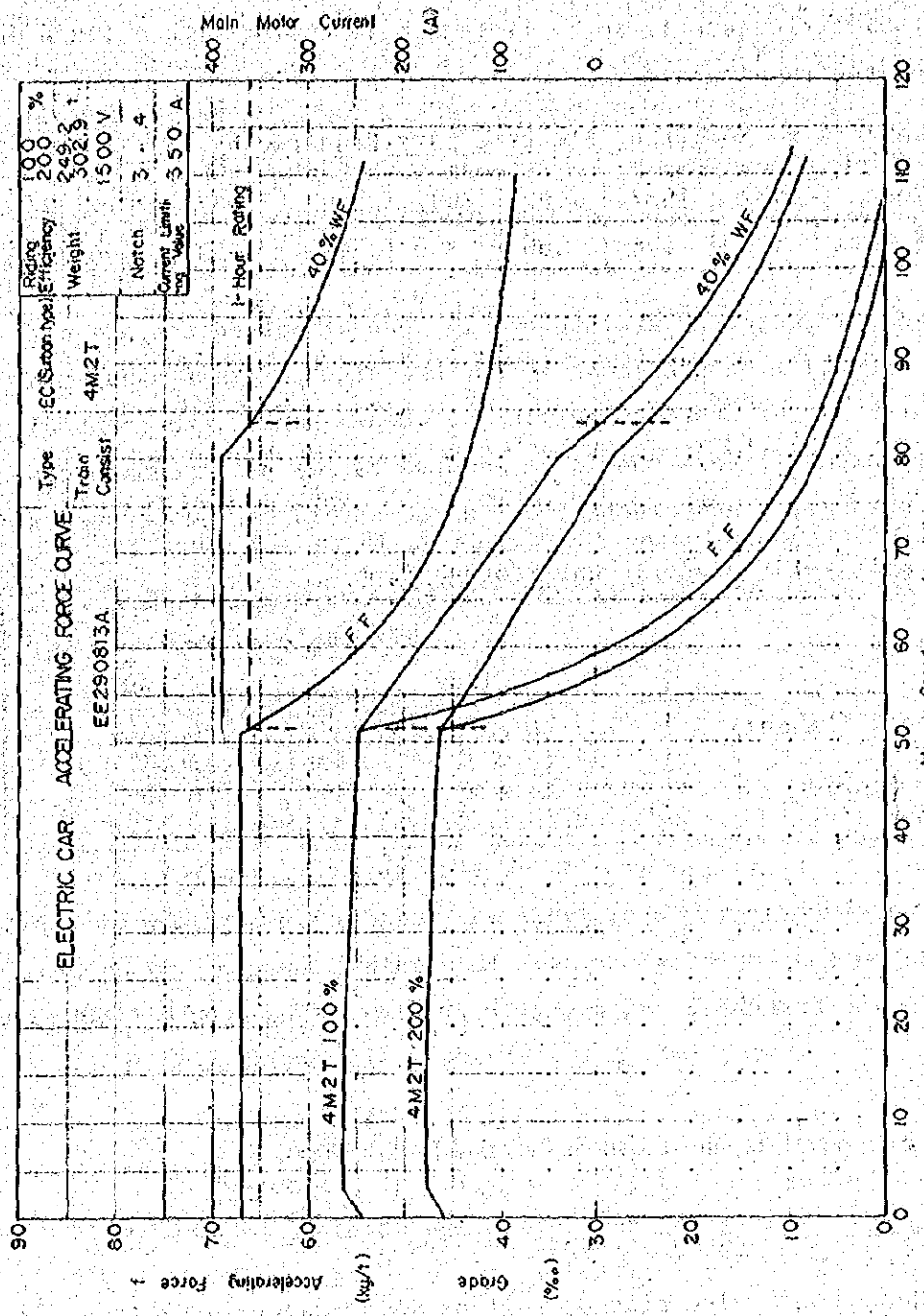
Table 4-8 Principal Characteristics of Electric Railcars

Item	Unit	Numerical Value
Track gauge	mm	I,676
Electric System		DC 1500 V
Performance of one set of motor cars (2 cars).		
Rating per hour: Output	KW	960
Voltage	V	1,500
Current	A	720

Table 4-8 (Cont'd)

Item	Unit	Numerical Value
Current limit value (power running braking)	A	450
Maximum permissible speed	Km/h	110
Normal Accommodation capacity (sitting + standing seats)	Passengers	Multiple unit electric cars: 150 Intermediate cars: 160
Seat arrangement		Longitudinal
Weight (empty)	t	M car: 38; M' car: 35; Tc car: 31
Weight (loaded)	t	M car: 58; M' car: 55; Tc car: 51
Principal dimensions of body:		
Length between coupling faces	mm	20,000
Body length	mm	19,500
Body width	mm	3,250
Maximum height	mm	3,937
Distance on centers between bogies	mm	13,800
Bogie:		
Fixed wheel base	mm	2,100
Wheel diameter	mm	860
Main motor: System		DC series interpole motor
	A	Continuous rating: 315
	A	Rating per hour: 360
Number of motors (one unit for two ars)		8
	KW	120
Gear ratio		4.82
Control:		
Control system		Series & parallel, weak field, dynamic braking, multiple-unit control
Controller		Electrically-driven camshaft contact type
Circuit voltage	V	100
Brake		Dynamic brake, straight electromagnetic brake, hand brake
Air compressor		C 1000/M'car
Motor generator		20 kVA/M' car
R.M.S. current (average inter-station distance: 2.8 km)		
2MIT basic make-up		Off-brake operation: 170 " Set time: 170 x 1.1 = 187"
	A	Current intensity: 324

Fig. 4-8 Electric Car Accelerating Force Curve



4-4. Required Number of Electric Car and Electric Car Storage

Number of electric cars required for planned train operation by year is as follows. In 1982, 168 electric cars (132 in service and 36 stand-by) will be required for 28 trains. In 1987, the number of trains will be increased by 30 to 50% as compared with 1982, but the increase in number of electric cars is to be limited only to 20%, i.e., 198 cars by shortening the running time.

Table 4-9 Number of Electric Cars Required by Year

Year	1982	1987	1992	1997	2002	2007	2012
No.of Cars	168	198	300	350	450	550	600

For electric car storage tracks, the dispersed storage of electric cars will be problematic from the view point of management and will require larger station facilities. Consequently, the centralized storage of electric cars should be adopted as far as circumstances permit. For this purpose, a new electric car depot should be constructed at Landhi.

Table 4-10 Electric Car Storage Plan

Storage Area	Number of Cars	
	1982	1987
EC depot (Landhi)	132 (6 cars x 22 trains)	150 (6 x 25)
Pipri	12 (6 x 2)	18 (6 x 3)
Wazir Mansion	12 (6 x 2)	18 (6 x 3)
Karachi City	12 (6 x 2)	12 (6 x 2)

Two electric car storage tracks should be installed at Pipri and Wazir Mansion and starting stations for main line down and up trains, respectively. At Karachi City, electric railcars should be stored on main tracks.

4-5. Inspection and Repair of Electric Cars and Railcar Depot

4-5-1 Inspection and Maintenance Services

The present situation of railcar maintenance in Pakistan is not necessarily satisfactory. The frequency of car troubles is quite high. For the introduction of new cars, periodical effective maintenance without any reduction of utilization efficiency of electric cars will be required particularly for the prevention of accidents.

For this purpose, an inspection and repair service conducted between operations is ideal. Except major overhauls, this service should be

performed in the railca depot.

(1) Categories of inspection

Five categories of inspection should be performed periodically; daily inspection, regular inspection, truck inspection, important parts inspection and general inspection. In addition to these inspections, special inspections should be performed as required upon occurrence of a trouble and running inspections of cars in operation should be executed.

For the time being, periodic inspections should be performed at least at the following intervals, taking inexperience with new cars into consideration.

- Daily inspection: every 1,500 km; every two days
- Regular inspection: every 15,000 km; every 30 days.
- Truck inspec ion: every 100,000 km; every 6 months.
- Important parts inspection: every 250,000 km; every 1,5 years
- General inspection: every 500,000 km; every 3 years.

When a higher class inspection coincides with a lower inspection, the lower class inspection should be omitted and both inspections should be considered to have been executed.

(2) Details of Inspection

a. Daily inspection:

This inspection covers the replenishement and replacement of consumable items as well as an external inspection of the condition and action of current collectors, door closing devices, braking devices, bogie travelling devices, interior devices, low-tension auxiliary rotary machines, low-tension auxiliary circuit devices, etc. Daily inspections should be carried out in the car depot.

b. Regular inspection:

This inspection is for the condition, action and function of current collectors, extra-high-tension circuit devices, principal-circuit devices, high-tension auxiliary circuit devices, bogie travelling devices, car bodies, instruments, accessory devices, etc. as well as on the insulation resistance of electric parts with these devices and parts left intact. Regular inspections should be carried out in the car depot where electric cars to be inspected are based.

c. Truck inspection:

This inspection should be carried out in the car depots where the electric cars to be inspected are based. Certain principal

machines and devices, including main motors, bogie travelling devices, basic braking devices, etc., should be removed or overhauled and inspected in detail.

d. Important parts inspection:

In addition to those items included in the bogie inspection, this inspection should cover important items including current collectors, auxiliary rotary machines, relays, contacts, air brakes, etc. This inspection should be carried out in the workshop.

e. General inspection:

This inspection should be carried out in the workshop by overhauling each portion of cars and inspecting the entire cars in detail.

4-5-2 Car Depot

(1) Location and Layout

For the purpose of performing this inspection, repair and servicing of electric cars, a special car depot for electric cars should be constructed on the Pipri side of Landhi, a principal station on the main line. In order to reduce the incidence of main line trains and electric cars entering or leaving the shed at the same time, the depot should be joined to both up and down main line tracks. For track layout, electric car storage tracks and inspection, repair and servicing tracks should be arranged in series so as to make yard operations more smooth.

(2) Installations Required

Installations required for performing daily inspections, regular inspections, truck inspections and special repairs should be provided (for 168 cars for 1982). By 1987, EC storage tracks should be partially extended.

	(No. of tracks)	(Effective length of tracks)
EC storage track - 1982:	20	260m (Though an initial length of 140 may be sufficient because of the 6 car train sets, 260m should be adopted to eliminate any extra work in future.)
- 1987:	23	
Regular inspection track	2	135 (250 in future)
Washing/daily inspection track	3	140 (260 in future)
Truck repair track	2	90
Grinding track	1	350 (540 in future)
Drill track	1	140 (260 in future)

Inspection and repair installations including, regular inspection shed, truck inspection shed, inspection and repair equipment, automatic washing equipment, grinding shed, etc. are required. Buildings including railcar depot office, signal cabin, workshop, accommodation for motormen, yardmen and car inspectors, etc. are required.

4-5-3 Electric Car Workshop

(1) Location and Layout

Since the initial number of electric cars is less than 200, the requirements for general and important part inspections of electric cars can be met by the partial extension of the existing shop for diesel locomotives at Karachi Cantt.

For this extension, available equipment now used for the inspection and repair of diesel locomotives so far as circumstances permit. Service room for car entry, and dismantling/fitting-out bay, car body repair bay, parts bay (bogies, wheels, main motors, etc.) and electrical bay should be arranged as shown in Fig. 4-11 so as to make shop work more smoothly.

Fig. 4-9 Car depot location

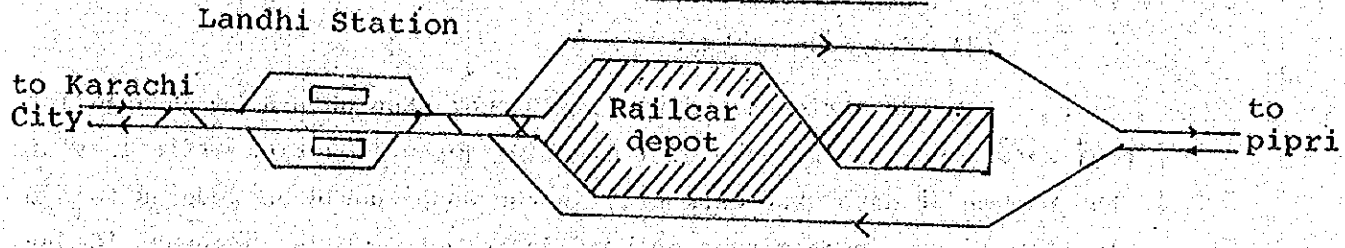
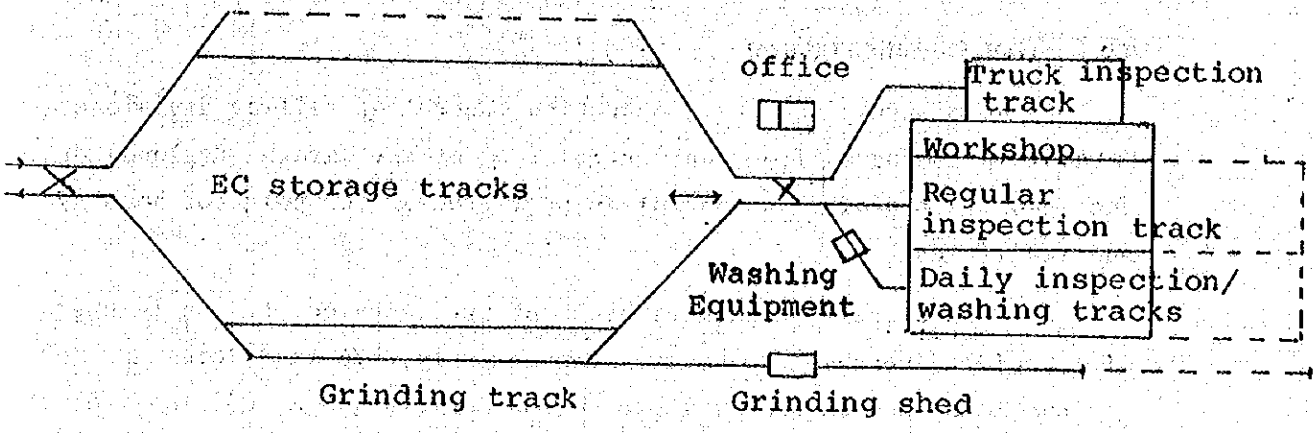


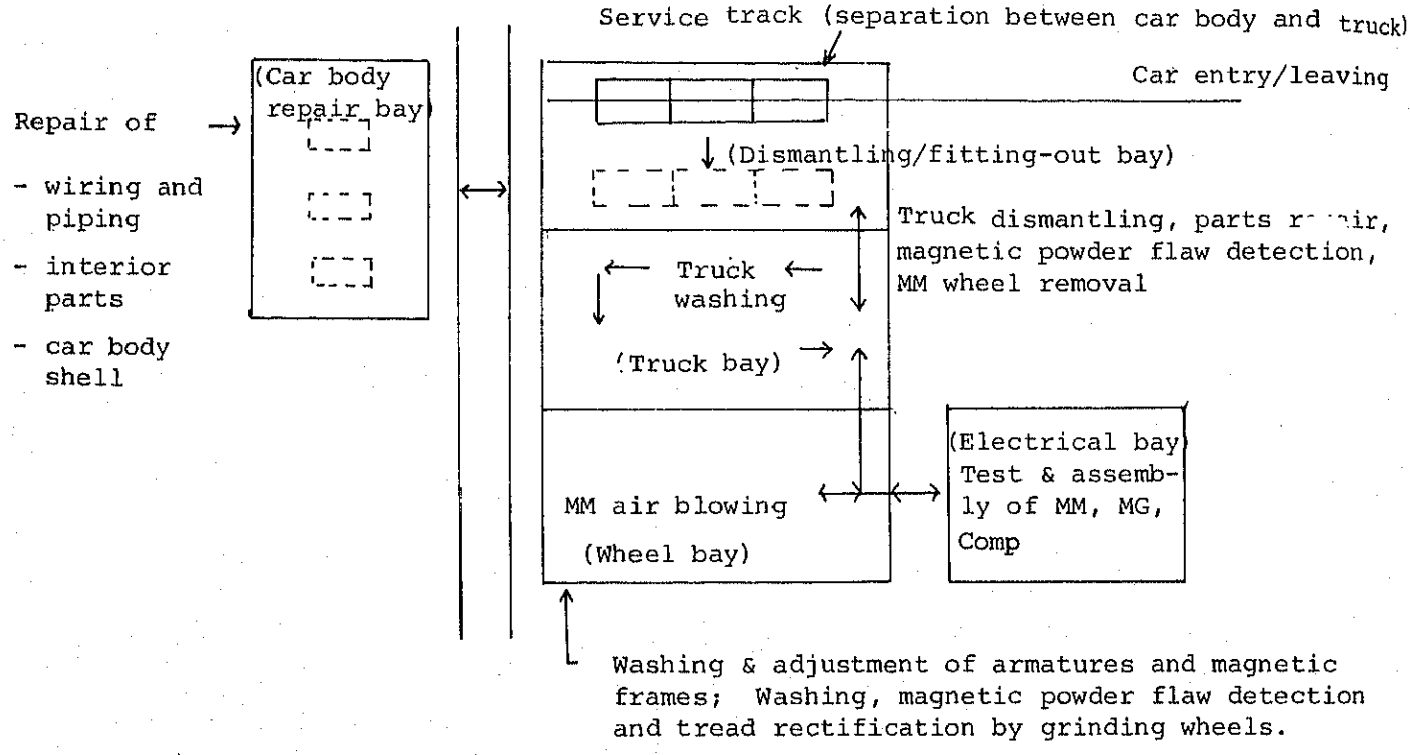
Fig. 4-10 Car depot layout



Symbols: ——— initial installation

- - - - - future extension

Fig. 4-11 Flow chart of inspection and repair operations of electric cars in shop



(2) Progress of Work

Electric cars entering the workshop should be grouped into 3 car sets. For the purpose of increasing the utilization efficiency of cars, the number of days that cars stay in the shop should be reduced to a minimum In view of the inexperience in handling electric cars, however, 10-day-work is reasonably considered.

4-6. Train Operation Control

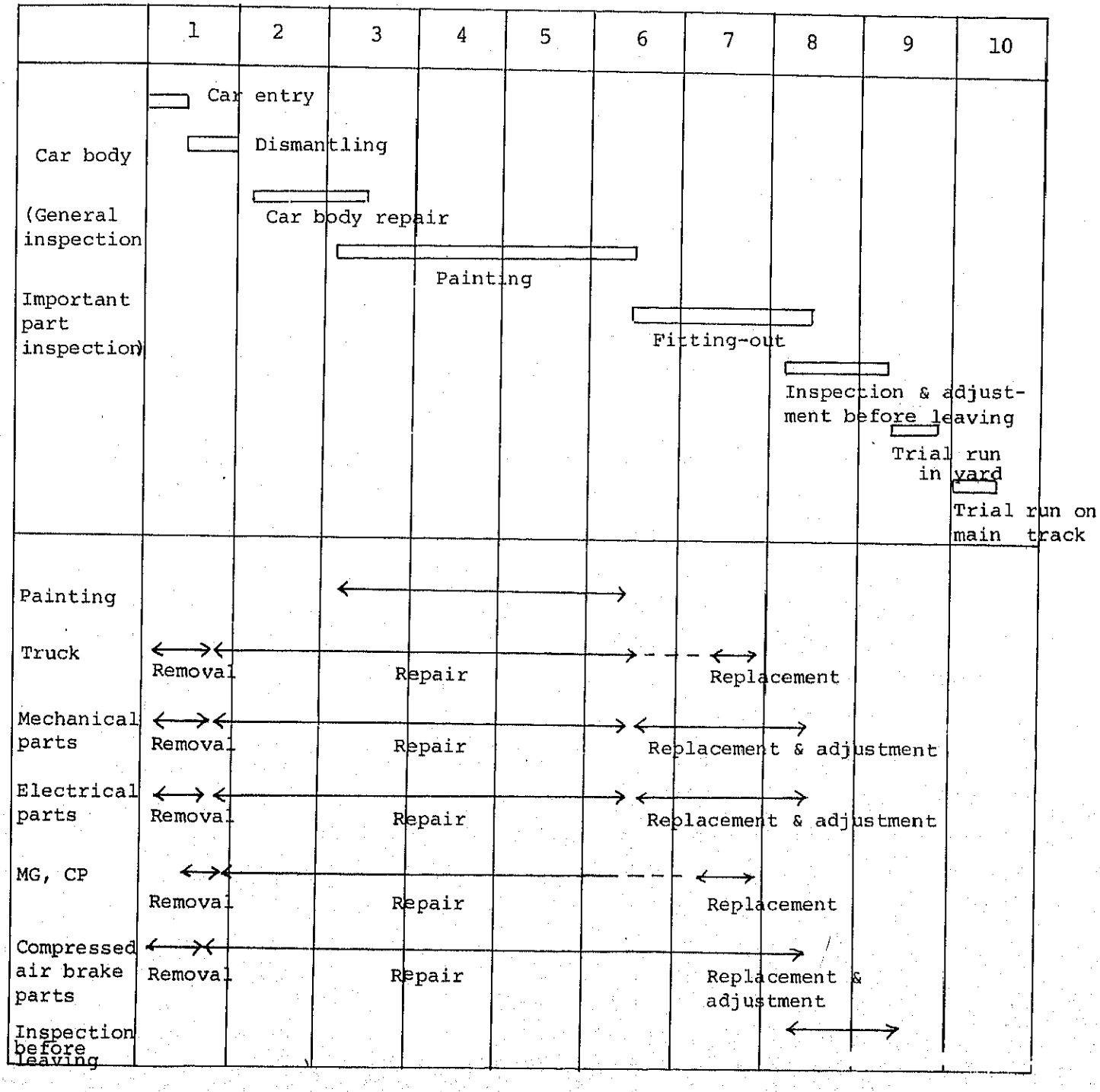
At present, the train operation control of railway divisions around Karachi is conducted from the control room of the Karachi Regional Office. The actual state of this control is poor from a view point of both systems and facilities.

Once electric cars have been put into service, trains in operation will rapidly increase in number. Consequently, CTC facilities now in use for the main line should be improved and modified. In addition, the strengthening of control circuits is required.

Traffic control should be reorganized into train control covering operation adjustment and transport arrangement of all trains including electric cars, electric car control covering arrangements for the operation

Table 4-11 Typical Progress of Electric Car Repair

(10 day work)



of locomotives and their operators. These controls should be placed under the general control of one chief traffic controller.

The CTC control center is now located at Karachi Cantt Station. This center should preferably be integrated with the control room of the Karachi Regional Office to achieve centralized control.

In addition, telecommunication systems should be strengthened so that necessary communications from train operator (or maintenance personnel) through station masters and the control department to the traffic service authority and maintenance service authority may be rapidly assured when any train accidient occurs.

4-7. Education and Training of Personnel

For the commencement of operation of this project (in 1982), electric car operators and operation conductors, each totaling about 120 to 150 persons, will be required. In both the car depot and shop, approximately the same number of personnel will also be required for electric car maintenance.

Prior to starting operation, these operating personnel and a certain number of foremen should receive the necessary education for about 6 to 10 months depending on their occupation. The contents of this education include fundamental education mainly electrical engineering (except for operation conductors), practical education and in-service training. In-service training will require the actual operation of electric cars. Consequently, two or three sets of electric cars should be delivered to the site at least 6 months before start the operation of this project.

A certain number of personnel who are expected to assume leadership in future should preferably be sent to Japan to receive and gain thoroughly education and experience prior to starting the above mentioned education and training. Returning to Pakistan, these personnel should instruct the general personnel.

CHAPTER 5

Civil Engineering Plan

5-1. Phase 1

This Section describes the individual stages of Phase 1 previously mentioned in subparagraph 3-3-1: Utilization and Modernization of Existing Lines.

5-1-1 KCR Line

(1) Grade separation of level crossings

KCR has 29 level crossings and 4 road overbridges between Drign Colony and Karachi City. Since the time of these existing level crossings being closed is long and they constitute an obstruction to road traffic, the grade separation of level crossings should be promoted. Since grade separation of level crossings generally requires a long period of time, an automatic gate (a combination automatic signal and gate) should be provided to level crossings so as to shorten the time the gate is closed, and thereafter grade separation of the level crossing be provided as required.

As all the existing grade separated crossings are of the road overbridge type, the level crossings to be grade separated hereafter will follow the same type. However, because the road on the Site area runs near and parallel to the railway, if the part of the road forming a level crossing is upgraded, the slopes formed as it was by the upgrading will cause the road to undulate. This would adversely affect the funtion of the road. In order to solve this problem, the construction of an elevated railway could be envisaged, but even so there will still be a problem; the freight line must be left on the ground because of private sidings.

With all these problems taken into consideration, the following two alternatives were studied.

Alternative 1 (Fig. 5-1-1): The railway should be electrified in the existing state of single-track line.

Alternative 2 (Fig. 5-1-2): The distance of 6.5 kilometers centering on the Site area and the distance of about 1.5 kilometers from both sides of level crossings No.4 and 5 should be first upgraded to form an elevated railway, then electrified.

(2) Renovation of the existing structures necessitated by electrification.

Due to electrification using electric cars the height of platforms must be raised from their present heights above rail level of the 2 feet 6 inches to 3 feet 6 inches. Nording Wallace Road overbridge should be raised from the present 16 feet 2 inches (between the underside of the girder and the road surface) to 19 feet.

(3) Storage track of electric cars should be installed in Wazir Mansion Station.

(4) In Alternative 1, the distance between turnouts in the section from the Site to Shah Abdul Latif is short, so this section should be made into a double-track line.

(5) In Alternative 2, an elevated railway sections should be made in the form of double-track lines.

(6) The existing tracks conform to B Grade 1 of the Trackway Standards. To cope with the increase in future through tonnage and higher speed of trains, all tracks should be replaced by the year 1981 with those conforming to A Grade 1 of the Trackway Standards, using long rails and prestressed concrete sleepers.

5-1-2 Main Line

(1) Level crossing

There are at present 4 road overbridges and 10 level crossings between Karachi City and Pipri. Grade separation of these crossings, if adopted, would require a considerable cost of construction. Therefore, in the planning under consideration, grade separation is envisaged to be promoted step by step by means of road overbridges, and automatic gates alone should be provided so as to reduce the time the gates are closed. No specific grade separation will be performed.

(2) Renovation of the existing structures necessitated by electrification

Due to electrification using electric cars, the height of platforms should be raised from the present height above rail level of 2 feet 6 inches to 3 feet 6 inches. The height from the underside of the girder of station foot overbridges to the rail level should be raised from the present 16 feet to 19 feet, and for this purpose the foot overbridge should be elevated.

The height from the underside of the girders of road overbridges, straddling Scandal Point, Clifton and Wagoda, to the rail level

Fig. 5-1-1 Modernization Plan of The Existing Railways
(Alternative 1)

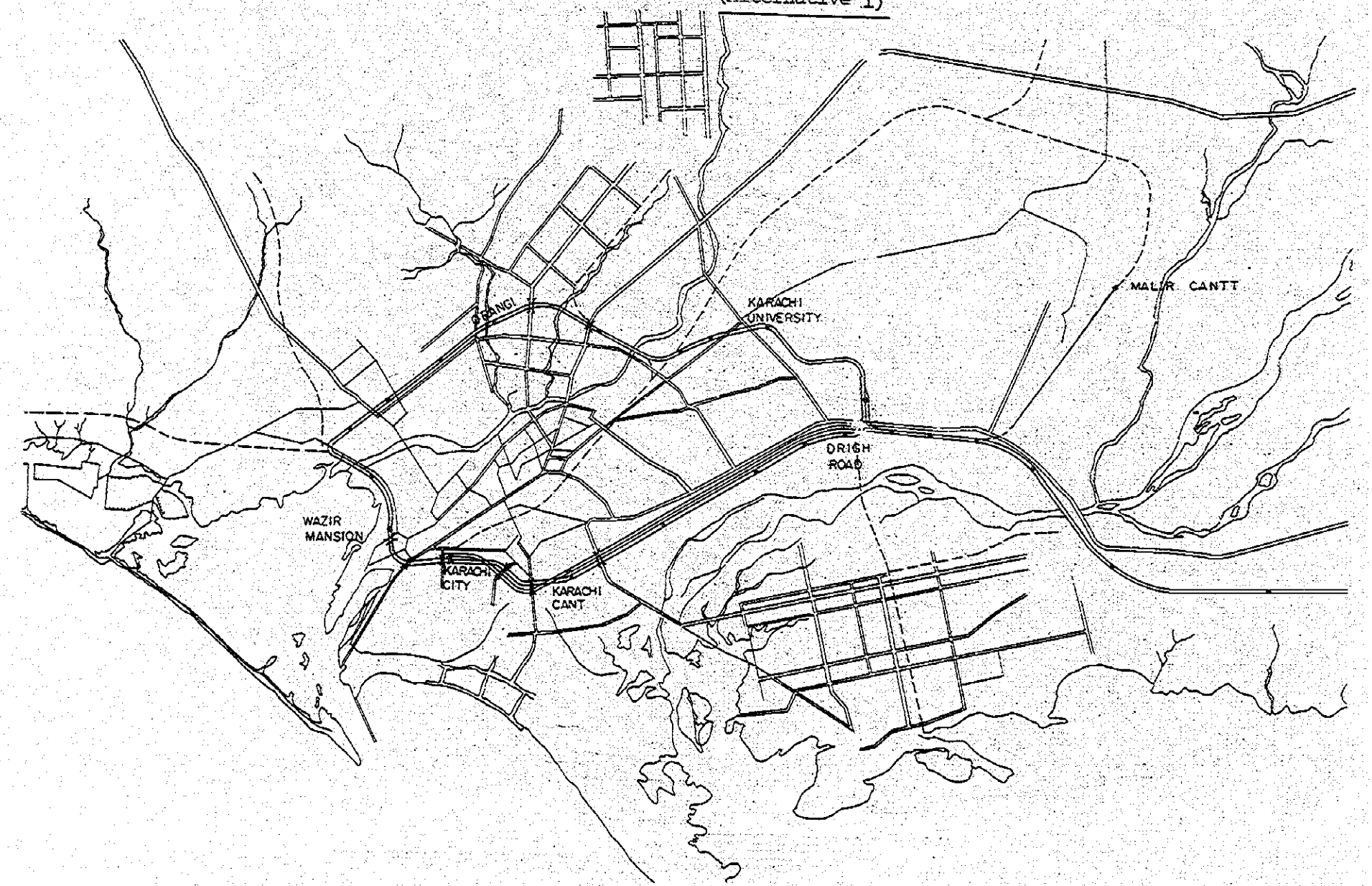
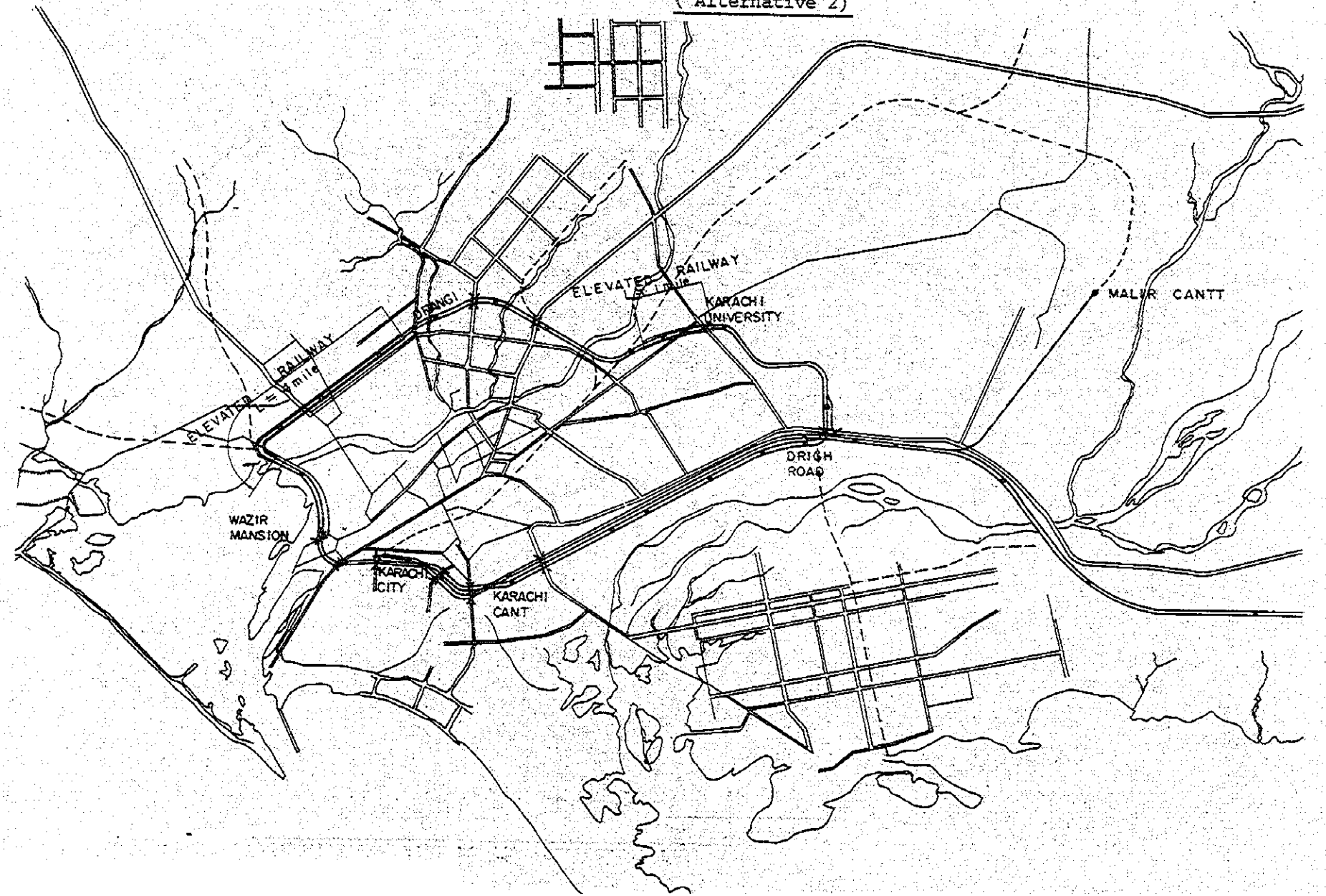
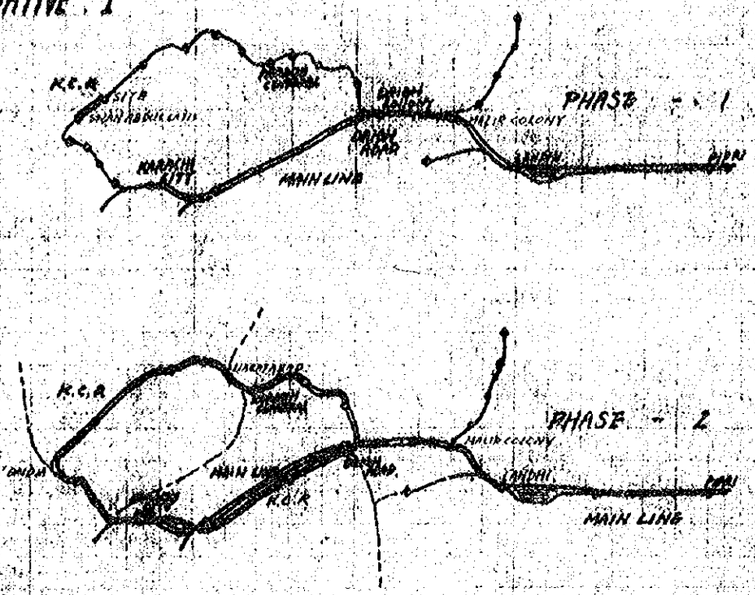


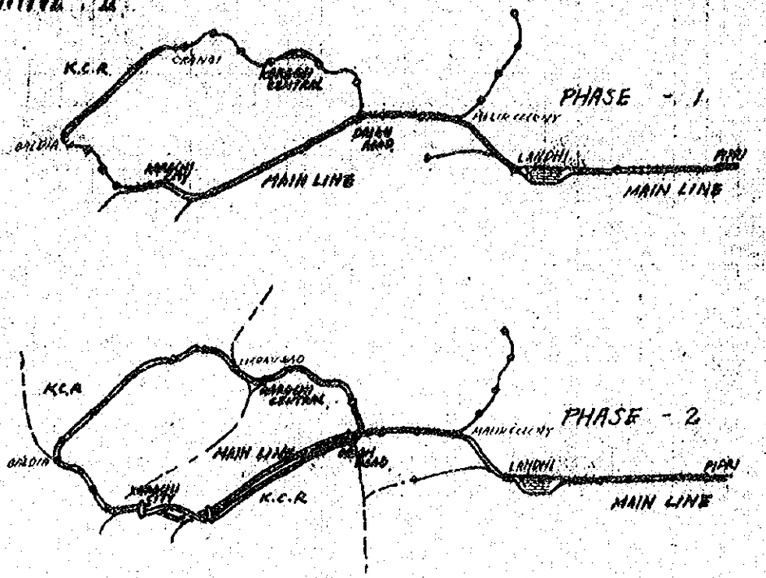
Fig. 5-1-2 Modernization Plan of The Existing Railways
(Alternative 2)

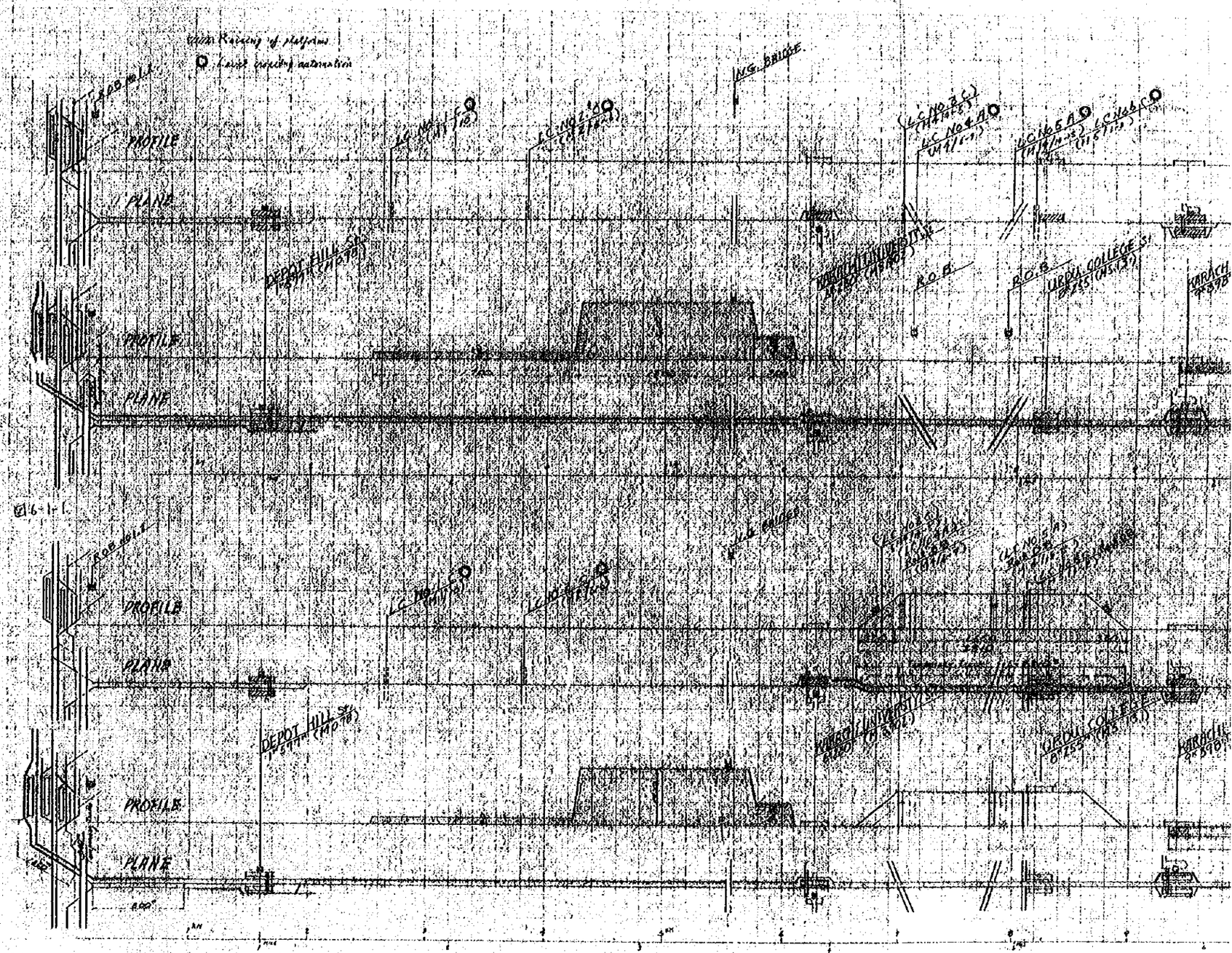


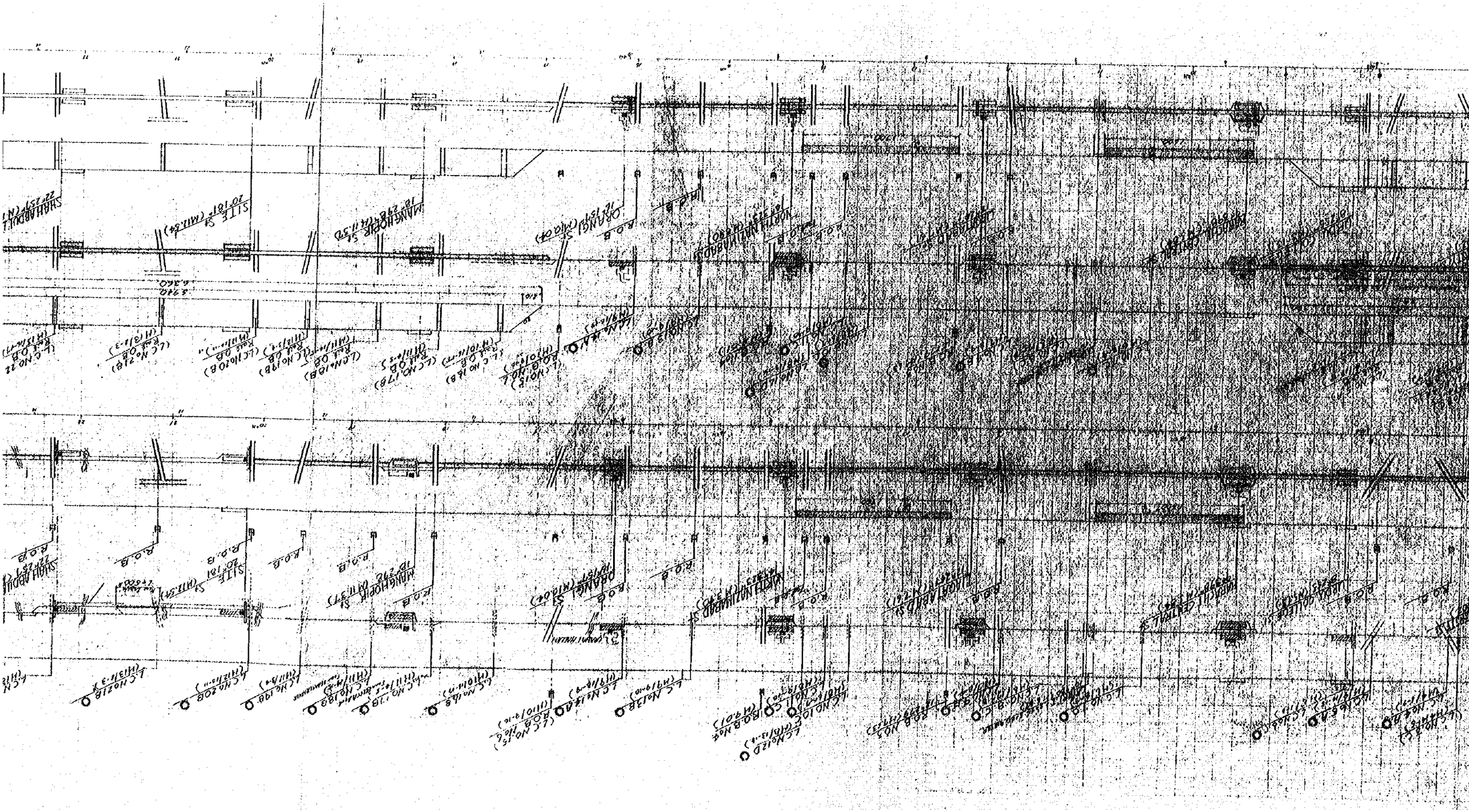
ALTERNATIVE . I

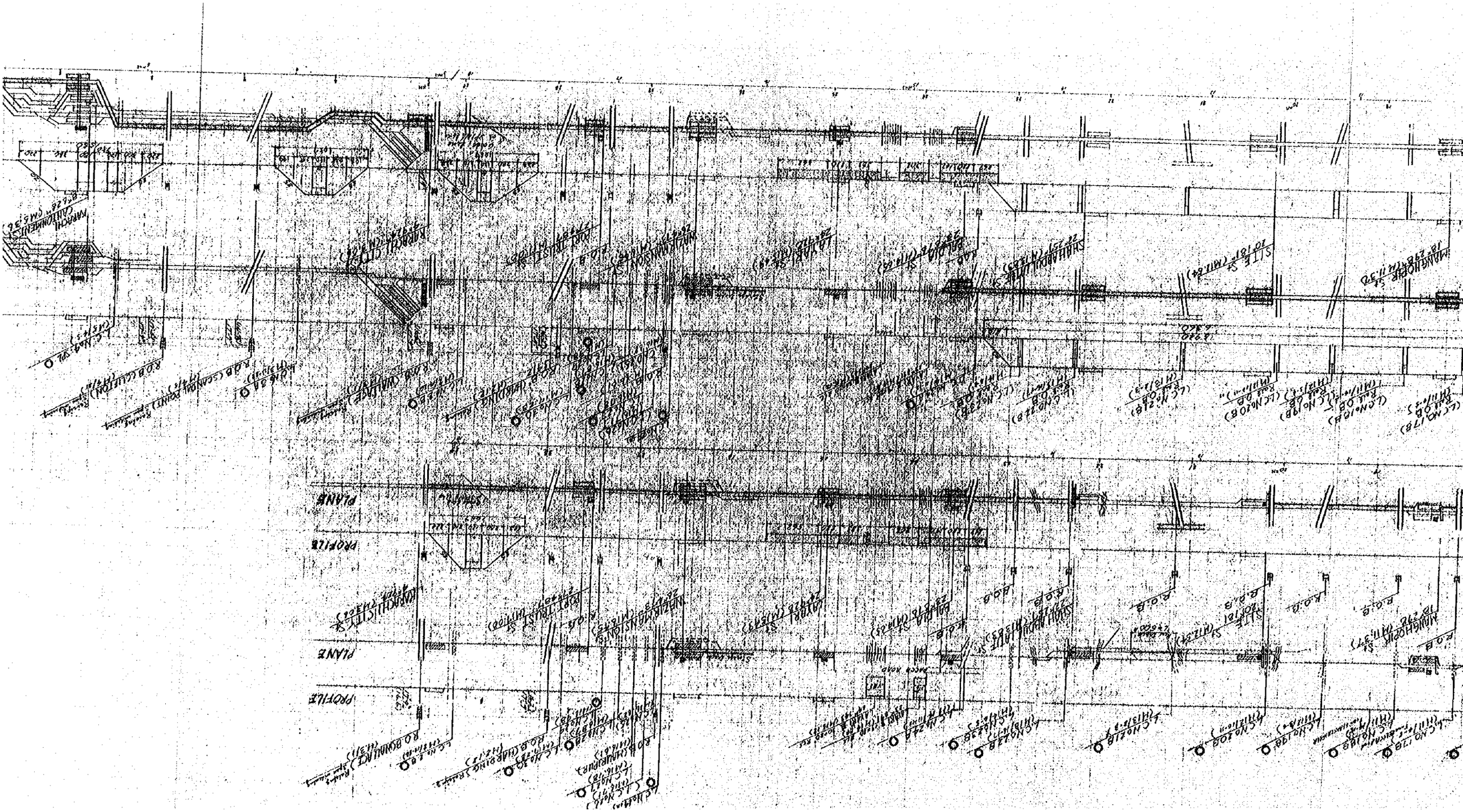


ALTERNATIVE . II








PLAN
PROFILE
PLAN
PROFILE

TYPICAL CROSS

CUT SECTION

EMBANKMENT SECTION

STATION

PROFILE

PLANE

PROFILE

PLANE

KARACHI CITY

KARACHI CANTONMENT

CHANESAR HALT

DEPARTURE YARD

KARSAZ HALT

AIR FORCE HALT

L.C No.7

L.C No.8

L.C No.5 A

L.C No.6 B

L.C No.7 B

L.C No.8 B

R.O.B (WAGODIA)

R.O.B (KALAPUL)

R.O.B (SCINDIA POINT)

R.O.B (CLIFTON)

R.O.B (WALLACE)

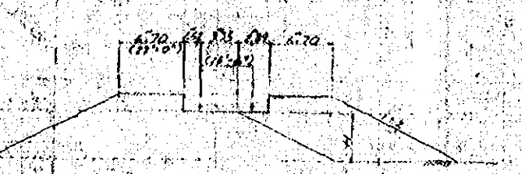
R.O.B (HARDING)

6-3-1

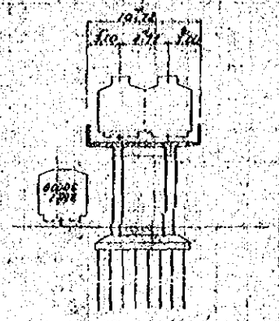
TYPICAL CROSS SECTION

SECTION

STATION

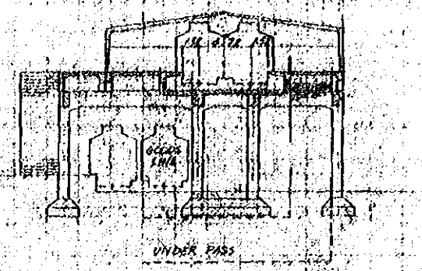


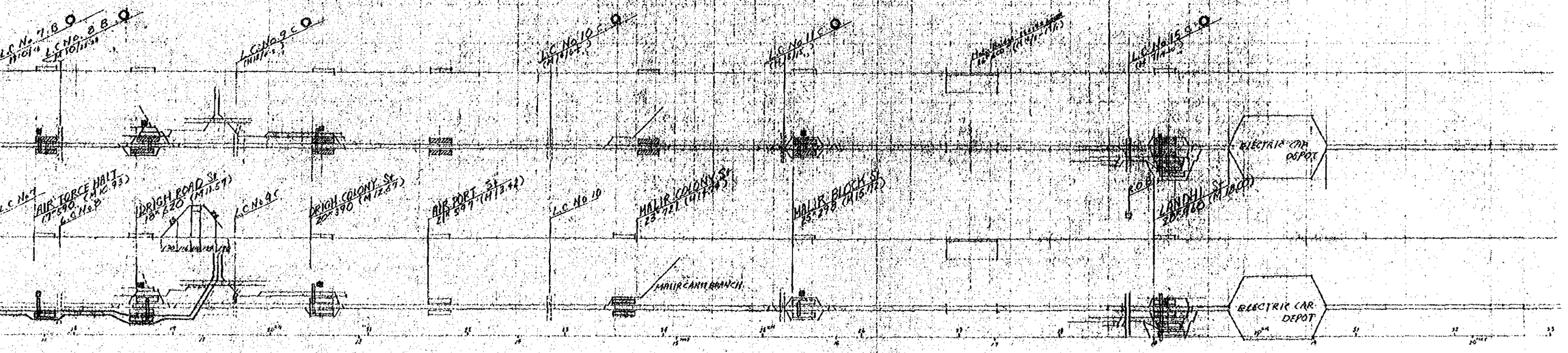
BRIDGE STRUCTURE FOR ELEVATED TRACK

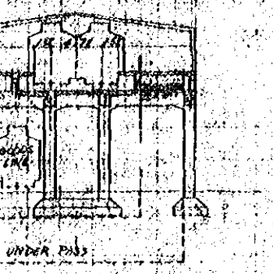


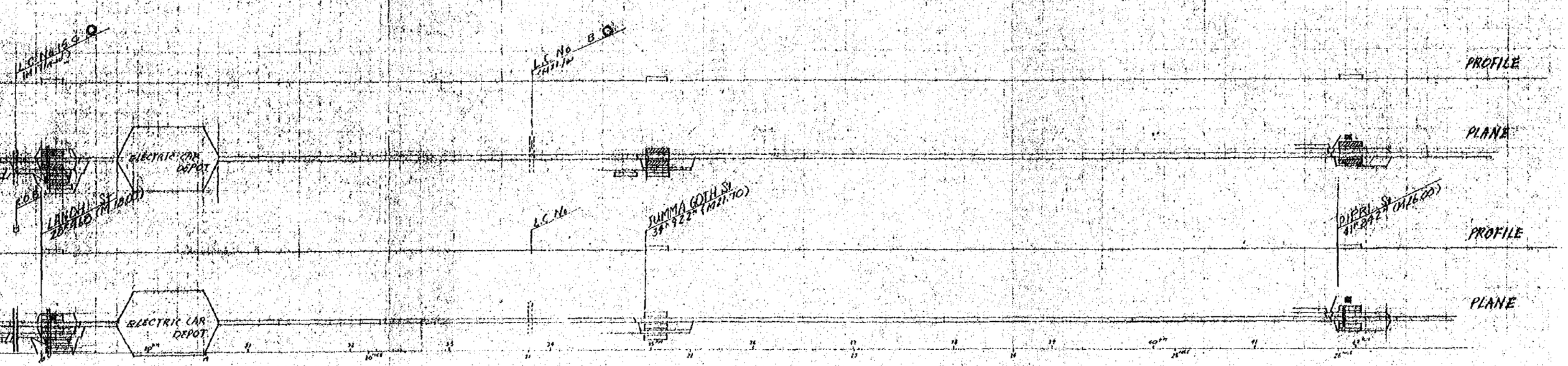
STATION BUILDING

KARACHI CANTT St








L.C. No
L.C. No
PROFILE
PLANE
ELECTRIC CAR DEPOT
LAIDLAW ST
JUMMA GOTH ST
L.C. No
PROFILE
PLANE
ELECTRIC CAR DEPOT

should be raised from the present 16 feet 9 inches to 19 feet, and for this purpose the girders should be elevated.

(3) A new electric-car depot should be constructed at a location adjacent to Landhi Station which is situated between Landhi and Jumma Goth.

(4) Similar to the KCR Line, the existing tracks of B Grade 1 of the Trackway Standards should be replaced with A Grade 1.

5-1-3 Malir Cantt Branch

The distance of about 7.6 kilometers between Malir Colony and Malir Cantt should be improved by raising the height of paltforms which will be required on account of electrification.

5-2. Phase II

5-2-1 KCR Line

(1) Drigh Road Station (Fig. 5-2-1)

A KCR Line platform should be provided aboveground adjacent to the south side of the existing main line paltform, so as to allow passengers to change trains across the connecting overbridge. KCR Line should run over Main Line closer to Drigh Colony Station, then across the south side to the north side in the direction of Depot Hill.

(2) For the laying of additional tracks to form the new double-track line, all necessary structures have already been planned and the foundations of bridges already completed. Therefore, the structures will be constructed in parallel using structures of the same type as existing structures.

(3) At present the KCR Line is linked with the freight line on the west side of the KCR Line platform of Karachi City Station. Since this will constitute an obstruction to the passage of KCR trains at the proposed frequency, the KCR Line should be elevated so as to run over the freight line. For this purpose, the existing KCR Line platform should be relocated on the south side of the main line platform.

(4) The new tracks should conform to A Grade 1 of the Trackway Standards using long rails and prestressed concrete sleepers.

5-2-2 Main Line

(1) Karachi City Station (Fig. 5-2-1)

The two lines in the freight yard adjacent to the south side of the existing main line platform should be removed and instead a KCR Line platform should be provided. The KCR Line will then run over the main line closer Karachi Cantt Station to the north side across the south side.

(2) Karachi Cantt Station (Fig. 5-2-1)

The existing main line platform is used for the arrival of short-distance electric cars and long-distance trains. As the KCR Line will pass over the main line closer Karachi City Station from the north side to the south side and further pass over the workshop line, Karachi Cantt Station should be elevated. Passing the station and then coming down on the ground, an additional line should be laid on the south side of the main line. Therefore, part of the track layout in the station yard should be relocated and at the same time most of the workshop line should be relocated. However, since the number of diesel locomotives and workshop facilities and equipment will decrease on account of electrification, the above relocations can be performed. The main line aboveground platform should be linked to the KCR Platform to be elevated by a new underpass.

(3) Departure Yard Station, Karsaz Halt Station and Air Force Halt Station should be provided with KCR Line platforms, but not main line platforms.

(4) In order to lay a double track line which will be provided with an additional line, the road overbridges straddling Scandal Point, Clifton and Wagoda should have one span added..(Fig. 5-2-2)

(5) Railway Bridges

The existing railway bridges are constructed either of steel, concrete or arched masonry. No particular defects can be seen in these bridges with respect to their functions and construction. Therefore, in cases where additional line is to be laid in parallel to these bridges, new bridges to be provided should be of the simple girder construction having clear spans and lengths identical to those of the existing bridges. For piers and abutment foundations, prestressed reinforced concrete piles should be used and they should be constructed of reinforced concrete.

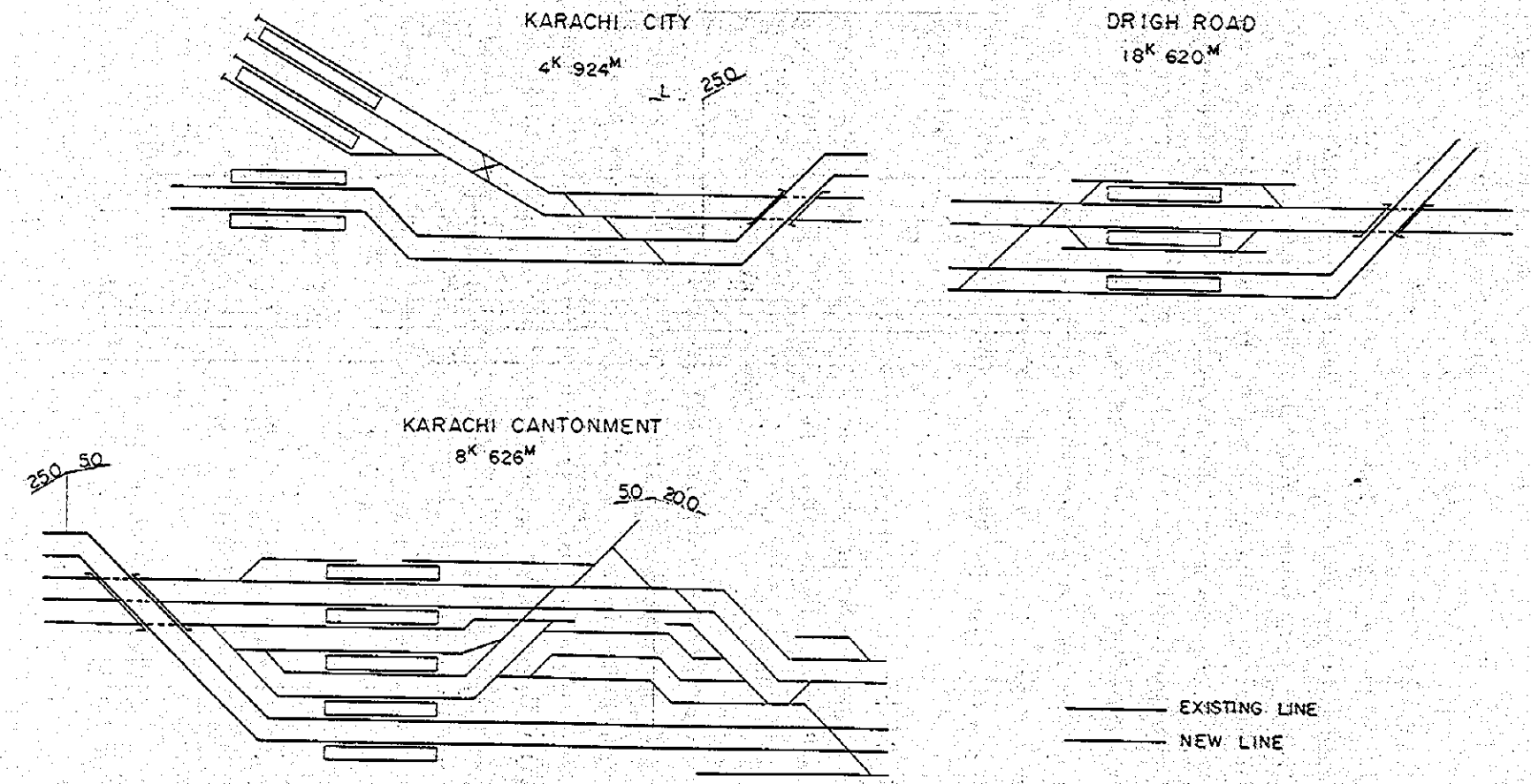


Fig. 5-2-1 Track Layout in Stations

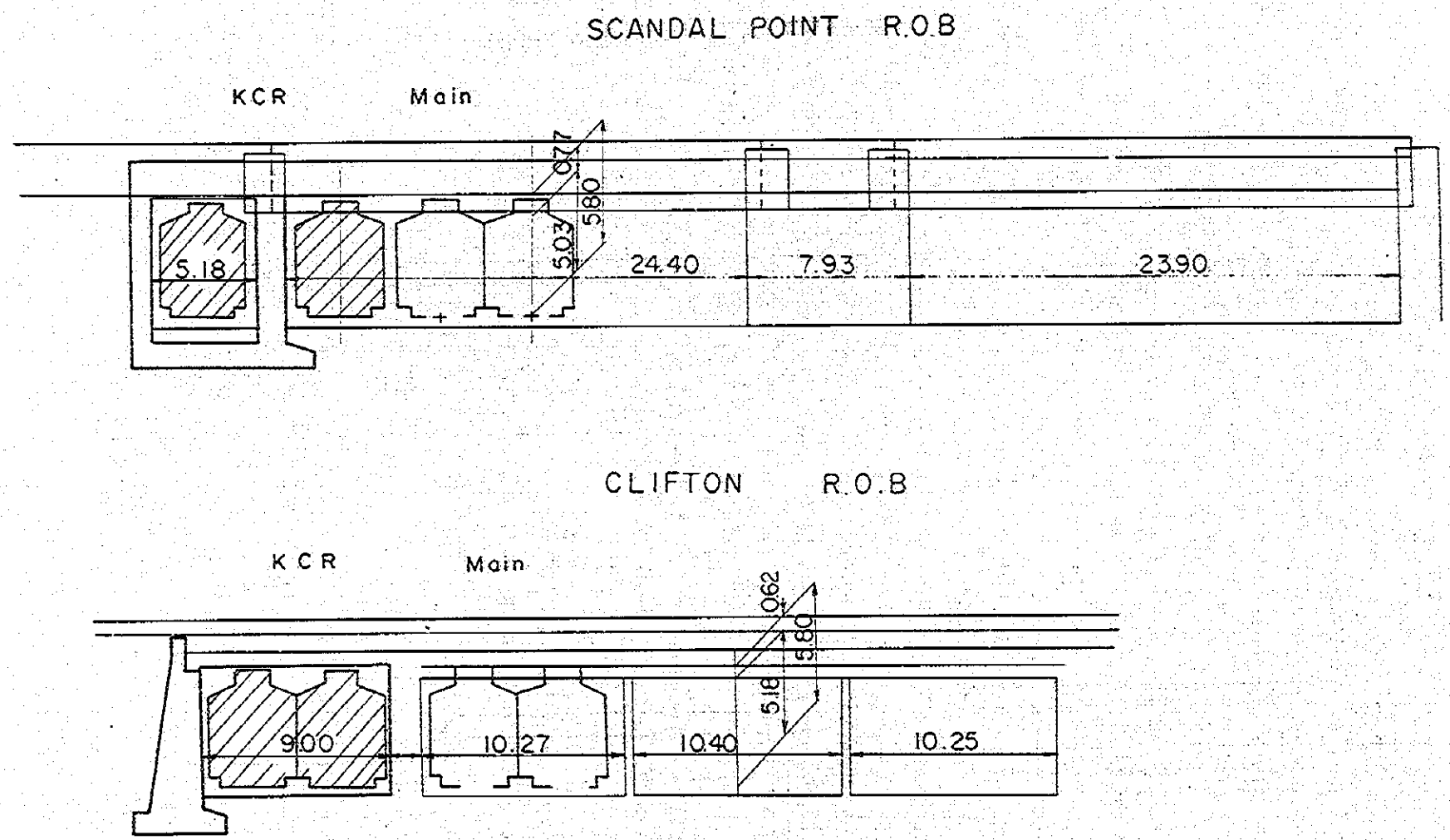


Fig. 5-2-2 Remodeling Plan of overbridge

5-3. Construction Methods

5-3-1 Civil Structures

(1) Filling

As shown on Fig. 5-3-1, for the section of track additions on the KCR Line, the subgrade surfaces under consideration will have cross-sections capable of permitting the flow of surface drainage. However, since the existing subgrade in curved sections is superelevated, where the width of subgrade is to be extended, such subgrade should have its slope filled with earth in such a manner as to permit the flow of surface drainage and should be superelevated in accordance with the type track construction.

As the amount of earthwork was determined on the basis of the data and roadway diagram obtained by site reconnaissance, variations in the amount of earthwork determined may occur as a result of future investigation and survey.

In principle, cut soil should be used for filling material except that where the soil transport distance is long, in which case, filling material should be obtained from a nearby borrow pit.

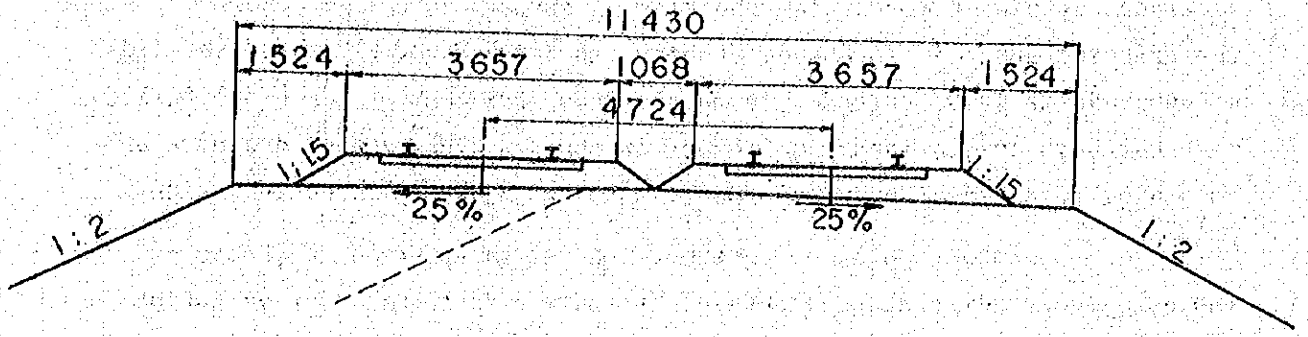
(2) Cutting

Assuming that the face of the slope to be cut is graded similarly to the permanent way, it is envisaged that the areas consisting of earth should be cut at a gradient of 1 vertical to 1 horizontal and those of weathered rock at 1 vertical to 0.5 horizontal, both approximately. Near Baldia Station and Layari Station which adjoin the coast, the slopes should be protected with stone pitching. The amount of earth to be cut may vary as a result of future investigation and survey because it was based on data obtained through the site reconnaissance.

5-3-2 Elevated Bridge

In Alternative 2 of Phase I, an elevated bridge should be constructed on the west side of the existing line on the Site area. The existing station should be removed and instead, a temporary station should be provided at a different location near the existing station, so as to permit work on the existing station. This elevated bridge should be a rigid frame constructed of reinforced concrete, consisting of deck slabs girders, beams, columns and footings. (See Fig. 5-3-2) However, some prestressed concrete girders may be used. After completion of the elevated bridge, passengers can ride the elevated line, but freight transported by the ground line which should run mostly at night time. By doing this, the level crossing will

EMBANKMENT



CUTTING

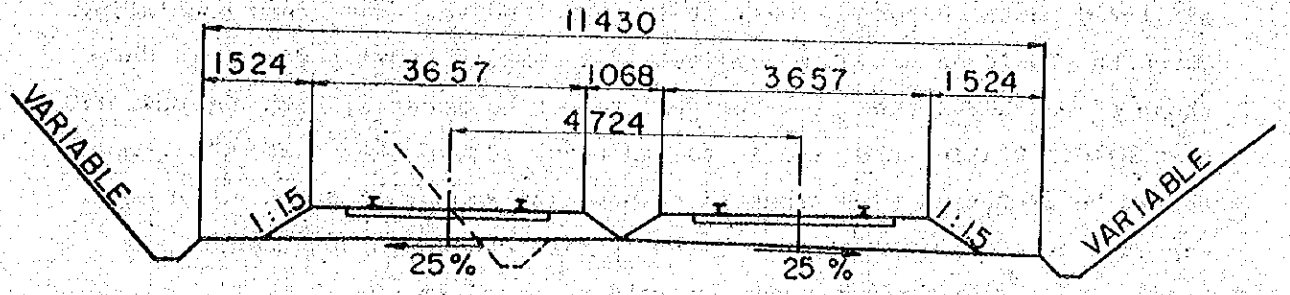


Fig. 5-3-1 Standard Earthwork (Double Track Section)

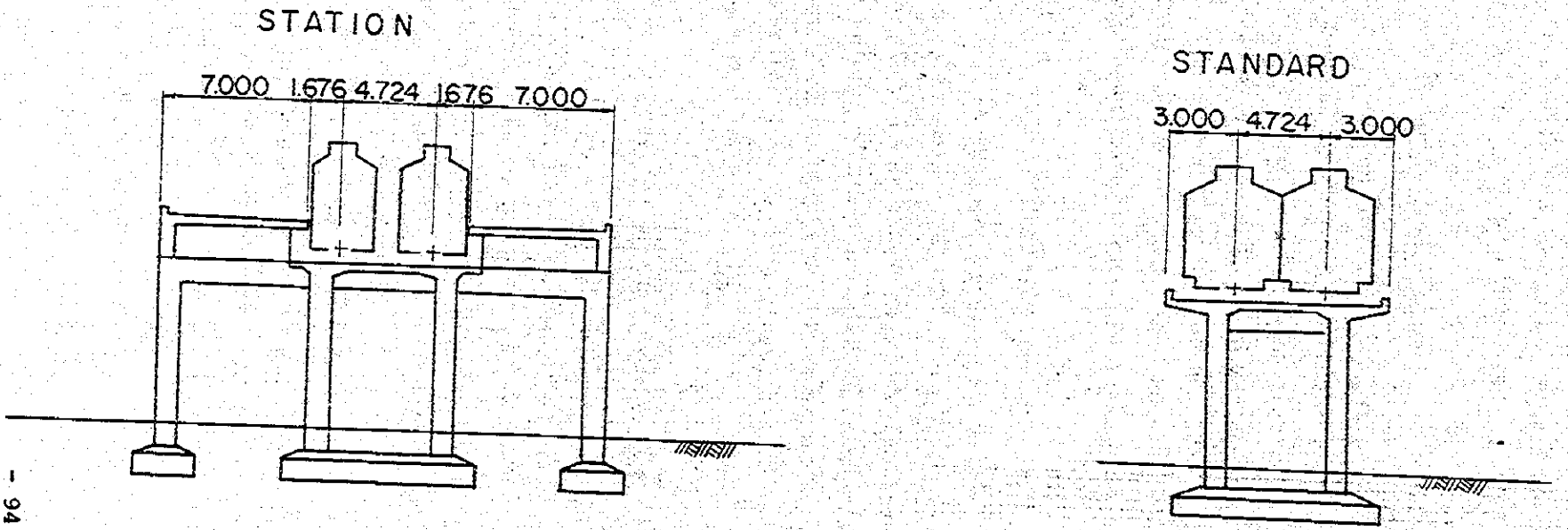


Fig. 5-3-2(a) Elevated Bridge

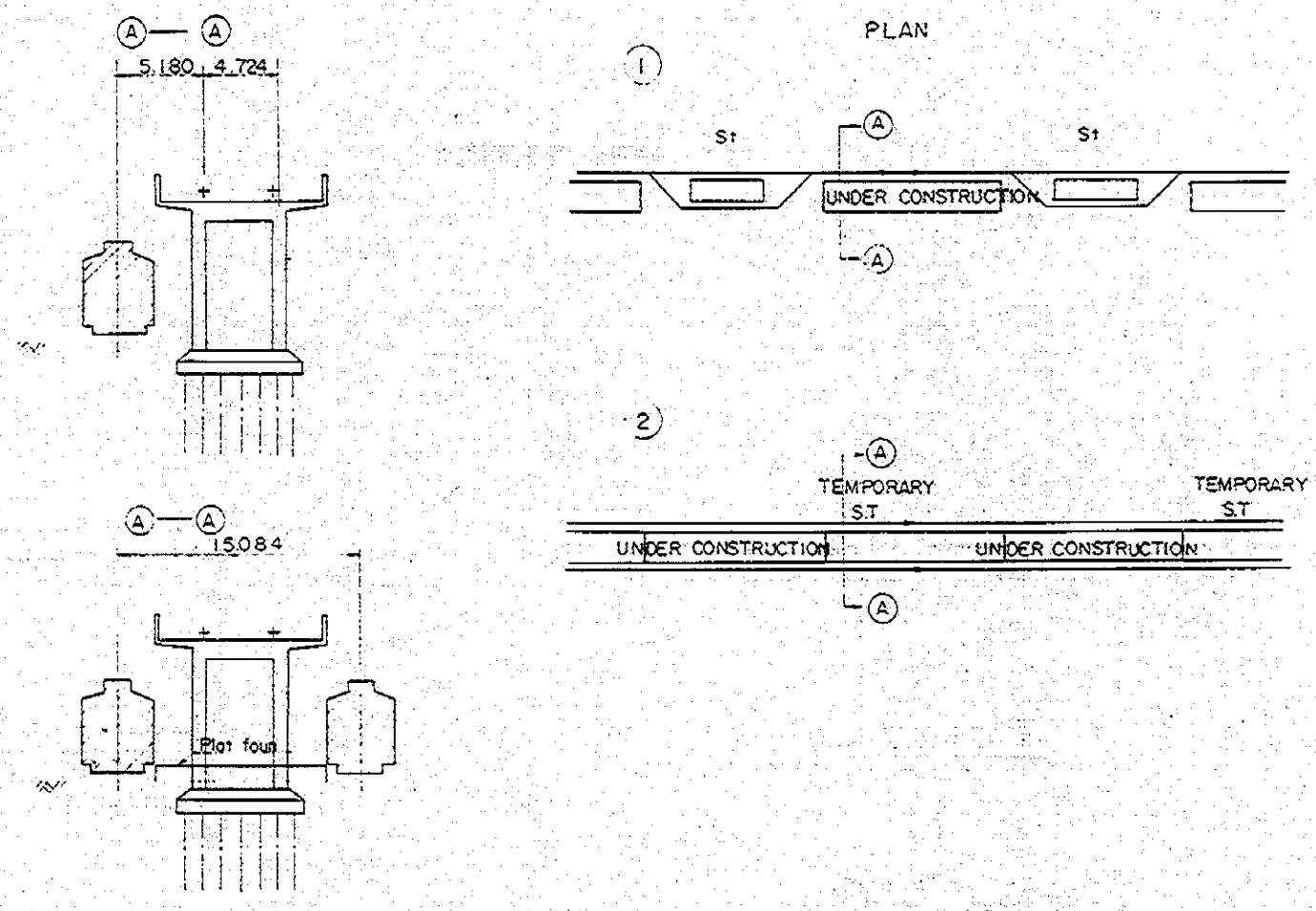


Fig. 5-3-2(b) Execution Process of Elevated Railway

be closed only at night time, hence it will not be interferred with automobile traffic. The construction of elevated bridges near KCR No.4 and 5 level crossing should be carried out after the proposed parts of the existing line have been relocated.

5-3-3 Over-road Bridges

An over-road bridge is a bridge straddling the road over which elevated track runs. Whre the road is provided with a median strip, bridge piers should be erected on that median strip to form two spans. Where the road is narrow and has no median strip, piers should be erected so that the bridge consists of one span. The superstructure of the bridge should be constructed of prestressed concrete girders, with consideration given to the reduction of future maintenance cost.

5-3-4 Run-over Bridge

A run-over bridge is a bridge to be provided where the KCR Line runs over the main line. This run-over bridge should be constructed of abutments or piers located near the live trolley lines while electric-car trains are running. Steel-plate girders or composite girders should be installed over the live trolley line. As this work is dangerous because it must be done near the live trolley lines, a high level of skill and experience are required. (Fig. 5-3-4)

5-3-5 Addition of Road Over Bridge

If only one span is to be added to the existing road over bridge, the road traffic is not required to be interrupted, but interruption for a short time or one-way traffic may be necessary. If the existing road over bridge is old and requires reconstruction, the addition to and reconstruction thereof should be done at the same time.

5-3-6 Improvement of Tracks

Improvement of the existing tracks under Phase I should be performed locally and in consecutive order. The existing turnout No.8 should be replaced with No.12 on the KCR Line and the main line.

5-4. Design Standards

Major design standards and values to be employed for this project are shown on the following table comparing the existing lines with proposal

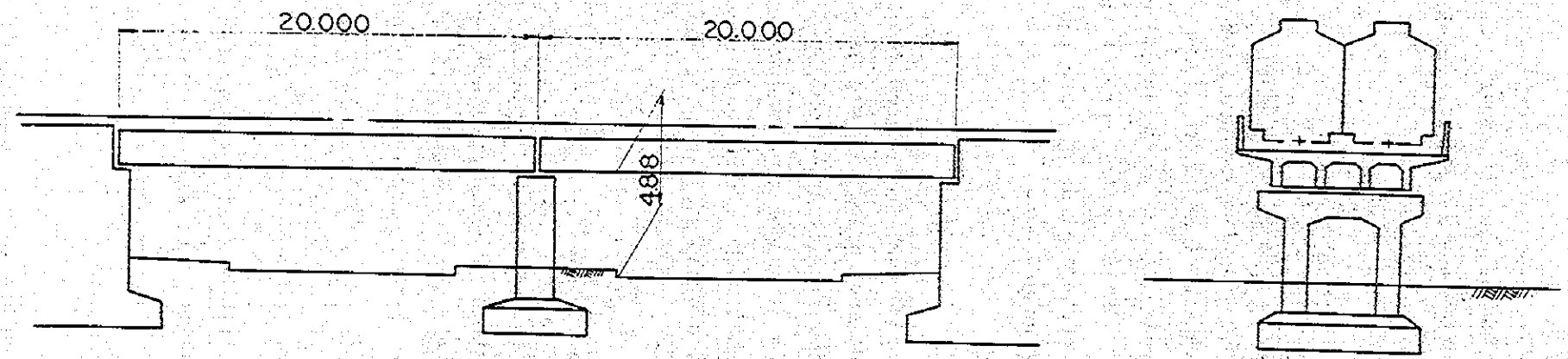


Fig. 5-3-3 Over-road Bridge

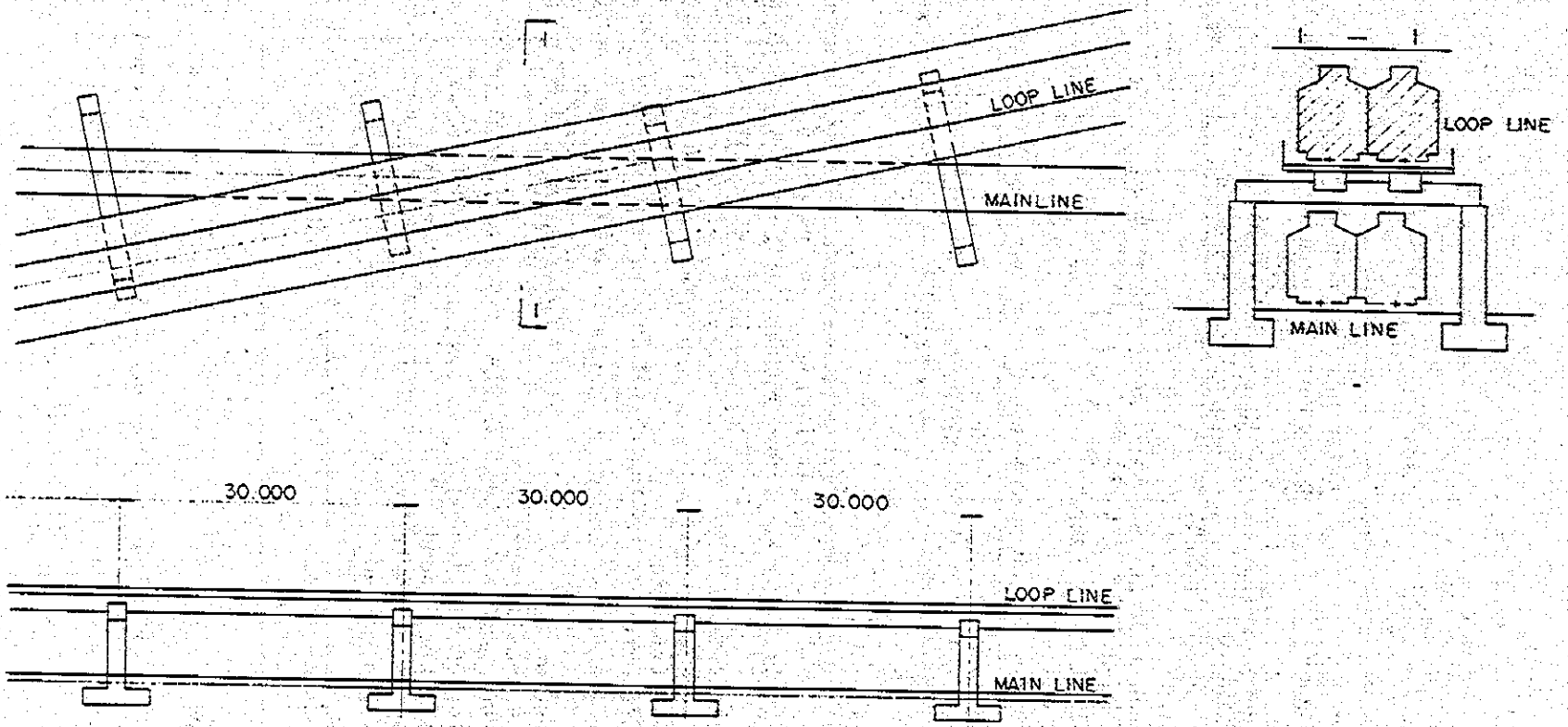


Fig. 5-3-4 Run-Over Bridge

lines.

5-4-1 Permanent way

Category	Existing permanent way	Proposed permanent way	Remarks
Minimum curve radius	718 ft	1,000 ft	
Maximum slope	10 o/oo	25 o/oo	
Distance between track centers: Other than at stations Station yard Of parallel four-track lines, distance between two tracks	15 ft 6 in 16 ft	15 ft 6 in 16 ft 16 ft	
Turnout	No.8 - No.12	No.12	

5-4-2 Materials

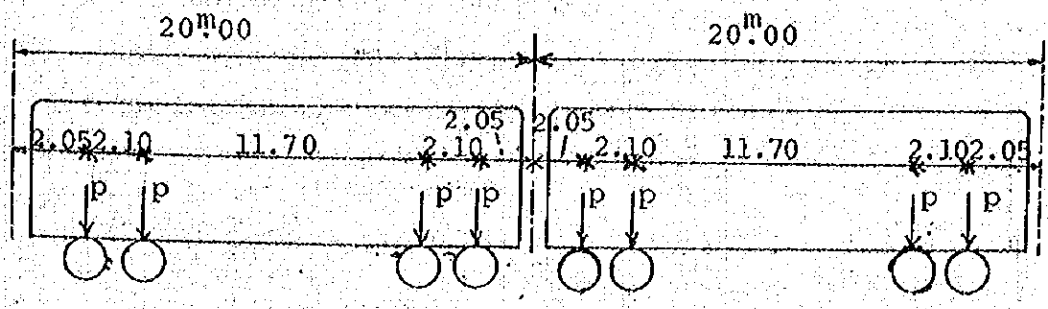
Category	Existing permanent way	Proposed permanent way	Remarks
Amount of cement used: Superstructure Substructure		320 kg/m^3 280 kg/m^3	Ordinary Portland cement
Concrete strength: Superstructure Substructure		$\sigma 28$=400kg/cm^2 $\sigma 28$=240kg/cm^2 $\sigma 28$=200kg/cm^2	P.S.C R.C. R.C.
Allowable tensile stress of reinformcement: Deformed bar, round plain bar, round		σAa=1600 - 1800kg/cm^2 σAa=1400	
Allowable tensile stress of steel plates and shapes:		σAa=1400 - 1600kg/cm^2	
Tensile strength of PC steel material		σpu=150-170 kg/mm^2	

5-4-3 Live Load

The maximum axle load of the locomotives currently used is 20 tons. As the load of proposed electric cars is less than the existing axle load of locomotives, as shown below, it will be completely safe if the existing load is adopted for design.

Electric-car load: Axle load p = 15^t

Electric-car load: Axle load p = 15^{t}



5-4-4 Rolling Stock and Construction Gauge

Rolling stock and construction gauge should conform to PR Schedule of Dimensions 5'6" gauge. (Fig. 5-4-4)

5-5. Improvement of Maintenance and Administration

In carrying out the modernization of the existing railways, the maintenance of buildings and structures, and the improvement of tracks and the reshuffling of the administrative setup must be promoted. Since a long period of time is required for training engineers who are and will be engaged in the abovementioned services, an education scheme should be conducted in accordance with a training plan.

Also, consideration should be taken for the maintenance of tracks in a short time through efficient operation of machines. This could be achieved by employing more maintenance staff and machines.

Fig. 5-3-5 Construction Gauge and Rolling Stock Gauge