CHAPTER 3. FORECAST OF RAILWAY TRAFFIC VOLUME

Passenger and Goods Traffic Volume, GDP, GNP, Population as shown in this Chapter, were taken as follows:

(1) Table 3-6 is based on the Yearbook of Information, 1980–81, published by the Pakistan Railways.

(2) Table 3-7 is based on the Pakistan Economic Survey, 1980–81, published by the Government of Pakistan, Finance Division, Economic Adviser's Wing.

(3) Table 3-8 is based on the Tentative Data provided by the National Transport Team of the Islamic Republic of Pakistan, dated March 31, 1982.

3-1 Goods Traffic Volume

3-1-1 Forecast of gross ton-kilometers

Relationship between the goods traffic volume (see Table 3-6) in the past three decades and GDP (see Table 3-7) probably most correlative to its trend was analyzed from various statistical approaches. Consequently the following model equation of GDP/factor elasticity analysis (which proves most satisfactory correlation) was obtained:

$$\text{Log } Y = 0.415 \text{ Log } X + 263.147$$

Y : Traffic volume (million ton-kilometers)

X : GDP (ten million Rs.)

A projected GDP was introduced into this equation and the gross ton-kilometers in future was forecasted. As the projected GDP, the existing estimate value (see Table 3-8) was used. The result of forecast is shown below (see Table 3-1 and Fig. 3-1).

Year	Ton-kilometers (millions)	Annual mean growth rate (%)
1985	10,608	2.766
1990	12,118	2.697
1995	13,812	2.651
2000	15,741	2.649

3-1-2 Forecast of ton-kilometers by block

Gross ton-kilometers of each year concerned was distributed to each block according to the block-wise distribution ratio for a 1980–1981 period (see Table 3-2 and Fig. 3-2).

3-2 Passenger Traffic Volume

3-2-1 Forecast of gross passenger-kilometers

Relationship between the passenger traffic volume (see Table 3-6) in the past three decades and the individual factors (GNP, GDP, population (see Table 3-7)) and combination of multiple of these factors probably most correlative to its trend was analyzed from various statistical approaches. Consequently the following model equation of population/factor primary regression analysis (which proves most satisfactory correlation) was obtained:

$$Y = 2.255\,X - 2621.33$$

Y : Traffic volume (million passenger-kilometers)

X : Population (ten thousands)

A projected population was introduced into this equation and the gross passenger-kilometers was forecasted. As the projected population, the existing estimate value (see Table 3-8) was used. The result of forecast is shown below (see Table 3-3 and Fig. 3-3).

Year	Passenger-kilometers (millions)	Annual mean growth rate (%)
1985	18,872	3.352
1990	21,814	2.940
1995	24,887	2.671
2000	28,351	2.641

3-2-2 Forecast of passenger-kilometers by block

The number of through passengers at a center of block and passenger-kilometers by block were estimated from the number of passengers from each station for a 1980—1981 period. Then the gross passenger-kilometers of each year concerned was distributed to each block according to the distribution ratio thus determined (see Table 3-4 and Fig. 3-4).

Table 3-1 Forecast of Gross Ton-kilometers

(unit: million tons)

Year	Ton-kilometers	Year	Ton-kilometers
1980 - 81	9,255	1991 - 92	12,439
1981 - 82	9,511	1992 - 93	12,769
1982 - 83	9,774	1993 - 94	13,108
1983 - 84	10,045	1994 - 95	13,455
1984 - 85	10,323	1995 - 96	13,812
1985 - 86	10,608	1996 - 97	14,178
1986 - 87	10,894	1997 - 98	14,553
1987 - 88	11,188	1998 - 99	14,939
1988 - 89	11,490	1999 - 2000	15,335
1989 - 90	11,800	2000 - 2001	15,741
1990 - 91	12,118		

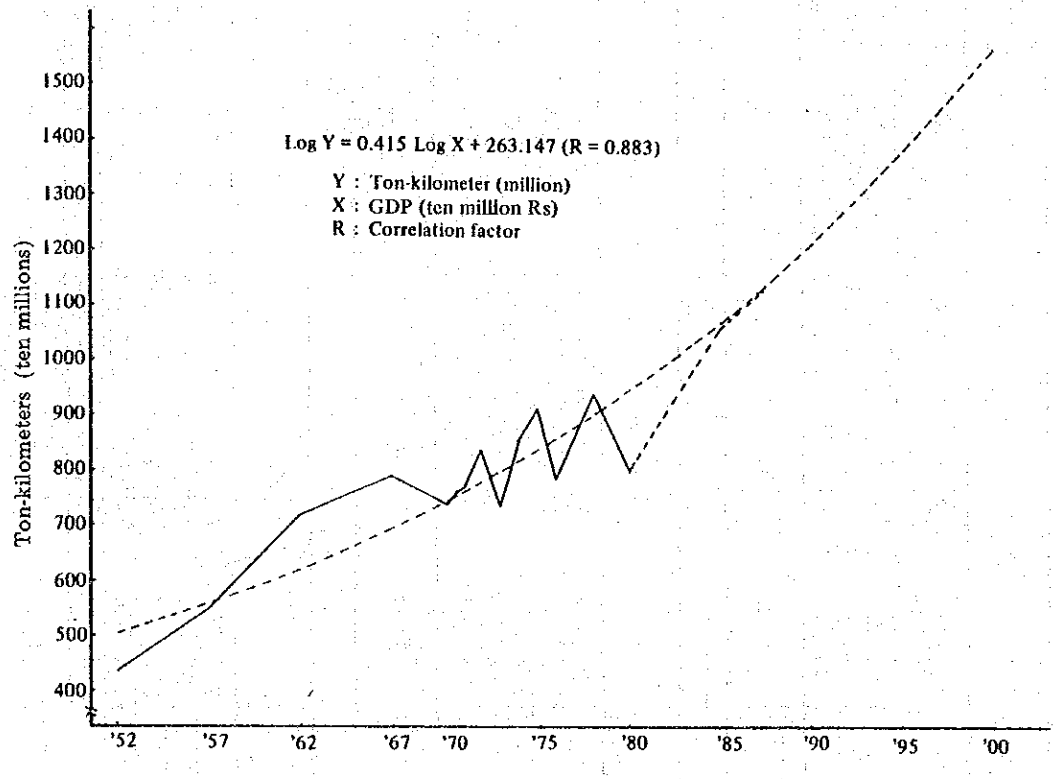


Fig. 3-1 Forecast of Gross Ton-kilometers

Table 3-2 Estimate of Goods Traffic Volume per Major Block

Year \ Block	1	2	3	4	5	6	7	8	9	10
1980	18,423	755,687	373,847	1,335,341	1,238,616	699,707	151,077	497,805	228,229	310,947
1985	24,398	1,012,003	500,698	1,789,571	1,659,092	937,747	202,613	667,243	305,510	416,894
1990	27,871	1,156,057	571,970	2,044,308	1,895,256	1,071,231	231,454	762,222	348,998	476,237
1995	31,768	1,317,665	651,926	2,330,083	2,160,196	1,220,981	263,809	868,775	397,786	542,812
2000	36,204	1,501,692	742,975	2,655,508	2,461,893	1,391,504	300,653	990,109	453,341	618,621
Percentage distribution	0.23	9.54	4.72	16.87	15.64	8.84	1.91	6.29	2.88	3.93

Year \ Block	11	12	13	14	15	16	17	18	19	20
1980	113,713	151,094	128,087	27,129	10,668	89,097	141,849	103,167	15,014	63,752
1985	152,755	202,613	171,850	36,067	13,790	119,870	189,883	137,904	20,155	85,925
1990	174,499	231,454	196,312	41,201	15,753	136,933	216,912	157,534	23,024	98,156
1995	198,893	263,809	223,754	46,961	17,956	156,076	247,235	179,556	26,243	111,877
2000	226,670	300,653	255,004	53,519	20,463	177,873	281,764	204,633	29,908	127,502
Percentage distribution	1.44	1.91	1.62	0.34	0.13	1.13	1.79	1.30	0.19	0.81

Year \ Block	21	22	23	24	25	Others	Total
1980	221,798	129,904	181,150	49,446	127,616	754,576	7,917,739
1985	297,024	173,971	242,923	65,770	170,789	1,010,942	10,608,000
1990	339,304	198,735	277,502	75,132	195,100	1,154,845	12,118,000
1995	386,736	226,517	316,295	85,634	222,373	1,316,284	13,812,000
2000	440,748	258,152	360,469	97,594	253,430	1,500,118	15,741,000
Percentage distribution	2.80	1.64	2.29	0.62	1.61	9.53	100.0

Note : For the scope of block, refer to the Table 3-5. The total of other sections comes under the column "Others".
Unit: Thousand ton-kilometers, %

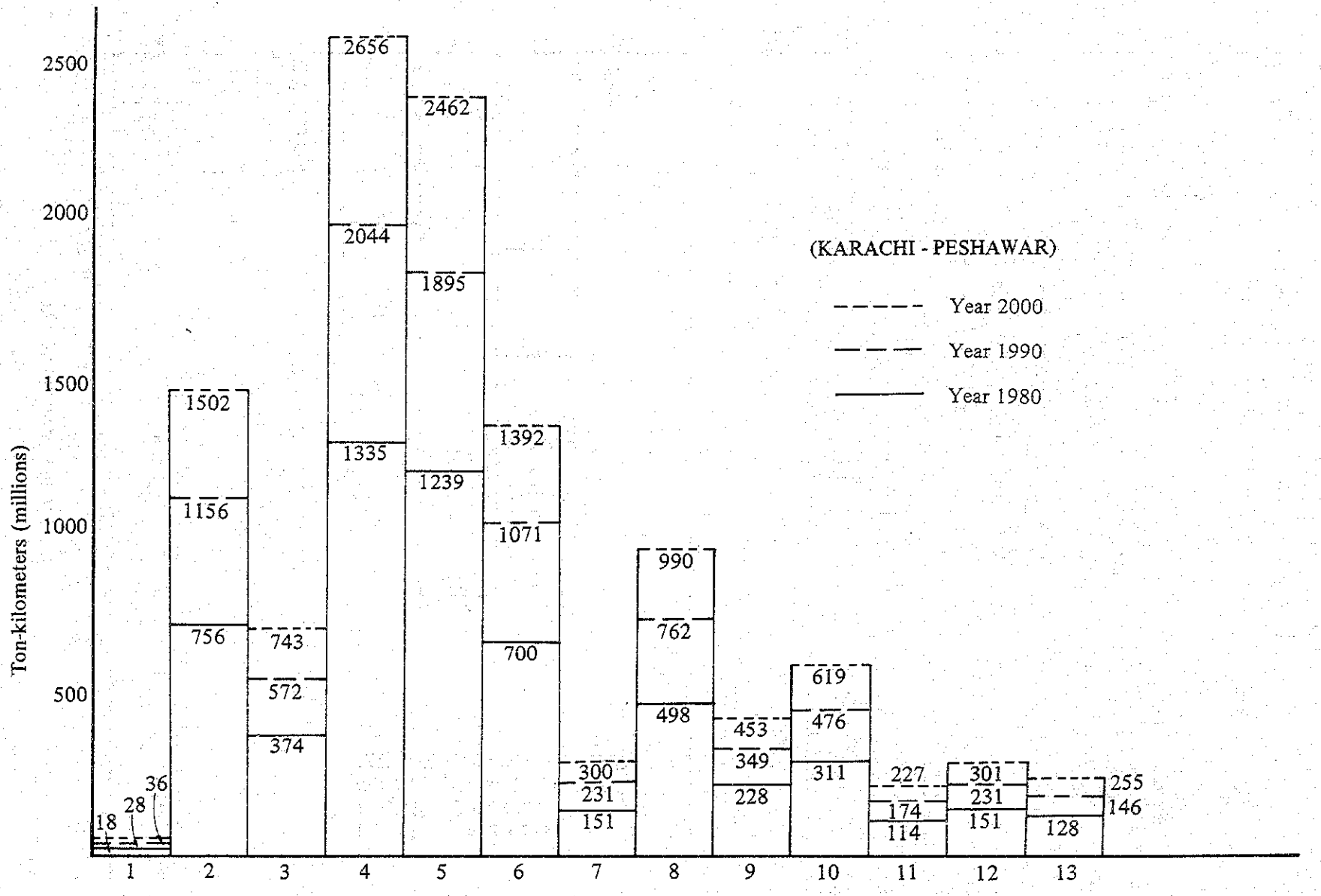


Fig. 3-2(1) Goods Traffic Volume per Major Block (Ton-kilometers)

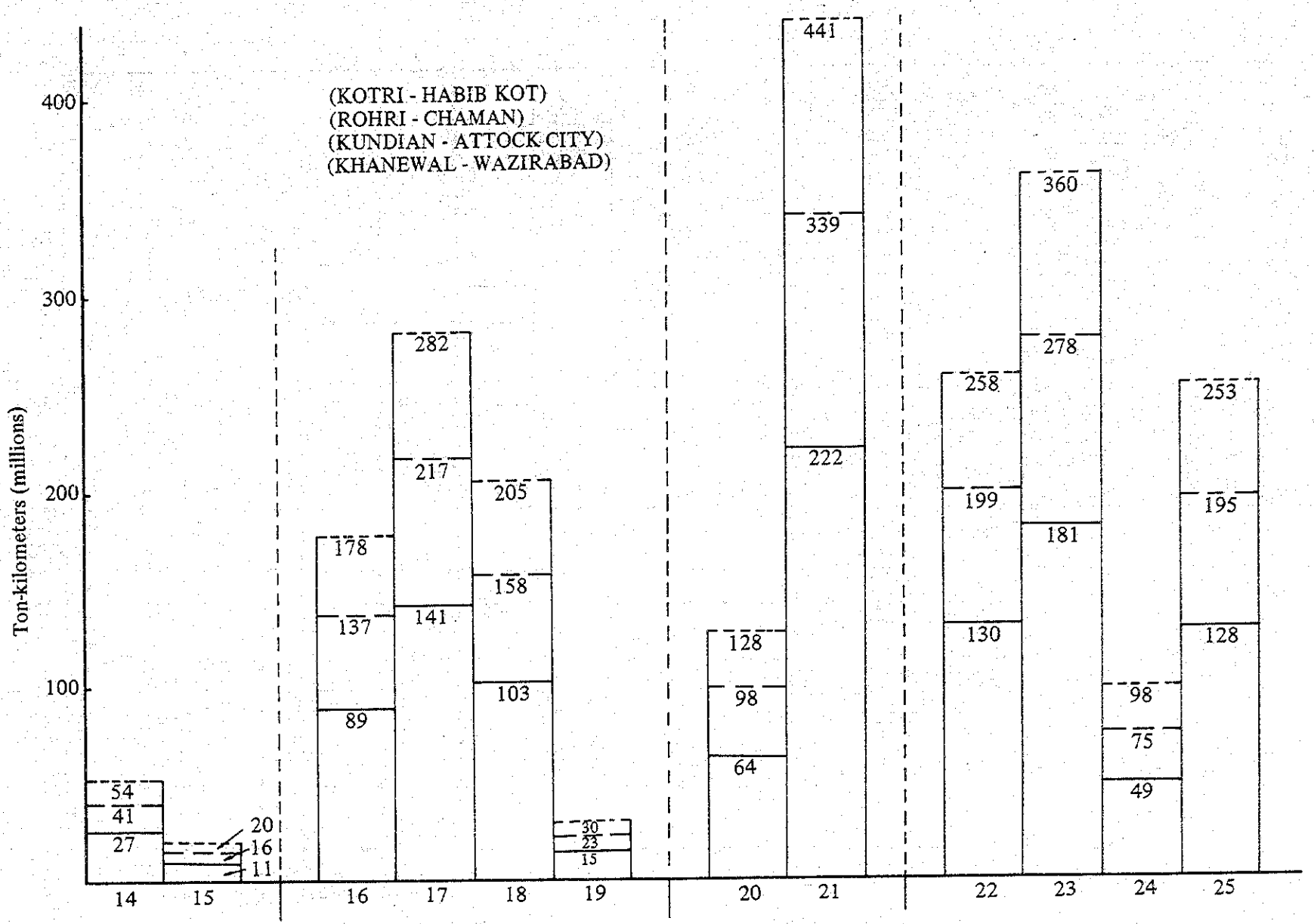


Fig. 3-2(2) Goods Traffic Volume per Major Block (Ton-kilometers)

Table 3-3 Forecast of Gross Passenger-kilometers

(unit: ten millions)

Year	Gross passenger-kilometers	Year	Gross passenger-kilometers
1981 - 82	1,654	1992 - 93	2,300
1982 - 83	1,709	1993 - 94	2,361
1983 - 84	1,767	1994 - 95	2,424
1984 - 85	1,826	1995 - 96	2,489
1985 - 86	1,887	1996 - 97	2,554
1986 - 87	1,943	1997 - 98	2,622
1987 - 88	2,000	1998 - 99	2,691
1988 - 89	2,059	1999 - 2000	2,762
1989 - 90	2,119	2000 - 2001	2,835
1990 - 91	2,181		

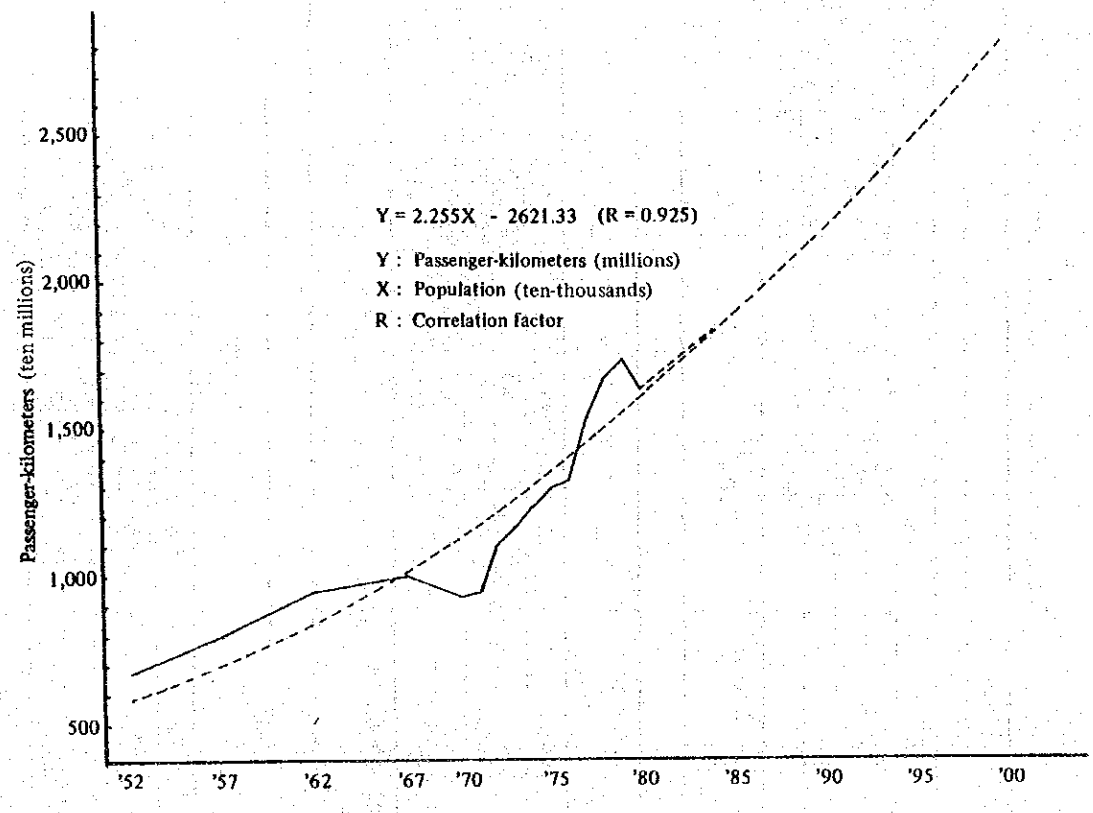


Fig. 3-3 Forecast of Gross Passenger-kilometers

Table 3-4 Estimate of Passenger Traffic Volume per Major Block (Passenger-kilometers)

Year \ Block	1	2	3	4	5	6	7	8	9
1980	10,000	1,376,000	511,000	2,251,000	1,922,000	1,076,000	247,000	799,000	1,019,000
1985	11,000	1,593,000	591,000	2,604,000	2,221,000	1,246,000	285,000	925,000	1,180,000
1990	13,000	1,841,000	683,000	3,010,000	2,568,000	1,440,000	329,000	1,069,000	1,363,000
1995	15,000	2,100,000	779,000	3,434,000	2,929,000	1,643,000	376,000	1,219,000	1,556,000
2000	17,000	2,393,000	887,000	3,911,000	3,337,000	1,871,000	428,000	1,389,000	1,772,000
Percentage distribution	0.06	8.44	3.13	13.8	11.77	6.6	1.51	4.9	6.25

Year \ Block	10	11	12	13	14	15	16	17	18
1980	1,746,000	1,316,000	523,000	396,000	3,000	99,000	25,000	80,000	58,000
1985	2,019,000	1,523,000	606,000	459,000	4,000	115,000	28,000	92,000	68,000
1990	2,334,000	1,760,000	700,000	530,000	4,000	133,000	33,000	107,000	79,000
1995	2,663,000	2,008,000	799,000	605,000	5,000	152,000	37,000	122,000	90,000
2000	3,034,000	2,288,000	910,000	689,000	6,000	173,000	43,000	139,000	102,000
Percentage distribution	10.70	8.07	3.21	2.43	0.02	0.61	0.15	0.49	0.36

Year \ Block	19	Others	Total
1980	70,000	2,784,000	16,311,000
1985	81,000	3,221,000	18,872,000
1990	94,000	3,724,000	21,814,000
1995	107,000	4,248,000	24,887,000
2000	122,000	4,840,000	28,351,000
Percentage distribution	0.43	17.07	100.0

Note : For the scope of block, refer to the Table 3-5. The total of other sections comes under the column "Others".
Unit: Thousand passenger-kilometers, %

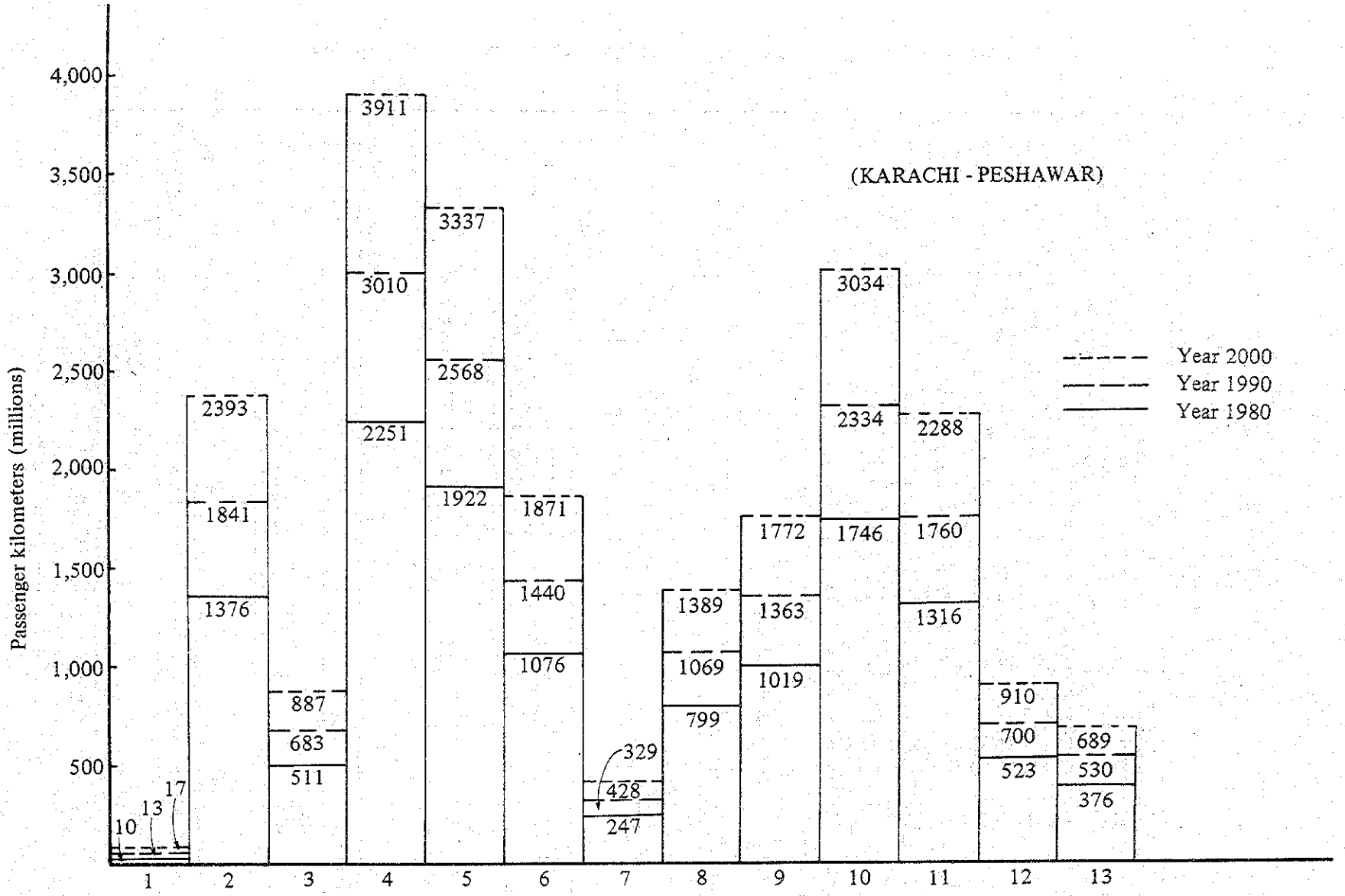


Fig. 3-4(1) Passenger Traffic Volume per Major Block

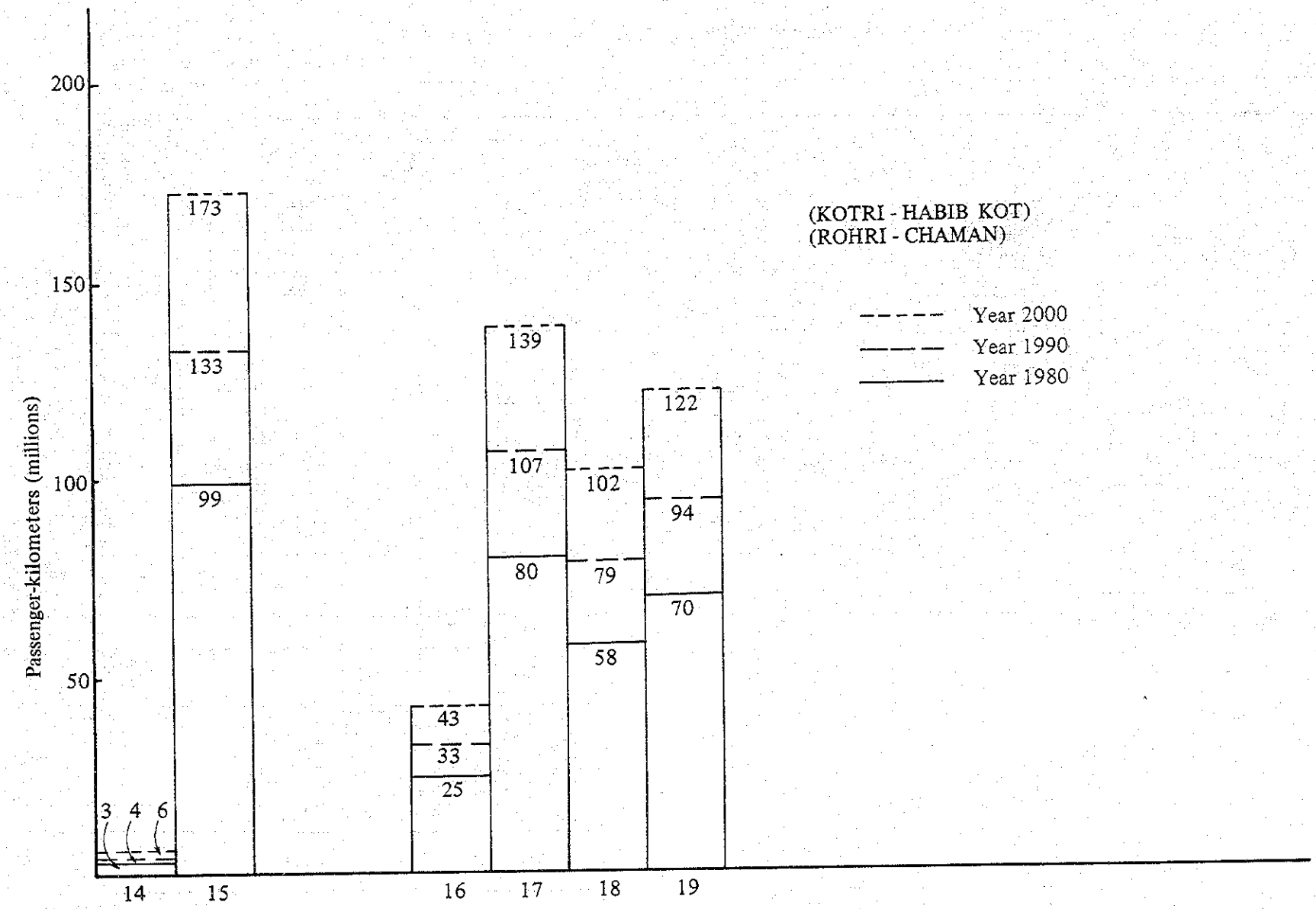


Fig. 3-4 (2) Passenger Traffic Volume Per Major Block (Passenger-kilometers)

Table 3-5 Schedule of Block Classification

Karachi - Peshawar Cant

Block No.	Section	Section kilometers
1	Karachi City - Karachi Cant	3
2	Karachi Cant - Kotri	166
3	Kotri - Tando Adam	63
4	Tando Adam - Rohri	243
5	Rohri - Khanpur	212
6	Khanpur - Samasata	124
7	Samasata - Lodhran	28
8	Lodhran - Khanewal (Chord & Loop)	90
9	Khanewal - Sahiwal	119
10	Sahiwal - Lahore	166
11	Lahore - Lalamusa	133
12	Lalamusa - Rawalpindi	157
13	Rawalpindi - Peshawar Cant	173

Kotri - Habib Kot

Block No.	Section	Section kilometers
14	Kotri - Dadu	180
15	Dadu - Habib Kot	166

Rohri - Chaman

Block No.	Section	Section kilometers
16	Rohri - Jacobabad	89
17	Jacobabad - Sibi	154
18	Sibi - Quetta	142
19	Quetta - Chaman	141

Kundian - Attock City

Block No.	Section	Section kilometers
20	Kundian - Lalamusa	255
21	Lalamusa - Attock City	239

Khanewal - Wazirabad

Block No.	Section	Section kilometers
22	Khanewal - Shorkot Cant	63
23	Shorkot Cant - Faisalabad	108
24	Faisalabad - Sangla Hill	43
25	Sangla Hill - Wazirabad	110

Table 3-6 Passenger and Goods Transport Record

(Average)	Goods traffic volume (ton-kilometers)	Passenger traffic volume (passenger-kilometers)
1950 - 55	4,378	6,779
1955 - 60	5,480	8,064
1960 - 65	7,213	9,534
1965 - 70	7,900	10,025
1970 - 71	7,494	9,329
1971 - 72	7,756	9,515
1972 - 73	8,363	11,069
1973 - 74	7,377	11,694
1974 - 75	8,544	12,354
1975 - 76	9,096	12,957
1976 - 77	7,857	13,199
1977 - 78	8,557	15,375
1978 - 79	9,375	16,713
1979 - 80	8,598	17,316
1980 - 81	7,918	16,311

Table 3-7 Past Transition of GDP, GNP and Population

	GDP (million Rupees)	GNP (million Rupees)	Population (ten thousands)
1952 - 53	12,865	12,852	3,798
1957 - 58	15,815	15,811	4,290
1962 - 63	20,056	20,008	4,890
1967 - 68	27,659	27,636	5,637
1970 - 71	32,434	32,362	6,149
1971 - 72	32,812	32,883	6,334
1972 - 73	35,179	35,360	6,524
1973 - 74	37,901	38,085	6,720
1974 - 75	39,393	39,651	6,921
1975 - 76	40,699	41,410	7,129
1976 - 77	41,727	43,022	7,343
1977 - 78	44,805	47,700	7,563
1978 - 79	46,891	49,953	7,790
1979 - 80	50,157	53,292	8,023
1980 - 81	53,020	56,237	8,260

Table 3-8 Projection of GDP and Population

Annual growth rate	GDP (%)	Population (%)
1980/81 - 1987/88	6.8	2.9
1987/88 - 1999/2000	6.5	2.4

CHAPTER 4. LOCOMOTIVE INTRODUCTION PLAN

4-1 Current State of Locomotives

The task of railway is to ensure rapid and safe transport of passengers and goods according to the demand. This target can be achieved only when three elements of railway — locomotives (motive power), rolling stock (transport container), and tracks (transport way) — are well coordinated.

Pakistan Railways underwent conversion of motive power at extremely early time after the independence in 1947. It planned for introduction of diesel locomotives while employing the oil burning system for steam locomotives to unify fuel. Old steam locomotives have been replaced by increasing diesel locomotives. At present, Pakistan Railways has 471 diesel locomotives and almost all of trunk line trains are dieselized.

There are yet 381 overaged steam locomotives most of which are more than 60 years old. They are mainly used for local trains on branch lines or in stations and marshalling yard for shunting. Table 4-1 shows the present allotment of locomotives.

Pakistan Railways started introduction of diesel locomotives fairly early in its history. Because it purchased diesel locomotives from many countries for a long time according to the transport demand, there are at present as many as 24 types of locomotives. Therefore, it is suffering the difficulties of maintenance and parts procurement due to difference in structures and dimensions and lack of interchangeability among various parts.

Ten types have already passed the normal life, and most of diesel locomotives, which were introduced in 1960 and after and are currently in operation, will reach the normal life by the year 2000. Of steam locomotives, as many as 314 units have passed the normal life of 45 years.

Table 4-1 Allotting Status of Existing Locomotives

Diesel Locomotives

Sheds	Nos. of Allotment			
KARACHI	153	H.	109	
		L.	44	
ROHRI	87	H.	53	
		L.	34	
LAHORE	123	H.	65	
		L.	58	
KUNDIAN	34	L.	34	
QUETTA	9	H.	9	
SIBI	13	H.	13	
SAMASATA	18	H.	18	
RAWALPINDI	34	H.	17	
		L.	17	
TOTAL	471	H.	284	
		L.	187	
Ineffective	79	H.	45	(15.8%)
		L.	34	(18.2%)
In Serviceable	392	H.	239	(84.2%)
		L.	153	(81.8%)

Note: H. means as Heavy duty use
L. means as Light duty use

Steam Locomotives

Sheds	Nos. of Allotment	
KOTRI	25	
ROHRI	18	
KHANPUR	4	
PAD IDAN	10	
LAHORE	30	
FAISALABAD	18	
WAZIRABAD	14	
QUETTA	23	
SIBI	12	
SAMASATA	46	
KHANEWAL	31	
MULTAN	10	
SHORKOT	6	
RAWALPINDI	42	
ATTOCKCITY	2	
LA LA MUSA	8	
PESHAWAR	5	
NOWSHERA	9	
MALAKWAL	31	
MARI INDUS	3	
KUNDIAN	21	
Loco. Works	13	
TOTAL	381	
Ineffective	76	(20%)
In Service	305	(80%)

Tables 4-2 and 4-3 show respectively the expiry conditions of diesel and steam locomotives by each type.

It is considered essential to replace overaged steam locomotives by more effective diesel locomotives for modernization of motive power and to standardize diesel locomotives, which are now too diversified, to ensure smooth maintenance because they have to wait for necessary spare parts and materials.

Table 4-2 Expired List of Existing DEL.

Classes		Mfd.	Re-engined	No.s in 1982	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	2000	01	02	03	04	05	06	07
ADE	36	1947		3																								
ALU	14	1953		5																								
GEU	61	1954		10																								
FAU	66	1954 ~ 1957		5																								
CLP	15	1955 1956		9																								
ALPW	16	1956		2																								
"	18	1958		43																								
ALU	95	1958 1959		25																								
"	18	1961		30																								
"	12	1962 1963		53																								
"	20	1962 ~ 1964		52																								
GEU	64	1965		2																								
ALU	24	1967		20																								
"	26	1966		1																								
GEU	20	1970		42																								
"	15	1970		23																								
GMU	30	1975		36																								
"	15	1975		32																								
ARP	20	1952	1976, 1979 1980	23																								
ARU	20	1955	1976, 1980 1981, 1982	21																								
GMCU	15	1979		30																								
HAU	10	1980		4																								
"	20	1982		28																								
HPU	20	1982		10																								
No.s of DEL (Present Allotment) to be deleted reaching Over age.					8	10		11	5	43	25	23	30	21	53	52	2	1	20			65				68		

Overage
Over Normal life + 10 years
Normal life
Over 10 years after Re-engined

Table 4-3 Condition of Steam Locomotives

Classes	Manufactured in	No.s in 1982	1991	2001
HG/S	1913, 1919, 1923	74		
SP/S	1904, 1909, 1911 to 1915, 1922	29		
XA	1926 to 1931	27		
CWD	1945, 1946	67		
SG/S	1904 to 1908 1910 to 1913 1915 to 1920, 1923	130		
SG/C	1904 to 1908 1910 to 1915	54		
Total		381		

4-2 Maintenance of Diesel Locomotives

As a part of modernization of motive power, Pakistan Railways is pushing forward one by one the programmes shown in the "Modernization of Locomotive Facilities (Sept. 1981)".

It is also improving the maintenance system.

(1) Maintenance system

The maintenance of diesel locomotives is executed at places to which the locomotives are assigned base sheds, advanced base sheds — and at repair workshops.

Table 4-4 shows the maintenance schedule by inspection and repair, and Fig. 4-1 the maintenance facilities.

Table 4-4 The Scheduled List for Maintenance

Item	Period	Time allowed	Carried out in
Trip Inspection	Every trip	1.5 hours	Advance Base Shed
A Schedule Check	Every week	2.5 hours	
B Schedule Check	Every 2 weeks	4.5 hours	
C Schedule Check	Every month	6.0 hours	
D Schedule Check	Every 3 months	1 day	Base Shed
E Schedule Check	Every 6 months	2 days	
F Schedule Check	Yearly/100,000 miles	7 days	
Class II Repair	3 years/300,000 miles	15 days	Repair Shop
Class I Repair	6 years/600,000 miles	25 days	

(2) Maintenance capacity

The Central Diesel Locomotive Workshop in Rawalpindi and Karachi Workshop in Karachi Cantonment have been gradually expanded in their capacity, and at present, the former workshop can perform overhaul of 300 diesel locomotives and the latter 120 (420 in total).

Pakistan Railways is also promoting the programms of "Modernization of Locomotive Facilities", which is expected to raise the maintenance capacity of advanced base sheds, base sheds and repair shops.

(3) Rehabilitation of existing locomotives

As a counter plan for overaged locomotives, some locomotives will be subject to the replacement of engine and related parts in the workshop in Lahore. The Central Diesel Locomotive Workshop in Rawalpindi performes the production of a part of spare parts, supplying them to workshops and sheds.

Re-engining of existing locomotives was started in 1976, and 44 units (2 types as ARP-20 and ARU-20) have been re-engined up to present and contributing to reinforcing traffic capacity. Rehabilitation through re-engining is the most effective method of extending the normal life of existing locomotives with the minimum cost.

However for the positive improvement of traffic in future, the introduction of new and standardized locomotive is considered indispensable.

4-3 Rotation of Locomotives

Table 4-5 shows the availability of existing locomotives. As of 1980/1981, unavailable locomotives due to wait for imported parts and restoration of damaged locomotives amount to 18.79 + 7.30 ≒ 26 units, 5.5% of the total. If these locomotives could be used, the availability will be as high as 86.7%.

Table 4-6 shows the average diesel locomotives running-kilometers per day (engine-kilometers per day).

Table 4-5 Average No.s of Ineffective DEL.

Years	Under repair in Shed/Shop	Awaiting Imported Spares	Re-engining in Shop	Accident	Total
1979/1980	52.46 (10.91%)	19.54 (4.06%)	7.61 (1.58%)	8.69 (1.63%)	88.80 (18.18%)
1980/1981	55.67 (11.46%)	18.79 (3.86%)	6.69 (1.41%)	7.30 (1.47%)	88.46 (18.27%)
Av. No.s	54	19	7	8	88

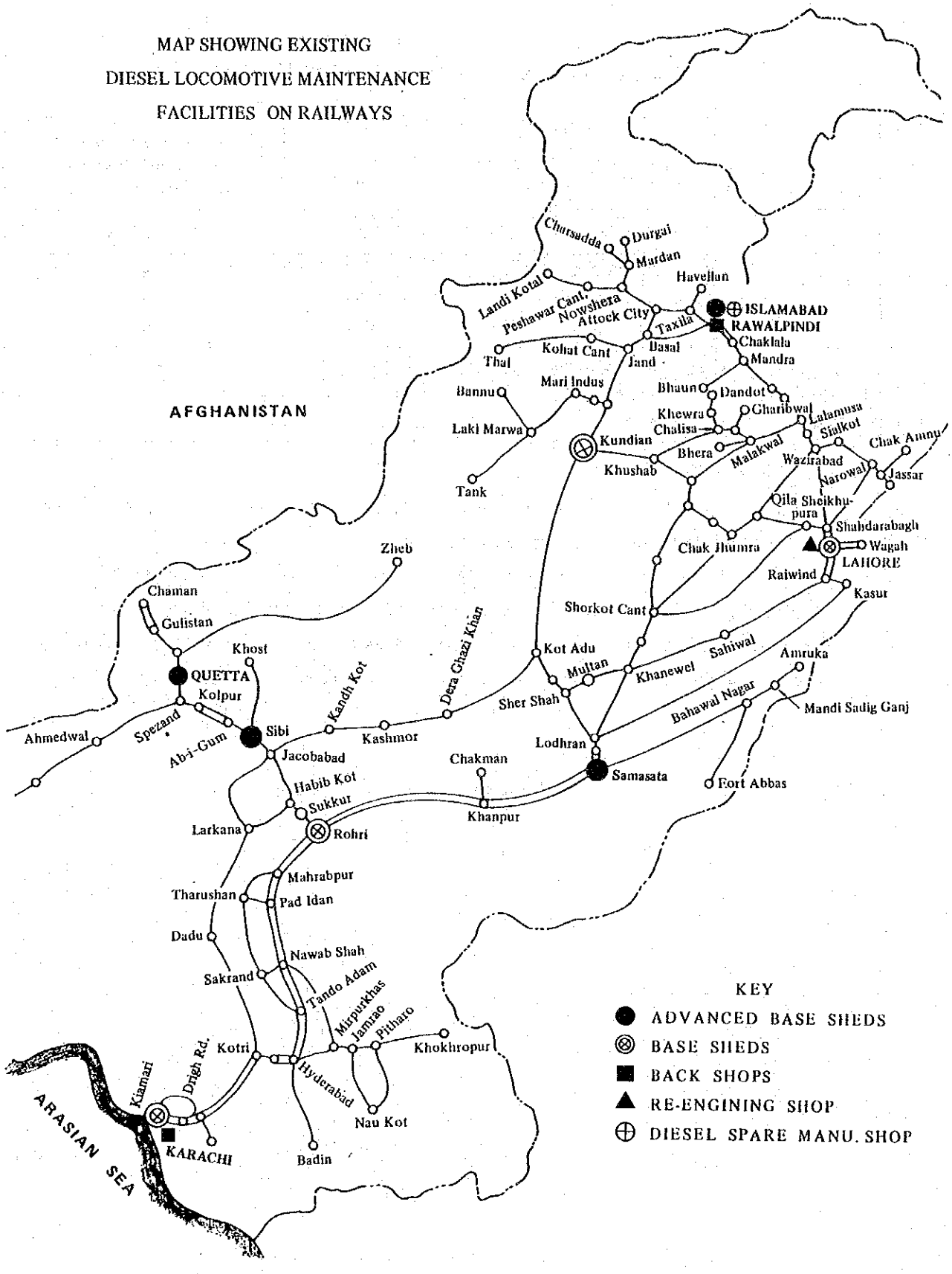


Fig. 4-1 Diesel Locomotive Maintenance Facilities

Table 4-6 Running-km per Day per a DEL. in Use

	Passenger	Mixed	Goods	Total all services including Shunting and Departmental
1981-1	462.9	254.8	223.5	317.4
1982-1	464.6	253.1	231.7	326.2
Upto 1981-1	477.0	234.9	205.7	314.3
Upto 1982-1	453.6	248.5	207.3	308.9
Target	579.0	-	290.0	-

The actual record as of 1981 and 1982 (up to January) is below the target (indicated by the World Bank Report) by 20 to 30%.

Among various measures of increase of running-kilometers per day, there are such methods as the cutdown of locomotive turn-round time by re-arranging the rotation of locomotives and the establishment of punctual operation to scheduled time.

4-4 Transport Capacity

(1) State of railway transportation as of 1980/1981

Passenger traffic volume	1,631,129,000 passenger-km	
Goods traffic volume	7,917,739,000 ton-km	
Annual passenger trains	164,150 trains per day	
	450 trains per day	
Goods trains	62,434 trains per year	
	171 trains per day	
Mean traffic volume per train	Passenger	99,370 passenger-km
	Goods	126,820 ton-km

Pakistan Railways have three types of gauges; BG (route length 7,765.93 km), MG (route length 445.58 km) and NG (route length 611.35 km). 88% of the total route is of BG, with traffic volume occupying 90% of all traffic volume. Figs. 4-2 to 4-5 shows goods train and passenger train routes on the BG section.

(2) Growth of traffic volume expected in future

Table 4-7 shows the growth of traffic volume, with the traffic volume as of 1980/1981 indexed at 100, which is expected every five years in the future demand forecast.

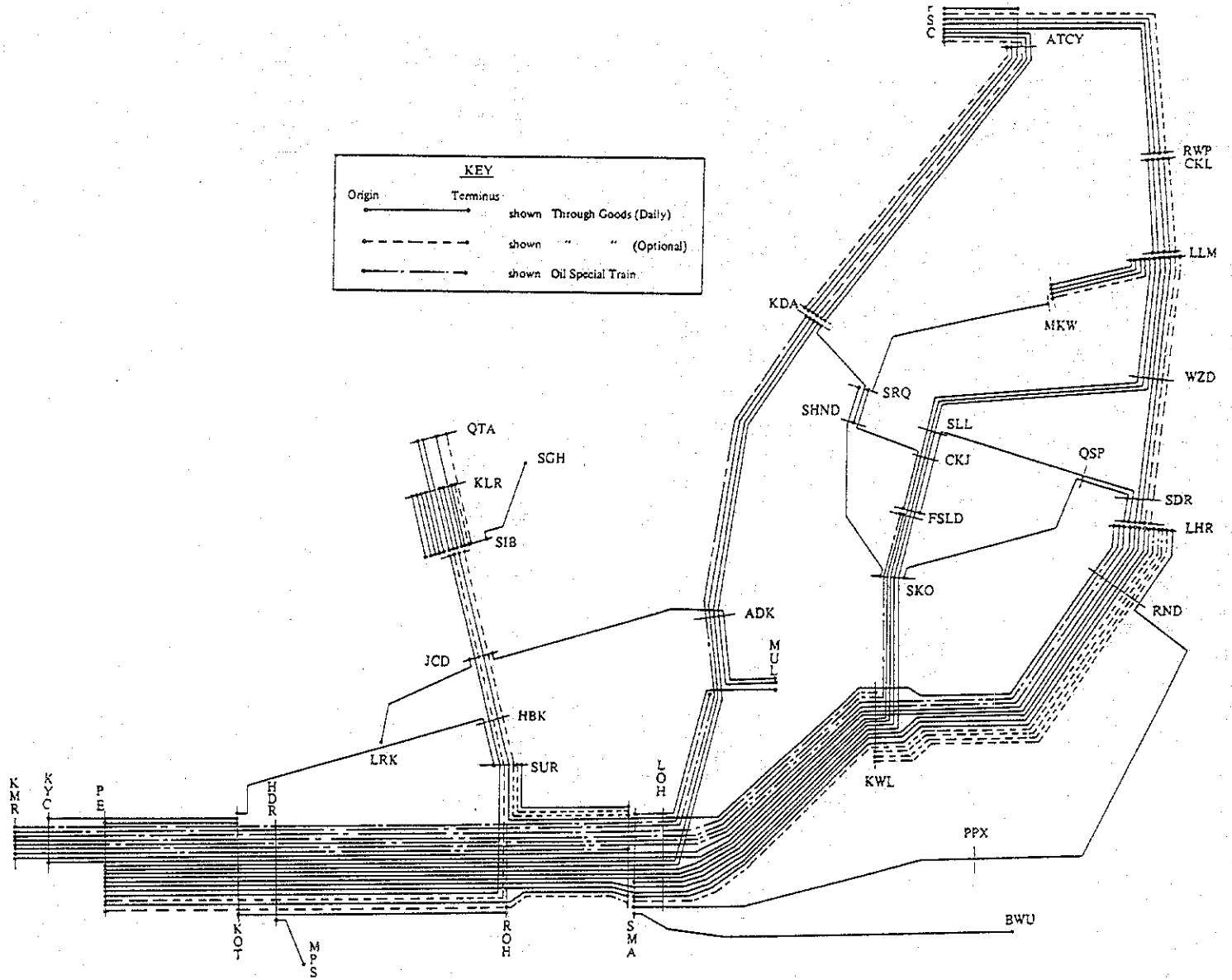


Fig. 4-2 GOODS TRAIN RUNNING ROUTE [B.G.]
(Through Goods included Oil Special)

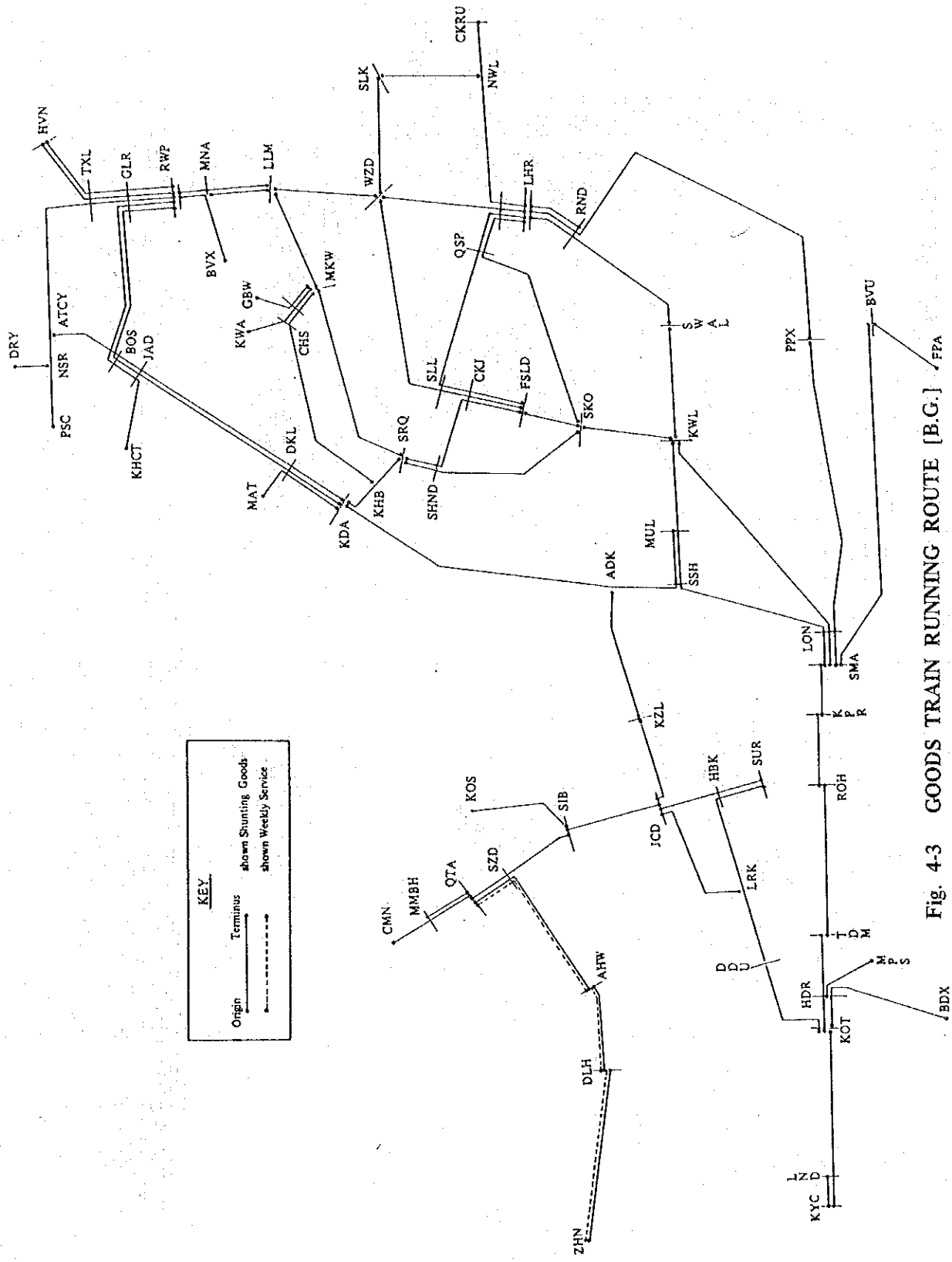


Fig. 4-3 GOODS TRAIN RUNNING ROUTE [B.G.] (Shunting Goods Train)

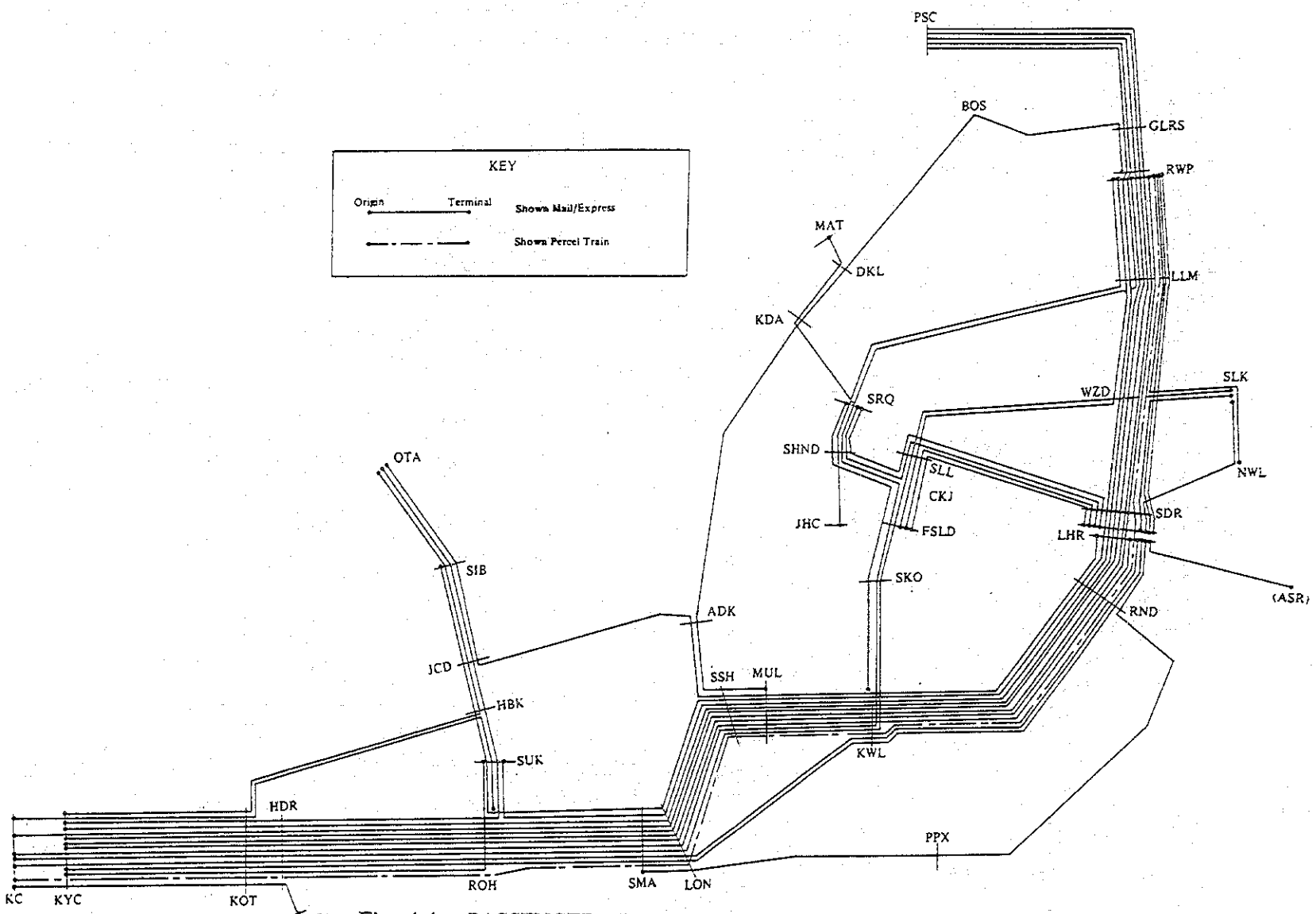


Fig. 4-4 PASSENGER TRAIN RUNNING ROUTE [B.G.]
(Mail/Express Train included Percel Train)

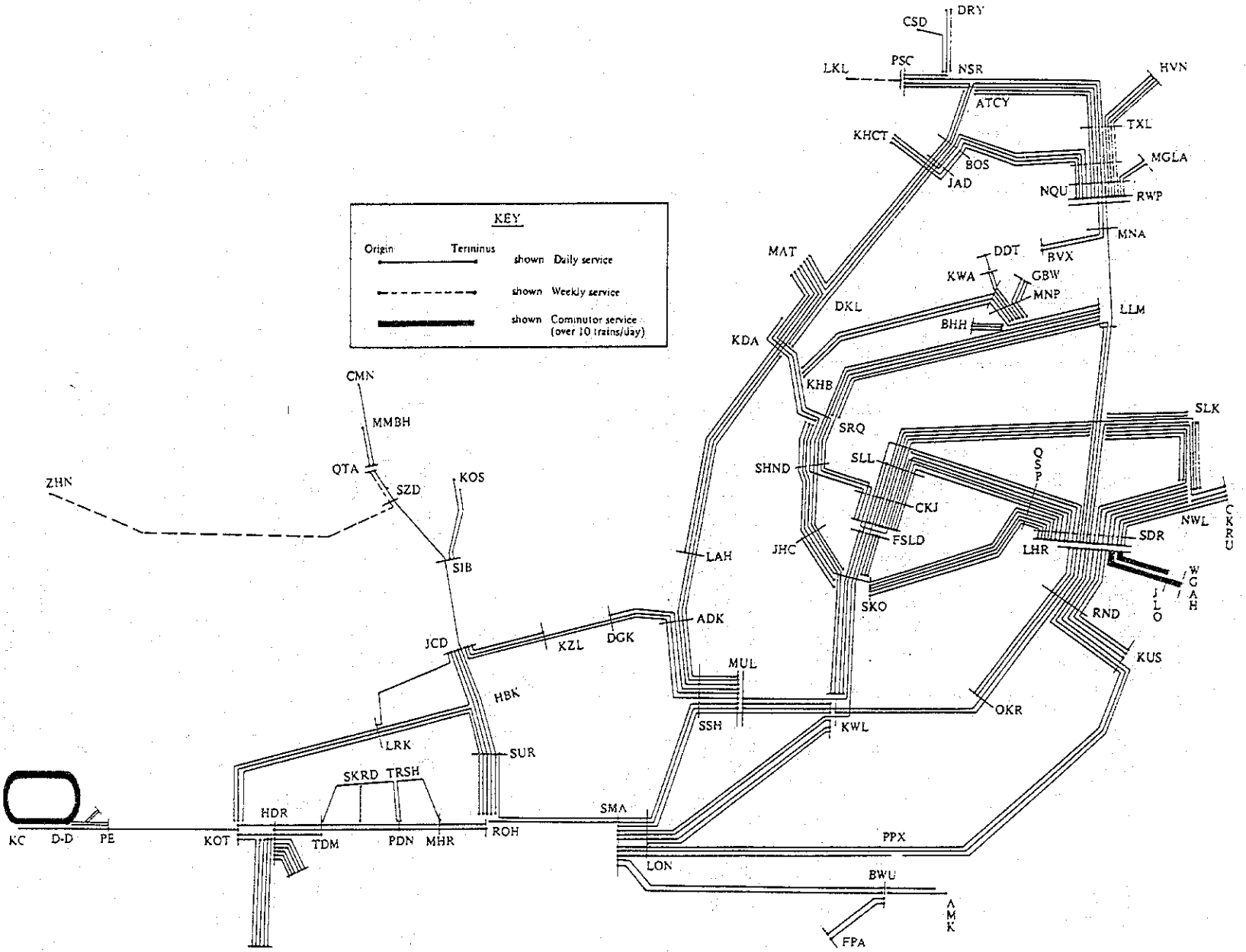


Fig. 4-5 PASSENGER TRAIN RUNNING ROUTE [B.G.]
(Regular Train included Mix.)

Table 4-7 The Growth Ratio of Traffic Volume

Years	Passengers	Goods
1980/81	100	100
1985	115.7	133.9
1990	133.7	153.0
1995	152.6	174.4
2000	173.8	198.8
2005	198.0	226.6
2010	225.6	258.2

4-5 Calculation of the Required Number of Locomotives

4-5-1 Conception underlying the method of calculation

From the results obtained through the analysis of the present conditions of operation and maintenance of the locomotives in Pakistan Railways, and also, through forecasts of railway traffic as mentioned in the preceding sections, the number of locomotives required in the future has been calculated under the following concept.

(a) Calculation of the number of Steam Locomotives in terms of Diesel Electric Locomotives

The total number of SL's possessed at present has been clasified into three groups passenger trains, mixed trains, goods trains and shunting & departmental trains, and each converted in terms of DEL.

(b) Determination of the basic number of DEL's

The number of DEL's required was calculated by assuming that all trains hauled by locomotives in 1981 were by DEL's, and this value is to be used as the 'Basic Number of Locomotives' in estimating the number of DEL's required in the future.

The calculation of the 'Basic Number of Locomotives' was made on the premise that the working efficiency of the locomotives used for passenger and goods train would be increased by 25%.

(c) Calculation of the number of DEL's required in the future

Calculations were made of the number of locomotives required conforming to the increase in traffic volume for every 5 years for a period of approximately 30 years by applying the 'Basic Number of Locomotives' mentioned in (b) and by taking into consideration a 15% ineffectiveness.

4-5-2 Calculation of the number of locomotives in terms of DEL.

The numbers for the DEL and SL which form the basis for the calculations in Table 4-11 have been obtained from data given in the "Performance Review" Pakistan Railways Year Book", and "Operation Daily Report" furnished by Pakistan Railways.

For calculating the existing number of SL's in terms of DEL, the following equation was employed generally.

Number of DEL's = (Number of SL's in operation at present) x
(Conversion factor = 2/3) ..... (1)

Here, the conversion factory (2/3) have been obtained from value in the "Locomotive Study".

Table 4-8 Engine km/day (Performance Review 31 March 1982)

Unit: km/day

Kind of train	DEL	SL	Remarks
Passenger	464.6	169.9	Target = 579.0 for DEL
Mixed	253.1	188.0	
Goods	231.7	67.1	Target = 290.0 for DEL
Total	326.2	148.6	Total is incl. Shunting & Dept.

Table 4-9 No.s of train/year (Pakistan Railways Year Book 1981)

Kind of train	Hauled by DEL	Hauled by SL
Passenger	103,855	26,475
Mixed	4,645	20,528

Table 4-10 Present Nos. of Locomotive in Service (Operation Daily Report 29 March 1982)

Kind of train	DEL	SL	Total
Passenger & Mixed	165	80	245
Goods	168	62	230
Shunting & Dept.	59	163	222
Total Nos. in Servie	392	305	697
Nos. of Allotment	471	381	852

The number of DEL and SL to be used for passenger trains and mixed trains can be obtained through the values given in Tables 4-8 to 4-10 in the followig manner:

165 x 103,855/(103,855 + 4,645) = 158 ..... DEL's for passengers
165 x 4,645/(103,855 + 4,645) = 7 ..... DEL's for mixed

80 x 26,475/(26,475 + 20,528) ÷ 45 SL for passenger
80 x 20,528/(26,475 + 20,528) ÷ 35 SL for mixed

Table 4-11 Calculated Nos. of Locomotives in Service

Kind of train	DEL	SL	Total
Passenger & Mixed	165	80	245
(Passenger)	(158)	(45)	(203)
(Mixed)	(7)	(35)	(42)
Goods	168	62	230
Shunting & Dept.	59	163	222
Total Nos. in Service	392	305	697
Nos. of Allotment	471	381	852

The number of DEL used for passenger and goods trains is determined by taking into consideration that the working efficiency of DEL can be improved 25% up.

But for mixed train, it is considered that the improvement of working efficiency is very difficult for characteristics of the train.

The number of DEL used for shunting and departmental is adopted in accordance with the data shown on "Locomotives Study", as the detailed condition of them is made not clear.

Table 4-12 have been prepared from the data on Table 4-11 by calculating the data on the later into the former under these conditons mentioned above.

Table 4-12 Nos. of Locomotive in Terms of DEL

Kind of train	DEL	SL·Conv.	Total
Passenger & Mixed	126	54	180
(Passenger)	(119)	(30)	(149)
(Mixed)	(7)	(24)	(31)
Goods	126	42	168
Shunting & Dept.	59	108	107
Total	311	204	515

Table 4-12 shows the number of DEL that would be required if it is assumed that all tractive transportation is effected by DEL in 1981/2.

The 25% up in efficiency is judged to be a value which is appropriate and attainable due to the following reasons.

(a) The figure provided by the World Bank as the target value for running kilometers per day for DEL's to be used for the haulage of passengers and goods is about 25% above actual results. (Refer to Table 4-8.)

(b) Requirements for DEL have been calculated by Pakistan Railways "Locomotive Study" on the prerequisite of 25% increase in working efficiency.

4-5-3 Basic Number of DEL's

In calculating the number of DEL's required in the future, the basic number of locomotives are shown in Table 4-13.

Table 4-13 Basic number of DEL's

Kind of train	Nos. of Loco. in terms of DEL
Passenger & Mixed	180
(Passenger)	(149)
(Mixed)	(31)
Goods	168
Shunting & Dept.	167
Pilot	23
Total	538

4-5-4 Number of DEL's required in the future

The following is mentioned as methods for strengthening the transport capacity:

(a) Increase in the number of trains compatible with traffic volume.

(b) Increase in the number of cars per train.

Generally, these methods are adopted individually or collectively as dictated by overall considerations such as traffic demand and effects of capital outlay. Here, (a) has been established as a prerequisite, with the number of locomotives required being increased in proportion to the estimated expansion ratio in traffic volume occuring every 5 years. (Refer to Table 4-7.)

However, for locomotives for shunting and departmental use and for pilot use, as they are intended for special applications and their range of operation limited, increase in the required number will not expand at the same rate as for the estimated increase for the country as a whole. Consequently, for these locomotives, calculations will be made on the basis of an increase of 10% in the year 2000 as against the present number.

The required number of locomotives as calculated under conditions as given above is shown in Table 4-14.

Table 4-14 The No. of Locomotives to be Required

Years	Passengers (incl. Mixed)	Goods	Shunting & Dept.	Pilot	Total	Grand total incl. 15 % ineffectives
1980/1981	180	168	167 190	23	538	619
1985	208	225	195		628	722
1990	241	257	200		698	803
1995	275	293	205		773	889
2000	313	334	209		856	984
2005	356	381	213		950	1093
2010	406	434	217		1057	1216
2012	426	455	219		1100	1265

4-6 Plans for the Introduction of Locomotives

As against the number of required locomotives shown in Table 4-14, from among the locomotives in use of present, some will be screened out under the following conditions:

(a) DEL's will be scrapped 30 years after manufacture.

(b) Most of the SL's are being operated considerably in excess of their normal life span, and they will be replaced successively by DEL's beginning with the oldest.

On the other hand, manufacture of new locomotives will be started in 1986 and proceed at the rate of 5 units for the first year, 8 for the second, 10 for the third, 16 for the fourth and from the fifth year (1990) onwards, 25 units (for details refer to Chapter 5.). The calculation of balancing with the required number of locomotives is obtained as shown in Table 4-15.

Table 4-15 Locomotives Introduction Plan

Years	Necessary No. of DEL's	New DEL's to be Produced	To be deleted		Actual Allotment of DEL's*	Balance
			Existing DEL's	SL's (conv. DEL's)		
1980/1981	619	—	—	—	724	+105
1985	722	import $\begin{matrix}38\\+30\end{matrix}$	18	—	774	+52
1990	803	64	107	77 (51)	680	-123
1995	889	125	158	77 (51)	546	-343
2000	984	125	86	77 (51)	584	-400
2005	1093	125	68	77 (51)	590	-503
2010	1216	125	34	73 (49)	632	-584
2012	1265	50	—	—	682	-583
Total	—	682	471	381 (254)	—	—

* including conv. DEL of S.L.

4-7 Study of the Scale of the Factory

From the results of the studies mentioned above, an appraisement will be made to determine the scale of the factory from the following two standpoints.

(a) In what manner should the scale of the new factory be determined to turn out enough locomotives for satisfying minimum traffic demands? That is to say, what will be the minimum scale of the factory capable of replacing the scrapped old locomotives at the time of the factory is completed.

(b) Will not investment in new facilities be required in order to supply locomotives to cope with the increased traffic volume expected to occur in the future? or, will it be sufficient to simply change the manufacturing method, such as the adoption of a 2-shift system? In other words, does not the plan call for plant and equipment on an excessively samll scale?

First, calculations for a minimum scale can be made as follows:

As of 1985, the number of DEL's required will be 722 but, the actual number allocated will be 774 in terms of DEL's (refer to Table 4-15.).

Consequently, if traffic demand progresses on the same level as for 1985, and if the surplus for that year of 52 locomotives and the 38 new units introduced in 1982 are taken into consideration, it will be necessary to screen out the following number of locomotives till 2012:

$$774 - (52 + 38 + 30) = 654$$

For this reason, it is judged that a plan would be appropriate if a margin of 15% is considered for the equipment capacity of the factory, with the work to be undertaken under a single shift, as follows:

$$654/(2012 - 1985) = 24.2 \fallingdotseq 25 \text{ locomotive/year}$$

If traffic volume increases as estimated in Chapter 3, the number of locomotives required to meet this increase will be $1265 - 722 = 543$ units, so that productive

capacity, including a margin of 15% will be as follows:

$$543/(2012-1985) \times 1.15 \fallingdotseq 23 \text{ .....locomotive/year}$$

As annual increase in productivity of 20 locomotives can be easily dealt with through the adoption of a 2-shift system with equipment capacity capable of producing 25 locomotives a year.

Although the actual demand for traffic volume is expected to be subject to variations to changes in social and economical conditions taking place within Pakistan, to National Development Plans or to conditions related to progress made in pursuing improvement plans for Pakistan Railways, a factory with an annual production of 25 locomotives is on an approximately adequate scale as judged from the results of the studies mentioned above.

CHAPTER 5. LOCOMOTIVES DOMESTIC PRODUCTION PLAN

5-1 Target of Domestic Production

5-1-1 Progressive method of domestic production

The domestic production is to be executed progressively according to the plan.

(1) Table 5-1 "Outline of Progressive Programme of Domestic Production" shows the framework of Progressive Production Programme.

2000 PS Class diesel-electric locomotives are to be produced domestically.

Phase I, Part 1 is included in the stage of complete knock-down and has already been undertaken by the Pakistan Railways.

This project covers up to Phase II, Part 1.

(2) In view of minimum in-house concept, the use of facilities of the public and private sectors as well as procurement of parts from these sectors will be considered for the locomotive factory.

(3) Tables 5-2 and 5-3 "Parts and Materials of Domestic Production" show the result of study on locomotive components which can be possibly manufactured domestically.

Table 5-2 shows parts and materials which can be manufactured with the existing facilities and technology of Pakistan.

Table 5-3 shows those parts and materials which require introduction of facilities and technology transferred from foreign country for production.

The years of domestic production in the table are target years.

It is advised to raised the ratio of domestic production, schematically to improve technology and quality level and to lower production cost through

the future study, trial manufacture, testings, improvement and new installation of the facilities in Pakistan as well as technological cooperation with foreign countries.

5-1-2 Detailed contents of domestic production target

Detailed contents of domestic production target as follows:

(1) 1st Year

(a) Underframe and bodies

Sub assembly of underframe and bodies are imported. Here after, manufacturing work of loco. body will be done at the Locomotive Factory. (welding, machining, painting, piping, wiring, furnishing testing, etc.)

Coupler, buffer, body's parts (handrail, step, door, cow catcher, tanks/reservoirs, window, etc.) will be domestic production.

(b) Bogie

Sub assembly of bogie frame will be imported. Here after, manufacturing work of bogie frame will be at the Locomotive Factory. (welding, annealing, painting, machining, furnishing, testing, etc.)

Axle, axle box, gear case, brake shoe/head, sand box, brake rigging, etc. are domestic production.

(c) Various component

Air brake equipment will be imported.

Battery, filter, safety glass, rubber hose, shaped rubber, fire extinguisher, gauges/meters, electric fan, pipe/tube, gear/pinion, bolt/nut, etc. are domestic production.

(d) Control equipment

Control equipment will be imported.

(e) Electric rotaiting machine

Main alternator will be imported.

As to traction motor and auxiliary alternator, component parts will be imported or partial domestic production and assembling. Testing and mounting work will be done by Pakistan Side.

(f) Diesel engine

Diesel engine will be imported. Coupling and mounting work to loco. body will be done at the Locomotive Factory.

(2) 2nd Year

(a) Underframe, bodies and bogie frame

Underframe, bodies and bogie frame are completely domestic production.

(b) Others

Others except (a) are same to 1st year's work.

(3) 5th Years

(a) Various components

Coil spring, radiator core, radiator fan, aux. gear box, bolt/nut, tumbler switch, buzzer, propeller shaft, anti-vibration rubber, blower, etc. are domestic production.

(b) Others

Others except (a) are same to 2nd year's works.

(4) 10 Year

(a) Diesel engine

Assembling/testing and partial manufacturing of parts for diesel engine are domestic work.

(b) Various components

Assembling/testing and partial manufacturing of parts for brake equipment are domestic work.

Electric Cable/wire will be domestic production.

(c) Electric rotating machine

Assembling/test of main alternator is domestic work.

(d) Others

Others except (a) ~ (c) are same to 5th year's work.

5-1-3 Target of domestic production

The domestic production ratio is defined as follows and the target of domestic production was determined:

$$\text{Ratio of domestic production (\%)} = \frac{\text{Price of imported locomotive} - \text{Price of imported parts}}{\text{Price of imported locomotive}} \times 100$$

The target of domestic production on the basis of Tables 5-2 and 5-3 is shown below in the table.

Target of Domestic Production

	Phase I Part 2	Phase II Part 1		Pahse II Part 2
Year of domestic production	1	2	5	10
Ratio of domestic production (%)	20	30	35	50

5-2 Annual Programme of Locomotive Production

On the basis of progressive programme of domestic production, the annual programme of production was established with due consideration of the employment and training of required manpower and learning and mastering of technology. The initial production year is included in Phase I, Part 2 and the 2nd production year and after are included in Phase II, Part 1. It was assumed that the production will reach a 25 units/year level on the fifth year. For details of programme, refer to Chapter 6. "Organization and Operation".

5-3 Transfer of Locomotive Manufacture Technology

The Locomotive manufacture technology will be transferred via documents and personnel. Transfer of technology is planned for the following items this time. But, the transfer of technology for domestic production of parts which will be produced at other factory will be excluded in this project.

5-3-1 Drawings and documents

(1) Assembling drawings

A complete set of drawings for locomotive assembling, wiring, and piping.

(2) Manufacture drawings

A complete set of manufacture drawings for parts to be manufactured in the locomotive manufacturing factory.

(3) Drawings for special tools and jigs

A complete set of drawings for special tools and jigs necessary for manufacturing of locomotive and parts in the factory.

(4) Testing and inspection manual

A complete set of testing and inspection manuals for locomotives and parts manufactured in the factory.

(5) Assembling and manufacture manual

A complete set of manufacture manual for locomotives and parts manufactured in the factory.

(6) Specification of purchased parts

A complete set of specification for parts purchased by the factory.

5-3-2 Manufacturing jigs and special tools

A complete set of manufacturing jigs and special tools (excluding simple jigs and tools) required for locomotive assembling and parts manufacture in the factory.

5-3-3 Training of engineers and apprentices

The technology and arts will be transferred through dispatch of Pakistan engineers and apprentices to foreign country and through dispatch of foreign engineers to Pakistan.

The plan is detailed in 6-4, Training.

Table 5-1 Outline of Progressive Programme of Domestic Production

Item No.	Description \ Phase / Part	Phase I	Phase II		Remarks
		Part 2	Part 1	Part 2	
1	Body Underframe	Partial manufacturing of underframe	Fabrication of underframe	ditto	
	Body	Partial manufacturing of body	Fabrication of body	ditto	
	Piping	All piping works	ditto	ditto	
	Wiring	Wiring works except control cubicle	All wiring works	ditto	
	Assembling	Assembling of whole locomotive	ditto	ditto	
	Painting	Whole painting including under coat	ditto	ditto	
2	Bogie Bogie frame	Partial manufacturing of bogie frame	Fabrication of bogie frame	ditto	
	Assembling	Assembling of bogie	ditto	ditto	
3	Various component Brake equipment	Procurement	ditto	Assembling and partial manufacturing	
	Radiator, Gear, Wheel, Axlebox, etc.	Progressively local production	ditto	ditto	
4	Controlling equipment	Procurement	ditto	ditto	

Item No.	Description \ Phase / Part	Phase I	Phase II		Remarks
		Part 2	Part 1	Part 2	
5	Electrical Rotating machine Main alternator	Procurement of main alternator complete,	ditto	Assembling of main alternator	
	Traction motor Auxiliary alternator	Assembling and partial manufacturing	ditto	ditto	
6	Engine	Procurement of diesel engine complete	ditto	Assembling and partial manufacturing of engine and its accessories	

Note: 1. Abovementioned work shows working contents to be done by Pakistan Railways.

Table 5-2 Parts and Materials of Domestic Production

Category 1

o Start domestic production
* Need for trial production

Parts/Materials		Programme of Domestic Production		Manufacturer
		- 2 years	- 5 years	
Steel plate	Underframe, Carbody, Bogie Frame	o		P.R. (Loco./Factory)
	Cab, Engine Hood, Fuel Tank	o		— do —
	T/M Gear Case	o*		— do —
	Sand Box	o		— do —
	Brake Rigging	o		— do —
	Step	o		— do —
	Hand Rail	o		— do —
	Door	o		— do —
	Water Tank	o		— do —
	Fuel Tank	o		— do —
	Window Sash	o		(Carriage/Factory)
	Cow Catcher	o		(Loco./Factory)
	Air Reservoir	o*		— do —
Forging, Casting & Machining	Coupler	o		P.R. (Moghalpura W/S)
	Buffer	o		— do —
	Coil Spring		o*	— do —
	Brake Shoe	o		— do —
	Shoe Head	o		— do —
	Shoe Cotter	o		— do —

Parts/Materials		Programme of Domestic Production		Manufacturer
		- 2 years	- 5 years	
Forging, Casting & Machining	Axle	o*		HFF and HMC
	Axle Box	o		— do —
	Center Pin	o		— do —
	Aux. Gear Box		o*	Public/Private Sector
	Pully	o		P.R. (Loco./Factory)
	T/M Gear	o*		Public/Private Sector
	Bolt, Nut	o	o*	— do —
Piping, Wiring, etc.	Pipe/Tube	o		Public/Private Sector
	Pipe Joint	o		— do —
	Window Glass	o*		— do —
	Light Fitting	o*		— do —
	Electric Fan	o		— do —
	Packing	o		— do —
	Tumbler Switch		o	— do —
	Buzzer		o	— do —
	Fire Extinguisher	o		— do —
	Gauges/meters	o	o*	— do —
	Rubber Hose	o*		— do —
	Shaped Rubber	o*		— do —
	Filter	o		— do —
Assembling	Wheel Set	o		P.R. (C.D.L. W/S)

Table 5-3 Parts and Materials for Domestic Production

Category 2

o Start domestic production
* by technical Cooperation

Parts/Materials	Programme of Domestic Production		Manufacturer
	- 5 years	- 10 years	
Radiator Core	o*		Private/Public Sector
Radiator Fan	o*		— do —
Proppeler Shaft	o*		— do —
Anti-vibration Rubber	o*		— do —
Electric Cable/Wire		o*	— do —
Main Alternator		o*	— do —
Traction Motor	o*		— do —
Auxiliary Generater	o*		— do —
Air Brake Equipment		o*	— do —
Diesel Engine		o*	— do —
Blower	o*		— do —

5-4 Domestic Production of Parts

In this report, the domestic production of parts have been determined as to the type of parts and the target year, but to realize this objective, the following must be carried out:

(1) That the parts, when domestically produced, are properly priced and competitive.

(2) That the performance and quality of the domestically produced parts are satisfactory as ascertained through test and trial use of produced parts.

(3) Where technical cooperation is required, the selection of the cooperator and negotiations.

(4) Selection of the manufacturer of the domestically produced part and establishment of a concrete schedule.

CHAPTER 6. CONSTRUCTION PLAN OF LOCOMOTIVES MANUFACTURING FACTORY

6-1 Presupposition and Outline of the Plan

6-1-1 Function of the factory

The function of the locomotive manufacturing factory is manufacturing and assembling of diesel-electric locomotives and of electric locomotives in the future. To achieve this purpose, following major facilities will be incorporated into the manufacturing factory:

(a) Administrative office

(b) Locomotive manufacturing factory

(c) Jig and tool manufacturing shop and maintenance shop for mechanical and electrical facilities

(d) Material storehouse

6-1-2 Scope of locomotive manufacturing work

One the basis of domestic production target of locomotive in Item 5-1, the scope of locomotive manufacturing work in this factory includes:

(1) Car body and underframe

From cutting, processing, and welding of steel materials to final assembling and painting of locomotives

(2) Bogie

From cutting, processing, welding, fabricating, annealing, and machining of steel materials to final assembling of bogies.

(3) Traction motor and wheel set

Assembling to bogie

(4) Wiring and piping

From cutting and processing of wiring and piping material to installation to locomotives.

(5) Engine and main alternator

Coupling, centering, and installation to locomotives.

(6) Auxiliary generator, controller, brake equipment, and radiator installation to locomotives.

(7) Overall assembling, adjustment, inspection, and test run of locomotives.

6-1-3 Scope of auxiliary work

The scope of auxiliary work of this factory includes:

(1) Maintenance of mechanical and electrical facilities of the factory and of buildings.

(2) Manufacturing and repair of jigs, tools, and fixtures used in the manufacturing of locomotives.

(3) Receiving and distribution of electric power

(4) Generation of acetylene gas and compressed air

(5) Receiving of natural gas

(6) Treatment and distribution of feed water

(7) Treatment and recycling of effluent from work

(8) Sewage disposal

(9) Refuse incineration

6-1-4 Scale of the factory

The locomotive manufacturing factory will have a capacity of manufacturing 25 units of locomotives in a year on a single- shift base work system, as described in Chapters 4 and 5. The final assembling and furnishing shop of locomotive in the factory will have sufficient space in order to meet increasing number of locomotives produced in the future.

In this plan, it was assumed that the manufacturing facilities are sufficiently cope with the increased number of locomotives in the future if the two-shift base work system is introduced in the works from cutting steel materials to assembling it in block and the works of machining. This plan was considered really rational from viewpoint of minimum in-house facilities because the highest efficiency could be achieved with minimum machining facilities which is normally required the large number of machines and plants.

6-1-5 Material storage capacity

The capacity of storehouse and outdoor stock yard for material storage will have a capacity to cope with the locomotive manufacturing for about one year.

Engines, electric equipment, auxiliary equipment, electric wires, pipes, thin steel plates, and interior outfits will be stored indoors. The storehouse is planned to have the overhead travelling crane to handle heavy items like engines, etc.

Thick steel plates and shaped steels will be stored in the outdoor stock yard which is to be equipped with the 15-ton yard crane.

Since increase of stored quantity of materials causes to increase stocks and spaces to store, and to raise storing cost, it is advisable to minimize the increase as much as possible.

6-2 Locomotive Manufacturing Factory Plan

6-2-1 Location of the factory

As shown in Fig. 6-1, the factory will be located in the Barabandah Area about 12 km north of Nowshera. Details of the factory and surrounding environment are shown in Fig. 6-2.

6-2-2 Factory layout plan

The factory will be constructed along the existing main railway line, with the siding track to be branched from the main line into the factory. The factory yard will be sized while avoiding infringement and shift of existing 66 kV power transmission line and SUI gas line and securing sufficient allowance for future expansion.

As shown in Fig. 6-3, the land on the north and south side of the factory will be alloted for the staffs and officers' colony and the land outside of the west boundary wall will be kept to allow for future expansion. Besides, this plan secures a sufficient space for future construction of factory facilities on the west side of main workshop building inside the factory. Due consideration is also paid on the track arrangement for future expansion.

The access ways for factory employees and material transport vehicles are planned so that they can access to the center of the factory directly from the existing national road and the administrative office, employees' canteen, rest shelter, clinic, etc. are planned adjacent to the main workshop building so as to decrease the walking distance as much as possible.

(1) Work flow of locomotive manufacturing

To minimize parts handling frequency and transport distance in the main workshop building as well as to ensure straight work flow, the work method to transport carbody and underframe using overhead travelling crane is adopted.

Fig. 6-4 shows the work flow of locomotive manufacturing in the main workshop building. Namely, the main building is made up from three buildings and the central building contains steel plate processing and block fabrication shop, machining shop, and parts storehouse.

The parts flow is from this central building to the assembling building on each side.

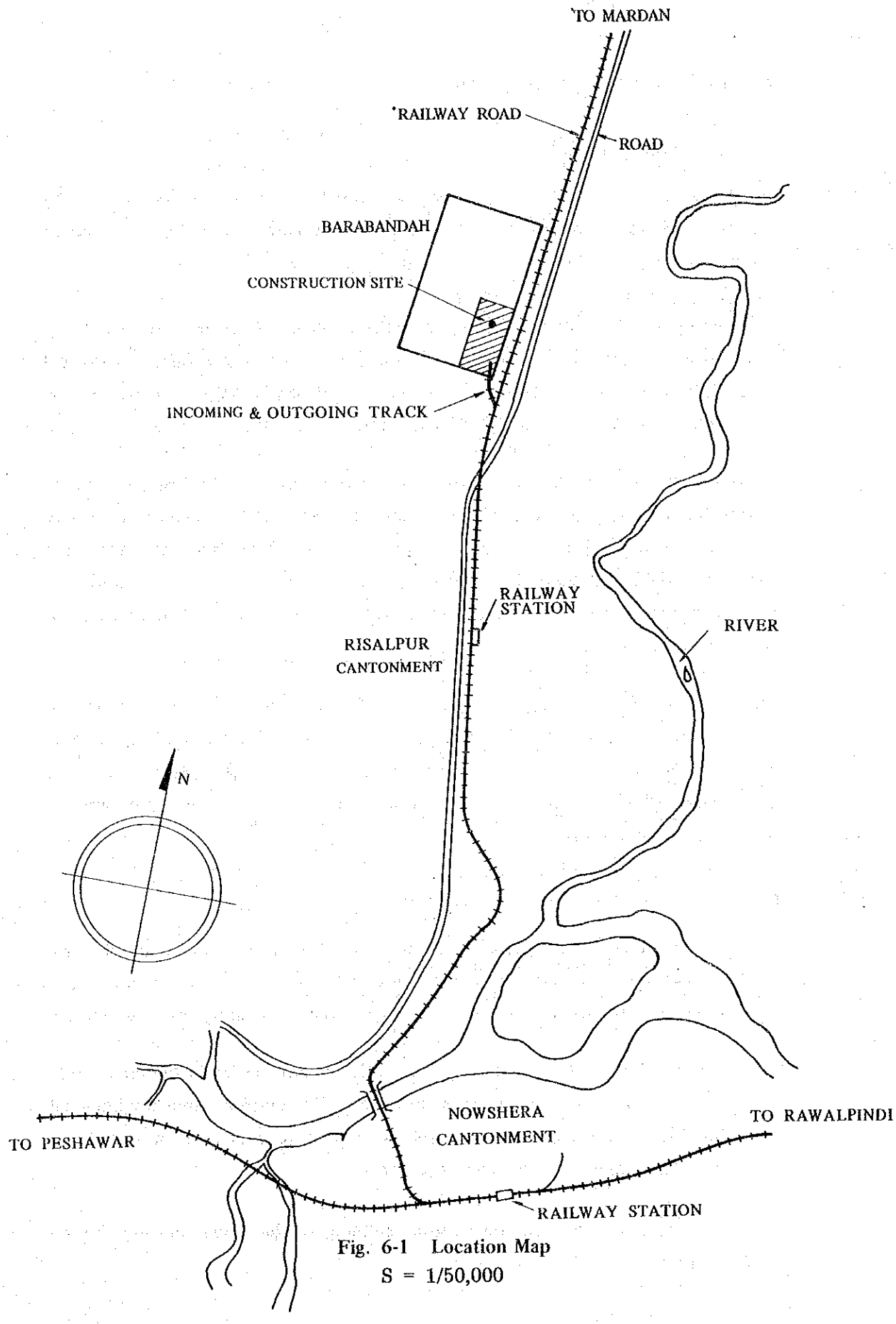


Fig. 6-1 Location Map
S = 1/50,000

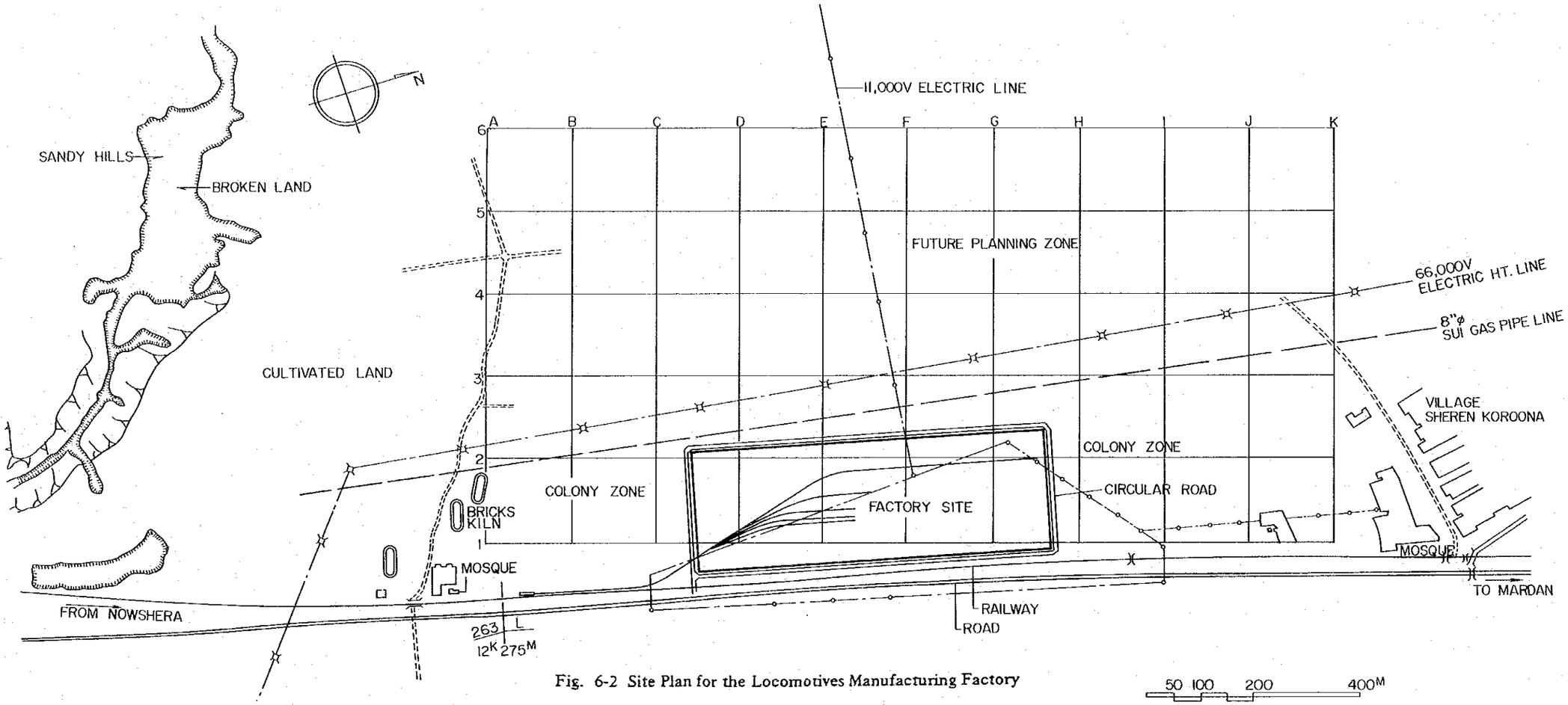


Fig. 6-2 Site Plan for the Locomotives Manufacturing Factory

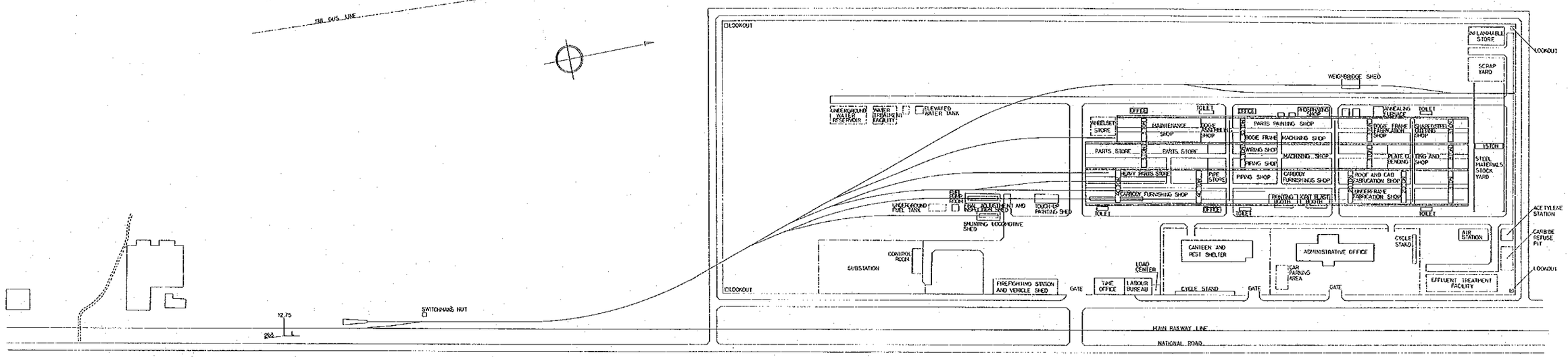


Fig. 6-3 General Layout Plan

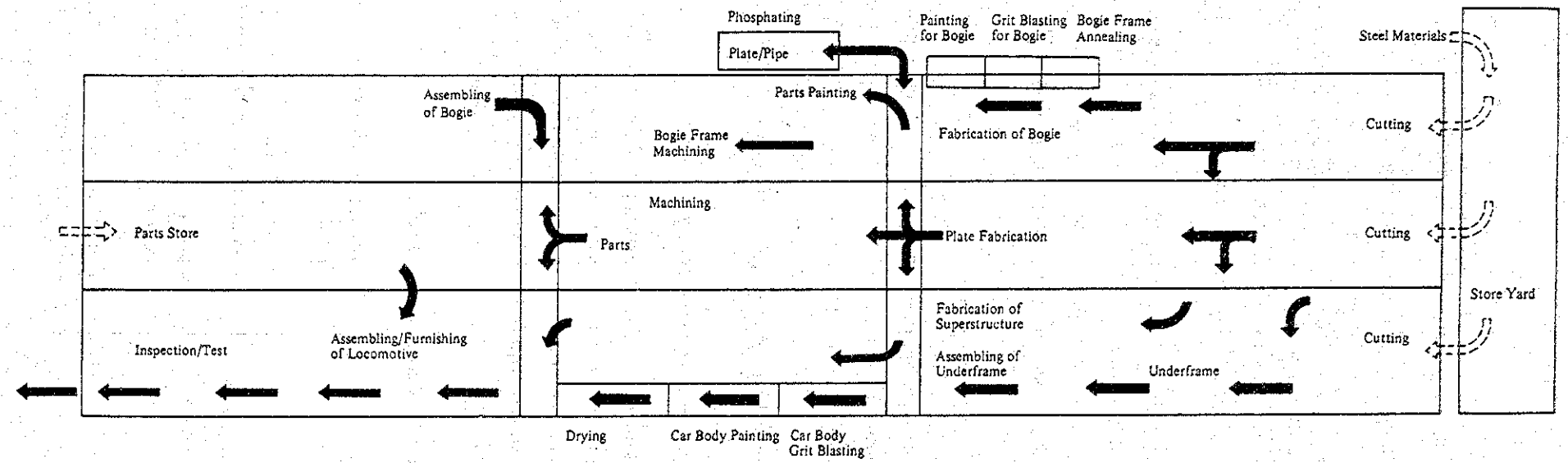


Fig. 6-4 Locomotive Manufacturing Flow Diagramme

(2) Presuppositions for determination of scale of facilities

(a) Main building for manufacturing locomotives

As described in 6-1-4, the factory main building is planned to have a capacity of manufacturing 25 units in a year on single-shift base work system. The locomotive final assembling and furnishing shop is planned to be able to accommodate 12 units of locomotives.

The main building is made up from three buildings, with a total length of 324 m and width of 74 m. Adjacent to the bogie assembling shop in this main building, the jig/tools manufacturing shop and machine maintenance shop are planned to be arranged.

(b) Administrative office

The manufacturing department and pure indirect department will be housed in the administrative office. And this office will be located adjacent to and parallel with main workshop building for convenience of going and coming to and from outside of the factory and of communication between office side and workshop side.

(c) Apprentice training facility

Training facilities of existing training institute of the Pakistan Railway and other public institutes will be expanded and improved to provide graduates from the governmental and Pakistan Railways' training institutes with special technologies required for manufacturing of locomotives.

Details of training are as follows:

Basic Exercise
- Mechanical (Machining, lathe, milling machine, shaper)
- Welding, plate working (semi-automatic welding, gas cutting, shearing of steel plate)
- Electric rotating machine (terminal processing, assembling and tightening)
- Inspection, test (exercise for electric circuit, measuring technology)

(d) Others

In addition to the above, the scale of the employees' on-duty/off-duty control facility, welfare facilities like canteen, rest shelter, clinic, etc., garage, and storehouse will be determined according to the number of employees and the manufacturing number of locomotives.

(3) Facility scale

On the basis of the layout plan in Fig. 6-3, the scale of facilities is outlined below.

a)	Land area	154,100 m²
b)	Building floor area by use	
	Main workshop	23,382 m²
	Auxiliary workshop	1,275 m²
	Storehouse	570 m²
	Office	4,726 m²
	Welfare facilities	1,527 m²
	Power room (including water treatment)	716 m²
	Garage	819 m²
	Others	25 m²
	Total	33,040 m²
c)	Track	
	Indoor track	840 m²
	Outdoor track	2,100 m²
	Turnout	10 m²

6-2-3 Main facility plan

(1) Machinery and plants

(a) Machinery and plants for locomotive manufacturing

Machinery and plants for locomotive manufacturing are listed below:

(i) Machines for cutting, forming, and machining of steel plate and shaped steel.

(ii) Welding jig for block assembling of carbody and underframe.

(iii) Machining facility for bogie frame and underframe.

(iv) Steel plate surface treatment facilities (phosphating treatment, grit blasting, painting, drying, etc.).

(v) Inspection and test facilities (magnaflux flaw detection, ultra sonic flaw detection, electric test).

(vi) Overhead travelling crane, transport machine, dummy bogie.

(b) Auxiliary machine

Machines and plants indirectly related to the locomotive manufacturing in the general work of the factory are listed below:

(i) Machinery for the maintenance of mechanical and electrical facilities as well as for manufacturing and repair of tools and jigs.

(ii) Machinery for transportation within workshop and for material handling.

(c) Utility service facilities

(i) Natural gas pipeline facility

Gas pipeline for heating will be branched off from the existing low-pressure SUI gas line. The pipeline will be laid underground outside of the building and above inside of the building.

(ii) Acetylene gas station and pipeline

Acetylene gas pipeline for gas cutting of steel plate and steel materials will be laid from the station to each workshop underground outside of the building and above inside.

(iii) Air compressor and air pipeline

These will be provided to supply compressed air for work. Air pipeline will be laid underground outside of the building and above inside.

(iv) Deep well

Groundwater will be used as industrial water. Water will be stored in the underground water reservoir and elevated water tank. These tanks will have a capacity to feed water to the colony. The quality of groundwater is not suitable for drinking, then the water treatment facility will also be provided.

(v) Effluent treatment and recycling facility

To save water resource, industrial water will be recycled.

(2) Civil engineering and building

(a) Track

(i) Rolling stock and construction gauge

The rolling stock and construction gauge to be applied to the plan of various factory facilities will be as shown in Fig. 6-5.

(ii) Formation level

The height of the top of rail will be 400 mm from the formation level. To construct the road bed.

(iii) Track center distance

The minimum track center distance will be 5 m or more in the factory.

(iv) Minimum radius of curvature

Minimum radius of curvature of track will be 300 m in the factory.

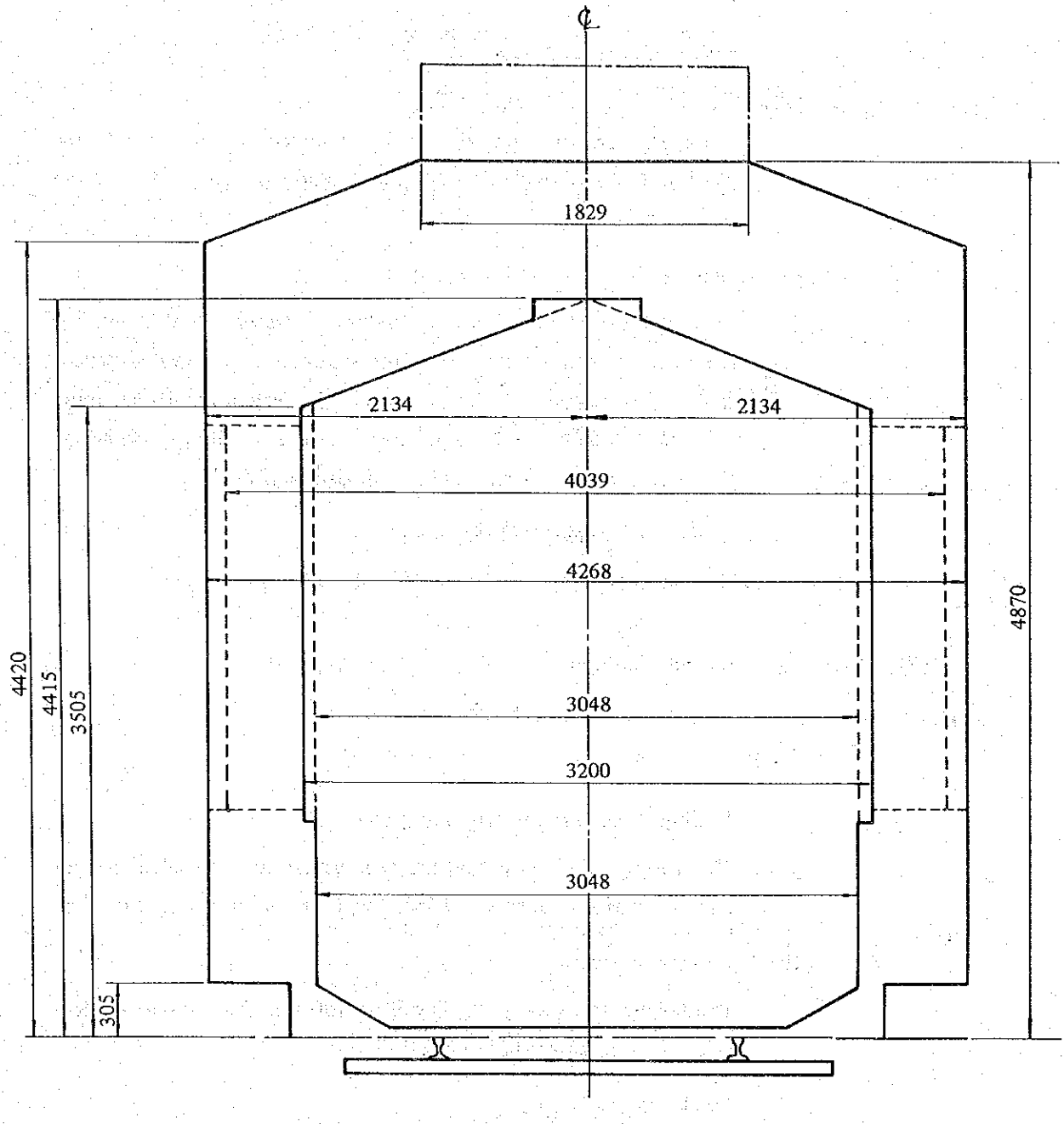


Fig. 6-5 Rolling Stock and Construction Gauge

(v) Track structure

Standard track structure will be of crushed stone ballast, with concrete sleepers and 37 kg/m rails. The ballast thickness will be 15 cm.

(vi) Turnout

Turnout No. 12 will be used for branching off from the main line, and No. 8 1/2 will be used for factory siding track. These are simple turnout operated by the switch box with weighted lever.

(b) Civil engineering

(i) Drainage

Rainwater will be directly discharged into rivers from the underground drainage.

(ii) Feed water pipe

Industrial water will be distributed from the elevated water tank, via underground pipe, to each consumption point.

(iii) Boundary wall

The factory will be separated from the outside with the brick wall.

(iv) Inspection pit

The inspection pit with side pit will be provided to the locomotive final assembling track, final adjustment and inspection shed for assembled locomotive, and shunting locomotive shed.

(v) Road

Paved roads will be provided in the yard, between buildings and around the factory. The roads surrounding factory will separate factory from the colony.

(vi) Workshop buildings

The main workshop building and auxiliary workshop building will be principally of steel construction, with the floor of pressure strength appropriate for each use. The wall will be principally of

reinforced concrete or brick construction. The shop with possible noise generation will be of noise proof and noise shield construction and the shops where fine dust should be avoided will be of closed construction. These shops will be isolated from other shops.

Heat insulation material will be used in a roof structure as a countermeasure against high temperature. Materials and work process which require only a limited maintenance cost will be employed.

(vii) Administrative office building and others

The building of the administrative office, welfare facilities, and power room will principally be of reinforced concrete or brick construction, and materials to be used will have a sufficient strength appropriate for use. The administrative office and substation control room will be equipped with the air conditioning system.

(viii) Foundation

The construction and work process for building foundation and machine foundation will be determined after measurement of bearing force of ground by boring.

(3) Site electrical systems

Electric power of dual feeder, 50 Hz, three phase, 132 kV will be received from the power transmission lines of WAPDA in view of stability and reliability of power services to the factory facilities.

A substation will be provided to interface with the WAPDA and to step-down received 132 kV power to 11 kV for distribution in the factory. Load centers will be also provided in the local electric rooms and the main workshop building, where, distributed 11 kV power will be stepped-down to low voltage (3-phase, 230-Y/400 V) for utilization.

(a) Substation facilities

(i) Dual banks of 3 phase, 132 kV equipment will be provided to supply power from one circuit if the other may fail/shunt-down.

(ii) The substation facilities will comprise 132 kV power receiving equipment, power transformers, 11 kV power distribution equipment, and related auxiliary equipment in dual bank systems.

(iii) 132 kV equipment and power transformers will be installed outdoor and relay panels, distribution panels and operation panels will be installed in the substation building.

(iv) The operator(s) will be assigned to the substation for monitoring and operation of the power systems and switchgears.

(b) Power distribution lines

(i) High voltage power distribution lines in the factory will be of 11 kV, three phase, three wire, 50 Hz; and will make up a ring circuit which can cope with electrical outage/shut-down of power transmission systems of the WAPDA or failure of power distribution systems of the factory. High voltage power distribution lines will be installed within underground duct banks and will supply power to each load center.

(ii) Low voltage power distribution lines utilizing for each building, machinery and exterior lights will be of underground cabling system and will be installed within concrete trough, duct bank or directly burial system. Electric systems of the low voltage distribution lines will be of 230-Y/400 V, 50 Hz, 3 phase, 4 wires.

(c) Load centers

Load centers will be provided as utilizing access equipment comprising distribution transofrmers, distribution panel(s) and auxiliary equipment; and will step-down 11 kV distributed power to low voltage.

(d) Standby generator

In the case of electrical outage or shut-down on the commercial power systems, standby generator will be provided to supply power to heavy duty equipment for administration, safety and security, exterior security lights and fire fighting and alarm equipment of the factory. The generator will be of diesel engine driven alternator of which electric systems will be 230-Y/400 V, 50 Hz, 3 phase, 4 wires.

(e) Site lighting systems

Site lighting will be made by pole-mounted lights, and will be provided to ensure traffics of vehicles and workers, outdoor light works and security of the factory site.

(4) Telecommunication facilities

Telecommunication facilities will be provided to make efficient administration and communications in the factory, and will consist of telephone system, public address system, master clock system and fire alarm system.

(a) Telephone systems

(i) PABX and telephone system

Electronic private automatic branch exchanger (EPABX) and extension telephones will be installed to communicate with inter-offices of the factory or between a officer and an external general subscriver. EPABX equipment will be installed in the telecom. equipment room of the administrative building. And extension telephone sets will be installed in each office and key points of the factory yard for security to communicate between guard station and a patrolling guard.

(ii) Train operation telephones

As the siding track to the factory is branched off from the railway main line between Risalpur and Rashkai, train operation dispatch/block telephones will be installed at the both stations, turnout switchman hut and administrative office to ensure train operation and blocking of this section.

(b) Public address system

Public address system will be provided as an announcing system in general use; and also be provided to dispatch patrol men, in case of emergency. This system will consist of amplifier, operation panels, microphones and speakers. Amplifier will be installed in the telecom. equipment room, operation panels in the administrative office and guard station, and speakers in the offices, workshops and outdoor.

(c) Master clock system

Master clock system will be provided to unify and keep working time schedule, and will consist of a master unit installed in telecom. room and slave clocks installed in each office, workshop and outdoor.

(d) Fire alarm system

Fire alarm system will be linked with fire fighting equipment. The centralized alarm panels will be installed in the fire station and guard station, and each building will be equipped with receiving panel and alarm bell(s). Each office and workshop will have fire detectors and/or alarm pushbutton.

(5) Branching facilities for the siding track to the factory

To branch off the siding track to the factory, the dual switching type manual operation turnout will be installed on the railway main line, as shown in Fig. 6-3. The turnout switchman will be assigned and a switchman hut will be provided to operate the turnout. In addition to the switching, the switchman will be responsible for issuing and receiving the token ticket of the line-clear and making departure signal to the engine driver of a train under communication with dispatchers at the adjoining both stations of the main line, and administrative office of the factory through the train operation telephones.

6-2-4 Additional facilities for future manufacturing of electric locomotives

As for the additional facilities for manufacturing electric locomotives in the future, manufacturing facilities of locomotives are same as that of diesel electric locomotives, but the following facilities for testings after assembling, that is, trial run, inspection, and adjustment will be newly required.

(1) Trial run track

As shown in Fig. 6-6, the trial run track will be laid along the existing railway main line. About 1,000 m will enough for effective length.

(2) Overhead contact lines

Overhead contact wires will be installed on the trial run track, the approach tracks from final adjustment and inspection shed to the trial run track, and the inspection track in the inspection shed. A disconnecting switch will be provided to isolate the contact wires in the shed and outdoor. Total length of the contact wires will be assumed 1,400 meters approximately.

(3) Substation for propulsion power supply

The substation will be provided to supply propulsion power of single phase 50 Hz, 25 kV to overhead contact wire system for test running of manufactured electric locomotives. A propulsion power transformer will be installed and connected to a 132 kV primary feeder of a power transformer of the primary substation. Propulsion substation will be located in the primary substation yard or in a spare lot near the electrifying tracks.

(4) Final adjustment and inspection shed

This inspection shed will be constructed in this project. The building height and access way height are determined to be able to provide overhead contact wire for the future plan of electric locomotive manufacturing. In the future, the hanging scaffolds will have to be provided to carry out adjustment, inspection, and test of roof-mounted equipment (pantograph, etc.) of electric locomotives.

6-3 Organization and Operation

6-3-1 Organization

(1) Policy of organization

The organization of locomotive factory was determined as follows to ensure the maximum function as an independent manufacturing factory.

(a) The entire organization will come under the control of general manager.

(b) The organization is divided into the line division and the staff division.

(c) The inspection and testing section will come under the direct control of general manager.

(d) The maintenance section in charge of maintenance of factory's facilities and machines will be established.

The governmental training school is used for the training of apprentice. No particular training institute will be provided to the factory.

(2) Organization

Fig. 6-7 Organization for Locomotive Factory, shows the organization chart prepared on the basis of above policy.

6-3-2 Personnel

(1) Calculation of required manpower

The required manpower was calculated as follows:

(a) Direct manpower

The number of direct manpower is calculated using the following equation:

$$\frac{\text{(Production units) x (Production time required per unit)}}{\text{Man-hour per person}}$$

For the production time required per unit, the productivity estimated for carriage in foreign country and Pakistan was used.

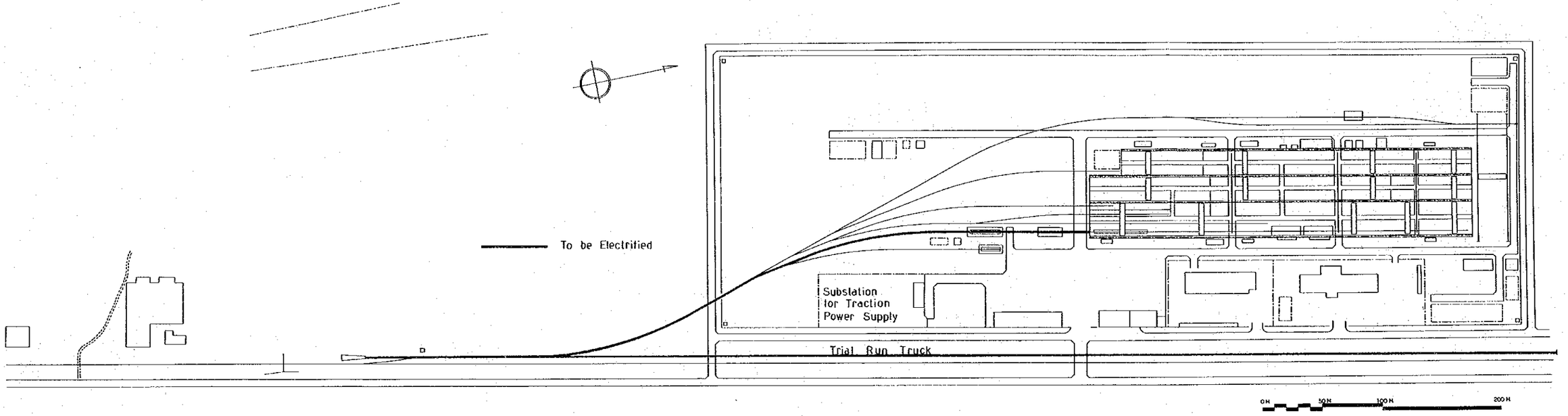


Fig. 6-6 Additional Facilities for Manufacturing of Electric Locomotive

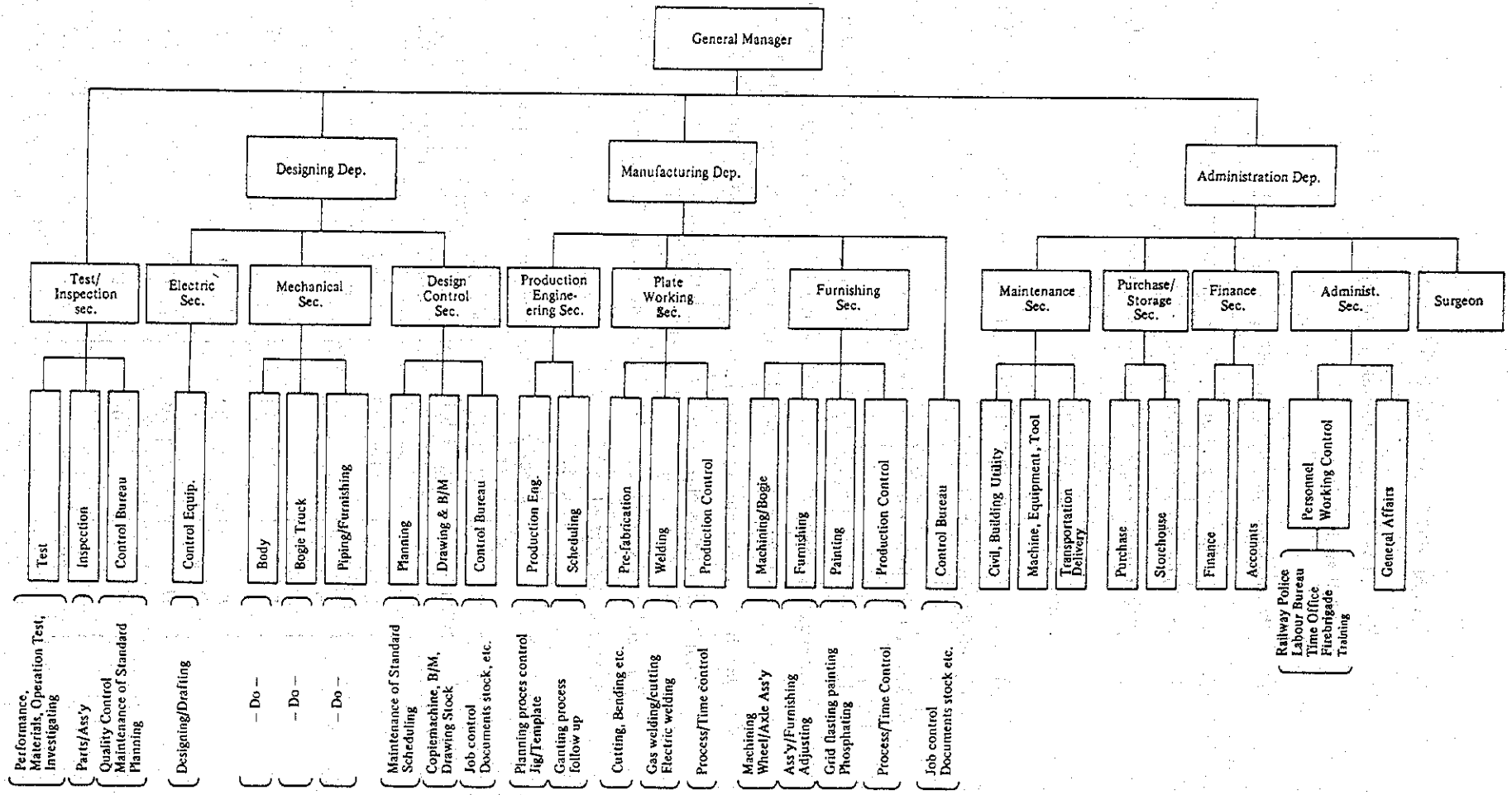


Fig. 6-7 Organization for Locomotive Factory

(b) Manpower of administrative division;

The personnel of administrative division was determined on the basis of job analysis.

(c) Manpower at production startup

The manpower at a production startup will require more compared with stabilized production condition.
This calculation is estimated for production result of carriage Factory.

(2) Calculation of manpower

The manpower was calculated from the above (1) and six grades (S, A, B, C, D, and E) were determined.

The calculation shows 889 workers for 25 units/year.

Table 6-1 "Personnel for Locomotive Factory" shows the manpower of the factory, Tables 6-2 "List of Staff/Labour" the manpower for each depatment and section, Table 6-3 "Number of Engineers by Speciality" the engineers classified according to specialties, and Table 6-4 "Number of Artisans by Trade" the artisans classified according to trades.

For information, Table 6-5 "Personnel for Locomotive Factory/Carriage Factory" is attached.

Table 6-1 Personnel for Loco. Factory

Grade	R.N.S.P.	Out-turn 25 No.s/year		
		Staff	Labour	Total
S	20 - 21	2	-	2
A	18 - 19	13	-	13
B	15 - 17	27	-	27
C	11 - 14	78	-	78
D	5 - 10	125	356	481
E	1 - 4	175	113	288
Grand Total		420	469	889

Table 6-2 List if Staff/Labour (1)

(Out-Turn 25 No.s/Year)

No.s of persons	Staff and establishment							Labour			Total
	S	A	B	C	D	E	Total	D	E	Total	
1. General Manager	1						1				
2. Administration Dept.		1					1				
Surgeon		1	1		7	5	14				
Administration Sec.		1					1				
General Affairs			1	2	4	13	20				
Personnel Working Control											
Firebrigade				1	9	10	20				
Time Office				1	4	5	10				
Labour Bureau			1	2	4	3	10				
Railway Police				1	5	14	20				
Training				1	2	1	4				
Finance Sec.		1					1				
Account			1	3	7	9	20				
Finance			1	2	4	3	10				
Purchase/Storage Sec.		1					1				
Storehouse			1	2	4	18	25				
Purchase			1	2	5	2	10				
Maintenance Sec.		1					1				
Transportation			1	2	7	12	22				
Delivery											
Machine Equipment, Tool			1	2	3	10	16				
Civil Building Utility			1	2	3	10	16				

Table 6-2 List if Staff/Labour (2)

(Out-Turn 25 No.s/Year)

No.s of persons	Staff and establishment							Labour			Total
	S	A	B	C	D	E	Total	D	E	Total	
3. Manufacturing Dept.	1						1				
Control Bureau			1	1	3	5	10				
Furnishing Sec.		1					1				
Production Control			1	4	4	3	12				
Painting			1	1	2	2	6	19	6	25	
Furnishing			1	6	2	3	12	106	34	140	
Machine/Bogie			1	3	2	2	8	43	16	56	
Plate Working Sec.		1					1				
Production Control			1	4	4	4	13				
Welding			1	5	3	3	12	115	33	148	
Pre-fabrication			1	5	3	3	12	73	27	100	
Production Engineering Sec.		1					1				
Scheduling			1	3	3	3	10				
Production Eng.			1	6	6	3	16				

Table 6-2 List if Staff/Labour (3)

(Out-Turn 25 No.s/Year)

No.s of persons	Staff and establishment							Labour			Total
	S	A	B	C	D	E	Total	D	E	Total	
4. Designing Dept.		1					1				
Design Control Sec.			1				1				
Control Bureau				1	2	2	5				
Drawing & B/M				1	2	3	6				
Planning			1	1	1	2	5				
Mechanical Sec.		1					1				
Piping Furnishing				1	2	2	5				
Bogie frame			1	1	2	2	6				
Body			1	1	2	2	6				
Electric Sec.		1					1				
Control Equip.			1	1	2	2	6				
5. Test/Inspection Sec.		1					1				
Control Bureau				2	2	2	6				
Inspection			1	4	5	6	16				
Test			1	4	5	6	16				
Administration Dep.Total	G.M. 1	6	10	23	68	115	223				223
Manufacturing Dep. Total	1	3	10	38	32	31	115	356	113	469	584
Designing Dep. Total		3	5	7	13	15	43				43
Test/Inspection Sec.Total		1	2	10	12	14	39				39
Grand Total	2	13	27	78	125	175	420	356	113	469	889

Table 6-3 Number of Engineers by Specialty

(1) Engineer Classification (Grade A to C)

Divisions	Mechanical	Electrical	Civil engineering & building	Production control	Production technology						Total
					Plate working	Welding	Mechanical	Painting	Assembling	Electrical	
Design	7	3									10
Inspection	5	6									11
Production engineering				12							12
Manufacturing division				10	7	6	4	2	7	2	38
Maintenance	3	2	2	3							10
Total	15	11	2	25	7	6	4	2	7	2	81

(2) Grade/Specialty (Engineer)

		Years of experience		
		Graduate of University	Graduate of College	Graduate of Vocational shcool
Grade A	R.N.S.P. (18 - 19)	15 -	20 -	-
Grade B	R.N.S.P. (15 - 17)	7 -	15 -	-
Grade C	R.N.S.P. (11 - 14)	2 -	5 -	8 -

Table 6-4 Number of Artisans by Trade

(1) Number of artisans

Trade		Out-turn 25 No.s/year		
		D	E	Total
Plate work	Preparation	73	27	100
Welding	Welding	61	13	74
	Welding assembling	54	20	74
Sub Total		188	60	248
Assembling	Wiring	37	12	49
	Piping	37	12	49
	Assembling (Body, Bogie)	32	10	42
Painting		19	6	25
Mechanical		43	13	56
Sub Total		168	53	221
Total		356	113	469

(2) Qualification of artisans by grade

Grade	Year of experience		Note
	Graduate of high school	Graduate of middle school	
D	5 —	10 —	R.N.S.P 5 — 10 Skilled Labour
E	1 —	1 —	R.N.S.P 2 — 4 Semi-skilled Labour R.N.S.P 1 Un-skilled Labour

Table 6-5 Personnel for Loco. Factory/Carriage Factory

	P.R. P.C.1 Proforma Loco factory	JICA F/S Locomotive Factory	Carriage factory
Planned out-turn per year	25 Locos	25 Locos	150 Cars
Skilled labour	320 (58.2%)	356 (75.9%)	1,357 (58.6%)
Semi-skilled labour	—	113 (24.1%)	593 (25.6%)
Un-skilled labour	230 (41.8%)		366 (15.8%)
Total labour	550 (100.0%)	469 (100.0%)	2,316 (100.0%)
Labour	550 (56.6%)	469 (52.8%)	2,316 (83.2%)
In-direct section	421 (43.4%)	420 (47.2%)	469 (16.8%)
Total	971 (100.0%)	889 (100.0%)	2,785 (100.0%)

(3) Calculation of manpower at production startup

The personnel for the locomotive factory was determined on the assumption that the skillness (for total manpower of staff and labour) at production startup was 80% in the Carriage Factory.

	Year	1	2	3	4	5	6	7	8
	Production	5	8	10	16	25	25	25	25
Manpower	Labour	300	500	500	597	673	548	493	469
	Staff	315	320	340	370	420	420	420	420
	Total	615	820	840	967	1,093	968	913	889

Fig. 6-8 Personnel of Loco. Factory (Out-Turn 25 Nos./Year)

Fig. 6-9 Out-Turn of Loco. Factory (Out-Turn 25 Nos./Year)

Fig. 6-10 Stuff Position of Carriage Factory Islamabad (Administration & Workshop Combined)

Fig. 6-11 Out-Turn record of Carriage Factory Islamabad

Fig. 6-12 Study of Productivity in Loco. Factory (Out-Turn 25 Nos./Year)

Fig. 6-13 Study of Productivity in Carriage Factory

Details are shown in the above Figures.

Year	Labour	Staff	Total
1	300	315	615
2	500	320	820
3	500	340	840
4	597	370	967
5	673	420	1,093
6	548	420	968
7	493	420	913
8	469	420	889

Personnel

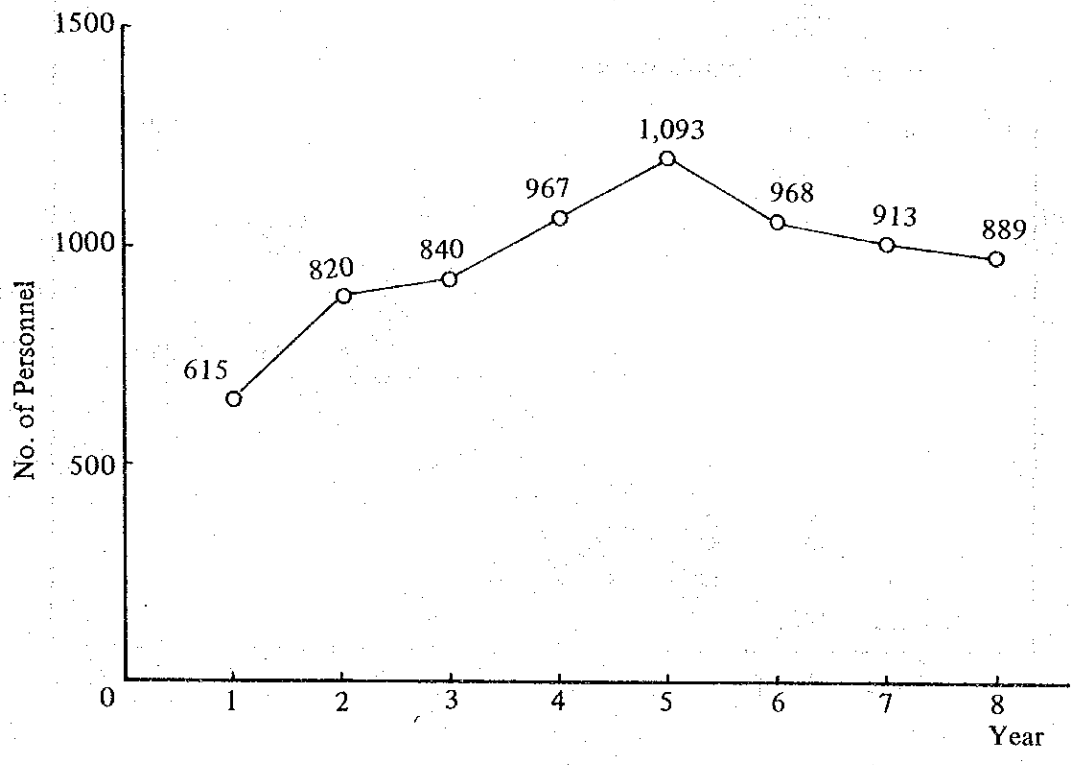


Fig. 6-8 Personnel of Loco. Factory
(25 No.s/Year)

Year	Out-turn	Cumulative No.s
1	5	5
2	8	13
3	10	23
4	16	39
5	25	64
6	25	89
7	25	114
8	25	139

Out-turn

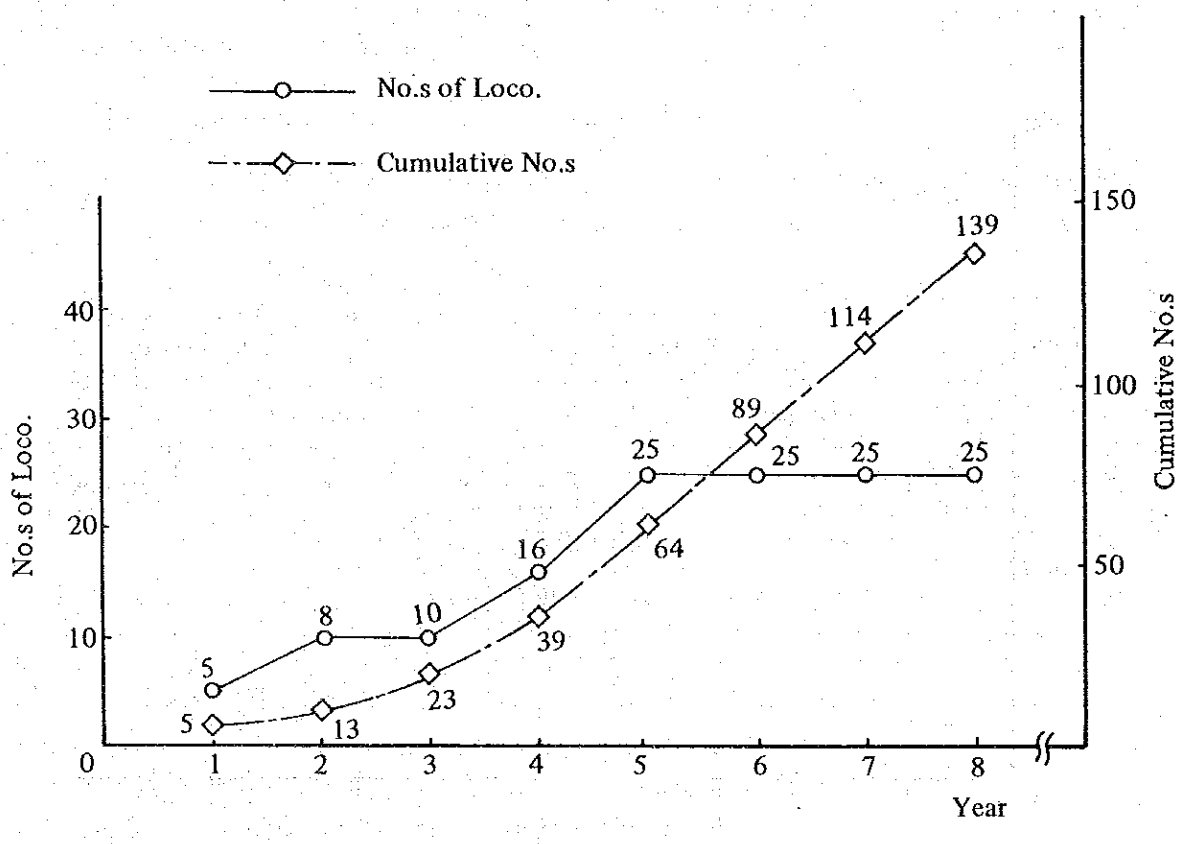


Fig. 6-9 Out-turn of Loco. Factory
(25 No.s/Year)

S.No.	Year	Sanction Strength	On roll
1	December, 1971	934	628
2	December, 1972	1107	791
3	December, 1973	1135	833
4	December, 1974	1135	845
5	December, 1975	1954	1658
6	December, 1976	2862	2200
7	December, 1977	3930	2251
8	December, 1978	3930	2670
9	December, 1979	4250	2680
10	December, 1980	4037	2817
11	December, 1981	4037	2847

Staff Position On-roll

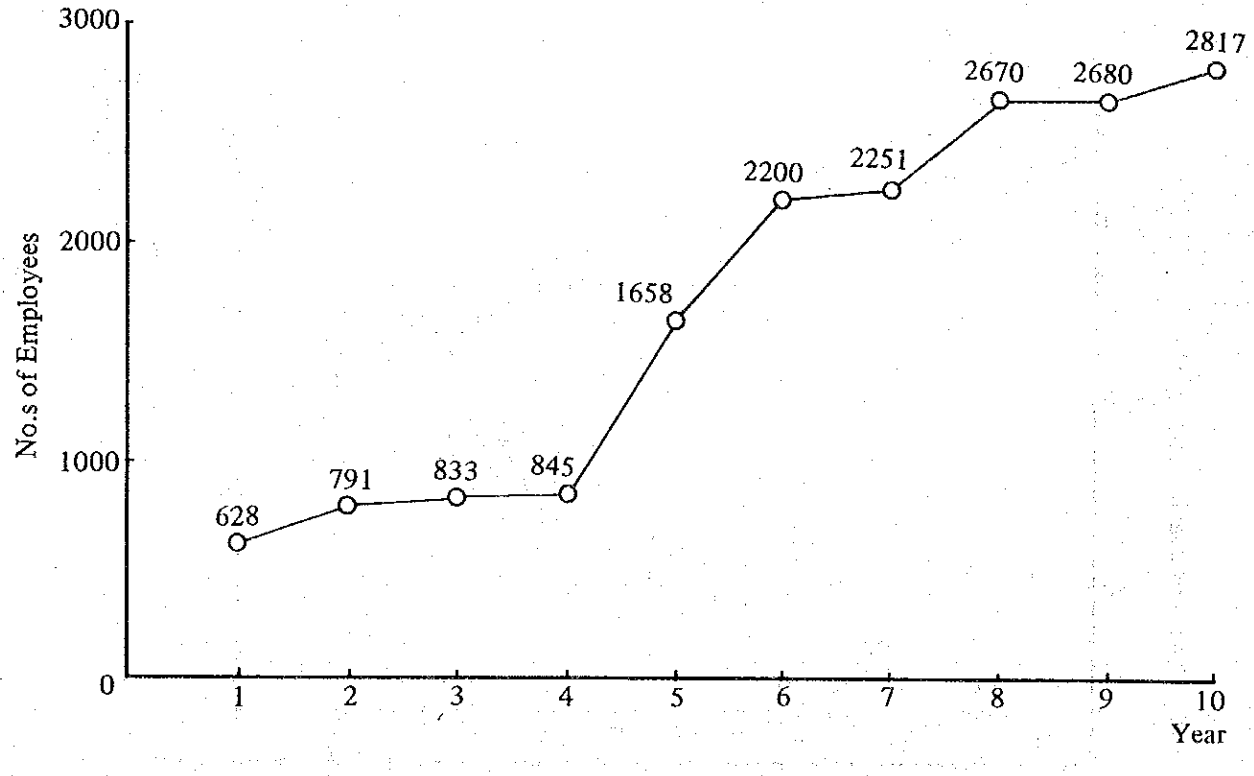


Fig. 6-10 Staff Position of Carriage Factory Islamabad
(Administration & Workshop Combined)

Year	P.R. Carriages Out-turn of carriage factory	*Moghalpura workshops	B.R. carriages
1971-72	13		
1972-73	24		
1973-74	13		
1974-75	52		
1975-76	55	25	
1976-77	100	25	
1977-78	75	25	25
1978-79	43	44	107
1979-1980	135 (Physical O/Turn 102) P/Car 8=32 P/Van 3=12	44	27
1980-81	104 (Physical O/Turn=95) WFCN = 1.2 WGS	10	22
1981-82	103 (Upto the end of March)	5	TPP

* Out-turn of carriage Factory is 50%

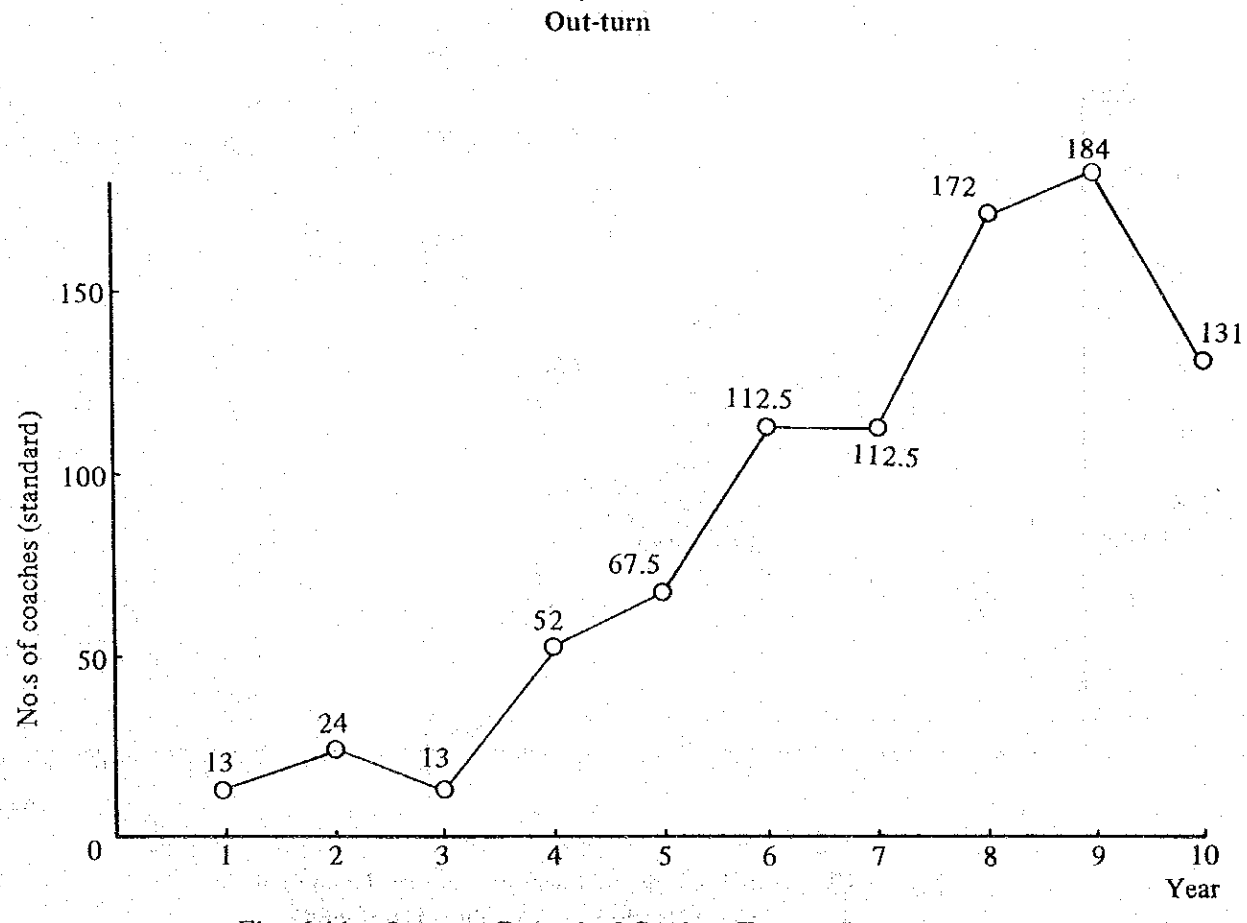


Fig. 6-11 Out-turn Record of Carriage Factory Islamabad

(1) Out-turn/Personnel

Year	Out-turn		Personnel		Personnel Out-turn C=(B)/(A)
	No.s/ Year	Cumulative (A) No.s	No.s/ Year	Cumulative (B) No.s	
1	(5)	(5)	(615)	(615)	(123)
2	8	8	820	820	102.5
3	10	18	840	1,660	92.2
4	16	34	967	2,627	77.3
5	25	59	1,093	3,720	63.1
6	25	84	968	4,688	55.8
7	25	109	913	5,601	51.4
8	25	134	889	6,490	48.4

(2) Learning Curve

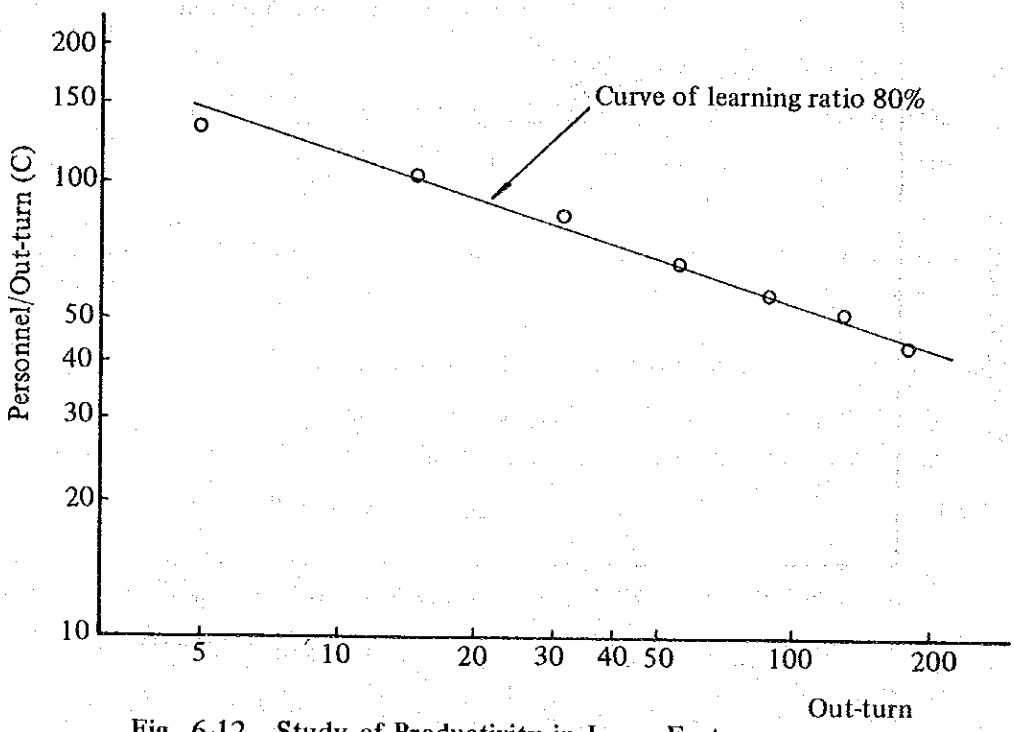


Fig. 6-12 Study of Productivity in Loco. Factory (Out-turn 25 No.s/Year)

Learning Analysis of Carriage Factory Islamabad

Year	Out-turn		On-roll		On-roll/ Out-turn C=(B)/(A)
	Nos./year	Total (A)	Nos./year	Toal (B)	
1	13	13	628	628	48.3
2	24	37	791	1,419	38.4
3	13	50	833	2,252	45.0
4	52	102	845	3,097	30.4
5	67.5	169.5	1,658	4,755	28.0
6	112.5	282	2,200	6,955	24.6
7	112.5	394.5	2,251	9,206	23.3
8	172	566.5	2,670	11,876	20.9
9	184	750.5	2,680	14,556	19.4
10	131	881.5	2,817	17,373	19.7

Lerning Curve

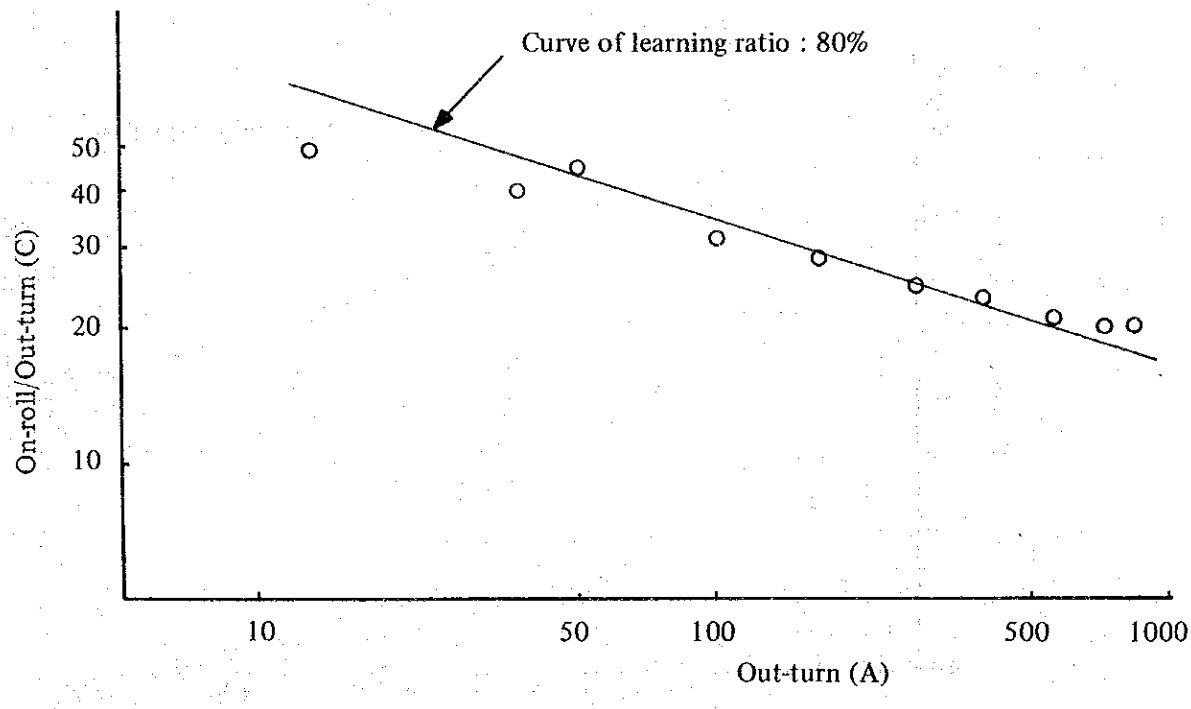


Fig. 6-13 Study of Productivity in Carriage Factory

The organization and manpower plans may not be parfect, though that were determined on the basis of actual state of Pakistan. It is essential that the officials of Pakistan Railways undertake in-depth study on the plan.

6-3-3 Operation

(1) Operation at a production startup

Pakistan Railways is advised to make the preparatory study on the following points:

(a) Preparation of special tools and jigs

Special jigs and tools should be purchased from foreign manufacturers. But the simple tools and jigs should be manufactured beforehand with necessary drawings supplied under the technological agreement with locomotive manufacturer.

(b) Employment and training of personnel

A large number of workers must be employed, and the productivity can be improved through preparatory training. The training will be dealt with in 6-4 and 7-3, Training Programme.

(c) Preparation for arrangement of items to be manufactured outside and purchasing items

For the procurement in Pakistan, preparation of technical specifications for procurement and selection of manufacturer should be done. The parts which need confirmation of performance and trial manufacturing should be selected.

(d) Establishment of production programme and arrangement job

The production control system must be established.

(e) Drawing and manufacturing and testing manual

Under the technological agreement with the locomotive manufacturer, the manufacturing drawings and the manufacturing and testing manuals should be obtained.

(f) Preparation of components for five units for the initial production year

In general, trouble may frequent because of considerable uncertainty in the initial roduction year. It may be reasonable to involve into this project components for five units equivalent to Phase I, Part 2 of this progressive programme of domestic production.

(g) Operation guidance for factory operation

For this project, it was proposed to receive production guidance of specialized engineers of foreign manufacturer for about one and a half year at appropriate time. (See Chapter 7-3 Training Programme). Though not included in this project, the guidance of about three experts will be effective for the entire factory operation for two or three years.

Execution schedule for above mentioned operation program is shown in Fig. 7-1.

(2) Production programme

The yearly production programme is shown in 5-2.

6-4 Training

6-4-1 Training Plan

The Training in the project was planned as follows:

(1) Fostering of training instructors (practice overseas)

Pakistan Railways has already been practising manufacturing of carriages and wagons and repairing and maintenance of locomotives. As to manufacturing a locomotives, instructor in this connection are to be trained abroad since this is a quite new field (for engineer and artisans).

(2) Training for apprentices

For training of prospective skilled labours, the training is to be practised in accordance with the prevailing training of Pakistan Railways in addition to a new field as to manufacturing of a locomotives. Many trainees are to be trained in face of constructing of the locomotive factory.

(3) Retraining for artisans

For those workers who have already trained, and others who have been qualified skill to some extent, the training for them is to promote their skill by having them learned necessary techniques for manufacturing of locomotive in accordance with their degree of skill.

(4) Manufacturing guidance at a time of commencement of manufacturing in the factory

Foreign engineers are to execute manufacturing guidance to manufacture locomotives in Pakistan together with commencement to manufacture in the factory. As to items (2) and (3) above, continuous training is to be done by training schools of Pakistan Government and Pakistan Railways.

Necessary personnel as required when commencement of operation will be some 600 men (inclusive of direct labours, and administrative personnel). Therefore, schematic training schedule is required.

6-4-2 Description of training

(1) Training of apprentices

Engineers and technicians of Pakistan Railways, will be trained and educated overseas. As to details, see Table 6-6.

(2) Training of apprentices

Training for necessary personnel as required by a newly proposed locomotive manufacturing factory, is to be made by existing training facilities in Pakistan Railways.

(3) Production guidance at a time of manufacturing commencement

Production guidance is made by inviting foreign engineers to locomotive manufacturing factory. See details in Table 6-6.

(4) Retraining for artisans

This is subjected to workers who have been trained and those who have graduated from governmental training school. Training will be limited to special techniques for manufacturing of locomotives. Contents of the training are to learn special techniques as undermentioned through basical training and practices.

Welding and plate working
Electric work (Drawing and wiring)
Machining (Drawing, piping and machining)
Inspection and testing

As to training descriptions of freshmen training and training of improved technology are shown in Table 6-7.
As to detailed carriculum, Pakistan Railways should map out based on the table.

Table 6-6 Training Programme

(1) Training of Paskistan Engineers and Technicians in Foreign Country

	Item	Description	Persons concerned	Man x period (MAN-MONTH)
1	Design	Design and standard	B	1 x 3
	Drafting	Drafting, arrangement of production	C	1 x 3
2	Production as a whole	Production technology, production control	A	1 x 6
			B	1 x 6
3	Welding	Welding of parts, welding of large parts	C	1 x 3
			D	1 x 3
4	Plate working	Preparation, plate working and assembling	C	1 x 3
			D	1 x 3
5	Assembling	Assembling and fitting	C	1 x 3
			D	1 x 3
6	Machining	Machining of parts, machining of bogie frame	C	1 x 3
			D	1 x 3
7	Piping	Pipe bending and cutting, installation of piping	C	1 x 3
			D	1 x 3
8	Wiring	Preparation of wiring, wiring of locomotives	C	1 x 3
			D	1 x 3
9	Inspection and test	Test of electric circuit, parts test, overall test	B	1 x 3
			C	1 x 3
10	Rotating machine	Assembling of rotating machine	C	1 x 3
			D	1 x 3

(2) Production Guidance at Production Start

Item		Description	Leader	Man x period (MAN-MONTH)
1	Overall control	Production as a whole	E	1 x 12
2	Design	Design, preparation for production	E	1 x 12
3	Production as a whole	Production technology, production control	E	1 x 6
4	Welding	Welding	T	1 x 9
5	Plate working	Plate working, preparation	T	1 x 9
6	Assembling	Assembling and fitting	T	1 x 9
7	Machining	Machining	T	1 x 9
8	Piping, wiring	Piping, wiring	T	1 x 9
9	Rotating machine	Test and inspection of rotating machine	T	1 x 6
			E	1 x 6
10	Controller	Assembling of control circuit	T	1 x 9
11	Inspection	Inspection and quality control, test of locomotives	E	1 x 9
			E	1 x 9
12	Maintenance	Maintenance system of mechanical and electrical facility	E	1 x 9
			T	1 x 9

Total 132 men-month

Note : E = Engineer
T = Technician

Table 6-7 Outline of Training Curriculum

Trade of training	Job	Lessons	Practices	Remark
Mechanical drawing	Preparing of parts drawing and assembly drawing. Plate layout, cutting plan and weight calculation of materials	Mechanical drawing, Machine element, Strength of materials, Structure of diesel electric locomotive.	Mechanical drawing Preparation of shop drawing, dies and bill of materials	
Electrical drawing	Drawing of electrical instruments Preparation of wiring diagram	Electrical drawing, Electrical engineering strength of materials. Structure of diesel electric locomotive.	Drawing of control panel Wiring diagram	
Electrical outfittings and wiring	Wiring of main and control circuit Out-fitting and adjustment of electrical instruments	Structure of diesel electric locomotive, Strength of materials, Drawing and outfittings of electrical instruments	Preparation of detailed wiring chart Wiring and adjustment of electrical instruments	Model of circuit
Welding	Welding of underframe, bogie frame, body and parts	Drawing, Strength of materials, Welding method, Structure of diesel electric locomotive.	Fillet welding and butt welding, Manual welding, semi-automatic welding and gas cutting.	
Outfittings of pipes	Piping for air, vacuum, water, oil and electricity. Fixing, inspection and adjustment of valves in these connections.	Structure of diesel electric locomotive. Strength of materials, Drawing and outfittings of piping.	Cutting and bending of pipes. Fitting of valves and pipes. Test of pipings and their fixtures	
Machining	Machining of bogie frame and locomotive's parts. Estimate of work time	Structure of diesel electric locomotive, Machine elements, Machining method, Strength of materials and drawing. Machining by machine tools with numerical control.	Machining by lathes and milling Machines.	Models of control for machine tools

Trade of training	Job	Lessons	Practices	Remark
Inspection	Performance test of locomotive. Inspection of parts. Quality control and quality assurance.	Structure of diesel electric locomotive. Machine elements, Strength of materials, Electric engineering preparation of electric circuit drawing. Measuring method	Mesuring and test of materials and parts Wiring and test of electrical instruments. Performance test of Locomotive.	Measuring instruments Test machines and equipments.

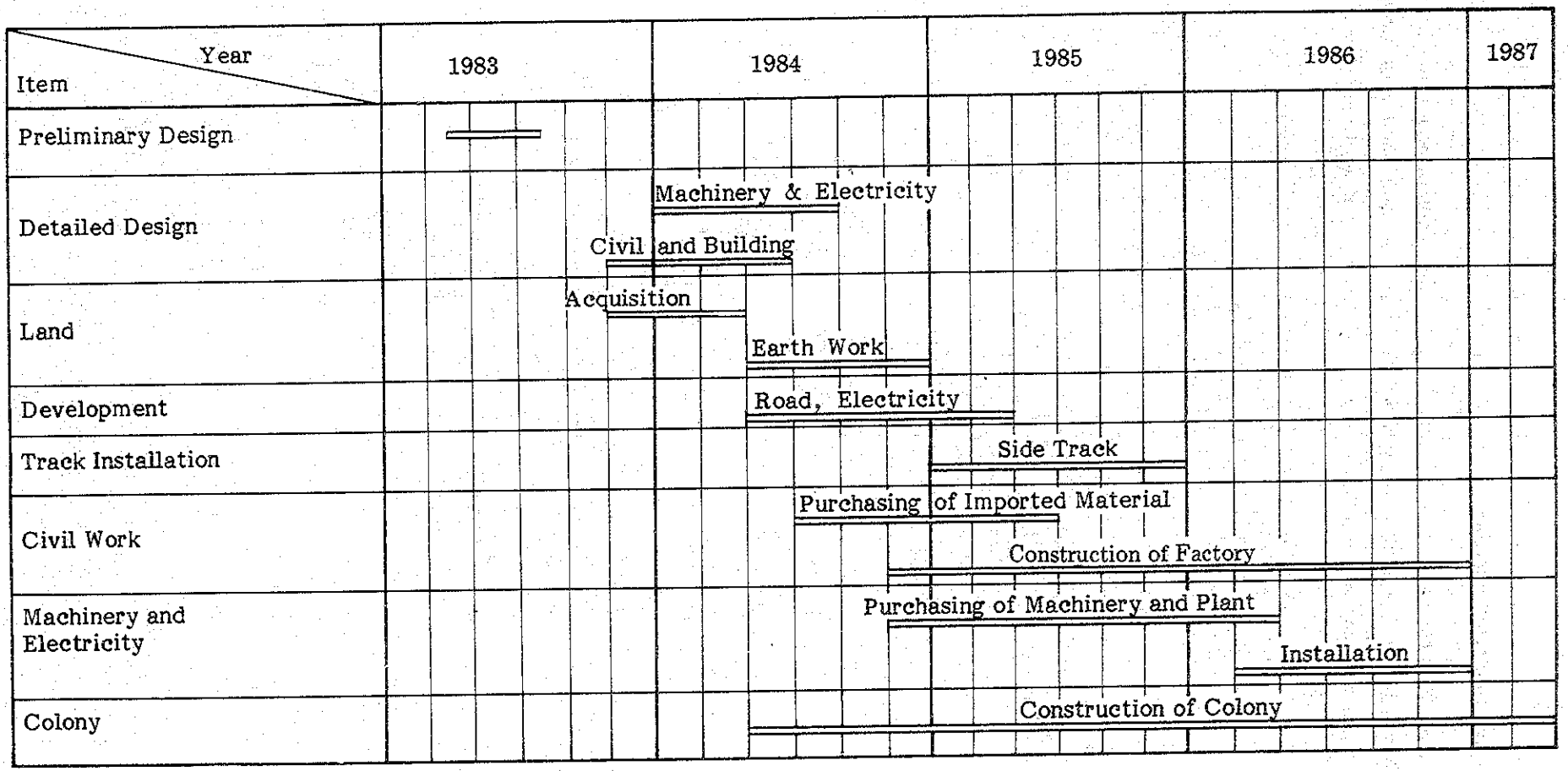
Note: 1. Objectives for education and training — for graduates from governmental training institute.

2. Training Period — for freshmen 1 year; for improved technology 3 months

6-5 Construction Work Schedule

Taking commencement time of operation at the locomotive manufacturing factory into consideration, detailed designs to take place in future and work progress in accordance with the construction contract and execution of works are shown in the Fig. 6-8.

Table 6-8 Time Schedule for Construction of Loco. Factory



6-6 Cost of Project

Calculation of the cost of project was made taking into consideration of contingency of five percent of construction cost, cost rise rates of 10 percent for foreign currency portion, and 20 percent for domestic currency portion respectively. These are shown in the Table 6-9.

Locomotive material and parts cost for start-up work of the factory are shown in the Table 6-12.

The calculation was based on the exchange rate of: 1 Rs. per 21.585 Yen.

Table 6-9 Breakdown of project cost

Unit: Million Rs.
(million Yen)

Item \ Cost		Foreign Currency	Domestic Currency	Total
Construction Cost	Machinery	182.12 (3,931.06)	84.85	266.97
	Civil/Building	28.26 (609.99)	281.40	309.66
	Electricity	24.00 (518.04)	44.42	68.42
	Utility	23.26 (502.07)	23.01	46.27
	Fitting/Appliance	—	0.93	0.93
	Sub-total	257.64 (5,561.16)	434.61	692.25
	Contingency	12.88 (278.06)	21.73	34.61
	Total	270.52 (5,839.22)	456.34	726.86
Engineering Cost		61.16 (1,320.14)	8.34	69.50
Total		331.68 (7,159.36)	464.68	796.36
Amount of Price Rise		33.17 (715.94)	81.58	114.75
Grand Total		364.85 (7,875.30)	546.26	911.11

Note: Figure in the brackets shows Yen (Unit: Million Yen)

Table 6-10 Breakdown of Annual Construction Cost

Unit: million Rs
FC : Foreign currency
DC : Domestic currency

Type of work		Const-ruction cost	1st year				2nd year				3rd year				Total			
			Material		Labour		Material		Labour		Material		Labour		Material		Labour	
			FC	DC	FC	DC	FC	DC	FC	DC	FC	DC	FC	DC	FC	DC	FC	DC
Machinery	Production machinery	137.56					127.96					3.84	3.20	2.56	127.96	3.84	3.20	2.56
	Auxiliary machinery	53.16	8.62				41.24	0.26	0.22	0.17		1.06	0.88	0.71	49.86	1.32	1.10	0.88
	Import charges	76.25		3.70				72.55								76.25		
	Sub-total	266.97	8.62	3.70			169.20	72.81	0.22	0.17		4.90	4.08	3.27	177.82	81.41	4.30	3.44
Civil/ building	Land acquisition	5.90		5.90												5.90		
	Colony	93.35				25.76				36.34				31.25				93.35
	Civil/Track	24.95	1.18	5.95		5.94		2.38		2.38		3.56		3.56	1.18	11.89		11.88
	Building	172.71	8.81			21.71	9.99	58.54		25.33	8.28	28.28		11.77	27.08	86.82		58.81
	Import charges	12.75		4.51				4.51				3.73				12.75		
	Sub-total	309.66	9.99	16.36		53.41	9.99	65.43		64.05	8.28	35.57		46.58	28.26	117.36		164.04
Electricity	Electric facility	46.29					3.24	3.88		1.87	18.21	10.81	2.55	5.73	21.45	14.69	2.55	7.60
	Import charges	9.13						1.38				7.75				9.13		
	WAPDA, etc. share in expense	13.00				0.05				12.15				0.80				13.00
	Sub-total	68.42				0.05	3.24	5.26		14.02	18.21	18.56	2.55	6.53	21.45	23.82	2.55	20.60
Utility	Utility service	36.30									23.26	7.98		5.06	23.26	7.98		5.06
	Import charges	9.97										9.97				9.97		
	Sub-total	46.27									23.26	17.95		5.06	23.26	17.95		5.06
Fitting and sppliance		0.93										0.93				0.93		
Total		692.25	18.61	20.06		53.46	182.43	143.50	0.22	78.24	49.75	77.91	6.63	61.44	250.79	241.47	6.85	193.14

Table 6-11 Breakdown of Annual Engineering Cost

Unit: million Rs
FC: Foreign currency
DC: Domestic currency

	1st year		2nd year		3rd year		Total		
	FC	DC	FC	DC	FC	DC	FC	DC	Total
Consultant fee	8.99	4.64	8.85	1.85	8.85	1.85	26.69	8.34	35.03
Technical training fee	1.55				16.24		17.79		17.79
Technology transfer fee	13.90		2.78				16.68		16.68
Total	24.44	4.64	11.63	1.85	25.09	1.85	61.16	8.34	69.50

Table 6-12 Locomotive Material and Parts Cost

Unit: million Rs
FC: Foreign currency
DC: Domestic currency

	1st year		2nd year		3rd year		Total		
	FC	DC	FC	DC	FC	DC	FC	DC	Total
Materials					46.33	9.14	46.33	9.14	55.47
Import charges						19.77		19.77	19.77
Total					46.33	28.91	46.33	28.91	75.24

Note: Figure in the brackets shows Yen (Unit: Million Yen)

6-7 Annual Fund Plan

Calculation of the Project Cost was made on the basis of annual estimate of disbursement schedule. Also calculation of necessary annual fund was, as described in 6-6 above, made taking into consideration of amounting to ten percent rise of foreign currency and amounting to twenty percent rise of domestic currency. The resultant amount is as shown in Table 6-13.

Table 6-13 Annual Fund Plan

Unit: million Rs.

	1st year	2nd year	3rd year
Construction			
Foreign currency portion	21.49	210.96	65.12
Domestic currency portion	91.78	271.15	173.32
Engineering			
Foreign currency portion	26.89	12.79	27.60
Domestic currency portion	5.57	2.22	2.22
Rolling stock parts			
Foreign currency portion			50.96
Domestic currency portion			32.72
Total			
Foreign currency portion	48.38	223.75	143.68
Domestic currency portion	97.35	273.37	208.26

As to source of fund, The Pakistan Government is to raise fund of foreign currency portion by long term loan on one hand, and is obtaining from domestic currency through the annual budget of the Pakistan Government on the other.

CHAPTER 7. IMPLEMENTATION PROGRAMME AND CONSULTANT PLAN

7-1 Implementation Programme of the Project

The contents of implementation programme of this project is described in this sub-section.

The time frame of the project is shown in Fig. 5-1.

After completion of feasibility study, following works will be necessary to carry out prior to construction of the factory.

(1) Detailed design
(2) Tender of construction work and mechanical and electrical facilities
(3) Tender evaluation and contract
(4) Construction of the factory

Explanation by work is as followings.

(1) Detailed design

The detailed design of the factory, preparation of the drawings for construction, determination of items and specifications of construction works and mechanical and electrical facilities, preparation of tender specifications and cost estimation as well as preparation of details of implementation programme of construction works will be carried out based on the feasibility study and preliminary design.

(2) Tender of construction works and mechanical and electrical facilities

Tender will be carried out according to the tender specifications prepared by detailed design.

(3) Tender evaluation and contract

It will be necessary to make contract with appropriate tenderer based on the result of evaluation.

(4) Construction of the factory

The construction of the factory will be carried out based on the implementation programme of construction works.

To commence the manufacturing of locomotives, the factory should be construct by carring out of construction schedule control, budget control, construction work and inspection of mechanical and electrical facilities, etc.

Outline of construction schedule is described in paragraph 6-5. The works as mentioned above should be carried out by consultant for smooth construction of the factory. And the works will be included in this project.

Following works will be necessary for production of locomotives at the New Factory.

(1) Technology transfer
(2) Employment and training of employees
(3) Establishment of organization of the factory and production system
(4) Domestic production of parts
(5) Preparation for production of first year

Explanation by work is as followings.

(1) Technology transfer

Following items will be included in the technology transfer necessary for production of locomotives.

(a) Drawings and documents
(b) Jigs and special tools necessary for production
(c) Training of engineers and apprentices

The details of technology transfer is described in paragraph 5-3.

(2) Employment and training of employees

It will be necessary to employ the employees necessary for production, and to train the employees so as to be able to master the technology for manufacturing of locomotives.

The engineers and technicians which will be trained at foreign country by technology transfer should train the employees prior to production start.

The details of training plan is described in paragraph 6-4.

(3) Establishment of organization of the factory and production system

It will be necessary to determine the organization of the New Factory and to establish the production system for operation of the Factory.

(4) Domestic production of parts

It will be necessary to determine the specifications of parts to be produced domestically and name of manufacturers.
Trial production of parts will be carried out to meet necessity and performance of parts will be confirmed.

(5) Preparation for production of first year

The production of five locomotives in the first year will be planned in this project. It will be necessary to determine the production programme and to prepare the arrangement and parts necessary for production.

7-2 Organization for the Promotion of Domestic Production of Locomotives

A promoting organization will be formed in Pakistan in order to study and to take measures for the various problems, and to conduct test runs and start production at the earliest date.

Items to be dealt with by the project team are as follows:

(1) Construction of a locomotive factory

Recognition and checking of the construction plan, supervision of the construction work, supervision of the constructional budget, evaluation of the estimates for the constructional equipment.

(2) Administration of the factory

Determination of the organization of the factory, the recruiting and training of personnel, and factory production system.

(3) Plan for domestic production

Determination of the parts to be made domestically, selection of the makers, performance of the parts, testing of the quality of the parts, trial manufacture and research.

(4) Transfer of technology, selection of a technical cooperator and contents, education and training of the staff.

7-3 Detail Design

The detailed design based on preliminary design must be started according to the Time Schedule as shown in Table 6-8.

Detailed design work consists of the following:

(a) Detailed design drawing
(b) Detailed design calculation
(c) Technical specifications
(d) bill of quantity
(e) Cost estimate
(f) Construction schedule

To carry out these duties, consultants within Pakistan and in other countries should be called in. From among these duties, those which presumably should be entrusted to consultants in other countries are the following:

(a) Technical coordination and advice on detailed designs for the civil engineering works, buildings and tracks to be carried out by consultants in Pakistan.

(b) Detailed designs for machinery, electrical and other facilities except those for civil engineering works, buildings and tracks.

7-4 Supervision for Construction

The supervision of construction work can be roughly classified into 2 types:

(a) Overall construction management of the construction of the manufacturing factory.
(b) Supervision for each type of work

Of the items mentioned above, the overall construction management would be most suitable to carry out by Pakistan Railways. But it would be advantageous if the consultant who formed the detailed design of the project should be over the supervision for over construction, and more over, the work can be expected to be carried out smoothly with close cooperation with Pakistan Railways.

It would be of advantage if the consultant who took charge of the detailed design were to supervise that part of the work designed, and it would be desirable if the supervisory work or these operations are placed under the control of the overall supervisor.

The supervision for construction to be carried out by consultant will be the following contents from approval of design to the issuing of certificate for completion.

(1) Approval of detailed drawings

(a) Examination and approval of technical specifications of machinery and electrical facilities submitted by contractor.

(b) Examination and approval of detailed drawings of machinery and electrical facilities submitted by contractor

(c) Approval of commencement of manufacturing of machinery and electrical facilities

(d) Examination and approval of major drawings for construction work.

(2) Construction programme

(a) Preparation of basic construction schedule

(b) Checking and coordination of details of construction schedule

(c) Approval of modification of design and temporary suspension of construction work

(d) Instruction or examination of change of construction work

(e) Planning, design, coordination and advice for particularly specified subjects

(f) Instruction for preparation of construction record and photographing

(3) Inspection and test

(a) Attendance for or approval of results of inspection and test of materials, plants, mechanical and electrical equipments and construction works within period of construction.

(b) Approval of delivery of materials, plants, mechanical and electrical equipment from manufacturer's factory.

(4) Completion test

(a) Attendance for completion test of each part of construction

(b) Issuing of certificate for completion

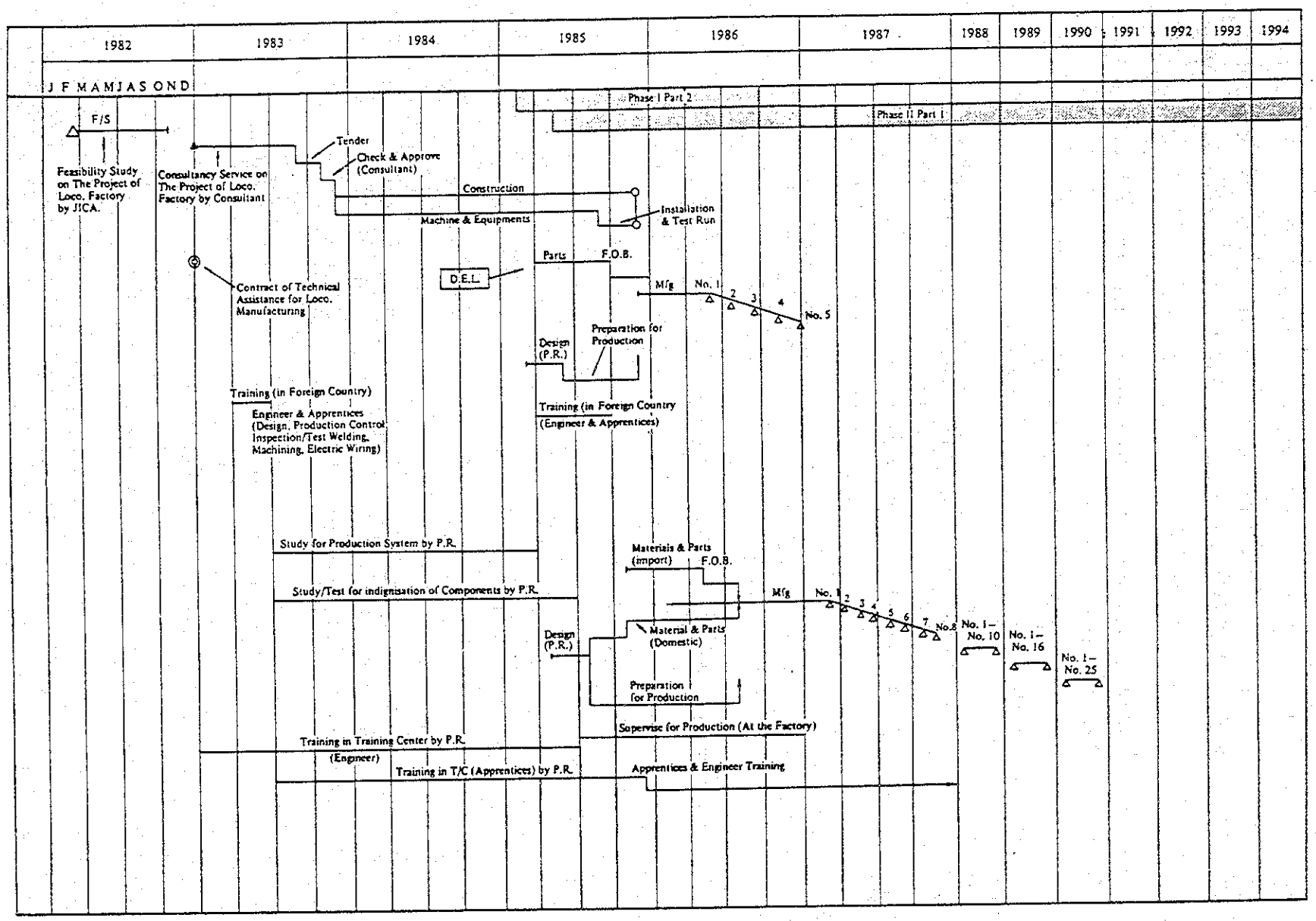


Fig. 7-1 Time Frame for Progressive Manufacturing of D.E.L.

CHAPTER 8. ECONOMIC AND FINANCIAL ANALYSIS

8-1 Economic Analysis

8-1-1 Objective

This project is for the construction and operation of a diesel electric locomotive manufacturing factory. The goal of this analysis is to determine if, through an optimum investment scale for factory construction and a reasonable operation plan, this project will prove meaningful from a socio-economic viewpoint.

8-1-2 Basic concept

On the basis of a "with/without" approach as is normally employed in the economic analysis of projects, the investment and cost required for introduction of locomotives as well as the cost saving benefit will be analyzed for each case of "with the project" (the factory will be constructed) and "without the project" (the factory will not be constructed). The economic internal rate of return (EIRR) will then be calculated.

With the project: The diesel electric locomotive manufacturing factory will be constructed and locomotives will be manufactured according to the production programme previously determined for this factory.

Without the project: The diesel electric locomotive manufacturing factory will not be constructed and locomotives, which might have been manufactured if the factory were constructed, will be imported.

8-1-3 Methodology and various assumptions

(1) Concept of the case "without the project"

The entire prospective demand for diesel electric locomotives will be over and above the planned capacity of the factory under consideration. Therefore, even in the case of "with the project," a certain number of locomotives will have to be imported and/or used longer than originally planned. For the purposes of this economic analysis, however, the number of locomotives to be produced in the case of "with the project" will be equated to those imported in "without the project". Investment in the case of "without the project" is zero and cost is equal to the cost of importing that number of locomotives planned to be produced in the case of "with the project."

(2) Concept of economic benefit

This project is for construction of a new factory, offering the following benefits for gross domestic production when viewed from the socio-economic viewpoint: promotion of employment opportunities, encouragement of related domestic industries, regional development, technological transfer and cost saving benefit. The above benefits (except for the cost saving benefit) are difficult to quantify, so this economic analysis will concentrate on a cost comparison between the cases "with/without the project." The cost difference between these two cases will be considered as the cost saving benefit.

Other benefits may arise in the course of implementing this project, but they too are difficult to quantify and thus are not included in the benefit computation of this economic analysis.

(3) Various assumptions

(a) Market price and economic price

The market price as of April, 1982 was chosen as a reference price, for all items. Because taxes and subsidies are transfer items, the economic price can be calculated by adjusting the market price by the amount of these transfer items.

(b) The life of fixed assets and re-investment

In determining the life of fixed assets, Pakistan Railways depreciation rates were used as basic figures. The life of fixed assets is 50 years for buildings and 20 years for mechanical facilities. It is assumed here that the same amount of reinvestment will be made after reaching the life of fixed assets.

(c) Project life and salvage value

The project life is set at 33 years (30 years after completion of the factory). But this period is simply the term period as dealt with in the analysis, and the factory itself of course will remain functional after termination of the period. In this connection, the salvage value of the fixed investment is computed as of the end of the project life and is deducted from the costs (i.e. considered as "benefits").

(d) Inflation

Accurate forecasting over the 33-year project life is rather difficult. Accordingly, the economic analysis ignores inflation completely, employing 1982 prices.

(e) Foreign exchange rate

For the calculation of the economic price of imported items, the price in Rs is calculated on the basis of the exchange rate. In the economic analysis, however, the difference between the official rate and effective rate (the difference arising due to import duty and export charges) must be accounted for. In the economic analysis of this project, the effective rate (i.e., shadow exchange rate) was calculated according to a generally approved weighted average tariff method.

Official rate	Rs.1.- = ¥21.585
Shadow exchange rate	Rs.1.- = ¥15.474

For the calculation basis of the shadow exchange rate, refer to the Appendix.