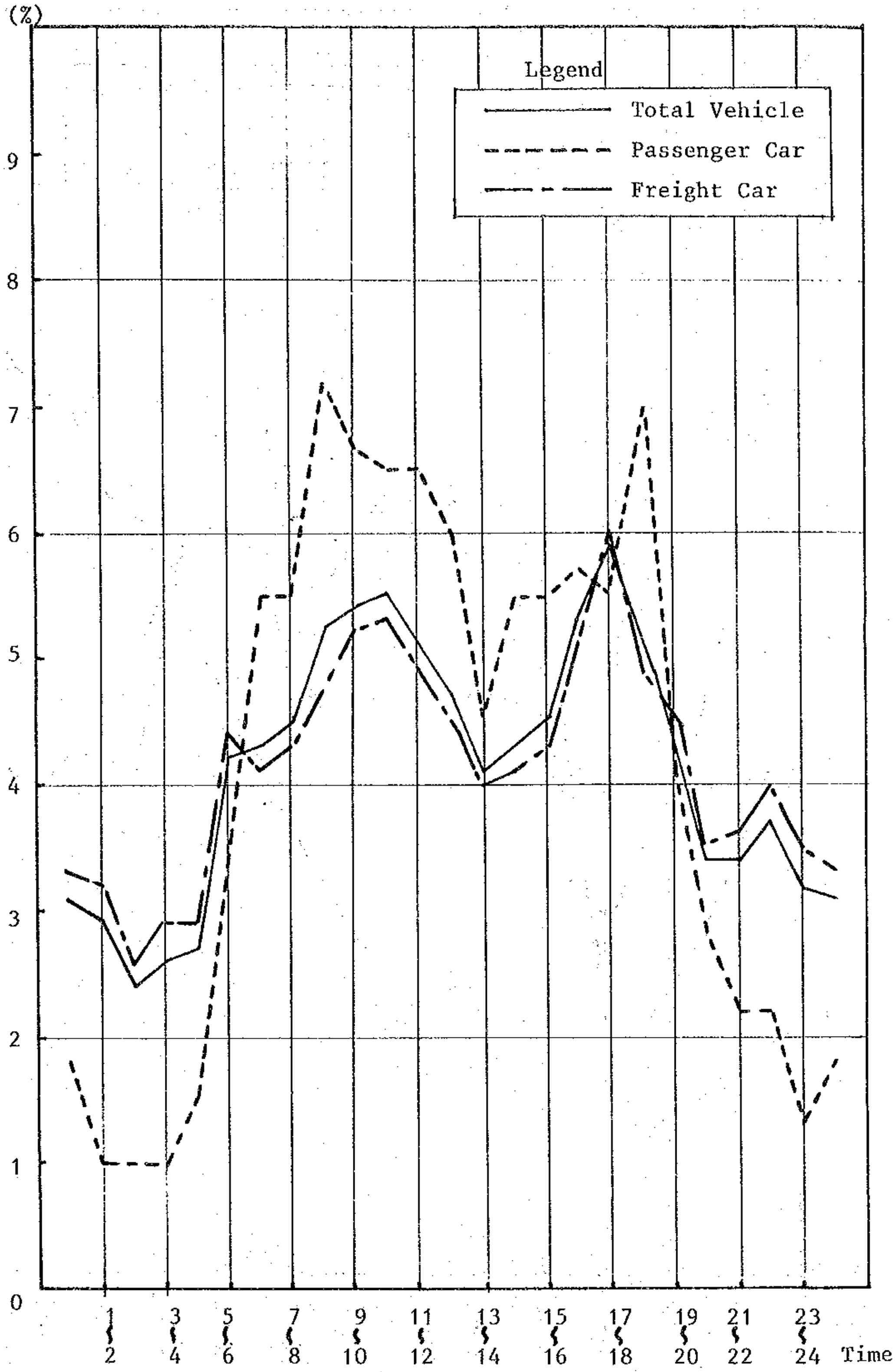
VIII. REFERENCE TABLES AND FIGURES ON ROAD TRANSPORT

(a) Jhelum Bridge

Source: Traffic Volume Survey by NTRC, 1982

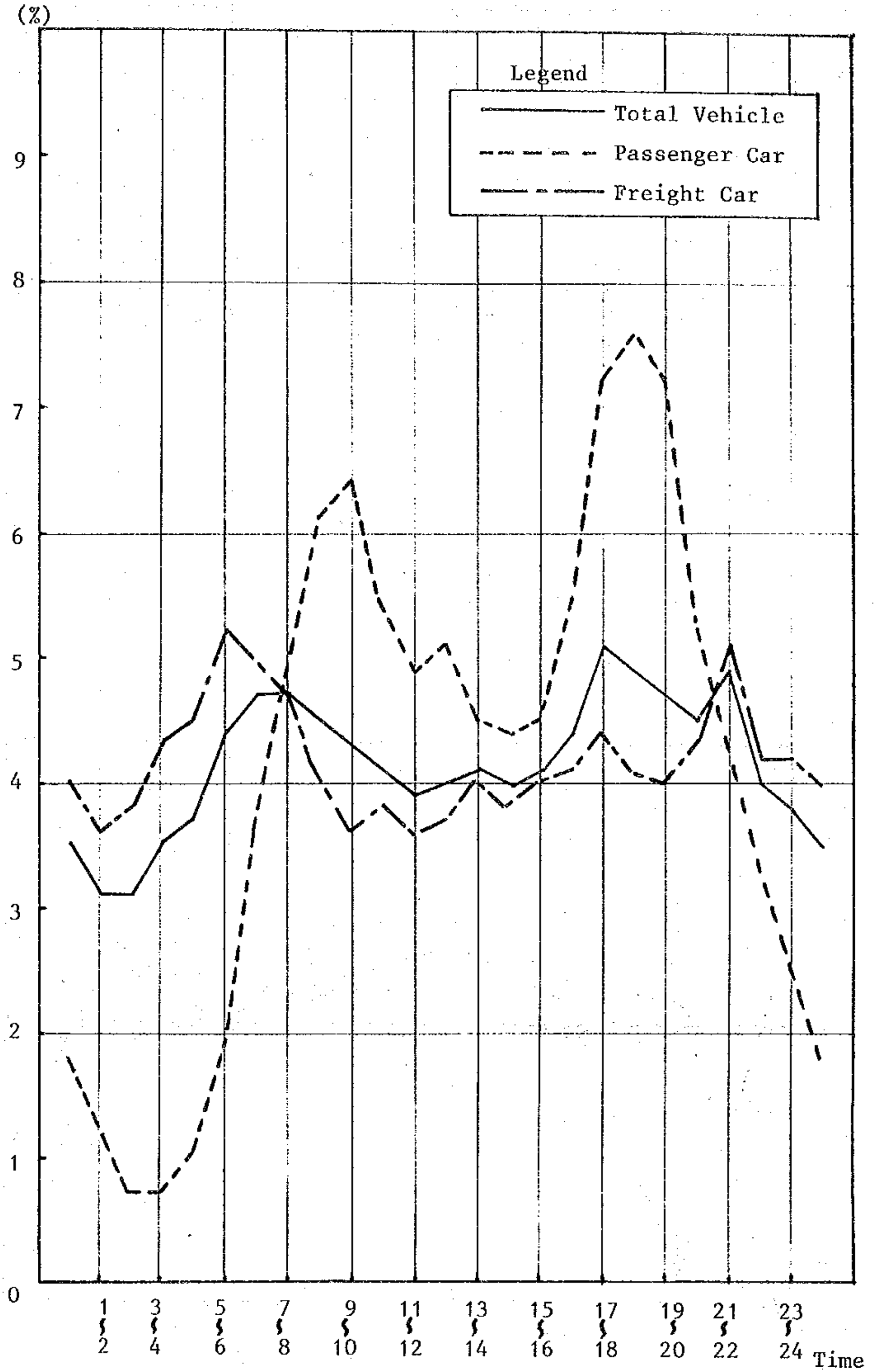
Fig. 1-(1) Hourly Traffic Volume Variation in a Day



(b) Sadiqabad

Source: Traffic Volume Survey by NTRC, 1982

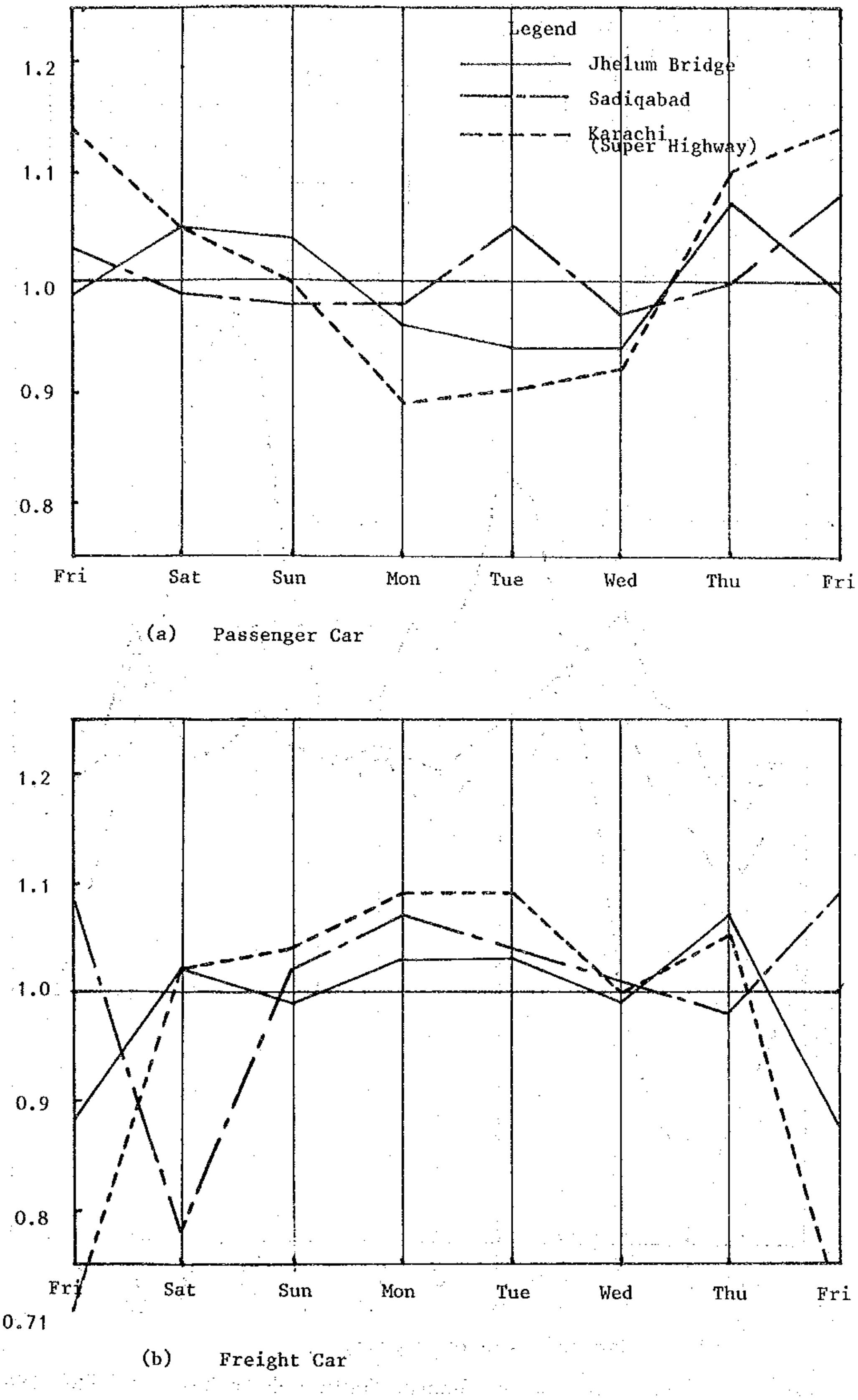
Fig. 1-(2) Hourly Traffic Volume Variation in a Day



(c) Karachi (Super Highway)

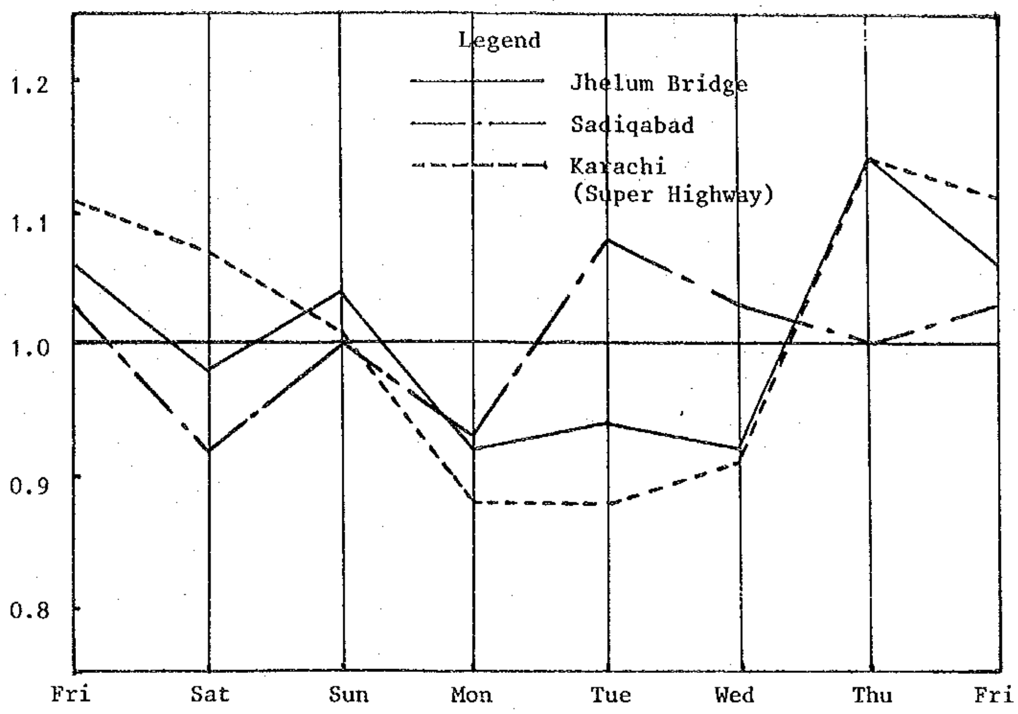
Source: Traffic Volume Survey by NTRC, 1982

Fig. 1-(3) Hourly Traffic Volume Variation in a Day

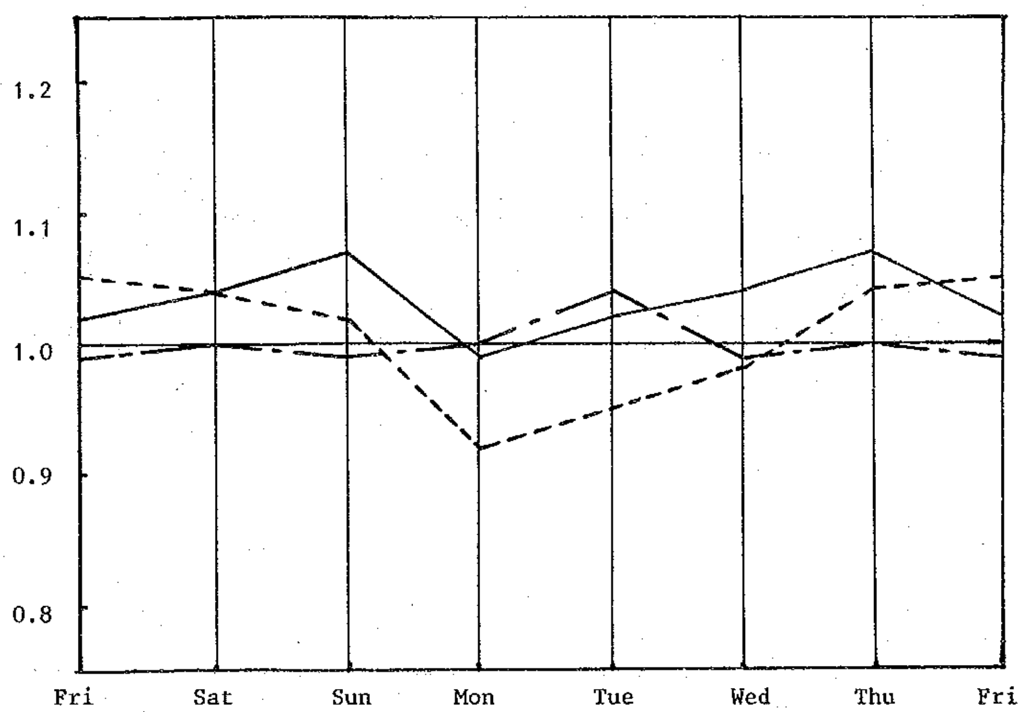


Source: Traffic Volume Survey by NTRC, 1982

Fig. 2-(1) Daily Traffic Volume Variation in a Week



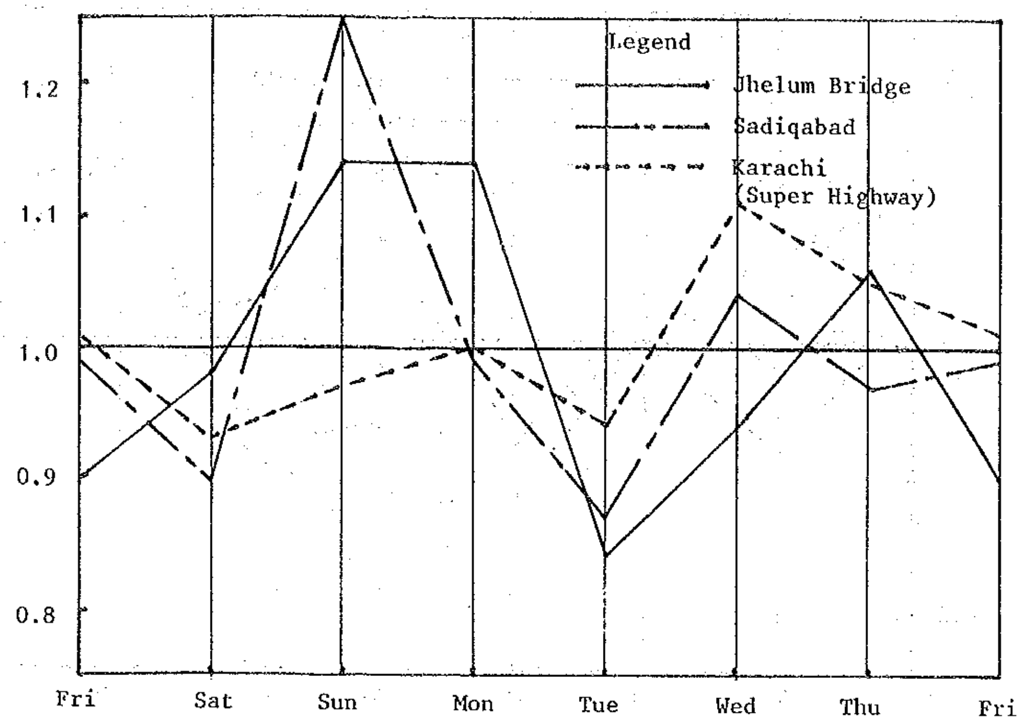
(c) Motar Car



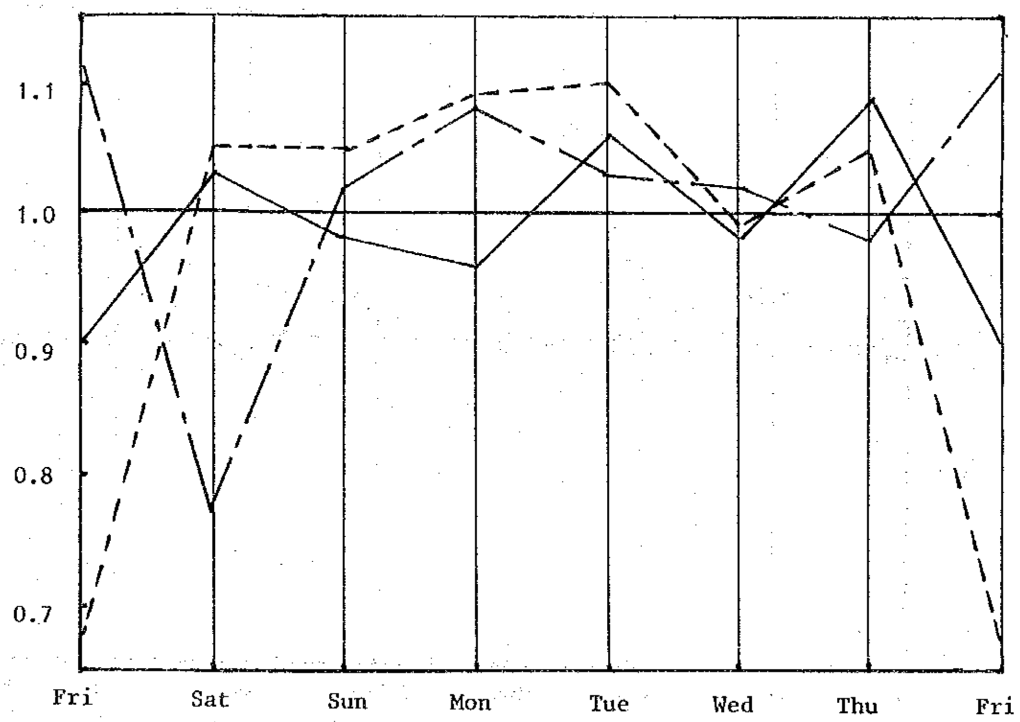
(d) Bus

Source: Traffic Volume Survey by NTRC, 1982

Fig. 2-(2) Daily Traffic Volume Variation in a Week



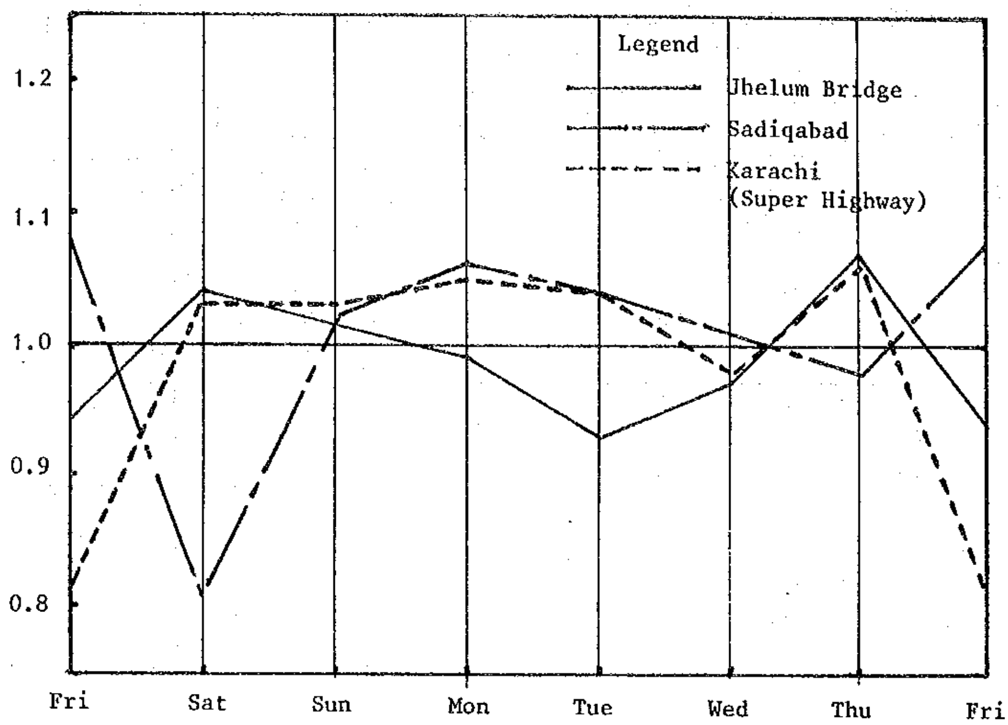
(e) Pick Up, Van



(f) 2 Axles' Truck (Mainly Bedford)

Source: Traffic Volume Survey by NTRC, 1982

Fig. 2-(3) Daily Traffic Volume Variation in a Week



(g) Total Vehicles

Source: Traffic Volume Survey by NTRC, 1982

Fig. 2-(4) Daily Traffic Volume Variation in a Week

Table 1 Number of Buses to be Implemented by Organization: PRTB (vehicles)

Fiscal Year	(A) Required Number of Buses on Road	(B) 25% Reserve (A) X 1.25	(C) Number of Buses Available from Previous Year (B) of Previous Year X 0.9	(D) Number of Buses to be Implemented (B)-(C)
1982/83	427	534	-	-
83/84	536	670	481	189
84/85	569	711	603	108
85/86	602	753	640	113
86/87	635	794	678	116
87/88	668	835	715	120
88/89	709	886	752	134
89/90	751	939	797	142
90/91	793	991	845	146
91/92	834	1043	892	151
92/93	876	1095	939	156
93/94	918	1148	986	159
94/95	959	1199	1033	166
95/96	1001	1251	1079	172
96/97	1043	1304	1126	178
97/98	1085	1356	1174	182
98/99	1126	1408	1220	188
99/00	1168	1460	1267	193

Notes: – Required number of buses on road is estimated in Table 5.
– It is assumed that 10% of buses wear out in each year.

Table 2 Number of Buses to be Implemented by Organization: SRTC (vehicles)

Fiscal Year	(A) Required Number of Buses on Road	(B) 25% Reserve (A) X 1.25	(C) Number of Buses Available from Previous Year (B) of Previous Year X 0.9	(D) Number of Buses to be Implemented (B)-(C)
1982/83	162	203	-	-
83/84	214	268	183	85
84/85	227	284	241	43
85/86	240	300	256	44
86/87	253	316	270	46
87/88	266	333	284	49
88/89	282	353	300	53
89/90	298	373	318	55
90/91	314	393	336	57
91/92	330	413	354	59
92/93	346	433	372	61
93/94	362	453	390	63
94/95	378	473	408	65
95/96	395	494	426	68
96/97	410	513	445	68
97/98	427	534	462	72
98/99	443	554	481	73
99/00	459	574	499	75

Notes: – Required number of buses on road is estimated in Table 5.
– It is assumed that 10% of buses wear out in each year.

Table 3 Number of Buses to be Implemented by Organization: NWFP RTB (vehicles)

Fiscal Year	(A) Required Number of Buses on Road	(B) 25% Reserve (A) X 1.25	(C) Number of Buses Available from Previous Year (B) of Previous Year X 0.9	(D) Number of Buses to be Implemented (B)-(C)
1982/83	270	338	–	–
83/84	236	295	304	0
84/85	249	311	274	37
85/86	262	328	280	48
86/87	275	344	295	49
87/88	288	360	310	50
88/89	305	381	324	57
89/90	322	403	343	60
90/91	339	424	363	61
91/92	356	445	382	63
92/93	374	469	401	68
93/94	391	489	422	67
94/95	408	510	440	70
95/96	425	531	459	72
96/97	443	554	478	76
97/98	460	575	499	76
98/99	477	596	518	78
99/00	494	618	536	82

Notes: – Required number of buses on road is estimated in Table 5.
– It is assumed that 10% of buses wear out in each year.

Table 4 Passenger Traffic Volume of Each Corporation

(million passenger-km/year)

Province	Punjab			Sind			NWFP			Baluchistan			Total		
Organization / Fiscal Year	PRTB	Private	Sub Total	SRTC	Private	Sub Total	NWFP RTB	Private	Sub Total	–	Private	Sub Total	Semi Public	Private	Sub Total
1983/84	2405	21640	24045	914	8226	9140	852	3407	4259	–	1125	1125	4171	34398	38569
84/85	2553	22975	25528	969	8725	9694	899	3596	4495	–	1201	1201	4421	36497	40918
85/86	2701	24309	27010	1025	9223	10248	946	3784	4730	–	1278	1278	4672	38594	43266
86/87	2849	25643	28492	1080	9722	10802	993	3972	4965	–	1354	1354	4922	40691	45613
87/88	2997	26977	29974	1136	10220	11356	1040	4160	5200	–	1431	1431	5173	42788	47961
88/89	3185	28660	31845	1204	10838	12042	1102	4408	5510	–	1536	1536	5491	45442	50933
89/90	3372	30344	33716	1273	11456	12729	1164	4657	5821	–	1640	1640	5809	48097	53906
90/91	3559	32029	35588	1342	12073	13415	1226	4905	6131	–	1745	1745	6127	50752	56879
91/92	3746	33713	37459	1410	12691	14101	1288	5154	6442	–	1849	1849	6444	53407	59851
92/93	3933	35397	39330	1479	13309	14788	1350	5402	6752	–	1954	1954	6762	56062	62824
93/94	4120	37081	41201	1548	13926	15474	1413	5650	7063	–	2059	2059	7081	58716	65797
94/95	4307	38765	43072	1616	14544	16160	1475	5898	7373	–	2163	2163	7398	61370	68768
95/96	4494	40449	44943	1685	15162	16847	1537	6146	7683	–	2268	2268	7716	64025	71741
96/97	4682	42133	46815	1753	15780	17533	1599	6395	7994	–	2372	2372	8034	66680	74714
97/98	4869	43817	48686	1822	16397	18219	1661	6643	8304	–	2477	2477	8352	69334	77686
98/99	5056	45501	50557	1891	17015	18906	1723	6892	8615	–	2581	2581	8670	71989	80659
99/00	5243	47185	52428	1959	17633	19592	1785	7140	8925	–	2686	2686	8987	74644	83631

Notes: (1) Passenger traffic volume in each province is estimated by JICA study team.
(2) Passenger traffic volume of each semi public corporation is calculated by assigning 10% for PRTB, SRTC and 20% for NWFP RTB.

Table 5 Required Number of Buses on Road of Each Corporation

(vehicles)

Province	Punjab			Sind			NWFP			Baluchistan			Total		
Organization / Fiscal Year	PRTB	Private	Sub Total	SRTC	Private	Sub Total	NWFP RTB	Private	Sub Total	–	Private	Sub Total	Semi Public	Private	Sub Total
1983/84	536	4820	5356	214	1926	2140	236	943	1179	–	311	311	986	8000	8986
84/85	569	5117	5686	227	2043	2270	249	995	1244	–	332	332	1045	8487	9532
85/86	602	5415	6017	240	2160	2400	262	1047	1309	–	354	354	1104	8976	10080
86/87	635	5712	6347	253	2277	2530	275	1099	1374	–	375	375	1163	9463	10626
87/88	668	6009	6677	266	2393	2659	288	1151	1439	–	396	396	1222	9949	11171
88/89	709	6384	7093	282	2538	2820	305	1220	1525	–	425	425	1296	10567	11863
89/90	751	6759	7510	298	2683	2981	322	1289	1611	–	454	454	1371	11185	12556
90/91	793	7134	7927	314	2827	3141	339	1357	1696	–	483	483	1446	11801	13247
91/92	834	7509	8343	330	2972	3302	356	1426	1782	–	512	512	1520	12419	13939
92/93	876	7884	8760	346	3116	3462	374	1495	1869	–	541	541	1596	13036	14632
93/94	918	8259	9177	362	3261	3623	391	1564	1955	–	570	570	1671	13654	15325
94/95	959	8635	9594	378	3406	3784	408	1632	2040	–	599	599	1745	14272	16017
95/96	1001	9010	10011	395	3550	3945	425	1701	2126	–	628	628	1821	14889	16710
96/97	1043	9385	10428	410	3695	4105	443	1770	2213	–	656	656	1896	15506	17402
97/98	1085	9760	10845	427	3840	4267	460	1838	2298	–	685	685	1972	16123	18095
98/99	1126	10135	11261	443	3984	4427	477	1907	2384	–	714	714	2046	16740	18786
99/00	1168	10510	11678	459	4129	4588	494	1976	2470	–	743	743	2121	17358	19479

Notes: (1) Required number of buses on road are estimated in a way thatt dividing passenger-km/year calculated in Table 4 by load factor in terms of passenger-km/vehicle · year.

(2) Load factor of PRTB: 41 passengers/vehicle x 300km/vehicle day x 365 days/year=4,489,500 passenger-km/vehicle·year

SRTC: 39 passengers/vehicle x 300km/vehicle day x 365 days/year=4,270,500 passenger-km/vehicle·year

NWEP RTB: 33 passengers/vehicle x 300km/vehicle day x 365 days/year=3,613,500 passenger-km/vehicle·year

(3) Average number of passenger transported per vehicle is based on the operational result of each corporation in 1980/81.

Table 6 Calculation of Axle Load Combination per 1,000 Trucks

(Case 1)

	Axle Load Group (1,000kg) (1)	Axle Load Distribution per 1,000 Trucks		(2) x 0.962 + (3) x 0.038
		2 Axles Truck (2)	4 Axles Truck (3)	
Single Axles	under 4	520	782	530.0
	4 - 5	424	220	416.2
	5 - 6	128	62	125.5
	6 - 7	78	54	77.1
	7 - 8	132	202	134.7
	8 - 9	194	308	198.3
	9 - 10	204	270	206.5
	10 - 11	174	62	169.7
	11 - 12	100	24	97.1
	12 - 13	34	12	33.2
	13 - 14	10	2	9.7
	14 - 15	2	2	2.0
Tandem Axles	under 6	-	15	0.6
	6 - 8	-	60	2.3
	8 - 10	-	84	3.2
	10 - 12	-	176	6.7
	12 - 14	-	292	11.1
	14 - 16	-	247	9.4
	16 - 18	-	105	4.0
	18 - 20	-	17	0.6
	20 - 22	-	3	0.1
	22 - 24	-	1	0.0

Case 1

- Type-wise vehicles share will continue at the present coditions (2 axles: 96.2%, 4 axles: 3.8%)
- Axle loads will not be regulated.

Table 7 Calculation of Truck Factor

(Case 1)

	Axle Load Group (1,000kg) (1)	Load Equivalency Factor (2)	Axles per Day per 1,000 Trucks and Combinations (3)	Equivalent 8.2 ton (18,000lb) Single Axle Loads per Trucks and Combinations (4)
Single Axles	under 4	0.00	530.0	0.0
	4 - 5	0.09	416.2	37.5
	5 - 6	0.21	125.5	26.4
	6 - 7	0.41	77.1	31.6
	7 - 8	0.73	134.7	98.3
	8 - 9	1.34	198.3	265.7
	9 - 10	2.43	206.5	501.8
	10 - 11	4.52	169.7	767.0
	11 - 12	8.32	97.1	807.9
	12 - 13	15.26	33.2	506.6
	13 - 14	28.00	9.7	271.6
	14 - 15	52.00	2.0	104.0
	Sub Total	-	-	3418.4
Tandem Axles	under 6	0.00	0.6	0.0
	6 - 8	0.10	2.3	0.2
	8 - 10	0.24	3.2	0.8
	10 - 12	0.52	6.7	3.5
	12 - 14	1.00	11.1	11.1
	14 - 16	1.76	9.4	16.5
	16 - 18	2.90	4.0	11.6
	18 - 20	5.36	0.6	3.2
	20 - 22	10.70	0.1	1.1
	22 - 24	20.22	0.0	0.0
	Sub Total	-	-	48.0

Total Single Plus Tandem Axles = 3466.4

Truck Factor $= \frac{3466.4}{1000}$

$= 3.47$

Case 1

- Type-wise vehicles share will continue at the present conditions (2 axles;96.2%, 4 axles:3.8%)
- Axle loads will not be regulated.

Table 8 Calculation of Axle Load Combination per 1,000 Trucks

(Case 2)

Axle Load Group(1,000kg) (1)		Axle Load Distribution per 1,000 Trucks: 2 Axles Truck (2)	Axle Load Distribution per 1,000 Trucks: 4 Axles Truck (3)	(2) x 0.962 + (3) x 0.038
Single Axles	under 4	610	826	618.2
	4 - 5	506	232	495.6
	5 - 6	152	66	148.7
	6 - 7	92	56	90.6
	7 - 8	158	212	160.1
	8 - 9	230	324	233.6
	9 - 10	242	284	243.6
	10 - 11	-	-	-
	11 - 12	-	-	-
	12 - 13	-	-	-
	13 - 14	-	-	-
	14 - 15	-	-	-
Tandem Axles	under 6	-	16	0.6
	6 - 8	-	62	2.4
	8 - 10	-	88	3.3
	10 - 12	-	182	6.9
	12 - 14	-	303	11.5
	14 - 16	-	255	9.7
	16 - 18	-	94	3.6
	18 - 20	-	-	-
	20 - 22	-	-	-
	22 - 24	-	-	-

Case 2

- Type-wise vehicles share will continue at the present conditions.
- Maximum axle loads will be regulated to 10 tons for single and 18 tons for tandem axle.

Table 9 Calculation of Truck Factor

(Case 2)

	Axle Load Group(1,000kg) (1)	Load Equivalency Factor (2)	Axles per Day per 1,000 Trucks and Combinations (3)	Equivalent 8.2ton (18,000lb) Single Axle Loads per Trucks (4) and Combinations
Single Axles	under 4	0.00	618.2	0.0
	4 - 5	0.09	495.6	44.6
	5 - 6	0.21	148.7	31.2
	6 - 7	0.41	90.6	37.1
	7 - 8	0.73	160.1	116.9
	8 - 9	1.34	233.6	313.0
	9 - 10	2.43	243.6	591.9
	10 - 11	4.52	-	-
	11 - 12	8.32	-	-
	12 - 13	15.26	-	-
	13 - 14	28.00	-	-
	14 - 15	52.00	-	-
Tandem Axles	Sub Total	-	-	1134.7
	under 6	0.00	0.6	0.0
	6 - 8	0.10	2.4	0.2
	8 - 10	0.24	3.3	0.8
	10 - 12	0.52	6.9	3.6
	12 - 14	1.00	11.5	11.5
	14 - 16	1.76	9.7	17.1
	16 - 18	2.90	3.6	10.4
	18 - 20	5.36	-	-
	20 - 22	10.70	-	-
	22 - 24	20.22	-	-
	Sub Total	-	-	42.6

Total Single Plus Tandem Axles = 1177.3

$$\text{Truck Factor} = \frac{1177.3}{1000} = 1.18$$

Case 2

- Type-wise vehicles share will continue at the present conditions.
- Maximum axle loads will be regulated to 10 tons for single and 18 tons for tandem axle.

Table 10 Calculation of Axle Load Combination per 1,000 Trucks

(Case 3)

Axle Load Group (1,000kg) (1)		Axle Load Distribution per 1,000 Trucks		(2) x 0 + (3) x 1
		2 Axles Truck (2)	4 Axles Truck (3)	
Single Axles	under 4	-	826	826
	4 - 5	-	232	232
	5 - 6	-	66	66
	6 - 7	-	56	56
	7 - 8	-	212	212
	8 - 9	-	324	324
	9 - 10	-	284	284
	10 - 11	-	-	-
	11 - 12	-	-	-
	12 - 13	-	-	-
	13 - 14	-	-	-
	14 - 15	-	-	-
Tandem Axles	under 6	-	16	16
	6 - 8	-	62	62
	8 - 10	-	88	88
	10 - 12	-	182	182
	12 - 14	-	303	303
	14 - 16	-	255	255
	16 - 18	-	94	94
	18 - 20	-	-	-
	20 - 22	-	-	-
	22 - 24	-	-	-

Case 3

- Trucks will be replaced completely to 4 axles trucks (ex. FIAT semi trailor)
- Maximum axle loads will be regulated.

Table 11 Calculation of Truck Factor

(Case 3)

	Axle Load Group (1,000kg) (1)	Load Equivalency Factor (2)	Axles per Day per 1,000 Trucks and Combinations (3)	Equivalent 8.2ton (18,000lb) Single Axle Loads per Trucks and Combinations (4)
Single Axles	under 4	0.00	826	0.0
	4 - 5	0.09	232	20.9
	5 - 6	0.21	66	13.9
	6 - 7	0.41	56	23.0
	7 - 8	0.73	212	154.8
	8 - 9	1.34	324	434.2
	9 - 10	2.43	284	690.1
	10 - 11	4.52	-	-
	11 - 12	8.32	-	-
	12 - 13	15.26	-	-
	13 - 14	28.00	-	-
	14 - 15	52.00	-	-
Tandem Axles	Sub Total	-	-	1336.9
	under 6	0.00	16	0.0
	6 - 8	0.10	62	0.6
	8 - 10	0.24	88	21.1
	10 - 12	0.52	182	94.6
	12 - 14	1.00	303	303.0
	14 - 16	1.76	255	448.8
	16 - 18	2.90	94	272.6
	18 - 20	5.36	-	-
	20 - 22	10.70	-	-
	22 - 24	20.22	-	-
	Sub Total	-	-	1140.7

Total Single plus

Tandem Axles $= 2477.6$

Truck Factor $= \frac{2477.6}{1000}$

$\fallingdotseq 2.48$

Case 3

- Trucks will be replaced completely to 4 axles trucks (ex.FIAT semi trailor)
- Maximum axle loads will be regulated.

Table 12 Basis of Pavement Design

Case	(A)Average Load Factor (Ton/Vehicle)=Load Factor of 2 Axles Truck x Share + Load Factor of 4 Axles Truck x Share	(B)Traffic Volume (Vehicle/Day/Lane) = 7,000,000(Ton/Year)/365(Day/Year)/(A)/2 (Lanes)	(C)Cumulative Number of Standard Axles for 20 Years(Axles/20Years/Lane) = Truck Factor x (B) x 365Days x 20 Years	(D) Pavement Design* by Road Note 29 (mm)			
				Sub Base Coarse Thickness	Base Coarse Thickness	Surface Thickness	Total
1	7.266 = 7.0 x 0.962 + 14.0 x 0.038	1,320 = 7,000,000/365 /7.266/2	33,437,000 = 3.47 x 1,320 x 365 x 20	280	255	165	700
2	6.389 = 6.1 x 0.962 + 13.7 x 0.038	1,500 = 7,000,000/365 /6.389/2	12,921,000 = 1.18 x 1,500 x 365 x 20	260	230	125	615
3	13.7 = 6.1 x 0 + 13.7 x 1.000	700 = 7,000,000/365 /13.7/2	12,673,000 = 2.48 x 700 x 365 x 20	260	230	125	615

Note: *CBR is supposed to be 5%.

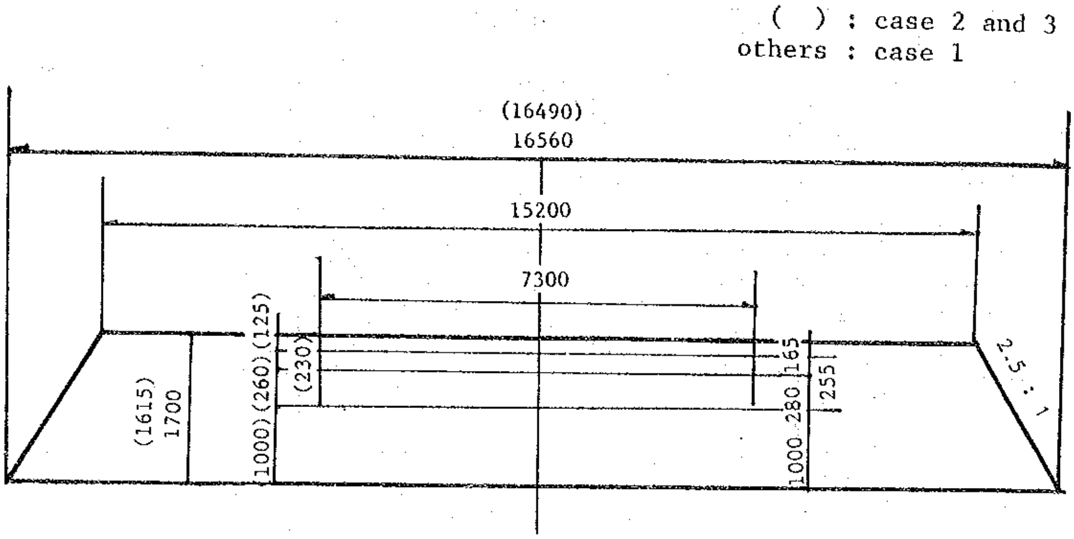


Fig. 3 Typical Cross Section

Case 1

Subgrade : $V = \{(15.2 + 16.56) \times 1.70 \times 1/2 - 0.70 \times 7.3\} \times 1000 = 21{,}886\ m^3$

Lower subbase : $V = 0.280 \times 7.3 \times 1000 = 2{,}044\ m^3$

Upper subbase : $V = 0.255 \times 7.3 \times 1000 = 1{,}862\ m^3$

Pavement : $A = 7.3 \times 1000 = 7{,}300\ m^2$

Case 2, 3

Subtrade : $V = \{(15.2 + 16.49) \times 1.615 \times 1/2 - 0.615 \times 7.3\} \times 1000 = 21{,}285\ m^3$

Lower subbase : $V = 0.26 \times 7.3 \times 1000 = 1{,}898\ m^3$

Upper subbase : $V = 0.23 \times 7.3 \times 1000 = 1{,}679\ m^3$

Pavement : $A = 7.3 \times 1000 = 7{,}300\ m^2$

Unit Cost 3,107,000 Rs./Km

Table 13 Construction Cost (Case 1)

Item	Unit	Quantity	Rate(Rs.)	Amount of Money(Rs.)	
				Local	F.E.C.
Road Bed Clearance Removing of Roots	m^2	66,800	4	267,200	−
Subgrade	m^3	21,886	80	1,488,250	262,630
Lower Subbase	m^3	2,044	150	282,070	24,530
Upper Subbase	m^3	1,862	230	400,330	27,930
Pavement	m^2	7,300	35	226,300	29,200
				2,664,150	344,290
Expenses	%	15	−	399,620	51,640
				3,063,770	395,930
				Total	3,459,700

Note: Land acquisition cost is excluded.

Case1

. Type-wise vehicles share will continue at the present conditions(2 axles:96.2%, 4 axles:3.8%).

. Axle loads will not be regulated.

Table 14 Construction Cost (Case 2, 3)

Unit Cost 2,968,000 Rs./Km

Item	Unit	Quantity	Rate(Rs.)	Amount of Money(Rs.)	
				Local	F.E.C.
Road Bed Clearance Removing of Roots	m^2	66,800	4	267,200	-
Subgrade	m^3	21,285	80	1,447,380	255,420
Lower Subbase	m^3	1,898	150	261,920	22,780
Upper Subbase	m^3	1,679	230	360,990	25,190
Pavement	m^2	7,300	35	226,300	29,200
				2,563,790	332,590
Expenses	%	15	-	384,570	49,890
				2,948,360	382,480
				Total	3,330,840

Note: Land acquisition cost is excluded.

Case 2
- . Type-wise vehicles share will continue at the present conditions.
- . Maximum axle loads will be regulated to 10 tons for single and 18 tons for tandem axle.

Case 3
- . Trucks will be replaced completely to 4 axles trucks (ex. FIAT semi trailor).
- . Maximum axle loads will be regulated.

Table 15 Basis to Estimate Number of Required New Vehicles

Type of Vehicles : Bus (Case A)

Particulars / Fiscal Year	(A)Traffic Demand (1,000Vehicle-Km/Day)	(B)Number of Required Vehicles on Road (A)/170 (1,000 Vehicles)	(C)Number of Vehicles Available from Previous Year (B) x 0.9 (1,000 Vehicles)	(D)Number of Required New Vehicles (B) - (C) (1,000 Vehicles)
1980/81	3,803	22	-	-
81/82	4,084	24	20	2
82/83	4,365	26	22	4
83/84	4,646	27	23	4
84/85	4,927	29	24	5
85/86	5,208	31	26	5
86/87	5,489	32	28	4
87/88	5,770	34	29	5
88/89	6,136	36	31	5
89/90	6,503	38	32	6
90/91	6,869	40	34	6
91/92	7,236	43	36	7
92/93	7,602	45	39	6
93/94	7,969	47	41	6
94/95	8,335	49	42	7
95/96	8,701	51	44	7
96/97	9,068	53	46	7
97/98	9,434	55	48	7
98/99	9,801	58	50	8
99/00	10,167	60	52	8

Note: Traffic demand is estimated by JICA Study Team. Intra zonal traffic is included.
Average daily mileage = 3,803,000 Vehicle-Km/Day/22,000 Vehicle = 170 Km/Day
Case A: It is assumed that present tendency will continue.

Table 16 Basis to Estimate Number of Required New Vehicles

Type of Vehicles : Bus (Case B)

Particulars / Fiscal Year	(A)Traffic Demand (1,000Vehicle-Km/Day)	(B)Number of Required Vehicles on Road (A)/170 (1,000 Vehicles)	(C)Number of Vehicles Available from Previous Year (B) x 0.9 (1,000 Vehicles)	(D)Number of Required New Vehicles (B) - (C) (1,000 Vehicles)
1980/81	3,803	22	-	-
81/82	4,086	24	20	4
82/83	4,369	26	22	4
83/84	4,652	27	23	4
84/85	4,936	29	24	5
85/86	5,219	31	26	5
86/87	5,502	32	28	4
87/88	5,785	34	29	5
88/89	6,144	36	31	5
89/90	6,502	38	32	6
90/91	6,861	40	34	6
91/92	7,219	42	36	6
92/93	7,578	45	38	7
93/94	7,937	47	41	6
94/95	8,295	49	42	7
95/96	8,654	51	44	7
96/97	9,012	53	46	7
97/98	9,371	55	48	7
98/99	9,729	57	50	7
99/00	10,088	59	51	8

Note: Traffic demand is estimated by JICA Study Team. Intra zonal traffic is included.
Average daily mileage = 3,803,000 Vehicle-Km/Day/22,000 Vehicle = 170 Km/Day
Case B: It is assumed that Pakistan Railway will be utilized much more for freight transport.

Table 17 Basis to Estimate Number of Required New Vehicles

Type of Vehicles : Motorcar & Wagon (Case A)

Particulars / Fiscal Year	(A)Traffic Demand (1,000Vehicle-Km/Day)	(B)Number of Required Vehicles on Road (A)/35 (1,000 Vehicles)	(C)Number of Vehicles Available from Previous Year (B) x 0.9 (1,000 Vehicles)	(D)Number of Required New Vehicles (B) - (C) (1,000 Vehicles)
1980/81	6,084	170	-	-
81/82	6,533	187	153	34
82/83	6,981	199	168	31
83/84	7,430	212	179	33
84/85	7,879	225	191	34
85/86	8,328	238	203	35
86/87	8,776	251	214	37
87/88	9,225	264	226	38
88/89	9,821	281	238	43
89/90	10,417	298	253	45
90/91	11,013	315	268	47
91/92	11,608	332	284	48
92/93	12,204	349	299	50
93/94	12,800	366	314	52
94/95	13,396	383	329	54
95/96	13,992	400	345	55
96/97	14,588	417	360	57
97/98	15,183	434	375	59
98/99	15,799	451	391	60
99/00	16,375	468	406	62

Note: Traffic demand is estimated by JICA Study Team. Intra zonal traffic is included.
Average daily mileage = 6,084,000 Vehicle-Km/Day/170,000 Vehicle = 35 Km/Day
Case A: It is assumed that present tendency will continue.

Table 18 Basis to Estimate Number of Required New Vehicles

Type of Vehicles : Motorcar & Wagon (Case B)

Particulars / Fiscal Year	(A)Traffic Demand (1,000Vehicle-Km/Day)	(B)Number of Required Vehicles on Road (A)/35 (1,000 Vehicles)	(C)Number of Vehicles Available from Previous Year (B) x 0.9 (1,000 Vehicles)	(D)Number of Required New Vehicles (B) - (C) (1,000 Vehicles)
1980/81	6,084	174	-	-
81/82	6,530	187	157	30
82/83	6,977	199	168	31
83/84	7,423	212	179	33
84/85	7,869	225	191	34
85/86	8,315	238	203	35
86/87	8,762	250	214	36
87/88	9,208	263	225	38
88/89	9,797	280	237	43
89/90	10,385	297	252	45
90/91	10,794	314	267	47
91/92	11,562	330	283	47
92/93	12,151	347	297	50
93/94	12,739	364	312	52
94/95	13,328	381	327	54
95/96	13,916	398	343	55
96/97	14,505	414	358	56
97/98	15,093	431	373	58
98/99	15,682	448	388	60
99/00	16,270	465	403	62

Note: Traffic demand is estimated by JICA Study Team. Intra zonal traffic is included.
Average daily mileage = 6,084,000 Vehicle-Km/Day/170,000 Vehicle = 35 Km/Day
Case B: It is assumed that Pakistan Railway will be utilized much more for freight transport.

Table 19 Basis to Estimate Number of Required New Vehicles

Type of Vehicles : Truck (Case A)

Particulars / Fiscal Year	(A)Traffic Demand (1,000Vehicle-Km/Day)	(B)Number of Required Vehicles on Road (A)/260 (1,000 Vehicles)	(C)Number of Vehicles Available from Previous Year (B) x 0.9 (1,000 Vehicles)	(D)Number of Required New Vehicles (B) - (C) (1,000 Vehicles)
1980/81	8,782	34	-	-
81/82	9,691	37	31	6
82/83	10,600	41	33	8
83/84	11,509	44	37	7
84/85	12,419	48	40	8
85/86	13,328	51	43	8
86/87	14,237	55	46	9
87/88	15,146	58	50	8
88/89	16,699	64	52	12
89/90	18,252	70	58	12
90/91	19,805	76	63	13
91/92	21,358	82	68	14
92/93	22,911	88	74	14
93/94	24,465	94	79	15
94/95	26,018	100	85	15
95/96	27,571	106	90	16
96/97	29,124	112	95	17
97/98	30,677	118	101	17
98/99	32,230	124	106	18
99/00	33,783	130	112	18

Note: Traffic demand is estimated by JICA Study Team. Intra zonal traffic is included.
Average daily mileage = 8,782,000 Vehicle-Km/Day/34,000 Vehicle = 260 Km/Day
Case A: It is assumed that present tendency will continue.

Table 20 Basis to Estimate Number of Required New Vehicles

Type of Vehicles : Truck (Case B)

Particulars / Fiscal Year	(A)Traffic Demand (1,000Vehicle-Km/Day)	(B)Number of Required Vehicles on Road (A)/260 (1,000 Vehicles)	(C)Number of Vehicles Available from Previous Year (B) x 0.9 (1,000 Vehicles)	(D)Number of Required New Vehicles (B) - (C) (1,000 Vehicles)
1980/81	8,782	34	-	-
81/82	9,439	36	31	5
82/83	10,097	39	32	7
83/84	10,754	41	35	6
84/85	11,411	44	37	7
85/86	12,068	46	40	6
86/87	12,726	49	41	8
87/88	13,383	51	44	7
88/89	14,482	56	46	10
89/90	15,581	60	50	10
90/91	16,679	64	54	10
91/92	17,778	68	58	10
92/93	18,877	73	61	12
93/94	19,976	77	66	11
94/95	21,074	81	69	12
95/96	22,173	85	73	12
96/97	23,272	90	77	13
97/98	24,371	94	81	13
98/99	25,469	98	85	13
99/00	26,568	102	88	14

Note: Traffic demand is estimated by JICA Study Team. Intra zonal traffic is included.
Average daily mileage = 8,782,000 Vehicle-Km/Day/34,000 Vehicle = 260 Km/Day
Case B: It is assumed that Pakistan Railway will be utilized much more for freight transport.

IX. RAILWAY PLANNING

1. Passenger Transportation

2. Goods Transportation
   - 2-1 High Speed Goods Transportation
     - (1) Container Trains
     - (2) High Speed Goods Trains
     - (3) Engine-km per Day per Locomotive of High Speed Goods Trains
     - (4) Terminals for Transporting High Speed Goods
   - 2-2 Ordinary Goods Transportation
   - 2-3 Elimination of Bottleneck of Transport
     - (1) Steep Grade Section between Sibi and Kolpur
     - (2) Between Lala Musa and Rawalpindi

3. Improvement of Railway Facilities

IX. RAILWAY PLANNING

1. Passenger Transportation

(1) Demand forecast for both the passengers and goods traffic are carried out for 51 zones (Fig. 1-1).

(2) Formation of the passenger trains is based upon the data reorganized to 20 zones mainly in large cities (Fig. 1-2).

(3) Aggregated OD data for 20 zones are as shown in Table 1-1.

(4) Transport volume based upon the main OD stations of the main line corresponding to 20 zones are revised as shown in Table 1-2. Those are original data needed to determine each operating section and number of trains.

(5) Based upon the above, the formation of trains is as shown in Fig. 1-3. In this case, the composition of trains is estimated as described below.

– Lond distance trains:

ACC (sleepers: 28)	1 coaches
2nd (sleepers: 16), sitters: 72)	14 coaches

Total capacity: 15 coaches, 1,260 persons

– Short distance trains:

2nd (sitters: 96)	15 coaches

Total capacity: 15 coaches, 1,440 persons

In the year 2000, the capacity of one train is to include an additional 10% standing passengers.

(6) Consequently the number of passenger trains for sections shown in Fig. 1-4 is obtained.

– A continuous line indicates the operating section of a train.

– Dotted line indicates the operation via another route.

– A figure on the line indicates the passengers transported by a train through the section.

– Top column indicates the traffic volume through the section.

– Second column indicates the transport volume through the section.

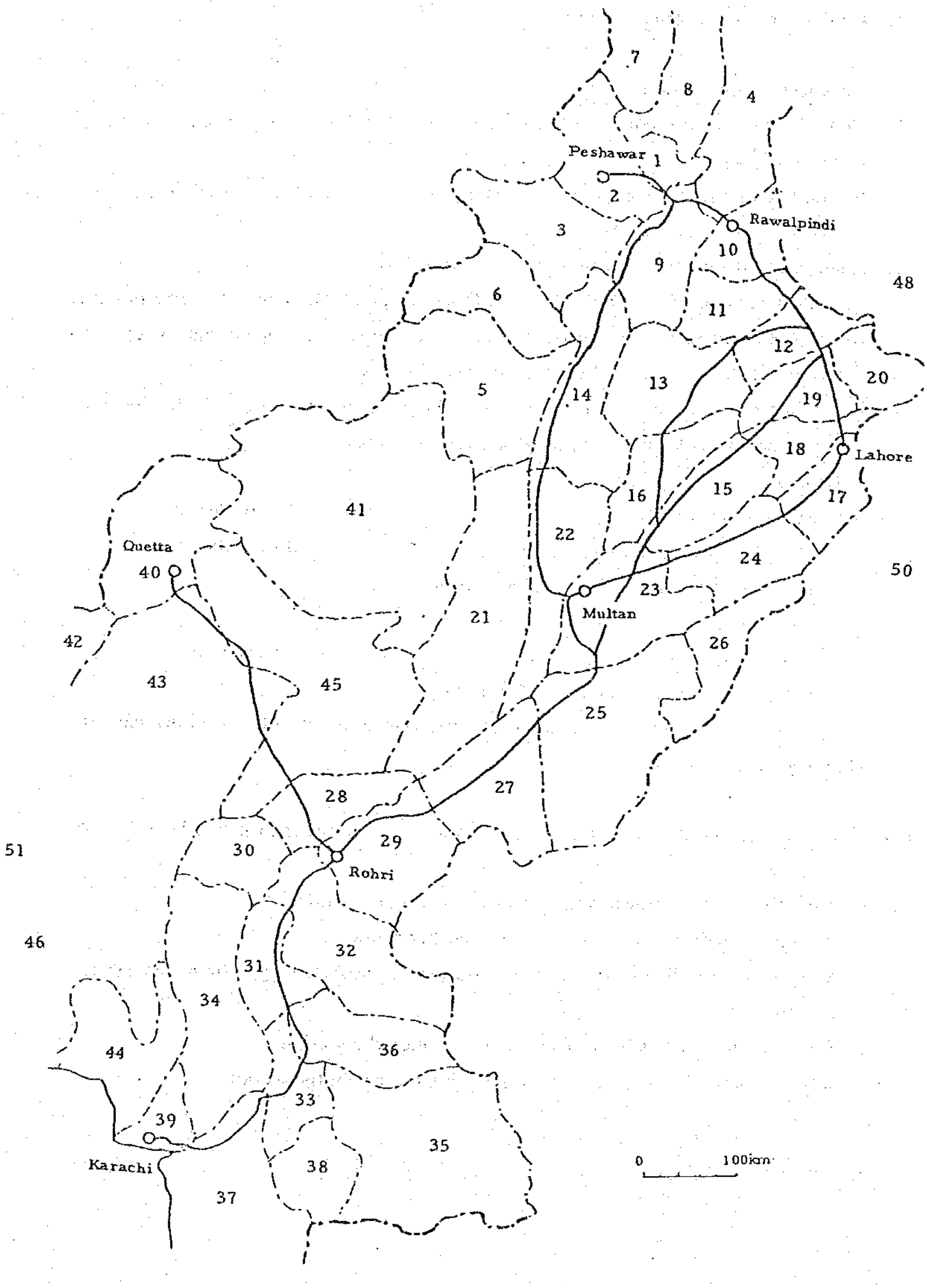


Fig. 1-1 51-Zone Map

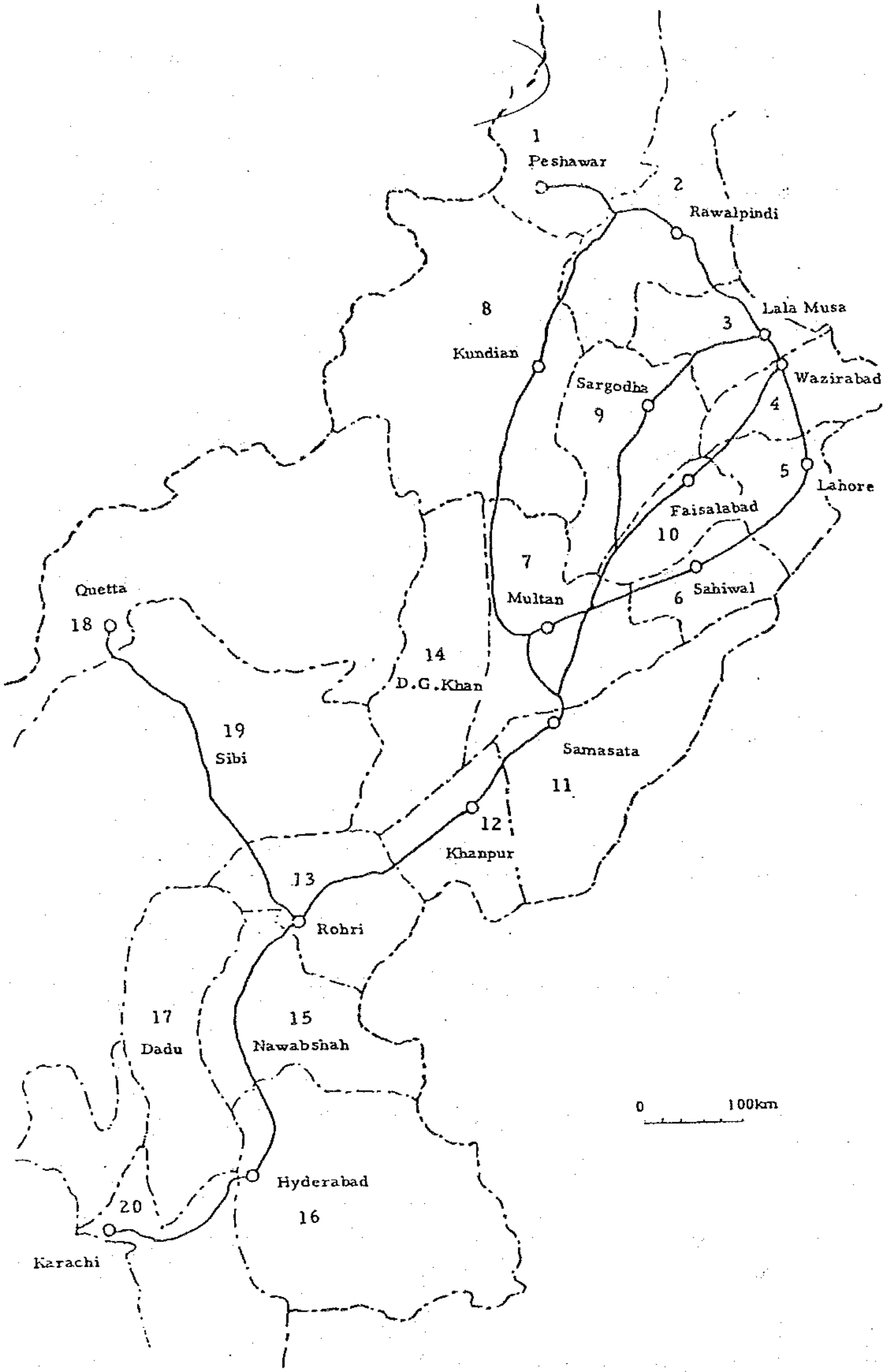


Fig. 1-2 20-Zone Map (Passenger)

Table 1-1 Passenger Traffic (1999/2000)

unit; 1000

PROJECTION PASSENGER

	1	2	3	4	5	6	7	8	9	10
1	64.	474.	29.	45.	100.	9.	12.	34.	26.	21.
2	474.	1225.	370.	400.	724.	52.	79.	210.	197.	290.
3	29.	370.	1176.	4999.	1240.	108.	75.	64.	448.	388.
4	45.	400.	4999.	3140.	5585.	271.	174.	97.	585.	1205.
5	100.	724.	1240.	5585.	16868.	782.	893.	158.	1052.	3246.
6	9.	52.	108.	271.	782.	0.	604.	26.	214.	151.
7	12.	79.	75.	174.	893.	604.	6481.	107.	686.	737.
8	34.	210.	64.	97.	158.	26.	107.	32.	394.	141.
9	26.	197.	448.	585.	1052.	214.	686.	394.	1293.	1676.
10	21.	290.	388.	1205.	3246.	151.	737.	141.	1676.	0.
11	5.	25.	29.	64.	257.	139.	570.	31.	177.	208.
12	3.	17.	17.	35.	212.	48.	135.	15.	69.	226.
13	10.	21.	14.	30.	165.	31.	70.	14.	46.	89.
14	3.	8.	7.	15.	30.	26.	195.	18.	36.	25.
15	3.	12.	12.	25.	66.	24.	54.	10	37.	67.
16	4.	18.	13.	28.	172.	24.	49.	11.	37.	58.
17	8.	17.	16.	34.	56.	31.	70.	13.	48.	36.
18	28.	19.	3.	6.	122.	3.	16.	1.	4.	4.
19	1.	4.	5.	10.	16.	9.	19.	5.	14.	10.
20	565.	1291.	168.	599.	4051.	30.	1275.	36.	331.	1314.
21	0.	0.	0.	0.	0.	0.	0.	0.	0	0.
22	1445.	5453.	9179.	17348.	35795.	2583.	12301.	1418.	7369.	9891.

PROJECTION PASSENGER

	11	12	13	14	15	16	17	18	19	20
1	5.	3.	10.	3.	3.	4.	8.	28.	1.	565.
2	25.	17.	21.	8.	12.	18.	17.	19.	4.	1291.
3	29.	17.	14.	7.	12.	13.	16.	3.	5.	168.
4	64.	35.	30.	15.	25.	28.	34.	6.	10.	599.
5	257.	212.	165.	30.	66.	172.	56.	122.	16.	4051.
6	139.	48.	31.	26.	24.	24.	31.	3.	9.	30.
7	570.	135.	70.	195.	54.	49.	70.	16.	19.	1275.
8	31.	15.	14.	18.	10.	11.	13.	1.	5.	36.
9	177.	69.	46.	36.	37.	37.	48.	4.	14.	331.
10	208.	226.	89.	25.	67.	58.	36.	4.	10.	1314.
11	126.	175.	61.	37.	43.	35.	54.	5.	14.	482.
12	175.	0.	221.	14.	117.	59.	131.	8.	26.	553.
13	61.	221.	846.	21.	1934.	149.	1041.	37.	175.	334.
14	37.	14.	21.	0.	11.	9.	17.	1.	7.	11.
15	43.	117.	1934.	11.	204.	848.	350.	9.	51.	436.
16	35.	59.	149.	9.	848.	7200.	430.	14.	32.	1425.
17	54.	131.	1041.	17.	350.	430.	1120.	22.	08.	395.
18	5.	8.	37.	1.	9.	14.	22.	33.	77.	420.
19	14.	26.	175.	7.	51.	32.	88.	77.	11.	35.
20	482.	553.	334.	11.	456.	1425.	395.	420.	35.	585.
21	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
22	2538.	2081.	5309.	490.	4331.	10617.	3975.	831.	608.	14356.

Table 1-2 Passenger Traffic Modified between Stations

unit; 1000

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
		PSC	RWP	LLM	WZD	LHR	SWAL	MUL	KDA	SRQ	FSLD	SMA	KPR	ROH	DGK	NWS	HDR	DDU	QTA	SIB	KYC
		1,380	3,967	9,009	12,820	11,893	2,582	6,193	287	2,606	5,021	2,411	2,081	5,907	0	3,779	3,380	0	798	597	13,771
20	Karachi	565	1,291	168	599	4,051	30	1,275	36	331	1,314	482	553	800		456	1,820				
19	Sibi													520					77		
18	Quetta													721							
17	Dadu																				
16	Hyderabad	4	18	13	28	172	24	49	11	37	58	35	59	204		848					
15	Nawabshah	3	12	12	25	66	24	54	10	37	67	43	117	2,005							
14	D.G. Khan																				
13	Rohri	47	61	38	80	359	74	175	33	112	139	146	393								
12	Khanpur	3	17	17	35	212	48	142	15	69	226	175									
11	Samasata	5	25	29	64	257	139	595	31	177	208										
10	Faisalabad				2,196			813													
9	Sargodha			1,014				829													
8	Kundian							151													
7	Multan	15	87	82	189	923	814														
6	Sahiwal	9	52	108	271	989															
5	Lahore	100	724	1,240	2,800																
4	Wazirabad	66	690	5,777																	
3	Lala Musa	42	469																		
2	Rawalpindi	521																			
1	Peshawar																				

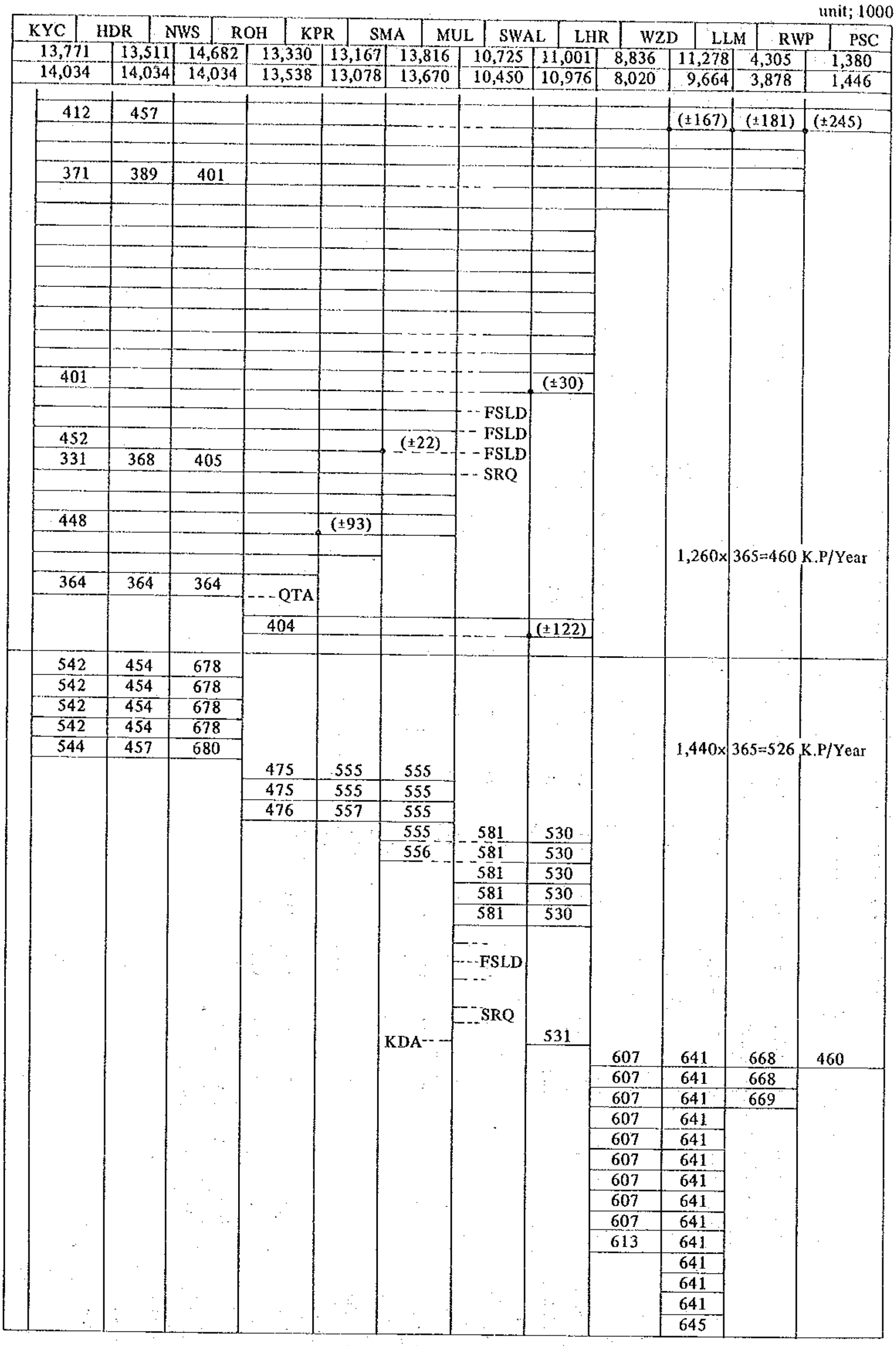


Fig 1-3 Passenger Train Formation

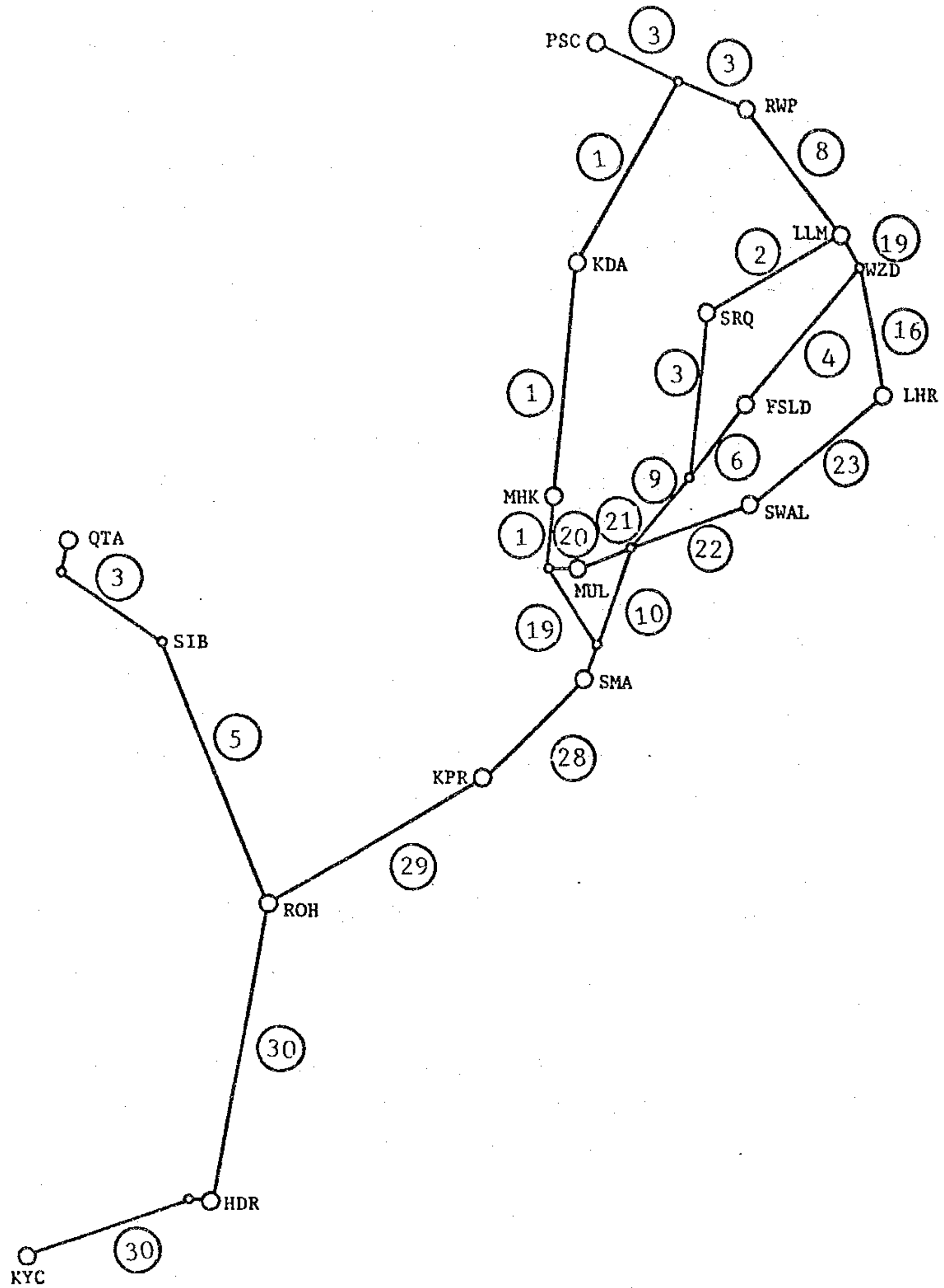


Fig. 1-4 Number of Passenger Trains

2. Goods Transportation

Goods transportation is considered separately for high speed and general transport.

2-1 High Speed Goods Transportation

High speed goods trains will be provided on the section between Karachi and Lahore where the traffic demand is especially high. For high speed goods transportation, both container trains and high speed goods trains are contained.

The high speed goods train consists of large bogie wagons instead of conventional 4-wheelers.

(1) Container trains

Container trains should have a fixed composition and train dimensions should be as large as possible, and then the exclusive operation at high speeds will be made between Karachi and Lahore. Trains will be designed as follows:

1) Train composition

- Train dimensions should be 3,000 tons maximum gross weight, and 900 m maximum length.
- A flat wagon will bear three containers. Tare Weight is 24 tons, and length is about 20.4 m.
- Past data of average net weight in a container shows 9 tons for import and 11 tons for export. The tare weight of a container is 1.6 tons.
- Designing weight of a loaded container is determined to be 13 tons with some allowance.

  Each train will have 42 wagons with the dimensions for each train being:

  Gross tonnage: $105 + (24+13x3) \times 42 = 2,751$ tons

  Length of train: $18 + 20.4 \times 42 = 875$ m

2) Number of trains

- Number of containers transported annually (from demand forecast Table 2-1):

  $1,215 \times 10^3 \div 9 = 135,000$

- Number of containers transported annually per train:

  $3 \times 42 \times 0.9 \times 300 = 34,020$

- Number of trains required: $135,000 \div 34,020 = 4$

3) Rotation of trains

– Design mean speed of trains:	60 km/h
– Design running time:	20 hours
– Over-night detention (once/rotation):	14 hours
– Detention for load handling work (per terminal):	9 hours
– Total turn-round time:	72 hours

4) Output of locomotives

Continuous rating (running resistance of 5 kg/t, transmission efficiency of 85%).

Traction (2,751 gross tons, speed of 60 km/h): 2,643 KW

During acceleration (0.35 km/h/sec, speed of 50 km/h): 4,625 KW

If the short-time overload factor is 120%, a continuous rating of 4,000 KW class is desired.

Table 2-1 Container Traffic (1999/2000)

unit; 1000

99/00
ZONE AGGREGATION CONTAINER RAIL

	IMPORT	EXPORT
1	104.82	101.27
2	136.56	35.64
3	6.92	49.28
4	15.89	25.40
5	123.23	299.39
6	698.44	140.91
7	102.98	173.78
8	0.0	0.0
9	26.16	139.30
10	0.0	0.0
11	0.0	0.0
12	0.0	0.0
13	0.0	0.0
14	0.0	0.0
15	0.0	0.0
16	0.0	0.0
17	1214.99	964.98

5) Number of wagons required

42 wagons x 4 trains x 3 days x 1.2 (spare factor) = 605 wagons

(2) High speed goods trains

High speed goods trains of fixed composition should be operated on the section between Karachi and Lahore where there are many goods to be transported between large cities. These trains should be heavy-weight trains the same as container trains and locomotives should be commonly operated in rotation.

1) Train Composition

- Train dimensions should be 3,500 tons maximum gross weight and 900 m of maximum length.
- Goods wagons should be the bogie wagons of 40-t class which have twice a capacity as the present ones. They will have a tare weight of 21.4 tons and the length of 16.5 m.
- A capacity of 44.8 tons and average loading factor of 90% are used for design.
- Restricted length, a train is comprised of 52 cars and has the following dimen-

sions:

Gross tonnage: $105 + (21.4 + 44.8 \times 0.9) \times 52 = 3{,}314$

Length of train: $18 + 16.5 \times 52 = 876$ m.

2) Number of trains

– Annual amount of transportation (from demand forecast in Table 2-3):

Up dry: $3{,}228 \times 10^3$ tons

Down: 748×10^3 tons

– Annual amount of transport per train:

$44.8 \text{ t} \times 0.9 \times 52 \times 0.9 \times 300 = 566 \times 10^3$ tons

– Design number of trains:

80% of annual mount of transport as target: 5 trains

3) Rotation of trains

– Design mean speed of trains: 50 km/h

Design running hours: 24 hours

– Rotation of trains

One way loading: 4 days

One day each for loading & unloading, and 2 days for round trip running.

Two way loading 6 days

Two days each for loading, unloading and round trip running. About 5 days on average is assumed since the ratio of the two way loading is about 25%.

4) Output of locomotives

Continuous rating (running resistance: 5 kg/t)

Traction (3,314 gross tons, speed of 50 km/h) 2,653 KW

During acceleration (0.35 km/h/sec at a speed of 40 km/h): 4,458 KW

A continuous output of 4,000 KW is sufficient if the short-time overload factor is 120%.

5) Required number of goods wagons

52 wagons x 5 trains x 5 days x 1.2 (spare factor) = 1,560 cars

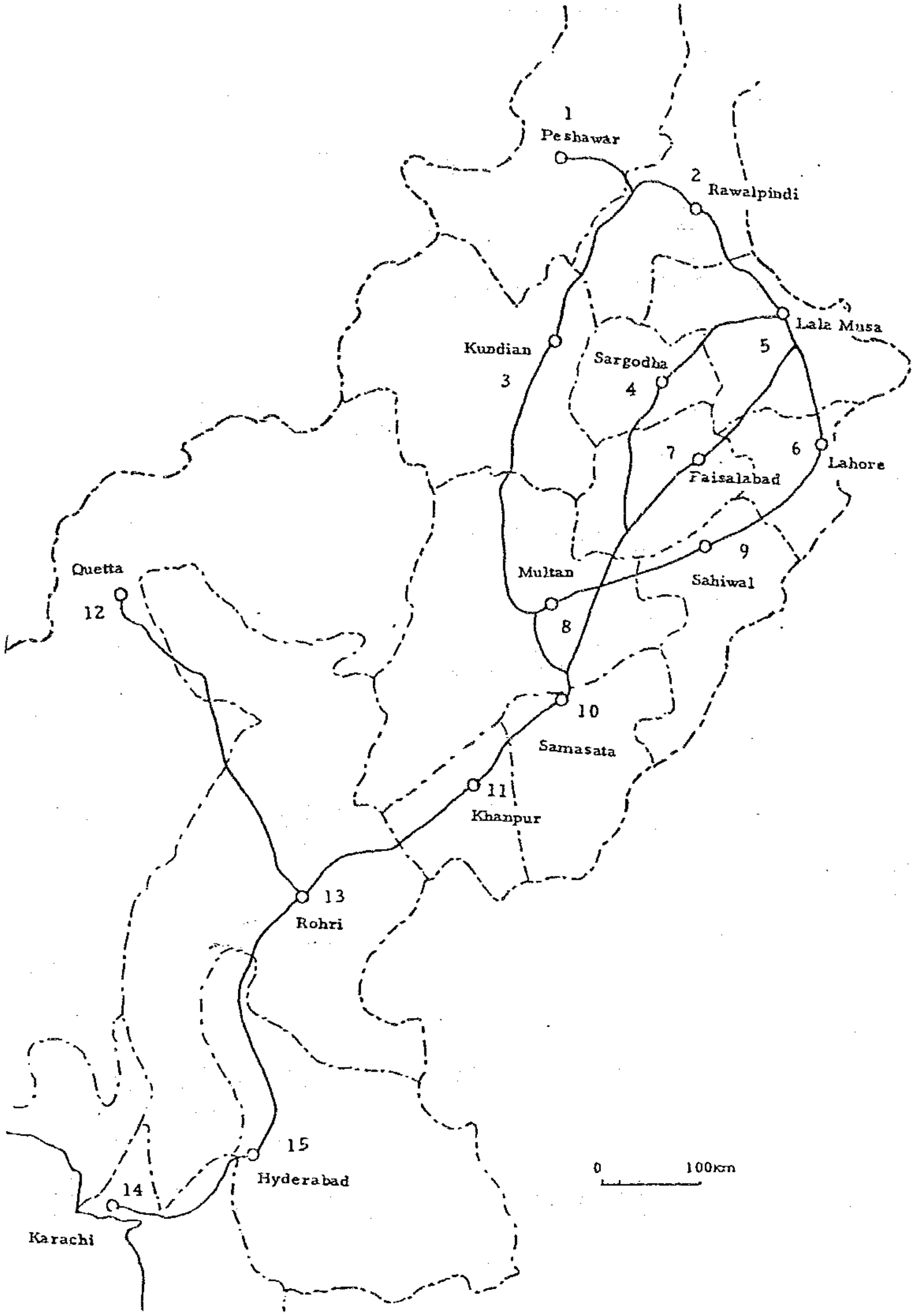


Fig. 2-1 15-Zone Map (Goods)

Table 2-2 Goods Traffic (1999/2000) – Case A

unit; 1000

ZONE AGGREGATION SUM RAIL 99/00

	1	2	3	4	5	6	7	8	9	10
1	0.	0.	0.	0.	61.	51.	7.	1.	2.	0.
2	0.	0.	0.	0.	0.	0.	0.	10.	4.	4.
3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.	0.	120.	0.	181.
5	0.	0.	0.	0.	0.	0.	0.	34.	35.	6.
6	77.	97.	0.	0.	0.	0.	0.	39.	0.	9.
7	73.	91.	0.	55.	0.	0.	0.	0.	0.	0.
8	641.	836.	201.	94.	186.	622.	252.	0.	0.	0.
9	429.	41.	0.	0.	0.	0.	0.	0.	0.	0.
10	15.	13.	5.	0.	19.	59.	27.	0.	0.	0.
11	14.	23.	0.	7.	65.	136.	0.	0.	0.	0.
12	302.	594.	0.	2.	340.	252.	37.	7.	24.	0.
13	122.	461.	17.	30.	271.	406.	156.	82.	236.	39.
14	290.	413.	81.	152.	205.	1352.	542.	1042.	301.	114.
15	6.	391.	3.	2.	60.	506.	7.	32.	10.	6.
16	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
17	2792.	3999.	510.	426.	2504.	4760.	1406.	1766.	830.	825.

	11	12	13	14	15	16	17
1	13.	4.	1.	535.	19.	0.	954.
2	0.	12.	1.	52.	2.	0.	1210.
3	0.	0.	0.	160.	40.	0.	1278.
4	26.	0.	15.	138.	19.	0.	1108.
5	14.	16.	32.	427.	27.	0.	1851.
6	18.	95.	20.	243.	24.	0.	955.
7	0.	37.	0.	257.	29.	0.	979.
8	0.	184.	34.	244.	34.	0.	3923.
9	0.	63.	0.	255.	3.	0.	1131.
10	0.	9.	0.	34.	1.	0.	445.
11	0.	264.	64.	104.	94.	0.	837.
12	0.	0.	22.	116.	0.	0.	1766.
13	0.	250.	0.	491.	1217.	0.	4303.
14	117.	361.	679.	0.	0.	0.	6146.
15	25.	82.	180.	0.	0.	0.	2154.
16	0.	0.	0.	0.	0.	0.	0.
17	428.	1447.	1444.	3886.	2018.	0.	29040.

Table 2-3 Goods Traffic (1999/2000) – Case B

unit; 1000

ZONE AGGREGATION SUM RAIL 99/00

	1	2	3	4	5	6	7	8	9	10
1	0.	0.	0.	0.	44.	80.	17.	16.	12.	1.
2	0.	0.	0.	0.	0.	208.	0.	21.	30.	5.
3	0.	0.	0.	0.	108.	195.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.	0.	124.	0.	205.
5	0.	0.	0.	0.	0.	0.	0.	33.	34.	6.
6	69.	79.	0.	0.	0.	0.	0.	38.	0.	11.
7	73.	82.	0.	0.	0.	0.	0.	0.	0.	0.
8	662.	831.	196.	94.	206.	612.	184.	0.	0.	0.
9	388.	34.	0.	0.	0.	0.	0.	0.	0.	0.
10	15.	12.	5.	0.	16.	52.	27.	0.	0.	0.
11	25.	41.	0.	23.	121.	156.	15.	0.	0.	0.
12	352.	679.	0.	17.	1319.	588.	413.	49.	79.	1.
13	283.	803.	17.	61.	360.	1414.	219.	390.	359.	55.
14	535.	724.	151.	368.	743.	3344.	917.	1522.	468.	218.
15	10.	507.	4.	2.	82.	564.	10.	74.	25.	13.
16	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
17	2413.	3792.	372.	565.	2999.	7213.	1801.	2267.	1007.	515.

	11	12	13	14	15	16	17
1	19.	25.	28.	1788.	58.	0.	2088.
2	5.	18.	14.	199.	7.	0.	507.
3	0.	0.	0.	372.	134.	0.	809.
4	116.	2.	42.	189.	21.	0.	699.
5	16.	29.	33.	1180.	53.	0.	1383.
6	39.	99.	41.	748.	38.	0.	1161.
7	0.	43.	11.	595.	42.	0.	847.
8	0.	209.	37.	710.	113.	0.	3853.
9	0.	68.	0.	415.	3.	0.	908.
10	0.	9.	0.	68.	2.	0.	206.
11	0.	244.	0.	156.	98.	0.	879.
12	2.	0.	0.	271.	1.	0.	3772.
13	0.	68.	0.	666.	1220.	0.	5915.
14	188.	896.	969.	0.	0.	0.	11044.
15	27.	86.	186.	0.	0.	0.	1591.
16	0.	0.	0.	0.	0.	0.	0.
17	412.	1798.	1362.	7356.	1790.	0.	35662.

(3) **Engine-km per day of locomotives for high speed goods trains**

An train diagram for the containers and high speed goods trains is shown in main text of the report. According to this example, the rotation schedule of 18 round trips between Karachi and Lahore is 23 days as shown in Fig. 2-2, and engine-km per day amounts to 954 km. The mean operating hours per day of a locomotive is 17.4 hours. This indicates that transportation with an extremely high efficiency can be made even for the goods trains as long as national rotation can be provided.

In performing this highly efficient transportation, it is required to re-examine the conventional criteria for train operation.

- o The container and high speed goods trains should be given the same privileges as limited express passenger trains.
- o Container and high speed goods trains should be rotated in fixed composition as a rule.
- o The rotation of wagons including spares should be reviewed.
- o 4,000 KW class locomotives should be in common for both container and high speed goods trains.
- o The inspection time for rolling stock should be determined based upon not only the period but also the running distance.

(4) **Terminals for transporting high speed goods**

In order to transport containers and high speed goods, a terminal line layout capable of performing quick rotation of trains and terminal facilities as a connecting station capable of performing the transhipment quickly between trains and trucks is required.

For efficiently operating the terminal, it is desired to build a new rational terminal separate from the existing Dry Port and Lahore freight front. For this purpose, the following two plans can be considered:

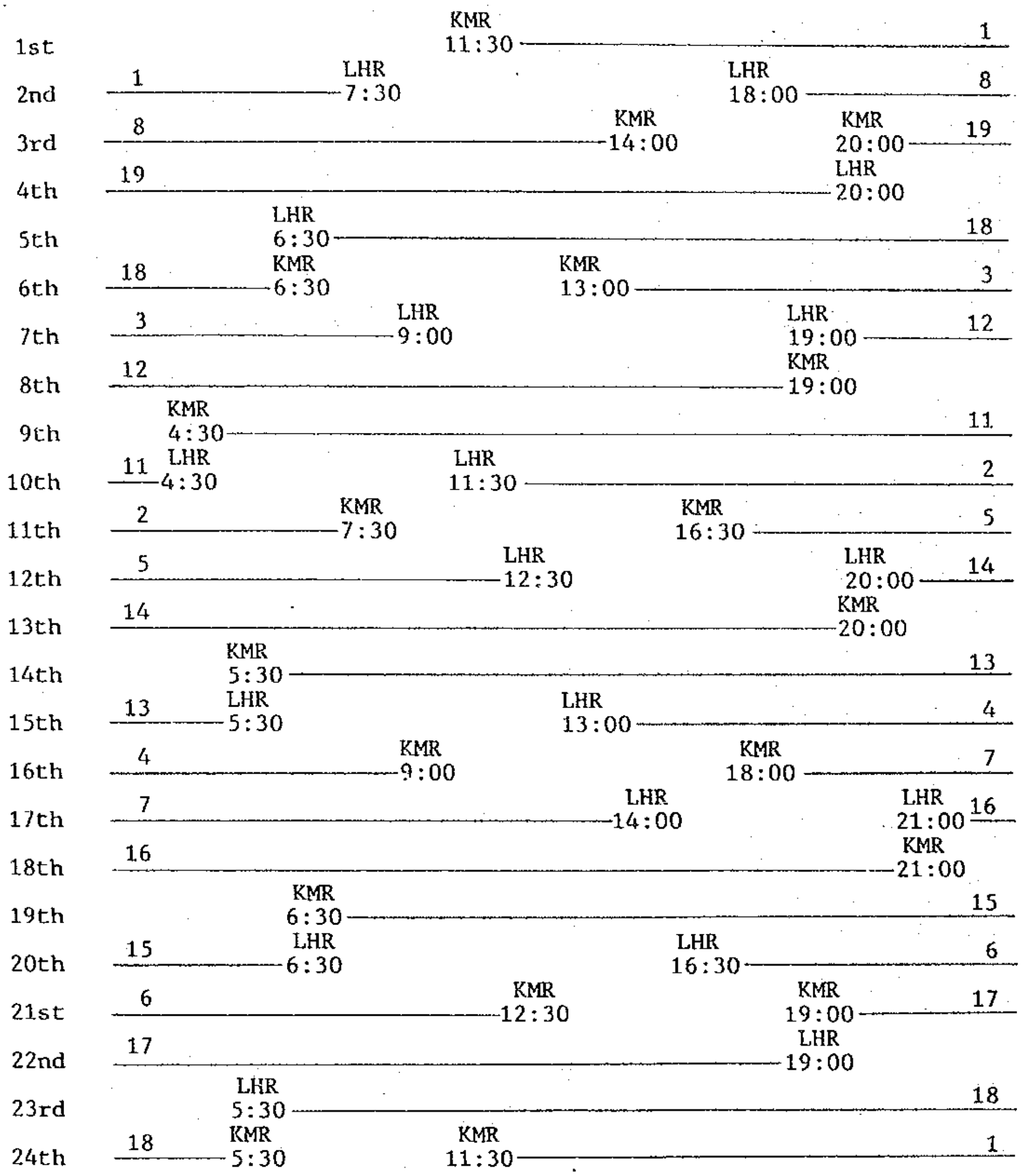
a) To use the new terminal exclusively for container and high speed goods trains.

b) To handle all goods in the new terminal.

According to plan a), the present yard can be utilized as usual and the construction cost can be lower. But improvements and additional facilities will be required with increases of traffic volume. According to plan b), goods can be all collected and delivered, an efficient base can be provided, and existing yards can be utilized for passenger carriages.

In the overall point of view, plan b) is considered to be more efficient. Fig. 2-3 shows an example of this plan.

- Island station type arrival and departure lines should be provided since many trains use the main lines.



Turn Round Time : 23 Days
1 - 8 : Container Trains
11 - 20 : High Speed Wagon Trains

Fig. 2-2 EL Rotation Diagram for High Speed Goods Train

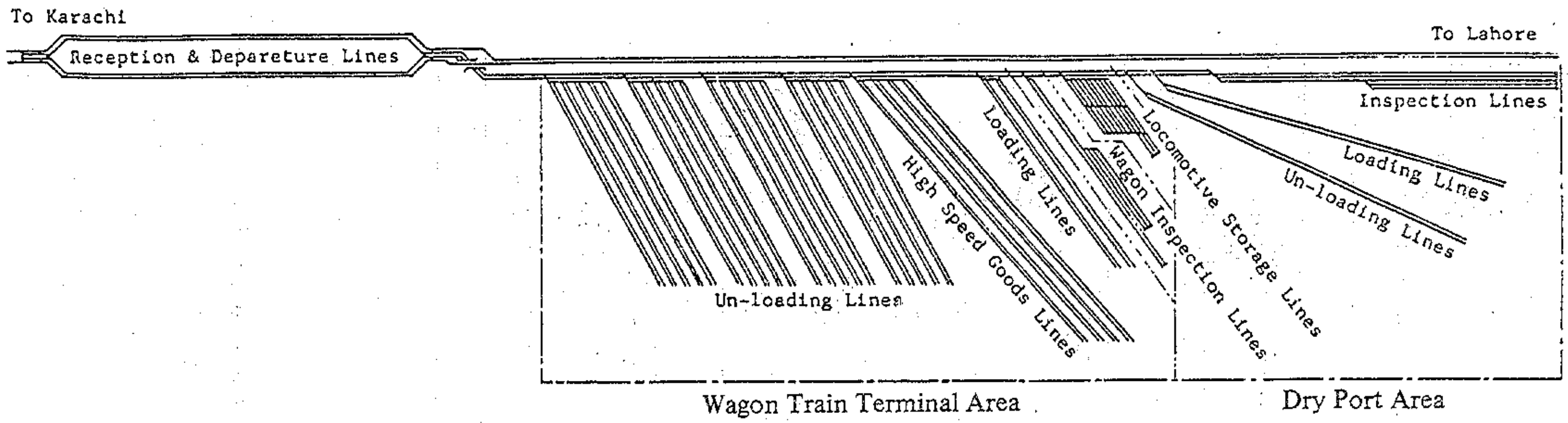


Fig. 2-3 An Example of Lahore Terminal Layout

- Terminals should be located at the northeast side of arrival and departure lines for the convenience of round trips to and from Karachi, and so as to not influence the through trains leaving Karachi and going beyond Lahore.
- Generally container wagons should be brought to unloading lines and, after unloading, should be moved to inspection lines. After inspection and replacement of defective wagons, they should be brought to the loading line and, after loading, should be moved to the departure line.

  This operation should be completed within approximately 6 hours.
- High speed goods trains should be brought to the high speed goods line and then unloaded. Since about 62 wagons (converted to 40-t class wagons) on average per day are expected from Lahore to Karachi in the year 2000, about two out of five trains arrived at should be loaded with goods and leave for Karachi. The remaining three trains should be sent inloaded.

  If the high speed trains are established, then the goods handling zone of the Lahore Station can be expanded.
- Most of ordinary goods arrive from Karachi, Hyderabad and Rohri. Excluding the goods shipped at high speed to Karachi, only one train will be needed per day. More than 90% of freight cars will be sent for unloading cars. If the transport of ordinary freight is also established, the tendency for concentration will be further intensified in Lahore.

  Working diagram at terminals is as shown in Fig. 2-4, 8 loading and unloading lines is required at Karachi terminal and 7 at Lahore.

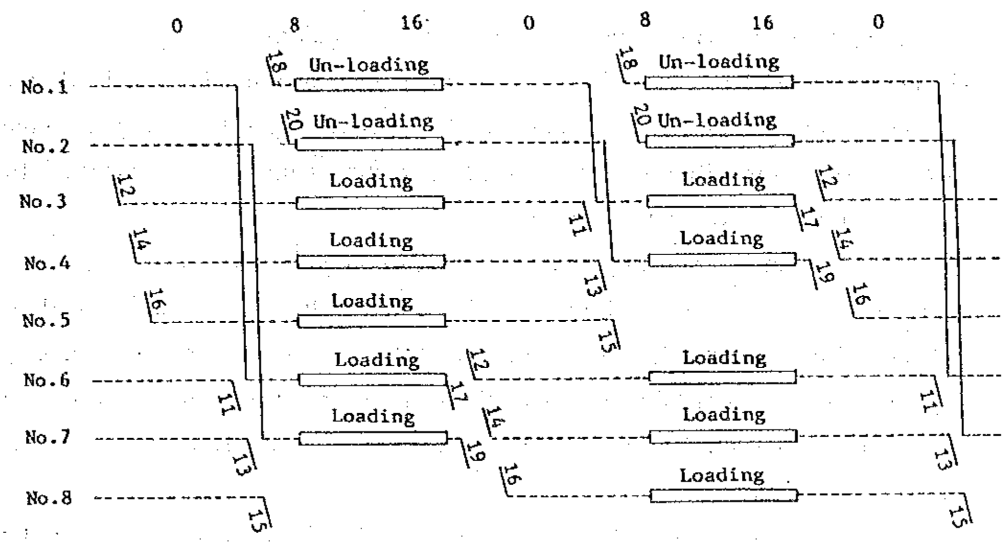
2-2 Ordinary Goods Transportation

(1) 15 stations have been selected as base stations for transporting goods. The handling area for each base station has been determined to be 50 to 100 km in radius by taking account of daily mobility of an automobile. These 15 zones are shown in Fig. 2-1.

(2) OD of 15 zones is shown in Table 2-2 "Case A" and Table 2-3 "Case B". OD table was prepared based upon the demand forecast made by the study team taking into account the following items:

1) Transport between adjacent base stations is to be performed on roads.
2) Roads are to be used for transport between base stations if the transport time on roads is considerably shorter than that for railways.
3) Road transport should be used if the amount of transport between centers is small.

Karachi Terminal



Lahore Terminal

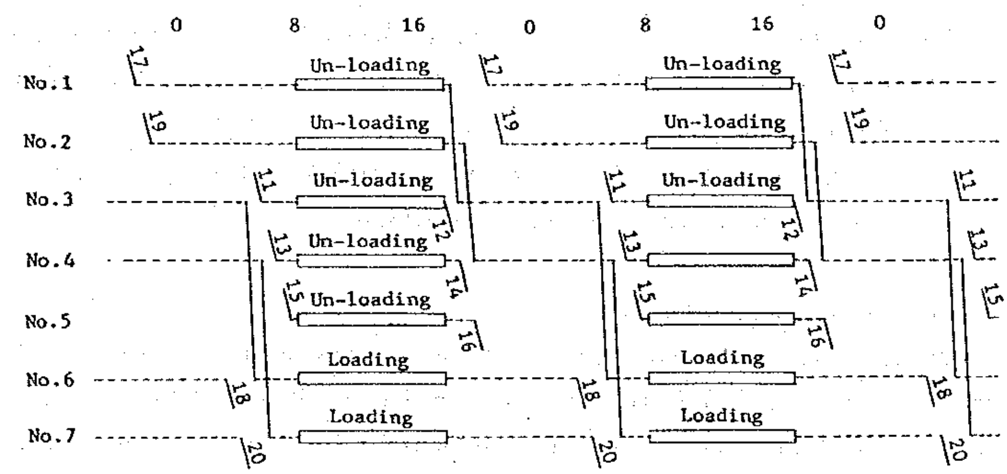


Fig. 2-4 Working Diagram for High Speed Goods Trains

(3) Formation of trains will become difficult between the base stations in the case of small amounts of transport and then the goods are to be aggregated to another base station. As a result, OD to be used as the original railway transport plan as indicated in Table 2-4 and Table 2-5.

(4) As a rule, the transport amount between base stations in Table 2-2, will be conveyed on each through train. Annual amount of transport for one train is as follows:

$T = W \times \alpha \times m \times \beta \times d = 392 \times 10^3$ tons/year

where, W: Weight per wagon, = 22.4 tons

α : Average loading factor, = 0.9

m: Maximum number of wagons per train, = 72

β : Seasonal unbalance factor, = 0.9

d : Annual operation days, = 300

Traction power = $m \times (W \times \alpha \times W_1) + W_0$ = 2,327 tons

where, W_1: Tare weight, = 10.7

W_0: Locomotive weight, = 105

(5) Consequently, the through trains (Up) between the base stations from Karachi to Peshawar should be as indicated in Fig. 2-5 "Case A" and Fig. 2-6 "Case B".

- A continuous line shows the operating section of a train.
- Section of dotted line indicates the operation via another route.
- Figure at the left end shows the load of one train.
- Figures at the middle and right end show the unloading.
- A train will not be connected in the middle.

(6) The numbers of trains determined above are as indicated in Fig. 2-7 "Case A" and Fig. 2-8 "Case B".

(7) Most of the 16 trains arriving at Lahore Station from the direction of Karachi will be sent back empty to the direction of Karachi.

2-3 Elimination of Bottleneck of Transport

(1) Steep grade section between Sibi and Kolpur

The present operation with devided trains in the section will steep grade should be changed to through operation by 1,000 t trains between Sibi and Quetta in order to greatly reduce the operating hours.

Table 2-4 Goods Traffic Modified between Stations – Case A

unit; 1,000

				Destination														
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
				PSC	RWP	KDA	SRQ	LLM	LHR	FSLD	MUL	SWAL	SMA	KPR	QTA	ROH	KYC	HDR
				1,969	2,960	307	287	1,207	3,531	1,028	1,367	612	359	213	1,377	1,048	3,056	1,509
Origin	1	Peshawar	694					61	51	7	1	2		13	(1.13) 4	1	535	19
	2	Rawalpindi	232						147		10	4	4		(2.13) 12	1	52	2
	3	Kundian	200														160	40
	4	Sargodha	499								120		181	26		15	138	19
	5	Lala Musa	591								34	35	6	14	(5.13) 16	32	427	27
	6	Lahore	622	77	97						39		9	18	(6.13) 95	20	243	24
	7	Faisalabad	487	73	91										(7.13) 37		257	29
	8	Multan	3,328	641	836	201	94	186	622	252					(8.13) 184	34	244	34
	9	Sahiwal	791	429	41										(9.13) 63		255	3
	10	Samasata	182	(8.1) 15	(8.2) 13	(8.3) 5		(8.5) 19	(8.6) 59	(8.7) 27					(11.12) 9		34	1
	11	Khanpur	771	(8.1) 14	(8.2) 23		(11.6) 7	65	136						(11.13) 264	64	104	94
	12	Quetta	1,696	302	594		2	340	252	37	7	24				22	116	
	13	Rohri	3,778	122	461	(13.4) 17	30	271	406	156	82	236	39		250		491	1,217
	14	Karachi	5,649	290	413	81	152	205	1,352	542	1,042	301	114	117	(14.13) 361	679		
	15	Hyderabad	1,310	(15.2) 6	391	(15.8) 3	(15.6) 2	60	506	(15.6) 7	32	(15.8) 10	(15.8) 6	25	(15.13) 82	180		

Table 2-5 Goods Traffic Modified between Stations – Case B

unit; 1,000

				Destination 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
				PSC	RWP	KDA	SRQ	LLM	LHR	FSLD	MUL	SWAL	SMA	KPR	QTA	ROH	KYC	HDR
				2,412	3,792	373	565	2,999	7,213	1,802	2,267	1,007	515	412	1,796	1,361	7,357	1,790
Origin	1	Peshawar	2,088					44	80	(1.6) 17	16	(1.6) 12	(1.8) 1	(1.8) 19	(1.13) 25	28	1,788	58
	2	Rawalpindi	507						208		21	(2.6) 30	(2.8) 5	(2.8) 5	(2.13) 18	14	199	(2.14) 7
	3	Kundian	809					108	195								372	134
	4	Sargodha	699								124		205	116	(4.13) 7	42	189	(4.14) 21
	5	Lala Musa	1,384								33	34	(5.8) 6	(5.8) 16	(5.13) 29	33	1,180	53
	6	Lahore	1,162	69	79						38		(6.8) 11	39	(6.13) 99	41	748	38
	7	Faisalabad	846	(6.1) 73	(6.2) 82										(7.13) 43	11	595	42
	8	Multan	3,854	662	831	196	94	206	612	184					(8.13) 209	37	710	113
	9	Sahiwal	908	388	34										(9.13) 68		415	(9.14) 3
	10	Samasata	206	(8.1) 15	(8.2) 12	(8.3) 5		(11.5) 16	(11.6) 52	(8.7) 27					(11.12) 9		68	(10.14) 2
	11	Khanpur	879	(8.1) 25	(8.2) 41		(11.5) 23	121	156	(11.6) 15					(11.13) 244		156	98
	12	Quetta	3,771	352	679		(12.7) 17	1,319	588	413	49	79	(12.8) 1	(12.8) 2			271	(12.14) 1
	13	Rohri	5,915	283	803	(13.8) 17	(13.7) 61	360	1,414	219	390	359	55		68		666	1,220
	14	Karachi	11,043	535	724	151	368	743	3,344	917	1,522	468	218	188	(14.13) 896	969		
	15	Hyderabad	1,590	(15.2) 10	507	(15.8) 4	(15.6) 2	82	564	(15.6) 10	74	(15.8) 25	(15.8) 13	27	(15.13) 86	186		

unit; 1000

KYC	HDR	ROH	QTA	KPR	SMA	MUL	KDA	SRQ	FSLD	SWAL	LHR	LLM	RWP	PSC
6,864	1,310	3,378	1,696	208		3,007			164	470	174			
		2,998		142	153	1,182	287	295	1,014	561	4,564	1,146	2,966	1,963

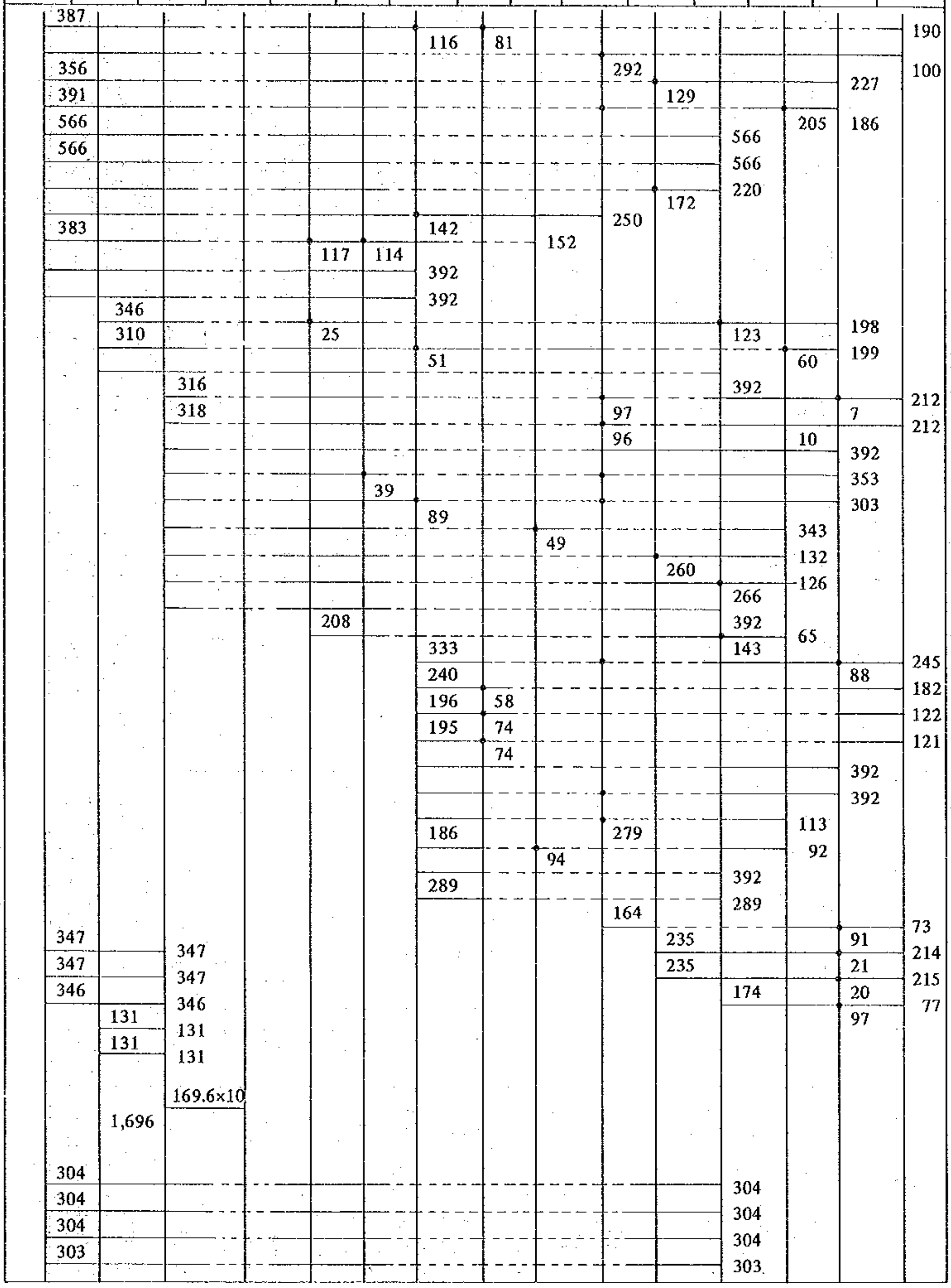


Fig. 2-5 Goods Train Formation – Case A

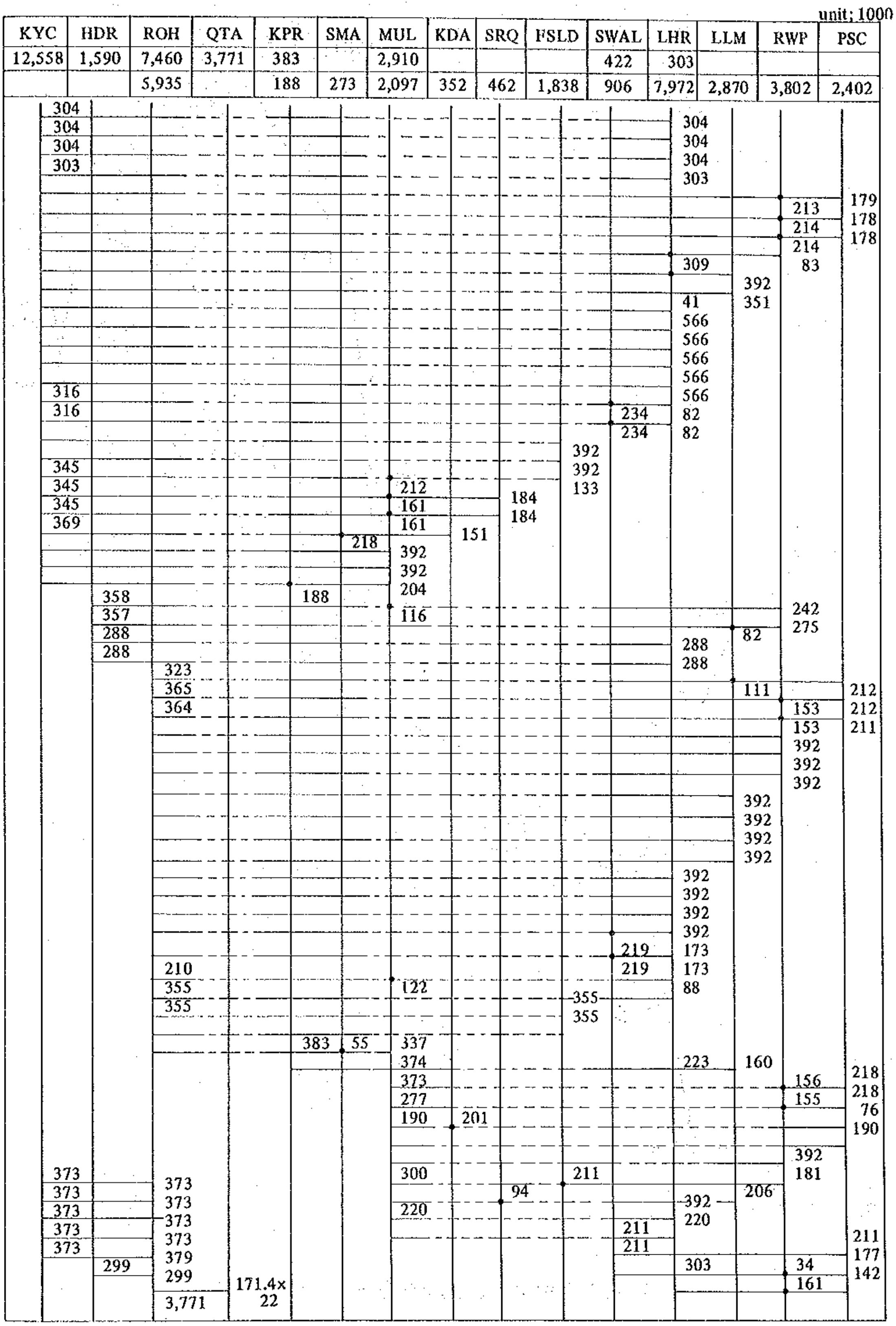


Fig. 2-6 Goods Train Formation – Case B

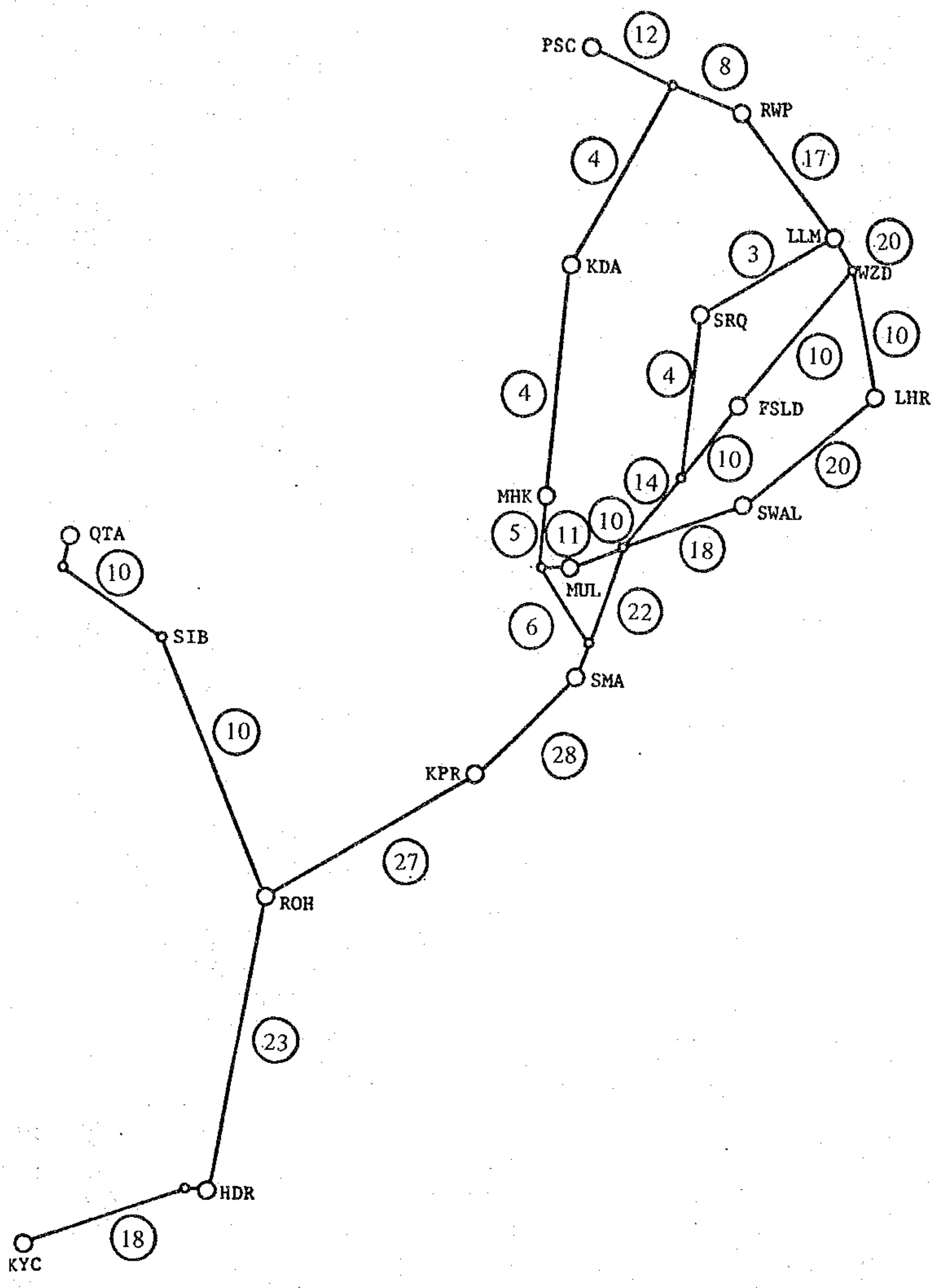


Fig. 2-7 Number of Goods Trains – Case A

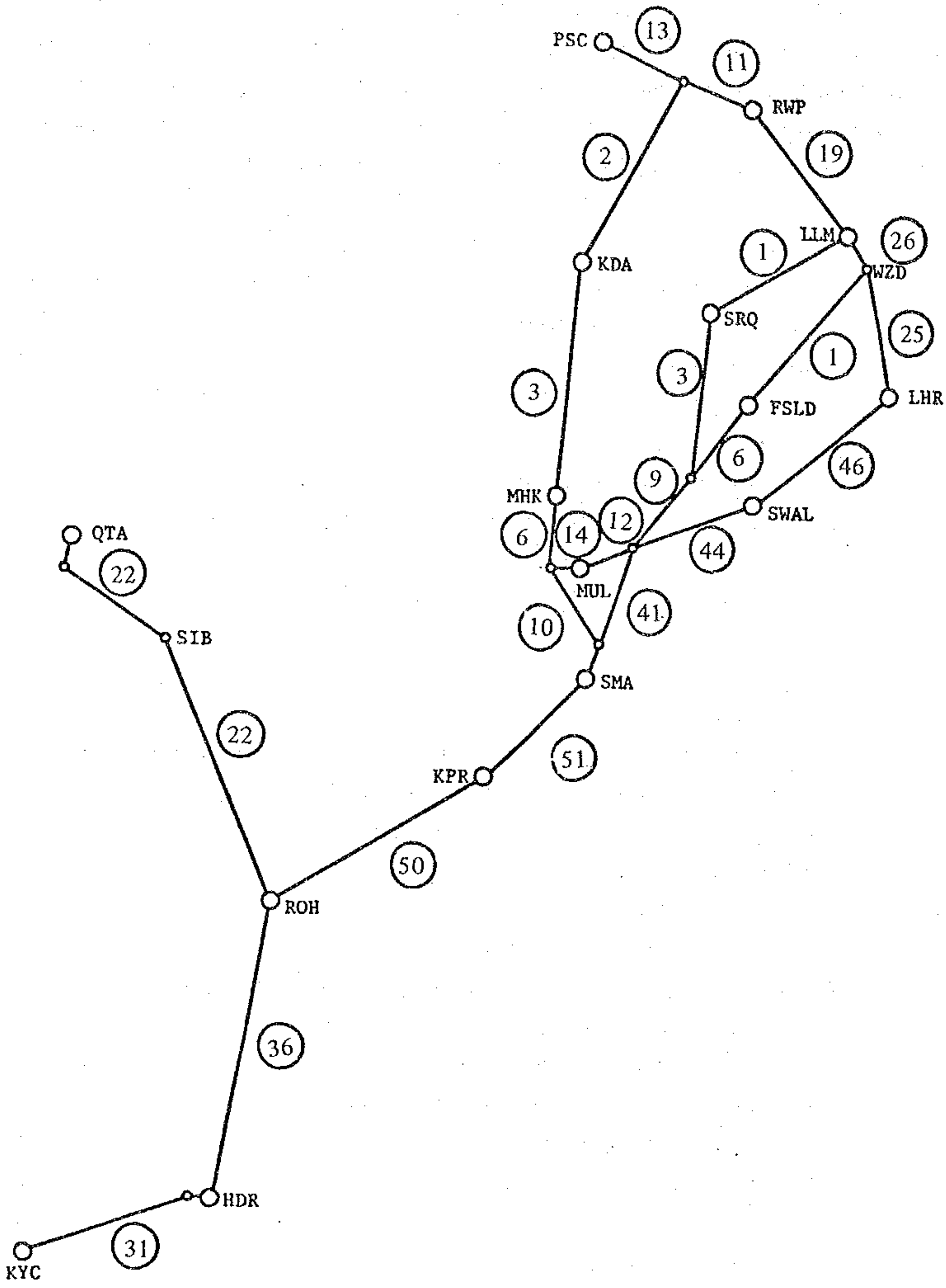


Fig. 2-8 Number of Goods Trains – Case B

Because of this, one additional locomotive should be used between Sibi and Ab-i-Gum and also two additional locomotives between Ab-i-Gum and Kolpur in order to secure the tractive force for Up trains and speed-suppressing brake for Down trains, and to eliminate the brake wagons and the division and addition of trains in the middle of the section. Also, at the same time, it is required to modify the operation regulation.

1) Train composition

- Gross weight of goods wagons of a train should be less than 1,000 tons. Because of this, the number of hauled wagons should be 32.
- Gross weight of a train

  DL (105) + wagons (10.7+22.4x0.9) x 32 + EL (105) x 2 = 1,303 tons
- Grade resistance:

  1,303 tons x 40 kg/t = 52 tons
- Running resistance (at the speed of 30 to 35 km/h)

  1,303 tons x 4 kg/t = 5 tons
- Tractive force of Up train: 57 tons
- Damping force of Down train: 47 tons

2) Performance of locomotive

- Since the present tractive tonnage of DL is 250 tons, the tractive force should be allotted to 20% for DL and 40% x 2 for EL.
- The allottment of braking force should be 50% x 2 for EL.
- Balance of speed:

  DL: 2,000 HP, 11.4 t traction: 39 km/h

  EL: 2,850 KW, 22.8 t traction: 40 km/h

The rating for EL was referred to the characteristics of the regenerative AC locomotives presently being used in Japan, and they are shown in Fig. 2-9.

- Mean speed will be about 30 km/h
- Tractive effort at starting the steepest grade (1/22.2):

  (45 + 8) x 1,303 = 69 tons

For DL: 69 x 0.2 = 13.8 tons

For EL: 69 x 0.4 = 27.6 tons

Current: 640 A (112%)

Adhesion coefficient (105 tons): 26.3%

There will be no problem as long as the weight of locomotive exceeds about 90 tons.

Rating Output $P_0 = 475 \times 6 = 2859$ kW
Rating Current $I_0 = 570$ A
Gear Ratio $p = 5.1$
Rating Traction Power = 24.3 t

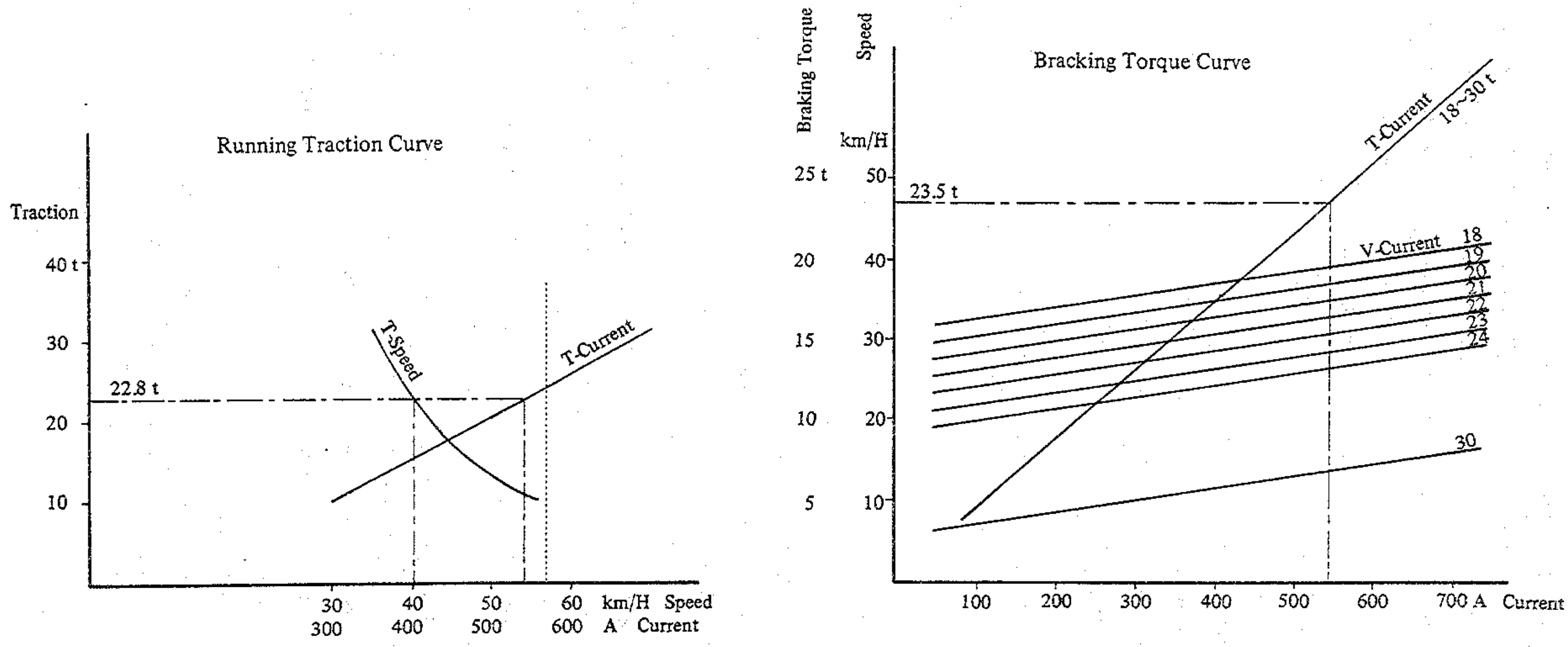


Fig. 2-9 Locomotive Performance for Bolan Section
(EF71 basis)

– Output of locomotive (per locomotive)

Up: Tractive tonnage of 1,303 gross tons, speed of 30 km/h: 2,253 KW

Down: Tractive tonnage of 1,303 gross tons, speed of 30 km/h: 1,583 KW

– Though the continuous output of present locomotives is sufficient, it is desired to have a locomotive with a short-time overload capacity in order to secure the tractive effort at starting and the acceleration at the climbing grade.

3) Regeneration brake

Since the weight of Down trains is larger based on the annual traffic demand, the regenerative speed-suppressing brake is effective.

– Mean weight of Up train: 895 tons

DL (105) + wagon (10.7x32x0.9) + load (272) + EL (105x2)

– Mean weight of Down train: 1,195 tons

DL (105) + wagon (10.7x32x0.9) + load (572) EL (105x2)

a) Between Ab-i-Gum and Kolpur (mean grade of 1/33, running resistance of 5 kg/t)

– Equivalent total output of Up train (for whole train)

895 gross tons, speed of 30 km/h 3,027 KW

– Virtual output of Up train (for EL traction)

895 gross tons, speed of 30 km/h: 2,421 KW

– Output of Down train

1195 gross tons, speed of 30 km/h: 2,090 KW

Since the grade is steep and the load of down trains is large in this section, about 86% of electric energy required for the Up train can be supplied by regeneration of by the down trains according to the calculations.

b) Between Sibi and Ab-i-Gum (mean grade of 1/120, running resistance of 4 kg/t)

– Equivalent output of Up train (for whole train)

790 gross tons, speed of 50 km/h: 1,569 KW

– Virtual output of Up train (for EL traction)

790 gross tons, speed to 50 km/h: 1,098 KW

– Output of Down train

1,090 gross tons, and speed of 50 km/h: 555 KW

Since the grade is gentler in this section, the regenerated power will decrease, and the utilization rate of the regenerated power of the Up trains will become 51%.

4) Rotation of locomotives

An example of locomotive rotation is shown in Fig. 2-10. From this, it will be known that the mean daily engine-km of the additional locomotive will amount to 380 km/loco-day.

(2) Between Lala Musa and Rawalpindi

There is a mountainous 83 km between Jhelum and Mandra in Lala Musa Rawalpindi section. The steepest grade in this section is about 1/100 and the continuous mean grade is 1/125 for the purposes of review.

- Gross weight of Up train

  EL (105x2) + wagon (10.2+22.4x0.9) x 72 = 2,432 tons
- Tractive effort per locomotive

  (10+4) x 2,432 ÷ 2 (kg) = 17 tons
- Balanced speed

  Balanced speed by the present locomotive is about 65 km.
- Tractive effort at starting (per locomotive)

  (10+8) x 2,432 ÷ 2 = 22 tons
- Adhesion coefficient: 22 ÷ 105 tons = 21%

  Present 80 t class seems to be sufficient.
- Output of EL

  2,432 gross tons, speed of 50 km/h: 2,337 KW

In overall point of view, operation is possible using ELs of the present class.

3. Improvement of Railway Facilities

3-1 Increase of Line Capacity

(1) Automatic signaling and relay interlocking devices

On the lines where the number of trains is large and where the limited expresses and high speed goods trains run, it is required to reduce the mean running hours by automatic blocking and relay interlocking. Between Karachi and Lala Musa.

On the Objective section lines with steep grades where a long running time is needed between two stations, it is also desired to reduce the waiting time due to passing and crossing by means of the automatic block and relay interlocking as well as the partial track doubling.

Objective section: Between Lala Musa and Rawalpindi
Between Sibi and Quetta

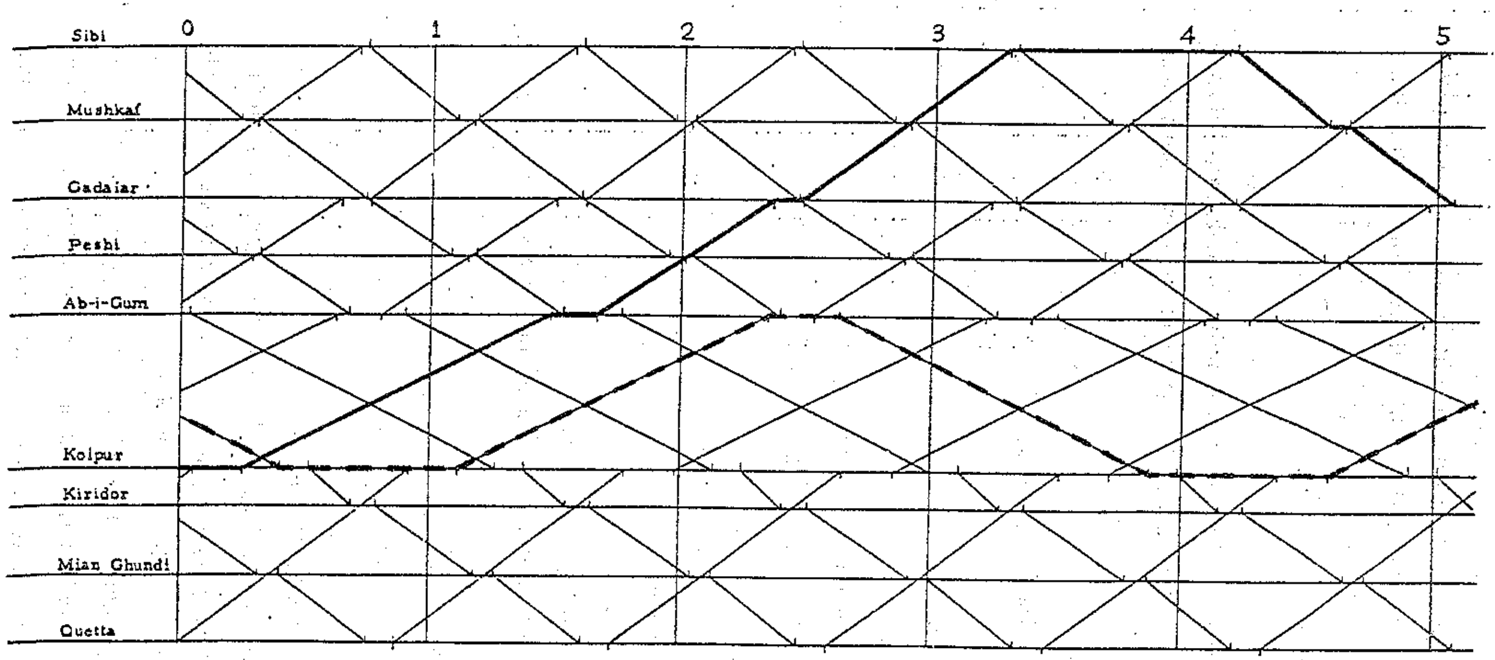


Fig. 2-10 Locomotive Rotation for Bolan Section

Also, on important lines where the transportation is closely related to the above sections, the operating time should be reduced by automatic block and relay interlocking.

Objective section: Between Rawalpindi and Peshawar
Between Rohri and Sibi
Between Khanewal and Faisalabad
Between Sher Shar and Mahmud Kot

(2) Tokenless

On lines with a large amount of transport next to (1) and which are required for transport between base stations, it is desired to provide tokenless blocks and color light signals. It is desired to provide remote signals so as to eliminate at the stations where electric power is not easily available, train speed reduction for confirming the signal indication at night.

Objective section: Between Sangla Hill and Wazirabad
Between Shorkot and Sargodha
Between Mahmud Kot and Kundian

(3) Track doubling

Track doubling is required on the sections where the number of trains is beyond the single line capacity.

Objective section: Between Lodhran and Khanewal (Chord Line)
Between Khanewal and Raiwind

Track doubling is required for sections where the number of trains is close to the single track limit and where high speed trains run frequently.

Objective section: Between Piran Ghaib and Khanewal
Between Lahore and Lala Musa

Tracking doubling is required on sections with steep grades where the number of trains is relatively large and where long running times are needed between two stations.

Objective section: Between Jhelum and Mandra

Track doubling is required on the sections adjacent to the doubled track sections where the number of trains is considerably large and the high speed trains run.

Objective section: Between Lodhran and Sher Shar
Between Lala Musa and Jhelum
Between Mandra and Rawalpindi

3-2 Increase of Speed and Tractive Force of Trains

(1) Electrification

By the tractive force of electric locomotive, the acceleration should be increased and the running time should be reduced. Also, the efficient transportation should be realized by increasing the units of train.

Objective section: Between Karachi and Khanewal (Chord & Loop)
Between Lahore and Lala Musa

The tractive force for steep grade sections should be increased, and bottlenecks on main lines should be eliminated in combination with additional locomotive in order to allow through transport between base stations.

Objective section: Between Lala Musa and Rawalpindi
Between Sibi and Kolpur

Sections requiring the train operation in close association with electrified sections should be also electrified.

Objective section: Between Sher Shar and Mahmud Kot

(2) Increase of Output of Diesel Locomotives

Output of DEL should be increased (3,000 HP) to allow the traction of 2,000 tons on the non-electrified sections.

Objective section: Between Khanewal and Faisalabad
Between Khanewal and Sargodha
Between Sher Shar and Kundian

(3) Extension of station loop (600 m → 900 m)

The station loop should be extended to perform the traction of 3,000 t class container and high speed goods trains. However, the train operation with minimum stopping times is effective for reducing the time and energy consumption.

Objective section: 17 stations including Kotri

3-3 Operation of High Speed Goods Trains

(1) Container trains

Loading and unloading is to be performed while maintaining fixed compositions. It is required to reduce the goods-handling time and to improve the turnover rate of the wagons. However, since the present terminal is in adequate for arrivals and departures of trains and for connection with automobiles, a new container terminal should be constructed. Also, new flat wagons should be provided for the high speed transport.

Objective section: Lahore

(2) High speed goods trains

High speed wagon trains corresponding to containers should be operated. Goods handling time in the terminal should be reduced to improve the turnover rate of the freight cars. The terminal for handling goods should be constructed in adjacent to the container terminal.

High speed goods wagons should also be newly provided and the arrival, departure, and inspection lines should be used in common with containers.

Objective sections: Karachi, Lahore

3-4 Reducing detention Time in Terminal

The goods-handling time in the goods base stations and the turn-round of wagons should be reduced. Mechanized goods-handling is also necessary.

Objective stations: 13 base stations

3-5 Improvement of Transport Fundamentals

(1) Track renewal

Track of the main lines should be mostly renewed except for the newly doubled sections.

Objective section: Between Karachi and Peshawar
Between Rohri and Quetta

For the sections where several through trains between the base stations are operated daily, the track should also be renewed in whole sections.

Objective section: Between Khanewal and Faisalabad
Between Shorkot and Sargodha
Between Sher Shar and Kundian

(2) Rail renewal

Rail of the branch lines should be replaced with 90-lb rail removed from the main lines where the through trains between the base stations run.

Objective sections: Between Faisalabad and Wazirabad
Between Sargodha and Lala Musa
Between Kundian and Attock City, and other sections

(3) Locomotive refurbishing

a) Electric locomotives

The presently owned 29 locomotives should be refurbished

b) Diesel locomotive

Most of 389 DLs, which are presently owned have not been re-engined and have an will economic life expiring by the year 2000, so that re-engining will be required.

c) Steam locomotives

The presently owned 457 steam locomotives should be quickly replaced by DLs.

(4) Passenger coaches

There are many wooden passenger coaches presently owned, so they should be replaced with steel coaches which offer a longer life expectancy.

(5) Goods wagons

Most of presently owned goods wagons are 4-wheelers with low speed limits and small capacity and, thus, some should be replaced with bogie wagons and the remainder should be improved with link suspension systems, reinforced couplers and air brakes in order to cope with the increased train speed and weight.