5.4 Modernisation of Brake Block Casting Facilities

5.4.1 Existing State and Problems of Brake Block Casting Works and Facilities

Jamalpur Workshop manufactures brake blocks for wagons (W/BGI-900, WA/BG-6158), coaches (BW-94, EMU-043) and locomotives (TB-1103, WDS-4, BG-2894). Brake block for wagons are made by metal mold casting, and those for locomotive and coach are made by sand mold casting except some kinds of product. The annual production amount is as shown in Table 5.4.1. In 1985, approximately 8,200 tons were produced. In addition to brake block, approximately 1,000 tons of cast iron sleepers were produced annually.

Table 5.4.1 Production of Brake Block

(Unit: metric tonne)

Item	Year	1981	1982	1983	1984	1985
Wagon	W/900					889.2
	BG/6158					2594.1
	Sub-total	4807.2	5577.3	5761.0	4333.3	3483.3
Coach	BW/94					2963.6
	EMU/043					660.4
	Sub-total	2057.3	2268.1	2200.4	2336.7	3624.0
Loco	BW/2894					309.5
	WDS-4					217.2
	TB/1103					531.5
	Sub-total	738.2	852.3	1260.2	1173.3	1058.2
Grand Total		7620.7	8697.7	9221.6	7843.3	8165.5

The machine layout is shown in Fig. 5.4.1, and the block diagrams for work flow are shown in Figs. 5.4.2 and 5.4.3. The assignment of workers is shown in Table 5.4.2. The present production ratio of metal mold casting to sand mold casting is 79 to 21 and ratio of workers assigned to these works is 78 to 22.

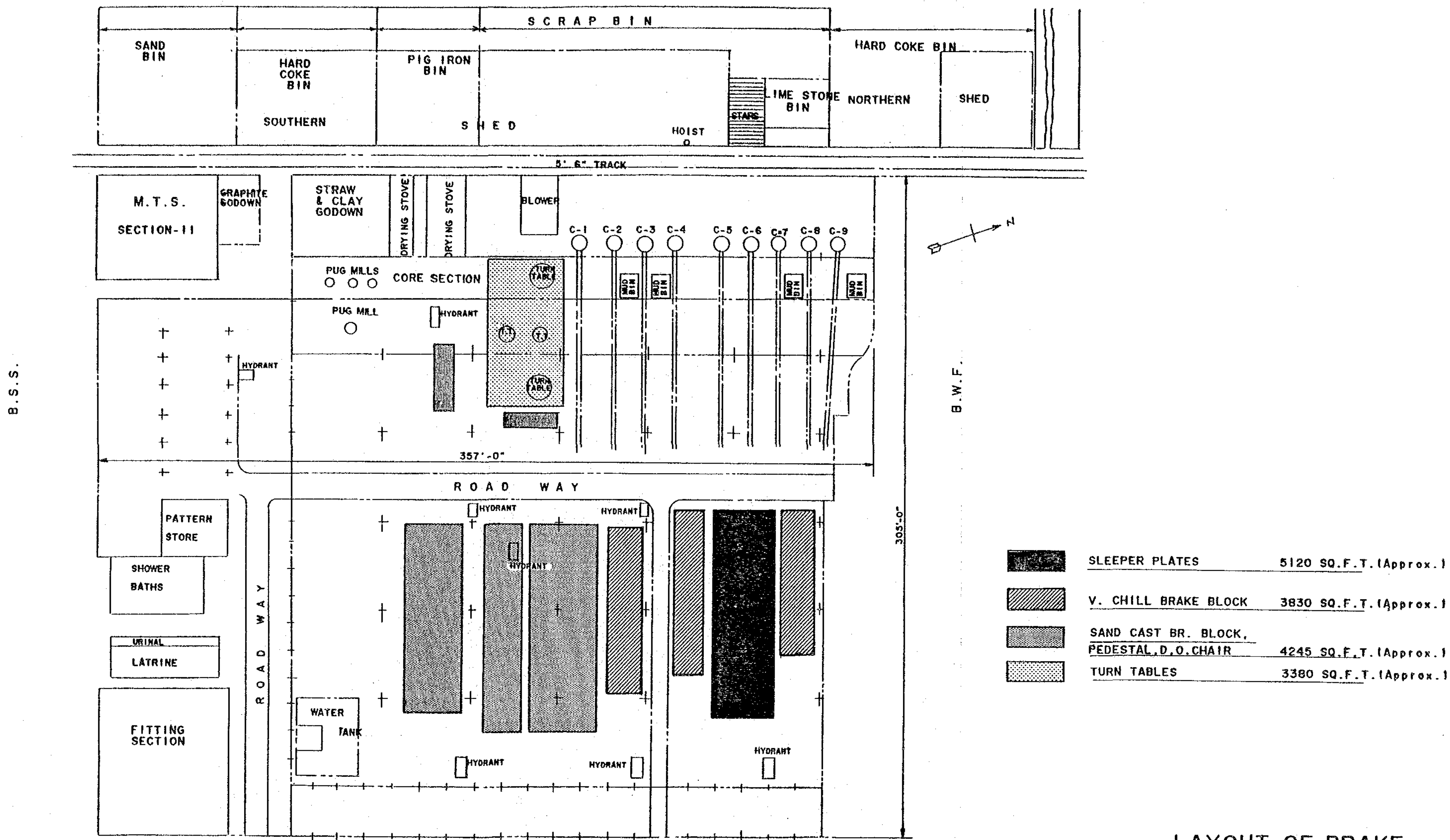


Fig. 5.4.1. LAYOUT OF BRAKE BLOCK & SLEEPER FOUNDRY (EXISTENT)

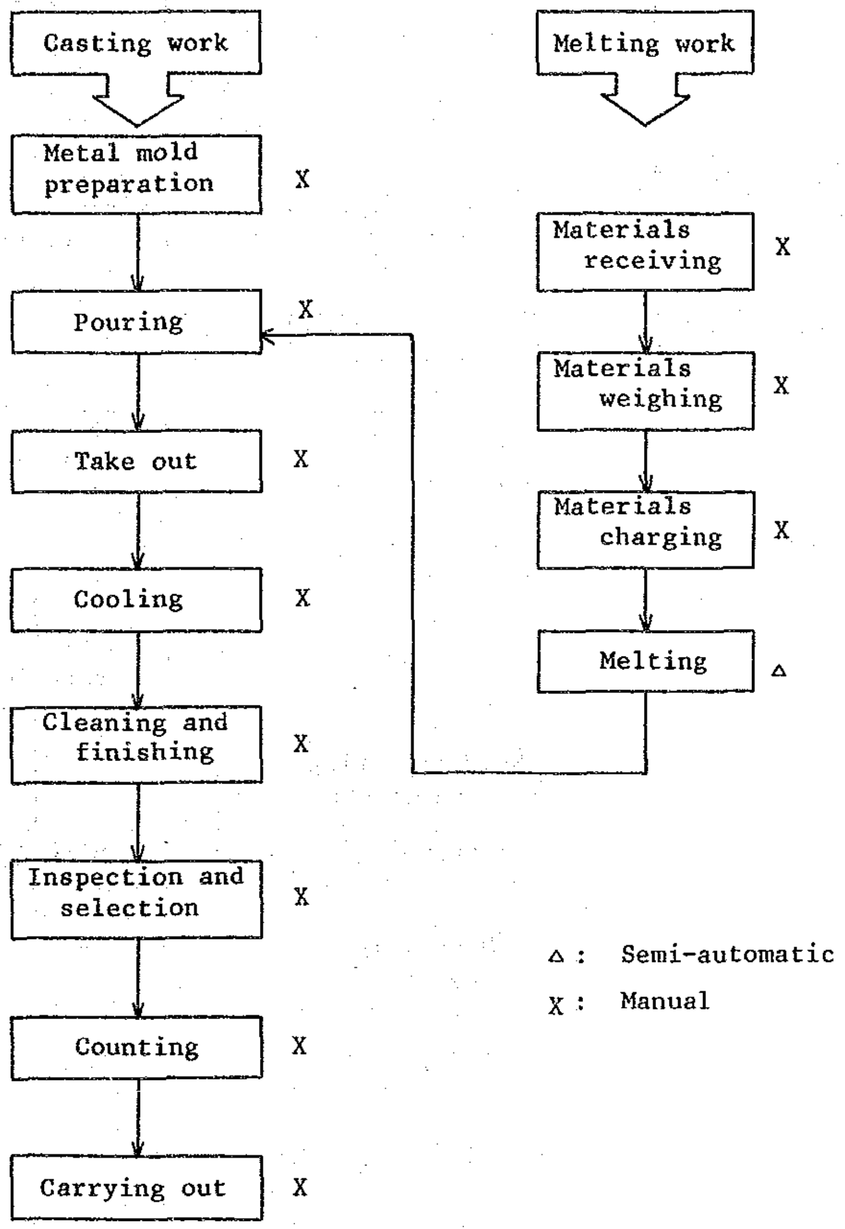


Fig. 5.4.2 Flow Chart of Brake Block by Metal Mold Casting Operation (Existing)

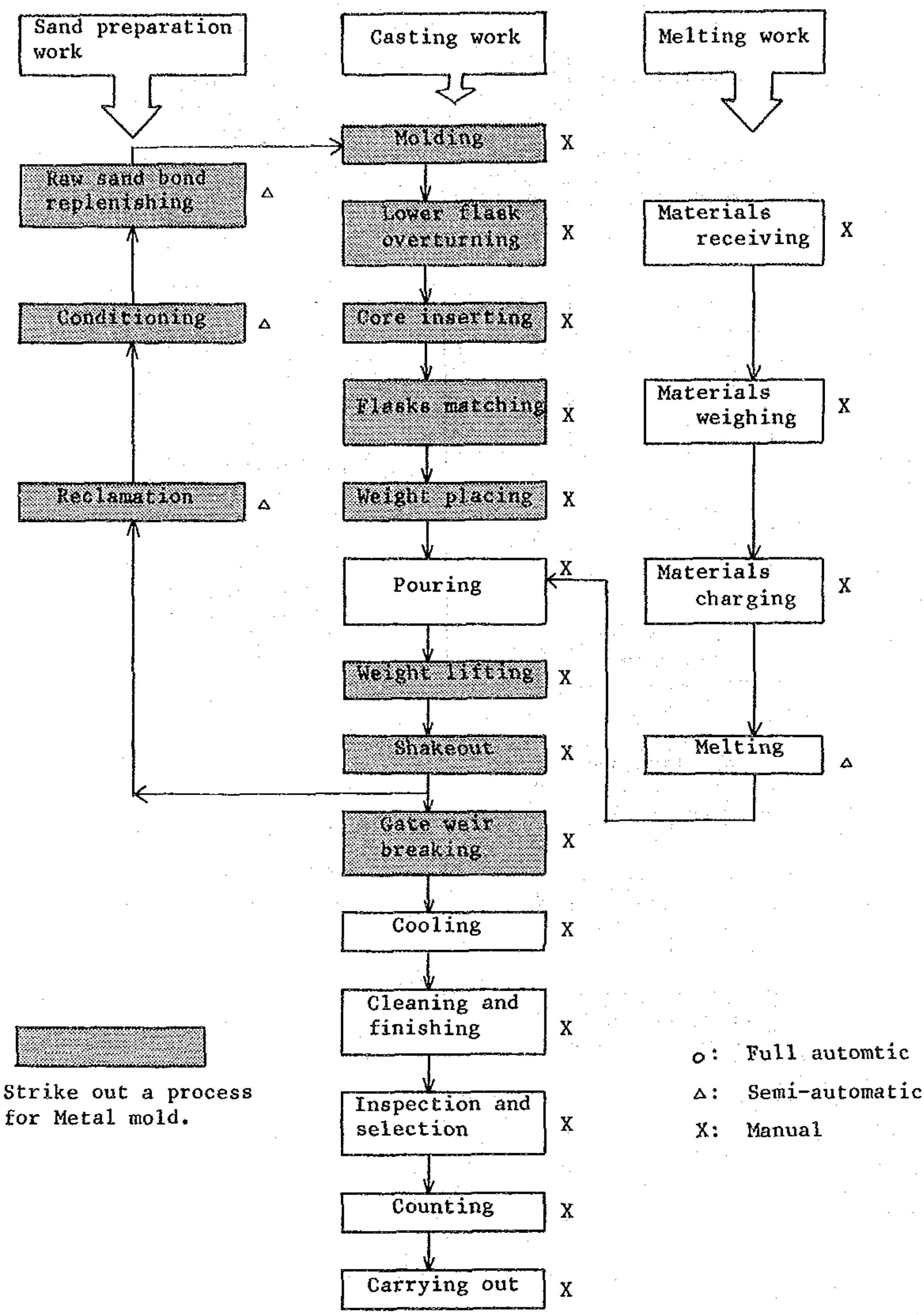


Fig. 5.4.3 Flow Chart of Brake Block by Sand Mold Casting Operation (Existing)

Table 5.4.2 Assignment of Workers for Casting of Brake Blocks

Description		Metal Mold	Sand Mold	No. of persons
Direct Workers	1. Melting	65	17	82
	2. Molding & Casting	248	59	307
	3. Reconditioning of Sand	1	14	15
	4. Miscellaneous	18	7	25
	Sub-total	332	97	429 *
Support Workers	1. Wood cutting, Smithy work etc.	11	2	13
	2. Maintenance personnel	40	8	48
	Sub-total	51	10	61
Total		383	107	490
Percentage		78%	22%	100%

* Leave Reserve 12.1%

We have described present state of brake block casting works as mentioned above. Some improvements in the facilities and works are necessary as shown below.

(1) Most of the work is being done manually and those works should be improved for enhancing work efficiency and safety and to reduced production cost.

(2) The yield ratio of products is 70%. As shown in Table 5.4.3 the rejection rate is 7% in case of metal mold casting and 12% in case of sand mold casting. To improve the yield ratio, improving the quality of products should be considered.

Table 5.4.3 Inferior Products

(1) Metal Mold Casting	7%
Short Casting	2%
Shrinkage	2%
Cavity/Cracks etc.	2%
Slag Inclusion	1%
(2) Sand Mold Casting	12%
Blow Hole	6%
Cold Shut & Slag Inclusion	4%
Sand Drop, Mis-match etc.	2%

(3) Following points should be considered in the present brake block casting method by metal mold.

1) Brake block casting by metal mold is more efficient than sand mold casting, because neither the sand reconditioning process nor sand molding process is necessary (refer to Fig. 5.4.3). However, metal mold casting is not always effective in casting volume and number of workers. The casting work by metal mold requires much man-power for preparation to correct the deformed molds and self-annealing. It seems that by the reason mentioned before the man-power of metal mold casting is almost equal to that of sand mold casting.

   In case of support work, replacement of metal molds is a problem (about 800 pieces of brake blocks can be produced by one set of metal mold and the cost of one set is about 1,325 Rs).

2) From the hardness histogram as shown in Fig. 5.4.4, it is clear that the hardness of brake blocks made by metal mold casting disperses very widely. Only 39% of products is distributed in the specified hardness range. If hardness is not considered in the rejection rate of products, it seems that the rejection rate of products made by metal mold casting is lower than the products made by sand mold casting.

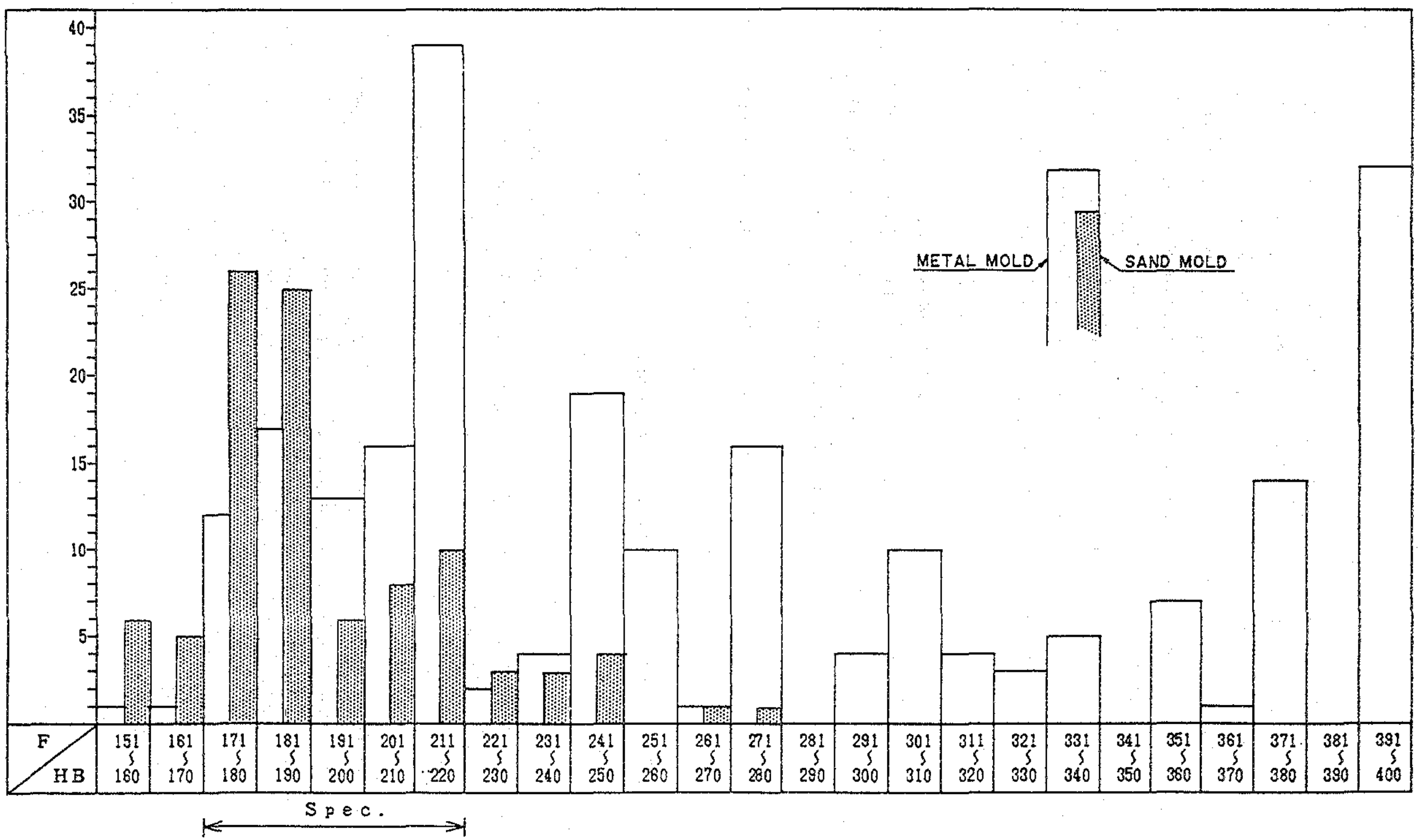


Fig. 5. 4. 4 Histogram of Brake Block Hardness (H.B.)

Wear resistance of the brake block is most influenced by hardness and hardness range is specified within HB150 - 220 in Indian Railways and also specified within HB220 - 250 in other countries. On-rail tests conducted by Japanese National Railways verified that wearing of the brake block within the similar hardness range is the least. It has been proved that, if the hardness of the brake block is within HB220 - 250 the brake block does not bite or melt the wheel. Accordingly, the hardness of brake block made by metal mold casting should be in the HB220 - 250 range.

(4) Most of the brake blocks for coaches and locomotives made by sand mold are now produced by manual operation. As shown in Fig. 5.4.4, the hardness is distributed within the specified range, but it will be necessary to improve the mass production system.

(5) The building has a low ceiling height and a poor working environment due to burned sand and other dust.

(6) Sand mill and other machinery are old resulting in poor work efficiency.

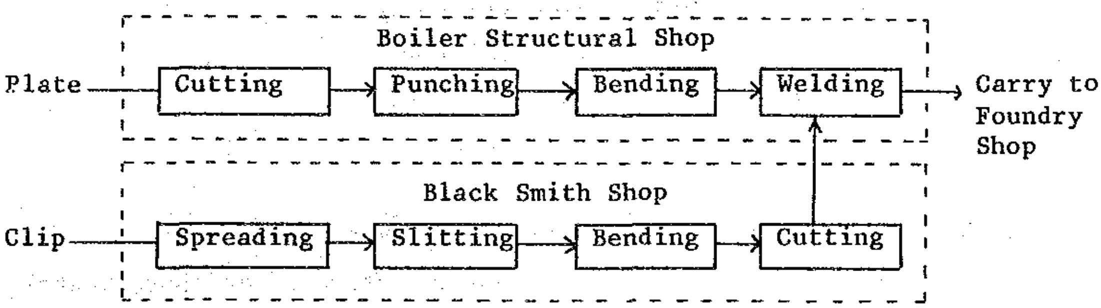
(7) The building has no EOT crane, and all handling work is being done manually. Installing a crane should be considered to ensure work safety, particularly in handling molten metal, and reduce labour requirements.

(8) Unloading from wagon, and carrying and storage of raw materials are being done manually. So, improvement of such works should be considered to ensure work efficiency and labour saving.

(9) Charging raw materials into cupola is being done by hand push trolley, but from the spreading of raw materials inside cupola, and from points on labour saving and safety, this system should be reconsidered.

(10) By improving the present treatment of slag and taken-out molten metal the working environment should be improved.

(11) The manufacturing process of back plate should be improved in efficiency, and manufacturing cost should be reduced, because present manufacturing process is complicated as described below.



5.4.2 Premises of Modernisation Plan for Brake Block Casting Facilities

Problems in modernising brake block casting work have been described in paragraph 5.4.1 and the premises of modernising casting facilities to resolve these problems and to manufacture high quality brake blocks efficiently, cheaply and safely will be described below.

(1) Planned casting volume of brake block

Brake block casting requirements at Jamalpur Workshop in 2000 are estimated below. Kinds of brake block in future are as follows.

For wagons	W/BG	900 (13.5 kg)
	WA/BG	6158 (15.3 kg)
For coaches	C/BG	4531 (13.5 kg)
	EMU -	043 (12.0 kg)
For locomotives	TB -	1103 (12.5 kg)
	WDS -	4 (17.0 kg)

BG/2894 (38 kg) for the steam locomotive is assumed not to be manufactured. Casting volume in 2000 is estimated at approximately 13,400 tons/year (refer to the Vol. II Table 1.3.1). Assuming an allowance of 20% as a requirement from other workshops for wagons, total casting volume is calculated as follows.

$$13,400 \times 1.2 = 16,000 \text{ tons}$$

Required tonnage of brake blocks for wagons in 2000 is estimated at approximately 7,100 tons/year. Total required tonnage of brake blocks for wagon is estimated as below by adding other workshop's requirements.

$$7,100 + (13,400 \times 0.2) \doteqdot 9,800 \text{ tons/year} \doteqdot 10,000 \text{ tons/year}$$

(2) Casting plant capacity

The casting plant capacity is calculated based on a double-shift working system to minimise the product cost. The plant capacity for one shift is calculated as follows.

1) Metal mold casting

a) Type of brake block — BG/6158, W/900

b) Time required from pouring to congealment and pulling down of mold — 70 - 90 sec/set

c) Annual producible number of brake blocks by using dies for 2 pieces per set.

$$\frac{3,600 \text{ set}}{70 - 90 \text{ sec}} \times 2 \text{ pc/set} \times 7 \text{ h} \times 295 \text{ days} = 424,300 - 330,400 \text{ pc/year}$$

d) Annual producible tonnage (unit weight ... 14.4 kg/pc)
(424,800 ~ 330,400 pc/year) x 14.4 kg/pc = 6,117 ~ 4,757 ton/year

e) Annual necessary casting volume
assumed as: rejection rate 7%
rate of machine stoppage ... 4%

9,800 ton/year x 1.1 = 10,780 ton/year

f) Number of metal mold casting plants to be installed

10,780 ton/year ÷ 5,500 ton/year ≑ 2 sets

2) Sand mold casting
a) Type of brake block
The brake blocks made by sand mold casting are for coaches and locos.

b) Annual necessary number of brake blocks to be casted
assumed as: unit weight .... 14.4 kg
rejection rate and rate
of machine stoppage 11%

6,000 ton ÷ 14.4 kg x 1.1 = 480,000 pc/year

c) Annual casting number of brake blocks
Taking into account the insertion of back plate or cores, casting work will be operated at intervals of two minutes by using flasks of 4 pieces casting per set. Annual castable number of brake blocks is calculated as below.

$$\frac{3,600 \text{ sec}}{120 \text{ sec}} \times 4 \text{ pc/set} \times 7 \text{ h} \times 2 \times 295 \text{ days} = 495,000 \text{ pc/year}$$

Annual necessary number 480,000 < Annual castable number 495,000.

Accordingly, the capacity of plant with two minute performance by using flasks of 4 pieces casting per set will be enough for future production volume.

Furthermore, the sand mold casting plant will have considerable margin in capacity and will be able to back up metal mold casting.

(3) Casting process

The casting process will be examined so as to modernise the present sand mold casting and metal mold casting.

1) Melting work

The cupola method will be selected over the induction furnace method, considering advantages and disadvantages (refer to the Vol. II Table 1.3.3) as well as availability of electric power. The cupola will be of the hot air blast with water cooling furnace type and the cupola capacity will be 6 ton/h and will be used commonly for sand mold casting and metal mold casting.

The capacity of cupola is calculated as below.

Necessary melting volume	... 16,000 ton/year ÷ 0.75 (yield ratio) = 21,333 ton/year
Working hour	... 14 h/day x 295 days = 4,130 h/year
Cupola capacity	... 21,333 ton/year ÷ 4,130 h/year = 5.17 tons/h ≑ 6 tons/h

2) Sand molding work

As the present sand molding work is being done manually, it will be mechanised to minimise the rejection rate of products and to improve work efficiency. As the mechanised sand molding apparatus will be applicable for casting various kinds of products by changing molds, this apparatus will have surplus capacity to cover machine stoppage of another plant.

3) Sand conditioning work

To minimise the rejection rate of products by stabilising the quality of sand mold and to improve work efficiency, the sand conditioning work will be mechanised and the adjustment of water content of sand will be automated.

4) Casting by metal mold

The casting system to be introduced will be based on the existing turn-table system.

To ensure the quality of products, to prevent the deformation of metal mold and to prolong the service life of metal mold, metal mold made from new quality material and the metal mold temperature control system will be introduced.

To improve the pouring efficiency, a plural number of products will be capable of being cast by one pouring work.

The hardness of brake block should be controlled so that the distribution of hardness will be within the specified range.

One round required time by existing turn-table system is 57 min., so assuming casting volume is 5,000 t/year/shift, 5 - 6 sets of casting plants will be needed, but to reduce the work area it should be reduced in 2 - 3 sets.

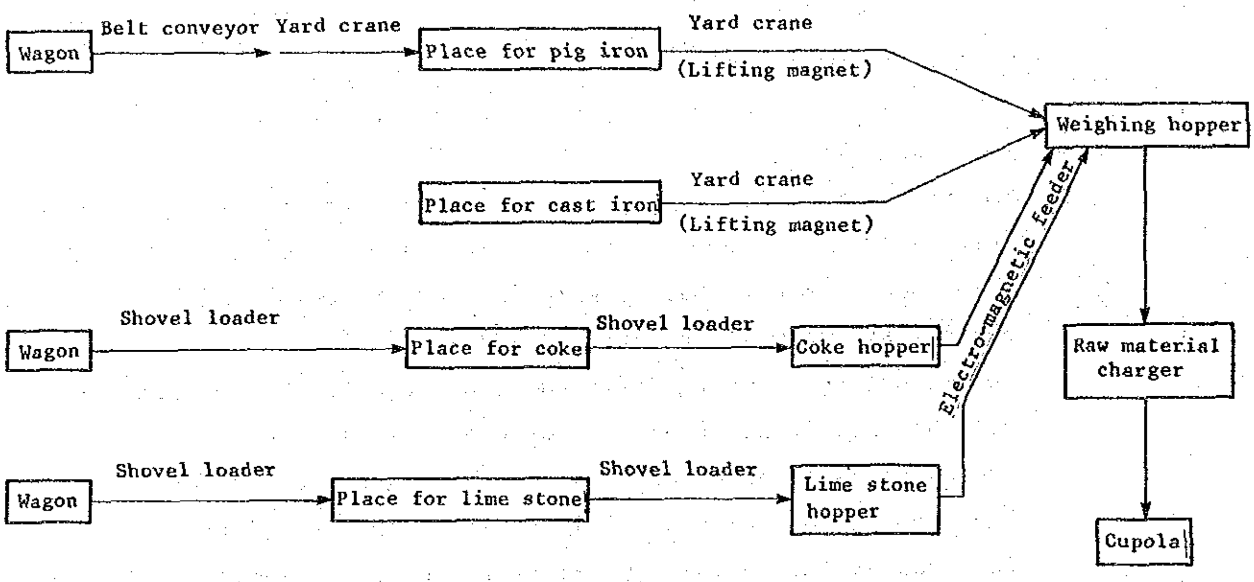
5) Pouring work

Pouring work will be mechanised to ensure safety and efficiency and labour requirements. Mechanisation systems include monorail or crane system, automatic carrying system, and automatic fixed point pouring system. The crane or monorail system will be selected considering facility cost and maintenance requirements. (refer to the Vol. II Table 1.3.4)

(4) Material handling and storing of raw materials and products, and raw material weighing and charging

A 3-ton yard crane-conveyor and shovel loader will be installed and delivered to facilitate unloading and storing raw materials from wagon and to increase safety and efficiency. Also, a 3-ton EOT crane is installed for pouring and handling products. However, most products will be handled by conveyor, and pallet and fork lift.

The weighing system of raw materials will be automated and charging system will be mechanised. (refer to the Vol. III Fig. 1-17) Transportation of raw materials by wagon should be done by open wagon for the conveniance of unloading.



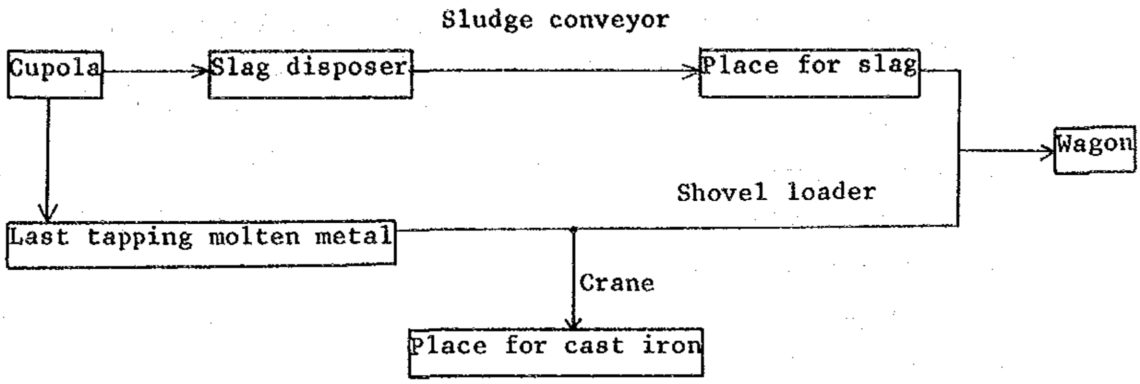
(5) Products processing

The products made by metal mold casting and sand mold casting should be stored on the pallet, and the products should be processed by shot blasting and stored after natural cooling. Number counting system will be mechanised and pallet storing will be applied.

(6) Improving the environment, others

To improve the work environment, the building will be remodelled and paved with concrete, and dust control measures will be provided. Slag treatment will be done by slag disposer and last tapping molten metal will be treated by suitable manner. (refer to the Vol. III, Fig. 1-19)

Brake block transportation by pallet between the work shop and the depot, instead of bulk cargo on wagons, will be recomended.

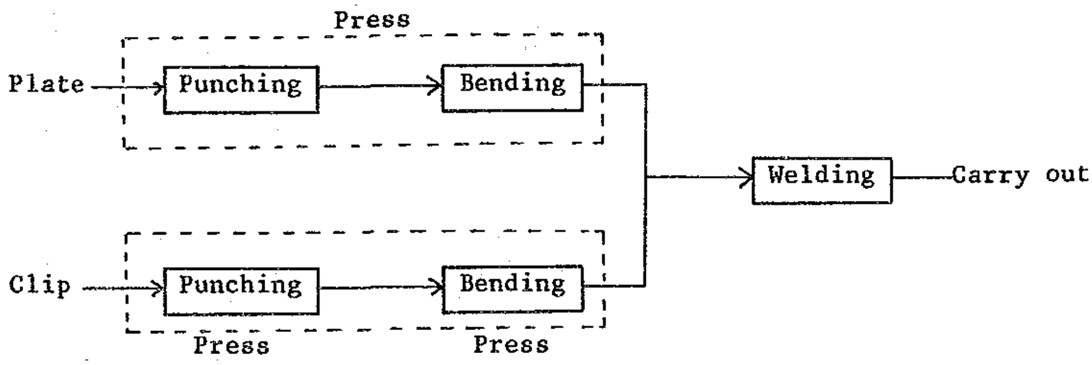


(7) Quality control of brake blocks

It will be necessary to consolidate the quality control of products by introducing the molten metal control system such as chill test by using silicon metre and wedge type test piece.

(8) Back plate manufacturing

The manufacturing process of back plate is as shown below.



The punching and bending work of plate should be done by one press and same works of clip should be done by two presses. The welding work should be done automatically.

These machines will be installed in the brake block casting work area or in the neighbouring work area.

(9) Proposed modification of brake block casting process

The brake block casting work is divided into the following works, each of which will be modified as shown in Fig. 5.4.5.

Melting work
Metal mold casting work
Sand molding work
Sand conditioning work
(Core making)
(Products processing)

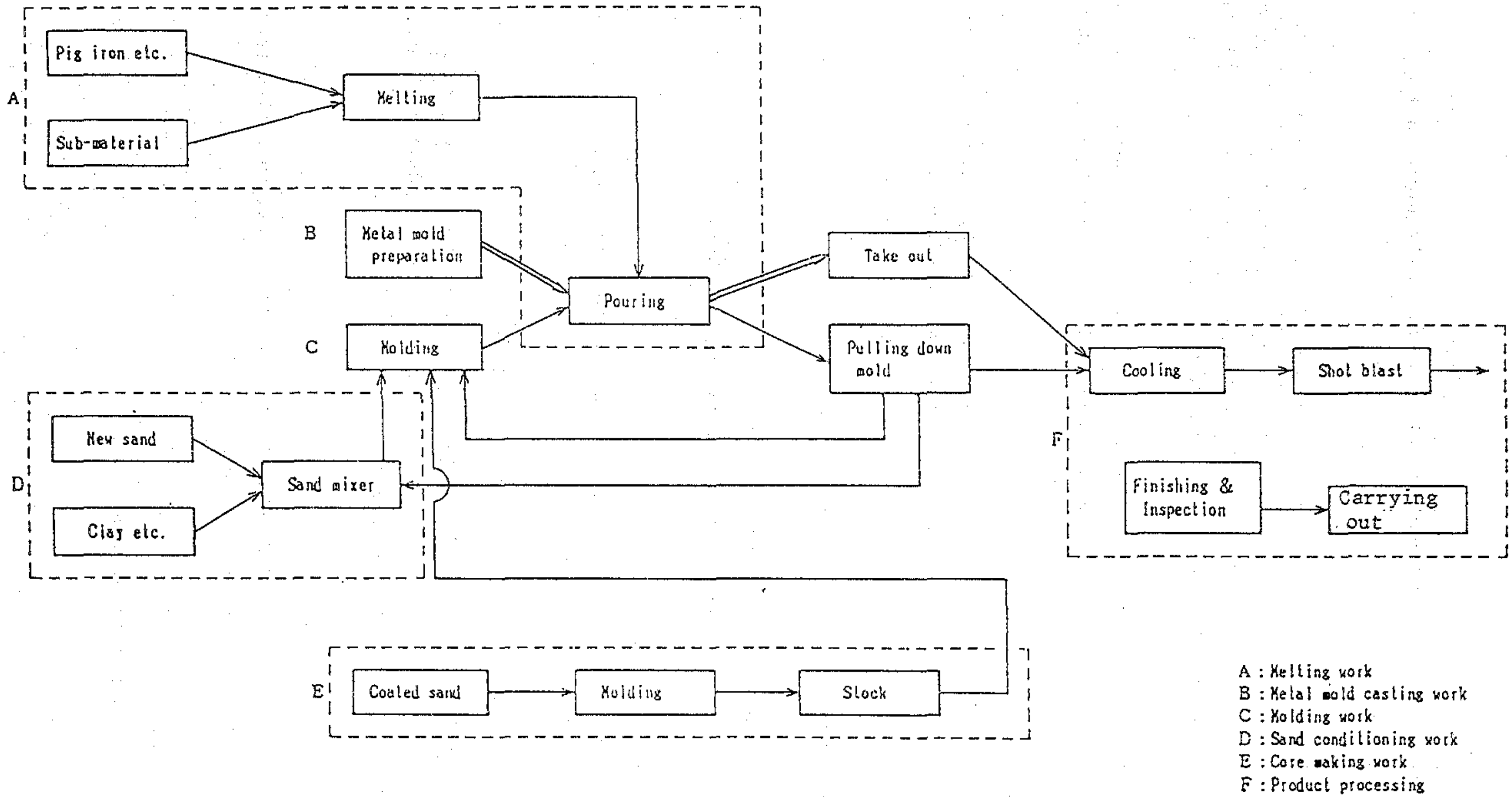


Fig. 5.4.5 Flow Chart of Manufacture of Brake Block

5.4.3 Determination of Modernisation Plan for Brake BlocK Casting Facilities

In accordance with the premises for modernisation of works described in the foregoing paragraph, the capacity of facilities will be designed to cast 16,000 tons of brake blocks annually. The melting process will be done by the cupola and molding process will be done by both sand mold and metal mold casting.

To improve the brake block quality, to save labour and to increase work efficiency, the following equipment and machines will be provided.

(1) Melting work
Cupola, fore hearth, automatic material charger, material scaling apparatus, dust collector, hot blast equipment, etc.

(2) Pouring work
EOT crane, pouring apparatus, etc.

(3) Metal mold casting work
Metal mold casting apparatus, diesinking machine, etc.

(4) Sand molding work
Automatic molding machine, pattern changing equipment, weight, flask, flask handling equipment, etc.

(5) Sand conditioning work
Sand mixer, sand cooler, water content control apparatus, rotary screen, sand handling equipment, magnet separator, dust collector, bond carrying equipment, etc.

(6) Products processing
Products cooling equipment, air cooling equipment, shot blasting equipment, dust collector, etc.

(7) Core making
Core making machine, sand mixer, etc.

(8) Handling and storing of raw materials and products

Yard crane, shovel loader, fork lift truck, pallet, EOT crane, conveyor, etc.

(9) Slag treatment work

Slag treatment facility, shovel loader, etc.

(10) Back plate manufacturing work

Press, automatic welding machine

The general shop layout is shown in the Vol. III Fig. 1-16. The major plant and machinery proposed are shown in the Vol. II Table 1.3.2.

Building area to be constructed or removed in the brake block foundry are summarised in Table 5.4.6.

Table 5.4.6 Summary of Building Areas (in Brake Block Foundry)

Item	Building area (m^2)
Building to be constructed	2,520
Building to be demolished	2,520
Net increase/decrease	0

5.5 Construction Cost (Jamalpur Workshop)

Construction cost excluding the education facility is as follows.
Calculation of construction cost is based on the following.

Exchange rate: 1 Rs. = 11.4 Yen
1 US$ = 12.87 Rs.
1 US$ = 146.1 Yen (as of June 24, 1987)

Import tax rate: 85%

Table 5.5.1 Rolling Stock POH Facilities

(Unit: Million Rs.)

Item \ Item of expenditure	New establishment			Replacement			Grand Total
	Domestic currency	Foreign currency	Total	Domestic currency	Foreign currency	Total	
Machinery	60.49	63.58	124.07	12.84	22.38	35.22	159.29
Civil & Building	46.86	-	46.86	-	-	-	46.86
Sub-Total	107.35	63.58	170.93	12.84	22.38	35.22	206.15
Import Tax	54.04	-	54.04	19.02	-	19.02	73.06
Grand Total	161.39	63.58	224.97	31.86	22.38	54.24	279.21

Table 5.5.2 Brake Block Casting Plant

(Unit: Million Rs.)

Item \ Item of expenditure	New establishment			Replacement			Grand Total
	Domestic currency	Foreign currency	Total	Domestic currency	Foreign currency	Total	
Machinery	17.33	70.16	87.49	-	-	-	87.49
Civil & Building	10.06	-	10.06	-	-	-	10.06
Sub-Total	27.39	70.16	97.55	-	-	-	97.55
Import Tax	59.64	-	59.64	-	-	-	59.64
Grand Total	87.03	70.16	157.19	-	-	-	157.19

Table 5.5.3 Laminated Spring Manufacture and Repair Facilities

(Unit: Million Rs.)

Item \ Item of expenditure	New establishment			Replacement			Grand Total
	Domestic currency	Foreign currency	Total	Domestic currency	Foreign currency	Total	
Machinery	8.98	-	8.98	-	-	-	8.98
Civil & Building	-	-	-	-	-	-	-
Sub-Total	8.98	-	8.98	-	-	-	8.98
Import Tax	-	-	-	-	-	-	-
Grand Total	8.98	-	8.98	-	-	-	8.98

5.6 Construction Schedule

5.6.1 Rolling Stock Inspection and Repair Facilities

Modernisation project of the Jamalpur Workshop should be advanced by remodeling the building and shifting repair shops while continuing the existing locomotive POH. It is anticipated that modernisation will have a considerable effect on the rolling stock POH, but too much emphasis on the possible repercussions could delay the modernisation. It is most desirable to start the modernisation from about 1990 when the annual number of steam locomotives to be repaired will steeply decrease. Further, the decrease will result in a pretty large surplus floor space inside the fitting shop and wheel shop. Therefore, it is desirable, first of all, to move or dismantle the machines inside the wheel shop and fitting shop. The rough construction schedule is shown in Table 5.6.1.

Table 5.6.1 General Construction Schedule of Rolling Stock Inspection and Repair Facilities

Item \ Year	1989	1990	1991	1992	1993	1994
Detailed Design	Machines and Electrical Facilities — Building —					
Move or Dismantle Machines inside Wheel and Fitting Shops	—					
Remodeling of Fitting Shop		—				
Move Work Areas		—	—			
Procurement of Machines for Wheel and Bogie Shops, BTC	—	—	—			
Installation of Machine for Bogie and Wheel Shops			—			
Move Machines into Boiler Shop				—	—	
Remodeling of Fitting Shop					—	
Construction of Engine Test Room					—	
Procurement of Machines for Engine Shop and Rotating Machine Shop				—	—	—
Installation of Machine for Rotating Machine and Engine Shops						—

5.6.2 Laminated Spring Manufacturing and Repair Facilities

Modernisation work of laminated spring manufacturing/repair facilities is desirable to be initiated in early 1990 in consideration of the period required for the advance design and work contract.

First of all, procurement of machinery to be newly installed and transfer of the machinery in the existing shop should be performed. Secondly, installation of the new machinery should be performed.

The rough construction schedule is shown in Table 5.6.2.

Table 5.6.2 General Construction Schedule of Laminated Spring Manufacturing and Repair Facilities

Item \ Year	1989	1990	1991
Detailed Design	Mechanical Equipment		
Procurement of Machines			
Relocation of Existing Machines			
Installation of Procured Machines			

5.6.3 Brake Block Casting Facilities

The brake block casting shop which is located in the building to be rebuilt will be shifted to other area where rebuilding work will not be hindered.

At the same time the existing cupolas will also be relocated. And then the rebuilding work will be performed. Thirdly, installation work of the new Casting plant will be performed.

The rough construction schedule is shown in Table 5.6.3.

Table 5.6.3 General Construction Schedule of Brake Block Casting Facilities

Item \ Year	1989	1990	1991	1992
Detailed Design	Mechanical Equipment —— Building ——			
Relocation of Existing Metal Mold Casting Facility		——		
Reconstruction of Building		——	——	
Procurement of Metal Mold Casting Facilities and Charging Facilities and Sand Molding Facilities		——	——	
Demolition of Cupola and Charging Facilities			——	
Installation of Cupola, Charging Facilities and Slag Disposer			——	——
Installation of Metal Mold Casting Facility				——
Installation of Sand Mold Casting Facility				——

5.7 Basic Plan of Personnel and Education

5.7.1 POH of Workload and Manpower

(1) Workload related to POH

Estimating the amount of workload involved in the locomotive POH at the Jamalpur Workshop is a little complex due to the decrease in steam locomotives and the increase in the diesel and electric locomotives.

Concerning the POH work of diesel and electric locomotives till 2000, if assumption is made that the work system remains the same as at present without being rationalised without introducing modern equipment, etc., total POH manhours of WDM, WDS, and EL would be proportional to the increase/decrease of the number of locomotives to be inspected/repaired, as shown in Table 5.7.1.

Total manhour 3,652,000 for POH including SL in 1985 will become 3,236,000 in 2000 due to phasing out of SL, and POH workload of the workshop will be reduced by changing to DL and EL.

However, POH workload of DL and EL will become about 4.5 times (3,236,000 manhours) the current 712,000 manhours, and in addition highly qualified engineers and skilled workers must be obtained in numbers.

Table 5.7.1 POH Workload Transition

Locomotive Classification		POH Manhours/ Locomotive Man hours	1985		2000 Non-modernised	
			No. of Locomotives	Total Man hours	No. of Locomotives	Total Man hours
				(Thousand MH)		(Thousand MH)
SL		14,000	210	2,940	0	0
DL	WDM	20,500	17	348	103	2,111
	WDS	13,500	27	364	30	405
EL		15,000	0	0	48	720
Sub-Total				3,652		3,236

As shown in Table 5.7.2, workshop personnel as of 1985 is steam 41%, diesel 10%, and others 48%, and with 1,990 administrative persons total number is about 14,270 persons.

Table 5.7.2 Number of Workshop Persons by Type of Work (1985)

	Steam	Diesel	Others	Total
Mechanical	5,043	1,314	4,704	11,061
Electrical	--	--	1,218	1,218
Total	5,043	1,314	5,922	12,279
Administrative	1,990			1,990
	Grand Total			14,269

Table 5.7.3 shows the transition of the number of persons directly and indirectly related to POH from 1985 to 2000.
5,785 persons in 2000 is an estimated number when POH for SL is reduced and work rationalisation progresses at the current rate.

Table 5.7.3 POH Workload and Manpower Transition

		Item	1985	2000	
				Unmodernised	Modernised
POH	SL	Direct POH Workload (thousand manhours)	2,940	0	0
		POH (persons) Direct + Indirect	5,043	0	0
	DL	Direct POH Workload (thousand manhours)	735	2,516	x 88.7% = 2,232
		POH (persons) Direct + Indirect	1,314	4,498	3,990
	EL	Direct POH Workload (thousand manhours)	0	720	720 x (7 + 3 x 88.7%)/10 = 696
		POH (persons) Direct + Indirect	0	1,287	1,244
Total POH (persons) Direct + Indirect			6,357	5,785	5,234

Table 5.7.4 Diesel POH Manhour Reduction by Type

POH content	Current POH manhour	POH manhour after Modernisation	Equipment to be installed
(WDM Type) Engine Block Piston & Cylinder Head Repairs to Turbo FIP Injector, Pump Blower Unit Air Brake	6,958	(20%) 5,566	Engine tester, Rotating Stand, Cleaner
Bogie attention Radiator Brake Gear alter	2,899	(15%) 2,464	Rotating Stand, Cleaner
Chassis attention Rt. Angle, Gear Box Cab attention	2,691	(10%) 2,421	Movable footing Elevated Platform, Carrier
Cleaning & Painting	1,095	(20%) 876	Electro-static Painting Machine, Cleaner
Loco Wiring Traction Generator and Auxiliary Traction Motor attention	3,454	(30%) 2,417	Automatic Commutater Groove Cutting Machine, Tester, Jig/Tool
Relay After trial repaid	1,285	(20%) 1,028	Tester, Movable footing, Elevated Platform, Crane
Battery attention Harness BKT, Master Contractor, Power Contractor, Bushes FSR	2,118	2,118	
Total manhour	20,500	16,890	Rate = 0.824

POH content	Current POH manhour	POH manhour after Modernisation	Equipment to be installed
(WDS Type) Disassembly & Assembly of Loco, Suri trans, R.G.B	5,878	(20%) 4,702	Movable footing Elevated Platform, Carrier, Cleaner
Disassembly & Assembly of Power Pack	3,796	3,796	Engine tester, Cleaner
Electric repairs, Painting	1,773	(10%) 1,595	Tester, Electro-static Painting Machine
Wheels Welding	578	(10%) 520	Wheel Lathe, Roller Bearing Cleaner, CO_2 gas Arc Welder
Side Rods, Machining, etc.	1,475	1,475	
Total manhour	13,500	12,088	Rate = 0.895

As shown in Table 5.7.4, work rationalisation accomplishment as to diesel POH will become about 82.4% in WDM and 89.5% in WDS for diesel POH by the implementation of the present modernisation plan. Accordingly, DL average work reduction rate is a value obtained by weighted mean process of estimated POH of 2,111,000 manhours and 405,000 manhours of WDM and WDS in 2000 (Table 5.7.1). The value thus calculated is about 83.5%.

(2,111 x 82.4% + 405 x 89.5%) ÷ (2,111 + 405) = <u>83.5%</u>

Assuming that annual POH manhour of present direct POH persons is 260 days x 8 hours x 1.33 (incentive earnings) = 2,766 manhours/year, in the case of diesel POH, POH direct persons is as follows:

735,000 manhours ÷ 2,766 manhours = 266 persons

Accordingly the ratio of direct persons and indirect persons is 266 : 1,048.
POH in 2000 when modernisation plan is implemented, was calculated by weighted means according to the personnel ratio based on the estimate of direct person's work rationalisation rate 83.5% and indirect person's rationalisation rate 90% as follows:

(266 x 83.5% ÷ 1,048 x 90%) ÷ (226 + 1,048) = <u>88.7%</u>

This is considered to be the final work reduction rate including diesel POH related direct and indirect.

Since EL POH work has many portions common with diesel, 30% is considered to be rationalised according to this modernisation plan, and diesel work reduction rate was applied to that portion.
When this project is implemented, the number of POH related personnel will become around 5,200 ultimately, as shown in Table 5.7.3.

Fig. 5.7.1 shows the transition of POH related work and personnel until 2000 in Jamalpur workshop. Since the personnel becomes 5,234 in 2000 from 6,357 at present, apparent personnel reduction is only around 1,100, but all 5,043 persons working in association with steam locomotive now must be transferred to other job assignments.
On the other hand, in DL and EL shops, there are only 1,314 persons of POH job titles at present, so the remaining 3,920 persons required will be transferred from 5,043 SL related persons.

As shown in Fig. 5.7.1, estimated personnel required in 1995 after implementation of modernisation project is calculated to be 4,050. As a transitional phenomenon, personnel will become minimum in this period temporarily, and then it will recover as work increases thereafter, and will become 5,284 in 2000.

On the other hand, the number of retired persons is 350 - 400 in these several years, persons exceeding the above have been employed, however, limiting new employees is considered necessary from the early period considering work reduction in 1995.

In 1995, of all 4,050 POH related personnel of DL and EL shops, about 2,700 persons excluding the present personnel of 1,314 must be acquired, and even if some repair of parts commissioned from the shed, etc. may remain after 1995, at least 2,000 persons must be transferred from the SL related shop.

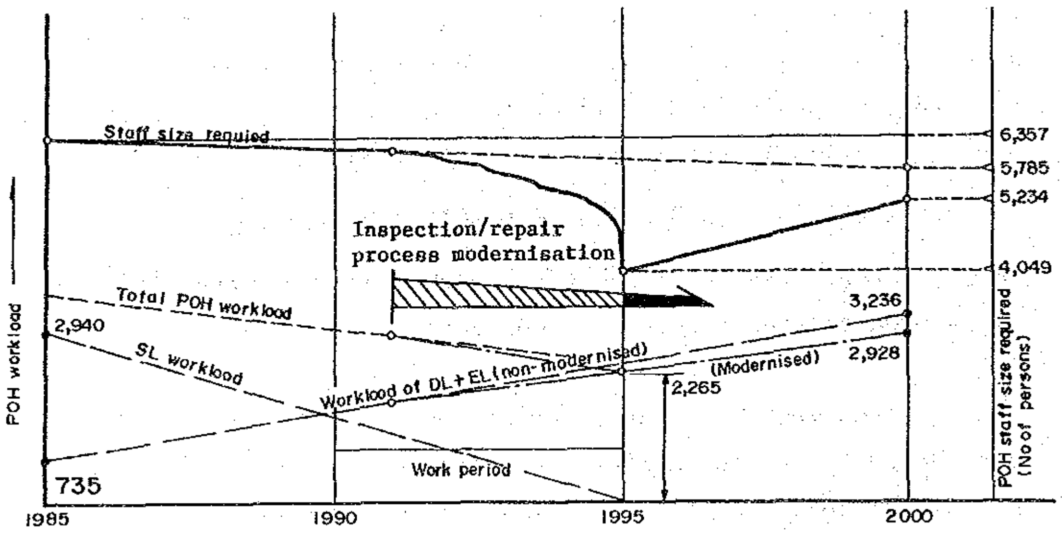


Fig. 5.7.1 Transition of POH Workload and Number of Personnel

(2) Production work, etc.

Production work, etc. other than POH work is about 1.1 times the POH work of this workshop. Consideration is made of the cases when modernisation is applied and when not applied to brake block casting line and laminated spring manufacturing and repairing line.

When capacity is strengthened with mechanisation kept at present level, i.e. when modernisation project is not applied, workload increases from 4,934,000 manhours (1985) to 6,201,000 manhours (2000) as shown in Table 5.7.5. This means additional requirement of about 550 persons.

In this calculation, workload increase due to capacity increase is kept down to about 70% increase considering efficiency enhancement of machine and work.

On the other hand, when the modernisation project is implemented, the number of personnel required for production work and other works is calculated to be 5,639, a reduction of about 280 persons from the present.

Table 5.7.5 Transition of Production Work and Others

Item			1985	2000	
				Non-modernised	Modernised
OTHERS	Production work (thousand man hours)	Brake block	1,393	2,320	670
OTHERS	Production work (thousand man hours)	Laminated spring	138	478	190
OTHERS	Production work (thousand man hours)	Others	3,403	3,403	3,403
OTHERS	Total manhours (thousand)		4,934	6,201	4,263
OTHERS	Number of personnel		2,156	2,709	1,863
OTHERS	- do -	(other work)	3,766	3,766	3,776
Total number of personnel			5,922	6,475	5,639

(3) Total number of workshop staff

Total number of Jamalpur Workshop staff can be summarised from the calculation of number of personnel for POH related work, production work and others as shown in Table 5.7.6.

Table 5.7.6 Transition of Total Number of Jamalpur Workshop Staff

Item	1985	2000	
		Unmodernised	Modernised
POH related work	6,357	5,785	5,234
Production work and others	5,922	6,531	5,639
Sub-Total	12,279	12,316	10,873
Administrative	1,990	1,996	1,762
Grand Total	14,269	14,312	12,635

The number of administrative personnel is calculated as being proportional to increase/decrease of personnel for production work and others.

As a result, the total number of personnel in Jamalpur Workshop in 2000 is 12,635. Accordingly, there lies a big problem to stabilise employment by the enlargement of business, such as by early development of new industries utilising surplus machines and facilities and engineering know-how in addition to production work currently underway, manufacture of bogie, motor rewinding, and receiving order for repair from other workshops, etc.

5.7.2 Education and Training

(1) Personnel transfer education

1) Education schedule

Total number of the Jamalpur Workshop staff in 2000 is supposed to be about 12,600. Though it may appear small personnel reduction of only about 1,600, many SL related personnel must be transferred to DL and EL as a result of dicrease in SL POH and related jobs of SL as described in 5.7.1.

The number of personnel to be transferred from SL related jobs is about 3,700 (5,043 - 1,314) as calculated from Table 5.7.3. These persons must be transferred to diesel related shops and others. Even if SL parts manufacture and parts repair for outstation, etc. remain in some quantity during several years after 1995, about 2,000 persons must receive transfer education during a short period ending in 1995 at which time SL disappears if this modernisation project is to be carried out effectively.

In this project, shop modification period is considered to be about 5 years from 1990, and education at BTC for job title transfer is urgently required. BTC facility strengthening must be performed during the first one year of the construction period, and education for transferring to diesel POH and others must be started as soon as possible.

For completing transfer education of 2,000 personnel within 4 years before the end of 1995, education facility with the capacity of about 500 persons/year must be constructed.

2) Education content

For the transfer education of personnel so far engaged in SL POH work, shops receiving education will be mainly SL shop, boiler shop, casting shop, forging shop, etc.

Between SL POH and diesel POH, accuracy of engine and parts differs to a considerable extent, and persons should be re-educated including general outline on POH work.

Since manual work element of SL is improved to a large extent, not only the knowledge of new POH method but also techniques for the operation and maintenance of new POH facilities are required.
To educate these persons in a short period, it is essential to develop an effective and efficient curriculum.
For the modernisation of workshop, particularly for the change in work content, such as the Jamalpur Workshop, unless the personnel acquire certain technical and skill levels, the purpose of modernisation can never be attained.
In the modernisation proposal, education and training given in Table 5.7.6 are performed as the SL to DL (EL and others) transfer education.

Table 5.7.7 Transfer Education Items in BTC

Education Course	Period	Trainees/ Class	Classes/ Year	Trainees/ Year
DL POH General Techniques (for Supervisor)	3 months	20	2	40
Inspection and Quality Control	3 months	20	2	40
POH Work Plan and Process Control	3 months	15	2	30
Unite Exchange Spare Parts Operation and Control	2 months	15	2	30
Diesel Engine POH Techniques	3 months	15	3	45
Electrical parts (Generator, Traction Motor) POH Techniques	3 months	20	2	40
Bogie POH Technique	2 months	20	2	40
Transmission POH Techniques	2 months	25	1	25
Control Equipment POH Techniques	2 months	20	1	20
Ultrasonic Flaw Detecting Techniques	2 months	10	2	20
Roller Bearing POH Techniques	1 month	10	1	10
Machining Techniques	3 months	15	2	30
Casting Techniques	2 months	15	2	30
Cleaning Techniques	0.5 month	15	3	45
Welding Techniques	2 months	15	3	30
POH Machine Operation and Maintenance Techniques	3 months	30	1	30
Total			31	505

3) Facility scale required for transfer education

Separate from current BTC, building and education facilities for transfer training should be planned and provided.

a) Facility scale

The scale required for transfer education is considered from the values of Table 5.7.7. so as to accommodate simultaneous number of 6-7 classes, and simultaneous trainees of about 100 persons.

20 trainees/classroom, instructor rooms are planned as shown in Table 5.7.8.

Table 5.7.8 Outline of Transfer Education Facilities

Item	Floor Space	No. of Rooms	Total Floor Space	Remarks
1. Classroom	50 m^2 (6m x 8m)	7	350 m^2	Reinforced 2-Storied building
2. Instructor's Room	35 m^2 (6m x 6m)	1	35 m^2	
3. Practice Room	65 m^2 (8m x 8m)	3	195 m^2	
4. Others	170 m^2	--	170 m^2	Passage/Lavatory, Warehouse, etc.
Total		11	750 m^2	

b) Education material

Education materials required for the promotion of knowledge and skill required for the transfer education, primarily new techniques and facilities to be introduced by this modernisation plan, will be provided.

Table 5.7.9 Education Materials Required for Transfer Education

Item	Quantity	Item	Quantity
1. Diesel Engine POH Education Material	1	9. Milling Machine	2
2. Transmission POH Education Material	1	10. Drilling Machine	2
3. Generator POH Education Material	1	11. Microcomputer	3
4. Traction Motor POH Education Material	1	12. Video Camera/Video Recorder	1
5. Control Equipment POH Education Material	1	13. Slide Projector	2
6. Ultrasonic Flaw Detector for Axle	2	14. Education Software	1 set
7. CO2 Gas Welder	2	15. Others	1 set
8. Standard Lathe	2		

c) Education Facility Costs

Construction cost and procurement costs of Education Facilities are as shown in Table 5.7.10.

Table 5.7.10 Construction Cost and Procurement Costs of Education Facilities

(Unit: thousand Rs.)

Item	Domestic currency	Foreign currency	Total
Building	3,750	0	3,750
Material	3,860	290	4,150
Sub-Total	7,610	290	7,900
Import Tax	0	247	247
Grand Total	7,610	537	8,147

(2) Overseas training of personnel

1) Training content and schedule

For new machines and techniques to be introduced in relation to workshop modernisation, particularly for imported ones, to assure operation immediately after work completion and sufficient effect, responsible engineers must acquire much knowledge about basic construction and operation of those equipment, action to be taken in case of trouble, etc. To grasp required information, training at the manufacturer before the introduction of equipment is indispensable.

Overseas training on newly introduced machines and new POH techniques shown in Table 5.7.11 must be conducted.

Table 5.7.11 Overseas Training Courses

Training Subject	No. of Trainees	Period	Modernisation-Related Item
(Main Equipment)			
1. Power Pack Tester	3	2.0 M	Engine/Generator
2. Mica Cutting Device	2	1.5 M	Traction motor/ Generator
3. Ultrasonic Flaw Detector	2	1.5 M	For axle
4. NC Boring Machine	1	1.0 M	For wheel
5. Brake Block Casting Plant	3	2.0 M	Sand-mold/Metal-mold
(Control & Technique)			
1. CO2 gas Welding Techniques	2	1.0 M	
2. Traction Motor Insulation Renewal Techniques	1	1.0 M	Traction motor/ Generator
3. Bearing Inspection/Repair Techniques	2	1.0 M	
4. Process Control/Material Control Techniques	2	1.5 M	
Total	18	Total Man•Month	27.0 M•M

2) Expenses for Personnel Overseas Training

Expenses required for overseas training are shown in Table 5.7.12.

Basis of calculation

Total number of trainees: 18

Total period: 27.0 months

Overseas country: Japan

Table 5.7.12 Expenses for Overseas Training

(Unit: thousand Rs.)

Travel Cost	Daily Allowance/Lodging	Total
679	1,421	2,100

Note: Overseas training expenses are all in foreign currency.

CHAPTER 6 PERAMBUR WORKSHOP

6.1 Present State of Workshop

6.1.1 General Condition

Approximately 130 years have elapsed since the establishment of this workshop in 1856 and although it is the oldest workshop in the Indian Railways, along with the change of times, it currently has become the inspection and repair workshop exclusively for the POH of BG coaches and wagons.

In line with the increase in POH requirements of the Southern Railway, the scope of the workshop has gradually grown and as of January 1, 1987 the total personnel of the workshop has become about 8,900 persons. (Refer to Table 6.1.1.)

Due to this increase, this workshop has become one of the major industries in Madras, together with the Integral Coach Factory (ICF) located adjacent to the workshop.

At present this workshop is in charge of POH for 2,670 coaches, 6,000 bogie wagons and 13,500 4-wheeler wagons.

The outturn of the workshop is shown in Table 6.1.2 and besides the POH, it undertakes parts repair/manufacture for and supply of parts to each depot or sick line within the Southern Railway, playing an important role in Southern Railway.

Table 6.1.1 Workshop at a Glance

Year eatablished		1856
Total area		485,000 sq.m.
Total covered area		78,700 sq.m.
Total no. of Machinery and Plants		608
Average monthly power consumed		2.32 Lac units
Water Supply	(Filtered)	25 K Litters/day
	(Unfiltered)	1.25 Lac Litters/day
Staff Strength		8,850

Table 6.1.2 Present Activities of Perambur Workshop

(1985/86)

Items			Outturn
Coaches	POH of coaching stock	(units/day)	13.5
	Corrosion repair of coaches	(units/month)	70
	Rehabilitation of 1st class coaches	(units/year)	90
	Conversion for Mid-on-Generation	(rakes/year)	6
Wagons	POH of goods stock	(units/day)	22
	Corrosion repair of BOX wagons	(units/month)	25
	Corrosion repair of four wheelers	(units/month)	165
	Conversion of BOX'R to BOX 'C' BOX to BOX 'T' BRH to BRH 'T'	(Wagons/month)	15
Miscel-laneous	Manufacture of vestibules	(Nos./month)	200
	Repair of shock absorbers	(Nos./month)	876
	Manufacturing of wheelsets	(Nos./month)	60
	Welding of tyre flanges	(wheels/month)	45

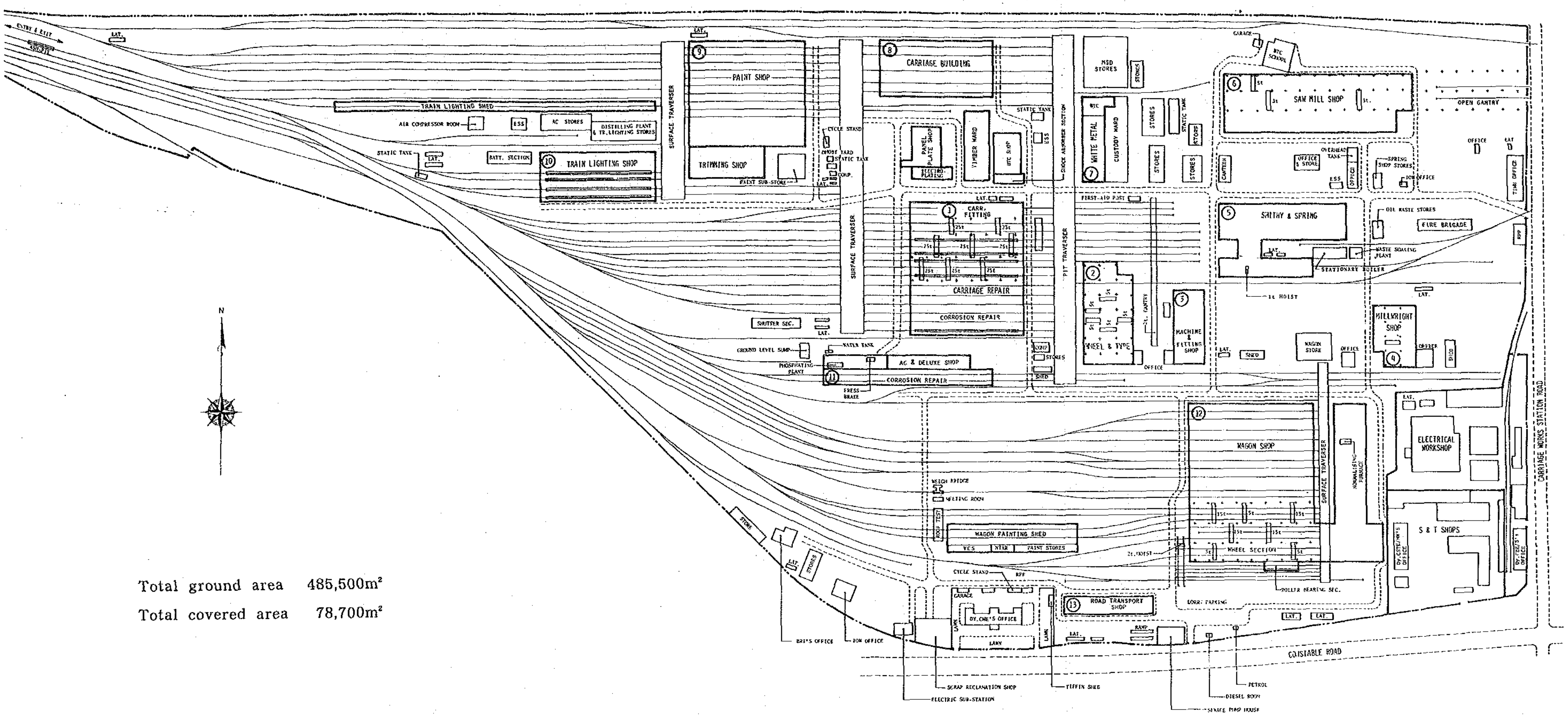
This workshop currently has the POH capacity for 7 coaches and 22 units of wagons per day.

When considering the increase in the number of rolling stock from the growth of railway transport volume in the future, there will bound to be a big shortage in the present POH capacity.

On the other hand, the corrosion repair of coaches greatly hinders the smooth flow of general POH work and the layout of the workshop as a whole should be reconsidered.

In line with the measures for improving the passenger service through the increase in AC coaches, the need for inspection and repair techniques for these coaches and the consolidation of corresponding equipment have become a pressing requirement.

The upgrading of rolling stock quality and improvement in productivity are very important not only for workshop modernisation but also for the Railways as a whole from the point of effective use of rolling stock and improving the transportation quality, making early improvement necessary.



Total ground area 485,500m²

Total covered area 78,700m²

Fig. 6. 1. 1 LAYOUT OF PERAMBUR WORKSHOP

6.1.2 Workshop Management

(1) Organisation of the workshop

The organization of the workshop is as shown in Fig. 6.1.2. There are four large sections under the C.W.M. which are controlled by the Works Manager (Plant), Production Engineer, Works Manager (Carriage) and Workshop Personnel Officer.

In these sections there are 12 shops and 3 offices, making up the entire workshop organisation.

Of these, the main shops directly related to POH of carriages and wagons are controlled by the Production Engineer and Works Manager (Carriage). Aside from these, there is an electrical shop controlled by the Additional Chief Electrical Engineer (A.C.E.E.) for the electrical parts of rolling stock and the electrical equipment installed in and outside the workshop.

(2) Personnel

The total personnel at the Perambur Workshop has currently reached the scope of 8,850 persons as shown in Table 6.1.3, including 22 at the Basic Training Centre, 34 in the Canteen and 247 for the Ministerial.

For the 7,251 general workers in the workshop, excluding the electrical shop, there is a supervisory staff of 529, equivalent to 6.8% of the whole.

The shop organisation, as shown in Fig. 6.1.3, is largely classified into Highly-skilled, Skilled, Semi-skilled and Un-skilled and the supervisory staff is composed of the Shop Superintendent, Asst. Shop Superintendent, Chargeman "A", Chargeman "B", Mistry and others.

The number of persons by grade of the 12 shops, exclusive of the electrical shop, is shown in Table 6.1.4.

Several Shop Superintendents (SS) are assigned to each shop and they control the actual work.

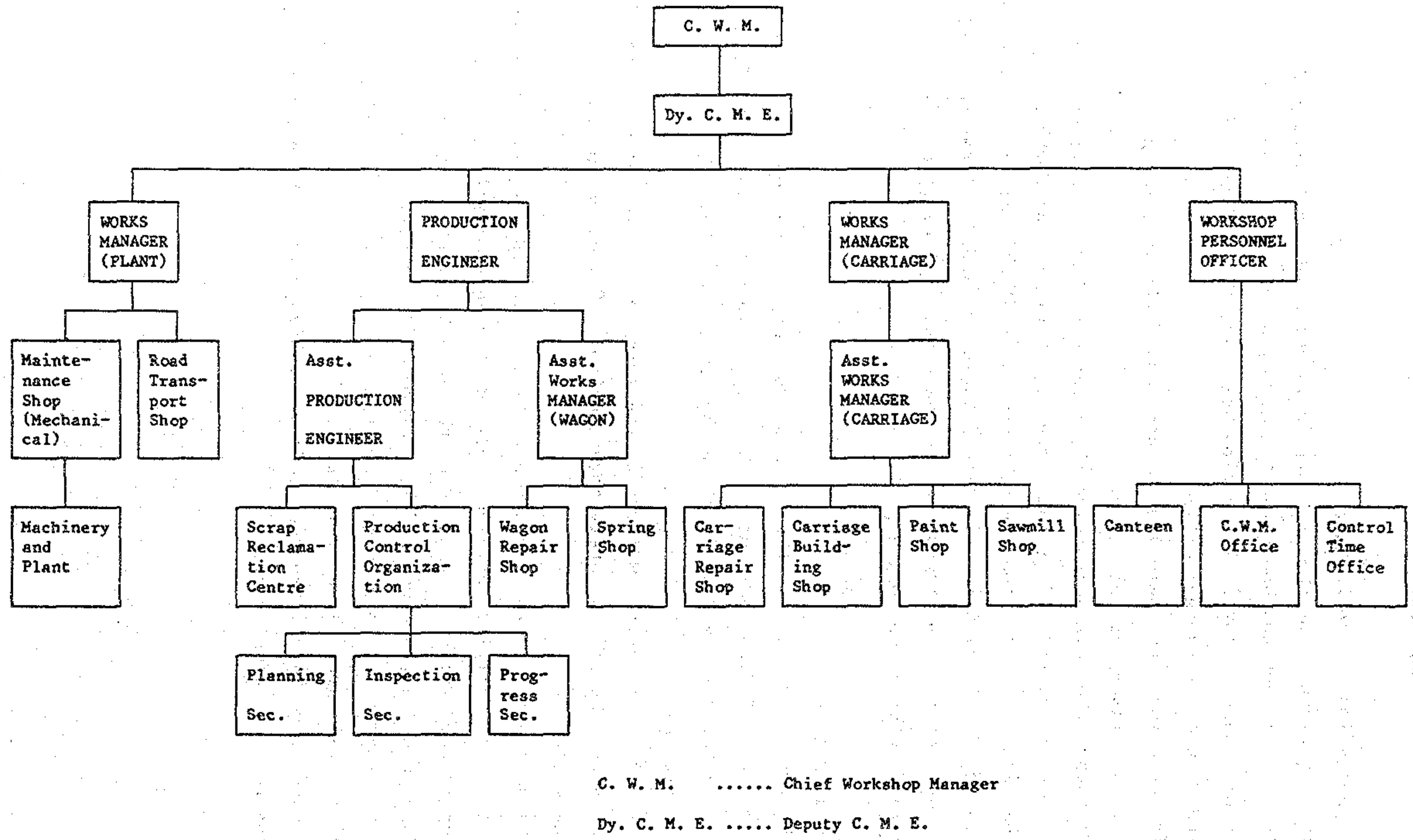


Fig. 6.1.2 Organisational Chart of Perambur Workshop

Table 6.1.3 Kinds of Staff and Worker

	Supervisory	Other than Supervisory	Total
Workshop Staff	517	6910	7427
Basic Training Centre	2	20	22
Canteen	1	33	34
Ministerial	9	288	297
	529	7251	7780
Electrical	-		1070
		Total	8850

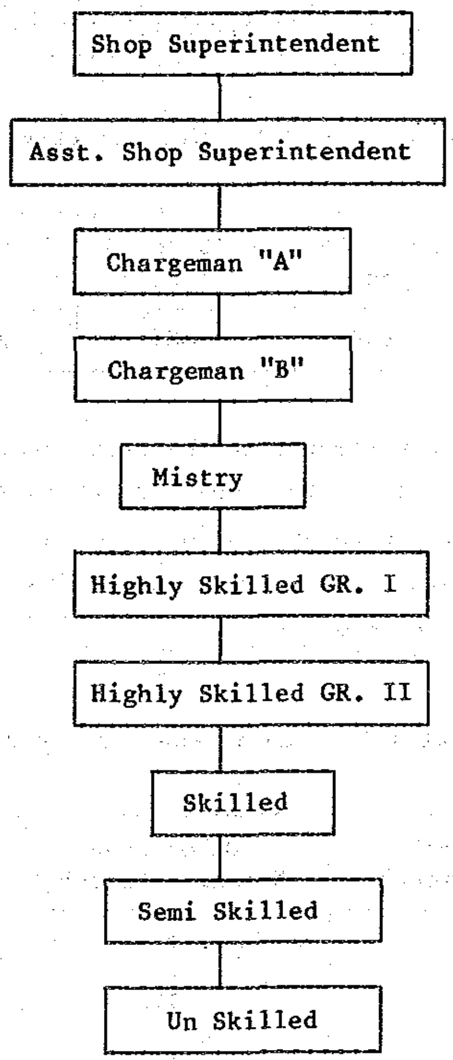


Fig. 6.1.3 Details of Organisation

The average length of service of the personnel at this workshop is shown in Table 6.1.5 and as can be seen from the table, those with 10 to 20 years of service are rather small in number while the greater part consists of those with more or less years of service.
These facts show that there is the need to strengthen the technical capability of the staff with intermediate length of service by the time of the sizable retirements to come.

Table 6.1.4 Manpower of the Shops in Perambur Workshop

	Supervisor					Artisan					Total
	SS	ASS	CH/man "A"	CH/man "B"	Mistry	H.SK -I	H.SK -II	SK	S.SK	U.SK	
12 Shops	42	97	128	141	112	1,382	1,818	2,209	887	611	7,427

Table 6.1.5 Length of Service of Personnel

Less than 10 years	10 to 15 years	15 to 20 years	20 years and above
3,532	899	485	2,856

Table 6.1.6 shows the retirements in the past several years.
Approximately 2.5% of the entire number retire in a year.
Of this number, normal retirements account for about 70% of the total, and of the remainder, many were due to death, etc. and the ratio of job quitting is very low.

Table 6.1.6 Number Retired in the Past Three Years

Year	Normal Retirements	Other than Normal retirements	Total
1984	168	61	229
1985	148	71	219
1986	186	64	250

(3) Service

The service situation at this workshop is shown in Table 6.1.7.

Table 6.1.7 Working Day/Hour

Items	Days/hours
Working days per year	291
Annual attendance rate of workers	85%
Working hours per week (Shop)	45
Annual average working hours per worker	2,328

6.1.3 Education and Training

(1) Present state of education

1) Education and training at Southern Railway

The departmental education in the Indian Railways, as stated in the outline of Para. 3.3.2, is carried out by the four centralised institutions and the approximately 160 training schools and centres located throughout the nation. The Southern Railway also undertakes education at these Zonal Training Schools and System Training Schools for the personnel in Group "C" and Group "D". The main courses of education and training in these training schools and centres are shown in Table 6.1.8.

Table 6.1.8 Main Courses of Education and Training

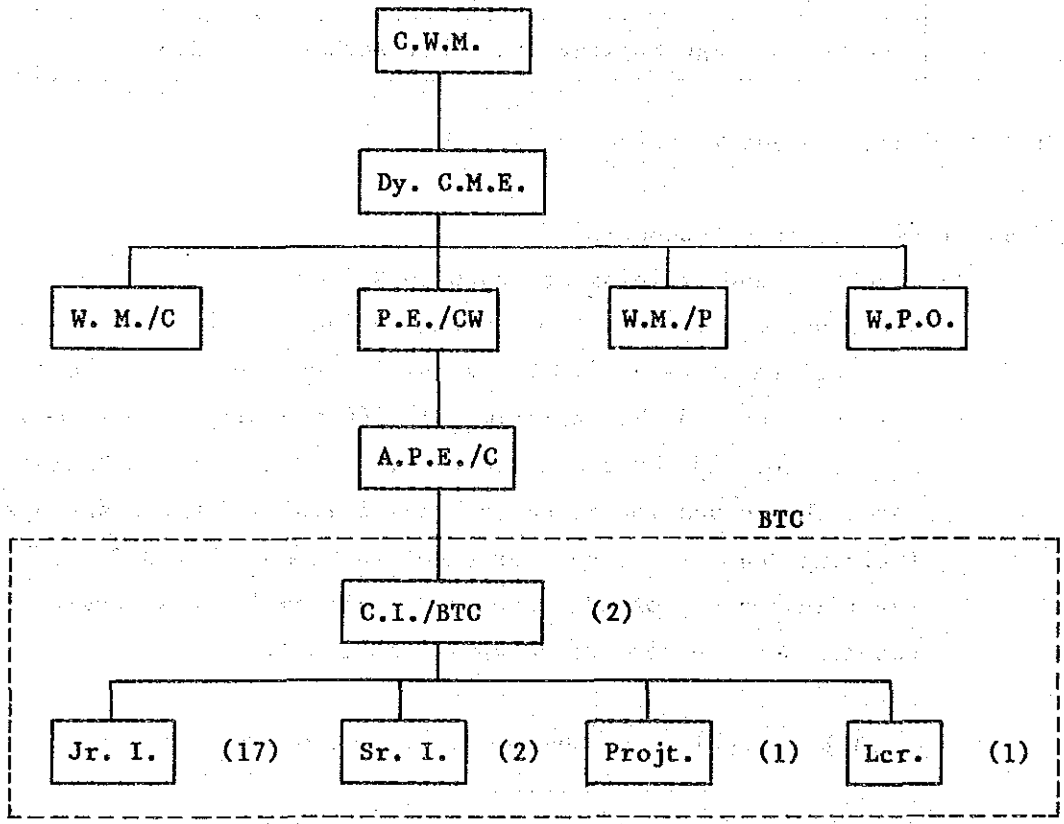
1) Initial and induction training
2) Refresher training
3) Promotional training
4) Other adhoc specialised training

An education and training school called a Basic Training Centre (BTC) has been placed in the Perambur Workshop, as shown in Fig. 6.1.4, to carry out training of workers in each shop for acquiring knowledge on new techniques and for maintaining the technical skill level of the shops. Besides, education for promotion or job changeover, etc. are also conducted to upgrade the workshop personnel.

2) Organisation of BTC

The BTC organisation of the Perambur Workshop is as shown in Fig. 6.1.5. Although it is placed under the management of C.W.M., it substantially is directly controlled by the Production Engineer (Carriage & Wagon).

The main staff of the BTC are two Chief Instructors (C.I.) and two Senior Instructors (Sr.I.) and under them are 17 Junior Instructors (Jr.I.), Projectionist and others, making up a total of twenty-odd members.



W.M./C .... Works Manager/Carriage
P.E./CW ... Production Engineer (C&W)
W.M./P .... Works Manager/Plant
W.P.O. .... Work Personnel Officer
A.P.E./C .. Asst. Production Engineer

C.I. ..... Chief Instructor
Jr.I. .... Junior Instructor
Sr.I. .... Senior Instructor
Projt. ... Projectionist
Lcr. ..... Lascar

Fig. 6.1.4 Organisation Chart of BTC

3) Education at BTC

The BTC of the Perambur Workshop was opened in 1958 to undertake five-year basic education and practical training courses so that the workers of all the different shops in the Perambur Workshop could become skilled workers (SK).

Act apprentice education was added to the education courses after 1965 in accordance with the Act Apprentices promulgated in 1961.

The main stay of the education and training at BTC is centered in the technical skill training for carriage & wagon inspection/ repair work and mastery is achieved by suitably alternating theoretical education and practical training.

These apprentices are basically Act Apprentices not connected with Indian Railways and after free education for about three years, those passing the examination are given priority to work at this workshop.

Besides the foregoing, BTC offers high level courses for skilled workers for promotion within the Indian Railways, refresher courses and changeover courses for those discharged from the armed forces.

The major education and training courses are shown in Table 6.1.9 but besides the three-year course for Act Apprentices, most are crash courses of less than one year.

Table 6.1.9 Major Training Courses

Training to Act Apprentices (1962 Act) to appear NCVT Exam. both Practical and Related instructions	Year
2. App./Ass - Training	1 year
3. App./Chargeman 'A' - training	1 year
4. App./Mechanic (Diploma) Chargemen 'B'	1 year
5. App./Mechanic (N. Dn.) 25% Quota from Skilled	2 year
6. App./Technical (Act)	1 year
7. Graduate Apprentice (Act)	1 year
8. App./TXR (Division)	9 months
9. Pre-promotional Course for SC/ST employees (Artizan)	1 month
10. Inservice Training from Khalasi to skilled-grade	1 year
11. C&W Training from Division	2 year

Actual results of the education and training for 1985 - 1986 at the BTC are shown in Table 6.1.10 and they show that there were 87 Indian Railways personnel and 248 outsiders. BTC also accepts trainees from other divisions.

4) Educational dispatch to other organs

In regard to educational courses not set up in Perambur Workshop's BTC, it is possible to assign education to other institutions within the Indian Railways and personnel can be dispatched to the following to maintain and improve the technical skill.

- IRIMEE (Indian Railway Institute of Mechanical & Electrical Engineering)
- ICF (Integral Coach Factory)
- RDSO (Research, Designs and Standards Organisation)
- ATI (Advanced Training Institute)
- And others.

The contents, etc. of the education are shown in Table 6.1.11.

Table 6.1.10 Basic Training Centre, Carriage & Wagon Works
Training Particulars of Apprentices and Other Trainees

Division		Trade						Non Trade	Total No. of Trainees	Duration of Training	REMARKS
		Fitter	Turner	Mecha-nist	Car-penter	Black Smith	Welder				
Training for Outsiders (Non. Rly. Training)	ACT/APP'S CW	87	4	10	47	4	15	-	167	3 Years	NOTE. DH=DIPLOMA/HOLDER
	ACT/APP'S AJJ	4	4	5	-	4	2	-	19	2 Years for welders	GR.ENGG. GRADUATE
	ACT/APP'S EW	-	-	-	-	-	-	-	1		
	TECH/APP'S D.H.	-	-	-	-	-	-	17	17	1 Year	Already left on 14.2.87
	TECH/APP'S/	-	-	-	-	-	-	-	1		
	DEF/PER'S	9	13	14	-	-	7	-	43	9 Months	
		SK.ARTI-SAN.	APP/ MECH. TXR/DH.	APP/ MECH. TXR.NDH	ASS/ CTXR/ GRADUATE						
Training for in service (Absorbed in Rlys.)	Carriage &	16	19	18	2				17	3 Years for Sk.Artisan	NOTE. N.D.H.= NON DIPLOMA HOLDER.
	Loco	1							39		
	MAS	22	3	-	2				22		
	MDU	-	-	2	-				5	2 Years for APP/MECH.H.	
	TPJ	-	-	-	-				2		
	MYS	-	-	-	-				-		
	TVC	-	-	1	-				1	1 Year for GR. APP'S.	
	PGT	-	-	-	1				1		
				SUMMARY AS ON 19.2.1987							
Outsiders In Service	Total No. of APP's			248	43	203					
	Total No. of in service.			87		87					
	(Absorbed in Rlys.)			335		290	(19.2.87)				

5) Dispatch overseas for training

The Indian Railways dispatch personnel not only to IR departments or domestic manufacturers, etc. but also to various foreign countries for education in new techniques. The Perambur Workshop has also sent personnel in recent years, as shown in Table 6.1.12, for the introduction of new techniques or improving the technical level of inspection and repair of rolling stock.

Table 6.1.11 List of Training Facilities Available for Workshop Employees

Name, Location, training course		Capacity	
1.Shop Supdt. Refresher Course for s.s. at IRIMEE/JMP.	2 Batches per year.	2 Staff per batch.	1.5 months
2.Ass Promotional course for Ass at DRIMEE/JMP.	- do -	- do -	1.5 months
3.Open Line course for Sr. Subordinates. IRIMEE	1 Batch per year.	- do -	1.5 months
4.Training of staff in the Maintenance of ICF Built coaches at ICF/PER.	3 Batches per year.	Min. 10 staff per batch.	1 month
5.Refresher course in Foundry Tech. and Metallurgy at JMP (Chargeman, ASS, SS & Lab. Supdt.).	Min. 6 Batches per year.	2 Staff per batch.	1.5 months
6.Training of Personnel in Ultrasonic Testing of Axles at RDSO/LKO (CMA's of LW Shop).	Min. 4 batches per year.	2 Staff per batch.	1 month
7.Advanced Training Institute at Guindy -(for ASS/Chargeman 'B'/App. Mech./Jr. Instructor etc.) Design of Gauges, Inspection fixtures, Machine Tool Maintenance.	Min. 6 batches per year.	2 Staff per batch.	1 month
8.Orientation course for Senior Subordinates of Machinist at (LF, LI, FO'A'/FD/STS VADODARA Inspector, TXR/HTXR.)	2 Batches	4 Staff per batch	15 days
9.Workstudy and G&M Apreciation course at JMP.	4 Batches per year.	3 Staff per batch.	10 days
10.Fuel Economy Initial Course at JMP.	Min. 2 Batches per year	3 Staff per batch	2 months
11.Diesel Supervisors Course at JMP.	Min. 9 Batches per year.	2 to 3 staff per batch.	5 weeks 8 weeks 4 weeks 3 weeks depending upon the Nature of course.
12.Training of other Railway Staff in Welding Tech. at ICF/PER.	Min. 9 Batches	3 Staff per batch.	1 month
13.Fuel Economy Refresher Course at JMP.	Min. 2 Batches per year.	3 Staff per batch.	1 month

Table 6.1.12 Actual Results of Dispatch Overseas for Education

Sl. No.	Year	Place of Training	Type of Machine	No. of trainees
1.	1982	U.K.	CNC vertical Boring Machine	Programmer -1 Mechanical Maintenance -1 Electronic/Electrical Maintenance -1
		Germany	MFD Wheel Press	Mechanical Maintenance -1 Electrical Maintenance -1
		Germany	Hegensheidt Underfloor Wheel Lathe - (at KJM)	Mechanical Maintenance -1 Electrical Maintenance -1
2.	1983	Japan	CNC Axle Turning Lathe	Programmer -1 Electrical/Electronic Maintenance -1
				Mechanical Maintenance -1

* Duration of Training -6 weeks.

6) Education facilities:

The BTC of the Perambur Workshop is composed of two buildings, one is a very old two-storied building consisting of a teaching staff room, classrooms, small library, audio visual room, store room, etc. and the other a steel-frame one-storied building with an auditorium.

The theoretical education utilises these facilities and the practical training is imparted in the shops and the training rooms provided with mechanical equipment.

Furnaces, welding machines and machine tools are installed in accordance with each practical training course but they do not sufficiently match the requirement. The superannuation of the practical training equipment, etc. such as machine tools, etc. is especially noticeable and, except for the video system, a delay is seen in the introduction of new and effective educational equipment or training methods.

6.1.4 Rolling Stock Inspection and Repair Facility

(1) Facilities of coach inspection and repair

The present facilities of inspection/repair of coach are, as shown in Fig. 6.1.5, based upon the repairing system to transfer carbody by three traversers.

The largest problem now in repairing coach is carbody corrosion which require many days for repair, and as a result, 30% of the coach in the workshop are being stabled at the stabling tracks shown below the Trimming Shop in the Fig. 6.1.5. The present state of facilities of repair are described below in detail based on the site survey.

1) Layout of work area

Coach entering the workshop for repair is led to In-coming Inspection Shed at first and inspection is carried out here.

As a result of the inspection, the coach with corroded carbody is transferred by two surface traversers to any of the three corrosion repair tracks, each of which is laid in the Carriage Building Shop, Carriage Repair shop, and AC & Deluxe Shop. And when the carbody repair is over, the coach is transferred to Carriage Repair Shop by shunting locomotive and surface traverser, and bogies are exchanged with repaired ones here.

The coach without corroded carbody is transferred to the Carriage Repair Shop from the In-coming Inspection Shed and light repair of carbody and exchange of bogies with repaired ones are carried out here.

After exchange of bogies is over, the coach is transferred to the Painting Shop by surface traverser, and painting of carbody is carried out here. After this, vestibule and seat are assembled to the carbody and then transferred to the Out-going Inspection Shed by surface traverser and here setting of lightings and final inspection and adjustment are carried out.

These are explanations of the layout of work area related to the body repair, and other than these, Wheel Shop is located at the opposite side of the Bogie Repair Shop across the pit traverser.

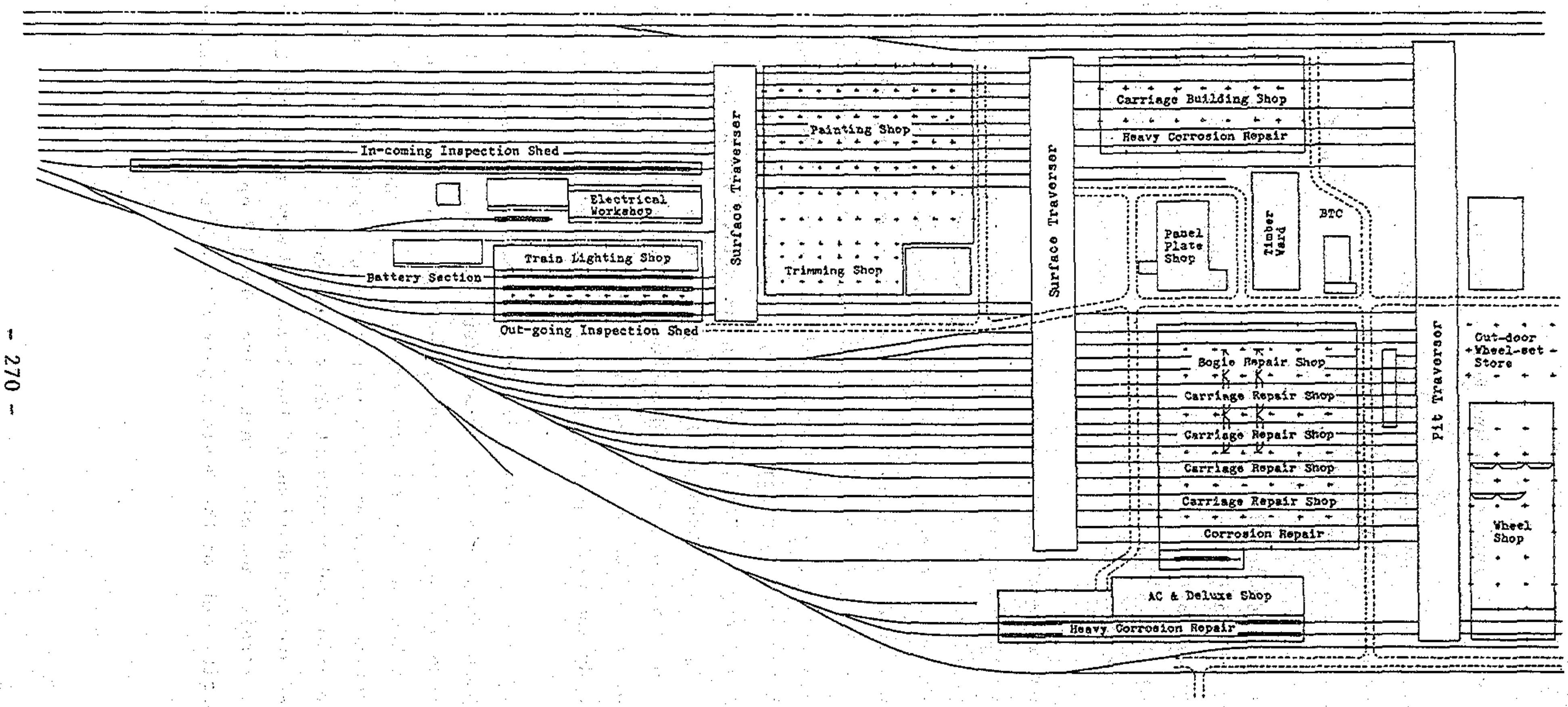


Fig. 6.1.5 Existing Carriage Repair Shops

Mentioned above is the present state of layout of the real work area, but the problems concerning layout of the work area when considering increase of number of coach to be repaired in future is as follows:

a) Holding capacity of carbody in the Carriage Repair Shop is too small even now.

b) There are no EOT cranes in three bays of building of Carriage Repair Shop.

c) There is only one track for adjustment of deluxe coach, and its capacity is too small.

2) Machinery and others for coach repair

a) Carriage repair shop building

In this building, 5 bays are used for repairing carbody of coach, but 3 bays out of 5 are not provided with EOT cranes. To increase the capacity of repair for the future demands, this condition will become a serious bottleneck. Area of Bogie Repair Shop is too small even at the present. Bogie Parts Repair Shop can be provided with overhead travelling crane during its construction, but it has no EOT crane.

b) Carriage building shop building

There is no special problems in the facilities related to the present repair work of corroded carbody.

c) Painting shop building

At present, manual painting with brush is adopted for carbody painting, but in future, if adoption of mechanised painting work is intended, it will be necessary to construct an additional building between the shop and traverser.

d) Bogie repair shop

This work area is very narrow and the floor is too dirty to keep a good working condition. There is caustic soda bath for cleaning bogie frame outside, but its capacity is too small to clean the number of the bogies to be cleaned in a day. Moreover, cleaning facilities for small parts is also insufficientt.

e) Wheel shop

Recently, improvement work of Wheel Shop has been completed and the Shop and its repair facilities are in good condition. But, work process of flaw detection of wheel set does not form a flow line and it will be improved hereafter. It is considered that the number of wheel sets to be repaired will increase by 50% according to the increase in the number of coach and 8-wheeler wagon, and it is necessary to increase and improve the capacity of repair facilities.

f) Roller bearing repair shop

The Roller Bearing Repair Shop has sufficient facilities and layout of the facilities is very good. But, as in the case of the Wheel Shop, increase of facilities should be made at the same time of improvement of the Wheel Shop.

g) Electrical workshop

The equipment used for repair in this Shop is generally old and the number of equipment is insufficient and work area is narrow and working condition is not good.

(2) Facilities of wagon inspection and repair

The present facilities for repairing wagon is shown in Fig. 6.1.6, Wagon Shop building with eight bays which are laid parallel, Wagon Painting Shop, Tank Wagon Washing Shed, and Wagon Smithy Shop which is built at the other side of the Wagon Shop across the surface traverser. The present facilities do not only have many problems on repair of wagon, but it also has basic deficiencies in the system of repair of 8-wheeler wagons which will be used in greater numbers in the future. The present state of facilities for wagon repair is described in detail below based on the site survey.

1) Layout of work area

At is shown in Fig. 6.1.6, surface traverser is provided at the back end of five bays of 4-wheeler wagon repair shop and the repaired wagon is sent into the repair shop bay where overhead travelling crane is provided, from the back end of the building.

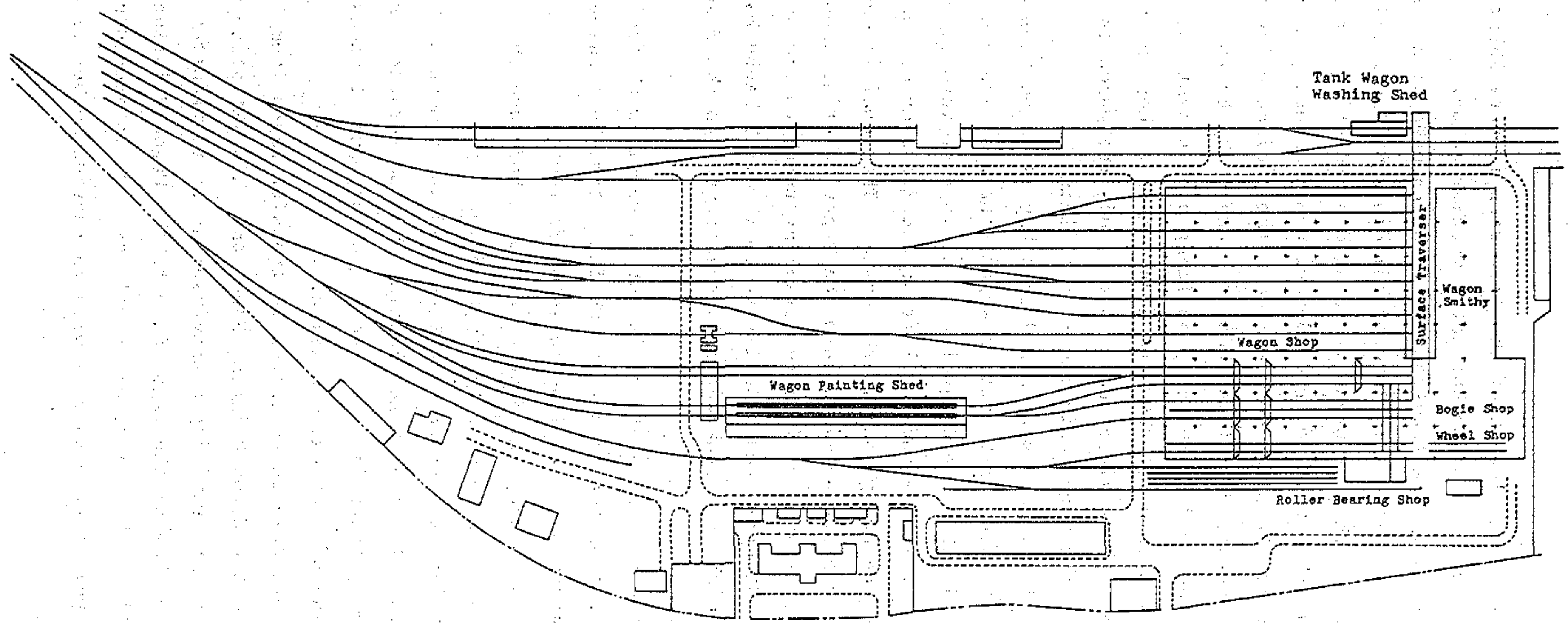


Fig. 6.1.6 Existing Wagon Repair Shops

Nevertheless, the length of the traverser is very short and it can transfer 4-wheeler wagon but not 8-wheeler wagon.
Further, even if the traverser is to be changed with a new large one, the layout and structure of buildings will not allow this.
At present, 4-wheeler wagon is shunted by shunting locomotive into the repair shop bays not provided with EOT crane, and the body of the wagon is stripped and repaired without dismounting wheels.
The wagon repaired in this shop is transferred by the traverser from the back end of the shop building and is sent into the repair shop bay provided with EOT crane and in this shop the wheels are exchanged with repaired ones. After this the wagon is sent by winch into the Wagon Painting Shop building.
The 8-wheeler wagon is repaired in a bay of Wagon Shop which is exclusively used for 8-wheeler wagon repair having provided with EOT crane in it. The 8-wheeler wagon is sent into the bay by shunting locomotive and the lifting and transfer of carbody for repairing are being done by the crane. The repaired wagon is transferred by using winch into the Wagon Painting Shop building.
Tank wagon is shunted from the stabling track to the surface traverser directly and transferred to the Tank Wagon Washing Shed.
After washing, the tank wagon is transferred to the Wagon Shop by traverser.
This is the present state of layout of repair work facilities, and the problems on the layout of the facilities in consideration of future repairing work of wagon is as follows:

a) There is no shop building to strip carbody and the stripping work is being done in the Wagon Shop.
b) The surface traverser cannot be used for 8-wheeler wagon.
c) The track for Tank Wagon Washing Shed is separate from the in-coming track lines to the Wagon Shop and it makes the shunting of tank wagon difficult.
d) There are only three tracks to transfer wagon from the Wagon Shop to the Wagon Painting Shed, and this situation will be improved by providing a traverser so as to transfer the wagon from any bay of the Wagon Shop to the Wagon Painting Shed directly. This improvement will be made in accordance with the new repair system to cope with increasing number of 8-wheeler wagon.

2) Machinery and others for wagon repair

a) Wagon shop building

At present, EOT crane is not provided in the repair shop bay of 4-wheeler wagon and this causes difficulties in handling heavy materials in this shop.

Therefore, exchange of coupler, wheel set, and axle box ought to be done in other bay after the wagon is being transferred to the other shop bay. The capacity of the crane provided in the Wheel Shop is 5 tons and the building cannot be used for repairing carbody at present and in future.

b) Tank wagon washing shed

The facilities for washing wagon are properly equipped, including boiler, but track layout leading to this shed is not appropriate and makes the shunting work of wagon difficult.

c) Wagon painting shed

In this shed, two tracks with inspection pits are provided. Originally, this Shed was used for painting carbody, but now it is used for adjustment and touch up of repaired wagon before leaving workshop and it is observed that the work floor, inspection pits, and tracks are in poor condition.

d) Bogie shop and Wheel shop

The Bogie Shop is divided into two work areas of light repair and heavy repair, and it is inconvenient to use the work area commonly. Besides, in the present wheel set repairing method, exchange of tyre and/or axle is being done in the Wheel Shop of Carriage and in this Shop only tread profiling of wheel is being executed.

e) Roller bearing shop

Facilities for repairing roller bearing in this Shop seemed much inferior than that of coach. It is necessary to improve the facilities as fast as possible in order to meet the demands of repair of increasing number of roller bearings.

f) Parts washing facilities

Washing facilities of stripped parts now is incomplete and guarantee of quality of repaired parts cannot be ensured. Adoption of washing plant is required expeditiously.

(3) Buildings and Other Facilities

The present building and facilities in Perambur Workshop are in inferior condition and the capacity of facilities cannot cope with the increasing work volume in future. At present, lack of work floor area is a serious bottleneck.

The present state is described below based upon the site survey.

1) Premises of the Workshop

The premises of the Workshop is vast and distance between buildings is great, but this good condition is thought to be a cause of the improper disposal of the scrap in the workshop. Scrap is scattered and piled in any vacant area in the premises of the Workshop, and in somecases, passages and tracks are buried under the scrap. Side trench of road and building is not provided in this Workshop and rain water flows into the building often cousing work suspension.

2) Track

Generally, track maintenance is poor: i.e., irregularity of alignment and height of rail, partial sinking of track, projectio of guard rail, and buried sleeper are observed at places.

3) Building

Building is mainly of steel structure and have brick wall, and the structure of the building is in good condition but roof and wall, mainly composed of asbestos slate and steel plate, are in need of repair.

Condition of floor surface of the building is very bad, especially in Wagon Shop: mud, rust, and oil are accumulated and cover all over the floor and it hinders the movement of the trolley and carrier into the work area of the Shop.

Lighting and illumination in the building are generally insufficient and work environment is poor.

4) Water supply and drainage

Drinking water is supplied from municipal water supply pipe, but as to other water for work, rain water on the roof of buildings in east half of the Workshop is utilised and drawn to the reservoir provided outside of the Workshop. The collected rain water in the reservoir is filtered and used for work. Rain water on the roof of the building in west half of the Workshop flows into the municipal drainage through main drainage of premises of the Workshop.

But, drainage facility of rain water on the ground is not well provided.

5) Power supply facilities

The capacity of sub-station is 5,750 kVA at present, and demands for this Workshop is about 2,600 kVA and there is 50% allowance. But capacity of No. 6 sub-station has no allowance against demands, and it is necessary to install one transformer additionally.

Further, existing 8 oil circuit breakers are overaged and it is necessary to exchange them with new ones. Not only this, almost all the equipment in the substation are very old and they should be exchanged with new ones in near future.

6.2 Modernisation Plan for Rolling Stock Inspection/Repair

6.2.1 Present Rolling Stock Inspection/Repair System and Problems

At present, the Perambur Workshop inspects about 1,800 coaches and about 4,400 wagons a year. A rapid increase is expected in the number of coaches, and the estimated number of coaches that the workshop is likely to inspect in the year 2000 is about 3,000. Among this, the number of air-conditioned coaches (AC coach) inspected will almost quadruple the current number.

On the other hand, as a result of converting from 4-wheeler wagons to 8-wheeler wagons, the number of 8-wheeler wagons to inspect/repair will about double the current number.

The following describes the problems of the current inspection/repair process and of the process control.

(1) Characteristics of coach-wagon inspection/repair in Perambur Workshop

This is a historic workshop established about 130 years ago. Since the establishment, no major facility improvement has been made and the equipment level is extremely low. Since the number of carriage repair shops equipped with an overhead traveling crane (EOT crane) is limited, a number of cars are kept waiting for repair at various spots. A large number of coaches are kept outdoors, and it is considered that the current state is at the limit of the repair capacity. One special condition due to the coach structure is that the workshop must execute a large amount of corrosion repair on the coach body panels. Many days are spent replacing the coach body panels, and this is a major element that restricts the inspection/repair capacity of the Perambur Workshop. Due to this fact, the Perambur Workshop is obliged to entrust the inspection/repair of the 250 to 300 corroded coaches annually to the next Loco Works.

The same comment applies to the body panels replacement work for 4-wheeler wagons, and this is the largest factor that prevents the

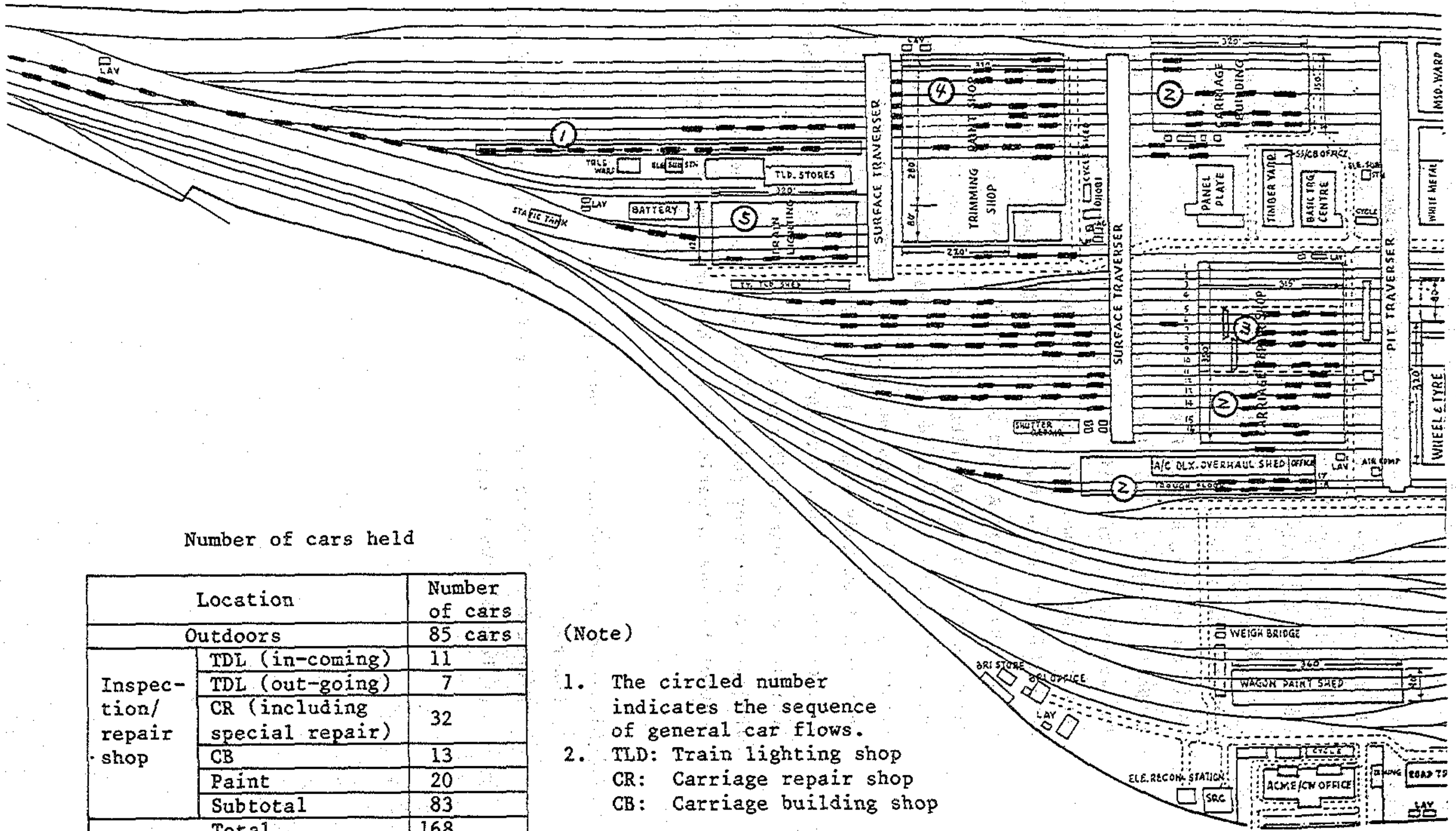
reduction of the inspection/repair cycle time. The work volume (number of days necessary for repair) largely varies between heavy repair and light repair on both coaches and wagons. As described earlier, since the number of buildings in which the vehicle is lifted and moved is limited, a vehicle that can be repaired quickly under ordnary circumstances is often not completed quickly by not passing over other vehicles needing a long time for repair. This makes the overall inspection/repair time of the Perambur Workshop very long.
The majority of the unit exchange spare parts, which can significantly reduce repair time, are not adequetly arranged (except wheels etc.) Accordingly, the workshop is forced to repair the currently used parts or cannibalise parts from other vehicles of the same type.
Being an old workshop, little of the floor in the work site and passages in the premise is paved. This is a great handicap for effective use of various handling equipment. In addition, scraps generated from body panels replacement are piled up in many places, and some of them are left even on the tracks, disturbing smooth movement of vehicle to be inspected/repaired.
Thus, there are many points to be improved. The current process control in classification of coaches and wagons is described below.

(2) Situation and problems of repair process

1) Coaches

Figure 6.2.1 shows the layout of the coach inspection/repair site of Perambur Workshop.

(as of March 3, 1987)



Number of cars held

Location		Number of cars
Outdoors		85 cars
Inspection/ repair shop	TDL (in-coming)	11
	TDL (out-going)	7
	CR (including special repair)	32
	CB	13
	Paint	20
	Subtotal	83
Total		168

(Note)

1. The circled number indicates the sequence of general car flows.
2. TLD: Train lighting shop
   CR: Carriage repair shop
   CB: Carriage building shop

Fig. 6.2.1 Layout of Coach Inspection/Repair Site and Car Holding State in Perambur Workshop

A coach enters the workshop site from the drawing left side and is checked for deficiencies, electrical and other parts being unloaded in the train lighting shop (TDL (in-coming)). After that, the coach is moved to a carriage repair shop (CR shop) and carriage building shop (CB shop) or to a special repair shop for body repair and corrosion repair. In the CR shop, carriage lifting crane is installed to handle coaches on 4 lines (total 12 coaches). The crane is used for lifting, bogie exchanging, inspecting coach bottom, and for lowering.

The repaired coach is painted in the paint shop and then sent to the train lighting shop (TDL (out-going)) for loading of electrical and other parts and final finishing. AC coaches are sent to CR shop #16 for loading and final finishing since they must be loaded and finished in a different way from ordinary coaches.

Corrosion on coaches is treated anywhere in the CR, CB, or special repair shop. At present, about 30% of the total coaches inspected must be given the corrosion treatment, and this work requires a long time. Nevertheless, since the ability of moving one coach over another is very limited, coaches are not moved quickly from one process to the other, resulting in a great number of coaches being held in the stabling lines. Table 6.2.1 shows the number of coaches held in various spots in the workshop.

Table 6.2.1 Number of Coaches Held in Plant (6 days)

Month and day		3/2	3	4	5	6	7	Average
Number of coaches held outdoors (A)		70	85	95	78	83	69	80.0
Number of coaches held in shops	TLD (in-coming)	8	11	9	9	8	10	9.2
	TLD (out-going)	8	7	9	13	15	4	9.3
	CR	24	24	25	22	25	25	24.2
	Special repair shop	8	8	9	9	7	7	8.0
	CB	13	13	13	12	9	10	11.7
	Paint shop	16	20	24	25	28	29	23.6
	Subtotal	77	83	89	90	92	85	86.0
Total (B)		147	168	184	168	175	154	166.0
Ratio of coaches held outdoors (A)/(B)		48%	51%	52%	46%	47%	45%	48%

(Note)
1. TLD: Training lighting shop
2. CR: Carriage repair shop
3. CB: Carriage building shop
4. About half of the coaches are long time stabled coaches.

As the table shows, about half of the coaches in the workshop are held outdoors.

It is considered that this is attributable to lack of facilities and lack of flexible movement of the coaches.

Although the shops can accommodate a total of 120 coaches, only about 70% of the capacity is utilised. Table 6.2.2 shows the holding capacity and the condition of use.

Table 6.2.2 Coach Holding Capacity of Each Building

Shop building	Scale	Capacity (number of coaches)	Average number of coaches held	Average use ratio	Remarks
TLD (in-coming)	11 (coaches) x 1 (line)	11	9.2	84%	
TLD (out-going)	4 (coaches) x 4 (lines)	16	9.3	58%	
CR	3 (coaches) x 10 (lines)	30	24.2	81%	Excluding #6 and #9
Special repair shop	5 (coaches) x 2 (lines)	10	8.0	80%	
CB	1 (coach) x 2 (lines) 3 (coaches) x 1 (line) 4 (coaches) x 2 (lines)	13	11.7	90%	Excluding parts shop
Paint shop	4 (coaches) x 10 (lines)	40	23.6	59%	
Total		120	86.0	72%	

The causes for utilising only about 70% of the capacity of each building and having about half of the total number of coaches waiting for inspection/repair are as follows:

a) Coaches cannot be moved in accordance with the actual time of repair.

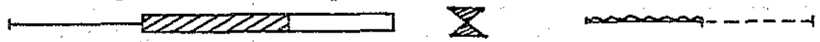
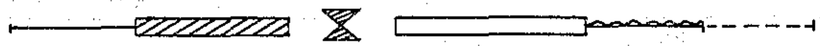
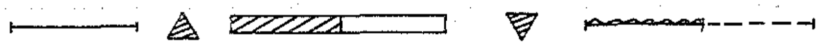
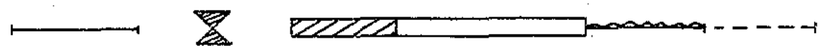
b) The equipment capacity of each shop is unbalanced, slowing work progress, disturbing effective use of overall work site, and preventing smooth repair.

The number of coaches to be inspected/repaired will increase in the future, and the points mentioned must be improved to manage this increase.

At present, the work is begun wherever it can be started with no standard work sequence established. This is inevitable because of restrictions in the equipment and facilities, but it is a serious problem since it complicates the process control and disturbs smooth progress.

Table 6.2.3 and Table 6.2.4 show the inspection/repair patterns and number of days necessary for inspection/repair for corrosion-treated coaches and ordinary repair coaches.

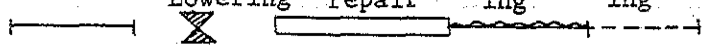
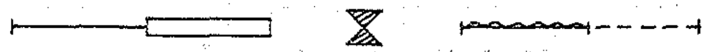
Table 6.2.3 Inspection/Repair Patterns and Number of Days Necessary for Each Task on Corrosion Treated Coaches

Case	Sequence of work	Ratio of occurrence	Remarks
1	Unloading / Corrosion treatment / Body repair / Lifting/lowering / Painting / Loading 	34%	
2		22%	
3		22%	A dummy bogie is used between lifting and lowering.
4		11%	
5		11%	

Number of days	Task	Unloading	Corrosion treatment	Body repair	Lifting and lowering	Painting	Loading
	Max. number of days/Min. number of days	2/1	80/3	12/1	9/2	12/2	3/2
	Max.-Min. ratio	2.0	26.7	12.0	4.5	6.0	1.5

Note: From the investigation of 9 POH cum corrosion coaches

Table 6.2.4 Inspection/Repair Patterns and Number of Days Necessary for Each Task on Ordinary Repair Coaches

Case	Sequence of work					Ratio of occurrence	Remarks
1	Unloading / Lifting/ Lowering / Body repair / Paint- ing / Load- ing 					88%	
2						6%	
3						6%	
Number of days	Task	Unloading	Body repair	Lifting and lowering	Painting	Loading	
	Max. number of days/Min. number of days	4/1	5/1	3/1	4/1	2/1	
	Max.-Min. ratio	4.0	5.0	3.0	4.0	2.0	

Note: From the investigation of 16 ordinary repair coaches

As the above tables indicate, it is extremely difficult to quickly determine the state of progress of inspection/repair on individual coaches, especially coaches requiring corrosion treatment since there are many inspection/repair patterns. Efforts must be made to establish a standard process sequence in order to realise smooth progress.

The facilities for corrosion repair, body repair, and painting must be improved since the number of days necessary for these processes greatly varies by the coach types, affecting the smooth repair schedules of the succeeding coaches.

The present average POH cycle time for all coach types is 15.2 days, as shown in Table 6.2.5. Table 6.2.6 shows detailed analysis of each process.

Table 6.2.5 Present POH Cycle Time by Coach Types

Coach type	Repair type	Ratio of number of coaches	Cycle time (number of days)
Ordinary coaches	Cum corrosion	28%	27.8 days
	Ordinary repair	68%	9.2
Air-conditioned coach	Cum corrosion	1%	41.2
	Ordinary repair	3%	24.4
Average		100%	15.2

(Note) The ratio of corrosion occurrence is 29%.

Table 6.2.6 Actual Results of POH Cycle Time for Coach Repair

Type of coaches and repairs		Number of days for each work							Total
		Survey of deficiencies and unloading	Lifting and lowering	AC parts unloading/ loading	Corrosion treatment	Body repair	Painting	Loading and finishing	
Ordinary Coaches	Cum corrosion	1.7	2.2	-	13.2	5.0	4.1	1.6	27.8
	Ordinary repair	1.3	1.6	-	-	3.0	2.1	1.2	9.2
AC Coaches	Cum corrosion	1.9	3.5	9.3	13.2	5.5	5.8	2.0	41.2
	Ordinary repair	1.6	3.5	9.3	-	4.5	3.5	2.0	24.4

Moreover, each shop, including bogie repair shop, is extremely narrow. This greatly disturbs smooth progress of the work. Also, the washing equipment and testing devices are not at a satisfactory level. Therefore, all equipment and facilities must be reviewed.

2) Wagons

Figure 6.2.2 shows the current layout of wagon repair shop.

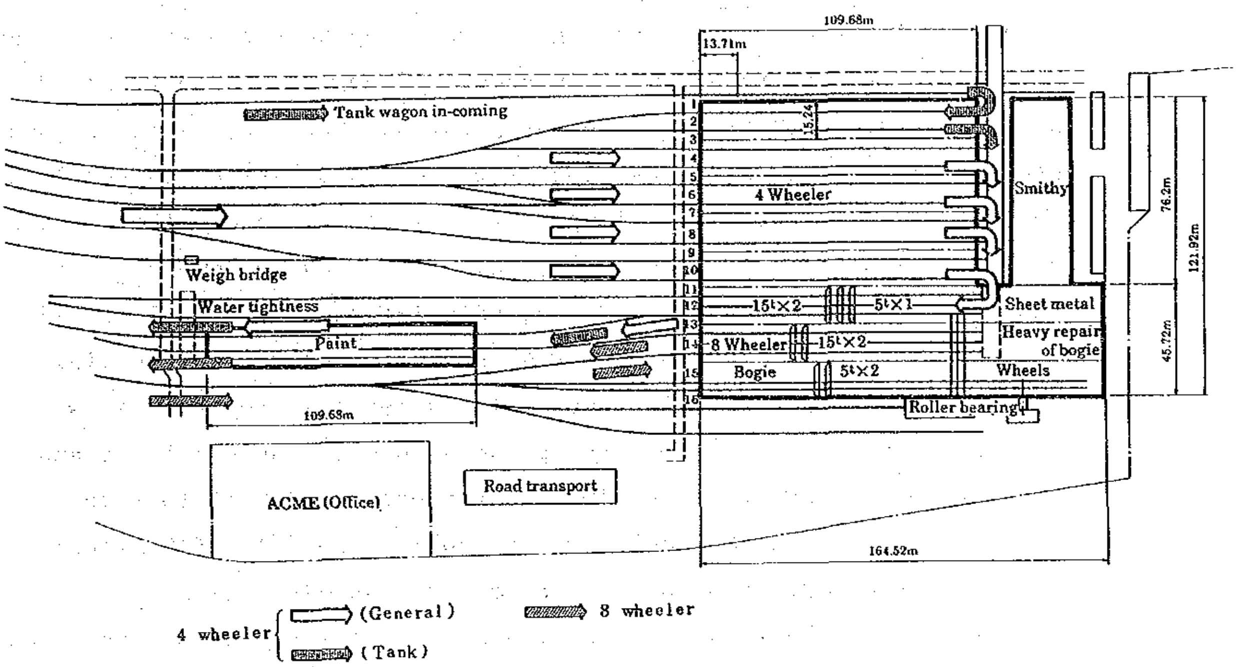


Fig. 6.2.2 Layout of Wagon Repair Shop and Flow of Wagons

At present, all wagon repair work, except heavy repair for wheel set, is conducted in this repair shop. 4-wheeler wagons enter from the drawing left side, and are sorted to repair lines for shops #1 to #10. The inside of a tank wagon is washed at the side of the body repair shop first and the wagon enters line #1 or #2 from the drawing right side through a traverser.

Each line of the body repair shop can hold ten wagons. In this shop, the parts are unloaded and loaded, the body is repaired, and corrosion treatment is given to the body panels with the wheels attached.

Repaired wagons are moved to line #11 or #12 through a traverser shown at the drawing right side, kept on a trestle by an overhead crane, and the wagon bottom is repaired. The body is then lowered to repaired wheels and the wagon is moved to the painting shop. 8-wheeler wagons entering #14 line from the drawing left side, are kept on a trestle by a crane, and all repair work is performed in this state. The bogie and wheels are repaired simultaneously, then, the body is lowered by a crane, and the wagon is moved to the painting shop through line #13.

Not many lines in the wagon repair shop have an overhead traveling crane to hoist the body. A crane is installed only for two lines each in the bogie wagon repair shop and 4-wheeler wagon lifting and lowering shop. Therefore, a winch is the only equipment to move the wagon body in the 4-wheeler wagon repair shop (#1 - #10 lines).

Because of the body structure, problems such as distortion and corrosion of the body panels and bending of the steel frame are found frequently on 4-wheeler wagons, and many days are spent repairing these defects. Also, the number of days necessary for the repair varies greatly by the wagon types.

Since the wagon bodies are moved by a winch on each line (one line holding ten wagons), as mentioned earlier, the wagon cannot be moved forward unless the preceding wagon is moved.

This greatly hampers efforts to reduce the cycle time, especially on 4-wheeler wagons.

As for bogie wagons, the number of crack repairs of bogie frame is increasing, and the repair space is becoming too small. The present bogie repair shop is also used for in-coming and out-going wheels supplied to outstation. This unfavorably affects effective use of the work area. Table 6.2.7 shows the POH cycle time for wagon at present.

Table 6.2.7 POH Cycle Time for Wagon Repair

Wagon type	Repair type	Ratio (Number of wagons)	Breakup of number of days			Total
			Body repair	Lifting and lowering	Painting/ inspection	
4-wheeler	Cum corrosion	33%	11.0 days	1.0 day	1.0 day	13.0 days
	Ordinary repair	44%	3.0	1.0	1.0	5.0
8-wheeler	Cum corrosion	4%	6.0	Included in Body repair	1.5	7.5
	Ordinary repair	19%	3.0	"	1.5	4.5
Average		100%	6.5		1.1	7.6

(3) Current situation and problems of material control and transportation within the workshop premise

The materials Perambur Workshop uses to repair the rolling stock amount to about 2,500 items (excluding electrical parts) and are controlled by the stores depot adjacent to the workshop. This stores depot collectively controls all materials used by the operating organisations of the zonal railway, and it belongs to a different organisation of the workshop.

Even though the materials handled by the stores depot are controlled by importance and monetary value, better inventory control and procurement control methods must be established since the clerical work up to the procurement takes a long time and a maximum procurement period of up to two years is necessary on some special items which are made by specific manufacturers only.

Since the Chief Workshop Manager has little purchase authority, it is essential that the inventory is controlled adequately, the quantity needed is forecasted as accurately as possible, and the stores depot is informed of the data correctly.

The problem that must be solved immediately is to eliminate the shortage of materials as this is a major factor delaying the repair schedule.

Also, in relation to unit exchange spare parts, which are as important as the materials, only several parts including the wheel set are arranged. To reduce the cycle time, the necessary quantity of unit exchange spare parts must be kept in the workshop.

Moreover, almost none of the passages in the workshop for transporting various materials and repair parts are paved, and the passage subsides excessively where it crosses with the rails. These cause difficulty in effective use of handling equipment like forklifts.

Furthermore, scrap from corrosion repair amounting to 1000 tonnes monthly is piled up in many places of the workshop, disturbing the efficiency of transportation. At some places, scrap is even piled on rails, causing difficulty in moving and holding the rolling stock to repair.

Under such circumstances, in addition to overall improvement of the rail and passages, how the scrap is treated must be reviewed.

6.2.2 Premises of the Modernisation Plan

The modernisation plan is drawn up on the premises mentioned below. The areas studied this time are the inspection/repair works of rolling stock, the machine-working and other works closely related to the inspection/repair of rolling stock, and the accessory facilities of various kinds.

(1) Estimation of the number of rolling stock to be repaired

The Perambur Workshop is responsible for POH of all broad gauge coaches assigned to the Southern Railway and is the only place for inspecting and repairing broad gauge wagons in the Southern Railway. As a result, the number of coaches and wagons to be inspected at the workshop in 2000 can be estimated based on the number of rolling stock assigned in the Southern Railway.

Since the POH period varies with the type of coaches from 12 to 24 months, the number of coaches assigned in 2000 is difficult to determine for each type. Therefore the number of coaches to be inspected at the workshop is determined by calculating the ratio of the number of coaches assigned to the number of those inspected (including those at the Loco works) as the average turning-in ratio.

At present, the Tirupati Workshop is being constructed in the neighbouring South Central Railway. When the workshop starts its full-scale operation in fiscal year 1991, about 600 coaches out of those assigned in the Southern Railway are scheduled to undergo POH there.

Therefore, the annual inspection of 600 coaches is out of this program's target range. On the other hand 300 coaches, whose inspection/repair are entrusted to the next Loco Works, are covered under this programme. The Perumbar Workshop will be responsible for their inspection after facility improvement.

Under these conditions, coaches to be inspected in 2000 are estimated as follows:

Air conditioned coaches	250 (21 per month)
Ordinary coaches	2750 (230 per month)

Similarly, it is difficult to determine the number of wagons to be inspected at the workshop simply from the POH period, partly because a different inspection period is applied to each type and partly because all wagons assigned to the Southern Railway are not inspected at the workshop.

Thus, the ratio of the number of wagons assigned in the past and that inspected at the workshop in corresponding years was used as a basis of estimation. The number of wagons to be inspected in 2000 is thus determined as follows:

8-wheeler wagons	1920 (160 per month)
4-wheeler wagons	1600 (133 per month)

In addition, the number of coaches and wagons to be inspected and assigned from 1987 to 1999 is determined by linear interpolation. The rolling stock inspection plan for Perambur Workshop is shown in Table 6.2.8.

Both coaches and wagons undergo corrosion repair whose cycle time varies greatly. Table 6.2.9 shows the breakup of the number of coaches and wagons for each type of inspetion.

Table 6.2.8 Rolling Stock Inspection Plan for Coaches and Wagons at Perambur Workshop

Classification and type			Year: 80	85	86	90	91	92	93	94	95	96	97	98	99	2000
Coach	Number to be assigned	Air conditioned	59	86	86	161	180	199	218	237	256	275	293	312	331	350
		Ordinary	2,418	2,490	2,585	3,004	3,108	3,213	3,318	3,422	3,527	3,631	3,736	3,841	3,945	4,050
		Total	2,477	2,576	2,671	3,165	3,288	3,412	3,536	3,659	3,783	3,906	4,029	4,153	4,276	4,400
	Number to be inspected	Air conditioned	38	64	68	120	133	146	159	172	185	198	211	224	237	250
		Ordinary	1,688	2,016	2,001	2,386	2,483	2,579	2,676	2,772	2,868	2,965	3,061	3,157	3,254	3,350
		Total	1,726	2,080	2,069	2,506	2,616	2,725	2,835	2,944	3,053	3,163	3,272	3,381	3,491	3,600
	ditto (by workshop) Perambur	Air conditioned	38	64	68	120	133	146	159	172	185	198	211	224	237	250
		Ordinary	1,688	1,727	1,724	2,086	1,583	1,679	2,076	2,172	2,268	2,365	2,461	2,557	2,654	2,750
		Total	1,726	1,791	1,792	2,206	1,716	1,825	2,235	2,344	2,453	2,563	2,672	2,781	2,891	3,000
	ditto (by workshop) Loco Works (Ordinary)		-	289	277	300	300	300	-	-	-	-	-	-	-	-
	ditto (by workshop) Tirupati (Ordinary)		-	-	-	-	600	600	600	600	600	600	600	600	600	600
Wagon	Number to be assigned	8-wheeler wagon	5,437	6,009	6,009	7,721	8,149	8,577	9,005	9,432	9,860	10,288	10,716	11,144	11,572	12,000
		4-wheeler wagon	16,532	13,624	13,494	11,639	11,175	10,710	10,247	9,783	9,319	8,855	8,392	7,928	7,464	7,000
		Total	21,969	19,633	19,503	19,360	19,324	19,287	19,252	19,215	19,179	19,143	19,108	19,072	19,036	19,000
	Number to be inspected	8-wheeler wagon	1,019	981	997	1,261	1,327	1,393	1,459	1,524	1,590	1,656	1,722	1,788	1,854	1,920
		4-wheeler wagon	3,728	3,384	3,387	2,876	2,749	2,621	2,493	2,366	2,238	2,111	1,983	1,855	1,728	1,600
		Total	4,747	4,365	4,384	4,137	4,076	4,014	3,952	3,890	3,828	3,767	3,705	3,643	3,582	3,520

(Note) (1) The vehicles to be assigned in 2000 are estimated from the rolling stock plan, and those to be inspected are determined from the average turning-in ratio in the past years.

(2) The number of vehicles to be inspected and assigned after 1990 are determined by interpolation connecting those in 1986 and 2000.

(3) The number of coaches to be inspected at the Perambur Workshop is calculated by subtracting the number of coaches to be inspected both at Loco Works and Tirupati Workshop from the total.

Table 6.2.9 Number of Rolling Stock to be Repaired by Type of Repair

Type of rolling stock	Category	Type of repair	2000		(Reference) 1986	
			Number of rolling stock repaired	Proportion	Number of rolling stock repaired	Proportion
Coach	Air-conditioned coach	POH cum corrosion	60	2%	18	1%
		Ordinary POH	190	6%	50	2%
		(Total)	(250)	(8%)	(68)	(3%)
	Ordinary coach	POH cum corrosion	690	23%	(277) 771	37%
		Ordinary POH	2,060	69%	1,230	60%
		(Total)	(2,750)	(92%)	(2,001)	(97%)
	Total		3,000	100%	(277) 2,069	100%
	<Cum corrosion total>		<750>	<25%>	(277) <789>	<38%>
Wagon	4-wheeler wagon	POH cum corrosion	400	11%	1,428	33%
		Ordinary POH	1,200	34%	1,959	44%
		(Total)	(1,600)	(45%)	(3,387)	(77%)
	8-wheeler wagon	POH cum corrosion	480	14%	188	4%
		Ordinary POH	1,440	41%	809	19%
		(Total)	(1,920)	(55%)	(997)	(23%)
	Total		3,520	100%	4,384	100%
	<Cum corrosion total>		<880>	<25%>	<1,616>	<37%>

Cum corrosion occurrence ratio by category	Year \ Type	Air-conditioned coach	Ordinary coach	4-wheeler wagon	8-wheeler wagon
	86	27%	38%	42%	19%
	2000	24%	25%	25%	25%

Note: Those figures which are circled are the actual number of coaches repaired at the Loco Works. (included in the figures directly written in the same column)

The inspection/repair fluctuation factors considered for calculating the scale of the facilities and equipment are 1.2 for coaches and 1.1 for wagons. The obtained scales are multipled by these factors.

(2) Cycle time

The most important objectives of this study are to reduce the cycle time and to increase the inspection/repair capacity. Therefore, the planned cycle time considering the various improvements mentioned later is adopted for this study, and the numbers referring to the improved cycle time are regarded as basic data for estimating the scale of the equipment. The planned cycle time is shown in Tables 6.2.10 and 6.2.11.

Table 6.2.10 Cycle Time Schedule by Type of Coach

Type of coach	Type of repair	Planned cycle time							
		Check deficiencies, unloading	Lifting & lowering	Loading & unloading of AC parts	Corrosion treatment	Body repair	Painting	Loading & adjustment	Total
Air-conditioned coach	POH cum corrosion	(1.9) 1.5	(3.5) 1.5	(9.3) 3.0	(13.2) 10.0	(5.5) 4.5	(5.8) 3.5	(2.0) 1.5	(41.2) 25.5
	Ordinary POH	(1.6) 1.4	(3.5) 1.5	(9.3) 3.0	-	(4.5) 3.5	(3.5) 2.5	(2.0) 1.5	(24.4) 13.4
Ordinary coach	POH cum corrosion	(1.7) 1.4	(2.2) 1.0	-	(13.2) 10.0	(5.0) 4.0	(4.1) 3.0	(1.6) 1.3	(27.8) 20.7
	Ordinary POH	(1.3) 1.1	(1.6) 1.0	-	-	(3.0) 2.5	(2.1) 1.5	(1.2) 1.0	(9.2) 7.1

Note: 1. All durations are given in actual working days.
2. Numbers enclosed in parentheses indicate the current state.

Table 6.2.11 Cycle Time Schedule by Type of Wagon

Type of wagon	Type of repair	Planned cycle time				
		In-coming inspection and cleaning	Body repair	Lifting and lowering	Inspection and painting	Total
4-wheeler wagon	POH cum corrosion	0.5	(11.0) 7.5	(1.0) 1.0	(1.0) 0.5	(13.0) 9.5
	Ordinary POH	0.5	(3.0) 1.7	(1.0) 1.0	(1.0) 0.5	(5.0) 3.7
8-wheeler wagon	POH cum corrosion	0.5	(6.0) 5.0	Included in Body repair	(1.5) 0.5	(7.5) 6.0
	Ordinary POH	0.5	(3.0) 2.3	"	(1.5) 0.5	(4.5) 3.3

Note: 1. All durations are given in actual working days.
2. Numbers enclosed in parentheses indicate the current state.

(3) Basic rationale for drawing up the proposed improvement plan

The plan for improving the facilities of the workshop is drawn up based on the analysis of the current inspection/repair work. It attempts to improve areas indispensable to reduce the cycle time and upgrade the quality of the rolling stock.

The facilities and level of machinery to be introduced should be properly selected to match the scale of the inspection/repair work. The scope and type of mechanisation to be introduced was selected from the ones commonly used in Japan which have given satisfactory results. The improvement plan was proposed in the form of various alternatives, and the most appropriate plan was drawn up by objectively evaluating the merits and demerits of these alternatives from various points of view.

The basic conditions considered for drawing up the improvement plans are mentioned below.

1) Improvements related to coach inspection/repair

a) In order to shorten the cycle time as much as possible, coaches should flow smoothly, and waiting time should be minimised. For this purpose, POH cum corrosion repair of ordinary coaches and air-conditioned coaches whose cycle time varies greatly, is to be repaired at the newly-planned body repair shop, and those coaches are to be placed on trestles. The crosswise arrangement system which uses cranes for the movement of the bodies is adopted in the shop. This system allows for the movement of the coaches with ease regardless of preceeding coaches.

b) As for the ordinary coaches, the present facilities are to be utilised as much as possible, since the cycle time does not vary so much, and the coaches are to be placed on the bogies in the existing body shop. Note that ordinary coaches are also to be repaired after being placed on the completed bogies at the lift/lower section of the new car body shop.

c) Attention will be paid to make it possible to carry out the methods of work prescribed in the maintenance manual drawn up by the Railway Board (e.g., the inspection and the painting of the equipment attached under the floor should be carried out on the trestles, the coach should be placed on the bogie after corrosion treatment is finished, bogie frame cracks should be repaired by using the manipulator, etc.).

d) Measures will be taken to make it possible to use the traversers located at both ends of the body repair shop even when the trestles are not used, to minimise stagnation of the body movement.

e) No pit will be provided in the body repair shop, to enable multi-purpose utilisation of the shop, improving the transportation efficiency and making it possible to introduce equipment of various kinds.

f) Such being the case, the disconnecting and connecting work required for the body lifting/lowering work will be carried out at the TLD (in-coming) and TLD (out-going).

g) Loading and unloading of equipment attached under the floor of AC coaches, which is now pit work, will be executed by using lifting trestles that can be moved by hand.

h) Adjacent lines in the body repair shop will be spaced according to the following criteria:
   - Lifting/lowering area
     Adjacent lines will be separated by 10 m to provide passageways for fork lifts and the like and space for temporary placement of the bogies and other parts/components removed from the car body.

- Repair area

  Adjacent lines will be separated by 7.5 m considering spaces to place tools and apparatus of various kinds, spaces to place sheet metals of various kinds and spaces to place scrap bins and the like.

i) The car body is subjected to considerable strain during corrosion treatment because this work is carried out by cutting and welding the body panels and the various structural members. members. The buried surface plate shown in Fig. 6.2.3 will be provided in the floor surface of this area to eliminate this strain.

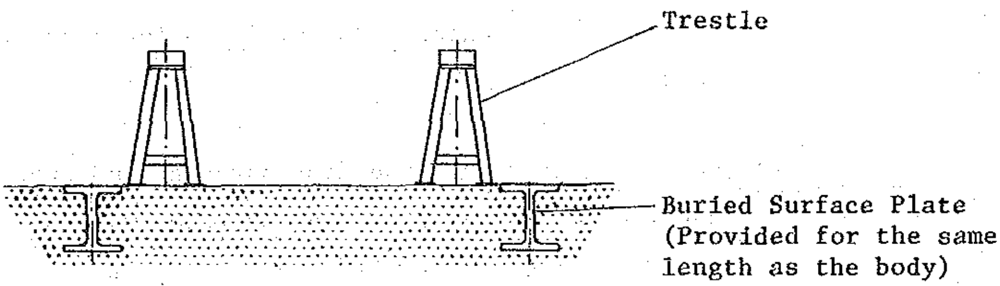


Fig. 6.2.3 Cross Section of the Buried Surface Plate of the Body Repair Area

j) The stabling lines located beside the TLD (in-coming) will be used to hold the rolling stock.

k) Rolling stock will be moved in the open air by using a rail cum road running type shunting vehicle; inside the repair shop stock will be moved using the hauling wire laid in the rail flange groove or the traverser winch.

l) Various tests for AC coaches after loading the components will be conducted at the AC final adjustment shed adjacent to the AC deluxe shop. Air-conditioning components will be tested synthetically before loading on the rolling stock to minimise test time in the AC final adjustment shed.

m) Plasma cutting equipment and CO2 (MIG) semi-automatic welding equipment will be installed in the workshop to improve corrosion treatment efficiency.

n) Lifting platform vehicles and unloading devices for underfloor apparatus will be provided in the workshop to improve the efficiency of body-related work.

o) Work of various kinds to be carried out in the body painting shop will be mechanised to minimise the painting time.

p) Special attention will be paid to each step of the undercoat treatment work such as applying of putty and the like, whose cycle time differs considerably according to the type of rolling stock, to prevent obstructing the flow of the rolling stock in the paint shop.

q) Decalcomania film sheets and the like will be adopted for lettering to minimise the process time.

r) The most appropriate washing equipment, such as injection washing device, oscillating washing device, etc. will be adopted for cleaning parts such as the bogie, roller bearing, etc.

s) Measurement fixtures and a manipulator allowing downward welding will be installed in the bogie repair shop.

t) An axial direction incidence ultrasonic flaw detector for axles will be installed in the wheel repair shop.

u) The roads in the workshop and the floor surface of the work areas will be paved to enable transport of materials as efficiently as possible. The rails will be thoroughly improved to eliminate the level differences at the point where they cross with the road.

v) A scrap yard will be provided to clear away scrap piled up everywhere in the workshop. Scrap bins will be provided in the body repair shop to sort out the scrap generated there by type.

w) The major machinery of the wheel shop will be provided with chip disposal devices.

x) The whole system of the wheel shop will be revised so as not to place the semifinished wheels inside the shop floor for a long period of time, and a yard for storage of finished wheels will be provided in the open air.

y) The roller bearing shop will be equippped with the required facilities.

z) Equipment such as pneumatic tools, electric tools, etc. will be provided as much as possible to improve the basic work efficiency such as bolt tightening. Indispensable facilities such as air piping, electric wiring, power outlet, etc. will be provided in each building to cope with the requirements of these tools.

z1) Places to store materials and spare parts with proper capacity will be provided in each workplace to enable checking the inventory at any time.

z2) The layout of the various workplaces will be arranged to minimise the transportation distances.

z3) Unit exchange spare parts will be provided in proper quantities.

2) Improvements related to wagon inspection/repair

Generally speaking, these improvements are the same as those related to the coaches, except for the following particulars.

a) Attention will be paid to putting into practice the work method prescribed in the maintenance manual drawn up by the Railway Board (e.g., water tightness test of covered wagons, welding work of tank wagons after cleaning its interior, etc.).

b) Ten 4-wheeler wagons are kept on each line in the body repair shop, and the wagon is moved in one direction. Under these cicumstances, wagons frequently wait as a result of differences in the progress of the work in each wagon. Surface traverser will be installed at the entrance of the body shop to solve this problem and allow the selection of the track where the wagon is to be kept.

c) A new in-coming inspection/cleaning shed will be constructed where each part of the body is perfectly cleaned. This shed prevents the dirt and dust in the wagon repair shop, is used for the survey of deficiencies, and helps in the selection of suitable places for the body to be placed.

d) Automatic painting equipment, drying equipment, etc. will be installed in the body painting shop. This equipment will be of common use type to handle both 4-wheeler wagons and 8-wheeler wagons in view of the future increases in the number of 8-wheeler wagons.

e) Container wagons, and the wagons with length over 16 m, that are not suited for automatic painting will be painted manually as done now.

f) Heavy repairs such as replacing wheels and the like are not being carried out in the wagon wheel shop, and this situation will remain unchanged.

g) Wheels supplied to outstation will be taken in from outdoors to make the most efficient use of the floor area of the bogie shop.

h) The sheet metal shop will be relocated to the body repair shop and an indoor pathway will be established to improve the efficiency of the body repair work.

i) The basic matters mentioned for the improvements related to the repair of coaches apply in all other aspects for wagons.

It is presumably possible to considerably reduce the cycle time by taking into account the points outlined above.

(4) Schedule to carry out the improvement programme

Setting fiscal year 2000 as the target year, this programme is examined including the facility scale required, improvement items and so forth. The number of coaches which the Perambur Workshop is to inspect/repair is expected to increase substantially by about 1.8 times in 2000. Since, the scale of coach related facilities are expected to be very large, trouble may occur at the present facilities or inspection/repair work may be forced to stop if the construction is implemented at one time. In view of these problems, including economic disadvantages like surplus buildup of equipment, though temporary, serious consideration should be made in construction planning.

It is concluded that this improvement programme should be carried out in two phases as follows:

Phase I : annual inspection/repair of 2,450 coaches for fiscal year 1995

Phase II: annual inspection/repair of 3,000 coaches for fiscal year 2000

Accordingly, the total programme is discussed in detail corresponding to the two phases.

(5) Comparison of each alternative

Six alternatives for coach related shop improvement plan are compared from various points of view based on the condition mentioned in the premises of the plan (See Fig. 6.2.4). The estimates lead to the conclusion that alternative 1 - 3, which is shown in Table 6.2.12, is the best. From here on, improvement plan is to be examined based on this alternative chosen.

All discussion is based on the prerequisite that the present body repair shops are most effectively used.

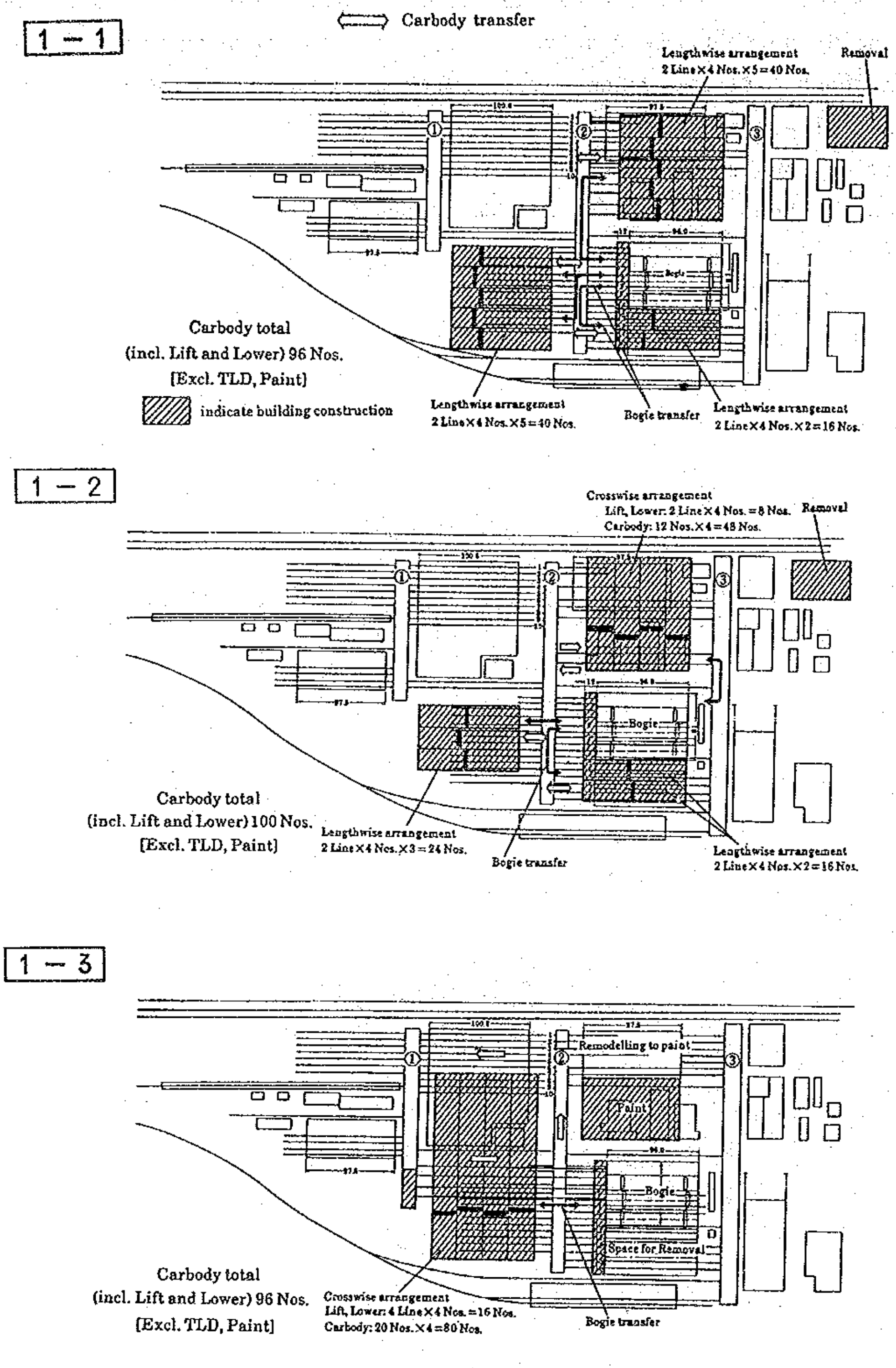
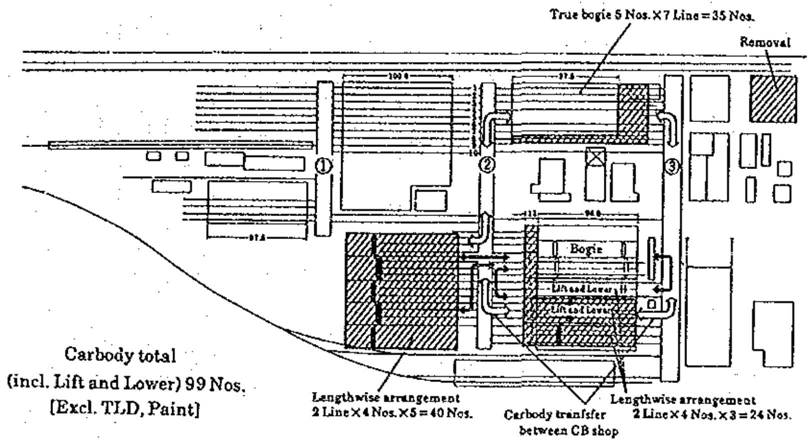
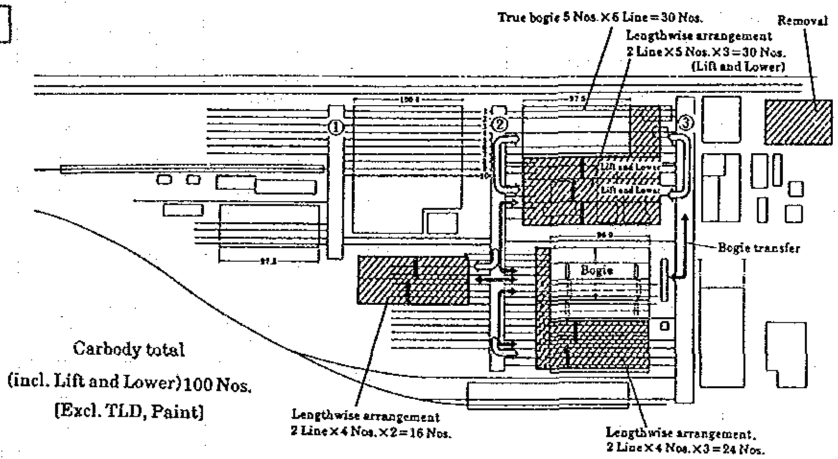


Fig. 6.2.4 (1) Alternatives of Layout for Coach Repair Shop

2 — 1



2 — 2



2 — 3

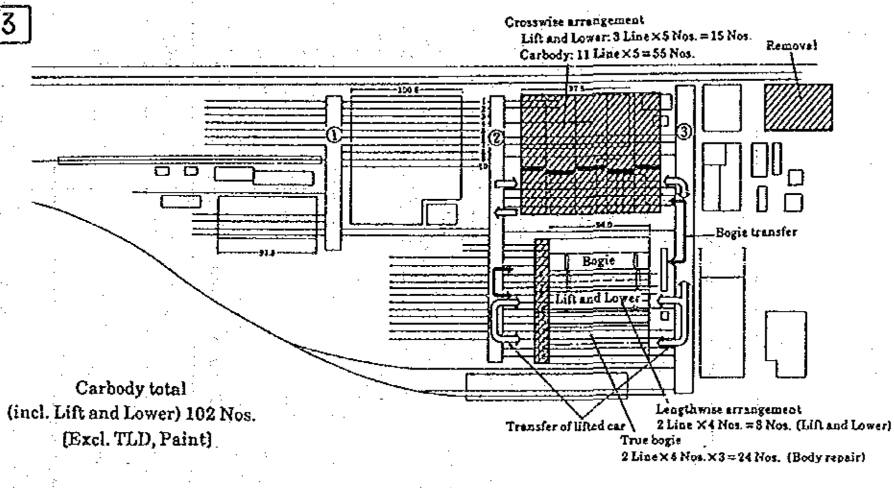


Fig. 6.2.4 (2) Alternatives of Layout for Coach Repair Shop

Table 6.2.12 Comparing the Various Alternatives (1/2)

Classification			1. All bodies supported by trestles Characteristics: Effective use of the body repairing place and elimination of waiting time. Cycle time: Approximately 3 days shorter than present Required capacity of body placement: 96 coaches			2. Some bodies supported by trestles Characteristics: Only repair work related to corrosion will be performed on trestles. The existing buildings will be used as much as possible. Cycle time: 1.0 day longer than Alternative (1). (0.5 days indoors and 0.5 days for moving from one place to another) Required capacity of body placement: 102 coaches		
No.			1	2	3	1	2	3
System			Lengthwise arranged system	Mixed lengthwise and crosswise arranged system	Crosswise arranged system	Lengthwise arranged system	Partially lenghtwise arranged system	Crosswise arranged system
Capacity of body place-ment	Heavy repairs	Lifting/ lowering	24	18	16	12	12	15
		Car repair	72	82	80	36	38	55
	Ordinary repairs	Lifting/ lowering	--	--	--	16	20	8
		Car repair	--	--	--	35	30	24
	Total		96	100	96	99	100	102
Area to be built (aprox-imate)	Body		26,670	24,170	22,860	18,200	18,470	17,570
	Removing obstacles		2,930	2,930	6,140	2,000	2,930	2,930
	Total		29,600 m^2	27,100 m^2	29,000 m^2	20,200 m^2	21,400 m^2	20,500 m^2
Movement of traverser when lifting/ lowering the body	Body		Traverser (2)	Traverser (2)	Traverser (2)	Traverser (2) and traverser (3) dispersed	Traverser (2) and traverser (3) dispersed	Traverser (3) and part of traverser (2)
	Bogie		Traverser (2)	Traverser (2) and traverser (3) dispersed	---	Traverser (2) and part of traverser (3)	Traverser (2) and traverser (3) dispersed	Traverser (3) and part of traverser (2)

Table 6.2.12 Comparing the Various Alternatives (2/2)

Classification		1. All bodies supported by trestles Characteristics: Effective use of the body repairing place and elimination of waiting time. Cycle time: Approximately 3 days shorter then present Required capacity of body placement: 96 coaches			2. Some bodies supported by trestles Characteristics: Only repair work related to corrosion will be performed on trestles. The existing buildings will be used as much as possible. Cycle time: 1.0 day longer than Alternative (1). (0.5 days indoors and 0.5 days for moving from one place to another) Required capacity of body placement: 102 coaches		
No.		1	2	3	1	2	3
System		Lengthwise arranged system	Mixed lengthwise and crosswise arranged system	Crosswise arranged system	Lengthwise arranged system	Partially lenghtwise arranged system	Crosswise arranged system
Remarks	Flow of body and bogie	×	○	◎	△	△	×
	Providing storage lines	×	△	△	×	○	○
	AC coach unloading/loading	○	○	○	○	○	×
	Measures for POH during construction period	○	○	△	△	○	○
Evaluation		×	△	The painting shop can be improved at the same time. ○	×	○	×

Note: ◎ Very good ○ Good △ Not bad × Bad