3.1.5 Rolling Stock

(1) General review

To meet consistently growing transportation needs, the Indian Railways has promoted the addition of rolling stock and replacement of the old and obsolete ones. Steam locomotives are gradually being replaced by diesel and electric locomotives, and the number of steam locomotives held at present is about half of the maximum in the past. Similarly, new types of coaching vehicles with better accommodation and more effective means for safety are being steadily introduced in service.

Bogie type wagons equipped with roller bearings and high tensile couplers are also being put into service to increase the loading capacity per wagon, running stability and running speed. It should be noted that special type wagons are being introduced for special type of traffic.

(2) Rolling stock fleet

1) Locomotives

The motive power fleet of the Indian Railways as on 31st March, 1986, comprised 5,571 steam, 3,047 diesel and 1,302 electric locomotives. A review of changes in locomotive fleet size in the past is provided in Table 3.1.13. The steam locomotive fleet was at its peak in the 1960's, but its size has been steadily reduced over the years consistent with the policy of the Indian Railways to go in for modern means of traction. Steam locomotives are gradually replaced by diesel and electric locomotives from the areas where there is a high traffic density.

By 2000, the last steam locomotive on a non-electrified line will be replaced by a diesel locomotive.

Table 3.1.13 Motive Power Fleet

Year	Type of locomotives			
	Steam	Diesel	Electric	Total
1	2	3	4	5
1950-51	8.120	17	72	8.209
1955-56	9.026	67	79	9.172
1960-61	10.312	181	131	10.624
1965-66	10.613	727	403	11.743
1968-69	10.046	996	513	11.555
1973-74	8.847	1.610	669	11.126
1977-78	8.215	2.025	901	11.141
1980-81	7.469	2.403	1.036	10.908
1983-84	6.217	2.800	1.194	10.211
1984-85	5.970	2.905	1.252	10.127
1985-86	5.571	3.047	1.302	9.920
Details of 1985-86				
BG	3.023	2.377	1.282	6.682
MG	2.244	578	20	2.842
NG	304	92	-	396

2) Coaching vehicles

The number of passenger coaches and their aggregate seating capacity over the years may be seen from Table 3.1.14. Addition to the coach fleet has been inadequate to accomplish the required overage coach replacements and to meet the sharply growing traffic demands.

The ages of the coaches held by the Indian Railways as of April, 1985, are indicated in the age-wise distribution list in Table 3.1.15. The Indian Railways discards any steel-bodied coach which has reached the age of 25 and any wooden-bodied coach which has reached the age of 30, in principle. In actuality, however, some 5,000 overage coaches are still in service to secure the necessary number of coaches to fill the demand.

Table 3.1.14 Review of Changes in Coach Fleet Size and Aggregate Seating Capacity

Year	Passenger coaches				Other Coaching Vehicles Number (b)
	EMU Coaches		Conventional Coaches		
	Number	Capacity	Number (a)	Seating Capacity	
1950-51	460	87.986	13.109	854.678	6.059
1955-56	574	101.409	15.984	1.050.811	6.730
1960-61	846	150.854	20.178	1.280.797	7.415
1965-66	1.355	250.825	22.804	1.426.918	8.763
1968-69	1.650	313.922	23.806	1.447.267	9.008
1973-74	1.892	366.998	26.108	1.589.461	8.422
1977-78	2.321	450.579	26.647	1.649.256	8.280
1980-81	2.625	500.607	27.478	1.696.127	8.230
1983-84	2.837	544.482	27.343	1.705.158	7.751
1984-85	2.957	585.595	27.825	1.745.622	7.789
1985-86	2.966	576.426	27.700	1.774.263	7.518
Details of 1985-86 BG	2.760	547.842	17.800	1.234.474	4.577
MG	206	28.584	8.696	503.065	2.779
NG	-	-	1.204	36.724	162

Note: Includes standing accommodation

(a) includes Rail Cars.

(b) includes luggagevans, mail vans etc.

Table 3.1.15 Age-wise Distribution of Coaches (April, 1985)

AGE (Years)	1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	TOTAL
BG COACHES														
STEEL BODIED	4480	2943	3411	2667	2743	978	61	2	2	16	1	-	-	17304
WOODEN BODIED	207	311	274	630	899	1322	480	89	58	285	60	89	216	4840
MG COACHES														
STEEL BODIED	514	947	1539	1902	2078	837	232	-	-	-	-	-	-	8049
WOODEN BODIED	62	211	250	359	910	1319	395	52	71	263	99	19	113	4123
NG COACHES														
TOTAL NG COACHES	93	151	43	135	276	198	66	6	26	154	71	62	139	1426
TOTAL	5362	4563	5517	5593	6906	4654	1234	149	157	718	251	170	468	35.742

Note: The figures in the columns to the right of the heading "Age" are the numbers of years counted from the time of production. Differences from Table 3.1.14 are attributable to the fact that the surveys were made at different points of time.

3) Wagon

The numbers of actual wagon holdings are listed in Table 3.1.16. The aggregate wagon fleet size as on 31st March, 1986, was 359,614, among which covered wagons predominated 52%. Another noteworthy point was a rise in the proportion of special type wagons to the total fleet size.

Table 3.1.16 Wagon Fleet

Year	Total wagons on line	Percentage of total number of wagons					
		Covered	Open high sided	Open low sided	Special (BOX, BOBS etc.)	Departmental	Total
1950-51	205.598	58.9	25.5	3.4	7.2	5.0	100
1955-56	240.756	58.1	24.7	4.2	8.7	4.3	100
1960-61	307.907	57.3	25.5	2.5	10.6	4.1	100
1955-66	370.019	53.1	27.2	2.1	13.3	4.3	100
1968-69	381.685	53.3	26.1	1.8	14.6	4.2	100
1973-74	388.366	52.8	25.8	1.7	15.6	4.1	100
1977-78	399.971	53.8	28.4	3.1	11.3	3.4	100
1980-81	400.946	53.3	28.3	3.2	11.8	3.4	100
1983-84	374.757	52.2	28.1	3.2	13.2	3.3	100
1984-85	365.392	52.1	27.8	3.4	13.4	3.3	100
1985-86	359.614	51.9	28.0	3.4	13.4	3.3	100
Details of 1985-86 BG	284.920	48.7	31.3	3.4	13.6	3.0	100
MG	70.908	65.0	16.2	1.6	12.6	4.6	100
NG	3.786	48.1	-	35.9	13.1	2.9	100

Recently, new fast-running types of bogie wagon designed to bear a heavy load have been put in service in an increasing number.

The special type wagon fleet size is shown in Table 3.1.17. There was a marked increase in the holdings of high sided open bogie wagons with side discharge arrangement for transport of coal and other bulk traffic, i.e., BOX type. Among all varieties belonging to the BOX type, the BOXN type showed an outstanding increase a gain of 4,000 over the number in the previous year.

Table 3.1.18 shows age-wise distribution of the wagons held by the Indian Railways. It discards any wagon which has reached the age of 40, in principle, but in actuality, approximately 12,000 overaged wagons are still in service.

Table 3.1.17 Special Type Wagon Fleet

Type of wagon	Stock at the year end B.G.	M.G.	Brief description
BOX	50.948	-	High sided open bogie wagons with side discharge arrangement for transport of coal and other bulk traffic.
BOY	862	-	Low sided open bogie wagons to carry iron ore etc.
CA/BCA	4.212	1.353	Wagon designed for the transportation of cattle.
BRH	7.733	-	Flat wagons for rails, steel-bars,etc.
BFU	419	131	Well wagons for over dimensional and heavy consignments.
Tank	30.802	4.689	Tank wagons for liquid consignments like petroleum products, molasses. vegetable oils,etc.
Container Flat	322	8	Flat wagons to carry container for door-to-door service.
BCX	18.977	-	Water-tight covered wagons for food-grains, cement etc.
BOBS/BOBX	2.387	-	Open Hopper wagons with bottom discharge arrangements to carry ballast, ores etc.
CRT	20.683	-	Water-tight-4 wheeler covered wagons having higher capacity for general goods.
BOXN	10.380	-	High sided bogie open wagon with improved components like cast steel bodies, high tensile couplers. cartridge taper roller bearing,air brakes etc. for enabling greater trailing loads for movement of bulk commodities like coal,iron ore,etc.

Table 3.1.18 Age-wise Distribution of Wagons

AGE (Years)	1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	TOTAL
BG WAGONS														
Bogies	20129	11821	12438	20248	23358	2836	440	411	212	70	57	38	168	92222
4 wheels	12452	17686	15160	28446	34517	51863	18212	8720	1334	1578	1848	841	1420	193878
In terms of 4 wheels	62181.5	47670.5	48321	79298	93026.5	60991.5	19131	9875.5	1779	1721.5	1965.5	719	1763.5	428124
MG WAGONS														
Bogies	1520	3838	2601	8290	5695	2190	1892	143	428	85	94	12	35	26821
4 wheels	121	369	91	2479	4020	26630	10621	140	351	617	1047	75	241	46802
In terms of 4 wheels	3161	8045	5293	19059	15410	31012	14405	428	1204	787	1235	99	311	100447
NG WAGONS														
Bogies	198	496	32	116	791	223	427	-	3	222	158	218	459	3341
4 wheels	73	6	-	-	18	7	3	11	135	50	162	38	170	671
In terms of 4 wheels	469	998	64	232	1598	453	857	11	141	494	474	474	1088	7353
Total														
Bogies	21847	16155	15071	28654	29844	5249	2759	554	641	377	307	268	660	122384
4 wheels	12646	18060	15251	30925	38553	78500	28836	8871	1820	2245	3057	754	1831	241349
In terms of 4 wheels	65791.5	56813.5	51678	98589	110034.5	92456.5	34393	10112.5	3124	3002.5	3674.5	1292	3162.5	533924

(3) Rolling Stock at Present

1) Diesel Locomotives

The Indian Railways uses mostly diesel electric locomotives for traction on broad-gauge lines and mostly diesel hydraulic locomotives in shunting yards. Initially, imported diesel locomotives were in service on the Indian Railways' lines, but its technology has made progress in the indigenous production of diesel locomotive. All of the diesel locomotives in service throughout the country are manufactured in Indian Railways' Production Units.

a) Main particulars

WDM1, 2, 3 and 4 diesel locomotives are used as traction means on broad-gauge lines. WDS1, 2, 3, 4, 4A, 4B, 5 and 6 are used for shunting purposes. Main particulars and general views of WDM2 and WDS4B are presented in Table 3.1.19 and Fig. 3.1.2 and Fig. 3.1.3 respectively. Main particulars of typical Japanese diesel locomotives are also given for comparison with those of the Indian models.

Table 3.1.19 Main Particulars of Diesel Locomotives

Main particulars / Class of Loco.		Main Line		Shunting	
		INDIA WDM2	JAPAN DD51	INDIA WDS4B	JAPAN DE10
Manufacturer		ALCO/DLW	JAPAN	CLW	JAPAN
Wheel Arrangement		C-C	B-2-B	0-C-0	AAA-B
Weight in Working Order (t)		112.8	78	60	65
Max. Axle Load (t)		18.8	13	20	13
Max. Body Length (mm)		17,120	18,000	11,000	14,150
Max. Tractive Effort (kg)		30,450	16,800	18,000	19,500
Max. Speed (km/h)		120	95	27	85
Diesel Engine	Type	251B-16Cyl. 45°V	DML61Z-12Cyl.60°V	6M282A(K) 6Cyl. LINE	DML61ZB-12Cyl.60°V
	Standard OUT-PUT (H.P)	2,600	1,100 x 2	700	1,350
	Max. r.p.m. (r.p.m.)	1,000	1,500	1,000	1,550
	Dry Weight (kg)	18,240	5,600	7,150	7,100
Transmission		Electric	Hydraulic	Hydro-mech (SURI) or hydraulic	Hydraulic
Brake	Loco.	Air, hand & dynamic	Air, hand	Air, hand	Air, hand
	Train	Vacuum	Air	Vacuum	Air

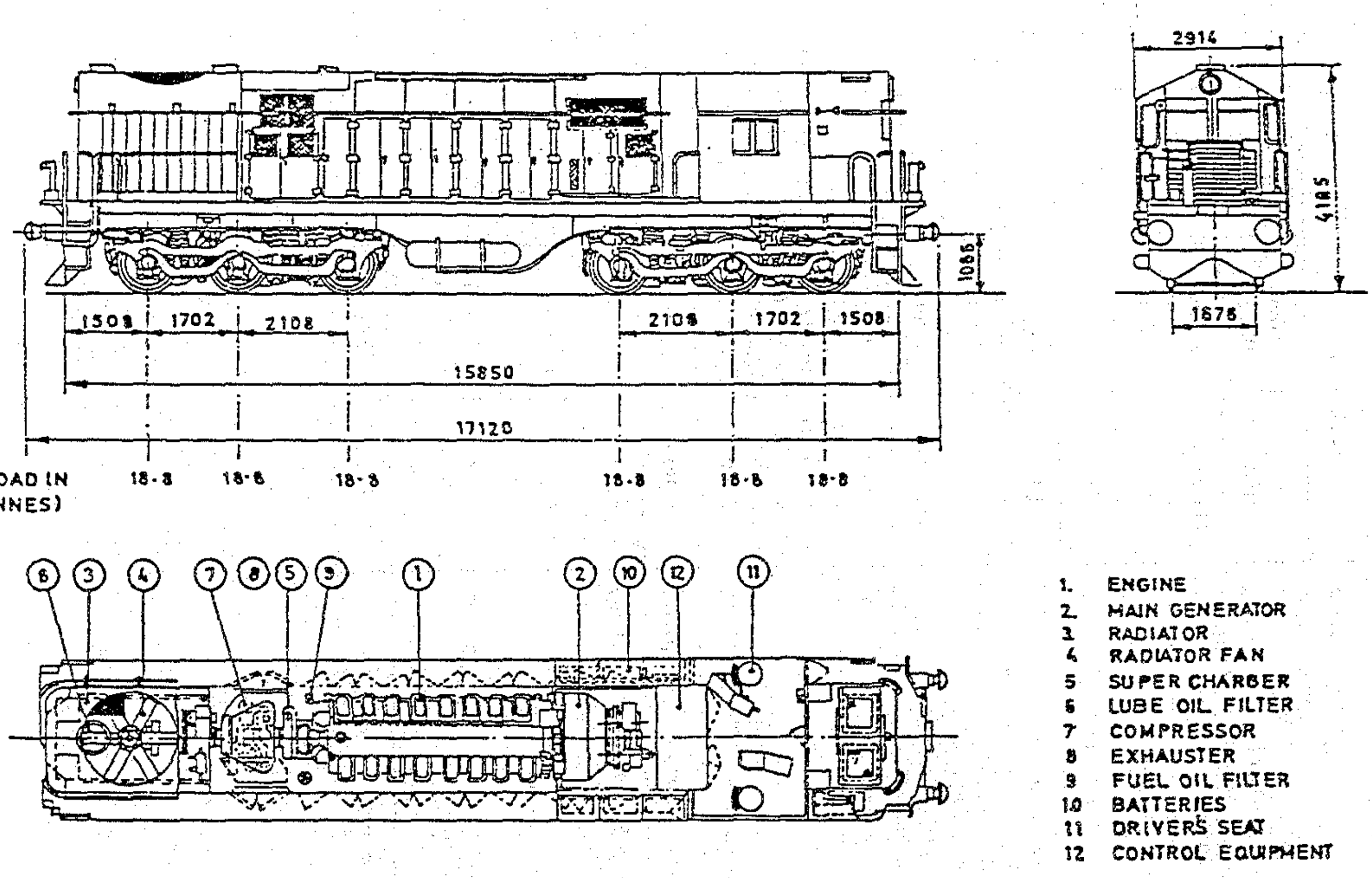


Fig. 3.1.2 WDM2 Diesel Locomotive

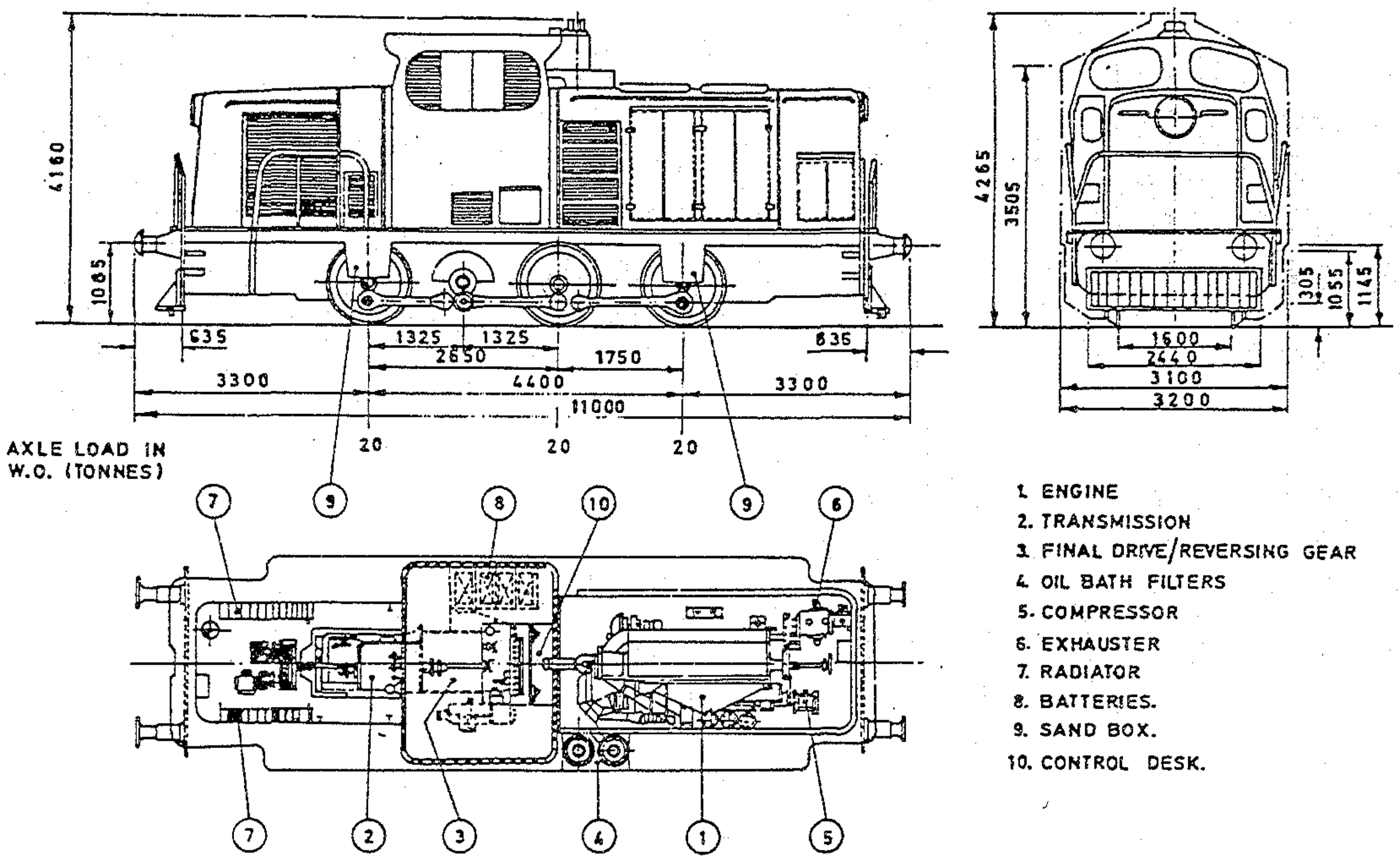


Fig. 3.1.3 WDS4B Diesel Locomotive

b) Failures of diesel locomotives

The failures detected on the 1,636 WDM2 diesel locomotives of the Indian Railways in 1985 are listed in Table 3.1.20.

Table 3.1.20 Failures Detected on Diesel Locomotives (WDM2 Class, 1985, Total No. of Cases)

Component	Number of Failure	%
Engine Components	771	35
Starting and Control Devices	678	30
Transmission Components	392	18
Brake System, Expressor Units	190	9
Vehicular Portion of Motive Power Unit	97	4
Miscellaneous	85	4
Total	2,213	100

2) Coaches

The Indian Railways primarily uses steel-bodied coaches. As a result of a measure to improve the service for passengers, air-conditioned coaches have been sharply increasing in recent years. Many of these Indian coaches are equipped with a lavatory at each of the four corners. Many of the coaches have a floor finished with cement.

Corrosion was detected on the steel structures of many coaches. An anti-corrosion provision has started to be incorporated in the design of coaches to be produced at the Indian Railways' Production Units.

a) Main particulars

Main particulars and general views of typical ordinary coaches and sleeper coaches are presented in Table 3.1.21 and Fig. 3.1.4 and Fig. 3.1.5 respectively. Main particulars of typical Japanese models are also listed for comparison with those of the Indian models.

Table 3.1.21 Main Particulars of Coaches

Class of Coach / Main Particulars	Second Class Coach		Air-Conditioned 2 Tier Sleeper Coach	
	WGS	OHA 12	WGACCW	OHA 25
Manufacturer	ICF	JAPAN	ICF	JAPAN
Gross Weight (t)	43.3	28.5-29.8	53.5	32.7
Max. Length (mm)	22,297	21,300	22,297	21,300
Max. Width (mm)	3,245	2,994	3,245	2,994
Max. Height (mm)	4,100	4,085	4,025	4,090
Max. Speed (km/h)		110		110
Brake	Vacuum	Air	Vacuum	Air
Lavatories	4	---	4	2
Air Condition	---	Yes	Yes	Yes
Passenger Capacity	90	88	46	34

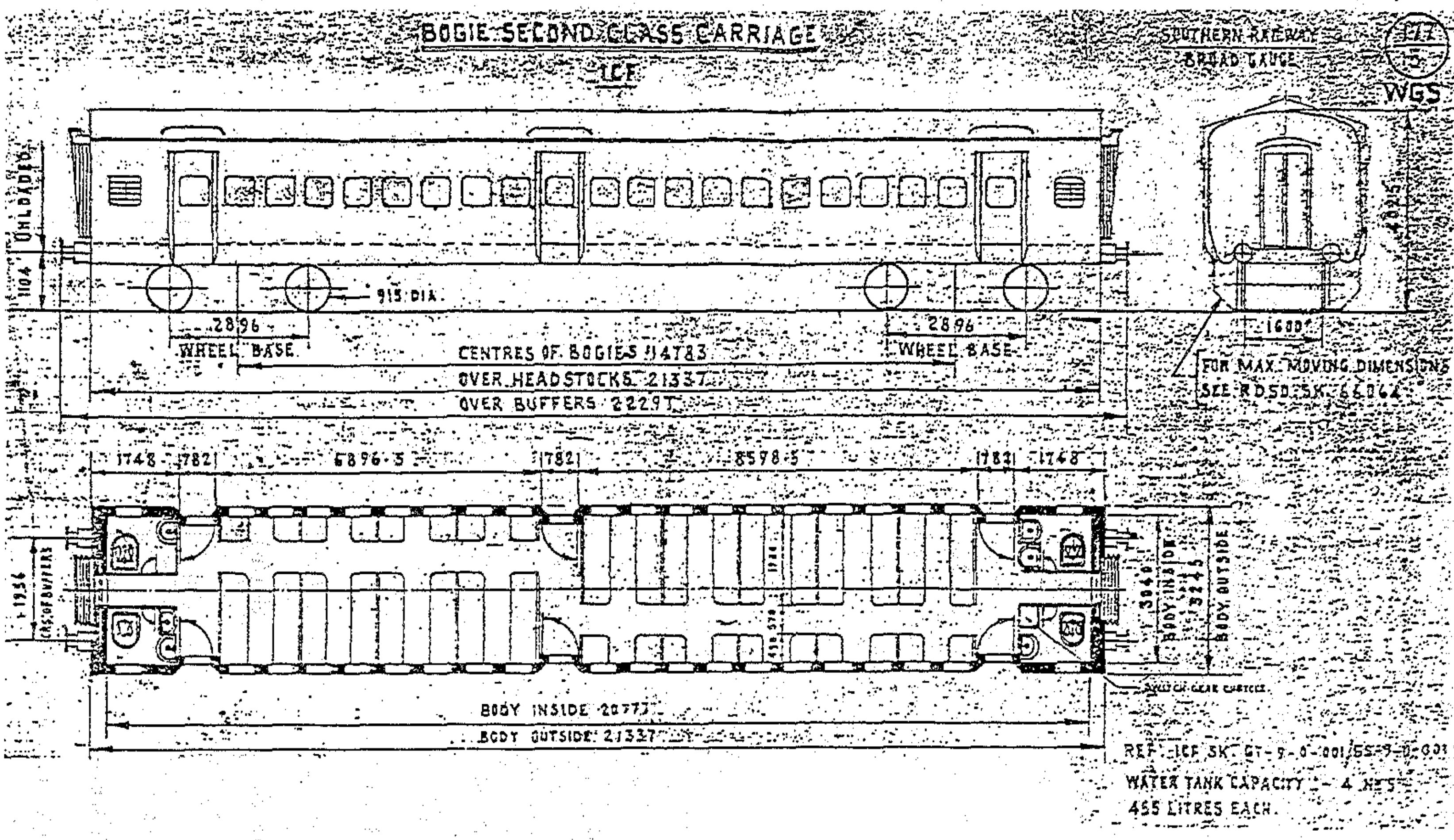


Fig. 3.1.4 WGS Type Coach

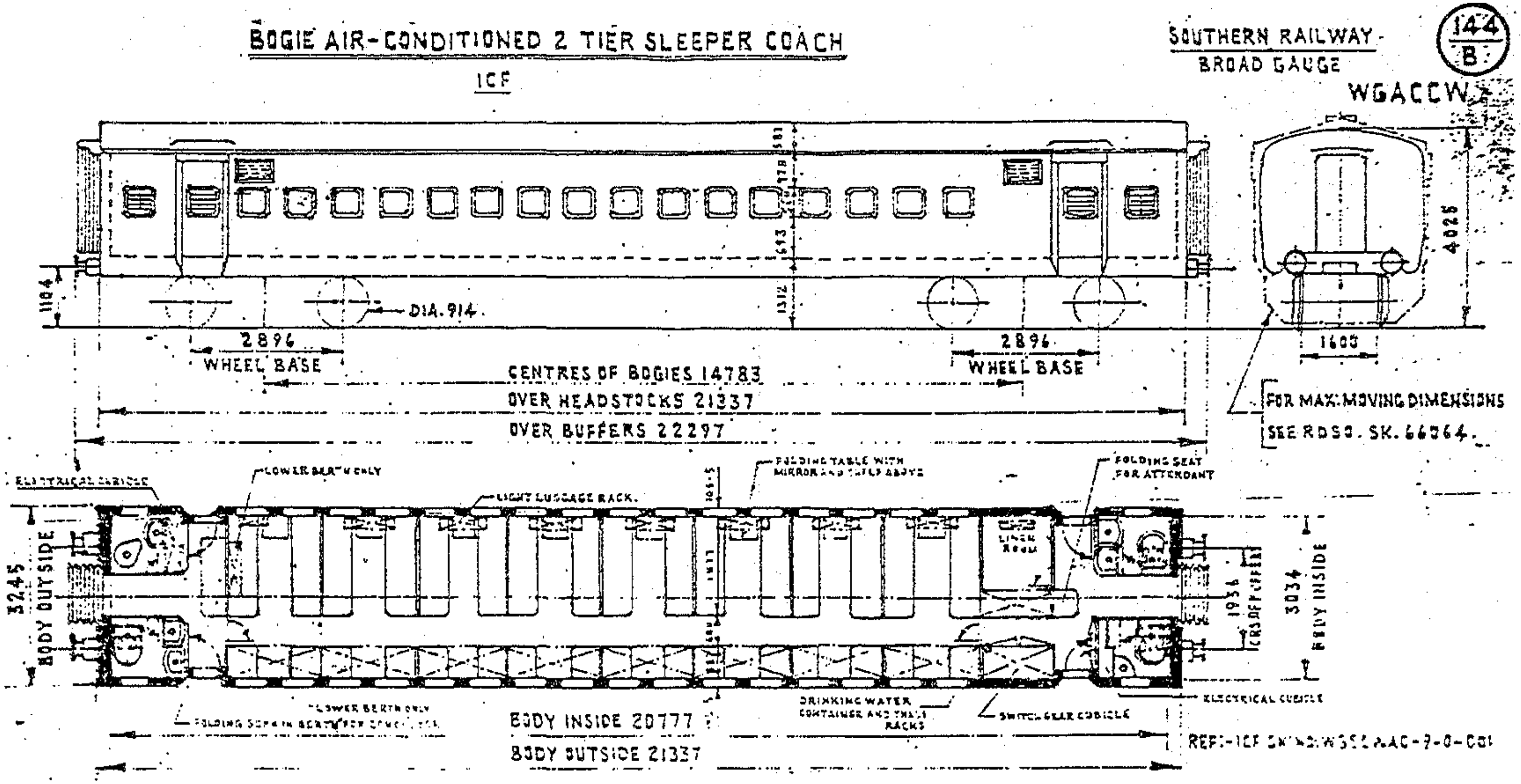


Fig. 3.1.5 WGACCW Type Coach

b) Failures of coaches

The failures detected on coaches from January to June, 1986, are listed in Table 3.1.22.

Table 3.1.22 Failures Detected on Coaches

Cause	Number of Failure	%
Bearing/Spring/Hanger/Axle Box/Bolster/Dash Pot/ Spring Broken	51	34
Hot Boxes/Roller Bearing Failures	21	14
Spring Suspension & Swing Link Failures	15	10
Buffering Gear Defect	10	7
Vacuum Trouble, Poor Brake Power/Brake Gear/ Brake Bending Cases	8	5
Wheel Defect	6	4
Misc.	40	26
Total	151	100

3) Wagons

The Indian Railways' wagons are divided into three categories -- 4-wheeler wagon, bogie wagon and special bogie wagon. Recently, the quantity of bogie wagons produced has been sharply increasing. The Indian Railways plans to switch over to production of bogie wagons primarily.

a) Main particulars

Main particulars and general views of typical wagon models are presented in Table 3.1.23 and Fig. 3.1.6, Fig. 3.1.7 and Fig. 3.1.8 respectively. Main particulars of their Japanese counterparts are given in Table 3.1.23 for comparison with those of the Indian models.

Table 3.1.23 Main Particulars of Wagons

Type / Main Particulars	Covered Wagon 4-Wheeler		Bogie Open Wagon		Bogie Covered Wagon Special	
	CRT	WAM80000	BOXN	TOKI25000	BCN	WAKI5000
Manufacturer	INDIA	JAPAN	INDIA	JAPAN	INDIA	JAPAN
Tare Weight (t)	13.10	11.00	22.47	17.00	24.03	21.00
Carrying Capacity (t)	27.54	15.00	58.81	36.00	57.24	30.00
Max. Length (mm)	8,822	9,650	10,173	14,186	15,429	15,850
Floor Area (m^2)	23.20	21.10	28.87	34.60	42.67	35.90
Cubic Capacity (m^3)	61.90	52.8	56.29	79.60	104.00	89.60
Brake	Vacuum	Air	Air	Air	Air	Air
Buffer Height (mm)	1,105	---	1,105	---	1,105	---

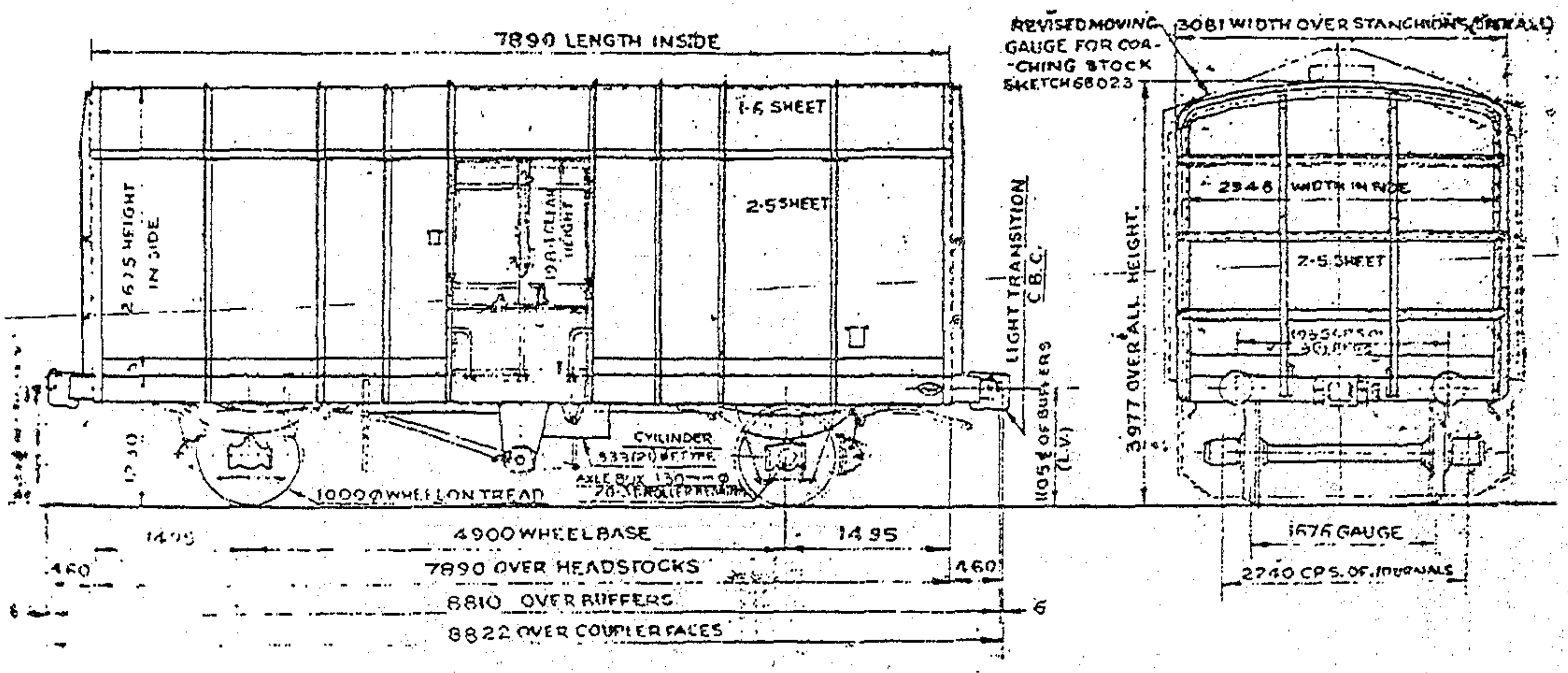


Fig. 3.1.6 CRT Type Wagon

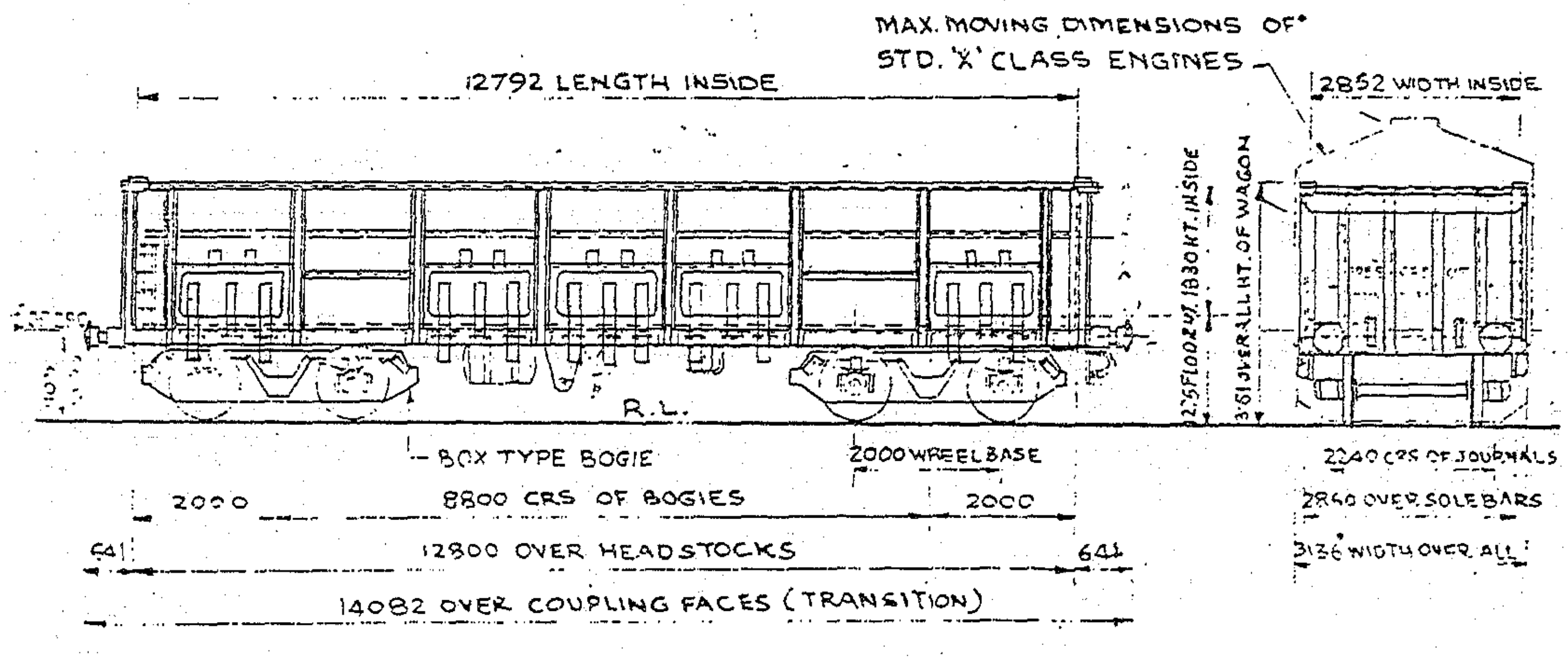


Fig. 3.1.7 BOXT Type Wagon

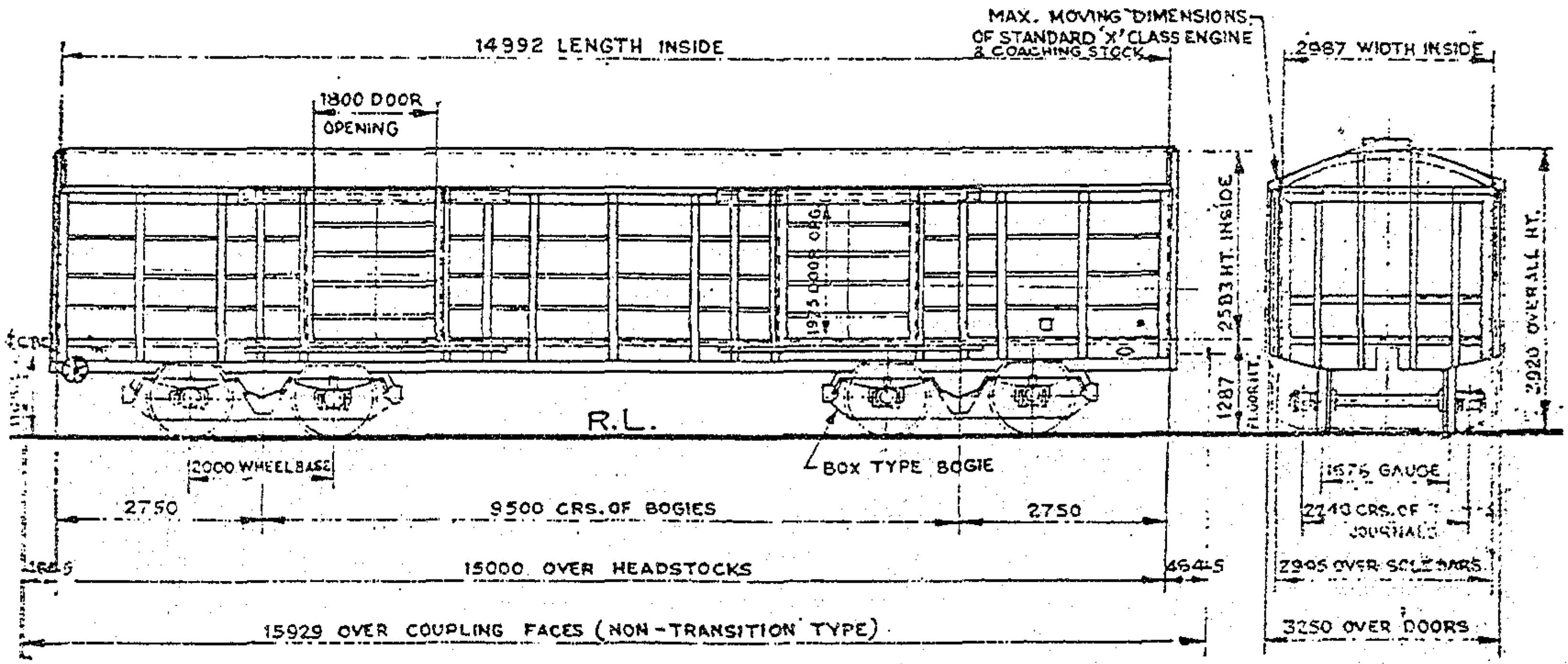


Fig. 3.1.8 BCX Type Wagon

(2) Failures of wagons in service

The failures detected on wagons of the Indian Railways in 1986 are listed in Table 3.1.24.

Table 3.1.24 Failures Detected on Wagons

Reason	No. of Instances	%
Spring Defect	23,624	36
Bogie Wagon	12,443	
4-Wheeler	11,181	
Hot/Warm Box	19,089	29
Plain bearing	16,895	
Roller bearing	2,194	
Trolley Defect (All Bogie Wagons)	6,533	10
Coupler Defect	1,446	2
Wheel Defect	992	2
Brake Gear & Others	13,418	21
Total	65,102	100

3.1.6 Rolling Stock Inspection and Repair

(1) Inspection/repair system

All rolling stock owned by IR is periodically inspected at an assigned workshop or depot/shed, and failed or damaged rolling stock is temporarily repaired on demand.

The rolling stock failed on running is mainly repaired on the sick lines of each depot, with replacement parts being supplied by the responsible workshop. To operate the rolling stock on a regular and long-term basis without failure, periodic preventive maintenance plays an important role. IR adopts and practices the well developed preventive maintenance system which is comparable to that of Japanese railways. The kind, content, standard, and items of preventive maintenance vary greatly with types, structures and operating conditions of rolling stock. The Railway Board establishes them for each type of rolling stock based on manuals prepared by the manufacturer and other information. Table 3.1.25 and Fig. 3.1.9 show the kind of inspections and their periodicities presently regulated.

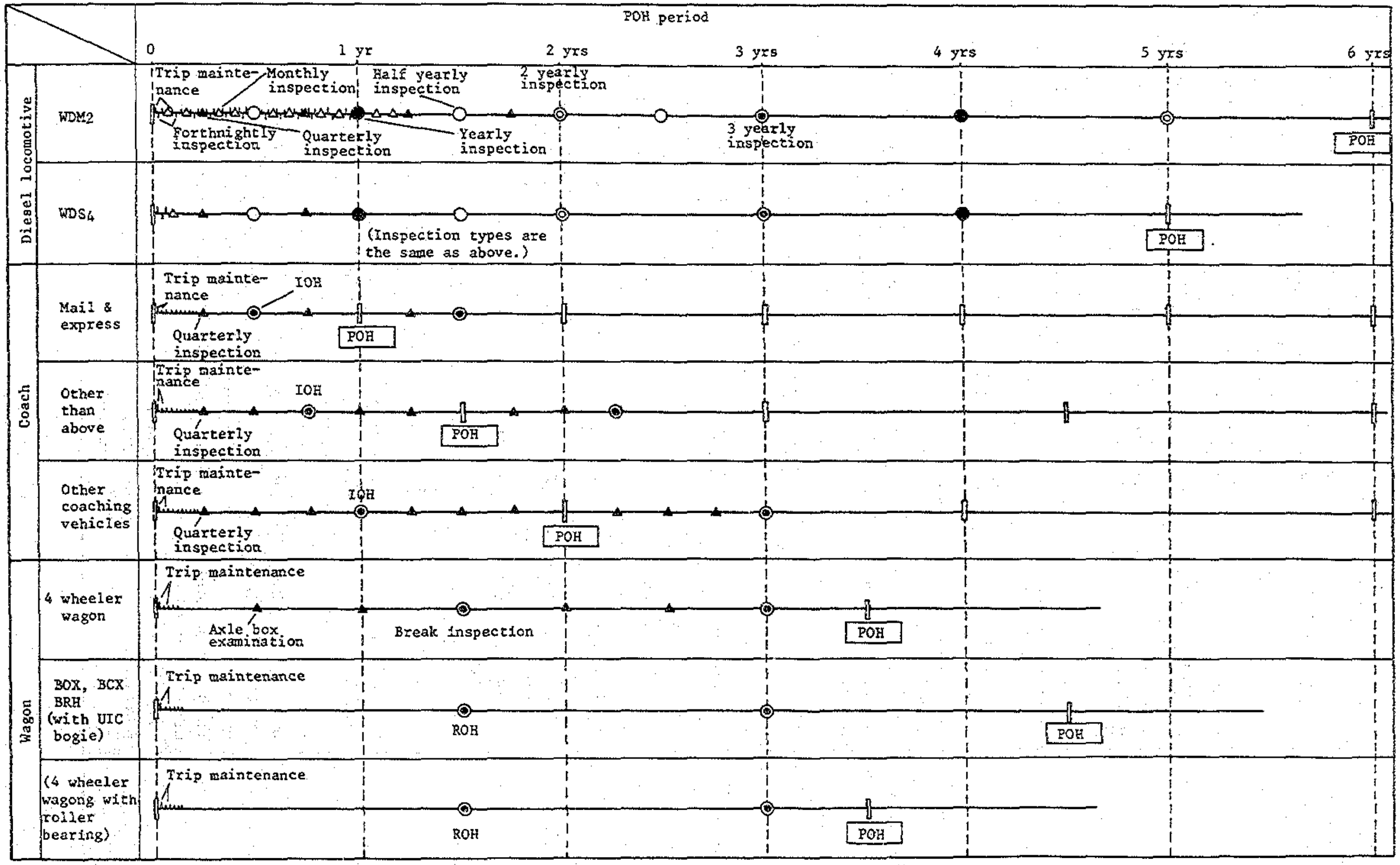
It should be noted that the periodical overhaul period for coaches is extremely short compared to other types, because of their body panels being seriously corroded. The periodical overhaul period for diesel locomotives is extremely long compared to other types, which has been realised by improving the intermediate overhaul at the locomotive shed.

In IR, the intermediate overhaul at the depot/shed and the periodical overhaul at the workshop are rather similar in its contents.

However, the workshop is principally responsible for heavy repair and plays a role as a parts supply centre for the depots/sheds.

Table 3.1.25 Periodicity of Rolling Stock Maintenance

Kind of Rolling Stock	Type and Usage	POH Periodicity	Kind and Periodicity of Maintenance Carried Out at Loco Shed or Depot
Diesel Locomotive	WDM_2 Mainline Locomotive	6 years or 800,000 km	Trip, fortnight, monthly, quarterly, half yearly, yearly, 2 yearly, 3 yearly
	WDM_4 Mainline Locomotive	6 years or 800,000 km	Trip, fortnightly, monthly, quarterly, half yearly, 1.5 yearly, intermediate overhaul (IOH 3 years)
	WDS_4 Shunting Locomotive	5 years or 200,000 km	Same as WDM_2
Electric Locomotive	WAG_4 Mainline Locomotive (Freight Service)	5 years or 600,000 km	Trip, monthly, bimonthly. quarterly, yearly, IOH (2.5 years)
Steam Locomotive	WP Passenger Service	290,000 km	S-1 (10 days) S-2 (Monthly) S-3 (Quarterly) S-4 (Half of IOH kilometrage) IOH (Half of POH kilometrage)
	WG and WL Freight Service	193,000 km	
Coach	Mail & Express	12 months	Trip inspection Roller bearing inspection (Quarterly) IOH (Half of POH period)
	Other Than Above	18 months	
	Other Coaching Vehicles	24 months	
Wagon	4 Wheeler	(First POH 48 months) General 42 months	Trip inspection, axle box examination (half yearly) Vacuum cylinder overhaul (18 months)
	BOX, BCX, BRH (with UIC Bogie)	54 months	Trip inspection Routine overhaul (ROH, 18 months)
	Tank Wagon and CRT (4 Wheeler with Roller Bearing)	(First POH 48 months) General 42 months	



(Note) Except for POH, inspections at the depot or shed are shown.

Fig. 3.1.9 Maintenance Period for Typical Types of Rolling Stock

(2) Rolling stock inspection at the depot/shed and the workshop

1) Diesel locomotive

Because the diesel locomotives are key elements in IR's train operation, each of the inspections is carefully carried out compared to other rolling stock; in the yearly and longer-period inspections, disassembled inspection is conducted for the engine, supercharger, expressor, and other engine parts and equipments, as well as the traction motor. Any repair which is not possible at the shed is carried out at the workshop, and parts required for repair at the shed are supplied by the responsible workshop.

2) Coach

At the depot, coaches undergo trip inspection between operations and quarterly inspection, mainly on roller bearings. Intermediate overhaul (IOH) is conducted at 1/2 of periodical overhaul period. In IOH, coaches are lifted and bogie and wheels are removed for inspection. Inspection of brake parts and instruments, ultrasonic inspection of wheel set, and painting of body panels are also conducted. Moreover, minimum required repair for corroded body panels is performed at some depots.

3) Wagon

At the wagon depot, wagons undergo trip inspection in train rakes between operations, axle box inspection which is aimed at exchange of oil and pads for plain bearings, and routine overhaul (ROH), which is carried out every 18 months.

In ROH, wagons are lifted, and brake gear, laminated spring, draft and buffing gear, and other parts essential for stable running are removed for inspection. Patch-up repair and touch up painting are also performed for body panels.

For inspections carried out at the depot or shed, required parts and equipment, except for purchased ones, are manufactured or repaired at the responsible workshop, which thus serves as a parts supply centre.

The periodical overhaul for each type of rolling stock is conducted at the workshop. In addition to the parts repaired at depot/shed, the workshop is responsible for disassembling, cleaning, inspecting, assembling and painting all parts and equipments to maintain reliability of the rolling stock at a sufficient level. Vehicles other than the wagons are subjected to required inspections at the assigned depot or shed, while the wagons are assigned to a non-particular depot because they are used in a wide range beyond the boundary of the depots. The same practice is observed in the workshop inspection for the wagons, which are selected from wagon depots near each workshop for periodical overhaul. As a result, large depots are arranged at freight collection points, where the inspections can be carried out relatively frequently.

3.1.7 Workshops

The Indian Railways has 49 workshops for periodical overhaul and heavy repair of rolling stock throughout the country. All of these workshops are under the supervision of the Headquarters of Zonal Railway, and ordinary administration matters are committed to the discretion of Zonal Railway. Hence working hours and other conditions differ from one workshop to another.

General administration for each workshop is carried on under the overall supervision of the Chief Mechanical Engineer (C.M.E.) at the Headquarters of the Zonal Railway, assisted by the Chief Workshop Manager (C.W.M.) assigned to be in charge of the workshop. All Zonal Railways have a Chief Workshop Engineer (C.W.E.) working under C.M.E.

C.M.E. at each Zonal Railway oversees the inspction and repair activities at individual depots as well as those at workshops and therefore assumes general and ultimate responsibility in respect to rolling stock inspection and repair activities at the workshops and depots of the Zonal Railway.

Although a workshop has a large work force, the power of C.W.M., as general supervisor at that workshop, is relatively limited. Purchase of materials needed for rolling stock inspection and repair, for instance, is a duty of the Stores Section under the Chief Material Manager (C.M.M.) at the Headquarters of the Zonal Railway. The electric parts and equipments of coaches are inspected and repaired by the Electrical Section under the Chief Electrical Engineer (C.E.E.).

The Railway Board makes ultimate decisions about such important matters as large-scale improvement of a workshop, integration and abolition of workshops, through discussions and makes an arrangement with the Headquarters of the Zonal Railway concerned. The necessary budget appropriations are then sanctioned.

The aggregate staff size of the workshops is approximately 160,000 (approximately 3,300 per workshop on the average), but the staff size ranges very widely from approximately 14,000 at the Jamalpur Workshop to about 150 at the Udaipur Workshop. The area of the workshop premises also ranges widely from some 2 million m^2 to approximately 8,000 m^2, and its average is about 200,000 m^2. The majority of workshops were constructed by independent local railway companies before the birth of the Indian Railways, and they definitely need some rearrangement and modification in such respects as their geographical distribution, their roles and kinds of rolling stock in charge. The kinds of rolling stock in charge by each workshop are currently being reviewed. With the progress of the programme for conversion from metre gauge and narrow gauge to broad gauge, the POH work load for MG/NG rolling stock has sharply decreased.

On the other hand, new coach inspection/repair workshops are under construction at Bhopal and Tirupati to increase the POH capacity for coaches which are growing in number now, and are scheduled for completion in 1990.

The names of workshops and the types of rolling stock in charge by them are listed in Table 3.1.26.

Table 3.1.26 Workshops and Kinds of Rolling Stock in Charge

ZONAL RAILWAY Workshop	Kinds of Rolling Stock in Charge											Remarks
	Broad gauge							Narrow gauge				
	Loco				Passenger		Wagon	Loco		Coach	Wagon	
	SL	DEL	DHL	EL	Coach	EMU		SL	DHL			
CENTRAL												
1. Matunga					○	○						
2. Parel	○	○	○	○								
3. Kurla							○					
4. Jhansi					○		○					
5. Bhusaval				○								
6. Kurduwadi								○		○	○	
7. Bhopal					(○)							To be open by 1990
EASTERN												
1. Jamalpur	○	○	○									
2. Kanchrapara				○	○	○	○					
3. Liluah					○		○					
4. Andal							○					
NORTHERN												
1. Charbagh	○	○		○								
2. Alambagh					○		○					
3. Jagadhari					○		○					
4. Amritsar			○									
5. Kalka										○	○	
6. Jodhpur								○		○	○	
7. Bikaner								○		○	○	

Note: (1) SL: Steam Loco
DEL: Diesel electric Locl
DHL: Diesel hydraulic Loco
EL: Electric Loco
EMU: Electric multiple unit

(2) Narrow gauge includes metre gauge

Table 3.1.26 Workshops and Kinds of Rolling Stock in Charge (Cont.)

ZONAL RAILWAY Workshop	Kinds of Rolling Stock in Charge											Remarks
	Broad gauge							Narrow gauge				
	Loco				Passenger		Wagon	Loco		Coach	Wagon	
	SL	DEL	DHL	EL	Coach	EMU		SL	DHL			
NORTH EASTERN												
1. Gorakhpur	○				○			○		○	○	
2. Izatnagar								○		○	○	
3. Samastipur											○	
NORTHEAST FRONTIER												
1. Dibrugarh								○		○	○	
2. New Bongaigaon					○					○	○	
3. Tindharia								○		○	○	
4. Baghdogra											○	
5. Pandu											○	
SOUTHERN												
1. Perambur (Loco.)		○		○	○							
2. Perambur (C&W)					○		○					
3. Golden Rock		○							○	○	○	
4. Mysore								○		○	○	
SOUTH CENTRAL												
1. Lallaguda	○				○							
2. Hubli								○		○	○	
3. Guntapalli							○					
4. Tirupati					○							To be open by 1990

Note: (1) SL: Steam Loco
DEL: Diesel electric Locl
DHL: Diesel hydraulic Loco
EL: Electric Loco
EMU: Electric multiple unit

(2) Narrow gauge includes metre gauge

Table 3.1.26 Workshops and Kinds of Rolling Stock in Charge (Cont.)

ZONAL RAILWAY Workshop	Kinds of Rolling Stock in Charge											Remarks
	Broad gauge							Narrow gauge				
	Loco				Passenger		Wagon	Loco		Coach	Wagon	
	SL	DEL	DHL	EL	Coach	EMU		SL	DHL			
SOUTH EASTERN												
1. Kharagpur	○	○		○	○	○	○					
2. Nagpur								○		○	○	
3. Raipur							○					
4. Adra							○					
5. Mancheshwar					○							
WESTERN												
1. Dohad	○											
2. Parel & Mahalaxmi					○	○						
3. Ajmer								○	○	○	○	
4. Kota							○					
5. Udaipur											○	
6. Morvi										○	○	
7. Junagarh											○	
8. Gondal										○		
9. Jaipur											○	
10. Partapnagar					○		○	○		○	○	
11. Bhavnagar										○		

Note: (1) SL: Steam Loco
DEL: Diesel electric Locl
DHL: Diesel hydraulic Loco
EL: Electric Loco
EMU: Electric multiple unit

(2) Narrow gauge includes metre gauge

3.1.8 Financial Situation

The financial results shown in Table 3.1.27, indicate that the Indian Railways is still a viable enterprise. Its monopolistic position is still maintained. The price elasticity of railway transportation demand is extremely low, and an increase in railway fares will lead directly to an increase in railway revenue.

As a proof of its sound finances, the conservative depreciation policy may be mentioned. In 1955/56 fiscal year, the depreciation cost makes up 16% of the total operating expense.

Furthermore, the current assets greatly exceeds current liabilities. One third of the fixed capital is financed with earned surplus.

The fixed capital other than capital surplus is all financed by the Government, and the IR has to pay 6% dividend on the government investment.

Table 3.1.27 Financial Results of the Indian Railways

(Rs. in Crores in 1986 price)

	1950/51	1955/56	1960/61	1965/66	1973/74	1982/83	1983/84	1984/85	1985/86
Capital-at-charge	5,229	6,882	9,134	11,670	9,261	9,058	8,638	8,885	9,078
Cross traffic receipts	1,663	2,246	2,743	3,194	2,707	5,466	5,690	5,746	6,428
Working Expenses	1,331	1,834	2,151	2,538	2,536	4,850	5,320	5,514	5,823
Net traffic receipts	332	413	592	655	170	616	371	232	605
Miscellaneous transactions	-32	-55	-64	-68	-39	77	62	57	81
Net revenue receipts	301	357	528	587	132	692	433	290	686
Dividend and other payments	206	256	336	452	407	545	484	499	507
Surplus or Deficit (-)	96	101	192	81	-275	148	-51	-210	179
Percentage of Net Revenue to the capital-at-charge	5.8	5.2	5.8	5.0	1.4	7.6	5.0	3.3	7.6
Operating ratio (percent)	81	82	79	78	94	88	94	96	91
GNP deflator	6.32	7.10	6.01	4.35	2.38	1.25	1.14	1.07	1.00

Source: Indian Railways Year Book 1985 - 86

3.2 Indian Railways Modernisation Plan

3.2.1 Transport Capacity Augmentation Plan

As mentioned already, the combined passenger and freight railway transport demand is expected to double by the year 2000, and transport capacity augmentation to meet that growing demand is a task of extreme importance.

The passenger traffic and freight traffic on railways in the 35 years from 1950 to 1985 increased 335% and 400%, respectively.

The Indian Railways has been making consistent modernisation and transport capacity buildup efforts to date through its First to Seventh Five Year Plans.

The major tasks under the First Five Year Plan were rehabilitation of the assets battered by excessive use during World War II and replacement of overage assets. To meet the growing transport demand, the railways' transport capacity was augmented through modernisation of motive power and improvement of signalling facilities, tracks, etc. The Seventh Five Year Plan, started in 1985, is currently carried out to attain the specified targets by the terminal year, 1990. The sector-by-sector outlays are graphically shown in Fig. 3.2.1.

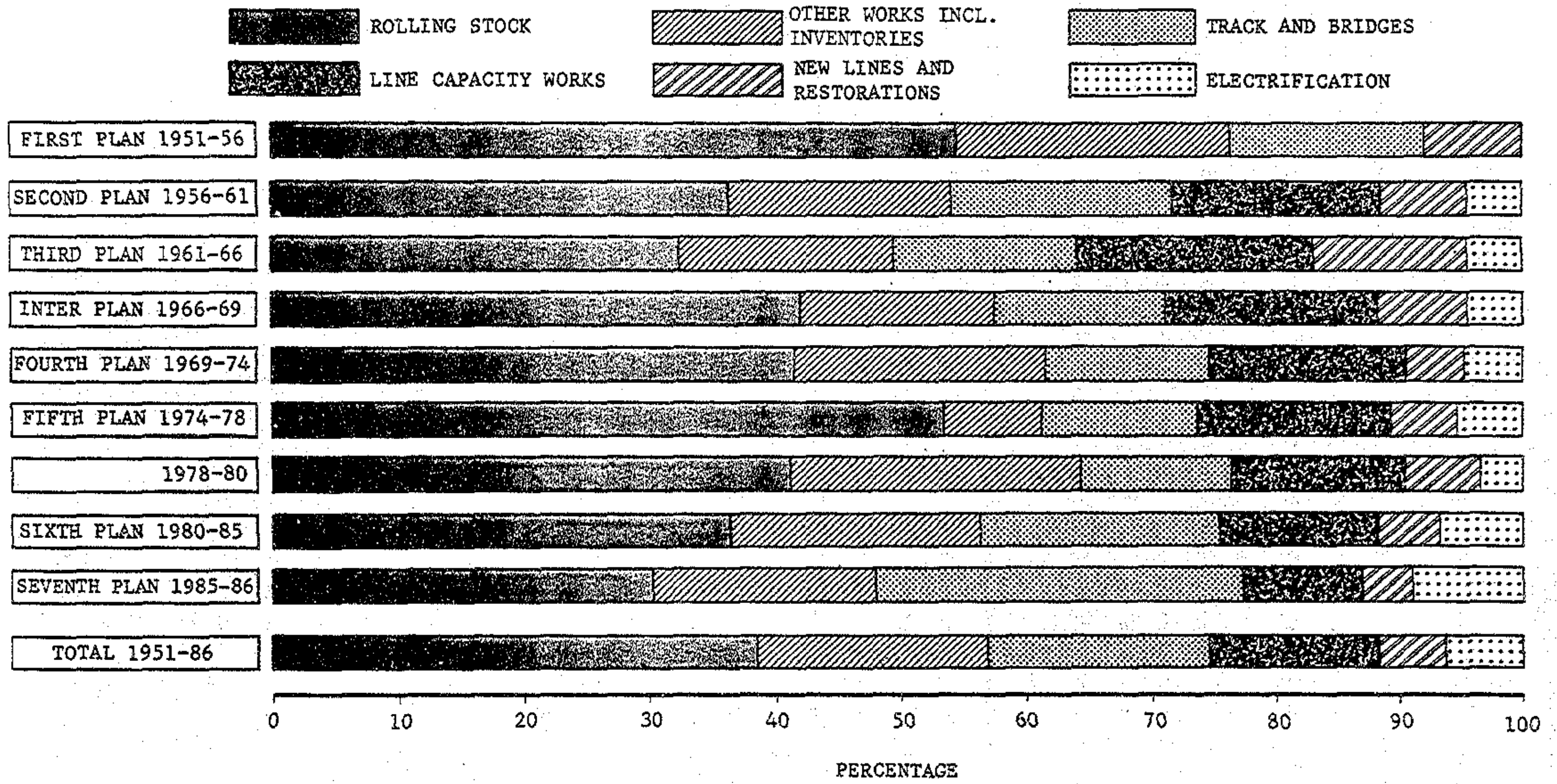


Fig. 3.2.1 Sector-by-sector Outlays in the Past

Here is an outline of the Indian Railways' plan for transport capacity augmentation in 15 years from 1986 through 2000 which includes years under the Seventh Five Year Plan.

In the passenger traffic sector, this augmentation plan puts a main emphasis on medium- and long-distance intercity transport and big city commuter transport.

As for freight traffic, the plan places a primary emphasis on mass transport and container transport to handle the growing cargo volume in these two sectors.

For this purpose, the following measures will be taken:

1) Introduction of heavier freight and longer passenger trains
2) Increase of locomotive traction force and, in some cases, increase of the balancing speed of locomotives in multiple-unit mode (including those on sloped lines)
3) Reduction of the speed differential between passenger trains and freight trains by raising the speed of the latter
4) Raising of the speed of regular trains
5) Concentration on point-to-point bulk movement with unit trains
6) Alleviation of overcrowding on trunk lines
   Special weight will be given to the dispersing of freight traffic from heavy-density routes to existing alternative routes, construction of high-speed passenger-dedicated corridors, etc.

3.2.2 Rolling Stock Modernisation Plan

Under the current rolling stock modernisation plan, which holds the key to the transport capacity augmentation, outlays amounting to Rs.14,250 crores, which include investments for replacement of assets, will be made in the next 15 years. This amount accounts for 32% of the aggregate amount of outlays on railways. The proportion of outlays on rolling stock to the investments in railways from 1951 to 1986 was approximately 38%. The percentage figure under the rolling stock modernisation plan (32%) is a little lower than this figure. Breakup of the rolling stock to be newly produced under the plan is presented in Table 3.2.1.

Table 3.2.1 Rolling Stock Production Plan

Kind of Rolling Stock	Production	
Diesel Locomotive	2,924	(Locomotives)
Electric Locomotive	1,500	(Locomotives)
Coach	30,000 - 31,000	(Vehicles)
EMU	5,000 - 6,000	(Vehicles)
Wagon	300,000	(Units)

Details of the assets to be replaced by the year 2000 are given in Table 3.2.2.

Table 3.2.2 Details of Assets to be Replaced by 1999-2000

Item	Overaged as on 31-3-85	Further arising till 31-3-2000	Total
1. Loco			
Steam			5,970
Diesel	12	412	424
Electric	19	182	201
2. Coaches	4,241	17,631	21,872
3. EMUs	134	1,562	1,696
4. Wagons	20,740	194,161	214,901

Motive power modernisation is being pushed forward as one of the major programmes of the Indian Railways. By the year 2000, the last steam locomotive in service will be replaced by diesel. A total of approximately 6,000 steam locomotives held by the Indian Railways at the end of 1984 are to be replaced by 2,500 diesel locomotives.

The electrification plan, if it is carried to the maximum scale, will provide electrification on a total of 10,000 track kms in fifteen years up to the year 2000.

This plan will call for the development and commissioning of large-power-output diesel and electric locomotives, introduction of electric trains on suburban lines near big cities, etc.

Under this plan, 4,000 HP diesel locomotives will be put in service on B.G. lines as means of traction for high-speed passenger trains and heavier freight trains, and 1,800 HP to 2,000 HP diesel locomotives on M.G. lines. Also 1,800 HP to 2,000 HP diesel locomotives will be put in service on B.G. branch lines and in B.G. shunting yards, and approx. 1,300 HP diesel locomotives on M.G. branch lines and in M.G. shunting yards. The Indian Railways is currently purchasing new 6,000 HP electric locomotives. After running tests, it will select one model and start manufacturing it domestically. That model will be used for high-speed passenger trains and heavier freight trains.

Coaches and wagons predominate in number, and many of them are overage vehicles. If the rolling stock production and replacement programme is carried out, complete replacement of wagons 40 or more years old, steel-bodied coaches 25 or more years old and wooden-bodied coaches 30 or more years old will be attained in the year 2000.

The seating capacity per coach will be increased by enlarging the body, reducing the coach weight, using air brakes. Also steps for qualitative improvement will be taken to provide better service for passengers by improving the lighting, installing an air conditioner and so on. All these efforts will be made to meet the increasing transport demand.

Four-wheeler wagons account for 65% of the wagon fleet at present. The load capacity per wagon is still small, and the maximum speed has to be limited to a low level. From this reason, all wagons to be produced from now on will be of the bogie type. The load capacity per wagon will be sharply increased, vacuum brakes will be replaced by air brakes, and the maximum speed level will be raised.

If a train formation is lengthened because of an increase in the haul load, the train is subject to various restraints imposed by ground facilities. Since vast facility improvement expenses would be incurred if such restraints are to be eliminated, it is essential to make some adjustments on the rolling stock side. An example of freight train so adjusted is given below.

The BOXN open wagon is a new type with a length of 10.7 m, air brakes, a tare of 24 t and a loading capacity of 57 t. Up to 60 wagons of this type can be interconnected without varying the effective length of 680 m of the side track. Thus this train provides a loading capacity larger by 30% or more than that of a 3,600 t train formed of 14 m-long bogie wagons, the capacity by wagon of both type being nearly equal.

Thus the growing transport demand will be met with the newly designed wagon, which will permit minimisation of wagon requirements.

3.3 Workshop Modernisation Plan in the Indian Railways

3.3.1 Necessity of Workshop Modernisation

The rolling stock inspection/repair workshops in India were originally constructed by privately-owned railway companies in the latter half of the 19th century and the early part of the 20th century. All these railways were nationalised in 1944 followed by integration of the system in 1952, and these workshops were taken over by the newly established Indian Railways. Having been developed independently by the railway companies at different times, there were substantial differences in layout, organisation, personnel size, facilities and work procedures and this was one obstacle to efficient rolling stock maintenance, workshop modernisation and other aspects.

The Indian Railways decided to develop the transport infrastructure to cope with an increasing transport demand with a series of Five Year Plans. In 1951, it started the First Five Year Plan which aimed at augmentation of the urgently needed transport capacity. More Five Year Plans were subsequently carried out, and outlays were made mainly for the purpose of reinforcing the transport capacity. This brought about acquisition of additional rolling stock and provision of line capacity.

To increase indigenous capacity for manufacture of rolling stock, ICF was set up in Madras as a coach production unit in addition to CLW, which had manufactured steam locomotives since 1950. DLW was set up in Varanasi, and manufacture of diesel locomotives for trunk lines was started there in 1964. At present, CLW manufactures electric and diesel locomotives, and ICF manufactures coaches and EMU's. Now almost 100% of the rolling stocks needed are indigenously manufactured in India. Some time around 1960, four workshops were set up at Kota, Jagardi, Raipur and New Bongaigan to increase the POH capacity for coaches and wagons, and another workshop was newly built in Bhusaval to add to the POH capacity for Electric locomotives. At the workshops set up earlier, however, there was no alternative but to meet the need of POH requirement by a partial improvement because of limited financial resources.

Accordingly, facilities at these workshops became more or less superannuated, and incompatible with increasing POH work. As a result, the productivity at the workshops lowered, and the POH cycle time was increased. Advances in motive power modernisation and changes in rolling stock structure have necessitated sophisticated POH work at workshops, but the existing facilities at those workshops are technically inadequate for that purpose.

Increase in POH cycle time at workshops reduces the availability of rolling stock, and the overaged facilities and the facilities unsuited for the repair work of modern rolling stock cause a decline in quality of rolling stock and possible failures.

According to the traffic demand forecast in the "Corporate Plan", the freight traffic demand and passenger traffic demand on the Indian Railways in the year 2000 will be approx. 400 billion tonne kms and approx. 400 billion tonne kms respectively. These are about twice the current freight and passenger traffic volume. To cope with such demand growth, it is the Indian Railways' urgent task to establish a rolling stock maintenance system matching with the increase in the the rolling stock holding.

3.3.2 Objectives of Workshop Modernisation

The Indian Railways started the workshop modernisation back in 1979. Phase I of this programme, intended for four workshops and 1 production unit, was completed in 1985, and Phase II is in progress now. The workshops selected for this study are a part of the 10 workshops identified in Phase III by the Indian Railway Board.

The ultimate aims of workshop modernisation are to secure good quality of rolling stock, to carry out its economical maintenance to improve the productivity and to upgrade the repair technology at the workshop by developing an integrated maintenance and repair network on a national basis in line with the modernisation plan of the Indian Railways.

Thus the Indian Railways' basic objectives in workshop modernisation are as follows:

1) To achieve reduction in POH cycle time of rolling stock and to enlarge periodic overhaul capacity of workshop to match the rationalised work-load requirement
2) To improve performance and availability of rolling stock and effect economy in the cost of rolling stock maintenance
3) To introduce improved repair technology in the workshop and improve the productivity of manpower

The Indian Railways made plans for assignment of POH workloads and providing POH capacity at the workshops on a national basis at the end of the Seventh Five Year Plan. Those parts of the plans which concern the workshops dealing with the B.G. rolling stock are presented in Table 3.3.1.

The above plans include the following details of the B.G. workshops:

1) Workshop where POH activity is to be stopped. 2
2) Uni-activity workshop 4
3) Workshop where POH activities are to be decreased. 5
    - 3 activities → 2 activities 2
    - 4 activities → 3 activities 2
    - 6 activities → 5 activities 1
4) Workshop to be newly constructed 2

Reduction of POH activity is an effective measure to improve workshop productivity. It is generally understood that these plans indicate the future direction of workshop modernisation.

Table 3.3.1 Projected Capacity of BG Workshop

Kind of Rolling Stock		Steam* Loco.	Diesel Loco.	Electric Loco.	Coach	Wagon	EMU's
1986/87	No. of Workshop	13	7	6	17	15	6
	POH Capacity	107.5	35.5	19.5	2643	8714	294
1989/90	No. of Workshop	5	7	7	16	12	6
	Projected POH Capacity	83.5	42.5	29	3108	9745	390
Increase in POH Capacity per Workshop ( ) in %		8.4 (200)	1.1 (122)	0.9 (128)	39 (125)	231 (139)	16 (156)

Note 1. Units of POH capacity means No. of rolling stock for locomotive and 4-wheeler unit for coach and wagon.

2. * marked column includes BG and MG locomotives.

3.3.3 Workshop Modernisation at Present and Prospects

(1) Outline of Phase I

The repair workshops at Kancharapara, Kharagpur, Lower Parel and Matunga and one production unit (CLW) were selected for Phase I. The aims of modernisation were the reduction of POH cycletime, increase of productivity and improvement of rolling stock quality through the following actions:

1) Introduction of modern, high-efficiency machinery
2) Improvement of workshop layout
3) Facilitating material movement by providing proper material handling equipments

A main emphasis was put on machinery and plant replacements. In fact, 70% of the project cost was entailed by them.
The outcome of the modernisation efforts is presented in Fig. 3.3.1.

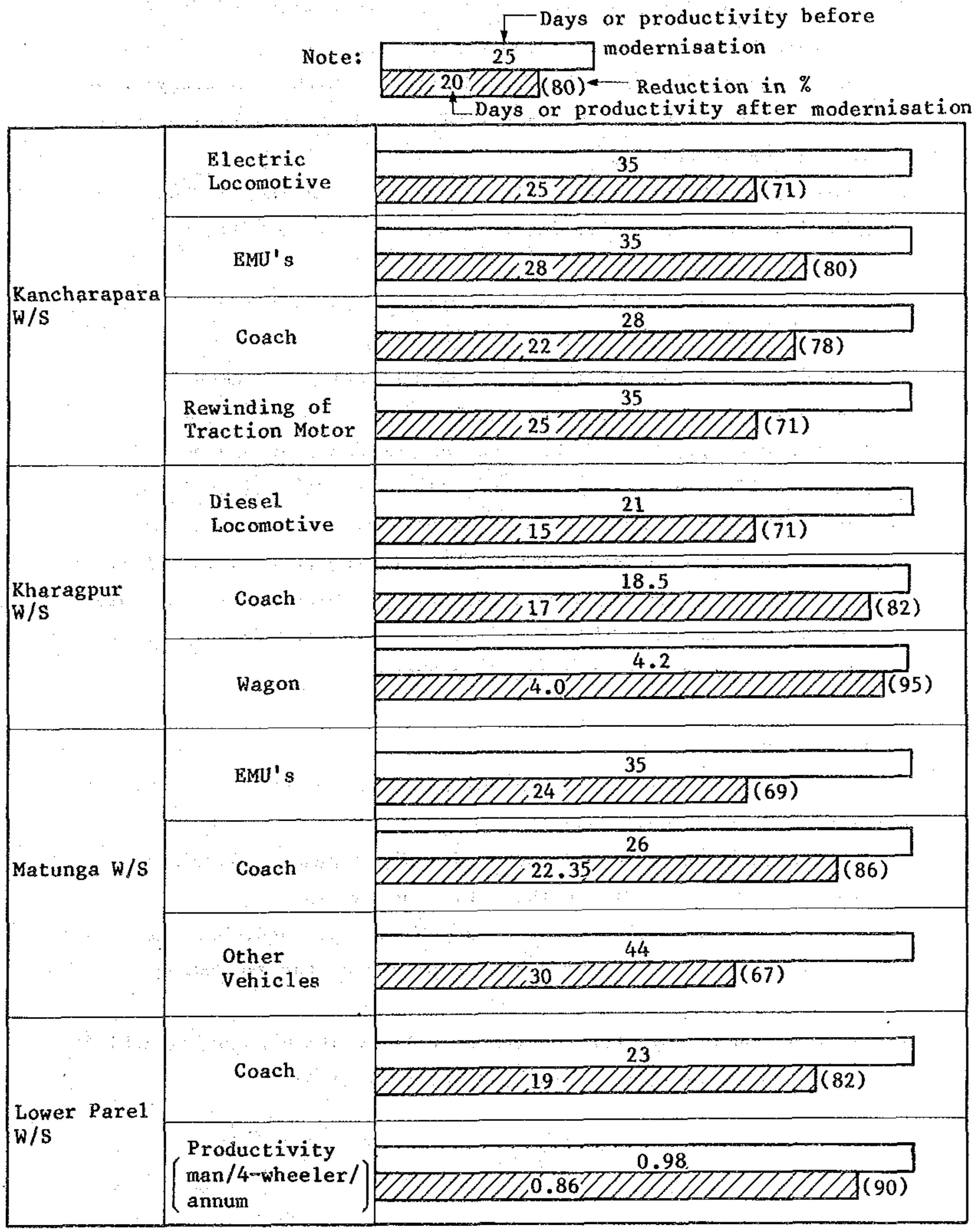


Fig. 3.3.1 Attainment of Objectives in Phase I

(2) Outline of Phase II

The workshops at Parel, Liluah, Jagadhri, Golden Rock, Kharagpur and Ajmer and one production unit, ICF Madras, were selected for Phase II of modernisation. Major improvements in Phase II are as follows:

1) Increasing productivity by introduction of high technology, high productivity machines in place of low productivity machines for repair operation also
2) Improving working system including improved lay-out and better material handling facilities to ensure better workflow and material movement
3) Introduction of modern processes with modern machines,
4) To ensure better material handling
5) Introduction of better quality control/testing equipments to ensure improved standards of quality.

As for the outlays, 61% of the total amount was expended on machinery, 25% on civil engineering, 11% on electrical appliances, and 3% on the rest. As in Phase I, a main emphasis was put on machinery, but the outlays per workshop and the percentage figure for civil engineering increased over the corresponding levels in Phase I. It can be seen from this that larger-scale improvements of buildings and others are envisaged in Phase II.

(3) Outline of Phase III

The Railway Board identified the following 10 workshops for the workshop modernisation project:

Amritsar, Charbagh, Dohad, Kota, Jhansi, Perambur (Carriage & Wagon), Gorakhpur, Dibrugarh, Hubli and Jamalpur

The aims of modernisation have already been explained, but the project will be pushed forward with emphasis on the following activities:

1) Improved technology for repairs of rolling stock adopting mobile system for important components/sub. assemblies

2) Provision of improved material handling equipment and suitable layout changes
3) Provision of unit exchange spares
4) Replacement of machinery and plant with high technology and higher productivity machines
5) Modification and expansion to the existing workshop structures to cater for increased workload and better work-flow
6) Development of adequate personnel support through organized training
7) Provision of testing equipment for rolling stock to ensure reliability during the repairs.

The achievements at the workshops for B.G. rolling stock and the plans for them are presented in Table 3.3.2. 28 workshops in all are to deal with B.G. rolling stock in 1989-90, and approximately 60% of the workshops including workshops in Phase III were identified as those needing modernisation.

Table 3.3.2 BG Workshop Modernisation Programme

	No. of BG Workshop	Modernisation Programme			
		Phase I	Phase II	Phase III	Total
Central Rly.	5	1	1	1	3
Eastern Rly.	4	1	1	1	3
Northern Rly.	4		1	2	3
North Eastern Rly.	1			1	1
Northeast Frontier Rly.	1				-
Southern Rly.	3		1	1	2
South Central Rly.	2				-
South Eastern Rly.	4	1	(1)*		1
Western Rly.	4	1		2	3
Total	28	4	4	8	16

* Same workshop in Phase I

(4) The role of the workshops

1) Perambur Workshop (C&W) is a major workshop in Southern Railway dealing with broad gauge carriages and wagons, and has the second biggest POH capacity of carriages among the Indian Railway Workshops. The rolling stock holding in Southern Railway is likely to increase in number and will be of modern design. At present, no assignment of POH work load of rolling stock other than carriage and wagon is envisaged, therefore, the Workshop will keep playing an important role as a major workshop in Southern Railway.

2) Jamalpur Workshop is a major workshop for POH of steam locomotives and B.G. diesel locomotives in Eastern Railway. In keeping with the replacement programme from steam to diesel locomotive, the Workshop is planned to deal with diesel locomotive as far as POH activity is concerned beyond 1996, and POH of electric locomotive is under consideration as a part of the diversification of activities of the Workshop. Therefore, the Workshop will have a more important role for the POH of locomotives in future.

CHAPTER 4 PREMISES OF THE WORKSHOP MODERNISATION PLANNING

CHAPTER 4 PREMISES OF THE WORKSHOP MODERNISATION PLANNING

4.1 Railway Traffic Demand Forecast

4.1.1 Basic Concept

(1) Purpose and methodology

The traffic demand up to the year 2000 will be forecasted by reviewing and analysing the following data and materials:-

1) Socio-economic and transportation data
2) Socio-economic development plan of India
3) Transport projections planned by Indian Railways and the Authorities concerned

From the methodological viewpoint, this study will be carried out based on the under-mentioned step-by-step examinations, including the time series regression analysis and multi-regression analysis.

(Step-by-step examination)

a) Examination of the total passenger and freight traffic volume of entire India and their socio-economic background

⇩

b) Analysis of the railway's market share, in terms of passenger-kms and tonne-kms, and by commodity-wise approach

⇩

c) Railway traffic projections for the year 2000/2001
- o Number of railway passengers & passenger-kms
- o Number of railway freight tonnes & tonne-kms

Further detailed methodology or process of the traffic demand forecast is shown in Fig. 4.1.1.

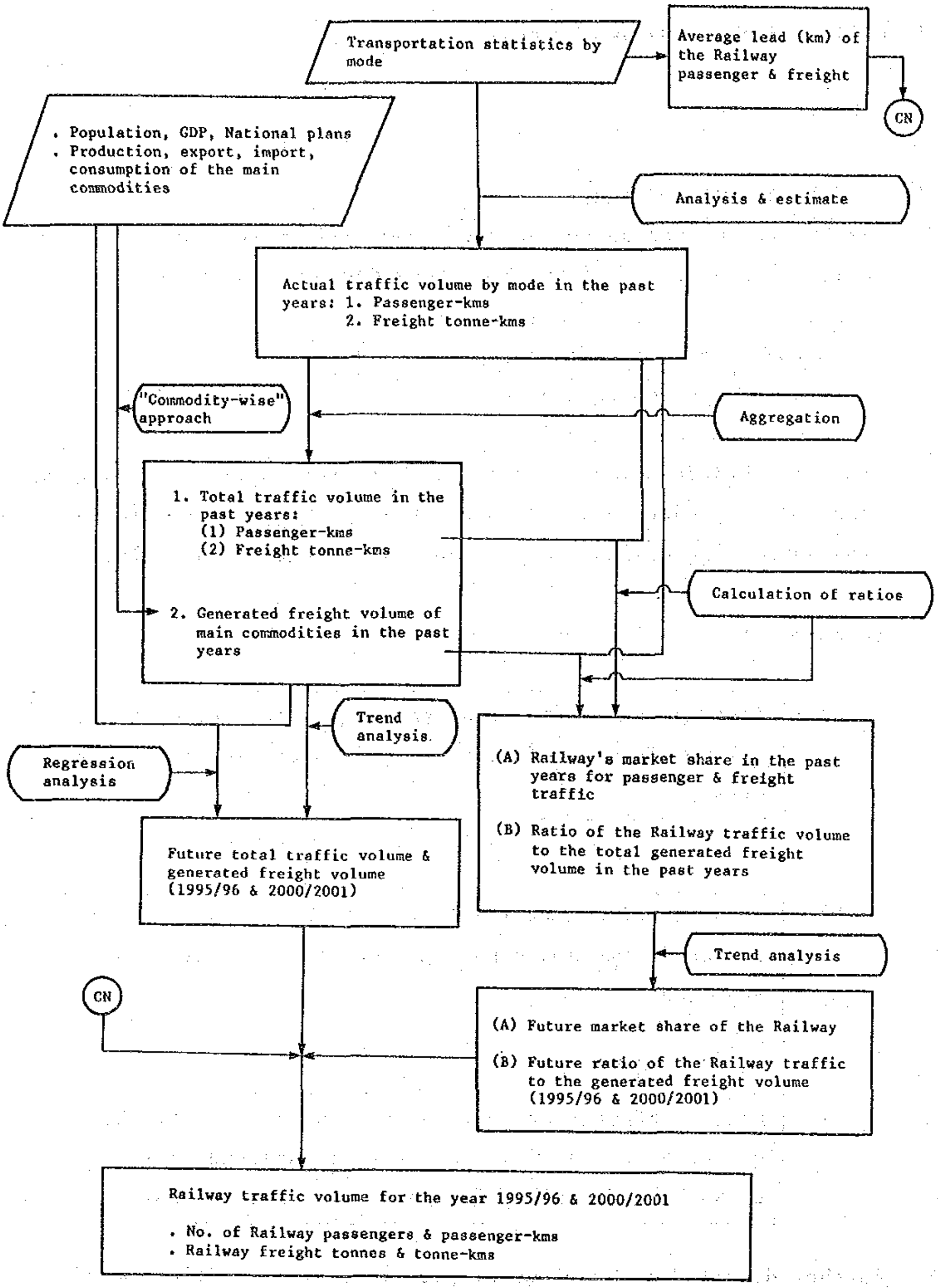


Fig. 4.1.1 Methodology of Traffic Demand Forecast

(2) Major preconditions

1) Future socio-economic framework

Socio-economic framework is one of the most fundamental concepts in the study of traffic demand forecast.

It is usually represented by the total population and GDP of the country concerned. In this study, the values projected by the Seventh Five Year Plan are adopted as the basic data for the determination of total populations and GDPs up to the year 2000 in India.

a) Total population

The total populations in the past years based on the census, and projected in the above-mentioned five year plan is shown in Table 4.1.1.

Table 4.1.1 Actual and Projected Population in India

Year, etc. \ Item		Population at the end of the period (Million) as on 1st March		Average yearly growth rate (%) (Total population)
		Total	Urban (%)*	
Actual	1941-51	361	63 (17.3)	-
	1951-61	439	79 (18.0)	2.0
	1961-71	548	109 (19.9)	2.2
	1971-81	685	160 (23.3)	2.3
	1981-86	761	192 (25.2)	2.1
Projected	1986-91	837	230 (27.5)	1.9
	1991-96	913	274 (30.0)	1.8
	1996-2001	986	326 (33.1)	1.6

Source: 1. Registrar General, India
2. Seventh Five Year Plan, Vol. 1

Note : * Percentage means urbanisation rate.

b) GDP

The GDPs projected in the before-stated five year plan are shown in Table 4.1.2.

Table 4.1.2 GDP

<table>
<tr><th>Item \ Year</th><th colspan="2">1984/85 (Actual)</th><th colspan="2">1989/90</th><th colspan="2">1999/2000</th></tr>
<tr><td>1. GDP at factor cost (Rs. crores at 1984-85 prices)</td><td colspan="2">193,428</td><td colspan="2">246,881</td><td colspan="2">402,143</td></tr>
<tr><td>2. Average yearly growth rate (%)</td><td>-</td><td colspan="2">5.0</td><td colspan="2">5.0</td><td>-</td></tr>
</table>

Source: Seventh Five Year Plan, Vol. 1

2) Transportation conditions by mode
The relative deviations in the service levels (transport time, cost, etc.) provided by the available transportation modes may lead to the change in the market shares of the respective modes. In this study, however, any such deviation or any modernisation project in transportation leading to such a deviation are not taken into consideration.

3) Capacity of transportation facilities
The future transport capacity of railways, highways and airways including rolling stock and other transport facilities are assumed to impose no significant restrictions on satisfying traffic demand.

4.1.2 Forecast of Passenger and Freight Traffic Demand

The annual railway traffic demand in future years up to 2000 was forecasted by using the procedure described earlier and the calculation formulae presented in (1) below.

(1) Forecast of total railway traffic demand

The annual total railway traffic demand in future years up to 2000 was forecasted on the basis of the annual total railway traffic volume figures in past years and a regression analysis of socio-economic data.

The predicted demand values were obtained by using the following formulae:

$$\log(PTK) = 1.033203 + 0.5268555 \cdot \log(POP \cdot GDP) + \log(POP)$$

$(R = 0.9809)$ .... (1)

where,

- PTK: passenger-kms (in million)
- POP: Total population (in million)
- GDP: GDP at factor cost (in Rs. crores)

$$\log(FTK) = -4.867188 + 0.9672852.\log(GDP)$$

$(R = 0.9712)$ .... (2)

where,

- FTK: Freight tonne-kms (in million)
- GDP: GDP at factor cost (in Rs.crores)

Items aggregated in the total traffic volume are as follows.

Total passenger-kms
- Railway passenger-kms
- Road (buses, cars and two-wheelers) passenger-kms (Estimated)
- Airline passenger-kms

Total freight tonne-kms
- Railway freight tonne-kms
- Road (truck) freight tonne-kms (Estimated)

Coastal shipping is excluded from the aggregation due to it's small weight in the total traffic.

Table 4.1.3 Total Traffic Demand up to the Year 2000/2001

Traffic demand \ Year, etc.	1984/85	Forecasting		
		1990/91	1995/96	2000/2001
Passenger-kms (in billion)	588.5	835.3	1,100.2	1,387.6
Freight tonne-kms (in billion)	328.8	440.2	557.2	705.8

(2) Forecast of railways' market share

1) Market share in terms of passenger-kms and that in terms of freight tonne-kms

Railways' share of the total passenger traffic and their share of the total freight traffic are defined below:

$$\begin{Bmatrix}\text{Railways' share of}\\ \text{total passenger traffic}\end{Bmatrix} = \frac{\begin{Bmatrix}\text{Railway passenger traffic in}\\ \text{passenger-kms}\end{Bmatrix}}{\{\text{Total passenger traffic in passenger-kms}\}}$$

$$\begin{Bmatrix}\text{Railways' share of}\\ \text{total freight traffic}\end{Bmatrix} = \frac{\begin{Bmatrix}\text{Railway freight traffic in freight}\\ \text{tonne-kms}\end{Bmatrix}}{\{\text{Total freight traffic in freight tonne-kms}\}}$$

2) Railways' share of the total passenger traffic and share of the total freight traffic in future years were estimated on the basis of a trend analysis of railways' actual shares in past years.

Table 4.1.4 Estimated Railways' Market Share up to the Year 2000/2001

(in percentage)

Item	Railways' share (SH)			Applied formulae for the estimate
	(1984)	1995	2000	
Passenger	38.5	32.9	30.2	log (SH) = 5.114258 - 0.0170670·t (R = 0.8227)
Freight	52.5	45.5	42.6	log (SH) = 5.06006 - 0.0130730·t (R = 0.905144)

(3) Railway traffic demand forecast up to year 2000/2001

The expected demand for railway passenger traffic and that for railway freight traffic were calculated by multiplying the predicted total passenger traffic by railways' share of that total traffic and by multiplying the predicted total freight traffic by railways' share of that total traffic respectively.

The railway passenger traffic volume and freight traffic volume so calculated were 419.0 billion passenger-kms and 300.7 billion freight tonne-kms respectively.

(4) Generated freight volume by main commodity and railway freight traffic

1) In addition to the procedure described earlier, the "commodity-wise approach" was also used to predict freight traffic demand. Table 4.1.5 shows the generated freight volume figures by kinds of commodity -- food grains, coal and lignite, petroleum, iron and steel, cement (five major items) and others -- based on the past trend and the values projected for the year 2000 in the Seventh Five Year Plan by the government.

Table 4.1.5 Generated Freight Volume up to the Year 2,000/2001

(in million tonnes)

	Generated freight volume			Projections for 2000
	(1984)	1995	2,000	
1. Food grains	145.5	174.8	192.2	235 - 240
2. Coal and lignite	147.4	238.9	302.5	417
3. Petroleum	41.4	78.8	105.0	87.7
4. Iron and steel	14.6	23.8	27.1	21
5. Cement	29.5	43.7	55.3	87
6. Others	50.8	65.7	77.1	100.6
Total	429.2	625.7	753.2	948.3-953.3

2) Forecasted ratio of railway freight traffic to generated traffic volume by main commodity

Table 4.1.6 below shows the ratios of railway freight traffic to generated traffic volume by kinds of commodity forecasted on the basis of the past trend.

Table 4.1.6 Forecasted Ratio of Railway Freight Traffic to Generated Traffic Volume by Main Comodity

(%)

	(1984/85) ACTUAL	1995/96	2000/2001
1. Foodgrains	13.7	17.8	18.7
2. Coal and	62.1	59.5	58.7
3. Petroleum	44.0	42.5	41.6
4. Iron and Steel	56.9	56.9	56.9
5. Cement	56.9	56.9	56.9

Note: It was presupposed that the ratio figures in 1984 for "4. Iron and Steel" and "5. Cement" would remain unchanged.

3) Forecast of freight traffic demand by commodity-wise approach

The traffic demand figures for the five major items were obtained by multiplying the generated freight volume by railways' market share (ratio of railway freight traffic to generated traffic volume), and similar figures for "others" were based on the trend in railway traffic (actual). The forecast values are listed in Table 4.1.7.

Table 4.1.7 Predicted Freight Traffic Demand Figures

Base \ Year		1984	2000
Trend base	Tonnage	236.4	366.4
	Tonne-kms	172.0	* 303.5 289.1
Government Projection base	Tonnage	236.4	467.9
	Tonne-kms	172.0	* 387.6 369.2

* Including "non-revenue". Up 5%

(5) Railway Traffic Demand Forecast up to the year 2000/2001

The results of the railway traffic demand forecast by the procedure mentioned above are summarised in the Table 4.1.8.

Table 4.1.8 Results of Railway Traffic Demand Forecast

Traffic Demand \ Year			1984 (Actual)	2000
Passenger	Passengers (in million)		3,333.0	5,625.7
	Passenger-kms (in billion)		226.6	419.0
Freight	Trend base	Tonnage (in million)	236.4	366.4
		Tonne-kms (in billion)	172.0	303.5
	Government projection base	Tonnage (in million)	236.4	467.9
		Tonne-kms (in billion)	172.0	387.6

4.2 Rolling Stock Plan

4.2.1 Premises of Rolling Stock Planning

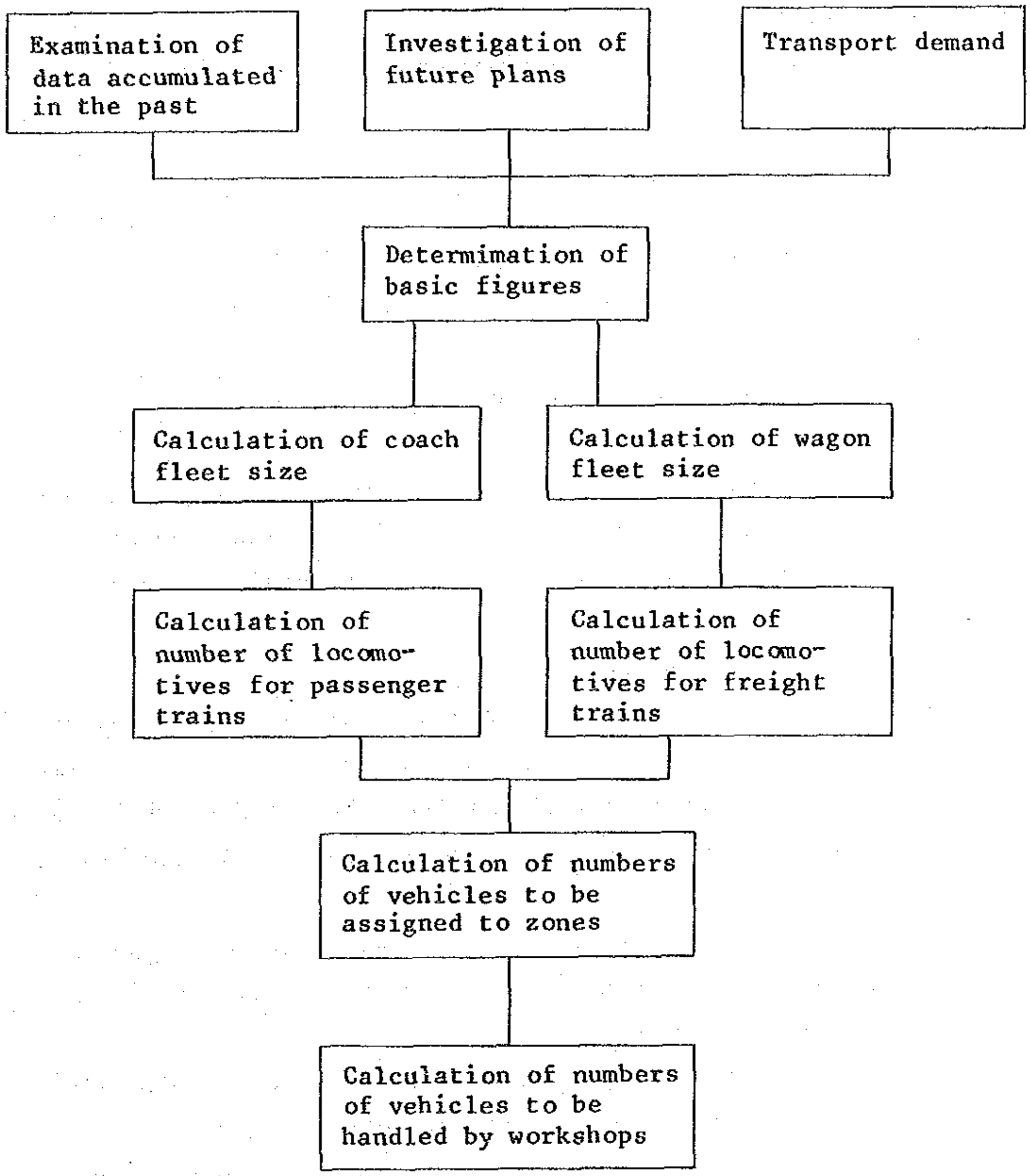
(1) The scale of a workshop is fixed primarily by the number of vehicles necessary to match the expected transport demand. The rolling stock number was calculated according to the requirement in the year 2000, with the machinery and plant life cycle taken into account.

(2) At present, there is no indication of any sharp change in the transport structure of SR and ER due to special area development.
The rolling stock quantity required to meet the transport demand for entire IR was determined and vehicle assignment to the individual zones was based on the ratio of vehicle assignment at present.

(3) The adoption of longer trains, higher speed and other measures are believed to be highly effective for some specific lines, but they will not be discussed here because this is a general study of the entire Indian Railways.
As to the load factor and other values which should be determined as a matter of management policy, current levels were adopted; thus many of the base figures for calculation purposes were derived from the performance data.

(4) The Indian Railways has set up a long-range plan extending to the year 2000. We predicted the transport demand and drew up the rolling stock plan taking that long-range plan fully into account.

4.2.2 Planning Procedure



4.2.3 Calculation of Coach Fleet Size

(1) Basic value setting

The following expressions are established.

$M = A \times W$

$W = L \times N$

whrere

M: Traffic volume (Total passenger-kms)

A: Average number of passengers per coach (person)

W: Vehicle-kms (km)

L: Average vehicle-kms per vehicle (km)

N: Number of vehicles

When traffic volume and average number of passengers per coach are known, vehicle km can be obtained. When, in addition, average vehicle-kms per vehicle is known, the number of vehicles required for the transportation can be obtained.

1) Average number of passengers (A)

Though the setting of average number of passengers per vehicle is a matter to be decided by management policy, it has been estimated due to failure to obtain concrete value. In NON-SUB, the passenger rate against the number of seats per vehicle exceeds 100% in the average.

From the tendency up to date, average numbers of passengers per vehicle will further increase, and the present level is to be maintained in the furure.

Though the average passenger efficiency of SUB (EMU) DOES NOT EXCEED 100%, at least present passenger efficiency must be maintained with the actual situation of peak time zone being considered.

2) Average vehicle-kms per vehicle day (L)

Average vehicle-kms per vehicle is B.G. 310 km/day and M.G. (including N.G.) 176 km/day. When assumption is made that B.G. is mainly improved, the average vehicle-kms per vehicle is B.G. 410 km/day, and M.G. 190 km/day in 2000.

The average vehicle-kms per vehicle of SUB (EMU) on a long term basis is showing a gradual increase. Assuming that the future increase will concentrate on B.G., average vehicle-kms per vehicle in 2000 is estimated to be B.G. 355 km/day and M.G. 280 km/day.

(2) Calculation of coach fleet size

Table 4.2.1 shows the calculation result of number of vehicles in 2000.

Table 4.2.1 Holdings of EMU and Coaches in 2000

(vehicle)

	SUB (EMU)		NON-SUB	
	B.G.	M.G.	B.G.	M.G.
Number of Passenger Vehicles (vehicle)	5,000	420	23,000	14,200
Number of Other Coaching Vehicles (vehicle)	-	-	5,100	3,100
Number of Vehicles Held (vehicle)	5,000	420	28,100	17,300

Proportion of the number of other coaching vehicles to the entire vehicles is decreasing year after year, however cut-down may have a limit unless there is a great change in the mail luggage service system. Component ratio of both B.G. and M.G. in 2000 is about 18% of the total.

4.2.4 Calculation of Number of Locomotives for Passenger Trains

(1) Basic value setting

The following relation equations are established.

$$T = W/B$$

$$N_L = T/L_L$$

where

T: Passenger train-kms (km)

B: Average number of vehicles per train (vehicle)

W: Vehicle-kms (km)

N_L: Number of locomotives (car)

L_L: Average locomotive traveling distance (km)

1) Average number of vehicles per train (B)

According to 1985 record, B.G. was 12.5 cars, and M.G. 9 cars. Assuming that the number of cars consisting mainly of B.G. will increase in the future, it has been estimated that average number of vehicles in 2000 is B.G. 15 and M.G. 9.

2) Calculation of train-km

Train-km in 2000 is calculated as follows from the vehicle-km and vehicles per train.

Table 4.2.2 Passenger Train-kms in 2000

	B.G.	M.G.
Train-kms (in million km)	280	133

3) Train-kms by type of traction

Regarding train-km obtained in 2), train-kms by type of traction was examined. Change in train-km by traction is shown in Table 4.2.3.

In B.G. it is estimated that electric traction will increase to a large extent.

Table 4.2.3 Train-kms by Type of Traction

(in million km)

	SL		DL		EL		
	B.G.	M.G.	B.G.	M.G.	B.G.	M.G.	
Train-kms by Type of Traction in 1985/86	63	58	89	28	51	1	Annual Report
Train-kms by Type of Traction in 2000	0	0	127	130	153	3	

4) Estimation of engine-kms

Of the train-kms by diesel traction in 2000, totaling 257 million, 121 million kilometres were train-kms of trains presently hauled by steam locomotives and since this figure is derived from trains run primarily on non-trunk lines, the diesel-engine-kms therefore was separately determined.

At present, engine-kms per engine day of both broad-gauge and metre-gauge steam locomotives are 200 km/day or less. A 50% increase was anticipated taking into account instances in Japan. Engine-kms for diesel and electric locomotives were inferred from the results in the past.

Table 4.2.4 Engine-kms in 2000

	B.G.	M.G.
DL (SL → DL) (km/day)	300	300
DL - do -	820	600
EL - do -	600	430

(2) Calculation of number of passenger locomotives

Table 4.2.5 shows the number of passenger locomotives calculated based on the above condition.

Table 4.2.5 Number of Passenger Locomotives

		B.G.	M.G.	Total
DL	Transfer from SL	575	530	1105
	DL traction from the past	213	330	543
	Sub-total	788	860	1648
EL		699	19	718

4.2.5 Calculation of Wagon Fleet Size

(1) Basic value setting (Calculation method is the same as that for passenger car.)

1) Average load

1985/86 actual result is B.G. 13.3 t/unit and M.G. 11.4 t/unit. According to the estimate, average load in 2000 is B.G. 15t/unit and M.G. 12 t/unit.

2) Average vehicle-kms per vehicle day

Average vehicle-kms per bogie wagon is increasing in B.G., but remains at the same level.

It has been estimated that B.G. is 120 km and M.G. 60 km.

(2) Calculation of wagon fleet size

Goods transport demand in 2000 was examined in 4.1, and predicted value and planned value differ to some extent. Supposing that various measures will be added in the future plan, calculation here is performed by applying planned value.

Number of vehicles required for the transportation is 687,200 units.

Table 4.2.6 Number of Units Needed in 2000

	B.G.	M.G.	Remarks
Traffic at 2000 (million ton-km)	345,000	42,600	Total 387,600
Annual transport capacity per vehicle (ton-km)	657,000	262,800	
Net no. of vehicles (units)	525,100	162,100	Total 687,200

(3) Examination of number of vehicles in 2000

1) From the age distribution of cars held in 1985, cars reaching 40 or more years old in 2000 are as follows:

4 wheeler : 125,914 vehicles

Bogie Wagon: 10,813 vehicles (B.G. 4.228 vehicles, M.G. 6,585 vehicles)

4-wheeler conversion value of the bogie B.G. = 2.5 and M.G. = 2.0.

Number of bogie wagons in terms of 4 wheeler units is as follows:

B.G. : 4,228 x 2.5 = 10,570

M.G. : 6,585 x 2.0 = 13,170

Total: 23,740 units

Number to be replaced due to more than 40 years old is 149,654 units.

2) Number of vehicles held as of 1985 (in 4 wheeler units.)

B.G. : 426,124 units

M.G. : 107,800 units

Total: 533,924 units

3) Number of newly manufactured vehicles

Annual output : 20,000 units

Total in 15 years: 300,000 units

4) Number currently held + number newly manufactured - number disposed (as of 2000)

533,924 + 300,000 - 149,654 = 684,270 units

Accordingly, even when aged vehicles of 40 years or more are replaced, required transport ability can be secured by proceeding with new manufacture as scheduled.

(4) Wagon fleet in 2000

Wagon fleet corresponding to 687,200 units is as follows

Table 4.2.7 Wagon Fleet in 2000

(vehicle)

	B.G.		M.G.		Total	Remarks
	Bogie	4 Wheel	Bogie	4 Wheel		
1985 Holding Fleet	92,222	193,876	30,162	47,473	363,733	
Newly Manufactured Fleet	96,000	--	30,000	--	126,000	'85 unit ratio
Disposed Fleet	3,348	85,616	6,220	40,298	135,482	
Total	184,874	108,260	53,942	7,175	354,251	
Bogie Wagon Ratio (%)	63	--	88	--	--	

4.2.6 Calculation of Number of Locomotives for Freight Trains

(1) Basic value setting

1) Number of wagons per train

It has been estimated that average load per train in 2000 is 2,240 t in B.G. and 1,164 t in M.G. The bogie wagon rate is 63% in B.G. and 88% in M.G.

The sum of the net load of B.G. wagon and tare weight is about 80 t in bogie wagon and about 53 t in 4-wheeler.

The sum in the case of M.G. gross load is 33 t in bogie wagon and 22 t in 4-wheeler.

It has been estimated that number of wagons per train is 34 wagons in B.G. and 24 wagons in M.G.

2) Train-kms by type of traction

Train-km in 2000 is calculated as follows from the vehicle-km and the number of vehicles per train.

Table 4.2.8 Train-kms by Type of Traction (in million km)

		B.G.	M.G.	Total
Train-km	Total	376	56	432
	DL Traction	226	56	282
	EL Traction	150	-	150

3) Estimated value of engine-km in 2000 is shown in Table 4.2.9.

Table 4.2.9 Engine-kms in 2000

	B.G.	M.G.	Remarks
Engine-km in 2000 DL (km/day)	520	400	
Engine-km in 2000 EL (km/day)	480	-	M.G. is minimum transport amount.

(2) Number of locomotives for freight trains

Table 4.2.10 shows the number of locomotives for freight trains calculated based on the above condition.

Table 4.2.10 Number of Locomotive Needed in 2000

(vehicles)

	B.G.	M.G.
DL	1,190	380
EL	860	-

4.2.7 Number of Vehicles Held in 2000 and that by Zone

(1) Locomotives

Number of locomotives to be required for operation of coaches and wagons plus allowance (actual 34%) including POH, and stand-by is as shown in Table 4.2.11.

Shunting DL has been assumed to be 20% of all diesel locomotives held as a result of examination of actual condition.

Number of vehicles assigned by zone is based on the vehicle assignment ratio in 1985.

Table 4.2.11 Holding by Zones and by Kinds of Vehicle

(vehicle)

		DL		EL		COACH		EMU		WAGON	
		B.G.	M.G.	B.G.	M.G.	B.G.	M.G.	B.G.	M.G.	B.G.	M.G.
S.R	%	6	12	-	100	15	20	6	100	6	9
	No. of Vehicles	240	250	*1 (125)	30	4200	3500	300	400	18000	5500
E.R	%	19	-	21	-	17	1	36	-	20	-
	No. of Vehicles	730	-	500	-	4800	170	1800	-	58400	-
I.R	No. of Vehicles	3850 *2 (850)	2120 *2 (250)	2360	30	28100	17300	5000	400	293000	61100

*1 S.R. 1990 planned value is shown.
*2 Asterisked Figure *2 is for shunter and included in the total figure.

4.2.8 Number of Vehicles Assigned to Workshop

Table 4.2.12 shows the number of vehicles by type assigned to the workshops investigated. Number of vehicles assigned by workshop has been calculated with 5% margin. Figure of electric locomotive is the total number of locomotives of Eastern Railway.

The number of electric locomotives to be handled at Jamalpur Workshop and Kanchrapara Workshop is according to the I.R. policy.

Table 4.2.12 No. of Vehicles to be Handled at Individual Workshops

(Vehicle)

WORKSHOP	DL	EL	COACH	EMU	WAGON
PERAMBUR	-	-	4,400	-	19,000
JAMALPUR	770	530	-	-	-

CHAPTER 5 JAMALPUR WORKSHOP

CHAPTER 5 JAMALPUR WORKSHOP

5.1 Present State of Workshop

5.1.1 General Condition

The Jamalpur Workshop is located approximately 370 km northwest of Calcutta. It is in charge of the POH of all the steam locomotives and BG (Broad Gauge) diesel locomotives of the Eastern Railway.

This workshop was established in February 1862. It is one of the largest workshops in the Indian Railways, with a total area of approximately 570,000 m^2 and a staff strength of about 14,000 persons. (Refer to Table 5.1.1.)

The performance of the workshop is as shown in Table 5.1.2 and an outstanding feature is that the activities other than POH of locomotives account for about 45% of the total work done.

In line with the modernisation of motive power, the Indian Railways intends to convert this workshop into the main workshop for POH of diesel locomotives but, at the same time, aims promote the diversification of its activities to supplement the decrease in POH workload of steam locomotives.

The biggest reason for the diversification is that there is a strong demand in the area for creation of the maximum job opportunities at the workshop since the workshop is located in Jamalpur with a population of approximately 100,000 and with no special industries other than agriculture and quarrying, and this workshop has supported the economy of the town as the sole large enterprise in the area.

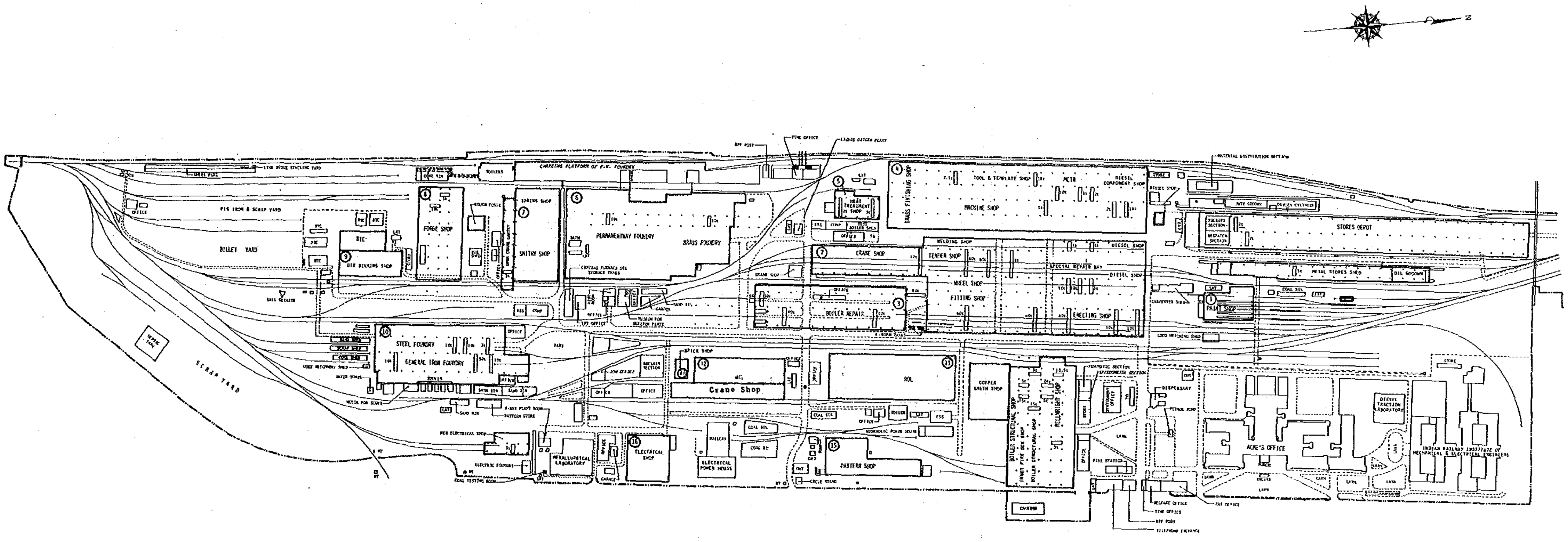
As to the workshop facilities, the following can be given as some of the characteristics.

This workshop has a local electric power plant generating 3500 KVA which accounts for one-half of the electric power requirements of the workshop. Water is supplied to the workshop and peripheral colonies by the special water supply facilities with the source at the Ganges River approximately 10 km away.

There are approximately 2,000 units of machinery but 1,500 units equivalent to 75% are overaged and require replacement. This workshop has come to the turning point from steam locomotives to diesel locomotives, and the introduction of new repair machinery and inspection and testing equipment required for the POH of modern locomotives together with the replacement of these old machinery, has become a pressing subject.

Table 5.1.1 Workshop at a Glance

Date Established		8th February, 1862
Total Area		574,650 sq.m.
Total Covered Area		234,720 sq.m
Total No. of Machinery and Plants		2,016
Total Connected Load		10,000 KVA
Power Requirement		7,000 KVA
Power Generated Locally		3,500 KVA
Pneumatic Power Installed		250 Cu.m/Min
Water Supply	(Filtered)	73 lac litters/day
	(Unfiltered)	118 lac litters/day
Electricity		24 mil.KWH
Industrial Gas		588 thousand Cu.m
Petroleum Products		4.9 thousand Cu.m
Staff Strength		13,960
Annual Turn Over		41.30 crores



Total ground area 574,650m²

Total covered area 234,720m²

Fig. 5. 1. 1 LAYOUT OF JAMALPUR WORKSHOP

Table 5.1.2 Performance Record of Jamalpur Workshop

	1982	1983	1984	1985	1986
(i) POH of Diesel Locos	14	22	32	44	70
(ii) POH of Steam Locos	182	192	195	209	226
(iii) POH of Steam Cranes	22	31	35	29	30
(iv) Manufg. of Diesel Cranes (10 T & 20 T)	3	9	7	7	9
(v) Manufg. of Tower Cars	--	--	13	12	18
(vi) Manufg. of Jamalpur Jacks	68	67	82	92	50
(vii) Manufg. of C.I. Brake Blocks (Avg. Nos. per month)	57,232	60,437	52,078	47,831	62,092
(viii) Manufg. of Con. Rods (Steam)	36	35	44	63	95
(ix) Outturn of Steel Castings (Avg. M/T per month)	50	50	47	44	58
(x) Repairs of Box/CRT laminated springs (Avg. Nos. per month)	357	394	510	560	642
(xi) Repairs of Wheels (Avg. Nos. per month)	255	328	314	347	348

Proposed activities:

1. Manufacture of 140 tonne Diesel Hydraulic break-down cranes.
2. Manufacture of laminated bearing springs for Box/CRT wagons.
3. Manufacture of Box Wagon bogies of UIC design.
4. Modernisation of Permanent Way Foundry.
5. Setting up Diesel Traction motor Rewinding Shop.

The workshop has a Chemical & Metallurgical Laboratory with a laboratory chief and staff of 63 and is equipped with various types of testing and measuring equipment. The main activity of the laboratory covers a wide range such as:

1) Quality feature analysis and raw material analysis in relation to iron manufactured parts, springs, welding, etc. and studies on work management methods.

2) Non-destructive inspection by ultrasonic testing, magnetic particle testing, etc.
3) Investigating cause of faulty rolling stock parts.
4) Various kinds of tests on rolling stock parts.
5) Suggestions in relation to materials specification of domestic parts.
6) Others.

Although the laboratory has contributed to the technical progress of the workshop or the improvement in quality of the rolling stock up to present, in order to cope with the technological progress in future rolling stock, there is the necessity to further upgrade the functions of the laboratory by the introduction of better high-level measuring instruments and devices and by other means.

The Indian Railway Institute of Mechanical and Electrical Engineering (IRIMEE) has been established in the premise of the workshop for training of the technical staff. The Basic Training Centre (BTC) of the workshop executes skill training of the workshop personnel in cooperation with this institute.

5.1.2 Workshop Management

(1) Organisation of the Workshop

The organisation of the workshop is as shown in Fig. 5.1.2. The workshop is under the control of CWM supported by four deputy chief mechanical engineers (Dy. CME), one deputy chief electrical engineer (Dy. CEE) and one chemical & metallurgical laboratory chief who are in charge of the respective sectors of technology or production management.

Fig. 5.1.3 shows the shops which especially have a deep relation with the diesel locomotives. The work load of the diesel locomotive POH activity at the Jamalpur workshop will not only increase but also require high quality of work. Therefore, it will be necessary to upgrade the technical skills, improve the equipments and facilities and consolidate the organisation so as to efficiently cope with the transition to diesel locomotive POH activity hereafter, especially in regard to the related shops.

There is a total of 48 shops in the workshop and these shops are controlled by 14 Works Managers (WM) and Assistant WM (AWM) and others.

There are 1 to 3 Shop Superintendents (SS) as persons responsible for each shop, supported by Assistant SS (ASS). Table 5.1.3 shows the organisation of the shops and the number of personnel for each organisation.

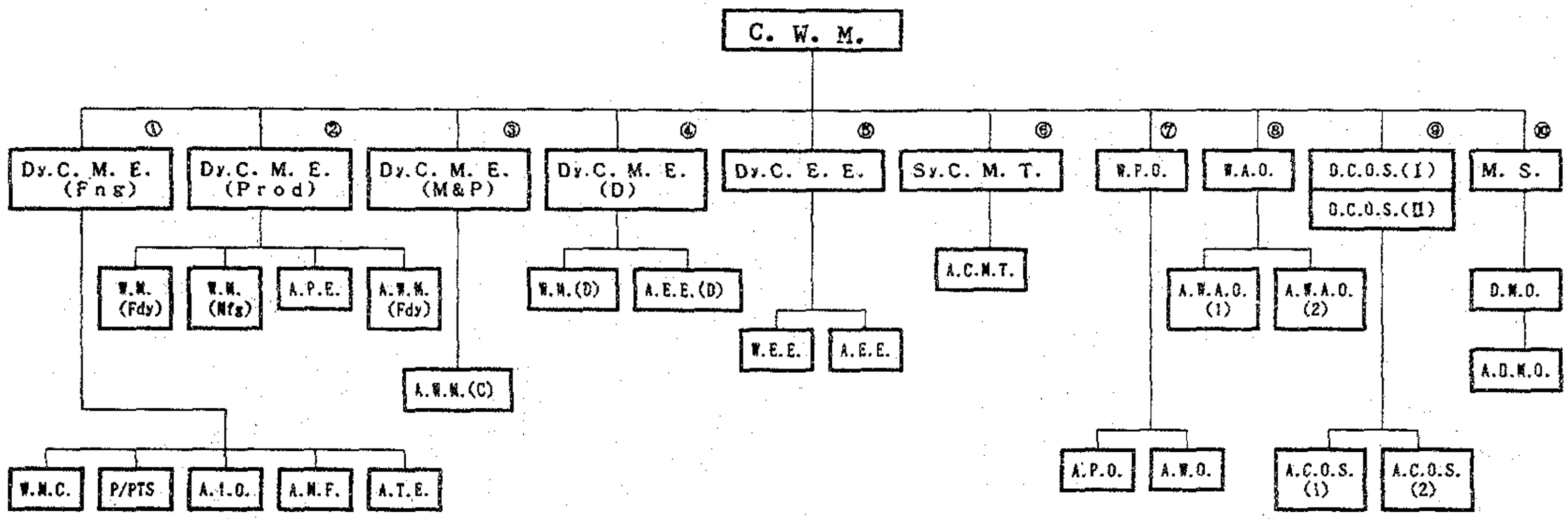
Besides these technical sectors, there are departments in charge of personnel, accounting, welfare and security.

Although the materials department is independent of the workshop organisation, in the case of the Jamalpur Workshop, there is a Stores Division in the workshop area and a Store House under its jurisdiction, and all the issuing and receiving of materials with the workshop are carried out via this Store House.

The strength of administrative staff is 1,990 in total and the ratio of the persons in the indirect departments is 19.5% out of the total number of personnel.

(2) Personnel

Out of the total number of approximately 14,000 workshop personnel, 12,000 persons belong to the shops (Refer to Table 5.1.3). The shop positions are divided into 10 categories and a system of promotion to an upper grade by examination is instituted. As to the skilled jobs, they are classified into about 20 categories according to the skill such as fitter, erector, welder, carpenter, etc. and these workers are classified into four grades according to the level of their skill as highly skilled (HSK) worker, skilled (SK) worker, semi-skilled (SSK) worker and unskilled (USK) worker. The base pay varies according to the grade, and in order to acquire the skill qualification of the upper rank, the worker must pass the examination. This kind of system has become a big driving force in upgrading the level of technical skill in the workshop. The Jamalpur district especially was a town of superior gun craftsmen in the past and the tradition remains even to this day, and together with the technical skill qualification examination system, the workshop has maintained a high level of technical skill.



C.W.M.	Chief Workshop Manager
Dy.C.M.E. (Fng)	Depty Chief Mechanical Engineer, Fitting
Dy.C.M.E. (Prod)	Depty Chief Mechanical Engineer, Production
Dy.C.M.E. (M & P) ...	Depty Chief Mechanical Engineer
Dy.C.M.E. (D)	Depty Chief Mechanical Engineer, Diesel
Dy.C.E.E.	Depty Chief Electrical Engineer
Sr. C.M.T.	Senior Chemist & Metallurgist
W.P.O.	All the Works concerning Personnel & Welfare of the staff
W.A.O.	Workshop Accounts Officer
D.C.O.S.	District Controller of Stores
M.S.	Medical Superintendent
W.M.C.	Works Manager (Crane)
P/PTS	Pranali Takniki School
A.I.O.	Assistant Inspecting Officer
A.M.F.	Assistant Manager Finishing
A.T.E.	Asstt. Manager Finishing
W.M. (Fdy)	Works Manager (Foundry)
W.M. (Mfg)	Works Manager (Manufacturing)
A.P.E.	Asstt. Production Engineer
A.W.M. (Fdy)	Asstt. Works Manager (Foundry)
A.W.M. (C)	Asstt. Works Manager (Crane)
W.M. (D)	Works Manager (Diesel)
A.E.E. (D)	Asstt. Electrical Engineer (Diesel)
W.E.E.	Workshop Electrical Engineer
A.E.E.	Asstt. Electrical Engineer (Diesel)
A.C.M.T.	Asstt. Chemist & Metallurgist
A.P.O.	Asstt. Personnel Officer
A.W.O.	Asstt. Welfare Officer
A.W.A.O.	Asstt. Workshop Accounts Officer
A.C.O.S.	Asstt. Controller of Stores
D.M.O.	Divisional Medical Officer
A.D.M.O.	Asstt. Divisional Medical Officer

Fig. 5.1.2 Organisation Chart of Jamalpur Workshop

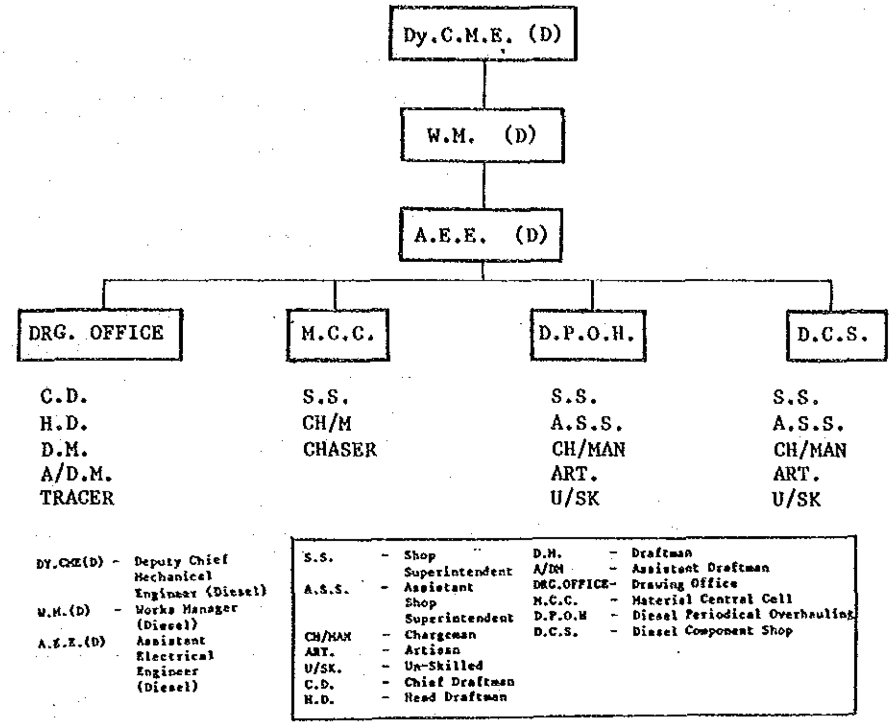


Fig. 5.1.3 Organisation Chart of Diesel Section

Table 5.1.3 Strength of staff in Jamalpur Workshop (Mar. 1987)

Administrative	Mechanical		940
	Personnel		319
	Accounts		42
	Electrical		204
	Stores		485
	Medical		
	Total		1,990
Shops	Supervisor	SS	84
		ASS	187
		CH/man A	186
		CH/man B	281
		Mistry	239
		Total	977
	Artisan	HSK-I	2,134
		HSK-II	2,439
		SK	3,558
		Khalasi helper (SSK)	1,378
		Khalasi (USK)	1,481
		Total	10,990
	Total		11,967
Grand Total			13,957

The recent trend in the number of retired personnel and new employment shows that there hardly is any person who retires before the retirement age of 58 years and the rate of labour turnover is small. This was also observed in the survey results made at the other workshops.

(3) Service

The form of service at this workshop is shown in Table 5.1.4. Since about 25% of the shop staff at this workshop is engaged in foundry and forge work, etc., they also work in the night shift.

Table 5.1.4 Form of Service

Items	Days/hours
Working days per year	295
Annual attendance day of workers	260
Working hours per week Office Shop	 36.5 44
Annual average working hours per worker	2,080

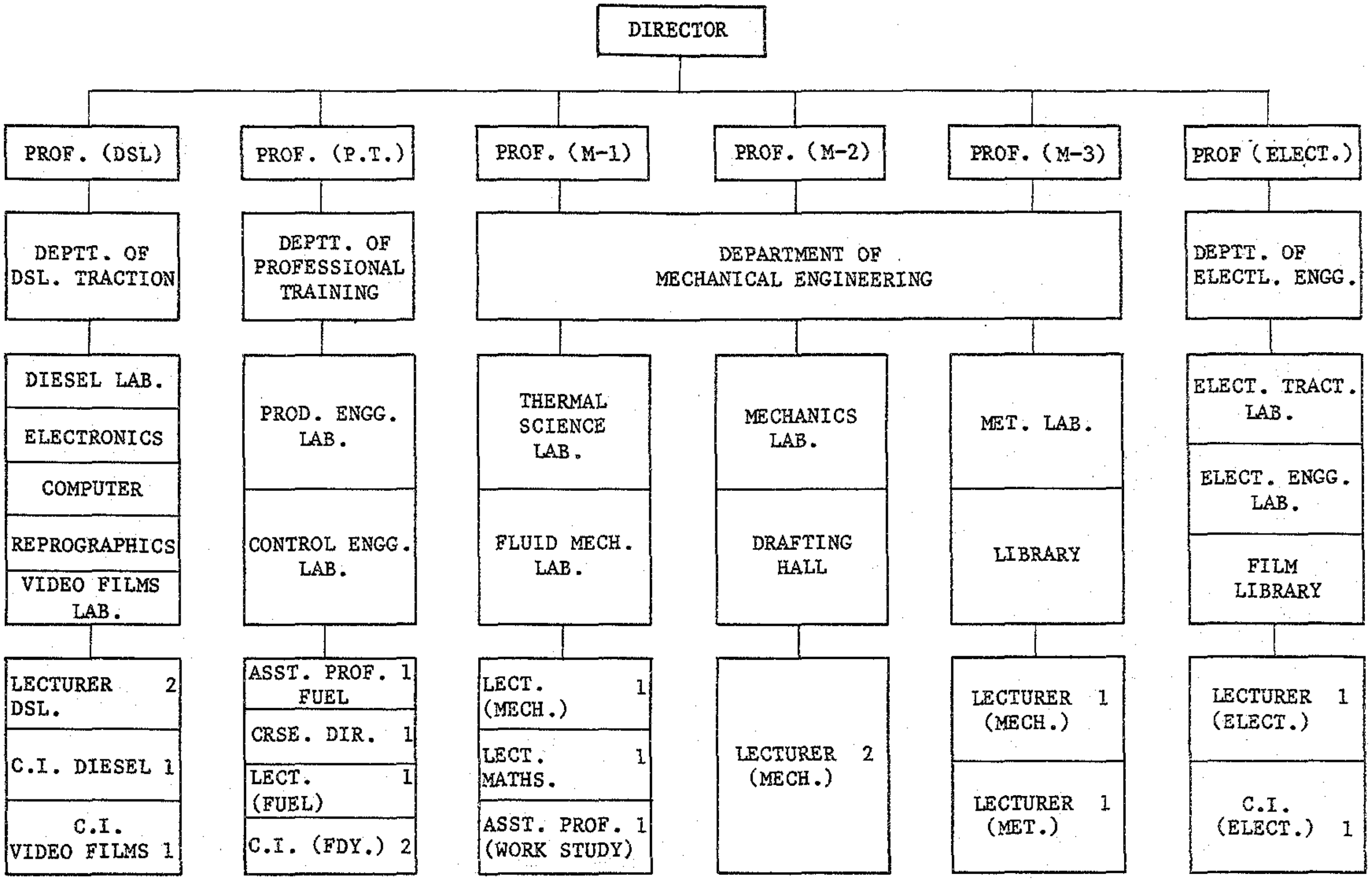
5.1.3 Training

(1) Present training institutions

1) IRIMEE

An outline of the organisation of IRIMEE is shown in Fig. 5.1.4 Six professors specialising in diesel traction technology, mechanical engineering, electrical engineering, etc. work under the supervision of the Director.

Key training statistics on IRIMEE are presented in Table 5.1.5. In 1986, a total of 776 employees of the Railways were trained at IRIMEE to upgrade the mechanical and electrical engineering abilities of officers and senior supervisors of the Railways.



CRSE = COURSE
PT = Practical Training

C.I. = Chief Instructor
MET = Metallurgy

Fig. 5.1.4 Organisational Set-up of IRIMEE

Table 5.1.5 Key Training Statistics

Staff		
No. of Teaching staff	20 Gazetted 4 Non-gazetted	
No. of non-teaching staff	96	
Training Courses and Trainee		
	1986	1985
1 Special Class Apprentices	75	84
2 Apprentice Mechanics	37	34
3 Diesel Orientation Course (Officers)	101	98
4 Diesel Conversion Course (Supervisors)	126	57
5 Foundry	68	50
6 Fuel	69	74
7 Electrical Supervisors	88	66
8 Workstudy	104	116
9 Shop Superintendent	108	68
Total	776	647

The special class apprentices recruited by UPSC (Union Public Service Commission) receive training for four years at IRIMEE where the trainees go through lecture-and-practice cycles, known as "sandwich method".

IRIMEE is equipped with diesel electric traction, diesel hydraulic traction, mechanics, electronics and microprocessor, fluid mechanics, production engineering, thermal science, electrical engineering and electric traction, metallurgical and other laboratories, a computer centre, a library, an auditorium with a capacity of 350, etc., all of which are contributing much toward maintenance of a high technical standard in the Railways' organisation.

2) Basic Training Centre (BTC)

The Eastern Railway operates a zonal training school, system training school and others to educate and train the zonal staff and upgrade their abilities. The Basic Training Centre (BTC) for the workshop staff is also operated within the workshop with the aim to raise the functional and technical levels of the workshop staff.

BTC, as shown in Fig. 5.1.5, is the part of the workshop organisation, and the principal of BTC is subject to supervision of Dy.C.M.E. (Finishing).

Major members of the BTC staff under the principal are 2 Training Incharge (T.I.) officers, 4 Chief Instructors (C.I.), 3 Senior Instructors (Sr. I.), 14 Junior Instructors (Jr. I.) and 1 Office Superintendent (O.S.).

BTC of the Jamalpur Workshop includes the System Technical School (STS) which offers promotional and refresher courses intended for driving personnel primarily. The principal of BTC holds the concurrent post of principal of the STS. The capacity and major training courses of BTC and the (STS) are shown in Table 5.1.6. Primarily short-term courses are conducted at the STS. BTC, on the other hand, conducts mainly long-term training courses. Like IRIMEE, it follows the lecture-and-practice-cycle principle.

Act apprentices receive the basic studies for 52 weeks and practice for a period variable in a range of 52 to 104 weeks according to the kind of job. The actual results of training for different categories in the basic training centre are presented in Table 5.1.7. The scale of training activities grew steadily through the years 1984, 1985 and 1986, and this is quite an encouraging trend.

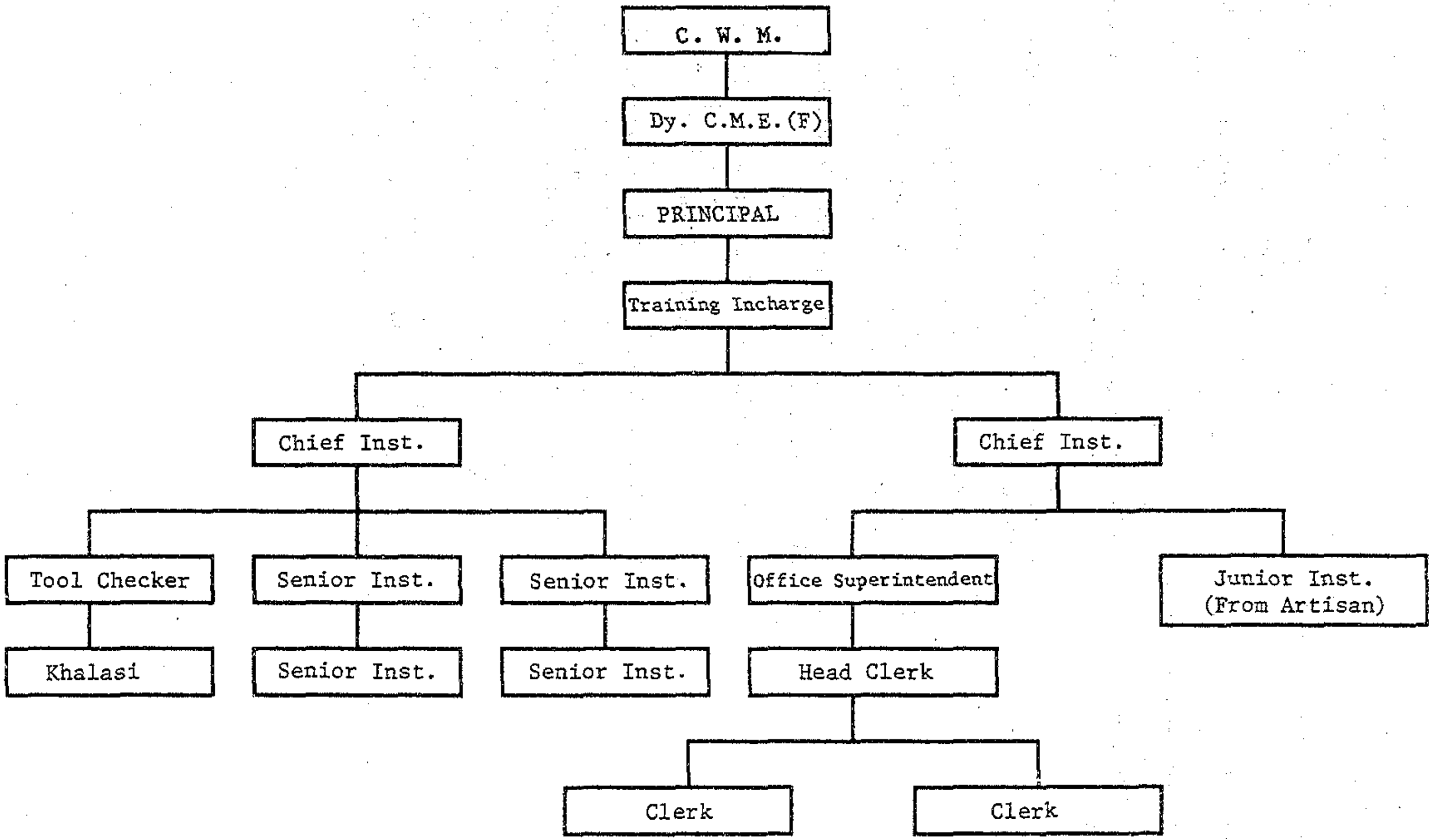


Fig. 5.1.5 Training Organisation at Jamalpur Workshop

Table 5.1.6 Capacity and Training Courses

Capacity		
Basic Training Centre	Practical	1,320
	Theoretical	90
System Technical School	Total trainees	236

Major Training Courses	
Basic Training Centre	1) Basic training and Shop training of Special Class Rly. Apprentices. 2) Basic Training and Shop Training of App. Mechanic (DH) 3) Shop Training of Intermediate App. Mech. 4) Basic Training, Shop training and Theoretical training of Act App. 5) Pre-promotional Training Course of Non. TT. Chargeman. 6) On job training of I.T.I. passed Trainees. 7) Crash course of SK. Machinist 8) Training of Government of India Trainees.
System Technical School	1) Promotional course for Fireman to Shunter (two courses in different dates) - 50 each 2) Promotional course for Shunter to Driver Cr. 'C' (two courses in different dates) -50 each 3) One week crash course Refresher for Driver Cr. 'C', 'B', 'A' and Special Grade -36

Table 5.1.7 Actual Results of Training for Different Categories in Basic Training Centre

Category of Trainees and Training Course	1984-85	1985-86	1986 to date	Duration of training
1. Special Class Rly. Appr.	83	70	69	104 weeks
2. Appr. Mech.(Diploma Holder)	21	27	29	80 weeks
3. Appr. Mech. Intermediate	11	12	12	65 weeks
4. Act Apprentices	130	265	266	2 to 3 yrs. depending on trade
5. Artisan trainee from shop	18	16	35	3 to 6 months
6. Pre-promotional course training for SC/ST supervisory	34	25	17	2 to 8 weeks
7. Shed staff (Training in specialised trades)	4	1	6	4 to 12 weeks
8. Govt. of India Trainees	3	8	7	1 year
9. Government sponsored from Engg.College/University	10	16	15	2 to 6 weeks
10. Inplant trainees (for sons) wards of Rly. employees	3	8	8	6 months
11. I.T.I. Apprec.	104	150	182	6 months
Total	421	598	646	

However, a total of approximately 650 individuals are trained annually, and the majority of these individuals are long-term apprentices. As more diesel and electric locomotives, in place of steam locomotives, will be brought to workshops for inspection/repair, it is as important as workshop modernisation to shift the main weight from steam locomotives to diesel and electric locomotives in the curriculum. In view of this, it is essential to introduce new subjects and new courses.

3) Training aids

The machines installed, though quantitatively insufficient relative to the number of trainees, are essentially good enough on the whole. Many machine tools and other training-aid items are well maintained, befitting a workshop specialising in locomotive inspection and repair, but they are generally overaged and outdated for training in operation and maintenance of the new equipment necessary for workshop modernisation in line with dieselisation.

Thus it is essential to introduce equipment helpful toward full mastery of new technology.

4) Training at outside institutions

The Jamalpur Workshop sends the Railways' employees to outside training institutions to upgrade their technical abilities. Details of training received by the instructors/apprentices outside during 1986-87 are given in Table 5.1.8.

5) Training in foreign countries

The Railways sends its officers and senior supervisors to factories and to firms abroad to introduce new technology and administration system through them. The staff of Jamalpur Workshop dispatched for foreign training is shown in Table 5.1.9.

Table 5.1.8 Details of Training Received by the Instructors/ Apprentices Outside during 1986-87

Name of the Organisation & Location	Course & Duration of Trg.	Category & Nos.
1) Advanced Trg. Institute Calcutta/ Dasnagar Howrah-5	-Instructors' (W/Shop) Course - 3 Months.	-Two Junior Instructors (w.e.f. 1-5-86 to 31-7-86)
2) Advanced Trg. Institute Calcutta/ Dasnagar Howrah-5	-Modern Technology & Advanced Pedagogy 2.5 Months.	-One Chief Instructor and One Junior Instructor (w.e.f. 13-10-86 to 2-1-87)
3) Central Staff Trg. & Research Institute, Calcutta, Dasnagar Howrah-5	-Training on Electronics 3 Weeks.	-Ten Apprentice Mechanic (Diploma Holder) (w.e.f.12-1-87 to 30-1-87)
4) Zonal Trg. School, E.Rly, Dhuli/Dhanbad	-Instructors Course on Development of Training & Instructional Skills.	-Two Jr. Instructors (w.e.f.2-3-87 to 6-3-87)

Table 5.1.9 Staff on Deputation on Foreign Training

Designation	Place of working	Deputation on Foreign Training	Period of training From.	To.
Prof.(Elec.)	IRIMEE	U.K. under Columbo Plan	For 12 weeks in Oct., 1984	
Prof. (PT:)	IRIMEE	U.K. under Columbo Plan	26.9.83	16.12.83
Dy. CME (F)	CWM	West Germany	1986 for 15 days w.e.f. 2-12-86	
A.S.S.	CWM	West Germany for 12 weeks training under 140-tonne Crane -M/s. Gottwald.	1986-for 75 days w.e.f. 2.4.86	

5.1.4 Facilities

(1) Rolling Stock Inspection and Repair Facilities

The rolling stock inspection and repair facilities in Jamalpur Workshop are concentrated in two buildings: one of which has five shops bays in it and the other has one shop for boiler repair. (Fig. 5.1.13.).

The present state of the rolling stock inspection and repair facilities is as shown below.

1) Shop layout

General layout of the shops in the buildings is shown in Fig. 5.1.13. This building consists of erecting shop bay, fitting shop bay, wheel shop bay, diesel shop bay (high), and diesel shop bay (low). First two bays are exclusively used for repair of steam locomotives. Also, most of the wheel shop bay is used for repairing wheels of steam locomotives, and only 15% of the total floor area is allocated to the diesel locomotive repair. Furthermore, three spans of the southern extremity of the diesel shop bay (high) are used for repairing the tender of the steam locomotive, and the rest of the floor is allocated to the area of carbody lifting and lowering, chassis repair, bogie repair, diesel engine repair, traction motor/generator repair, and other equipment repair. In the diesel shop bay (low), there are traction motor repair area, repair area for engine and transmission of the shunting diesel locomotive, repair area for expressor and turbo blower, and engine parts repair area. As clearly seen from the above, relatively small space is allocated to diesel locomotive repair because of requirements for the repairing work of steam locomotive. The present space is not sufficient for introducing new equipment and for improvement of shop facilities to cater for the work volume increasing with the number of diesel locomotives.

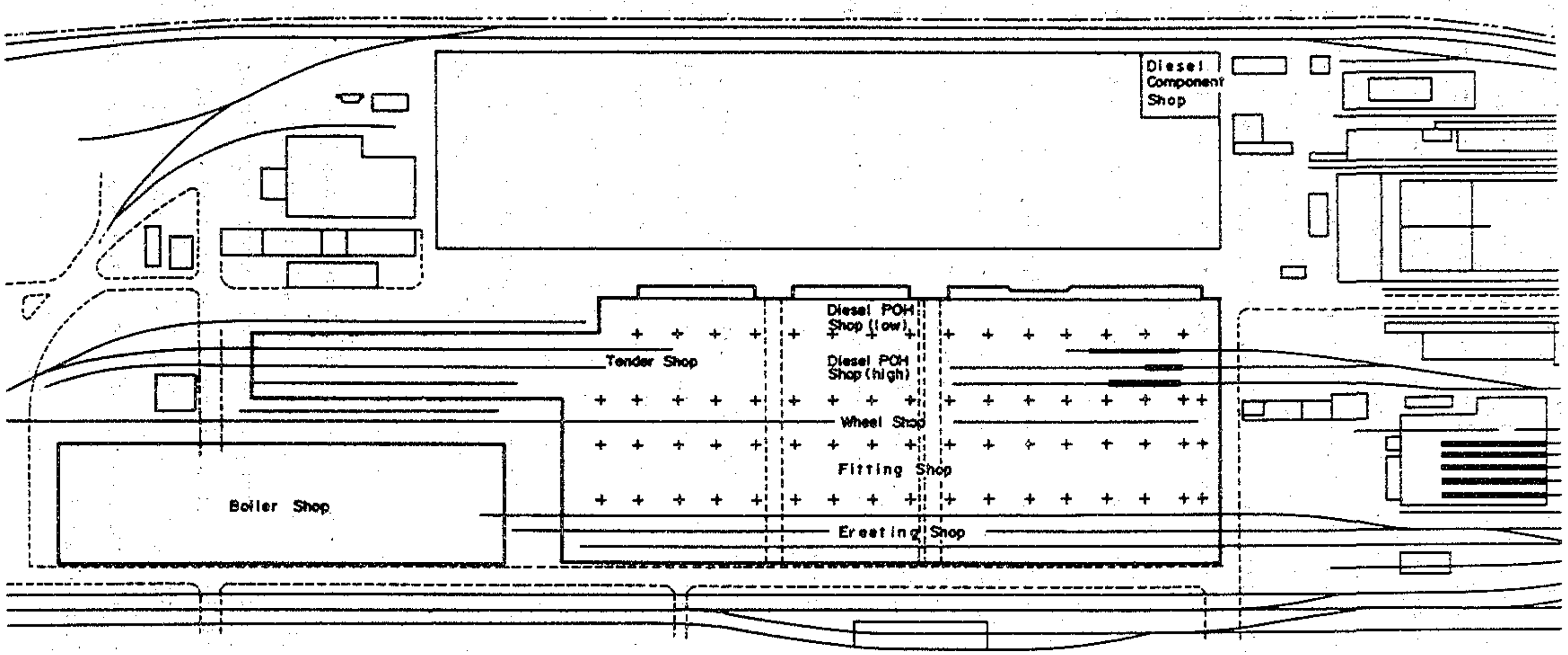


Fig. 5.1.13 Existing Locomotive Repair Shop

As a considerable amount of room in the floor space will be created in the erecting shop, fitting shop and the wheel shop in the future along with the decrease in number of POH of steam locomotive, it is considered that the coversion and transfer of shops can be carried out fairly easily, though some trouble is foreseen. However, it should be noted that the fitting shop bay is partitioned lengthwise into three bays by roof-supporting columns and will not be able to accommodate EOT crane. Thus, this part of the building will be remodelled to be used for repair work of diesel locomotive as described in a later section.

2) Machinery and other facilities for rolling stock inspection and repair

As for the four shop bays except fitting shop, the EOT cranes are provided in these shop bays and their capacities and quantities appear to be enough for POH works for the diesel locomotive and electric locomotive. The present state of existing machinery and other facilities for rolling stock inspection and repair is as described below.

a) Machines for repair of steam locomotive parts

While most of these machines will not be usable after the workshop terminated POH service for the steam locomotive, the machines for processing connecting rod of diesel shunting locomotive will be retained for future work. However, these machines are so deteriorated that it will be necessary to replace them with new ones with higher accuracy.

b) Parts washing facilities

Among the cleaning facilities and equipment being used at present, only the caustic soda bath to wash the bogie frame appears to be acceptable. At other facilities of water washing of radiator, oil washing of small parts, and washing of engine block, all works are being done by using brush and cloth. As a result, the working conditions are very poor and the parts are not cleaned well.

As the complete washing and cleaning of disassembled parts is the basis for improving the quality of repair works, specialised cleaning machines for respective washing work will be needed to clean the high-precision parts of the diesel and diesel electric locomotive which must be kept free from dirt and dust.

c) Repairing machines for electric rotating machine and engine
At present, only six kinds of machine are installed for the repair of electric rotating machine and engine.
  Armature commutator groove cutting machine
  Electric drying oven
  Water rheostat output testing stand
  Engine governor testing stand
  Injection nozzle tester
  Engine air inlet/exhaust valve grinder
There are no machines to test the traction motor, engine and other major machines before mounting them on the locomotive and it is the most serious problem in the efficiency of the repair work, lowering the quality of repair and lengthening the POH cycle time. In addition, machines for heavy repairing of the traction motor are not provided, and installation of these machines in future are now being planned in the Indian Railways.

d) Wheel set repair machines
Most of the wheel set repair machine installed in the workshop is for the repair of steam locomotive. However, judging from their type and performance, those used for servicing of the diesel locomotive can continue to be used for the future POH service for the diesel locomotive and electric locomotives, except for some machines which are deteriorated. However, the repair machines for roller bearing of the diesel locomotive are not satisfactory and much improvement will be necessary.

(2) Building and Other Facilities

The existing buildings and other facilities of Jamalpur Workshop are maintained in considerable good condition and these facilities will cater sufficiently for the future work volume.

The existing state of the facilities are described as below based on the site survey.

1) Workshop premises

As the building coverage of this workshop is very high and the distance between buildings is narrow, width of road inside the yard is considerably narrow. However, these roads are maintained in good condition and side ditches of road are also furnished completely. Accordingly, the measure for rainy season is sufficient. On the contrary, the maintenance of track is not so good, but it is appreciable that improvement of track is now progressing.

2) Buildings

Almost all of the buildings are steel framed and have brick wall structure. The maintenance of the buildings is good, but the roof should be repaired for the rainy season because some roofs have badly maintained protions. The floors in shops are maintained in relatively good condition.

The lighting of buildings is considerably good. Many incompletely ventilated shops are found, especially in the electric parts repair shop, exhausting facilities for poisonous gas generated from battery charging and acid washing are inadequate.

3) Water supply facilities

The drinking water and industrial water for the workshop and the colony are conducted from the Ganges river and are stored in the two reservoirs adjacent to the workshop premises. And the industrial water is supplied from the two reservoirs directly and the drinking water is supplied through the filtration plant located on the hill neighbouring the workshop.

The amount of water supplied per day are as follows:

Drinking water 7,300 m^3/day

Industrial water 11,800 m^3/day

As mentioned above, the water supply facilities are no problem as regards the performance and supply capacity in future.

4) Power supply facilities

The power consumed in the workshop are now all supplied from the mother substation owned by the State Electricity Board. However, a plant to receive the power from the transmission line network owned by the National Grid is now being advanced. Consequently, power supply of good quality can be expected and the amount of power supply suitable for future demands in the workshop will be secured.

But almost all of the electric equipment inside the workshop are very old (more than thirty years). It will be desirable to replace them one by one with new equipment.

The independent power plant is installed in the workshop, but this plant is very old and moreover the efficiency of power generation is low, and the unit power rate is three times that of the National Grid.

From the above reason, the independent power plant will only be used for emergency.

Some numbers of substation having 3.3 kV power distribution now remain in the workshop due to the relation with the existing independent power plant, but all the power distribution voltage will have to be unified to 11 kV.

5.2 Modernisation Plan for Rolling Stock Inspection/Repair

5.2.1 Present Rolling Stock Inspection/Repair System and Problems

At present, Jamalpur Workshop inspects and repairs approximately 200 steam locomotives and 50 to 60 diesel locomotives annually. IR plans to decrease the number of steam locomotives to be repaired and the workshop will be dedicated to servicing diesel locomotive in 1995.

At the same time, WDM2 type diesel locomotives operated on the main line are becoming the major work force.

Thus, the present state, problems, and schedule control practice of the rolling stock repair process will be discussed with emphasis on WDM2 type diesel locomotives.

(1) Characteristics of diesel locomotive repair work at Jamalpur Workshop

It is rather recently that the workshop has undertaken diesel locomotive inspection and repair; particularly, those for the main line started in 1982. Hence deficiency is seen in its organisation, manpower skills, equipment, and other aspects in coping with the diesel transformation.

As a result, diesel locomotives at the workshop are inspected and repaired in a manner similar to steam locomotives. While the diesel locomotive is made up as an assembly of engine, generator, traction motor, bogie and other components, the steam locomotive is made up of parts which are mostly custom-made to fit each body type, instead of complete and compatible parts. Thus, the repairing of the steam locomotive needs to be done in accordance with the schedule for each body. On the other hand, the repair schedule for diesel locomotives can be established separately for the parts and body. Moreover, most parts for the diesel locomotive can be fitted to any other diesel locomotive of the same type. As a result, the body repairing schedule for the diesel locomotive can be considerably reduced by keeping a sufficient number of unit exchange spare parts, if they require a relatively long time to repair.

However, the workshop does not fully take advantage of the unit exchange repair system. Secondly, the diesel locomotive uses the engine and other precision parts which have to be cleaned during the inspection and repair. At present, due to limited experience in servicing diesel locomotives and the relatively small number of units being inspected, the parts are cleaned manually, increasing the total repair time. The present conditions and problems of each task are discussed based on network analysis.

(2) Present state and problems of repair schedule at Jamalpur Workshop

The inspection and repair network flow for WDM2 type diesel locomotives is shown in Fig. 5.2.1, and a summary of analysis in Table 5.2.1. Layout around the diesel POH shop is shown in Fig. 5.2.2. As can be seen from this figure, most of the repair work is done in the same building. At present, the periodical overhaul (POH) of a WDM2 type locomotive takes about 25 working days (31 calendar days), 2.5 to 3 times the POH cycle time in Japan. Although direct comparison is difficult because of the differences in the structure of diesel locomotives operated in the two countries, various points needing improvement are found.

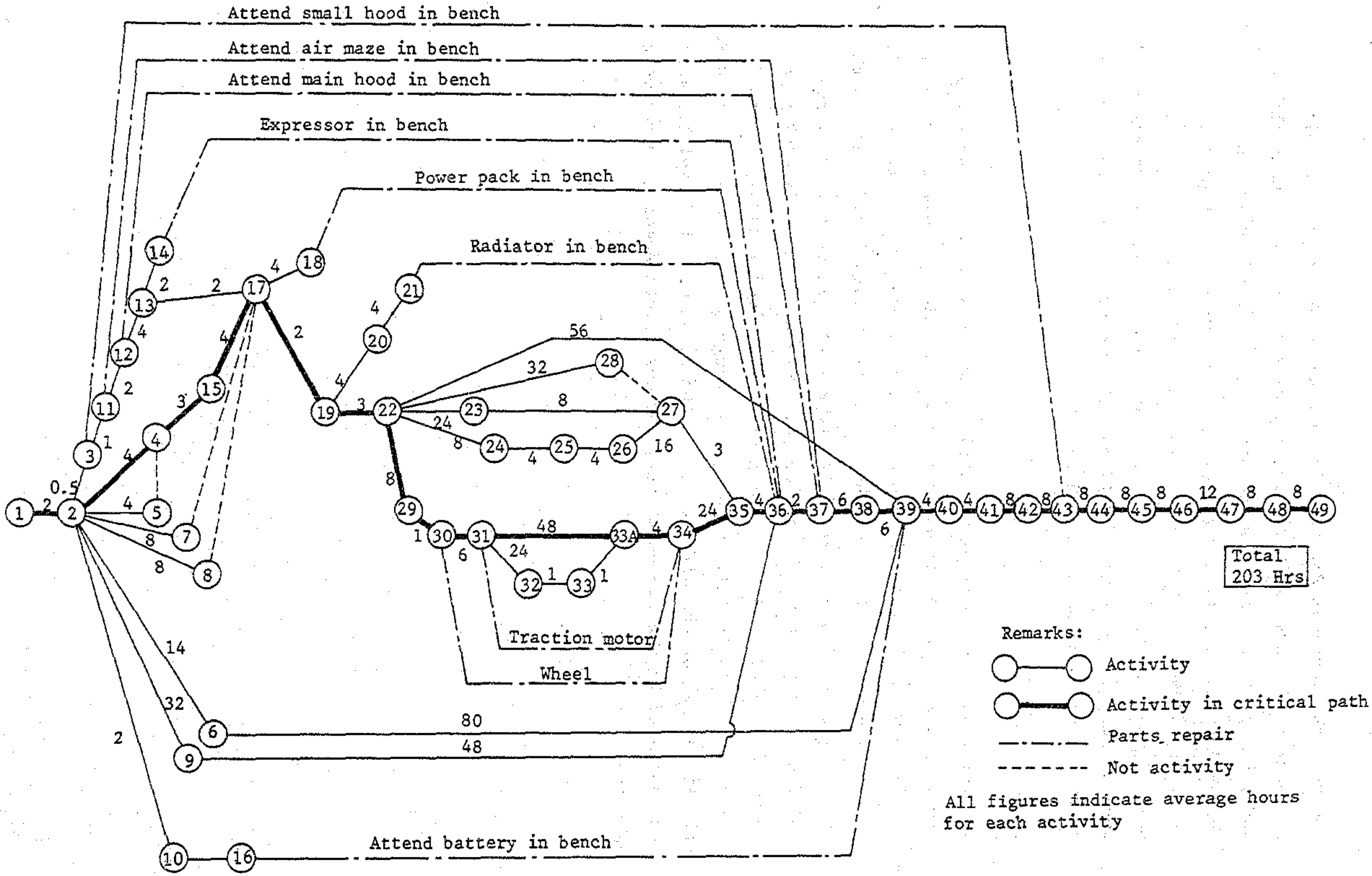


Fig. 5.2.1 Network Flow for Periodical Overhaul (WDM2) PRESENT

Table 5.2.1 Diesel Locomotive Process Analyses Chart (1/6)

Activity No.	Work content & working hour			Car body work	Work place	Remarks
	Work contents	Working hour	Float hour			
1 - 2	In-coming inspection	* 2	0	○	In-coming pit	Platform and trolley not equipped
2 - 3	Removal of small hood	0.5	(1) 1.5	○	"	"
2 - 4	Removing pipe (I), EXP pipe, and piping system in the hood	* 4	0	○	"	"
2 - 5	Draining lubricant, fuel oil, cooling water	4	-	○	"	
2 - 6	Disconnecting electrical parts	14	(2) 25	○	"	
2 - 7	Disconnecting traction motor and booster	8	-	○	"	
2 - 8	Removing bogie center pins, buffers, and buffer components	8	-	○	"	
2 - 9	Removing and cleaning brake parts	32	(3) 29	D	" , Brake shop	Washing device not equipped
2 - 10	Removing battery (I)	2	-	○	"	
3 - 11	Removing filter in the suction pipe	1	(1)	○	"	

Table 5.2.1 (2/6)

Activity No.	Work content & working hour			Car body work	Work place	Remarks
	Work contents	Working hour	Float hour			
3 - 43	Inspecting repairing small hood	8	(4) 136.5		Body repair shop	
6 - 39	Inspecting repairing electrical parts	80	(2)		Electrical parts repair shop	Testing device not equipped
11 - 12	Removing main hood	2	(1)	○	In-coming pit	Handling facilities not equipped
12 - 13	Disconnecting EXP and power pack	4	(1)	○	"	
13 - 14	Removing EXP	2	-	○	"	
9 - 36	Inspecting/repairing/testing brake parts	48	(3)		Brake shop	Testing device not equipped
12 - 37	Inspecting/repairing/painting main hood	48	(5) 57.5		Body shop	Manual painting
4 - 15	Removing pipes (II) - lubricant, fuel oil, and cooling water pipes	* 3	0	○	In-coming pit	Handling facilities not equipped
15 - 17	Removing pipes (III) cooler and radiator fan	* 4	0	○	"	"
13 - 17	Removing power pack	2	(1)	○	"	
17 - 18	Removing generator, dispatching to the shop	4	-		Engine shop	

Table 5.2.1 (3/6)

Activity No.	Work content & working hour			Car body work	Work place	Remarks
	Work contents	Working hour	Float hour			
17 - 19	Removing bogie	* 2	0	○	In-coming pit	
19 - 20	Removing filter and fan in radiator room	4	(6) 38	○	"	
20 - 21	Removing radiator	4	(6)	○	"	
19 - 22	Conveying body to washing shop	* 3	0	○	"	
22 - 23	Washing body	24	(7) 52	○	Body washing place	Body washing device not equipped
22 - 24	Disconnecting wiring on the body	8	55 (8)	○	Body repair shop	
24 - 25	Maintaining tank	4	(8)	○	"	
25 - 26	Painting body and tank (manual)	4	(8)	○	"	
26 - 27	Rewiring body (main circuit)	16	(8)	○	"	Wiring preparation shop not equipped
22 - 39	Replacing control circuit wiring	56	47 (9)	○	"	"
22 - 28	Cleaning and maintaining fuel tank	32	52 (10)	○	"	

Table 5.2.1 (4/6)

Activity No.	Work content & working hour			Car body work	Work place	Remarks
	Work contents	Working hour	Float hour			
22 - 29	Removing wheels, axles, and traction motor from the bogie	* 8	0		In-coming pit	
29 - 30	Dispatching wheels	* 1	0		"	
30 - 31	Dispatching traction motor	* 6	0		"	
31 - 32	Stripping and washing (soaking) bogie	24	(11) 18		Body repair shop	Bogie washing device not equipped
31 - 33A	Inspecting and repairing bogie frame	* 48	0		"	Many cracks occur
33A-34	Assembling brake CCY	* 4	0		"	
32 - 33	Ultrasonic testing of bogie (parts)	1	(11)		"	
33 - 33A	Identifying defects and damage	1	(11)		"	
34 - 35	Assembling (including wheels, axles, and traction motor)	* 24	0		Out-going pit	Load tester not equipped
23 - 27	Painting each section (body)	8	(7)	○	Body repair shop	Manual painting
27 - 35	Shifting body to assembly line.	3	(7)	○	"	

Table 5.2.1 (5/6)

Activity No.	Work content & working hour			Car body work	Work place	Remarks
	Work contents	Working hour	Float hour			
49 - 36	Installing power pack on body	2	-	○	Out-going pit	
35 - 36	Lowering	* 4	0	○	"	
36 - 37	Installing EXP	* 2	0	○	"	
37 - 38	Adjusting coupling for EXP and power pack	* 6	0	○	"	No platform
38 - 39	Installing main hood	* 6	0	○	"	"
39 - 40	Connecting cooling water pipe and water supply	* 4	0	○	"	Water filler not equipped
40 - 41	Injecting lubricant, and oiling	* 4	0	○	"	Oil filler not equipped
41 - 42	Cranking power pack	* 8	0	○	"	Power pack test is carried out after loading on car body (41 - 42 to 44 - 45)
42 - 43	Break-in of power pack	* 8	0	○	"	
43 - 44	Load test (grid resistance)	* 8	0	○	"	
44 - 45	Adjustment, maintenance	* 8	0	○	"	
45 - 46	Load test (water resistance) Final check shop	* 8	0	○	(Final check shop)	

Table 5.2.1 (6/6)

Activity No.	Work content & working hour			Car body work	Work place	Remarks
	Work contents	Working hour	Float hour			
46 - 47	Test running on the main line	* 12	0	○	(Main line)	
47 - 48	Adjustment and maintenance	* 8	0	○	Out-going pit	
48 - 49	Touch-up, final adjustment, and dispatch	* 8	0	○	"	
						(Other) . No spare engine available (no assembly). . Engine washing equipment not available. . Traction motor and generator inspection/repair equipment not available, obstructing the schedule.
	Total critical path time	203 Hrs (25.4 days)				

Note: The critical path is shown by asterisks (*). Group calculating float time (float: allowance time) is indicated by ( ).

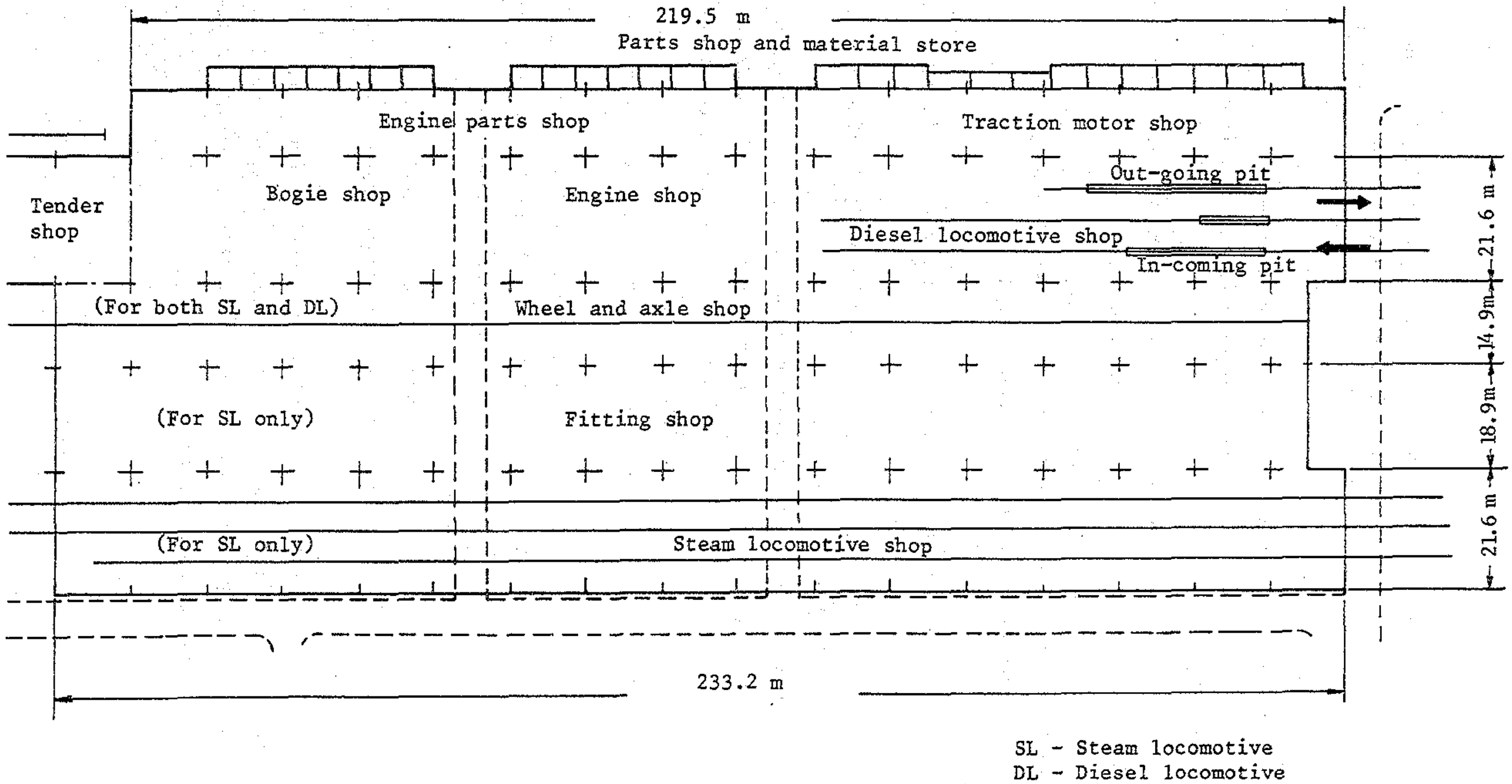


Fig. 5.2.2 General Layout around Diesel POH Shop

Furthermore, these schedules are delayed 1 to 3 days for approximately one third of the rolling stock handled at the workshop.

Major Causes of Delay

① Lack of repair materials (mainly imported ones)
② Movement in in-coming/out-going tracks hampered by the lack of tracks
③ Lack of spare parts (bogie, engine, traction motor, and converter)
④ Mica cutting for traction motor and generator
⑤ Lack of testing equipment
⑥ Heavy repair of bogie frame (cracks and others)
⑦ Failure of EOT crane and other equipment

To maintain and shorten the cycle time, priority should be given to improving these points:

The network flow (Fig. 5.2.1) and schedule analysis (Table 5.2.1) bring out the following points:

1) The critical path of the present work schedule is; stripping - lifting - repair of bogie - lowering - assembling - load test.
2) Particularly critical is the series of body work after assembling (Activity Nos. 35 - 36 and thereafter).
3) Moreover, most of these body work is performed on the out-going pit line.
4) As a result, in-coming/out-going pits located at the doorway of the workshop are occupied for long hours. In particular, all body- related work which constitutes the critical path is done on the in-coming/out-going pits.
5) Work related to electrical parts (control parts), brake parts, main hood, control wiring replacement, and bogie frame repair take too many hours.
6) Washing brake parts, body, and bogie takes too many hours.
7) Works related to the power pack and traction motor sometimes become the critical path due to the many activities involved and lack of unit exchange spare parts.

From the facility layout (Fig. 5.1.8) the following is pointed out:

8) Since the in-coming/out-going sections have pit structures where various work is carried out, spacing between the tracks is too narrow. As a result, if the main hood and wheels are temporarily placed in the space, there will be little space available for placing the body.

9) The engine parts shop is adjacent to the bogie shop which is apt to produce dust and this is detrimental to the precision parts.

10) The body and engine shop are side-by-side, so there is little service path available between them.

11) Small parts shops are partitioned into small rooms, resulting in ineffective use of space.

12) The wheel shop is long and narrow, requiring a crane to move wheels which are essentially easy to move by their own rotation.

Further explanations are provided for some of these points. 2) and 3): This is mainly attributable to test and adjustment of the power pack. Because no test equipment is available, the power pack is tested after being installed on the body, requiring about four days.

4): Since the present pit line is also used as an out-going pit for the tender unit of steam locomotives, there are frequent waits for completion of the DL work. Also, platform, transport equipment with lifters, and other related equipment are not available. Furthermore, the pit line is used to assemble the bogie, wheels, and traction motor, which should be done in other areas as much as possible.

5): Most most of the test equipment is manufactured at the workshop and spare parts are not enough, resulting in long hours of waiting.

6): Washing takes many hours because it is done manually, and besides, soaking in chemical tank also takes many hours.

(3) Situation and problems of stores control and conveyance

The workshop has a stores depot which is a department independent of the workshop organisation, managing approximately 20,000 items used at the workshop.

Although these materials are classified according to importance and value, it requires a relatively long time to procure them because of this separate organisational setup. In particular, procurement of imported items and custom-made items takes as long as two years. Thus, more appropriate inventory control and procurement management methods need to be developed.

Some fundamental improvements are required in this area because it is the most serious factor delaying the whole process. Sufficient provision of unit exchange spare parts is also considered to be very important in shortening the cycle time.

As shown in the present list of spare parts in Table 5.2.2, the workshop does not have spares of complete engine units, which poses a problem in maintaining the desired schedule. Provision of these parts is thus thought to be essential in ensuring efficient work when the work load increases in the future.

Table 5.2.2 Major Spare Parts Maintained at Jamalpur Workshop (Present)

Item	Quantity	Remarks
Engine block	2	Should be stored as a complete unit.
Engine crank shaft	1	
Fuel injection pump	32	
Cylinder head	16	
Supercharger	1	
Expressor	1	
Traction generator	1	
Bogie	2	
Wheel set	One set	
Traction motor	Two sets	
Other electrical parts	-	Many of them are not available.

Moreover, Jamalpur Workshop has to inevitably depend on wagons for most of its internal transportation of raw materials and coke, partly because brake blocks and other castings are produced in the workshop. For this reason, a lot of wagons are left in the workshop, which hampers the movement of locomotives to be inspected and repaired. Therefore, the number of these wagons must be decreased by making handling work more efficient. Also, utilising such convenient cargo gears as forklifts, which are not used very much, has to be considered.