THE IMPERIAL GOVERNMENT OF IRAN
THE MINISTRY OF ROADS AND TRANSPORTATION

REPORT ON PRELIMINARY SURVEY FOR HIGH-SPEED RAILWAY PROJECT OF THE SECTION BETWEEN TEHRAN AND MASHHAD

AUGUST 1975

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

The Honourable Minister of the Roads and Transportation of Government of the Empire of Iran expressed the desire to the Japanese Ambassador to the Empire of Iran in April this year to entrust the execusion of survey of a High-Speed Railway Construction Project between Tehran and Mashhad to the Japan Railway Technical Service and requested The Government of Japan to extend necessary cooperation for this purpose.

At this request of the Imperial Iranian Government, the Government of Japan decided to conduct a preliminary study as part of Japan's overseas technical cooperation, and this survey was executed by Japan International Cooperation Agency (JICA), an official agency responsible for the implementation of technical cooperation programme of the Government of Japan.

JICA dispatched a survey team consisting of sixteen engineers, headed by Dr. Mamoru Takiyama, Vice President in charge of engineering of Japanese National Railways, to the Empire from May 23rd to June 21st.

The team carried out the preliminary study on the high speed railway project between Tehran and Mashhad as being required by the Imperial Iranian Government and Iranian State Railways.

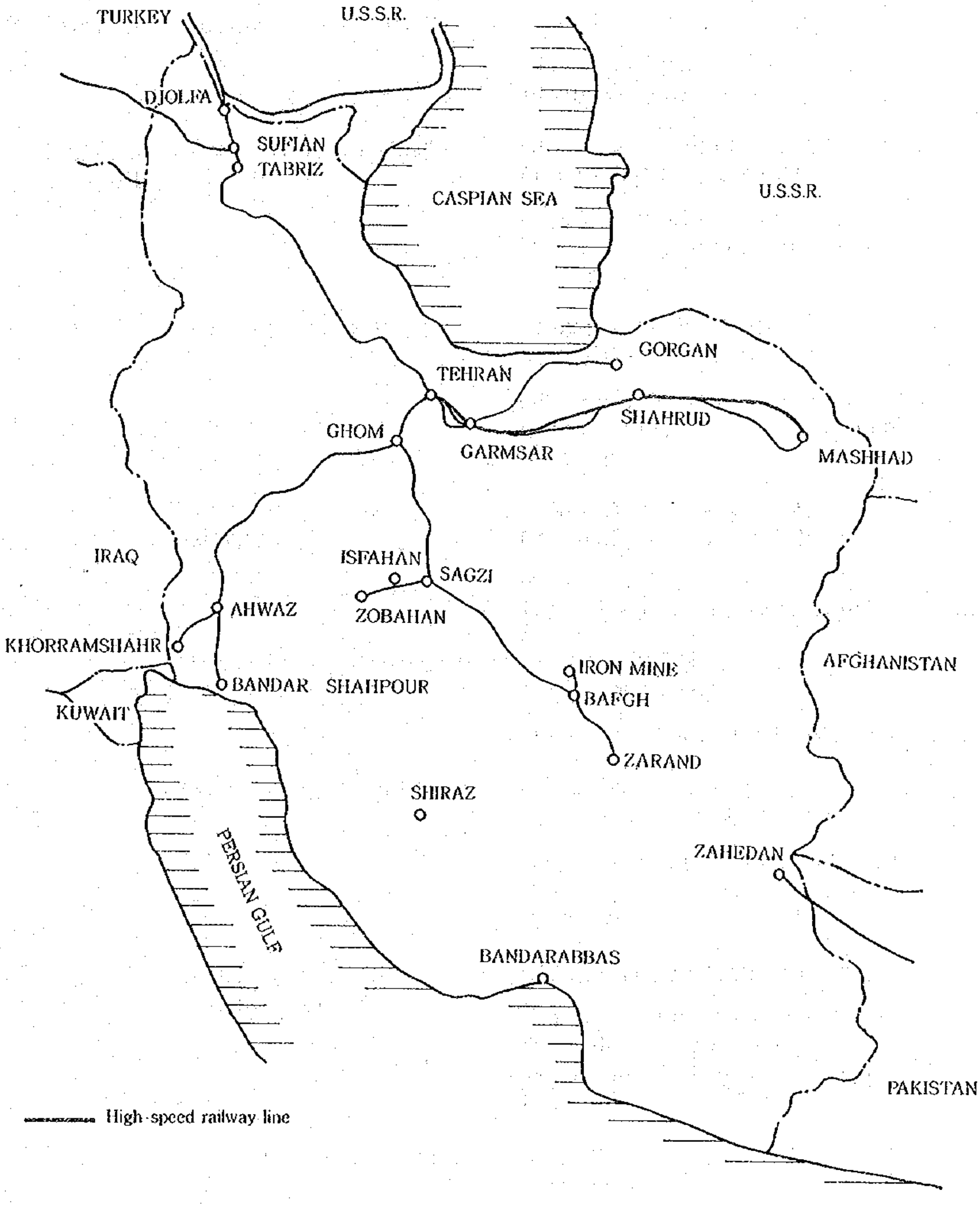
The team devoted its full effort to complete the preliminary survey report by studying the project carefully and reviewing the collected data.

It gives me a great pleasure, if this report, which I am submitting herewith to the Government of the Empire of Iran, contributes to the progress of the project and serves to enhance the economic development of the Empire of Iran and, further, to promote the friendly relations now existing between our two countries.

I take this opportunity to express my heartfelt gratitude to the Government of the Empire of Iran and staffs of the Iranian authorities concerned for the helpful cooperation extended to our team.

Shinsaku Hogen
President
Japan International Cooperation Agency

August 1975



The High Speed Railway Project Between Tehran and Mashhad in the Empire of IRAN

THE JAPANESE SURVEY TEAM FOR HIGH SPEED RAILWAY PROJECT IN THE EMPIRE OF IRAN

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Contents

I Inception of Project and Objective of Preliminary Survey

(1) The Eastern Line of the Iranian State Railways (hereinafter called ISR) extends eastward over a route length of 926 km from Tehran, the capital of Iran and with a population of 4 million, to Mashhad, the third largest city (population approx. 600,000), following the Silk Road, a vital communication route from ancient days. This trunk line has not only played an important role in regional development, it has served as a major means of transport for the vast number of pilgrims to Mashhad, the most holy city in Iran, making passenger traffic on the line the heaviest in the ISR.

(2) Thanks to the wise and farsighted guidance of His Imperial Majesty The Shahanshah Aria Mehr, the economy of Iran has shown remarkable growth and progress in recent years, and with the resultant rise in the living standards of the people, the traffic volume on the Tehran - Mashhad Line has been growing at a rapid pace from year to year. To be more specific, approximately 1,150,000 passengers were carried on the line in 1974, this being more than twice the number carried in 1966. Especially heavy is the passenger traffic in the three summer months and in the Iranian New Year, during which time special trains are operated for five round trips, in addition to the three round trips by regular trains, carrying 6,000 passengers a day, one way, at the peak.

As to the passenger traffic between Tehran and Mashhad by other modes of transport, that by road and air is quite large. This is especially so for the traffic by bus, the number of passengers thus carried being three to four times that carried by rail. Generally speaking, this seems to be due to the shortage of railway transport capacity, and during the peak season when most people want to make the pilgrimage to Mashhad, a shortage occurs in all modes - rail, air and bus - and it becomes extremely difficult to secure tickets for the trip.

(3) Technical exchange has taken place between the railways of Iran and Japan on several occasions in the past 10 years, and especially in the spring of 1974 and thereafter, there was close coordination between ISR and the Japanese National Railways (hereinafter called JNR) in performing intergovernmental technical cooperation and in executing a technical survey for formulation of a proposal by a Japanese consortium. (See Appendix I-1.)

(4) In early March 1975, the Government of Iran notified the Ambassador of Japan in Iran that having obtained His Imperial Majesty's sanction, it was the desire of the Government of Iran to entrust the Japanese with the construction of a high-speed railway between Tehran and Mashhad of the highest technical standard in the world.

Further, in April 1975, H.E. the Minister of Roads and Transportation, Government of Iran, in his letter to the Ambassador of Japan, confirmed the above communication and requested that action be taken urgently for the preparation of a proposal for a contract on technical studies which it was intended to have JARTS, the consulting engineers of JNR, undertake in preparation for the construction contract.

It is to be mentioned that just prior to the above, the Minister visited Japan at the invitation of the Minister of Transport, Government of Japan, and honoured with his presence the opening ceremony on 10th March of the Shinkansen section between Okayama and Hakata which he also inspected.

(5) To meet the expectations of the Government of Iran and in view of the great significance of the project, the Government of Japan held inter-ministerial discussions on the matter, and through the Japan International Cooperation Agency (hereinafter called JICA), organized a 16 member survey team composed of experts in various fields under the leadership of JNR's Vice-President - Engineering who is its highest ranking engineering officer. Upon arriving in Iran in the latter part of May 1975, the team conducted a survey for about one month with the close cooperation of the officers of the Ministry of Roads and Transpor-

tation, Government of Iran. (See Appendix I-2.)

The objective of the team is to conduct a preliminary survey in preparation for the next stage survey for drawing up the master plan of the project. The team seeks to gain a good understanding of the intentions of the Iranian authorities on the project, make a brief on-the-spot survey, collect necessary data and information, decide on the course to be taken with regard to the fundamentals of the project, identify the problems and propose solutions to them, and set up plans for the next survey.

(6) The Preliminary Survey Team, soon after arrival in Tehran, held a meeting on 24th May, with H. E. Javad Shaharestani, Minister of Roads and Transportation; H. E. Mussavian, General Manager of ISR. Mr. Mansori, Director of Construction; and Mr. Choobineh, Director General of Kohrasan Division, and with the Ambassador of Japan attending. At this meeting the team gained knowledge on the policy of the Government of Iran with respect to this project. (See Appendix I-3.)

The main points made clear at the meeting were;

(a) The technical level of the projected high-speed railway should be the highest in the world.

(b) The project should be implemented as soon as possible and completed not later than other major railway projects.

(7) The present report outlines the results of the preliminary survey, but at the same time, it has identified the problems involved. It is intended, therefore, to fully exchange views with the Iranian authorities based on the findings so that the project may be of the highest technical standard, making use of the experience in Japan, and meet the needs of the Iranian people.

II Basic Items in Planning

1. In General

1-1. Concept

The purpose of this plan is to construct a high-speed railway between Tehran and Mashhad where a great many Iranian people travel to link the two cities in the shortest possible time.

It is essential, therefore, to raise the maximum train speed. To raise the maximum speed, high motive power type rolling stock, as electric multiple unit car with motive power distributed to all its axles, is needed and the track must be so constructed as to enable high-speed operation in safety. But, at curves and at places with grades, the operating speed will have to be restricted to lower speeds. The existing line between Tehran and Mashhad abounds in curves and grades. Thus, the line is not fit for high-speed train operation. A new route with larger radius of curvature for much higher speed operation should be selected, and at the same time the length of the route should be made as short as possible. Improvement of grades is desired, too. But, in the case of the Mashhad Line, the terrains do not allow easing of the steepest grades. Adoption of electric multiple unit car type trains, therefore, is recommended, as these can negotiate grade section at high speed.

To decide the scale of facility scheme whether to make the new line single track or double track depends upon the traffic plan such as the number of trains and the number of cars to be operated. To establish above traffic plan, it is necessary to estimate the traffic volume.

The "Basic Items in Planning" explained in this Chapter have all been considered as inter-related matters from the point of view as mentioned above.

1-2. Estimation of Future Transport Demand

In 1974, a total of 1,150,000 passengers were carried by railway between Tehran and Mashhad, or an average of 1,581 passengers per day, one way, but this daily figure reached 2,400 during the peak in the summer season and Iranian New Year. Besides railway service, there is also bus transport which carries a greater number of passengers. It is expected that the passenger traffic to Mashhad will continue to grow in the future in line with the growth in the national economy, and that a considerable portion of the current bus traffic will shift over to rail if the speed and capacity of the railway were to be greatly raised. Further, people who had previously given up travelling because of the great amount of time required or lack of space may come to use the railway.

From this point of view, upon completion of a high-speed railway, the peak season transport demand in 1982, in terms of one way daily average, is estimated to reach 11,800 - 15,100 passengers (lower and upper limit), with these figures further increasing to 17,400 - 22,300 passengers in 1987.

This report has been based on these target figures. The extent to which railway capacity should be increased is, however, a matter to be decided also from national policy considerations.

1-3. Maximum Speed

The Tokaido Shinkansen, capable of the maximum speed of 210 km/h, was inaugurated in Japan 12 years ago. Stimulated by its success, studies in high-speed operation were initiated in various countries, and in a few countries including Japan, 300 km/h tests are already under way. The experiences in Japan have revealed, however, that the fatigue of the car and facilities is greatly enhanced by high-speed operation, giving rise to maintenance problems requiring solutions.

Generally speaking, it is considered that for practical purposes it would be most reasonable to take the maximum speed at 260 km/h, under the condition that the most up-to-date rolling stock and facilities are to be used. The Shinkansen lines now being constructed in Japan (totalling 835 km) for formation of a nationwide high-speed network are designed for the maximum speed of 260 km/h. Whilst there are differences in the environmental conditions of Iran and Japan, such as with respect to the effect of wind-blown sand and salt deposits, it is deemed that technical solutions can be provided for them. Hence, planning will be advanced taking the maximum speed at 260 km/h, with considerations made for the possibility of even higher speeds through further technical progress in the future.

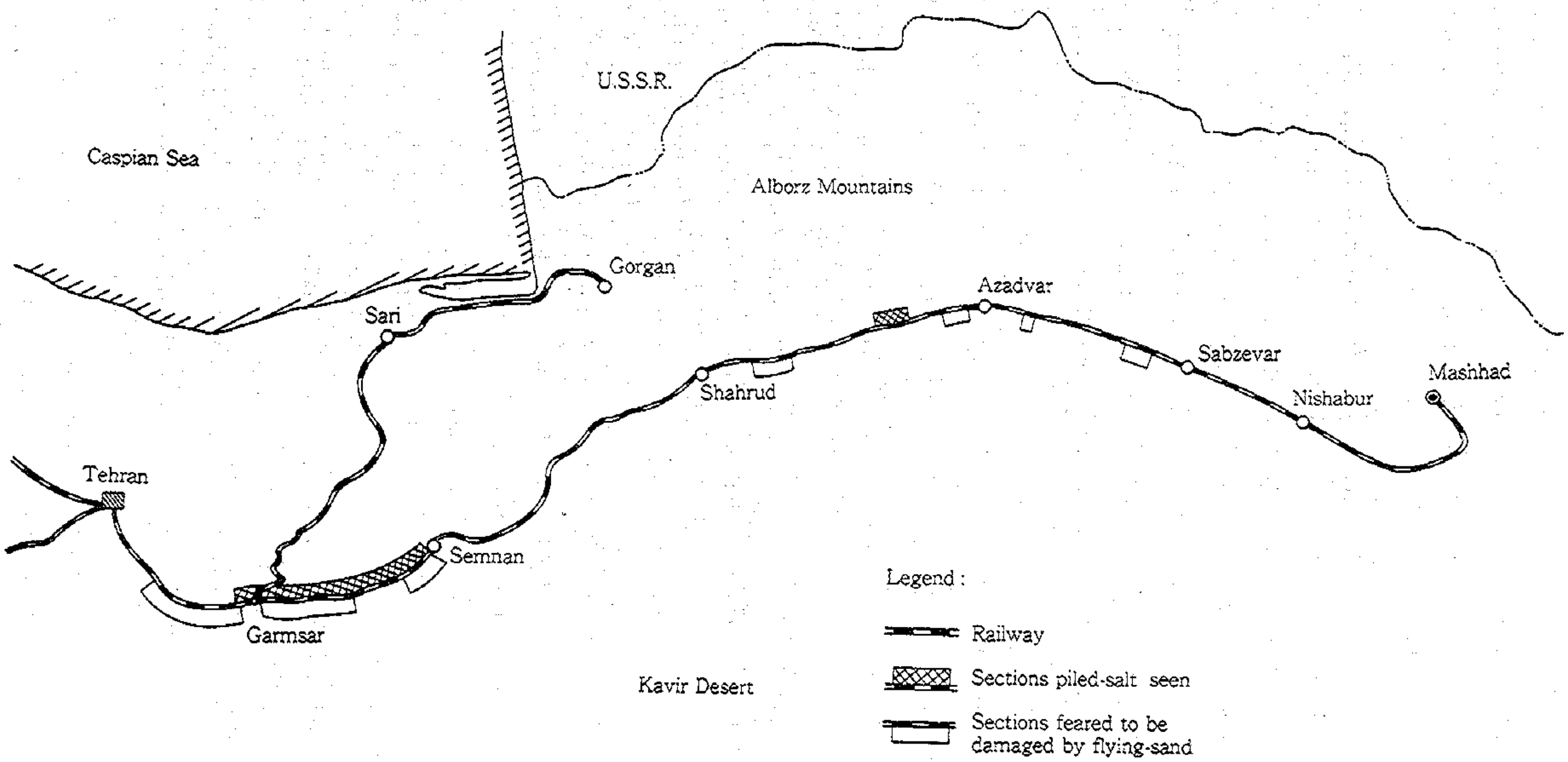
1-4. Situation of the Present Line

The present line runs through large expanses of plains for the greater part of its length. But east of Semnan it crosses a highland, ascending about 900 m over a 130 km stretch of grade section with many curves, and then descends. Between Nishabur and Mashhad there is a mountain range rising over 3,000 m and this is bypassed, but here, too, there are many grades and curves. The steepest grade is 15‰, and the sharpest curve 300 m in radius. All along the line there are places liable to be damaged by floods, this being particularly so in the section between Garmsar and Damgan. There are also many salt deposits along the line, mainly between Garmsar and Semnan, and their total length is about 110 km. Besides, on stretches aggregating 180 km, damage is liable to occur by wind-blown sand. (See Fig. II-1-1.)

1-5. Route Selection and Possible Routes

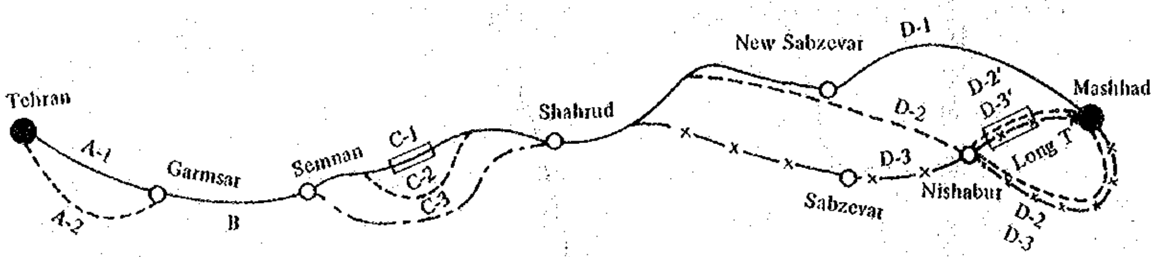
The curve radius should be made as large as possible to enable safe operation at high speed, and the minimum radius should be at least 4,000 m, excepting in unavoidable circumstances such as in station areas. In general, the topography is such that there are long stretches of continuous grades, making it difficult to ease them, but the steepest grade should be limited to 15‰. Needless to say, the shortest possible route should be selected.

Fig. II-1-1 Distribution of Areas Presumably Damaged by Salt and Flying Sand



The 1/250,000 scale maps with 100 m contour, available for all the required area, were used in combination with field inspection to select possible alternative routes. These are shown in Fig. II-1-2.

Fig. II-1-2 Alternative Route Plan



(a) Tehran - Garmsar — A-1 Route (along national highway)
A-2 Route (next to present line)

(b) Garmsar - Semnan — B Route (mostly next to present line)

(c) Semnan - Shahrud — C-1 Route (short cut by tunnel)
C-2 Route (bypassing highland)
C-3 Route (bypassing south)

Decision on the route will be made technically in the next survey, after studying more detailed maps of the required scale and the results of boring and other factors.

(d) Shahrud - Mashhad — D-1 Route (north short cut)
D-2 Route (next to present line)
D-3 Route (detour via Sabzevar)

Also mentionable are D-2' and D-3' Routes which are short cuts by three tunnels from Nishabur. In these cases it will become necessary to bore a 35 km tunnel through the 3,000 m high mountain range for which much time and money may be required. On the other hand, D-2 and D-3 Routes are detours and longer than D-1 by 50 km. In D-1, the construction will be relatively easy and the length is short, but it does not pass by Nishabur. But, by building a new station near the Sabzevar Station of the present line, and by providing high-speed bus service, for instance, to Sabzevar and Nishabur from the new station, it is considered that local demands can be met.

From this point of view, D-1 Route seems to be most preferable, though more detailed technical studies are necessary.

Supposing that the future route is to be the combination of A-1, B, C-1 and D-1, to be called Plan 1, the overall length will be 837 km, or 90 km shorter than the present line. On the other hand, the altitudes of the highest and lowest points on the line will be the same as those on the present line and it will have a section with continuous grades, the steepest of which will be 15‰.

1-6. Terminal and Stations

Most passengers using the Tehran - Mashhad Line travel directly from either of the cities to the other city, and hence, in the high-speed railway the main emphasis will be placed in direct through traffic between these two cities. Accordingly, the majority of the high-speed trains will be made to run straight through without stopping en route. Taking into consideration local demands and the location of cities, three stations at Semnan, Shahrud and New Sabzevar (a transfer station to Sabzevar and Nishabur) will be built, and some of the trains will be made to stop at these three stations.

In a large city, the higher the train speed becomes, the time consumed to come to the station becomes comparatively large, and this becomes a problem. In Tehran, the various functions of the city are moving to the north, and it is doubtful whether the present station would be suitable as the site of the station for the high-speed railway. A plan is being studied to move the station to a new location in the vicinity of Rey, but as this seems to be too far south in relation to the city centre, there could be the possibility of building the high-speed railway terminal for trains headed for Mashhad in the eastern part of the city centre. At any rate, this will have to be coordinated with Tehran city planning.

1-7. Rolling Stock

To meet the requirements for the maximum speed of 260 km/h and high-speed operation on continuous grade sections abounding in maximum 15‰ grades, it is necessary to adopt the electric multiple unit system in which all axles are powered.

Taking account of the traffic volume, rolling stock with the following main features are considered suitable.

Power system	AC 25 kV 50 Hz
Train composition	12 cars, all axles motored
Output	13,200 kW (1,100 kW per car)
Continuous rating speed	205 km/h
Maximum speed	260 km/h
Passenger capacity	Approx. 750

The power unit for the above is the same as that of the prototype car already manufactured in Japan, and is capable of amply meeting the stringent conditions of the grade section between Tehran and Mashhad.

As to the effect of wind-blown sand in the section between Tehran and Mashhad on the various equipment of the car and the effect of salt on electrical insulation, investigations will be made in the next survey and necessary countermeasures taken.

1-8. Transit Time

The transit time for the aforementioned train according to the motive power characteristics of the train to cover the 837 km distance of the route under Plan 1 as mentioned in 1-5, without any stops en route and with the train performingat itshighest capacity, will be 3 hours 30 minutes.

In actual practice, however, there will be the need to set up the train schedule for punctual daily operation, taking account of possible speed reductions caused by track maintenance and weather conditions, and to leave some margin for the train driver. What is important to the passenger is not merely speedy arrival at the destination, but arrival on time.

In the case of the Tehran - Mashhad Line, the scheduled transit time will be taken at 4 hours 20 minutes, leaving plenty margin time, taking account of the world's highest speed operation in an unexperienced environment, such as the effect of wind-blown sand.

1-9. Train Operation Plan

The following shows the number of trains that have to be operated in order to transport the number of passengers shown in 1-2, using trains composed of cars shown in 1-7, taking the average load factor at 80%.

	1982	1987
No. of trains in peak season	20 - 26	29 - 38

As to the usage of the high-speed line to be newly built and the present line, the following combinations are conceivable.

	High-speed line	Present line
Case 1:	Double track for daytime passenger express	Single track for freight and mail trains
Case 2:	Single track for daytime passenger express	Single track for freight and mail trains
Case 3:	Double track for daytime passenger express, nighttime freight and mail trains	Closed (Some sections could remain open.)

(1) Operation of high-speed trains on single track, having them cross one another en route over passing tracks, would increase the number of train stops and the high-speed merit will be lost. Hence, to offset this shortcoming, operation of eastbound and westbound trains separately at different periods of the day, is conceivable, but for practical purposes the number of trains that can possibly be operated one way would only be about 10, and this would not be

enough to meet the peak traffic. (See Fig. II-8-1)

(2) Double tracking of parts of the high-speed line, combined with the usage of the present line for night passenger trains as well, may provide the capacity to somehow meet the peak demand in 1982, but a shortage will most likely occur thereafter. On single track, the time zone for operation of trains each way will be limited.

(3) Several hours of train interval per day will be required for maintenance work on a high-speed railway, although this may not be the case every day. Further, it is difficult to operate freight trains and high-speed passenger trains in the same time zone because of the great difference in their speeds. Hence, in the case of Case 3 above, the operation of freight trains will be subject to severe limitations.

(4) Case 1 is desirable in securing flexible transport for both passenger and freight in the years to come.

(5) The choice on the cases mentioned above should be determined by the prospects of future traffic on the Mashhad Line, but even in case single track operation is to be adopted on a part of the line in the initial stage, permanent structures such as tunnels and bridges should be constructed to double track specifications from a far-sighted viewpoint, and facilities that can be added easily later may be made for single track.

1-10. Power Supply

To enable high-speed operation, the power source should be highly reliable and capable of withstanding the large capacity operating load. The line is to be electrified at AC 25kV 50 Hz and adoption of the AT (Auto Transformer) feeding system as on the Shinkansen in Japan will make it possible to space the substations 60 - 80 km apart, but in this case the substation load will be 20 - 33 MW, one hour maximum power. Further, to keep the voltage fluctuation of the power source within permissible limits, its short-circuit capacity has to be above 1,300 MW.

At present, the power transmission network along the line is not fully adequate, with the exception of the Tehran area, but this is expected to be strengthened in the future, and provision should be made for power supply at that time.

As the availability of satisfactory power source is an important requisite of this project, there will be the need for greater coordinative efforts thereon by the authorities concerned. As to the substation and the overhead contact wire, it is necessary to devise a highly reliable system from the standpoint of high-speed operation and local environmental conditions. In this connection, there is the need to set up countermeasures for the detrimental effect of salt on electrical insulation.

1-11. Train Control and Information Transmission

The following systems are considered to be essential for the safe and efficient operation of high-speed trains.

(1) ATC (Automatic Train Control System)

This detects the position of the preceding train and displays the permissible speed in the driver's cab of the following train to prevent collision, and should the speed of the following train exceed the one displayed, it automatically applies the brake.

(2) CTC (Centralized Traffic Control)

This enables the control of all trains on the section from a control room for their efficient and safe operation.

(3) Train Radio

This will be needed to maintain communication at all times between the dispatcher who controls the trains and the train crew. If there is the need, on-board public telephone service for the passengers can also be provided.

The following are especially essential for formation of the above system.

(a) Track circuit

Voltage is applied to both rails, by means of which the existence of a train on a section is detected and information is transmitted to the train. Due to the salt effect, leakage is apt to increase. Hence, there is the need to conduct tests at site to determine the extent of leakage, and when necessary, improvements may have to be made in the track structure as a countermeasure.

(b) Information Transmission Route

For short distance information transmission the physical line will be used, but for long distance, coaxial cable carrier or SHF or a combination of both will be used for reliable transmission.

2. Target for Traffic to Carry

2-1 Traffic as is at Present

(1) In general

In the growth of the traffic volume carried during the ten years from 1964 to 1973 the Mashhad Line exceeded the national total.

Taking the traffic volume carried in 1964 as 100, the national total and that carried by the Mashhad Line stood as shown in Table II-2-1:

Table II-2-1. Traffic Carried in 1973
(100 for 1964)

		National	Mashhad Line
Passenger service	Passengers carried	116	172
	Passenger car km	162	224
Freight service	Tonnage	210	236
	Ton-km	207	345

(See Appendixes II-2-1 and II-2-2)

Comparing the growth in passenger km or ton-km and the transport capacity (the passenger car km or freight car km) in order to see how the relation between the traffic and the transport capacity stands, we find the growth of traffic larger than that of the transport capacity. From this, though there may be other ways of looking at it, we may say that the transport capacity in general is running short, as shown in Table II-2-2.

Table II-2-2 Traffic Carried and Transport Capacity in 1973 (100 for 1964)

		National	Mashhad Line
Passenger service	Passengers km	162	224
	Passenger car km	115	179
Freight service	Ton-km	207	345
	Freight car km	195	210

(See Appendixes II-2-1, II-2-2 and II-2-3)

(2) Peculiarities of passenger service

Looking at the growth of passengers carried and passenger km, we find both the national total and the traffic by the Mashhad Line showing higher growth in passenger km than in the number of passengers carried. This obviously means that the average riding distance per passenger became longer.

Accountable for this seemingly is that in passenger service the practice in principle is to sell tickets no more than that fixed for the seating capacity, and to give priority to travelers riding through from one end of a line to the other end in selling tickets.

Table II-2-3 Average Riding Km per Passenger

Year	National	Mashhad Line
1964	374. 3 km	540. 0 km
1973	521. 5 km	703. 9 km

That the average riding km per passenger on the Mashhad Line is considerably greater than the national total, as is seen in the Table above, goes to show that the number of through passengers is comparatively large.

(3) Traffic between Tehran and Mashhad by mode of transport

The number of through passengers between Tehran and Mashhad by mode of transport increased during the four years (1971 to 1974), 1.81 fold by bus and 1.86 fold by airplane, 1.68 fold by private motorcar and 1.14 fold by railway ranking lowest among them all.
(See Appendix II-2-4)

This is because the use of railway is largely suppressed by the transport capacity as mentioned previously. Besides, the bus is overwhelmingly superior to the railway in frequency of service and has an advantage over its competitors in tariff rates.
(See Appendix II-2-7)

Grouping the users of various modes of transport by season, we find the traffic by mode of transport is heavier in summer than in winter by about two fold and the seasonal fluctuations extremely high, as seen in Table II-2-4 to follow:

Table II-2-4 Users of Various Modes of Transport by Season (per day, one way)

Mode of transport	Peak (Summer)	Light-traffic season (spring or winter)	Peak/light traffic
Railway	2,445 persons	1,218 persons (Spring)	2.0 fold
Bus	6,976	3,942 (Winter)	1.8
Airline	317	160 (Spring)	2.0
Private motorcar	920	525 (Winter)	1.8

(See Appendix II-2-5)

The season fluctuations are higher in railway traffic than in bus traffic, as is seen in the Table above. When we group the summer traffic by month, we find the number of railway users is highest in August 1.71 times as high as the annual average value. The fluctuation rate thus is highest in that month.

Table II-2-5 Number of Travelers by Railway and Bus in 1974
(100 for monthly average for the year)

Month	Period	Railway	Bus
July	6/21 - 7/20	141	119
August	7/21 - 8/20	171	141
September	8/21 - 9/20	160	148

(Appendix II-2-6)

(4) Bus service operation between Tehran and Mashhad

Information obtained directly from some of the bus service companies in Tehran and studied carefully discloses that there are nearly 20 companies engaged in operating bus routes between Tehran and Mashhad and the number of buses running on the routes reach 100 one way normally and 200 at the peak time in summer.

The bus service is rendered in three classes, as is shown in Table II-2-6, though the quality of service varies somewhat from company to company.

Table II-2-6 Bus Service Classes & Accommodations by Class

Class	Fare (rails)	Cooler	Reclining seats	Accommodating capacity (persons)
Super delux	700	Yes	Yes	30
Delux	460 - 480	No	Yes	36
Common	300 - 400	No	No	36

Note: 1. For Class Delux a raise of the fare up to 520 rials during the peak season is approved of by the Government.

2. The super delux class of service is rendered once a day by TBT alone, as on 10 July 1974, though Iran Peyma has a plan under contemplation to render the same class of service.

When asked why taking the bus instead of the train to Mashhad, some of the passengers gave the following reasons: (1) They could not buy rail tickets; (2) They could enjoy seeing the scenery along the route more on a bus than on a train.

Remark: The number of buses operated for Mashhad by each of the principal bus companies is as follows:

Iran Peyma:	8 to 13	Rovan Tour:	5
TBT:	3 to 15	Transport:	5
Levan Tour:	4 to 5	Ade:	2 to 4
Iran Tourist:	2 to 3	Gilau Tour:	6
Mihau Tour:	2 to 5	Auto Khorasan:	2 to 3

2-2. Target Value Aimed at in Operation of High-speed Passenger Service

(1) The way of thinking in attaining the target

The traffic volume by high-speed passenger trains on the new line will be made up with those passengers diverting from the existing railways and the routes of other modes of transport running parallel to it and the others induced by high speed in train operation.

The traffic volumes of the diverted and the induced will change depending mainly upon the quality (principally, speed and fares charged) of the service to be rendered by high-speed train.

As it is difficult at this time to envision the fare level for the future, besides, as such is a matter of policy to be taken, we have figured out the percentages of those diverting from buses and private motorcars to high-speed trains to be at least 30% and 10%, respectively, and the percentage of those induced to use high-speed trains 30%. (As to the maximum conceivable volume of those diverting from buses, we have considered the propensity of their users for traveling and set it to be 50%.)

No diversion of airline users is assumed.

(2) Calculation method followed

The traffic by rail, without taking the high-speed railway into consideration, is first sought in connection with GNP and then, adding to it the traffic diverting from buses and private motorcars and that induced by high-speed train operation, we have estimated the traffic volume after the high-speed railway is opened--that is, for 1982 and 1987 in two ways, the maximum and minimum conceivable.

(a) GNP & the Actual Number of Passengers

Year	GNP (in 100 m rials)	No. of Passengers (persons)
1971	9, 791	4, 821
1972	11, 680	5, 688
1973	17, 453	6, 901
1974	27, 786	7, 747
Average yearly growth	41. 6%	17. 1%
Growth rate ≈ 0. 411 $(\frac{17.1}{41.6})$		

Note: The number of passengers represents the total of those carried by all modes of transport (per day average, one way between Tehran and Mashhad).

(b) The Number of Passengers in Future

(Per day average, one way, by all modes of transport. No high-speed railway considered for 1982)

Year	GNP (In 100 m rials)	Annual GNP average growth rate	No. of passengers(persons)
1974	27, 786		7, 747
1982	116, 496	19. 6%	14, 445 ($= 7,747 \times (1 + 0.196 \times 0.411)^8$)

(c) No. of Passengers by Mode of Transport

	Share in 1974 (A)	(A) x No. of passengers in 1982 = 14,445 persons (persons)
Railway	20.4 (%)	2,947
Bus	67.5	9,750
Airline	3.3	477
Private motorcar	8.8	1,271
Total	100.0	14,445

Note: Since fluctuations in the shares of modes of transport in the future depend upon the transportation policy to be taken, we have assumed that there would be no changes in the shares after 1974 in calculating the number of passengers in 1982 given above.

(d) Railway Traffic Volume after the Opening of the High-speed Railway (1982)

In case high-speed railway not considered	2,947 persons
Diversion from buses	2,925 (= 9,750 persons x 30%)
Diversion from private motor-cars	127 (= 1,271 x 10%)
Induction by high-speed railway. .	884 (= 2,947 x 30%)
Total	6,883 (= Yearly average - Minimum value)
	8,833 (= Yearly average - Maximum value)
	= 6,883 + 9,750 x (50-30)%

Reference for the railway share of traffic in 1982 --

Without the high-speed railway 20.4%

After the opening of high-speed railway, max. value .... 57.6 $\left(\frac{8,833}{14,445+884}\right)$

The Shinkansen share of traffic between Tokyo and Shin Osaka in 1973 (Appendix II-2-8) 75.5

- Traffic during heavy-traffic season and light-traffic season:

p = persons; m = months

	Minimum value estimated	Maximum value estimated
Heavy-traffic season volume (Aug.)	11,770 p (=6,883 p x 1.71)	15,104 p (=8,833 p x 1.71)
Light-traffic season volume (excluding 3 summer months and half of Jan.)	4,871p $\left(= \frac{6,883p \times 12m - 11,770p \times 3.5m}{8.5m}\right)$	6,251p $\left(= \frac{8,833p \times 12m - 15,104p \times 3.5m}{8.5m}\right)$

- Traffic volume in 1987 (yearly average)

Min. value ..... 10,159 p $< 6,883\ p \times (1+0.196 \times 0.411)^5 >$

Max. value ..... 13,038 p $< 8,833\ p \times (1+0.196 \times 0.411)^5 >$

	Minimum value estimated	Maximum value estimated
Heavy-traffic season (Aug.)	17,372 p (=10,159 p x 1.71)	22,295 p (=13,038 p x 1.71)
Light-traffic season volume (excluding 3 summer months and half of Jan.)	7,192 p $\left(=17,372\ p \times \frac{6,251}{15,104}\right)$	9,230 p $\left(=22,295\ p \times \frac{6,251}{15,104}\right)$

(e) Transport capacity (No. of trains per day, one way, to carry the maximum traffic estimated above)
(That to carry the minimum traffic shown in ( ))

	1982	1987
Heavy-traffic season	26 trains (=15, 104 p ÷ 0. 8 (car utilization coefficient) ÷ 750 p (accommodating capacity) (20 trains)	38 trains (=22, 295 p ÷ 0. 8 ÷ 750 p) (29 trains)
Light-traffic season	12 trains (= 6, 251p ÷ 0. 7 ÷ 750 p) (10 trains)	18 trains (=9, 230p ÷ 0. 7 ÷ 750p) (14 trains)

(3) Problematic points

(a) Relationship between the traffic volume and the fare level of the high-speed railway

Although no effect of the tariff rate level to be set up for high-speed railway service is taken into consideration in our assumption, the fare rates will undoubtedly have a considerable effect upon the traffic volume even when the income level largely goes up. Weight therefore must be duly put on the factor of fare rates in estimation of the future traffic volume.

(b) Diversion of bus users

The diversion of bus users will be a vital factor in determining the traffic on the high-speed railway. Therefore, it must be carefully studied, not only quantitatively but qualitatively as well, using the questionnaire method, for instance.

Most of the bus users today seem to regard low cost more important than speed. However, as their income level goes up, as they begin to put more value on time, they will go for speed in traveling. When and to what extent they will have the propensity for speed determines the traffic volume diverting from buses to the high-speed railway trains.

(c) Approach to Tehran Station on the high-speed railway

As for the traffic of passengers taking high-speed railway trains at Tehran Station after alighting from the existing railway trains, buses, motorcars and airplanes, the approaches by subway or highway to the high-speed railway station in Tehran to and from the existing railway station and airport will be the determining factor in making effective use of the high-speed railway.

2-3. The Freight Service-to-be on the Mashhad Line

(1) GNP and the actual freight traffic

The volume of freight traffic in the two Regions (Northeast and Kohrasan) of the Mashhad Line increased during the nine years from 1964 to 1973 by 3.45 times--a yearly growth averaging 14.8%, almost corresponding to the yearly average growth of 17.6% in GNP.

Year	Ton-km (in 1,000 ton-km)	GNP (in 100 million rial)
1964	86,744	4,052
1973	299,626	17,453
Yearly average growth rate	14.8%	17.6%
Growth rate	0.841 $(= \frac{14.8}{17.6})$	

(2) Freight traffic volume in the future and the number of freight trains

(a) Freight traffic volumes in 1982 and 1987

Seeking the traffic volume in the future by using the relationship between GNP and ton-km, as these are presently, we find it to increase about five fold over 1973 in 1982, mounting to over 12 fold in 1987. (Road transport and changes in other conditions not taken into account.)

Ton-km multiplication

1982	5.08	$\langle = (1 + 0.235 \times 0.841)^{9} \rangle$
1987	12.54	$\langle = (1 + 0.235 \times 0.841)^{14} \rangle$

(0.235 = Annual average growth rate of GNP)

(b) Number of freight trains

Seeking the number of freight trains needed to haul the traffic volume, assuming the hauling capacity to be 3,000 tons (1,000 tons at present), we have: (Taking the number of trains at present to be 3, one way)

1982 .... 5 trains, one way $(= 3 \times 5.08 \times \frac{1000}{3000})$

1987 .... 12 to 13 trains, one way $(= 3 \times 12.54 \times \frac{1000}{3000})$

3. Natural Conditions

3-1. Topography and Geology in Brief

The planned route runs through the area almost a plain, lying between the Alborz Mountain Range on the north side running west to east and Kavir Desert on the south side. Here already a railway is constructed. But this line runs away from Kavir Desert and on to the comparatively flat area at the foot of the Alborz Mountains. A plateau forming part of the mountain range is seen sticking out on the plain. The rail line skirts round it, 300 m in minimum radius of curvature, and steepest grade of 15 $^{o}/oo$ with no tunnels. As a whole, no big rivers, no long bridges are seen.

The topography and geology along the existing railway line are as follows in brief:

(1) Between Tehran and Semnan

Leaving Tehran the rail line runs along the southern foot of the Alborz Mountain Range and goes through a section where some hills descend by a gradual slope. Near Garmsar the Alborz Mountain Range stretches out southward, but the rail line runs on a plateau with an easy slope. Seasonally this section is flooded with water from the mountains, giving rise to many streams. All these streams flow into the plain, ending up in the Salt Desert.

In the mountainous part of this section a tertiary sedimentary rocks of moraine and many volcanic rocks are found.

(2) Between Semnan and Mashhad

The line detours the plateau extending southward at the bottom of the mountain range from a point about 10 km east of Semnan and from near Damghan enters a flat area to reach Shahrud.

On the mountains tertiary deposits of volcanic rocks are seen. On the plateau, however, sand and gravel is largely distributed.

From Shahrud on to Nishabur the rail line passes through a long basin lying between the mountains on the south and north sides. Most of this area is made up with sand layer. The soft grounds are seen in some parts.

From Nishabur it runs along the southeastern edge of the Alborz Mountain Range to reach Mashhad located in the basin between the Alborz and Hezar-Masjid Mountain Ranges. In the mountainous area there are many alluvial rocks of the Mesozoic Era.

3-2. Meteorological Conditions

(1) In general

Studying the data we have obtained this time from the Meteorological Organization, we observe that the temperature in this area drastically changes in a day, by about 30 degrees Centigrade. The temperature changes over 60 degrees in a year. The annual rainfall ranges from 100 to 300 mm, heavier in the winter months. The wind velocity averages about 10 m/sec.

(2) Meteorological Data

Table II-3-1

	Temperature (°C)				Rainfall (m/m)				Most frequent wind direction	Average wind velocity (m/sec.)
					Yearly rainfall		Rainfall per day			
	Max. value	Average max. value in past five years	Min. value	Average min. value in past five years	Max. value	Average max. in past five years	Max. value	Average max. in past five years		
Tehran	42.8	41.1	-16.1	-10.5	386.2	225.8	26.0	21.5	West	7
Semnan	44.5	42.6	-12.5	-7.1	226.7	111.4	23.0	18.2	South	6
Shahrud	40.0	38.5	-14.4	-10.6	209.8	150.0	26.5	23.8	Northeast	5
Sabzevar	45.2	42.5	-19.8	-13.3	163.4	131.1	27.0	19.7	Northeast	11
Mashhad	43.4	40.5	-25.0	-19.9	222.9	177.4	26.1	21.3	Southeast	6

Note: The figures sought from data for five years, 1965, 1966, 1969, 1970 and 1971.

Max. Wind Velocity by Month (The data from 1973 to 1971, in Tehran)

Table II-3-2

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max. wind velocity (m/sec)	23	21	24	28	28	24	18	40	19	23	23	21

3-3. Natural Conditions Considered

In planning for the construction of a high-speed railway, mentionable as essential to be considered are the following natural conditions:

(1) Flying sand

The localities where the adverse effect of the "flying sand" is feared along the existing rail line in our study are:

Between Tehran and Garmsar, about 60 km
" Garmsar and Semnan, about 80 km
" Shahrud and Nishabur, about 40 km

The adverse effect of the sand blown up by the wind is that the sand so blown up and around piles up on the track and that the sand dust penetrates into the rolling stock equipment and instruments. Hence, the actual state need be studied and countermeasures hammered out by conducting various experiments.

(2) Salt

Salt-containing soil is found along the line, notably

Between Tehran and Garmsar, about 10 km
" Garmsar and Semnan, about 110 km
" Shahrud and Nishabur, about 20 km

Salt is harmful to electric insulation and corrodes metal components. Technical study, therefore, must be conducted to overcome its ill effects.

(3) Floods

Many are the areas where big floods are feared because of the terrains. Traces of floods have been noted here and there, too. In routing the high-speed railway and designing the track structure for it, care must be taken in this respect. The areas where floods are likely as we have concluded by our study are:

Existing kilometerage

Around 70 km - 110 km, about 40 km
" 130 km - 155 km, about 25 km
" 210 km - 230 km, about 20 km

Around 245 km - 350 km, about 105 km
" 570 km - 590 km, about 20 km
" 820 km - 900 km, about 80 km

(4) Temperature

The past records show that the maximum temperature is extremely high and the rise and fall in temperature conspicuously large. Studies and countermeasures, therefore, are needed to cope with the aggravation of electric insulation at the time of high temperature and the rail expansion and contraction due to the difference in temperature.

(5) Snowfall

As there is a snowfalling area where the planned route is to pass through, the actual state of snowfall here must be studied and countermeasures need be devised accordingly.

4. Matters Further to be Considered in Routing the High-speed Railway

4-1. Fundamental Items

(1) Minimum radius of curvature

With the riding comfort and safety in operating trains at the maximum speed of 260 km/h taken into consideration, the minimum radius of curvature will have to be 4,000 m. However, at entering and leaving stations and at other places where curves are deemed necessary, the radius will be less than 4,000 m.

4,000 m.

(2) Maximum gradient

The steepest grade of the main track is to be 15 $^{o}/oo$. The extension of the continuous grade on the main track, in the case of electric railcar trains, is to be decided, case by case, as such is to be determined by how high the temperature of the main motor rises.

(3) Intermediate stations

Intermediate stations will be constructed in Semnan, Shahrud and Sabzevar, the cities where the planned route is to pass through. Further investigation is duly necessary prior to the decision.

4-2. Others

(1) In order to cut down the traveling time, the line is to take a short-circuit route.

(2) To complete the construction in a shortest possible period.

(3) The construction cost to be lowest possible.

(4) In order not to hamper train operation, such areas where the wind blows up sand, the soil contains salt, snow falls and floods are likely, are to be avoided by all means.

5. Routing Considered

As it was not possible to obtain a topographical map drawn on a reduced scale, one to 50,000 (though such was partly available, it was useless in doing the series of work in routing the line), paper location was done on a drawing 100 m in the vertical distance of contour line and field reconnaisance performed to study on the routing of the line.

5-1. Between Tehran and Garmsar

(1) A-1 Route --- Short-cut route along the national highway

For the location of the new Tehran Terminal, the eastern district comparatively close to the city centre is considered. The route runs down south for about 10 km from the terminal and runs along the national highway to Garmsar. In a certain part there are spots where big seasonal floods are feared, caused by the rain water and thawing water from the mountains on the north side, as well as rock-salt zones that are topographically difficult to deal with. So, the routing must be decided with these spots taken into consideration.

Note: In Garmsar it is possible to construct the new station close to the existing station.

(2) A-2 Route-Routing in parallel to the existing line

The route goes down south for about 20 km from the new Terminal and runs in parallel to the existing line to Garmsar. There being some spots on the way where damage from sand-blowing up winds, salt and floods is to be feared, this aspect must be taken into consideration in selecting this route.

5-2. Between Garmsar and Semnan

In between these two cities, it seems possible to select a route running almost in parallel with the existing line. Beyond the spot about 10 km east from Garmsar Station there is a place where mountain streams concentrate, and spots remindful of floods in the past abound on the existing line. Anti-flood works, therefore, must be properly done in this section. The section being in the area lying lowest above the sea level, there are many sand layer. Countermeasures against sand flying and salt damage must, therefore, be taken properly and adequately.

Note: It is not easy to route the high-speed railway into the existing station of Semnan.

5-3. Between Semnan and Shahrud

For the routing from Semnan eastward across the mountainous area, thinkable are the following three routes:

(1) C-1 Route --- Short-cut routing through tunnel

From a spot about 2 km north of Semnan, the route runs at the foot of the mountains on the north side of the national highway and then cuts through the mountain plateau with a 15 km long tunnel. Out of the tunnel, the route runs almost in parallel with the national highway to reach Shahrud via Damghan. This route is the shortest one among those proposed between Semnan and Shahrud. But, as a long tunnel has to be drilled through, the geological and spring water conditions will have to be studied before discussing whether to select this route or not.

(2) C-2 Route --- Plateau detouring route

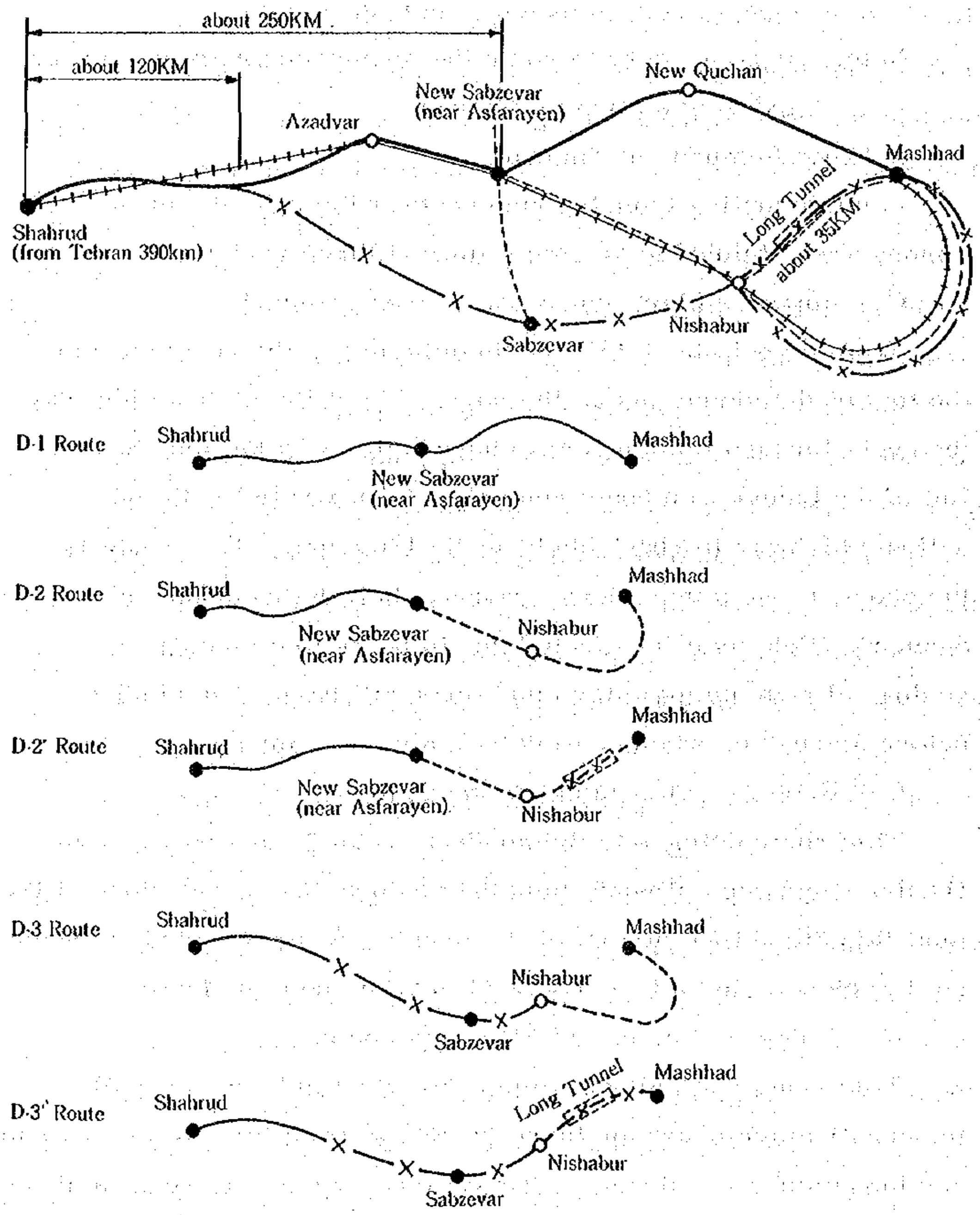
This route detours to the south from the tunnel entrance in (1) above and runs almost along the contour of the mid-slope of the mountains to get to the exit of the tunnel. A further study is needed on this plan, using a topographical drawing done in detail.

(3) C-3 Route --- Southward detouring route

This route runs almost along with the existing line, calling for construction of two or three tunnels to pass through the plateau and mountains. Besides, as it runs through the watery area at the foot of the mountains, steps must be taken properly and adequately in precaution.

5-4. Between Shahrud and Mashhad

Routes conceivable for the section are shown as follows:


about 250KM
about 120KM
New Sabzevar
(near Asfarayen)
New Quchan
Azadvar
Mashhad
Long Tunnel
about 35KM
Shahrud
(from Tehran 390km)
Sabzevar
Nishabur
D-1 Route
Shahrud
New Sabzevar
(near Asfarayen)
Mashhad
D-2 Route
Shahrud
New Sabzevar
(near Asfarayen)
Nishabur
Mashhad
D-2' Route
Shahrud
New Sabzevar
(near Asfarayen)
Nishabur
Mashhad
D-3 Route
Shahrud
Sabzevar
Nishabur
Mashhad
D-3' Route
Shahrud
Sabzevar
Nishabur
Long Tunnel
Mashhad

(1) D-1 Route --- Northward detour route

The route runs east from Shahrud along the existing line, and from the spot about 60 km southeast of Shahrud turns farther south to avoid the soft ground area. Near Azadvar it comes up again along the existing line to run on eastward. Near Asfarayen it runs gradually away toward northeast from the existing line. Then threading on the plain eastward between the Alborz Mountains, it runs along the national highway to reach Mashhad.

Although this route partly runs through a snowy area, the terrains here being good for aligning, it cuts down the track length over other proposed routes.

(2) D-2 Route --- Routing in parallel to the existing line

From Shahrud to Asfarayen the same as that in D-1 Route. From Asfarayen eastward it runs along the existing line to Mashhad via Nishabur.

The section where the route runs past the edge of the mountains calls for construction of the track structure on a large scale. Besides, the track kilometerage becomes long.

(3) D-2' Route --- Routing alongside of the existing line and short-cut with a tunnel beyond Nishabur

From Shahrud to Nishabur the same as that in D-2 Route. From Nishabur it runs east with a long tunnel bored through the southeastern end of the Alborz Mountain Range to reach Mashhad.

This route has the advantage of short-cutting. The tunnel length, however, reaches as long as about 35 km.

(4) D-3 Route --- Routing via Sabzevar with detour beyond Nishabur to Mashhad

Between Shahrud and Sabzevar, the route avoiding the geologically unfavorable area runs eastward alongside the existing line and then turns to the right to reach Nishabur via Sabzevar. From Nishabur the routing is the same as in D-2 Route, running along the existing line and taking a roundabout way southward to reach Mashhad. Abounding in spots where terrains are rugged on both sides of Sabzevar, this proposed route needs further study in detail.

The section where the route runs past the edge of the mountains calls for construction of the track structure on a large scale. Besides, the track kilometerage becomes long.

(5) D-3' Route --- Routing via Sabzevar and short cut with tunnel beyond Nishabur

Running in the same way as in the D-3 routes between Shahrud and Nishabur, the route here proposed is short cut from Nishabur on with a long tunnel to reach Mashhad.

Table II-5-1 Comparison of Routes Proposed between Shahrud and Mashhad (D-1, D-2, D-2', D-3 and D-3')

Route No.	Track length (km)	Stations may be constructed if needed	Major structures	Flood & snow damage	Connections with cities located in between
D-1	447	Shahrud – Azadvar – New Sabzevar (Near Asfarayen) – Near Quchan – Mashhad 175 / 70 / 87 / 115	With tunnels and viaducts in some sections (having access roads)	Snowfall areas in between	Connections at new Sabzevar Station possible o Nishabur, existing line, 112 km o Sabzevar City, road, 45 km
D-2	495	Shahrud – Azadvar – New Sabzevar (Near Asfarayen) – Nishabur – Mashhad 175 / 70 / 115 / 135	With tunnels and bridges in some sections	Flood feared in some areas	Possible for trains to stop at Nishabur
D-2'	448	Shahrud – Azadvar – New Sabzevar (Near Asfarayen) – Nishabur – Mashhad 175 / 70 / 115 / 88	With a long tunnel, about 35 km long, making construction period longer and cost higher	-	Possible for trains to stop at Nishabur
D-3	492	Shahrud – Sabzevar (City) – Nishabur – Mashhad 257 / 100 / 135	With tunnels and viaducts in some sections (having access roads)	Flood feared in some areas	Possible for trains to stop at Nishabur and Sabzevar
D-3'	445	Shahrud – Sabzevar (City) – Nishabur – Mashhad 257 / 100 / 88	With a long tunnel, about 35 km long, making construction period longer and cost higher With tunnels and viaducts in some sections	-	do.

Note: As a route to be extended to Afghanistan for through train operation, D-1, D-2' and D-3' are desirable.

5-5. Suggestions in Selecting the Route Most Desirable

The investigation conducted this time was to produce rough routes to serve as the essentials in picking up the most desirable one, making full use of the topographical map drawn on a scale of one to 250,000, which was submitted to us. The work had to be done within the time given. We firmly believe that the suggestions made herein will be most helpful in deciding upon the most desirable route for the construction of a high-speed railway.

The next step to be taken is to draw up as soon as possible a topographical map drawn on a properly larger scale and go on deciding upon the route desired, keeping in mind the suggestions herein made. We may add that in determining the route there is the necessity of conducting a geological survey in some of the sections.

Now our views on each section of the routes proposed:

(1) Between Tehran and Garmsar

A short-cut route (A-1 Route) along the national highway, short in length and comparatively free from such damages as to be caused by flying sand and salt, is desirable.

(2) The routes running past the highlands and mountains east of Semnan

Each of the proposed routes has its own merits and demerits in track length, in having or not having a long tunnel, in passing or not passing through an area where floods are feared, etc. These must therefore be carefully weighed, and the construction period and cost, as well as the maintenance cost to incur after the construction, must be all together taken into consideration before making the decision.

(3) Routes proposed between Shahrud and Mashhad

When the routes proposed are compared in the light of convenience resulting from through passenger service between Tehran and Mashhad and the work load involved in construction, we find:

(a) D-1 Route --- Northward detour route

Large in the degree of track length reduction and comparatively easy in work execution, this route is most desirable. As for the passenger service to Nishabur and Sabzevar the route calls for construction of a new Sabzevar Station near Asfarayen. Its merit of convenience thus stands out; for, from this station the users can travel on to the two cities by bus or existing line train.

(b) D-2 Route --- Routing in parallel to the existing line

With this route it is possible to construct a Nishabur Station. This, however, makes the route length longer by about 50 km than D-1 Route. It is undesirable, therefore, from the main purpose of through passenger service between Tehran and Mashhad.

(c) D-3 Route --- Detour route via Sabzevar

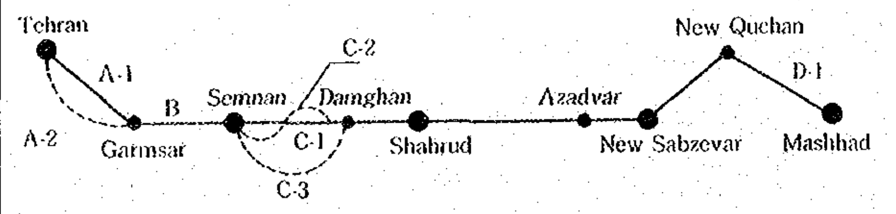
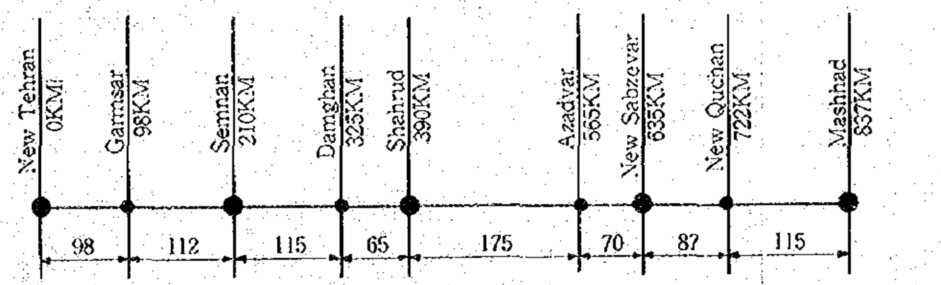
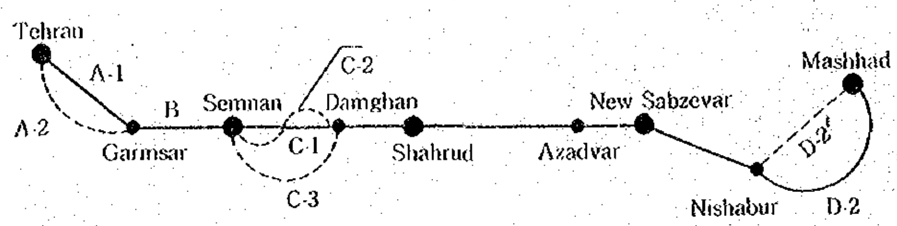
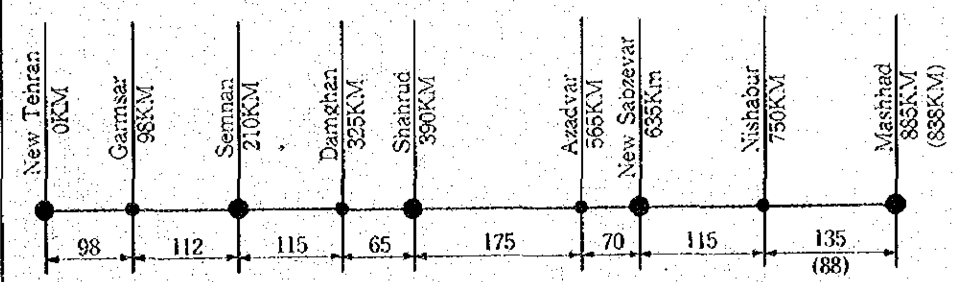
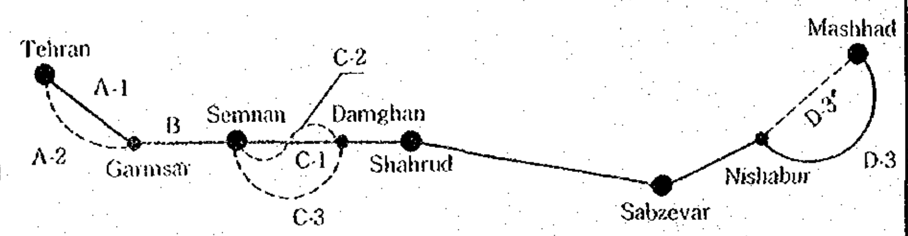
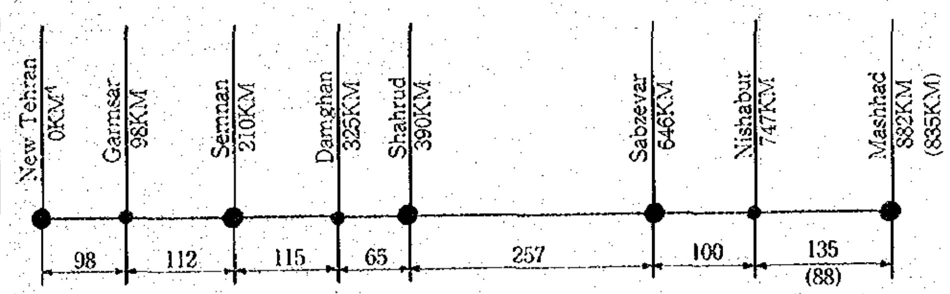
Though the establishment of Sabzevar and Nishabur Stations is possible, this makes the route length longer as in the case of D-2 Plan.

(d) D-2' and D-3' Route --- short-cut with a long tunnel

This route was proposed with the intention of overcoming the demerits of D-2 and D-3 Routes calling for a long route kilomerage. The route proposed, though much shorter in length, calls for construction of a long tunnel, about 35 km in length, the construction period being much longer than that of other routes.

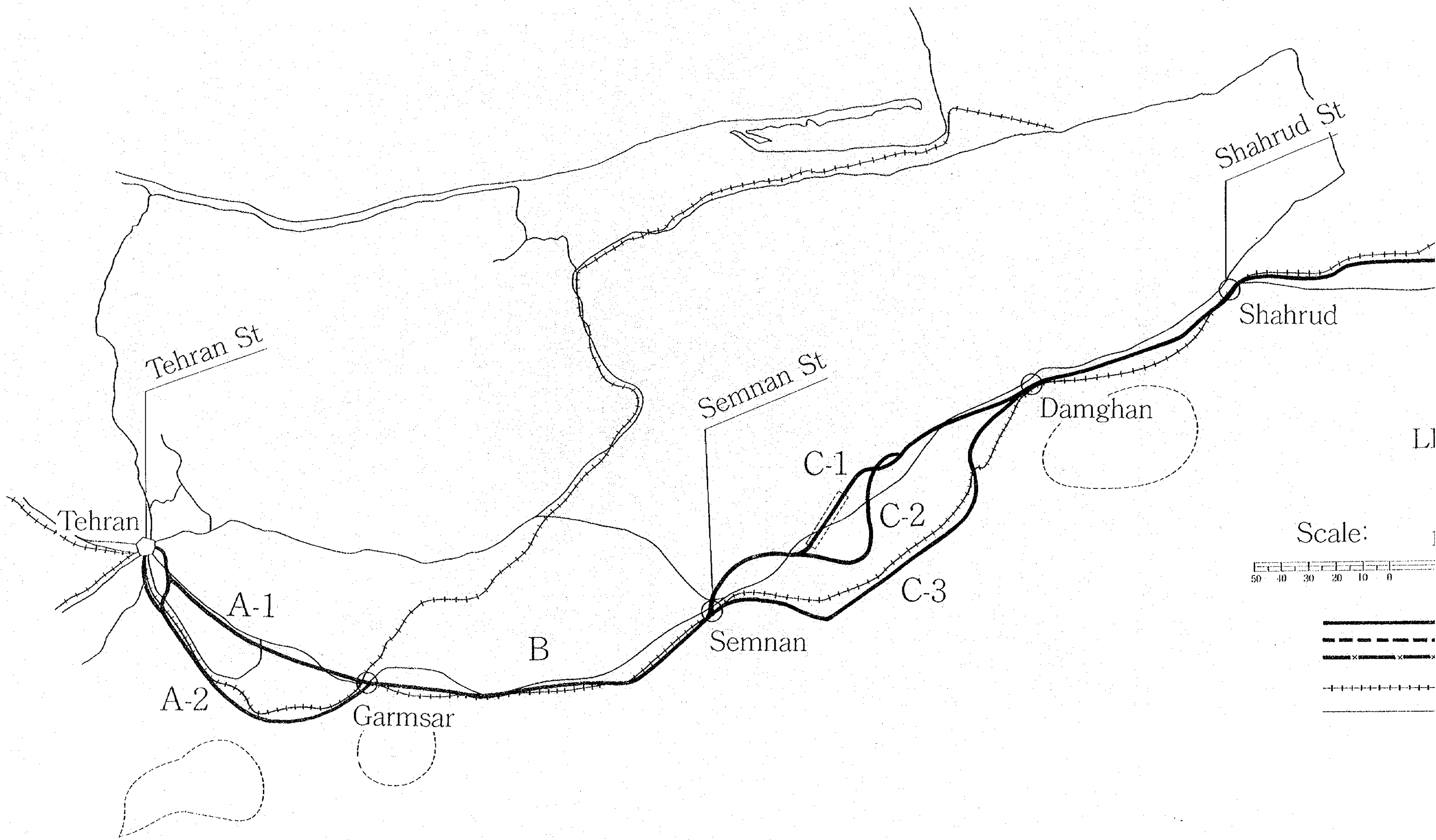
From the five routes so far studied, we may as well say that D-1 is the most desired one.

Table II-5-2 Features of Various Routes Proposed

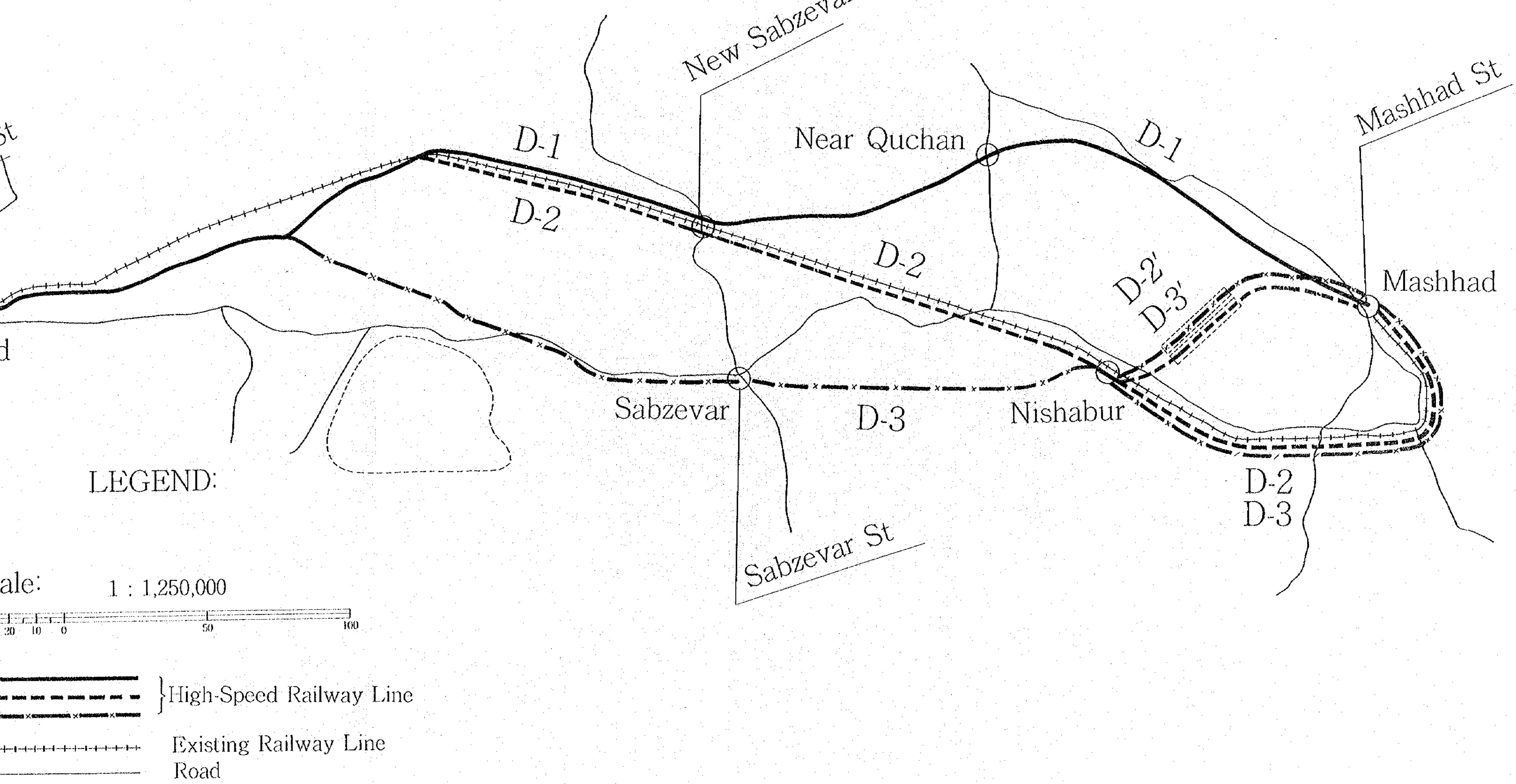
Item	Sketch map of route	Track length	Places where station and maintenance depot may be constructed	Remark
		KM		
1		837		A-1~B~C-1~D-1
2		885 (838)		A-1~B~C-1~D-2 (A-1~B~C-1~D-2')
3		882 (835)		A-1~B~C-1~D-3 (A-1~B~C-1~D-3')

Note: 1. Between Tehran and Garmsar there are two comparable routes proposed; A-1, 98km; A-2, 116km.
2. Between Semnan and Damghan there are three comparable routes proposed; C-1, 115km; C-2, 138km; and C-3, 131km.
3. The dotted line between Nishabur and Mashhad represent the Short-Cut route with a a long tunnel, about 35km long, and the figures in parentheses indicate the length in case the long tunnel is built.

Fig. II-5-3 ROUTE MAP BETWEEN



EEN TEHRAN~MASHHAD



6. Plan for Station

6-1. Basic Concept

In determining the location of a station, the layout of the various facilities existing in the city and the city planning for the future (including the plan for the modification of the layout of city facilities) should be well taken into consideration.

That is, locate the station in harmony with the plan for the improvement of the city environment, as well as in such a way as to make effective use of land within the city and to invigorate the city activities. What is more, as the railway is for bulk transport of passengers, each train hauling a great number of passengers, unlike other modes of transport, the station-to-be must have connections with roads and underground railways, so that the passengers can travel most conveniently between the rail terminal and their varying destinations.

As these are particularly important to such large cities as Tehran and Mashhad, great care must be taken in selecting the location for a station.

6-2. City Planning for this Project

From the reference materials and data we have obtained we understand there are the following plans under contemplation:

(1) Tehran City

In Tehran, capital city of Iran, where the population is rapidly growing, there is a plan afoot to build up the nucleus control functions of the governmental organs and others and the relative commercial facilities and dwellings in the Abbasabad district, a little way north to the city centre.

Build-up of city facilities mainly for dwellings in the northern and western parts of the city is also planned.

Thus the city activities of Tehran are showing the tendency to move northward.

To ease the traffic jam the city has a plan already drawn up for a city highway network in close coordination with the build-up of the national highways, and part of the plan is now being executed. For the same reason another plan for a subway network is also under contemplation.

(2) Mashhad City

Mashhad is the central city in the region. Also as the centre of economic development of Iran, it has extensive industrial development plans drawn up. As the consequence, concentration here of local control functions is planned and a population explosion is anticipated.

In the northwestern part of the city, plans are under way for the build-up of industrial plants and dwellings and these are already coming up, one after another.

In the city centre, plans are being pushed forward for the build-up of city facilities in harmony with the cultural facilities that have been existing from the olden days, without any harm done to the function and the meaning of the heritage.

A plan is also under deliveration to build up expressways in the rapidly developing city, so as to organically link up the various kinds of city facilities.

6-3. Railway Improvement Plans for this Project

For the Tehran Region, improvement of railway facilities is planned to cope with the rapid growth of the City of Tehran and in line with the city planning programs of this city.

Featured in these plans are renewal and a new layout of railway facilities. To be ready for the increase of passenger and freight traffic anticipated, plans drawn up are as follows:

(1) Build-up of passenger terminals

Passenger terminal functions are presently concentrated at Tehran Station only. The plan calls for dispersal and distribution of these functions with Tehran Station serving as the terminal of the South Line, a new station in Shahyad Plaza as that of the Northwest Line and another new one near Rey as that of the North and Northeast Lines, so as to reinvigorate the functions and enlarge the terminal capacity and, in this connection, construct a new line to link up with the existing line.

(2) Build-up of freight yards

The plan calls for the moving of the freight yard for the district from the present Tehran Station to near Aprine on the South Line to modernize this yard, as well as for the procurement of land for passenger terminal facilities of Tehran Station and for rolling stock inspection and repair facilities.

The plan also calls for construction of a short-cut line to link up the new yard in Aprine with every other line in a most efficient way.

6-4. Plan for the Terminals on the High-speed Rail Line Proposed

(1) Tehran Terminal

A plan for new Tehran Terminal should include a main station building suitable as a gate to the high-speed railway to Mashhad with the provision of parking lots for privately-owned cars and access to expressways and subways taken into account. Beside, thinking of the build-up plans of the City of Tehran as described in the preceding paragraphs, the Terminals is to be built in the eastern part of that city, though the decision is to be rendered only after studying the problem of land procurement here and the city plans in more detail. Occasion thus may arise calling for a modification of the plans in part.

As a countermeasure for this, a new terminal is being already planned near Rey. The two should be scrupulously compared with each other in merit, and paying the greatest attention to the users' convenience in addition to the direction toward which Tehran is growing and the scale at which it is growing, the conclusion must be carefully drawn out.

(2) Mashhad Terminal

One of the plans conceivable from the present state of the city structure and the plans for the future is for expansion of the existing rail line station. Another is to select a new location in the northern part of the city in coordination with the plans for expressways and a new layout of city functions.

In case of expanding the existing station for use it is necessary to have freight handling facilities large enough in dealing with cargoes to increase in the future, and keeping in mind the plan for the expansion of the freight car yard, provide a well-balanced and large enough station capable of handling both the passengers and freight in a most efficient way.

In locating the station at a new place, it is necessary to consult, heart to heart, with the Mashhad principal authority in charge of city planning and then erect a station well in harmony with the city to be renewed.

(3) Rolling stock base and connecting rail lines around Tehran

To facilitate this plan, an overhaul workshop and a car depot must be installed at Tehran and in order to increase the efficiency of rolling stock turnaround, it is mostly desirarous to build a car depot also at Mashhad.

In case of locating the new Tehran Terminal in the eastern part of the city, a track to link the new line and the existing line is needed. The purpose of this is to use it as the route for the running of new electric railcars from all the existing lines to the electric railcar base. Use of it in running high-speed rail line trains for through service on to other rail lines, is also feasible.

Fig. II-6-1 Plan for New Tehran Station and City Planning Program S=1/250,000

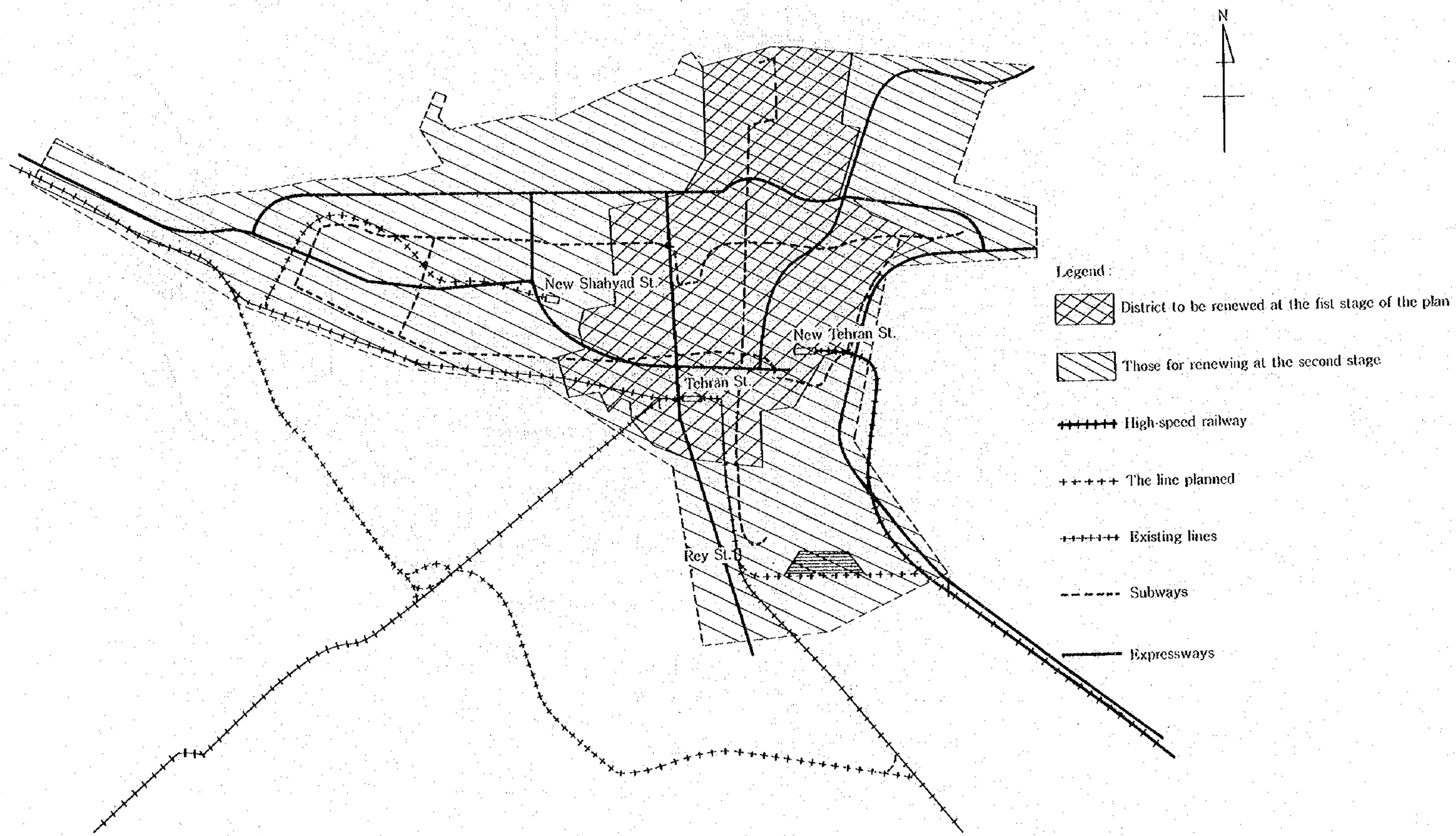
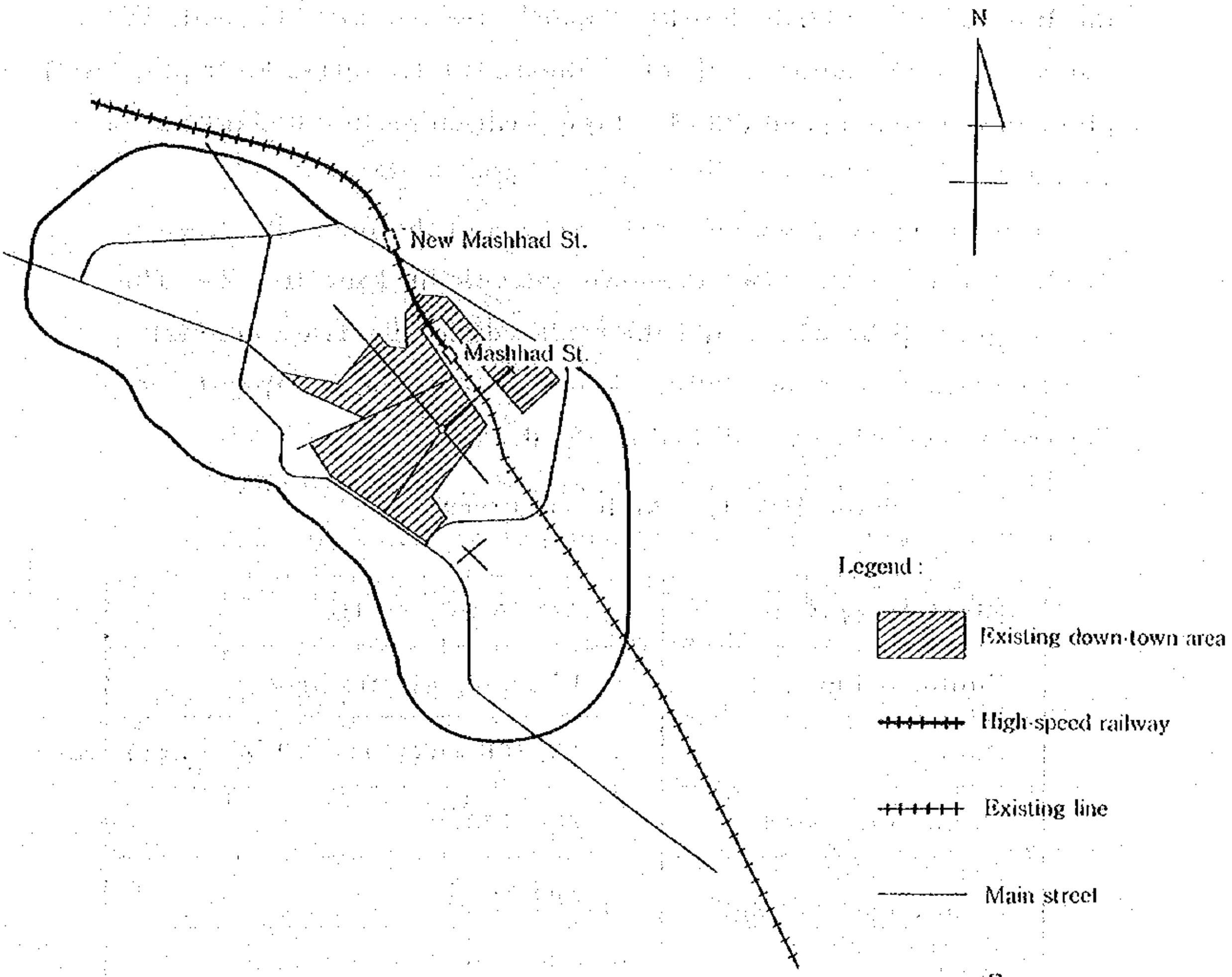


Fig. II-6-2 Plan for New Mashhad Station & City Planning Program

S=1/250,000



7. Rolling Stock

7-1. Performance and Features of Rolling Stock

Although several routes are proposed for the projected line, all have sections with continuous grade of 10 to 15 ‰ and since the line is to be operated at high speed, the output of the rolling stock will be of the same level as the EMUs (Electric Multiple Units) planned for high-speed (260 km/h) operation on the Shinkansen in Japan.

For reference, the general features of the plan are given in Table II-7-1 and the characteristic curves, in Fig. II-7-1. The car length will be 25 m, and the total weight of a train consisting of 12 cars will be about 850 t. The total passenger capacity of the train shown in Fig. II-7-2 is about 750.

Table II-7-1. Main Features

Electric system	AC 25 kV, 50 Hz
Composition	12 cars, all motored
Output	13,200 kW(1,100 kW per car)
Maximum speed	260 km/h
Rated speed (continuous rating)	205 km/h
Total weight of train	850 t
Seating capacity	About 750

7-2. Rolling Stock Gauge

The rolling stock gauge of Shinkansen train in Japan is wider than that of ISR train by 250 mm, the ordinary class car being provided with five seats in a row so as to accommodate more passengers. (Fig. II-7-3)

However, considering the fact that the UIC rolling stock gauge is adopted in ISR, seat capacity of this report is calculated based upon this standard, providing with three(3) seats in a row on first class car and four (4) seats on ordinary car.

Prior to selecting the rolling stock gauge standard -- wide one or narrow one -- careful study for increasing seat capacity is deemed necessary on following points:

(1) To what extent those projected high-speed cars are to be operated.

(2) The actual state of existing line where those cars are to be transported to the delivery point.

7-3. Matters for Consideration

(1) Sand

Sand hazards can be classified into those caused by blown sand and those by sand whirled up by train wind rapidly growing with the increase of train speed. Hence, detailed field surveys are necessary to incorporate sand hazard countermeasures in designing rolling stock.

(2) Salt

Large amount of salt is contained in the soil along the proposed routes of the projected line. Therefore technical studies must be made of salt hazards on cars, and the achievements thereof reflected on rolling stock designing.

(3) Meteorological condition

The maximum average temperature is about 10 degrees C higher than in Japan and since the altitude of the region where the projected line will pass is 1,000 to 1,500 m above sea level, the air density is thin and the humidity is low. These meteorological aspects will be duly considered when designing the electric equipment cooling systems of the cars.

Fig. II-7-1 Characteristic Curve
Composition : 12 cars (all motored)
Output : 13,200 kW

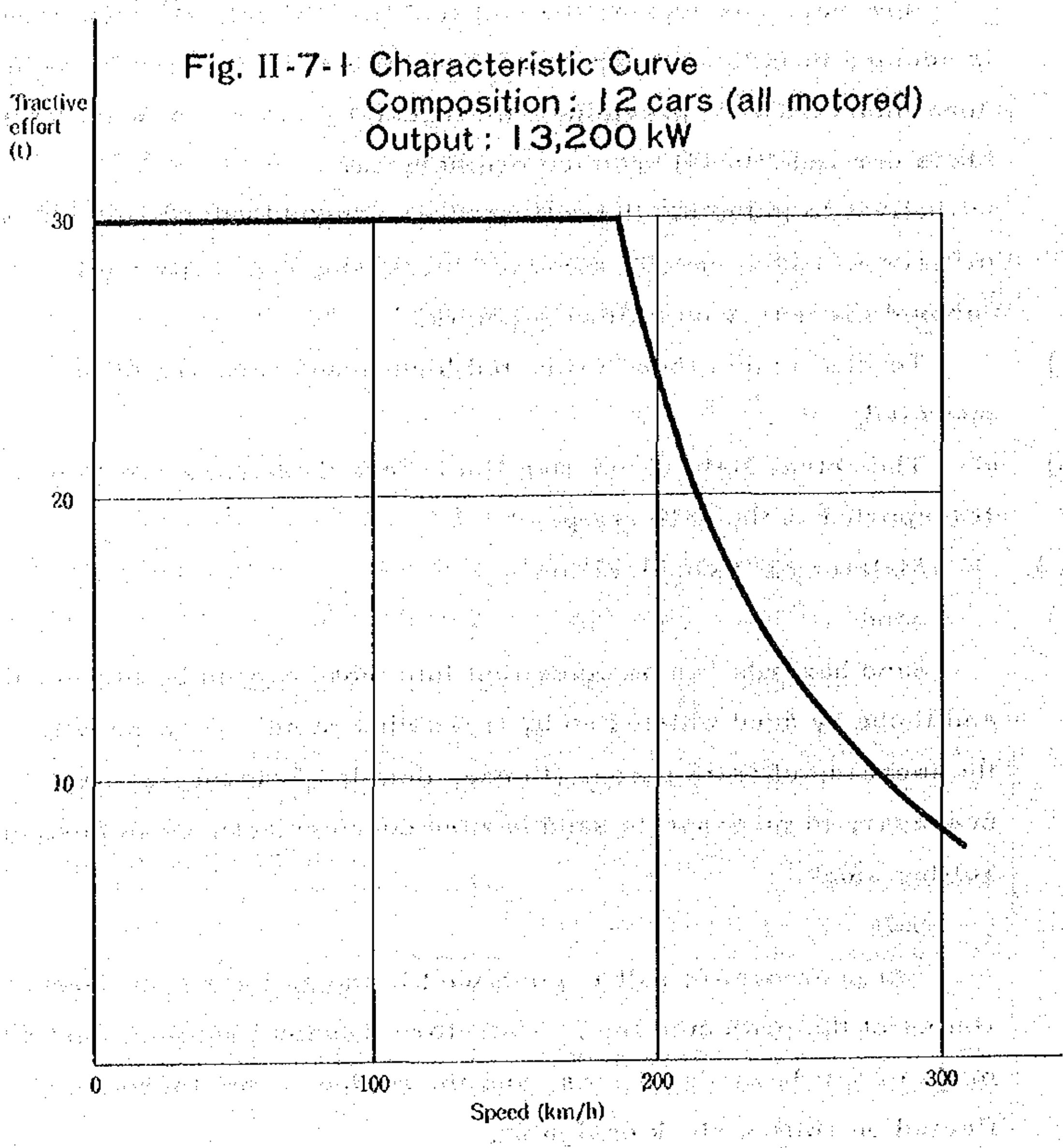


Fig. II-7-2 Side View and Layout of 12-car Train (unit : mm)

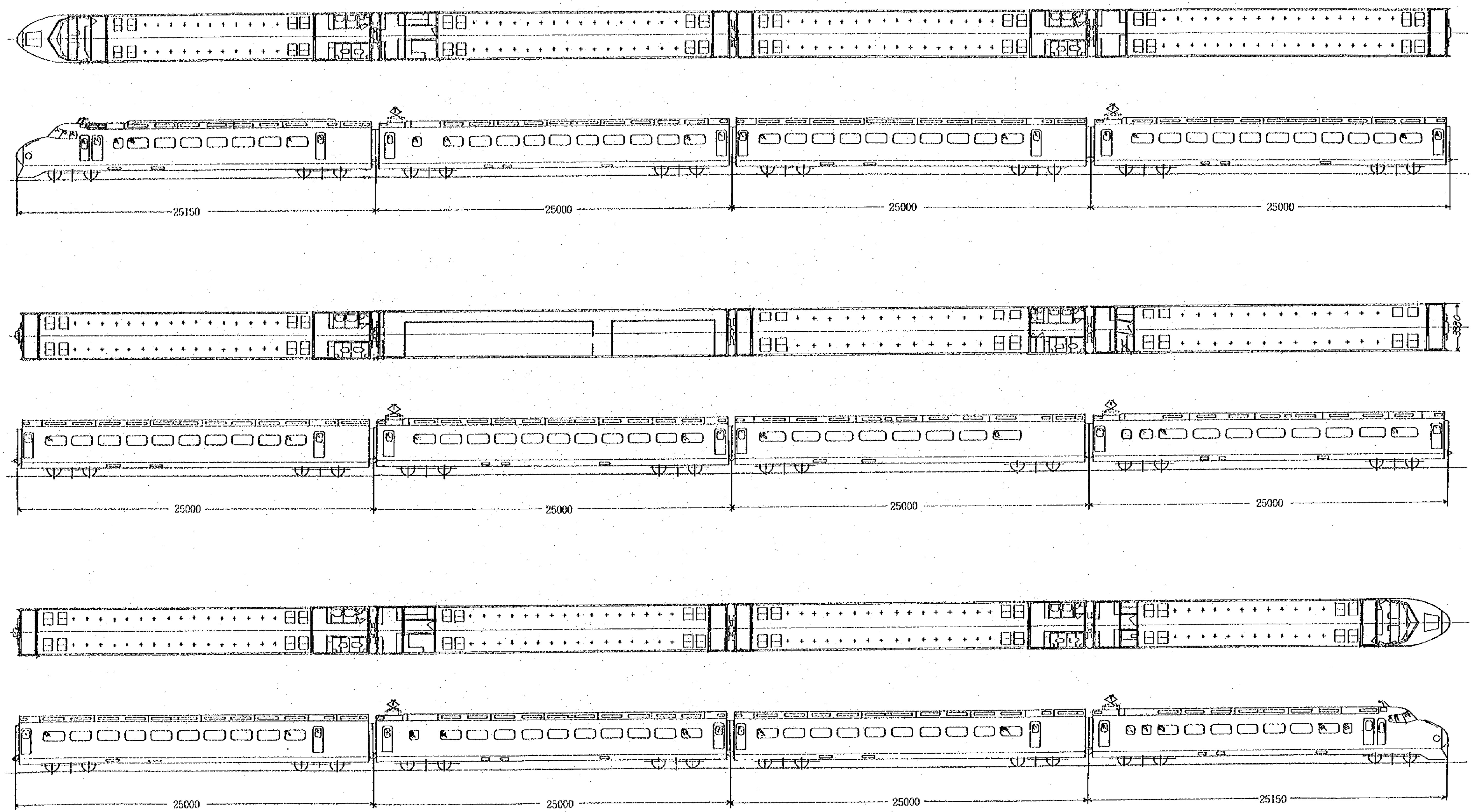
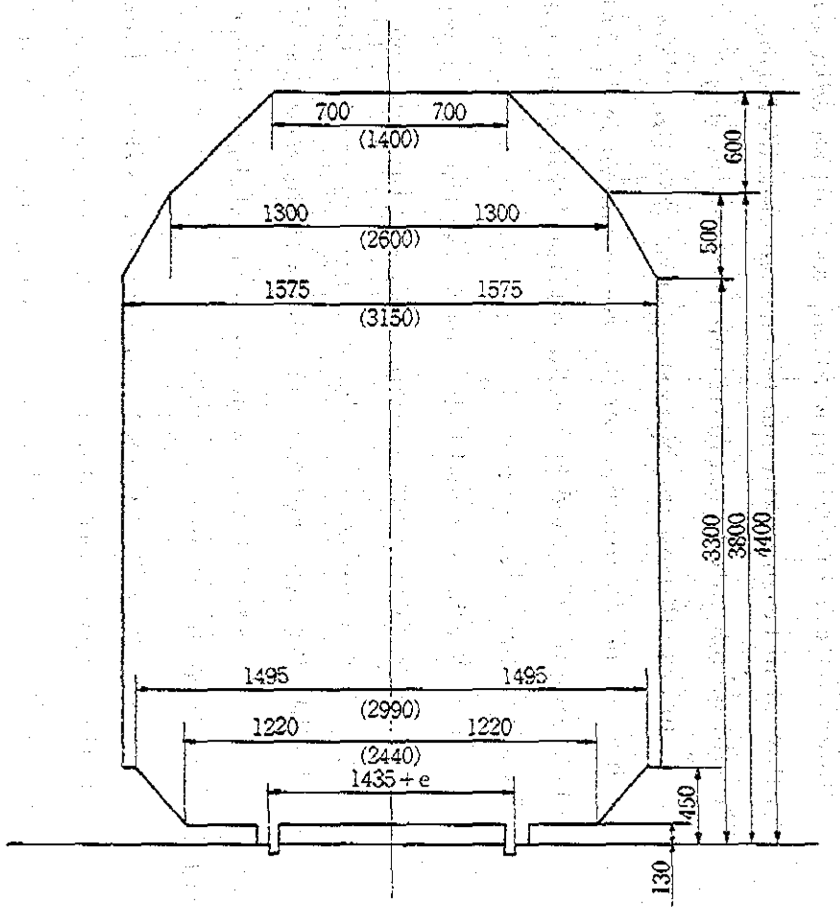
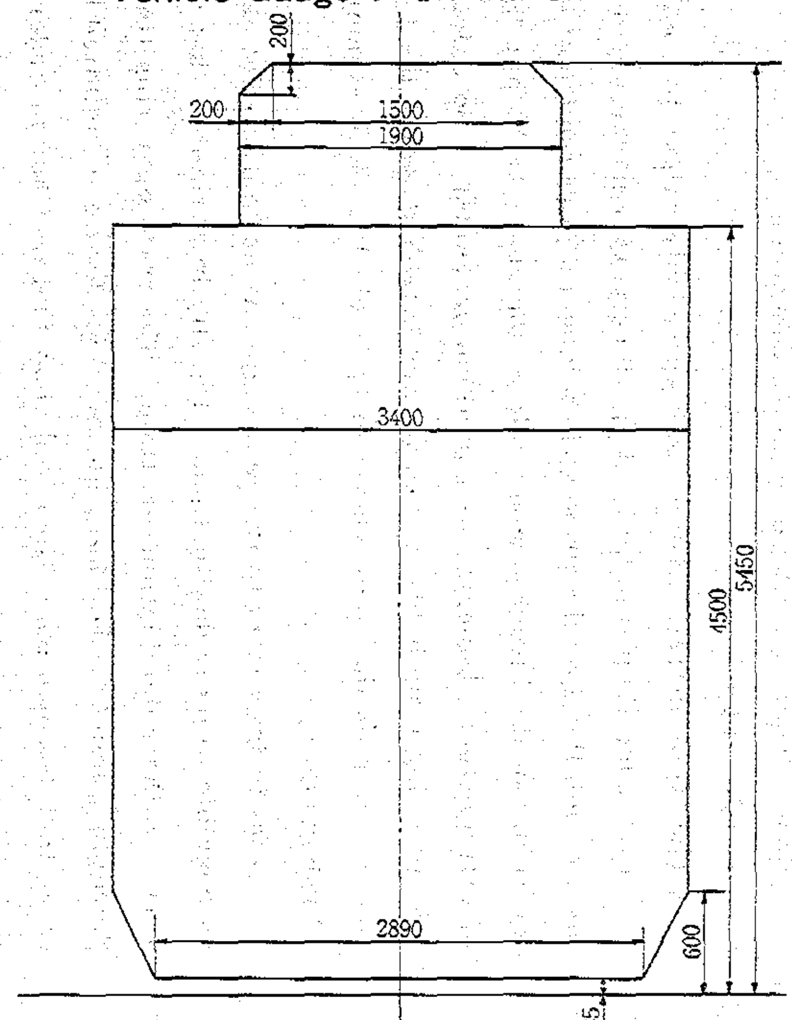


Fig. II-7-3 Vehicle Gauge

Vehicle Gauge of ISR



Vehicle Gauge of Shinkansen of JNR



8. Train Operation Plan

8-1. Basic Concept in Planning Train Operation

(1) Transit time

The train operating time can be precisely calculated only after the track conditions and the rolling stock performance are decided upon in detail. For the present it has been figured out just by using the result of the investigation made on the route-to-be and the capacity of rolling stock elements, as explained previously. So calculated, the operating time between Tehran and Mashhad, when the train is run non-stop on the route shown in 1, Table II-5-2, is 3 hours and 32 minutes.

What is important to the passengers is not only to get as quickly as possible to their destinations. Equally important is that they arrive at their destinations on time. The train operating time, therefore, must be decided with the slow-down necessitated by track maintenance operations and abnormal weather in order to ensure safety in train operation, as well as with a margin to be allowed in train operation taken into consideration, so that the trains could be operated punctually on time every day.

In calculating the operating time this time, we have set it to be 4 hours and 20 minutes on the route shown in 1, Table II-5-2 between Tehran and Mashhad in producing the train diagram, allowing enough time for two reasons:

(a) We have sought the operating time by using not very accurate track map, and, for this reason, there is the possibility of a change in the operating time.

(b) We have set the maximum train speed at 260 km/h-- a value that has never been attained so far in the world.

(2) Train make-up

The number of cars to each train, rolling stock capacity and seating capacity are decisive factors in drawing up a plan for train operation. These at the same time, are the basic factors in deciding the scales of the stations, rolling stock bases and electric and signal and other safety facilities.

Taking all together into consideration -- the target set for traffic, the seating capacity, the train frequency, the train length and the volume of electric current needed, we have set the train consist to be 12 cars to each in this plan proposed.

When the traffic increases in the future to necessitate a larger consist, improvement will have to be done then on the facilities and equipment. It is desirable, therefore, to keep this well in mind in providing facilities at the outset.

(3) Train frequency

From the target set for the traffic volume as stated before, we have estimated the train frequency needed to be as follows:

Table II-8-1. Traffic Volume & Train Frequency

	Assumption for 1982		Assumption for 1987	
	Passengers	Frequency	Passengers	Frequency
High target:				
Light-traffic season	6,251	12	9,230	18
Heavy-traffic season	15,104	26	22,295	38
Low target:				
Light-traffic season	4,871	10	7,192	14
Heavy-traffic season	11,770	20	17,372	29

Note:

(1) Both traffic and train frequency per day, one way.

(2) Seating capacity of a train set at 750 persons, the riding coefficient, 70% for light-traffic and 80% for heavy-traffic seasons.

(3) Less train frequency when wider rolling stock gauge is adopted.

(4) Train schedule time zone

The transit time of high-speed trains being so short as estimated, we have assumed all the trains to be day trains and set for the time being the first and the last trains for the day to leave and arrive at 6:30 and 21:30, respectively. This range of hours, 15 hours in this case, is called the effective time zone, and it should be definitely decided upon later after the trends of passenger movements are investigated.

(5) Intermediate stations

The proposed being a high-speed railway, it is desirable to minimize the number of intermediate stations.

As most of the users are through passengers between Tehran and Mashhad, we have considered two kinds of trains: Super express trains running non-stop and express trains stopping at every one of the stations in between Tehran and Mashhad.

Considering the number of passengers boarding at each station at present, we decided to have three stations in between for the route in 1, Table II-5-2--Semnan, Shahrud and New Sabzevar Stations. For the route in 2, Table II-5-2, to have Nishabur Station, instead of the New Sabzevar Station, and for that in 3, Table II-5-2, to stop the trains probably at Sabzevar and Nishabur.

From the number of passengers taking trains at present, we have figured out the number of express trains in 1982 to be 2 a day during the light-traffic season and 3 a day during the heavy-traffic season, and in 1987 to be 3 and 5, respectively.

The number of express trains and that of the stations to stop on the way will have to be definitely decided after further study on the trends of passenger movements at these intermediate stations.

8-2. How to Use the High-speed Rail Line & Existing Lines

The proposed high-speed rail line and the existing lines can be used in various ways as follows:

Table II-8-2. Use of High-speed & Existing Lines

	High-speed line	Existing lines
1	Double track for daylight high-speed trains for passengers	Single track for freight, mail and local passenger services
2	Single track for daylight high-speed trains for passengers	Single track for freight, mail and local passenger services
3	Double track for daylight high-speed train service for passengers For night time freight, mail and local passenger services	Close up (partly may be left as it is)

(1) In case the high-speed rail line is double-tracked

The high-speed railway is to be constructed independently from the existing line. It is for exclusive use by high-speed passenger trains and the existing lines are as at present for freight, mail and local passenger services.

Double-tracked, trains can be freely scheduled for any time zones during the day and, as trains can be operated at a high frequency, the line is capable of handling future increase in traffic. The plan thus is the desirable one in using the high-speed rail line.

(2) In case single-tracked (including partly double-tracked)

Both the high-speed and the existing lines are to be used in the same as in the preceding paragraph.

If a number of intermediate stations are set up and the trains are changed here for the use of the track as in the case of an ordinary single-track rail line, the transit time largely increases and the number of scheduleable train frequencies will be restricted.

Were a train capable of running non-stop between Tehran and Mashhad in 4 hours and 20 minutes to stop at an intermediate station to pass another, it would be delayed for 9 minutes in an average. Station facilities and operation would be costly. Besides, a high-speed rail line then would be meaningless as far as the transit time is concerned.

Other uses conceivable are to schedule west-bound trains and east-bound trains for different time zones and to partly double-track the line. (See Fig. II-8-1.)

(a) Different time zones for west-bound trains and east-bound trains

That is, schedule all the trains from Tehran to Mashhad to leave in the morning and turn all these trains back to Tehran in the afternoon after the last train from Tehran have arrived in Mashhad.

The number of scheduleable train frequencies here depends upon the effective time zone and transit time. Allowing 30 minutes for the trains passing each other at the stations and scheduling the trains at 15-minute intervals, as many as 12 trains can be put on the schedule for a day.

The trouble with this is that the number of time zones for train scheduling is restricted and hence, is not for symmetrical operation of west-bound trains and east-bound trains.

(b) In case of double-tracking at the end part of the line

If the end part of the line is double-tracked where trains can be turned around as in case of (a) above, the number of train frequencies can be increased corresponding to the length of the double-tracked. If 50% of the whole line is double-tracked, the number of scheduleable train frequencies, under the same conditions as above, will be about 21 times. For example, if the line is double-tracked between Azadvar and Mashhad, the train frequencies will be 18. (See Fig. II-8-2.)

(c) In case double track is partly laid in between the line

In case double track is laid partly on the way, west-bound and east-bound trains can be symmetrically scheduled, in the morning and in the afternoon.

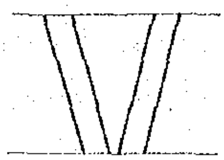
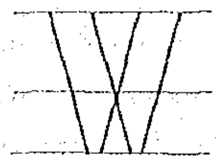
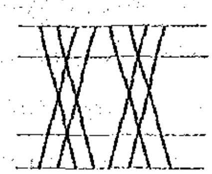
The longer the double-tracked section, the greater the range for the scheduling of trains, though there is a limit to this because of the effective time zone at the stations at the both ends of the line.

Calculated on the same conditions as mentioned before, the train frequencies when 50% of the line is double-tracked is 14 times.

With this method, the number of train frequencies for the double-tracked length is less than that in case of (b) above. Even when the double-tracked length is extended, 24 times is the limit, and the double-tracked length goes up to 79%. The time zones for train scheduling will be restricted here as in the other cases.

If the line between Semnan and Azadvar is double-tracked, the train frequency will be 12 times. (See Fig. II-8-3.)

Fig. II-8-1. Comparison between Single-track & Partly Double-tracked Operation

	Single-tracked	Partly double-tracked on one side	Partly double-tracked on the way
Diagram make-up			
Train frequency	12	21*, 18***	24**, 14*, 12****

* 50% double-tracked
** Double-tracked to a limit (79% double-tracked)
*** Double track between Azadvar and Mashhad
**** Double track between Semnan and Azadvar

Conditionally: Transit time, 4 hours and 20 minutes

Margine for cross-passing each other, 30 minutes

Effective time zone, 6:30 to 21:30

Train intervals, 15 minutes (Though it varies when express trains are put on the schedule, we set it 15 minutes in an average, assuming all the trains are super express trains for the sake of simplicity.)

Thus, if the trains are operated with single track, the transport capacity will run short in handling the traffic volume assumed. If partly double-tracked and *night trains are operated on the existing lines in addition, the transport capacity will be large enough to handle the traffic volume estimated for 1982, though not large enough, perhaps, when the traffic increases as is assumed for 1987. What is more, with all these plans the demerits lie in that the time zones for train scheduling are restricted and the effect of a train delay, once it occurs, will be considerably far-reaching.

*There is a way of operating night trains as at present, in addition during the heavy-traffic season. Conceivable is a way of operating these night trains partly on the high-speed rail line to shorten the transit time and to increase the number of trains during the heavy-traffic season for the convenience of users. (Fig. II-8-4.)

(3) In case of operating all kind of trains on the high-speed rail line

Although conceivable is the way of operating all the trains--high-speed trains, freight trains, mail and local passenger trains--on the double-tracked high-speed rail line, there are the following points to think about:

(a) The need of linking the high-speed rail line to a number of stations where freight trains, mail and local passenger trains stop, or of erecting stations for this.

(b) There being a great difference between high-speed trains and freight trains and others in speed, scheduling freight trains and others in the same time zones as for day time high-speed trains is hardly possible. Freight trains and others will have to be operated at night, but to operate through passenger and mail trains at night time is not possible. It would take the freight trains a very long time to reach their destinations, and the turnround coefficient of locomotives goes down, too.

(c) The high-speed rail line needs train intervals for track maintenance, reaching several hours a day, as it has to be carefully maintained in order to ensure safety in train operation. Operating of freight trains and others at night restricts these train intervals for track maintenance.

In order to carry on a flexible transport so as to meet the increasing demand in the future it would be necessary, as has been studied, to construct a double-tracked high-speed railway line leaving the existing line as it is for freight traffic and others.

Conceivable is the way to construct a single-tracked or a partially double-tracked high-speed railway line and operate trains not only by day but by night during heavy traffic seasons at the initial stage when traffic is light.

At any rate, it will have to be decided after the traffic volume and other conditions are studied further in detail.

8-3. Train Diagram

(1) Train diagram for the high-speed rail line

A train diagram drawn up to handle the highest target traffic assumed for 1982 and 1987 is shown as an example in Fig. II-8-5 and Fig. II-8-6. This one is for the route in 1, Table II-5-2.

(a) 20-minute interval is set as standard for super express trains.

(b) Stopping express trains at intermediate stations is scheduled in this 20-minute interval, and these trains are passed ahead at the stations. For this reason, the stations will have to be provided with the facilities needed in having a super express pass ahead an express train.
If the super express train interval is set at 30 minutes, an express train can stop at one station without having to be passed ahead by a super express train, shortening the transit time. Under the pattern of this diagram, however, every train stops at each intermediate station on the way, being passed ahead by a super express.

(c) Trains are lined up almost at equal interval. In case passengers crowd up at a certain hour, or when operation of additional trains is desired in the future, the train intervals can be shortened by about 10 minutes, if there are no express trains scheduled in between.

(d) When the trains turn around at the terminal stations, the time from arrival to departure is available for routine cleaning and getting the diners ready for service, requiring over 50 minutes, we assumed.

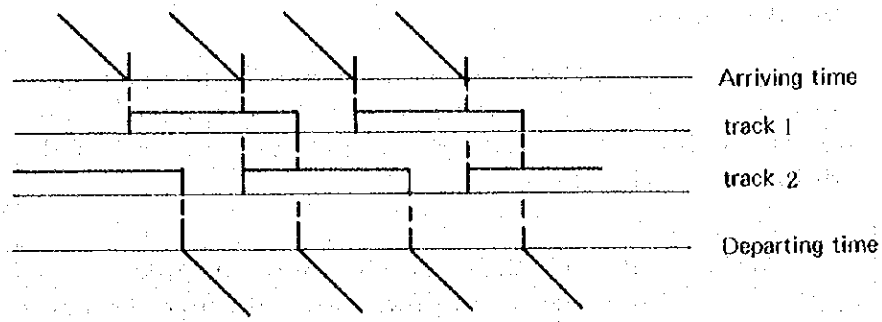
(e) It is assumed that 4 arriving and leaving tracks are needed for each of the terminal stations in order to handle the traffic assumed for 1982 and five tracks for that assumed for 1987. However, as a precautionary step against train delays and as there will arise the need of operating additional trains, 6 tracks in all are desired.

(2) Train stop for praying

No consideration is given in the train diagram mentioned above to the train stop for praying as is the train practice at present.

If such is necessary, lay two tracks to each direction for the platform of a station, so that two trains come in and leave, one after another. Then stopping for praying will be possible, though this lengthens the transit time (Fig. II-8-7)

Fig.II-8-7. Diagram Make-up for Two Arriving & Departing Tracks for Platform



Note: (Stopping time) = 2×(Train interval in minutes) − (No. of minutes allowed for the trains on same track)

That is, if the time allowed is 5 minutes for the train interval of 10 minutes, the train can stop at the station for 15 minutes.

8-4. No. of rolling stock

The number of rolling stock needed for the assumed train diagram of Figs. II-8-5 and II-8-6, as shown in the number of train units (Table II-8-3), will be as follows:

Table II-8-3. The Number of Train Units

	Assumed for 1982	Assumed for 1987
Light-traffic season*	(14)	(20)
Heavy-traffic season	28	39
Inspection and repair**	7	8
Total	35	47

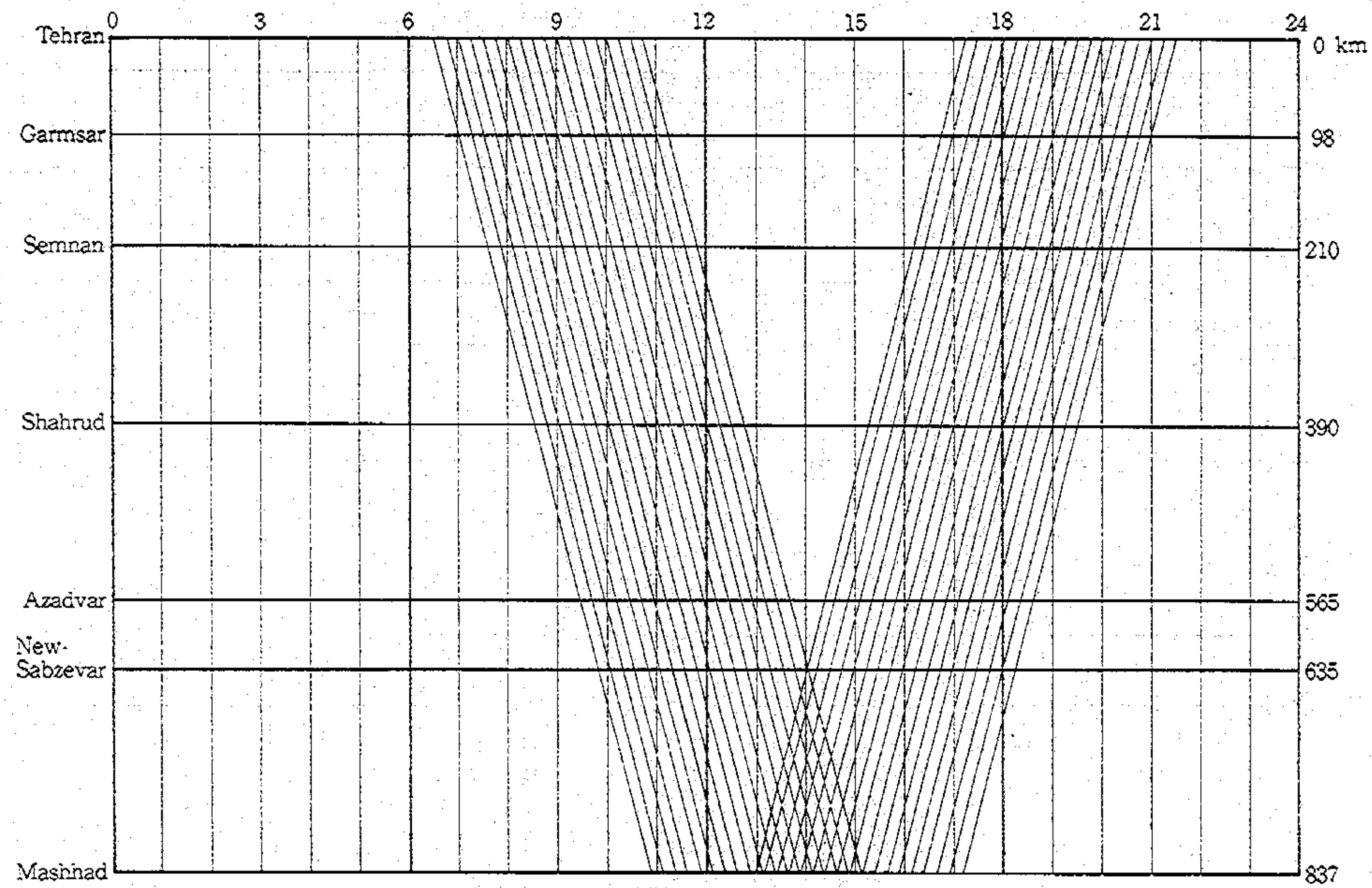
* The number of trains in parentheses for the light-traffic season is included in that for the heavy-traffic season.

** Figured out according to the inspection method adopted for the Shinkansen of JNR.

The figures for 1982 are at the time of its opening, and those for 1987 it is assumed that the inspection and repair interval thereafter will extend as much as that of the Shinkansen at present.

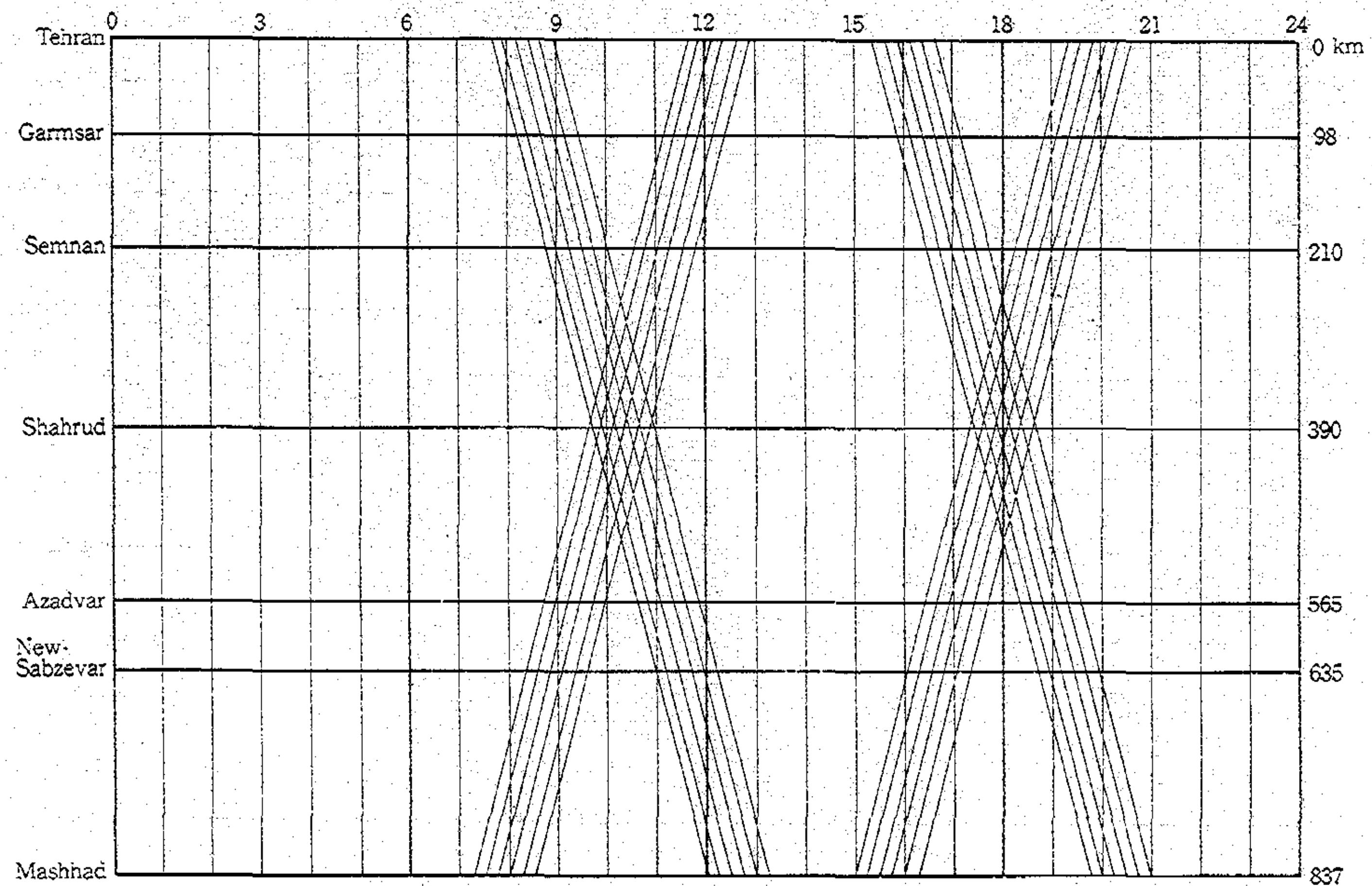
The number of train units needed depends upon the transit time, the way of making up the diagram, the turnaround time at the terminals, distribution of rolling stock, the rolling stock inspection method and other conditions. This is to be studied further in the context of the plan for the rolling stock bases.

Fig. II-8-2. Example Diagram in the Case of Double-Tracked Section Between Azadvar and Mashhad.



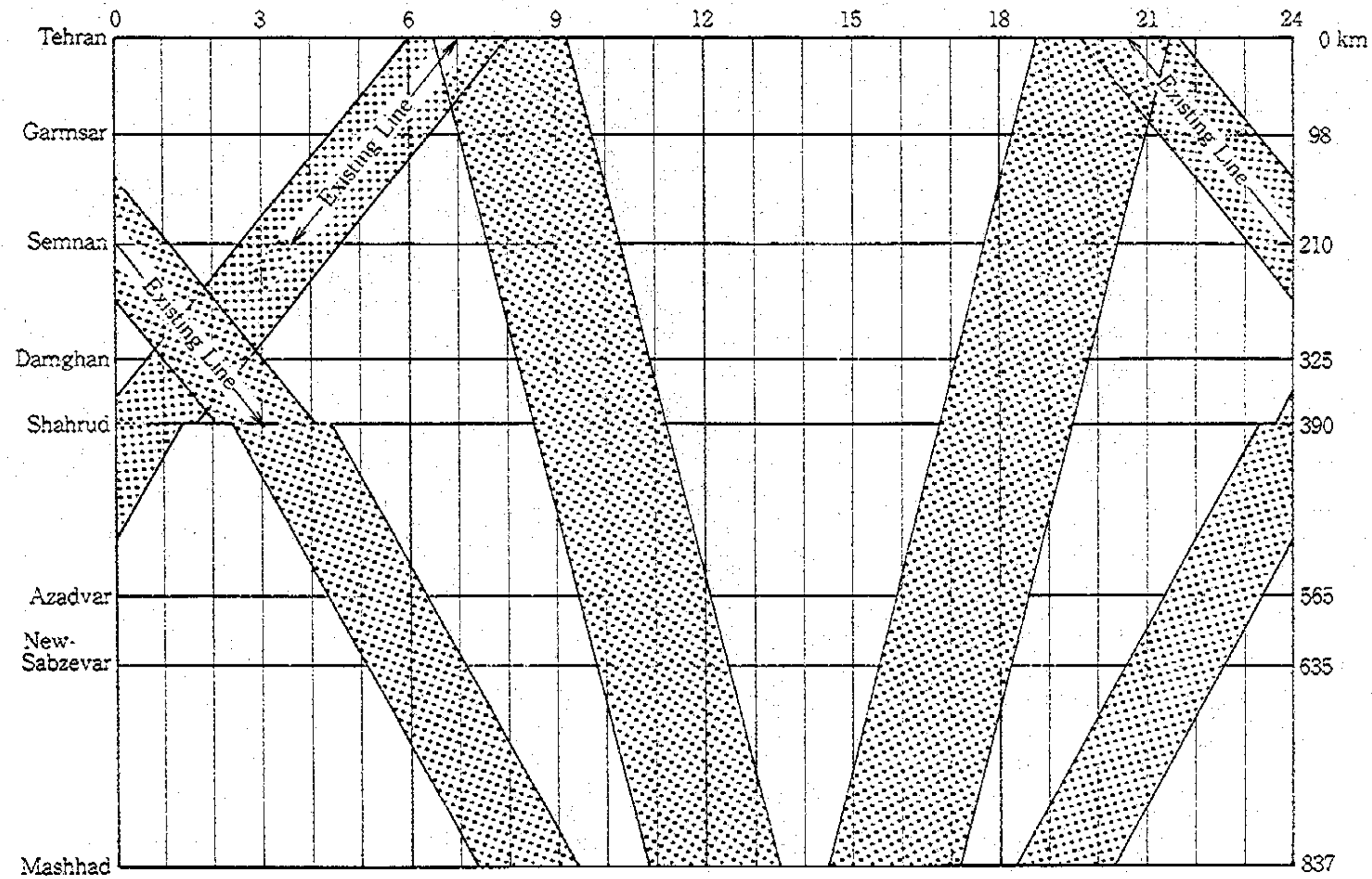
Note : 1. Effective time zone for train : 6°30′ ~ 21°30′
2. Margine time for crossing trains at Azadvar : 30 min.
3. Possibe train frequency : 18 times. (Average interval 15 min.)

Fig. II-8-3. Example Diagram in the Case of Double-Tracked Section Between Semnan and Azadvar.



Note : 1. Effective time zone for train : 6°30~21°30'
2. Margine time for crossing trains at Semnan and Azadvar : 30 min.
3. Possible train frequency : 12 times. (Average interval 15 min.)

Fig. II-8-4. Example Diagram in the Case of Joint Use of Single-tracked High-Speed Line and Existing Line Between Tehran and Shahrud for Night Trains



Conditions : 1. Single track automatic signalling between Tehran and Shahrud required
2. Connecting facilities between High-Speed Line and Existing Line at Shahrud and Semnan required
3. Night trains required to use the present Tehran station with track strengthened
4. Trains between Shahrud and Mashhad required to be hauled by Electric Locomotives

Problematic Point : Time for the track maintenance of High-Speed Line

Fig. II-8-5 Train Diagram on High Speed Line (Tehran-Mashhad)

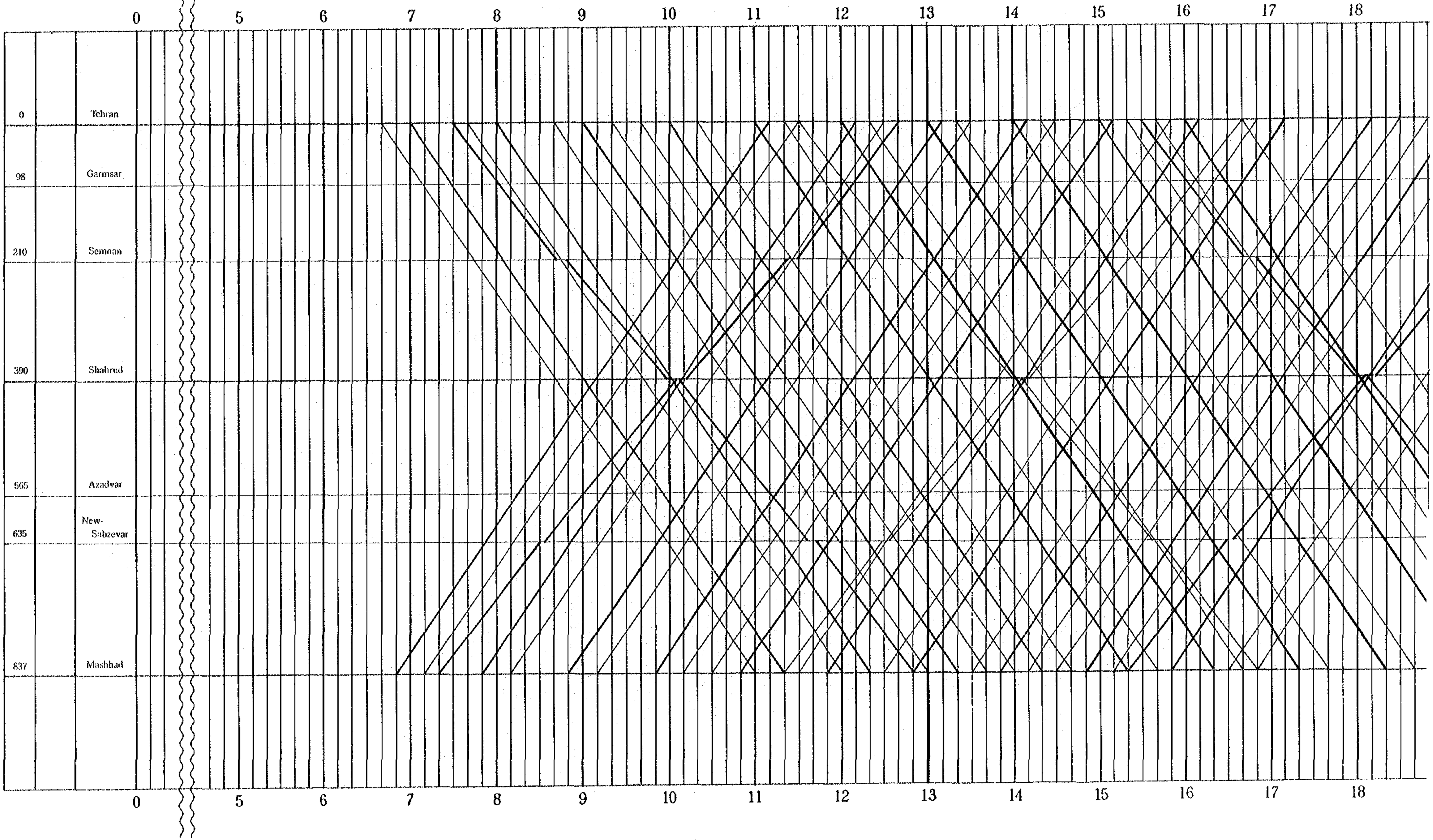


Fig. II-8-5 Train Diagram on High Speed Line (Tehran-Mashhad)

(Assumed for 1982)

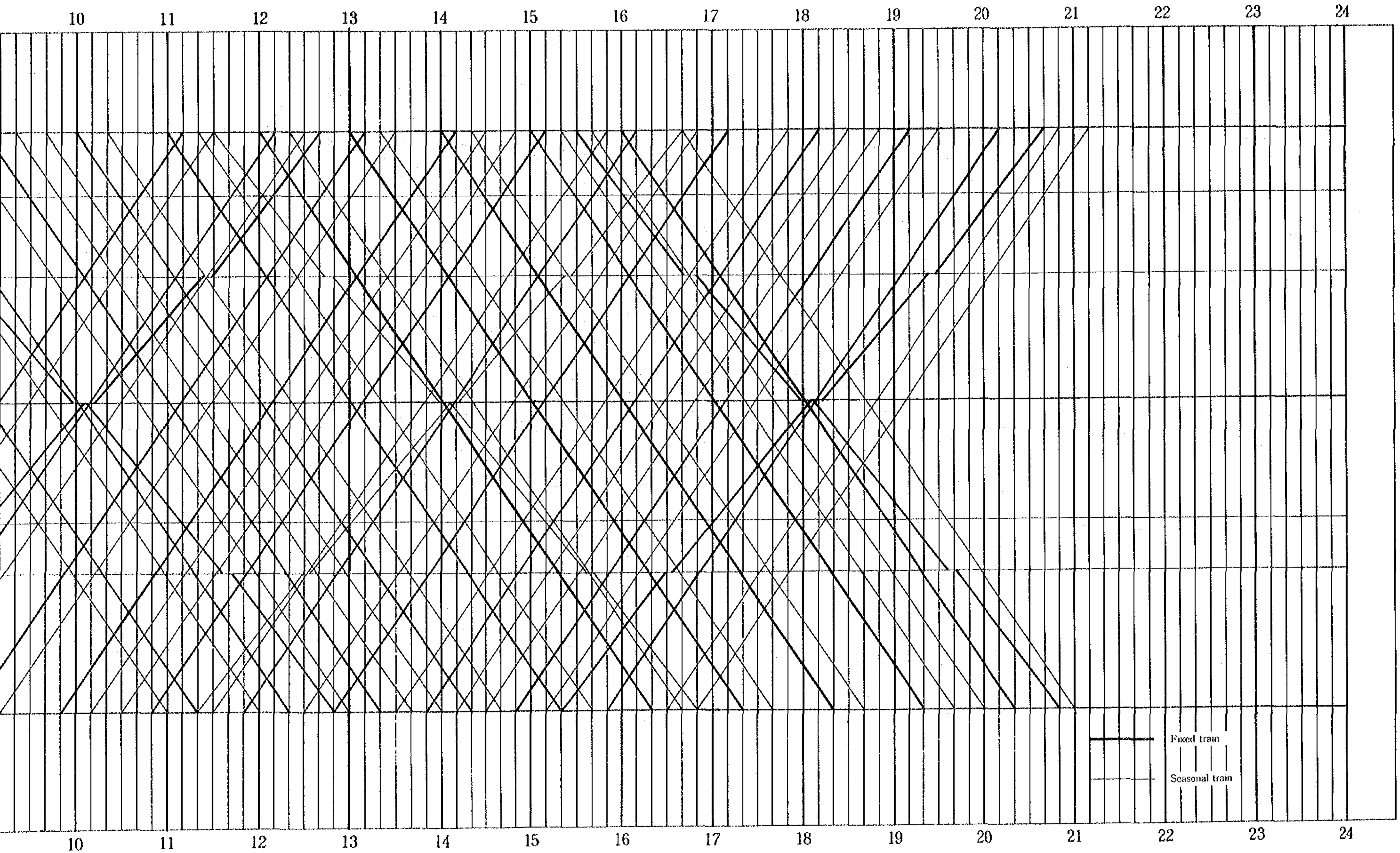


Fig. II-8-6 Train Diagram on High Speed Line (Tehran-Mashhad)

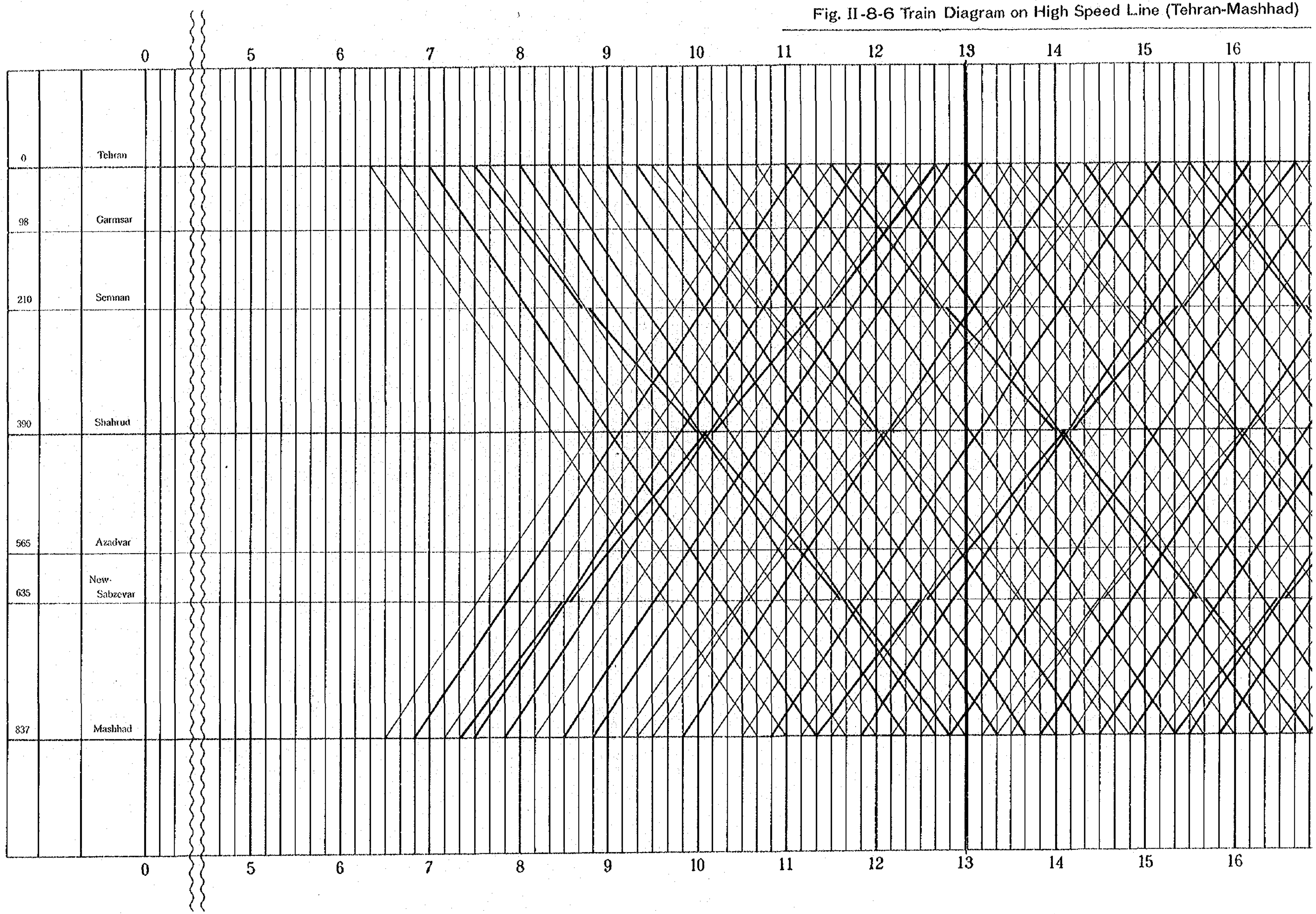
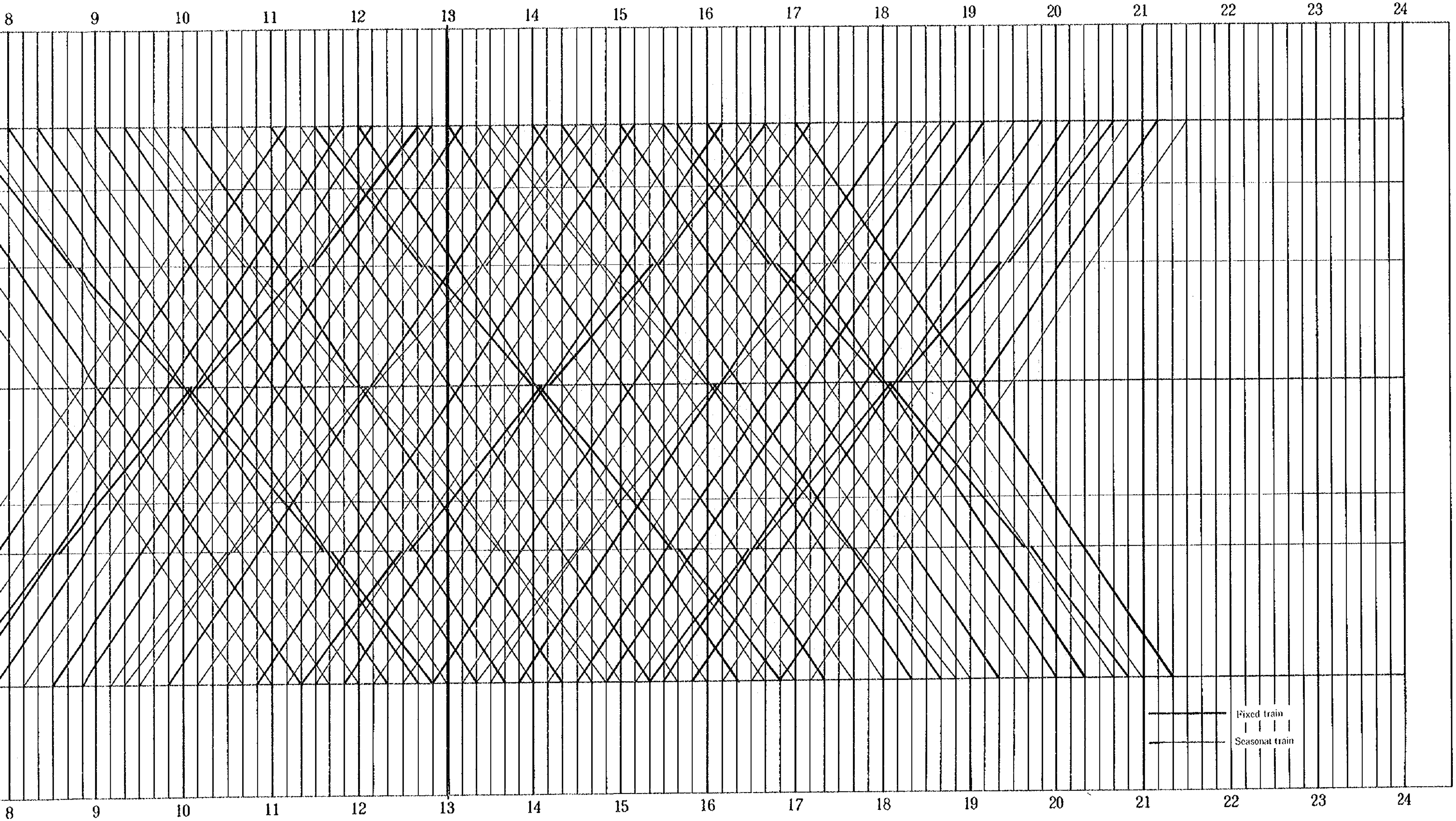


Fig. II-8-6 Train Diagram on High Speed Line (Tehran-Mashhad)

(Assumed for 1987)



9. Track

Track structures should be so designed as to be capable of 260 km/h high-speed operation and also to save labour force for maintenance.

Main Features

Rail	60 kg per metre
Sleeper	PC
Ballast	Crashed stones
Fastening device	Double elastic (Tie pad and spring clip used)

It is conceivable to adopt the Long-Welded-Rails, however further field study is necessary to definitely decide on their designs.

It will be decided to make measures to prevent sand from getting into the track after careful field surveys.

10. Electric Power Supply

10-1. Power Source Requirements

(1) Conditions of power supply

If electric railcars, the main features of which are shown in Table II-7-1, are used for high-speed operation, a 12-car train will require maximum power of about 25,000 kVA (single phase) with continuous fluctuations.

To assure reliable high-speed train operation, high quality power must be supplied, meeting the following requirements:

(a) The capacity of power source must be sufficiently large to withstand the electric traction load.

(b) The frequency fluctuation and voltage fluctuation of power source due to fluctuation of traction load must be within a permissible value to prevent ill effects on general consumers.

(c) Power must be supplied from highly reliable electrical facilities designed duly considering meteorological conditions to assure reliable high-speed railway transportation.

(2) Distribution of substations and power source requirements

If electric railcars given in 7. Rolling Stock are used and the train diagram in 8. Operation Planning is adopted, the distances between substations required will be 60 to 80 km, provided that AT feeding system mentioned elsewhere will be introduced.
The one-hour maximum power is 20-30 MW, and to make allowable value of the instant voltage fluctuation less than 3% with this load, short-circuit capacity should be 1,300 MW or more at the power receiving point, as shown in Table II-10-1.

Table II-10-1.

Item \ Year	1982 - 1987
One-hour maximum power (MW)	20* - 33**
Short-circuit capacity (MVA)	1,300 or more

Note: *Required for the transport capacity during the heavy-traffic season in 1982, and **for that in 1987, as estimated and shown in (e), (2), 2-2, 2 Target for Traffic to carry, when the distance between substations is 80 km.

10-2. Power Supply

According to the information received of long term projects for power development in Iran, the future plans for the power network along the high-speed railway between Tehran and Mashhad are as follows:

In the regions of about 400 km between Tehran and Shahrud and about 100 km between Mashhad and Quchan, power source network comprising super high-voltage transmission lines (230 kV) will be built from the power plants in the Tehran and Mashhad areas.

As for the 400 km between Tehran and Shahrud and 100 km between Mashhad and Quchan (Routes A-1, B, C-1 and D-1 given in 5. Routes Considered), power can be possibly taken from the projected power network.

However, there seems to be no large scale power development project in the 350 km Shahrud — New Quchan section. In such case the following two proposals can be envisaged:

(a) To build a power transmission line along the high-speed railway and link together the Tehran source and Mashhad source.

(b) To build a new power plant with high-speed railway being its principal load.

Selecting one of these two proposals should be made from a comprehensive viewpoint taking into account various aspects, including the future power demands.

10-3. Electrification System

AC electrification at 25 kV 50 Hz will be adopted as outlined in the following:

(1) Feeding system

AT feeding system which has been proved satisfactory at high-speed operation in Japan is recommended. (See Appendix II-10-1.)

This system possesses the following features:

(a) The feeding voltage can be raised to more than twice the contact wire-rail voltage and therefore the substation interval (distance) can be lengthened. Moreover, this system is suited for large capacity power supply.

(b) Since the current flowing in the rail is decreased, inductive interference to weaken current circuits such as the telecommunication lines can be mitigated, and also the rise of rail potential suppressed.

Having these features, this system is considered most suited for high-speed railways.

(2) Feeding circuits

The standard feeding circuit is shown in Fig. II-10-1. Feeding transformers are installed in substations to transform the voltage and supply trains with single-phase electric power. To maintain power balance of the source side, the upbound line and the down bound line are fed with current of different phase at the substation. For this purpose, sections are set up at substations and sectioning posts in the midway between substations. Since the contact lines with current of different phase confront each other at the sectioning post, automatic power changeover sections suited for high-speed operation are required at the sectioning post.

In selecting overhead contact system with high-speed performance of 260 km/h, meteorological conditions should be duly considered.

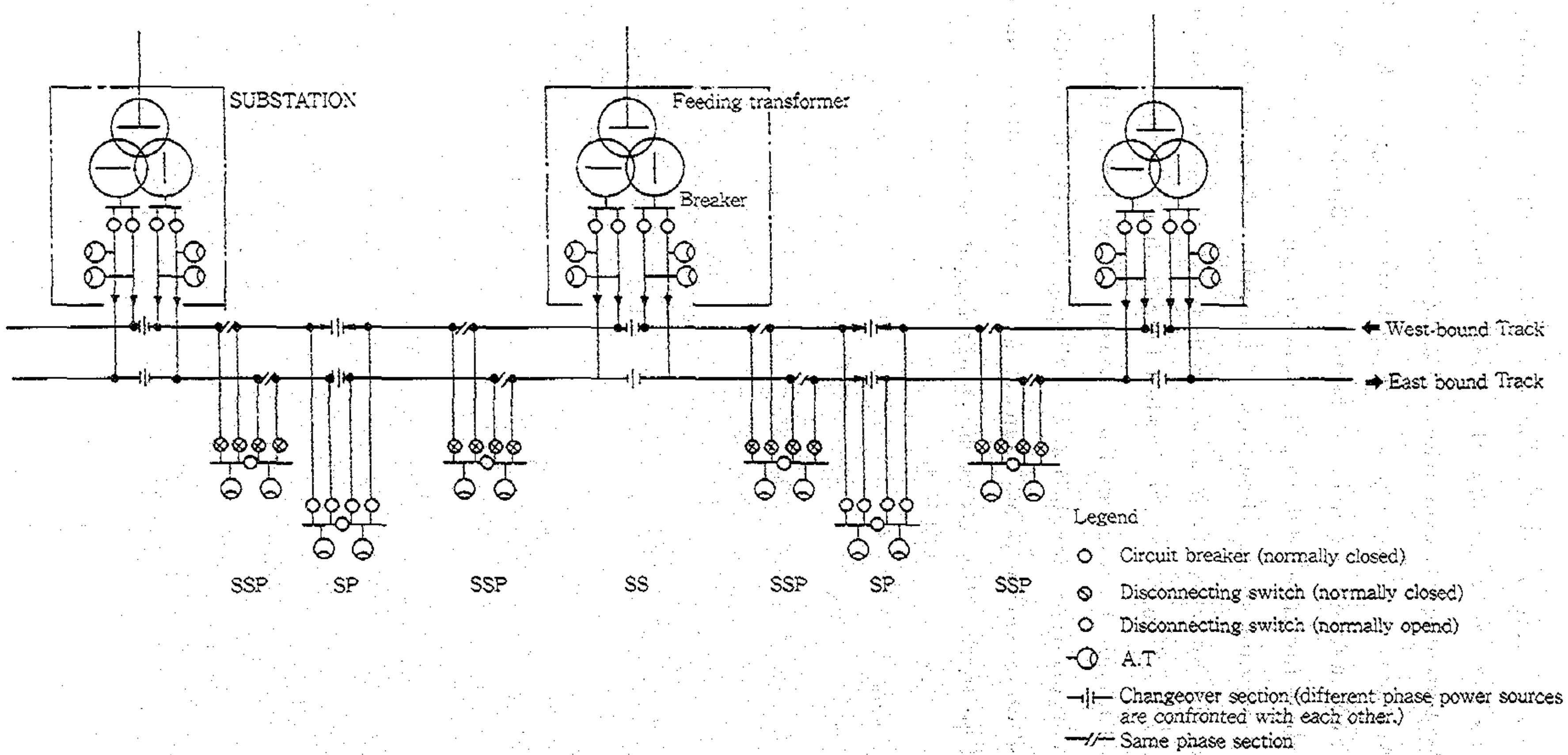
10-4. Meteorological Conditions Considered

As there are numerous rock salt areas along the Mashhad Line, countermeasures are necessary to prevent insulation breakdown of electrical facilities due to salt sandstorms.

According to the showings of simplified measurements performed during the survey, the equivalent quantity of salt was in the range of 0.03 to 0.21 mg/cm^2, somewhat larger than in Japan.

Although it seems that no measure have been taken in particular for protecting the insulation of existing electrical facilities, long period observation is necessary, so that the results of the observations could be fully reflected in the designing of insulation.

Fig. II-10-1 General Diagram of Feeding System



11. Train Control and Information Transmission

11-1. Train Control

(1) Safety requirements for high-speed operation

When operating trains at high speeds and with high frequence such as in the case of the proposed train schedule, the train speed is very much higher than in the conventional railway, and it is difficult to ensure safety by resorting to only the attentiveness of the motorman.

Required, therefore, for ensuring the safety of high-speed train operation are, among others, the functions

(a) To detect the location of trains

(b) To indicate the permissive train speed to the motorman by transmitting the speed signal into his cab

(c) To apply the brake to the train automatically when the train speed exceeds the permissive speed

(d) To set, lock or open routes in station yards without failure

(e) To efficiently and remotely control the operation of the group of trains that are operated at high speed and with high frequency

For the above functions, the automatic train control system (ATC), interlocking device, and centralized traffic control system (CTC) are necessary to provide.

(2) ATC

Under the ATC system the operation of trains are controled in the following way:

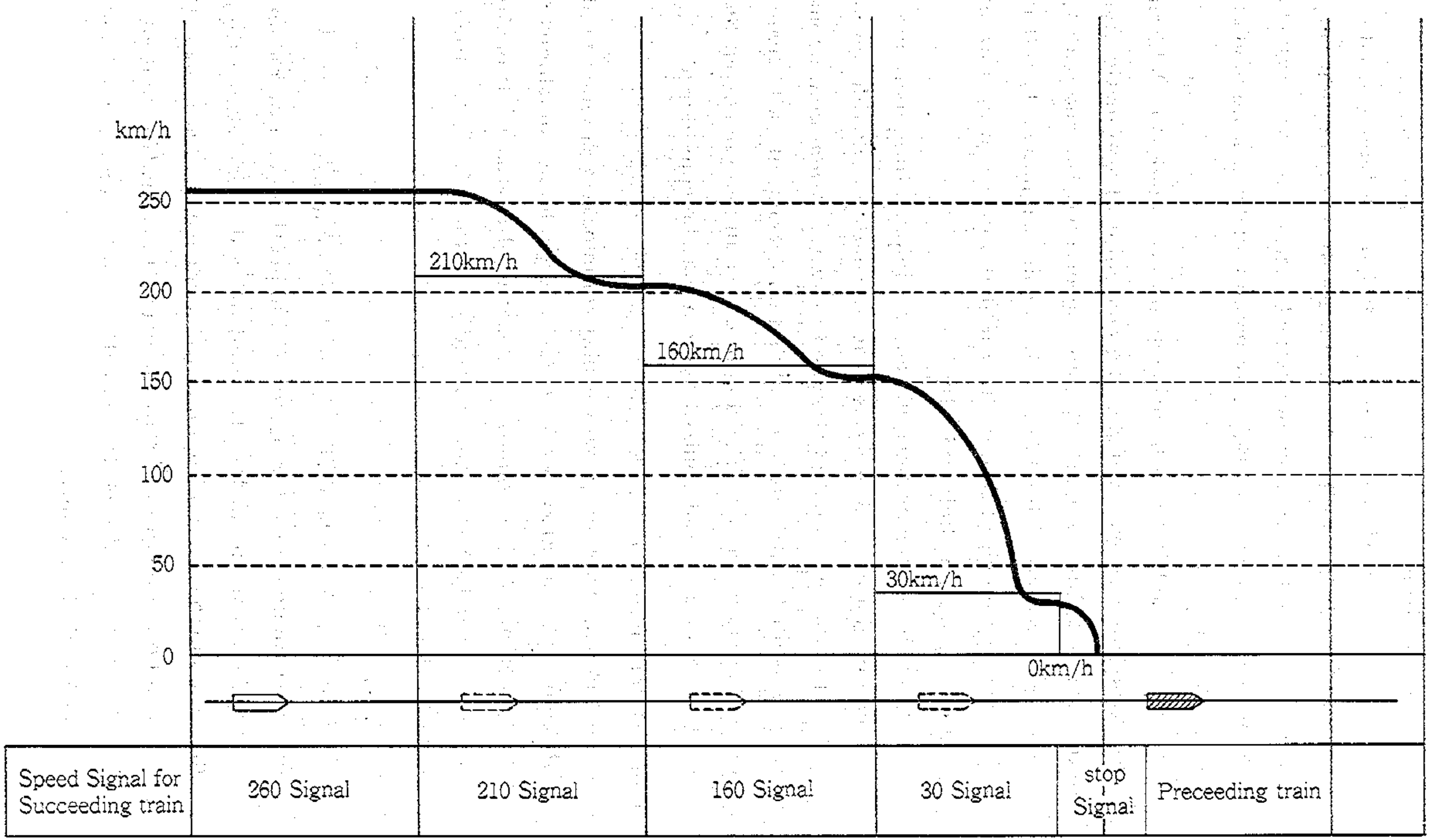
By detecting the location of a train and the one following and according to the number of blocking sections between them, the maximum permissive speed is specified for each of them. This speed is transmitted and indicated as a signal on the speed control panel installed in the motorman's cab.

When the train speed exceeds the permissive speed thus indicated the brake will automatically work. Then, when the train slows down below the permissive speed, the brake will automatically be released for the train to continue to operate.

By adopting this system the safety and efficiency of train operation can be improved as compared with automatic block system using wayside signal.

A run-curve between intermediate stations under the ATC system is as shown in Fig. II-11-1.

Fig. II-11-1 Run Curve by ATC Operation Between Stations



(3) Track circuit

Under the ATC system the speed signal is transmitted from the wayside device to the train without failure. For this purpose various methods have been developed and in use -- a method of using track circuits, a method of using treadles, a method of using wayside coils.

The method of using track circuits is not only for detecting the location of trains as under the conventional automatic signalling system but for transmitting the speed signal to the trains. By use of this method fail-safe requirements can be easily fulfilled. A secondary merit of this method is that a crack in or a break of rail can be detected electrically.

Capable of transmitting necessary information, reliable and economic, the method of using track circuits is considered most suited for the projected high-speed railway. When continuous track circuit is difficult to construct on account of salt, train operation under the combination of check-in and check-out block system and ATC point control system may be considered.

(4) Interlocking device

It is necessary to provide relay interlocking devices in all station yards and also to install electric switching machines at the turnouts. With automatic route control device additionally installed a route can be automatically set for a train to stop at or pass by the station.

(5) CTC

The effects of the CTC expected are as follows:

(a) Dispatching work for heavy traffic sections can be modernized, and dispatching orders transmitted with more reliability.
(b) The number of station employees engaged in train operation can be cut down thanks to the centralized traffic control.
(c) The working of wayside facilities can be surpervised and controlled remotely.

11-2 Information Transmission

(1) Information for high-speed train operation

Basic information transmission systems required for high-speed train operation are:

a. Communications to promote safety and efficiency of train operations:

Dispatching telephone (for dispatching orders from the control center to stations and to trains in operation), straight call telephone between stations, wayside telephone, anemometer and rainfall meter

CTC and CSC (Centralized Substation Control) channels (for transmitting data to control the working of the wayside facilities)

b. Communications for improvement of passenger service:

Information indicator and announcing device in station, exchange telephone, and public telephone on train

c. Communications for maintenance, control and utilization of installations:

Wayside telephone, straight call telephone for exclusive use (maintenance of way and electric power, signalling and telecommunication facilities), radio telephone for maintenance, exchange telephone, and teletypewriter

(2) Composition of information transmission lines

The composition of various kinds of transmission lines such as those of short distance for communicating with a nearby station from wayside and those of middle and long distance for communication between stations and also between station and CTC center are shown in Table II-11-1.

Table II-11-1 Composition of Communication Lines

Composition method	Short distance	Middle distance	Long distance
1	Physical line	Cable carrier	SHF (OH)*
2	Physical line	Coaxial carrier	Coaxial carrier
3	Physical line	SHF	SHF

Note: * Over the horizon SHF

For this project, 120 to 150 circuits will be apparently necessary. Channel such as those used in CTC and CSC and those for dispatching telephone are required to be stable and highly reliable.

From the viewpoint that room for additional channel should be provided to cope with the future increase of information volume, the composition method 2 or 3 shown in Table II-11-1 may be considered preferable. The composition of information transmission line however, should be decided on in accordance with the number of stations, operation and maintenance systems and organizational setup.

To provide against telecommunication interruption by chance of accident or work a minimum number of channel necessary must be secured by forming detour routes utilizing SHF, etc. As a means, SHF network of PTT may be available, or ISR can build its own SHF system.

(3) Train radio

To operate trains not only at high speeds and with high frequency but on lines where the distance between stations is long and CTC is adopted, train radio is necessary for the train dispatcher and crew to communicate at any point on the line for transmitting instruction and exchanging information and also for the train dispatcher to call up any particular train or all trains operating within his jurisdiction.

Frequency bands such as VHF and UHF can be used, and from the viewpoint of simplified facilities and easy maintenance, VHF requiring less unmber of radio base stations is advisable. In electric wave dead zones as in tunnels and in cuttings, special measures must be taken such as introduction of leakage coaxial cables.

By utilizing train radio facilities the following services can be provided:

(a) Public telephone service for communication between train passengers and PTT subscribers

(b) Communication between service motor car and field office

(c) Calling of personnel working along the railway line by radio pocket bells at times of emergency.

In the case of radio system, especially train radio system, the frequency band and the number of the electric waves to be used should be tentatively determined upon deciding on the functions of the system and then finalized upon consulting with other organs concerned and making necessary adjustments so that the waves can be used throughout the entire line between Tehran and Mashhad without being interferred by other radio stations.

11-3 Computer System

Computers are desirable for efficient train control and ticket sales or seat reservation. Suggested to adopt are the following computerized systems:

(a) Traffic Control System

This is a system whereby the computer, in lieu of the train dispatcher processes such dispatching work as route setting, supervision of train operation, car utilization planning and at times of train diagram disruption, promptly presentation of necessary data to the dispatcher for making traffic adjustments. Modernization of train dispatching work and promotion of safety are expected by this system.

(b) Seat Reservation System

This system is envisaged to handle a great number of seats expected with completion of the projected high-speed railway. It will not only control the sales of seats of each train, accept and process reservations but issue tickets or reserve seats.

Speedy sales of tickets and rationalized control of empty seats can be expected by this system.

The above systems should be adopted taking into account the management organization and system as well as the traffic policy of the new line projected.

11-4 Natural Condition and Other Matters for Consideration

A considerable number of salt domes were seen along the Mashhad Line. Salt concentration in the soil was measured by a simplified method.

At a spot about 10 cm under the ground surface where salt eduction was seen, the ratio of salt to soil neared 10 % in terms of weight ratio. This value is larger by two to three digits than that of normal soil in Japan.

It is believed that blown sand containing such large amount of salt will seriously affect the track circuit in some sections. Therefore, it is deemed necessary to conduct long term tests throughout wet and dry seasons to clarify the variations in track circuit leakage current according to the amount of blown sand (soil) and its piling condition. If necessary, the track structure will have to be changed.

Furthermore, tests must be carried out on earth resistance attainable in desert.

12. Consideration for Safety Operation on High-speed Railway

In order to secure the safety of high-speed operation of 260 Km/h, attentions must be provided much more than that for the ordinary one.

(1) As being described in paragraph of II-1-1, for train operation control, it is necessary to minimize as much as possible the attentivity and judge required for those to handle operational work and also to provide the system of fail-safe device.

(2) Being a high-speed operation, any obstacles on railway track will result the serious accident. It is therefore necessary to provide the separated crossing structure in order to avoid any natures to entering into the railway track and also necessary to establish the legal restrictions by Law to protect of such.

(3) Considerations must be made to construct structures as to avoid as much as possible for arising accident caused through disasters of Wind, Water-flood and Earthquake.

In adition, provisions are necessary stop trains detecting such occurance.

III. *How to Carry On Engineering Work*

1. Basic Items in Planning

The following are the matters considere as basic items in carrying on the engineering work hereafter. On these matters views must be exchange with the officials of the Iranian Government so as to fully reflect their designs in carrying out the work. When necessity arises as investigations progress, or when new technical achievements are attained, the basic items then will be modifieds as required.

1-1. Traffic Target

The target of passenger traffic on the high-speed railway-to-be on its opening (about 1982) is set at 11, 800 - 15, 100 passengers a day during the heavy-traffic season. Consideration will be given to the increasing traffic thereafter.

1-2. Maximum speed

It is to be 260 km/h for the time being. Facilities will be provided with consideration given to future speed-up expected with technical advance.

1-3. Policy in Selecting the Route

The minimum radius of curvature is to be over 4, 000 m, except at special spots of the line, and the steepest grade less than $15^{o}/oo$. Consideration will be given to prevention of disasters, as well as to the shortening of the route kilometerage and to the overcoming difficulty in work execution.

1-4. Terminals and Stations

The terminals at Tehran and Mashhad will be decided upon in coordination with the city planning projects in these cities, as well as in consideration of the passengers' conventence.

The in-between stations will be three: Semnan, Shahrud, and New Sabzevar (a transfer station for Sabzevar and Nisharhur)

1-5. Rolling Stock

The rolling stock is to be electric mutiple unit car type with motors mounted on all axles.

1-6. Usage of High-speed and Existing Lines

The high-speed line is to be double track for passenger train operation and the existing line for the operation of freight trains, mail trains and ordinary passenger trains, as well as night passenger trains, if needed. The high-speed line might be operated as a single-track line in its initial period to meet the traffic demand expected. However a further study will have to be made on the traffic in future.

1-7. Train Operating Plan

The high-speed electric railcar trains will be made up with 12 cars to each, most of the trains operated non-stop and some stopping at the three stations in between. The traveling time of the non-stop trains is set at 4 hours and 20 minutes in planning for the line.

1-8. Power Supply

Electification system is to be AC 25 KV, 50 Hz. AT system is to be adopted for power supply. The power sources will be strengthened to supply enough power.

1-9. Train Control

ATC (Automatic Train Control), CTC (Centralized Traffic Control) systems and train radio are to be provided for high-speed train operation.

1-10. Consideration for Natural Environmental Conditions

Using the experience gained and the latest achievements, attained in Japan, and making technical studies on the natural environmental conditions in Iran, a high speed railway, highly reliable and safe, will be constructed.

2. Main Points in Brief of Engineering Projects at Various Stages

2-1. Drawing up of the Master Plan

With a map drawn in a reduced scale, one to 50, 000, 20 m in contour, and other necessary data obtained, field surveying will be conducted. Boring and other field tests will be undertaken. Views will be exchanged with the Iranian Government authorities, city planners, power companies and other organs concerned, as needs arise, and further technical studies will be made to produce the master plan.

In the master plan the composition of main facilities and various standards for the facilities will be shown. The functions these are to perform, in other words, the transport capacity of the line aimed at will be made clear at the same time. Rough quantities of works to be undertaken, the budget for the works and construction period also will be shown. The plan then will be definitely decided upon with approvel by the Iranian Government authorities.

2-2. Design and Preparation of Papers Necessary for Contracts

The scale of the whole work being so large and the technical descriptions so diversified and high in level, the work will be executed over a considerably long time. In making contracts there are two ways: one is the bulk contracting over a long period, covering many aspects of work, and the other is contract, section by section, covering each aspect of work to be performed. Each method has its own merits and demerits.

In view of the very features of this plan, it seems desirable to study the second contracting method, using each of the contractors' unique technical capabilities to start the work earlier. In so doing, the work design is to be prepared to fit in with each contract to be given.

2-3. Supervision Over Work Execution

The works and the technical descriptions of equipment manufacturing so diversified as they are, and there being close technical connections among them, special weight is to be put on the managing of the work process. Especially when contracts are divided section to section in executing work, the supervisor must see to it that the work of each contractor well coordinated with each other and that the responsibility of each contractor is well defined.

2-4. Preparations for the Opening the Line: Training of Men for Operation and Maintenance

No less important than work execution itself is to have an enough number of men well trained by the time the line is to be opened. The plans for employing and training of men must be drawn up and implemented well in advance.

(1) The most effective way to secure experienced technical staff is to have those who have already acquired high technical education participate in the planning and designing of the works from the beginning.

(2) Desirable is to have those men who are to engage in maintenance of facilities take part in some of work execution, such as on track and electric facilities, so that they could be better trained, learning much from doing the actual work-in-field.

(3) Recommended is that a part of the line be completed two or three years before the opening as a test line, so that test runs could be conducted over a considerably long time and the durability of the facilities and rolling stock in the natural environment could be well ascertained. The men to be engaged in operation and a maintenance could receive actual field training, as well.

3. *Steps to be Taken in Drawing Up Master Plan*

Numerous and diversified are the matters to be investigated and studied. But the procedure in the main is as shown in Fig. III-3-1.

To be undertaken earliest above all are the following:

(1) Upon obtaining detailed topographical map, drawn at a reduced scale, one to 50,000, 20 m in contour, undergo paper location of route based on data obtained from the field survey and geological studies.

Further, to select the course for aerial photographic survey to complete topographical map for detail designing.

(2) Long-term testing of items conceived in relation to natural environment.

(a) Wind blown sands:

To ascertain the actual effects on cars and apparatuses in operation and obtain technical data needed in improving the track structure and rolling stock equipment to counter the effects.

(b) Salt:

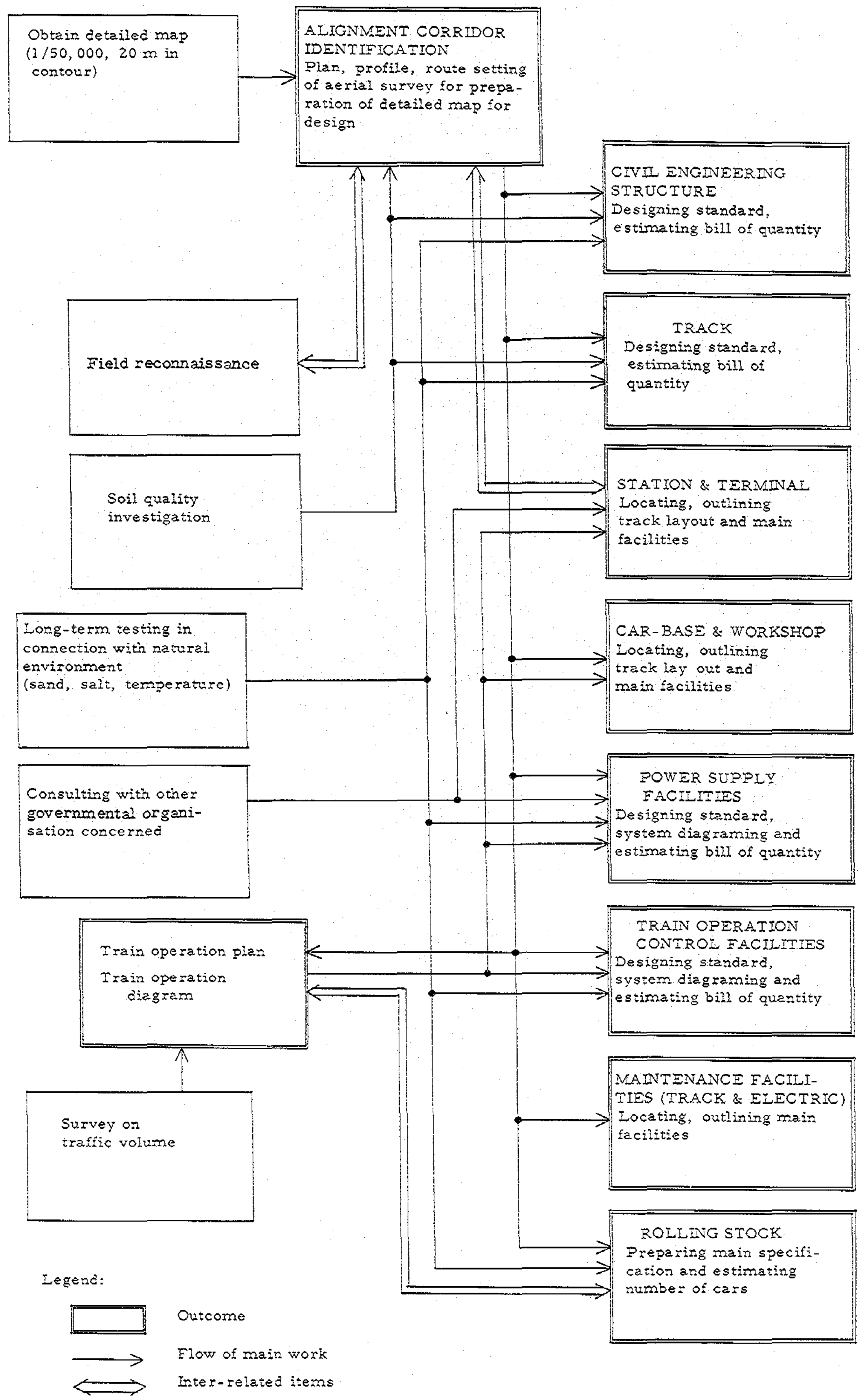
To probe into the effects of salt, such as track circuit leakage, and the electric insulation of the rolling stock equipment and power supply facilities. If necessary, gather technical data needed in producing countermeasures to be applied on the mechanism of track insulation, track circuit composition and rolling stock and over head equipments.

(3) Consultation with City Planners and Electric Power Suppliers

In drawing up the master plan, consulation with those parties concerned must be carried on as promptly as possible for coordination of this plan with the plans they have. It also is necessary to have the main points of this project reflected in their plans at the same time.

Fig. III-3-1

ENGINEERING WORK FOR FORMING MASTER PLAN



APPENDIX

Appendix: I-1

Railway Technical Cooperation from Japan

1. February - March, 1969
   Survey for the Trans-Asian Railway Network as requested by ECAFE

2. February - March, 1969
   Survey for the Construction of Marshalling Yard of the Iranian State Railways

3. October - November, 1970
   Survey for Raising Train Speeds between Tehran and Mashhad

4. February - March, 1974
   Survey for the Railway Modernization Centering of Southern Line

5. September - October, 1974
   Survey for the Double Tracking and Electrification of Southern Line

6. December, 1974
   Survey for the Route Selection for Double Tracking of Mountainous section of Southern Line

7. January - February, 1975
   Participation in the Evaluation Panel for Proposals in Modernization of Southern Line

Appendix: I-2

Itinerary of Survey Team

18 May 1975	Advanced team, Mr. Kure and 1 other arrived Tehran.
19 May 1975	Visited H. E. Vice-Minister, Mr. Pakdaman, Ministry of Roads & Transportation to discuss survey team schedule.
21 May 1975	Discussion made on schedule for survey team with H. E. Dr. Mussavian, Vice-Minister & General Manager of ISR, Mr. Choobinch, Director of Khorasan Division.
22 May 1975	Discussion made on obtaining necessary map with Mr. Mansori, Director General of Construction, Ministry of Roads and Transportation.
23 May 1975	Main group of survey team of 14 members headed by Dr. Takiyama arrived Tehran.
24 May 1975	All survey team members accompanied by H. E. Mr. IKAWA, Ambassador of Japan to Iran (1st Secretary, Mr. Kiriku also attended) paid courtesy visit to H. E. Mr. Shahrestani, Minister of Roads & Transportation Discussion made on basic item of survey. (H. E. Vice-Minister & General Manager of ISR, Director General of Construction, Ministry of Roads & Transportation and Director of Khorasan Division ISR attended)
25 May 1975	Discussion made on detail schedule of survey and data & references required
26 May 1975	Dr. Takiyama and 3 other members observed Tehran station yard.
27 May 1975	All team members left Tehran for overall survey tour by regular TURBO-TRAIN from Tehran toward Mashhad.

28 May 1975	Team observed the city of Mashhad area.
29 - 30 May 1975	Team left Mashhad for field reconnaisance by inspection train arranged by ISR (Mashhad-Tehran)
31 May 1975	Dr. Takiyama and 3 other members made aerial survey by flight (Teheran-Mashhad) At Mashhad, Visited Municipal office to explore city-planning
1 June 1975	Dr. Takiyama and 3 other members observed the city of Tehran and its vicinity.
2 June 1975	Dr. Takiyama and 3 other members, accompanied by H. E. Ambassador of Japan to Iran visited H. E. Minister of Roads Transportation to exchange views on project. All team members attended the party hosted by H. E. Minister of Roads & Transportation. (At Guest room of Tehran station)
3 June 1975	Courtesy visit to the Grave of Late King Shaha Reza. Dr. Takiyama and 4 other members left Tehran for Tokyo
4 - 7 June 1975	Mr. Enomoto and 6 other members left Tehran for field reconnaisance tour. (by special train and automobiles arranged by ISR)
4 - 6 June 1975	Sub-leader, Mr. Hirota and 4 other members observed railway facilities of Tehran district.
8 - 10 June 1975	Sub-leader, Mr. Hirota joined field-reconnaisance group sections between Shahrud and Mashhad.

	Remained other members at Tehran visited T.B.T. P.B.O. & other organs for study.
10 June 1975	Reconnaisance group led by Mr. Hirota, the Sub-leader studied over electric power state of Khorasan district.
	Mr. Magario and 4 other members observed facility of Mashhad station yard.
	Advisor, Mr. Uchimura left Tehran for Tokyo.
11 June 1975	Reconnaisance group of 8 members returned to Tehran by TURBO TRAIN completing the survey.
11 - 19 June 1975	Members are assigned individually for various study-works: (1) To obtain necessary data & materials on bus riding. (2) To visit I.S.R. P.B.O. M.O. INTO etc for collection of data
18 June 1975	Sub-leader, Mr. Hirota and 2 other members paid courtesy visit to H.E. Dr. Mussavian, Vice-Minister & General Manager of ISR prior to leave IRAN
20 June 1975	Left Tehran for Tokyo.

Appendix: I-3

Minute Note

Basic line for carry out the Tehran-Mashhad High Speed Railway Construction Project set out at the meeting held between H. E. Mr. Shahrestani, Minister of Roads and Transportation, the Imperial Government of Iran, and the Japanese Survey Team headed by Dr. Takiyama on 24th May 1975.

(1) Explanation made by H. E. Mr. Shahrestani, the Minister of Roads & Transportation, on the basic line for the project:

Our careful attentions shall be paid to His Imperial Majesty Shahanshah Aryamehr's prominent intention that the transportation system to be newly materialized between Tehran and Mashhad shall be of the most modernized and highest technical level.

Furthermore, this project shall be completed at the earliest time possible, though, as a matter of course, accuracy is the prerequisite for this project. It is expected that the project will be materialized at least before the other big-scale railway projects are finalized.

(2) Technical Matters

Opinion on technical matters for the project were mainly exchanged between H. E. Dr. Musavian, Vice-Minister of Roads and Transportation cum President of Iranian State Railways, and Dr. M. Takiyama, Leader of the Japanese Survey Team.

(a) The Ministry of Roads & Transportation will inform the Japanese Survey Team of the target of transportation capacity for Tehran-Mashhad New Line as well as its back data for review and study by the Japanese Survey Team.

(b) The route for the New Line shall be carefully selected so that the railway will have a larger radius for high speed operation. The highest operation possible, at least a speed in a range of 250-260 km/hr, is expected to be realized for this New Line.

(c) Locations of the terminal and other stations for the New Line shall be selected taking into consideration of expected transportation volume and city plans along the new railway line area as well. Taking into account the fact that most of passengers will move directly from and to Tehran-Mashhad, a number of stations for the New Line will be kept at the required minimum.

(d) New power plants will be constructed in accordance with the requirement of electric power supply for the New Line.

(e) Careful and sufficient study shall be made on the natural environment especially the effects (adverse) of sandstorm against the high speed operation required.

(f) Training for skilled operators and staff will be of vital importance for operation and maintenance of the New Line.

(3) Future Survey

(a) The Japanese Survey Team now staying in Iran has been dispatched to make the preliminary survey and play a role of data collection and fact findings for the main team to be sent in near future. The team will arrange data and findings in Japan and inform the Ministry of the results with back data later. The expenses for the survey have been borne by the Japanese Government up to now, but these for future activities will be borne by the Imperial Government of Iran.
Government of Iran.

(b) Mr. Choobineh, Director General of Korasan Division, acts as responsible person in this survey.

(c) The Ministry will cooperate with the Japanese Survey Team in field inspection necessary for the survey such as transportation etc., collection of data, topographical maps, air photos and so forth, and in exchanging opinions with the officials at the Ministry, and will bear all the costs and expenses for railway services for the survey.

Appendix II-2-1: Passenger Traffic, National Total & on Mashhad Line

Item \ FY	1964	1967	1970	1973
National Total:				
No. of persons carried (in 1,000)	3,614 (100)	2,808	3,731	4,198 (116)
Passenger km (in 1,000)	1,352,576 (100)	1,179,432	1,800,021	2,188,677 (162)
Passenger revenue (in 1,000 rials)	629,001 (100)	575,529	823,522	1,089,125 (173)
Mashhad Line:				
No. of persons carried (in 1,000)				
Northeast Region	171	155	224	242
Kohrasan Region	373	333	640	693
Total	544 (100)	488	864	935 (172)
Passenger km (in 1,000)				
Northeast Region	42,298	42,441	72,587	100,053
Kohrasan Region	251,442	257,327	495,899	558,121
Total	293,740 (100)	299,768	568,486	658,174 (224)
Passenger revenue (in 1,000 rial)				
Northeast Region	17,343	17,280	26,964	37,066
Kohrasan Region	105,441	115,694	223,647	281,147
Total	122,784 (100)	132,974	250,611	318,213 (259)

Note: The figures in parentheses represent indexes.

Appendix II-2-2: Freight Traffic Volume, National Total & on Mashhad Line

Item \ FY	1964	1967	1970	1973
National Total:				
Tonnage hauled (in 1,000 t)	3,600 (100)	3,545	4,267	7,549 (210)
Ton-km (in 1,000)	2,121,698 (100)	1,938,491	2,330,488	4,388,323 (207)
Freight revenue (in 1,000 rials)	2,596,308 (100)	2,175,008	2,807,883	5,344,777 (206)
Mashhad Line:				
Tonnage hauled (in 1,000 t)				
Northeast Region	64	92	38	111
Kohrasan Region	25	59	148	99
Total	89 (100)	151	186	210 (236)
Ton-km (in 1,000)				
Northeast Region	48,780	120,922	195,113	191,764
Kohrasan Region	37,964	62,879	102,137	107,862
Total	86,744 (100)	183,801	297,250	299,626 (345)
Freight revenue (in 1,000 rials)				
Northeast Region	29,223	31,675	16,136	47,589
Kohrasan Region	34,116	57,194	69,656	50,473
Total	63,339 (100)	88,869	85,792	98,062 (155)

Note: The figures in parentheses represent indexes.

Appendix II-2-3: Running Km of Passenger & Freight Cars by Year

Item \ FY	1964	1967	1970	1973
National Total:				
Passenger car km (in 1,000)	4,209 (100)	4,335	4,710	4,844 (115)
Freight car km (in 1,000)	6,535 (100)	6,294	7,192	12,741 (195)
Mashhad Line:				
Passenger car km (in 1,000)				
Northeast Region	451	540	900	903
Kohrasan Region	410	381	668	641
Total	861 (100)	921	1,568	1,544 (179)
Freight car km (in 1,000)				
Northeast Region	254	477	367	609
Kohrasan Region	220	265	375	387
Total	474 (100)	742	742	996 (210)

Note: The figures in parentheses represent indexes.

Appendix II-2-4: No. of Passengers Using Various Modes of Transport (Users departing from Mashhad, per day average)

Form of transport / Year	Railway	Bus	Airplane	Private motorcar	Total
1971	1,383 (28.7)	2,895 (60.1)	137 (2.8)	406 (8.4)	4,821 (100.0)
1972	1,656 (29.1)	3,399 (59.8)	155 (2.7)	478 (8.4)	5,688 (100.0)
1973	1,558 (22.6)	4,560 (66.0)	180 (2.6)	603 (8.8)	6,901 (100.0)
1974	1,581 (20.4)	5,229 (67.5)	254 (3.3)	683 (8.8)	7,747 (100.0)
1974/1971	114	181	186	168	168

Note: 1. Half of the users of buses and private motorcars assumed to those leaving for Tehran way.

2. The figures in parentheses indicate percentages.

Appendix II-2-5: Seasonal Fluctuations in the Number of Persons Using Various Modes of Transport (Travelers leaving from Mashhad, per day average)

- 1974 -

Season / Form of transport	Spring (3/21-6/20)	Summer (6/21-9/20)	Autumn (9/21-12/20)	Winter (12/21-3/20)	Total
Railway	1,218 (77)	2,445 (155)	1,336 (85)	1,304 (82)	1,581 (100)
Bus	4,642 (89)	6,976 (133)	5,301 (101)	3,942 (75)	5,229 (100)
Airplane	160 (63)	317 (125)	283 (111)	256 (101)	254 (100)
Private motorcar	592 (87)	920 (135)	679 (129)	525 (77)	683 (100)
Total	6,612 (85)	10,658 (138)	7,599 (98)	6,027 (78)	7,747 (100)

Note: 1. Half of the travelers by bus and private motorcar calculated.

2. The figures in parentheses indicate indexes taking the yearly average as 100.

Appendix II-2-6: No. of Persons Using Trains and Buses by Month
(No. of travelers leaving Mashhad in 1974)

	Railway		Bus	
	Users	Monthly fluc-tuations	Users	Monthly fluc-tuations
3/21 - 4/20	52,470	109	345,021	108
4/21 - 5/20	26,156	54	239,529	75
5/21 - 6/20	34,686	72	278,808	88
6/21 - 7/20	67,876	141	379,516	119
7/21 - 8/20	82,407	171	447,227	141
8/21 - 9/20	77,061	160	470,813	148
9/21 - 10/20	41,123	86	244,893	77
10/21 - 11/20	41,675	87	381,635	120
11/21 - 12/20	37,464	78	327,625	103
12/21 - 1/20	37,035	77	230,137	72
1/21 - 2/20	32,970	69	211,788	67
2/21 - 3/20	46,010	96	259,697	82
Total for the year (Monthly average for the above)	576,933 (48,078)	(100)	3,816,689 (318,049)	(100)

Note: 1. Monthly fluctuations indicate indexes taking the monthly average value for the year as 100.

2. The number of bus users is given as it is obtained in our study.

Appendix II-2-7: Transporting Conditions on Mashhad Line & Other Modes of Transport

	Fare (in rials)			Traveling time required	Service frequency (per day, one way)
	1st class	2nd class	3rd class		
Railway					
Turbo	1,750	1,450	-	9 hrs.	1
Express	1,205 - 1,020	650	-	15	1 (6)
Ordinary	-	560	375	17.5	1
Bus	300 - 480			18	100 (over 200)
Airplane	3,000			1.1	3

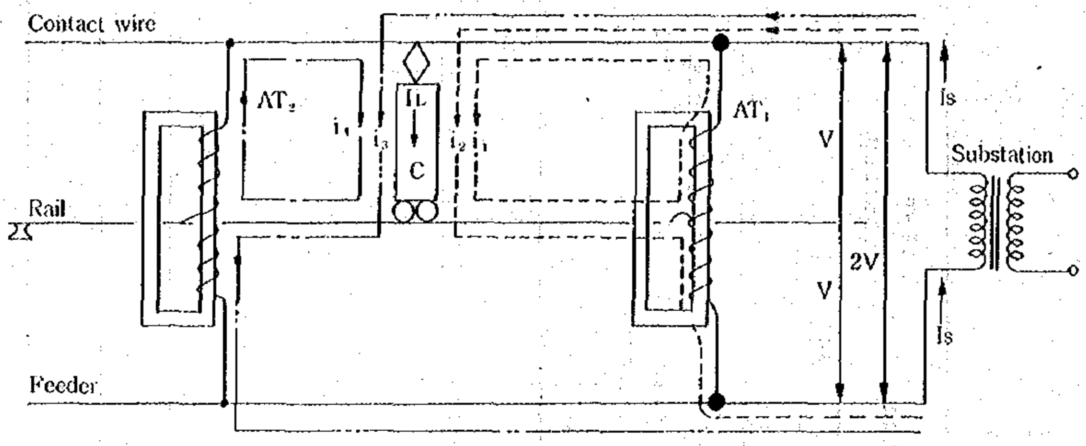
Note: 1. The figures in parentheses represent service frequencies at peak time.

2. The super delux class bus fare is 700 rials, but as TBT operates it only once a day, it is not shown in the Table given above.

Appendix II-2-8: Passenger Leaving & Arriving between Tokyo & Osaka by Various Modes of Transport and Transporting Conditions

Item / Form of transport	No. of persons carried per day average in 1973	Share	Fare & charges	Traveling time required	Service frequency
	(persons)	(%)	(yen)		
Railway					
Shinkansen	40,700	75.5	5,010	3 hrs. 10 min.	97 trains
Narrow-gauge lines	4,600	8.5	3,510 (Reserved seat on ordinary train)	9 hrs. 15 min.	3
Total	45,300	84.0			100
Motorcars					
Buses	1,200	2.2	3,300	9 hrs. 10 min.	(5 regular service "DREAM" type buses) (All others, sight-seeing buses)
Private cars	240	0.5			
Total	1,440	2.7			
Airline	7,200	13.3	9,800	0 hrs. 55 min.	27 flights
Total	53,940	100.0			

APPENDIX II-10-1 Circuit of AT Feeding System



Legend :

I_L: *Load current*
Is : Current from the substation
i_1 : Current induced by i_2 and supplied to load from AT_1.
i_2 : Current returning to the substation through the load and AT_1.
i_3 : Current returning to the substation through the load and AT_2.
i_4 : Current induced by i_3 and supplied to the load from AT_2.
V : Voltage between the contact wire and the rail (25 kV)
2V: *Feeding voltage from the substation*

$$I_L = i_1 + i_2 + i_3 + i_4 = 2Is$$
$$Is = i_2 + i_3$$
$$i_1 = i_2 ; i_3 = i_4$$