3-3 Train Running Time and Operation Speed

Running time and operation speed are the most important factors in discussing railway transportation. In this study however, a minute analysis of the running time between stations is omitted because the study aimed to determine the quantity of required rolling stock based on increasing transportation demand.

The current running times between the various areas of the country are shown in Table 3-3-1.

Reducing the train running time is advantageous from the standpoint of rolling stock planning because it improves rolling stock operation efficiency. In reality, however, reducing the train running time requires implementing integrated improvement schemes consisting of such measures as improving rolling stock performance, reinforcing the inspection and maintenance system, reinforcing the tracks, and improving the track layout and interlocking facilities of the stations. However, these aspects are not examined in detail in the present study. It is merely assumed that the speed can be increased by 20% in the future, as a yardstick for railway modernization. The speed by type of train is estimated on said assumption, as shown in Table 3-2-2, presented previously. Such being the case, the required quantity of rolling stock is calculated by drawing up the train plan based on Table 3-2-2.

3-4 Train Planning

3-4-1 Concept in Train Planning

In the present train planning primary importance is being placed on the inter-city transportation and less importance on suburban commuter transportation. Furthermore, commuter transportation is not considered in the demand forecast.

Such being the case, an increase in commuter transportation suburban train service is not considered in train planning. The current train operation scheme is merely expanded quantitatively to cope with the demand. The current train operation scheme of the BR and the number of trains operated per day are shown in Figs. 3-4-1 and Fig. 3-4-2 and in Table 3-4-1. Relevant data are rearranged in appropriate graphs and tables which are used to draw up the future plan. An example of said process (Dhaka-Chittagong section) is shown in Fig. 3-4-3 and Fig. 3-4-4.

Table 3-3-1 Access Time and Train Running Time between Principal Localities

Section	Item	Super EXP	EXP	PASS	MAIL	TG
Chittagong - Dhaka (320.79km)	Journey time	$6^h:10^m$	$6^h:05^m$	13:20	8:40	20:13
	Journey speed	$52.0^{km/h}$	$52.7^{km/h}$	24.1	37.0	15.9
	Permissible speed	$72.45^{km/h}$	$72.45^{km/h}$	64.40	72.45	32.20
	Booked speed	km/h	$67.62^{km/h}$	53.13	67.62	24.15
Dhaka - Bahadurabad Ghat (203.27km)	Journey time	-	$5^h:30^m$	6:50	7:45	11:30
	Journey speed	-	$37.0^{km/h}$	29.7	26.2	17.7
	Permissible speed	-	$64.40^{km/h}$	56.35	64.40	32.20
	Booked speed	-	$61.18^{km/h}$	53.13	61.18	28.98
Bahadurabad Ghat - Tistamukh Ghat	(Steamer)	Up $1^h:20^m$ Down $1^h:30^m$				
Tistamukh Ghat - Parbatipur (152.83km)	Journey time	-	$5^h:55^m$	-	7:35	-
	Journey speed	-	$22.8^{km/h}$	-	17.8	-
	Permissible speed	-	$56.40^{km/h}$ (24.15)	-	56.40 (24.15)	-
	Booked speed	-	$53.13^{km/h}$ (24.15)	-	53.13 (24.15)	-
Dhaka - Parbatipur Journey time			$14^h:05^m$		$18^h:30^m$	
Khulna - Parbatipur (378.75km)	Journey time	$10^h:20^m$	-	-	-	-
	Journey speed	$36.6^{km/h}$	-	-	-	-
	Permissible speed	$80.50^{km/h}$ (40.45)	-	-	-	-
	Booked speed	$75.67^{km/h}$ (37.03)	-	-	-	-

Pass Passenger train
Mail Mail train
TG Through goods

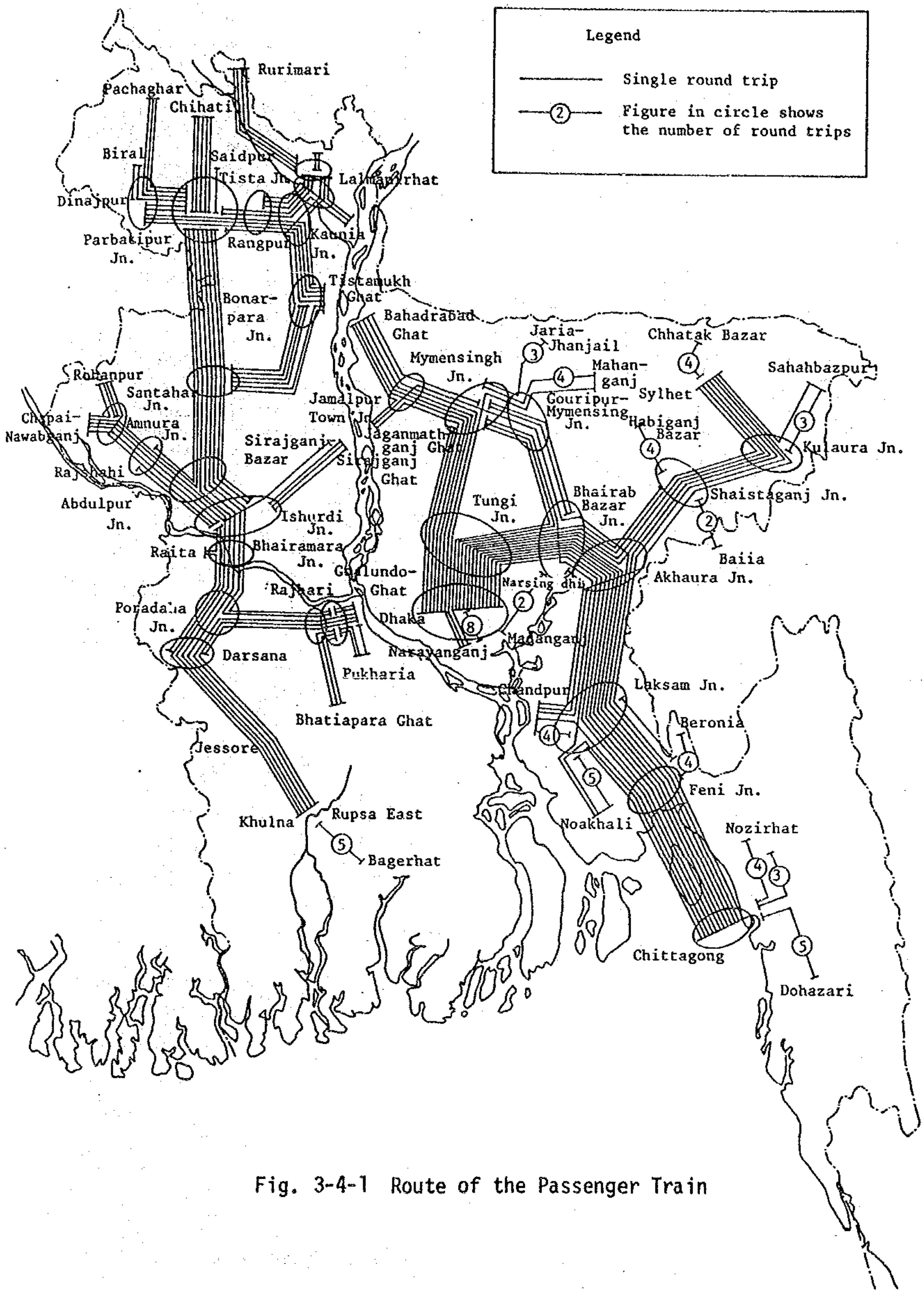

Fig. 3-4-1 Route of the Passenger Train

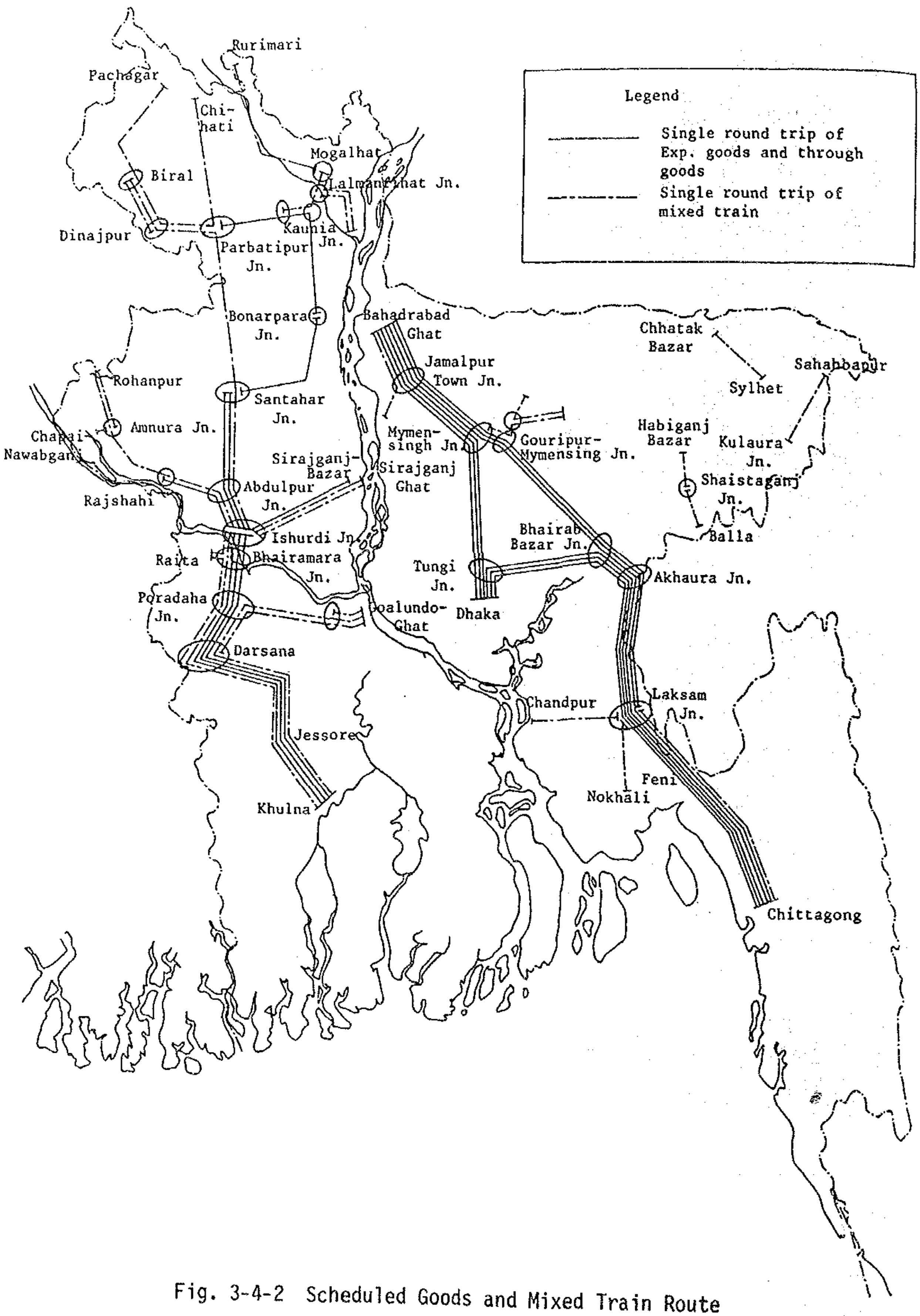

Fig. 3-4-2 Scheduled Goods and Mixed Train Route

Train No.	Class of train	Chittagong	CGFY	Feny	Laksam	Akhaura	Bhairab Bazar	Tungi	Tejgaon	Dhaka	Narayanganj	Train km	Train hour
13	Super EXP	7:00								13:10		320.79	6-10
RC-7	Super EXP (RC)	9:00								15:20		320.79	6-20
3	EXP	12:30								18:35		320.79	6-05
29	EXP	21:30								5:25		320.79	7-55
1	Mail	22:30								7:10		320.79	8-40
37	Pass	5:30				15:00 → SYT						200.84	9-30
59	Pass	10:00			16:40 → CDR							129.60	6-40
47	Pass	14:30			19:30							129.60	5-00
5	EXP	15:30					21:55 → JUJ					233.85	6-25
33	Pass	17:30									12:45	336.96	13-20
51	EXP	20:20				1:45 → SYT						200.84	5-25
FL 1	Mixed			5:00	6:45							129.60	1-45
JT 1	TG		2:00						0:10			312.74	22-10
JT 3	TG		10:00						4:30			312.74	18-30
JT 5	TG		16:30						13:45			312.74	21-15
JB 1	TG		6:30				20:30 → DWB					232.24	14-00
JB 3	TG		10:30				2:45 → DWB					232.24	13-15
JB 5	TG		22:30				10:15 → DWB					232.24	11-45

Fig. 3-4-3 Train Schedule (Chittagong-Dhaka) 1/16

Train No.	Class of train	From	Chittagong	CGFY	Feny	Laksam	Akhaura	Bhairab Bazar	Tungi	Tejgaon	Dhaka	Narayanganj	To	Train Km	Train hour
45	Pass	CDR →				6:55		12:00					→ MYN	104.25 Km	5H05M
53	EXP	NKA →				10:20					17:05			191.19	6-45
57	Pass	CDR →				16:00		21:00						104.25	5-00
49	Pass	CDR →				1:50	5:30						→ SYT	71.24	3-40
9	Mail	SYT →					3:55				7:40			119.95	3-45
99	Pass						4:30				8:35			119.95	4-05
69	EXP	SYT →					13:55				17:45			119.95	3-50
17	EXP	SYT →					16:50				19:50			119.95	3-00
35	Pass	SSJ →					17:45				22:55			119.95	5-10
8	Mail	PHBD →								7:13	8:05			22.94	-52
86	EXP	PHBD →								8:18	8:55			22.94	-37
40 (39)	EXP	MYN →						11:55				17:15		103.11	5-20
66	EXP	MYN →								18:37	18:10			22.94	-33
96	EXP	JUJ →								20:55	21:40			22.94	-45
12	EXP	BHBD →								21:35	22:20			22.94	-45
42	Pass	MGJN →								23:13	0:15			22.94	1-02
MBD-2	Pass	MYN →						20:55			1:20			86.94	5-05

Fig. 3-4-4 Train Schedule (Chittagong-Dhaka) 2/16

In the future plan, the train operation scheme is forecast merely by increasing the transportation traffic in correspondence to the growth of demand. The form of current train planning remains unchanged, as mentioned before, because only the cross-sectional traffic volume between the various areas of the country (administrative units) is estimated in the demand forecast. As a consequence, the number of through trains operating in the main sections of the railway network will be as shown in Table 3-4-2.

In reality, however, it is necessary to consider such measures as partial track duplication, track reinforcement, track layout improvements in the stations, and improvement of blocking systems or blocking sections, in addition the improvement of rolling stock performance. This is because the train operation scheme for 2020 is impracticable, in view of the insufficient track capacity of the existing operating facilities.

3-4-2 Passenger Transportation

(1) Train formation and seating capacity

The present train formation is determined by the basic operation scheme and is clearly described in the Working Time Table. But in reality, the general basic style is not following it.

The longest train consists of 13 carriages in the basic formation, but there are trains with 18 carriages when supplementary rakes are attached. As can be seen, efforts are presently being made to operate the trains with the best formation, in accordance with travelling section, type of train, travelling hour, etc. These efforts are improving the efficiency of rolling stock use. In reality however, it is necessary to standardize and unify the train formation pattern pari passu with the new rolling stock manufacturing plan because train formations should be uniform to enable the mutual cession of rolling stock between trains, if the number of trains should become very large in the future.

Most trains now contain one to four BC (bogie-covered wagons) which are used either as luggage vans or to alleviate congestion. However, the use of substitute carriages should be abolished as soon as possible by implementing the new rolling stock construction plan, in order to increase train speed and to improve passenger service.

Table 3-4-1 Total Number of Trains Operated per Day by BR

	No. of trains (train/day)		Total train-km of passenger trains (km/day)	Average daily goods transported (tons)
	Passenger	Goods (Average)		
BG	91	14.12	10595.3	2480.87
MG	279	49.00	24732.9	4836.08
Total	370	63.12	35328.2	7316.95

Table 3-4-2 Through-train Operation Scheme

		Chittagong Dhaka	Dhaka Mymensingh	Bahirab Bazar Mymensingh	Khulna Ishurdi	Bonarpara Parbatipur
1982	Super EXP	4 train	- train	- train	- train	- train
	EXP	4	8	4	6	4
	Pass	2	6	8	2	2
	Mail	2	2	-	-	2
	TG	6	6	6	6	2
	Total	18	22	18	14	10
1992	Super EXP	8	8	2	4	-
	EXP	12	12	8	10	12
	Pass	10	18	20	6	6
	Mail	2	2	-	-	2
	TG	8	8	8	8	4
	Total	40	48	38	28	24
2020	Super EXP	12	10	4	8	-
	EXP	16	16	10	10	14
	Pass	8	20	24	6	8
	Mail	4	4	2	2	4
	TG	12	12	12	12	4
	Total	52	62	52	38	30

The trains have different seating capacities because they do not have a standardized formation pattern. According to the available data, the average No. of passengers was 56 passengers in BG sections and 80 passengers in MG sections. In reality, the latter figure is close to the upper congestion limit and requires urgent improvement. It must be borne in mind however, that transportation demand is increasing rapidly. For the time being, the transportation plans are drawn up by assuming a congestion alleviation (for MG sections) on the order of 15% by 1992 and 28% by 2020 (refer to Table 3-4-3).

Table 3-4-3 Number of Passengers per Carriage and Congestion Alleviation Rate

		1982	1992	2020
BG	No. of passengers (persons/carriage)	56	68	73
	Passenger load factor (%)	54	65	70
	Congestion alleviation rate (%)	0	-21	-30
MG	No. of passengers (persons/carriage)	80	68	58
	Passenger load factor (%)	118	100	85
	Congestion alleviation rate (%)	0	15	28

(2) Train operation scheme and transportation capacity

Passenger transportation demand growth was discussed in the previous chapter. The transportation capacity required to cope with it, calculated by assuming the aforementioned conditons, is shown in Table 3-4-4.

Table 3-4-4 Future Plan of the Number of Passenger Trains (Approximate Calculations)

		1982 (Present state)	1992	2020
BG	No. of trains (train/day)	91	135	190
MG	No. of trains (train/day)	279	440	680

The figures in Table 3-4-4 are approximate, calculated based on passenger-kms. The average number of trains for 1992 and 2020 is based on increases by a factor of 1.5. The number of passengers per carriage is assumed to be as in Table 3-4-3. Therefore, the number of trains should be adjusted appropriately, according to the change in demand, by introducing such modifications as adopting of long train compositions or high-frequency operation with small-formation trains. Furthermore, from the technical standpoint, it is necessary to draw up the train operation scheme by considering the most appropriate train formation and the most appropriate number of trains, taking into account such factors as locomotive performance improvement, improvement of the blocking system, progress of track duplication, and upgrading of train speed.

3-4-3 Goods Transportation

The current train operation scheme includes goods trains only for through goods and express goods. The working timetable has no local goods trains. Furthermore, through goods trains are available only in the main railway divisions. In other divisions, goods are transported mostly by mixed trains. The current goods transportation status is shown in Fig. 3-4-2. According to 1982 operation data, the daily average number of trains was only 14.2 in BG sections and 49 in MG sections. Such being the case, it does not seem appropriate to discuss goods transportation volume in terms of the number of trains. The number of required rolling stock is calculated in terms of the number of goods wagons, and the relevant considerations are presented in 3-5, below.

Goods transportation demand in 2020 is expected to expand to 213% of the current demand. A goods train working timetable must be established for all lines up to that time. Furthermore, measures such as the operation of temporary trains (in addition to the regular ones) should be considered, in order to cope with fluctuations in goods traffic volume.

3-5 Operation and Number of Rolling Stock

3-5-1 Car-km

Railway traffic is expressed in terms of the travelling distance and the number of passengers riding (or the tonnage of goods loaded) on the rolling stock. Therefore, car-km, passenger-km, ton-km, are the yardsticks used to measure traffic. The current dimensions of the traffic of BR are shown in Table 3-5-1. The number of rolling stock required to cope with the anticipated increase in demand is calculated, in this study, by using car-km.

Table 3-5-1 Car-km and List of Related Dimensions

	Transported passengers or ton-km		Car-km		Daily car-km		Daily traffic per rolling stock	
	Passengers	Goods	Carriages	Wagons	Carriages	Wagons	Carriages	Wagons
	Passenger-km	ton-km	km	km	km	km	Passenger-km	ton-km
BG	$\times 10^3$ 1,528,026	$\times 10^3$ 215,029	$\times 10^3$ 700,099.2	$\times 10^3$ 20,199.8	205.7	13.3	12,544	140.9
MG	$\times 10^3$ 4,941,662	$\times 10^3$ 591,290	$\times 10^3$ 153,368.6	$\times 10^3$ 67,741.9	168.5	16.8	15,471	144.2
Total	$\times 10^3$ 6,469,688	$\times 10^3$ 806,319	$\times 10^3$ 853,467.8	$\times 10^3$ 87,941.7	-	-	-	-

3-5-2 Required Number of Carriages

The required number of rolling stock is calculated by using the car-km parameter. The total values of the annual cross-sectional traffic volume and the passenger-km to be transported, estimated from the transportation demand, are shown in Table 3-5-2. Calculation results of (carried out by determining the values of passenger-km, the number of passengers per carriage, and the rolling stock out of service rate in conformity with the list of vehicle characteristics) show that 3,054 passenger carriages will be required in 1992 and 3,890 will be required in 2020 (compared with 1,640 in 1982).

Table 3-5-2 Parameters for Calculating the Required Number of Carriages

			1982	1992	2020
Transportation demand	Total cross-sectional traffic (passengers/day)	*	265,371	594,881	835,514
		**	259,041	581,847	817,061
	Passengers: Passenger-km (passenger-km/day)	BG	4,024,597.3	10,998,809.6	17,328,499.8
		MG	17,289,815.9	34,750,095.8	46,128,003.2
		Total	21,314,413.2	45,748,905.4	63,456,503.0
Number of passengers per carriage (passenger) [Passenger load factor (%)]		BG	56 [54]	68 [65]	73 [70]
		MG	80 [118]	68 [100]	58 [85]
Number of carriage-km per day (km)		BG	224	250	300
		MG	193	250	300
Number of passenger-km per day and per carriage (passenger-km)		BG	12,544	17,000	21,900
		MG	15,471	17,000	17,400
Idle rolling stock rate (%) (Number of rolling stock being repaired (or waiting for repair) divided by the number of rolling stock in use)		BG	14.2	13.5	13.0
		MG	14.0	13.5	13.0
Required number of rolling stock		BG	366	734	894
		MG	1,274	2,320	2,996
		Total	1,640	3,054	3,890

Notes: * Including ferry passengers

** Excluding ferry passengers

3-5-3 Required Number of Wagons

The calculation results, based on the parameters shown in Table 3-5-3, show that 24,500 goods wagons will be required in 1992 and 35,780 units in 2020 (compared with 20,522 in 1982). The required number of wagons, calculated by interpolating these figures at 5-year intervals, is shown in Table 3-5-4.

Table 3-5-3 Parameters for Calculating the Required Number of Wagons

				1982	1992	2020
Trans-portation demand (per day)	Total cross-sectional transportation traffic (tons/day)		*	37,355	46,714	82,828
			**	37,202	44,772	79,180
	Goods ton-km (ton-km)	BG		665,752.8	813,544.8	1,526,092
		MG		2,328,132.6	2,941,665.0	5,247,612
		Total		2,993,885.6	3,755,209.8	6,773,704
Transportation traffic per day (ton-km)		BG		138	151	200
		MG		160	166	200
Idle rolling stock rate (%) (Number of rolling stock being repaired (or waiting for repair) divided by the number of rolling stock in use)		BG		6.1	6.1	5.8
		MG		6.0	6.0	5.6
Required number of rolling stock		BG		5,116	5,716	8,073
		MG		15,406	18,784	27,707
		Total		20,522	24,500	35,780

Notes: * Including ferry goods
** Exclusing ferry goods

Table 3-5-4 Number of Rolling Stock to be Provided Anew at Five-year Intervals

	Carriage			Wagon		
	BG	MG	Total	BG	MG	Total
1982	366	1,274	1,640	5,116	15,406	20,522
1987	550	1,797	2,347	5,416	17,095	22,511
1992	734	2,320	3,054	5,716	18,784	24,500
1997	763	2,441	3,204	6,137	20,377	26,514
2002	791	2,562	3,353	6,558	21,971	28,529
2007	820	2,682	3,502	6,979	23,564	30,543
2012	848	2,803	3,651	7,400	25,158	32,558
2017	877	2,924	3,801	7,821	26,751	34,572
2020	894	2,996	3,890	8,073	27,707	35,780

3-6 Rolling Stock Inspection and Repair System

3-6-1 Locomotives

Routine inspections and periodic inspections (up to six-month cycles) are conducted at the running shed. Periodic inspections at intervals of one year or more are conducted at the workshop. The Central Diesel Workshop (Back Shop) is being constructed at the present time to perform large-scale repair and maintenance (i.e., four-year, eight-year, and 16-year periodic inspections).

There are 15 stations with running sheds in the MG section and eight in the BG section. Of these stations, seven in the MG section and five in the BG section are for maintenance.

The locomotive inspection workshops are Saidpur Workshop (for a few steam locomotives), Parbatipur Workshop (for both MG and BG locomotives), Dhaka Workshop (for MG locomotives), and Pahartali Workshop (for MG locomotives).

The locomotive maintenance system is summarized below.

[Shed]	
Daily inspection	Schedule A
Fortnightly inspection	Schedule B
30-day inspection	Schedule C
90-day inspection	Schedule D
180-day inspection	Schedule E
[Workshop]	
1-year repair cycle	Schedule F
2-year repair cycle	Schedule G
[Back shop]	
4-year repair cycle	Schedule H
8-year repair cycle	Schedule I
16-year repair cycle	Schedule J

3-6-2 Carriages

Routine inspections and periodic inspections (with cycles under one year) are conducted at the Carriages & Wagons Depots (C & W Depots). Periodic inspections having greater than a one-year cycle are conducted at the workshops.

Eighteen stations in the MG section and eight in the BG section are equipped with C & W Depots.

The workshops Saidpur Workshop (for both MG and BG carriages) and Pahartali Workshop (for MG carriages) are in charge of inspecting carriages.

Saidpur Workshop assembles carriages by importing the underframe, bogie, electrical parts, etc. Pahartali Workshop was assembling carriages but no longer does so.

The carriage maintenance system is summarized below.

[Depot]

Daily inspection	Schedule A
Quarterly inspection	Schedule B

[Workshop]

		LE (Lift and enamel)	POH (Periodical overhaul)
Steel carriage		18 months	6 years
Wooden carriage		1 year	3 years
Other coaching vehicles	Steel	2 years	6 years
	Wooden	18 months	3 years

3-6-3 Wagons

Routine inspections and periodic inspections (with cycles under one year) are conducted at the C & W Depots. Periodic inspections having more than a one-year cycle are conducted at the workshops.

The C & W Depots and the workshops in charge of the maintenance of wagons are the same as those for carriages.

Pahartali Workshop was assembling goods wagons but no longer does so.

The maintenance system for wagons is summarized below.

[Depot]

Daily inspection
6-month inspection (Repacking)

[Workshop]	Periodic inspection
Nonstandard BG wagon	2 years
Standard MG and BG wagon	3 years

CHAPTER 4 ROLLING STOCK CONSTRUCTION PLAN

4-1 Current State of the Rolling Stock

Broadly speaking, the rolling stock possessed by BR consists of locomotives, carriages, and wagons. The existing rolling stock generally is operated as passenger trains and goods trains hauled by locomotives.

The composition of the rolling stock possessed by BR as of 30 June 1983 is shown in Table 4-1-1. (According to "Information Book 1983") The conditions of the rolling stock are not necessarily satisfactory. Some of the existing rolling stock are either superannuated or displaying conspicuous symptoms of body corrosion, requiring large-scale repairs, such as patching of the outer plate and reinforcement of the truck. The percentage of rolling stock which is actually available for use, considering rolling stock waiting for condemnation and rolling stock waiting for repairs, is 87.4% for MG carriages, 67.0% for BG carriages, 81.1% for MG wagons, and 80.7% for BG wagons, in terms of the figures shown in the Table 4-1-1.

The composition of the existing rolling stock by type of rolling stock is shown in Table 4-1-2 (Carriages), Table 4-1-3 (Other Coaching vehicles) and Table 4-1-4 (Freight Wagons).

The most numerous carriages are the Third Class (T) ones, which account for approximately half. In reality, mixed types such as Third Class with Luggage and Brake-Vans (TLR) or Second and Third Class (ST) are also numerous. Therefore, the existing carriages encompasses a very wide variety of types. In this connection, Table 4-1-2 also includes 21 diesel cars (Railcars and Trailer Coaches) that were introduced in recent years.

The Four Wheeled Covered Wagon (C) is significantly more numerous than other types, accounting for 2,722 of the 5,045 BG wagons and 9,717 of the 15,151 MG wagons.

Table 4-1-1 Summary of Rolling Stock

Items	Stock owned	Ineffective stock			Stock available for effective service
		Awaiting condemnation	Under or awaiting repairs	Total	
1. Locomotives					
(a) Broad gauge					
Steam	22	-	8	8	14
Diesel	76	1	17	18	58
Total	98	1	25	26	72
(b) Metre gauge					
Steam	86	8	35	43	43
Diesel	226	4	57	61	165
Total	312	12	92	104	208
2. Carriages					
(a) Broad gauge					
Passenger carriages	362	19	63	82	280
Other coaching vehicles	81	58	6	64	17
Total	443	77	69	146	297
(b) Metre gauge					
Passenger carriages	1,033	15	124	139	894
Other coaching vehicles	256	3	21	24	232
Total	1,289	18	145	163	1,126
3. Freight wagons (in 4-wheelers)					
(a) Broad gauge	5,045	227	222	449	4,596
(b) Metre gauge	15,151	1,000	405	1,405	13,746

Source: Information Book (BR)

Table 4-1-2 Types of Carriages Owned

Type	Broad gauge	Metre gauge
Bogie Carriages		
1. Fully air-conditioned (WJFC)	-	3
2. Composite first and air-conditioned (JFC, JFS)	6	21
3. First class (WYF, FC)	4	74
4. Second class (S)	9	104
5. Third class (T)	187	499
6. Composite first and second class (FS)	25	26
7. " first, second and third class (FST)	5	12
8. " second and third class (ST)	41	87
9. " third class with dining car (CDT)	9	11
10. " third class with postal compartment (TPP)	5	18
11. " second class with luggage and brake vans (SLR)	-	7
12. " third class with luggage and brake vans (TLR)	66	160
Four-wheeled carriages		
13. First class (EF)	1	-
14. Third class (ET)	-	6
15. Composite first and second class (EFS)	3	5
16. " second and third class (EST)	1	-
17 " third class with postal compartment (ETPP)	-	-
Total passenger carriages	362	1,033
Railcars and trailer coaches		
18. Railcars	-	7
19. Trailer coaches	-	14

Source: Information Book (BR)

Table 4-1-3 Types of Other Coaching Vehicles Owned

Type	Broad gauge	Metre gauge
Bogie vehicles		
Dining cars (CD)	1	8
Tourist cars (CT)	-	4
Luggage vans (L)	19	70
Motor vans (VK)	-	10
Miscellaneous including brake vans (VJ, VE, VV, VR, etc.)	1	9
Railway service vehicles (RA, RH, RS, RT, RR, etc.)	8	41
Four wheeled vehicles		
Luggage vans (EL)	2	14
Horse vans (EH)	1	8
Motor vans (EVK)	3	1
Carriage truck (EG)	1	1
Miscellaneous including brake vans (EVG, EVKP, EVE, ELR, etc.)	5	20
Railway service vehicles (ERB, ERD, ERS, ERH, ERT etc.)	40	70
Total:	81	256

Source: Information Book (BR)

Table 4-1-4 Types of Wagons Owned

Type	Broad gauge		Metre gauge	
	Units	Four wheelers	Units	Four wheelers
Covered wagons				
Four wheeled (C)	2,722	2,722	9,717	9,717
Bogie (BC)	449	898	476	952
Bogie covered fertilizers (BCF)	-	-	48	96
Open wagons (High-sided)				
Four-wheeled (KC)	677	677	92	92
Bogie (BKC)	-	-	603	1,206
Open wagons (Low-sided)				
Four-wheeled (KL, KM)	5	5	148	148
Bogie (BKL)	-	-	50	100
Flat wagons-				
Four-wheeled (FR, FT, KU)	6	6	11	11
Bogie (BFR, BFT, BKU, BFU)	37	74	356*	761*
Other wagons-				
Four-wheeled (KF, X)	1	1	2	2
Bogie	-	-	-	-
Petrol tank wagons				
Four-wheeled (TP)	17	17	-	-
Bogie (BTP)	15	30	88	176
Oil tank wagons				
Four-wheeled (TK, TL)	36	36	15	15
Bogie (BTK, BTL)	128	256	463	926
Molasses tank wagons				
Four-wheeled (TM)	10	10	17	17
Bogie (BTM)	75	150	40	80
Departmental wagons				
Four-wheeled (KH, KW, TW, FD, BVG)	65	65	264	264
Bogie (BKH)	49	98	294	588
Total	4,292	5,045	12,684	15,151

* Includes 49 well wagons.

Source: Information Book (BR)

4-2 Rolling Stock Life Concept

It is widely recognized that the amount of rolling stock to be manufactured or procured is estimated from the amount of rolling stock needed, not only to remedy the current shortfall or to meet increases in traffic demand, but also to replace worn-out rolling stock.

To provide some insight into this matter, a clear perspective on rolling stock life should be developed prior to examination. Generally speaking, rolling stock life may be classified into three categories:

. economic life,
. physical life, and
. obsolescence.

Economic life can be determined by the pattern of expenses for maintenance and repair that are required over time. Physical life is governed by such physical properties of the components as deformation, deterioration, and wear. Obsolescence of rolling stock that require the consideration of passenger comfort depends greatly upon the accommodation level (determined by competition and the commitment to improve the quality of life).

It is said that economic life considerations are dominant among the three types. Therefore, a commentary on current concepts of economic life (vis à vis the replacement of old rolling stock) follows.

As the age of rolling stock increases, the depreciation costs decrease markedly. However, maintenance costs increase steadily. An evaluation based on a quantitive comparison of these elements determines the economic life.

Among the calculation methods available, the Machinery and Allied Products Institute (MAPI) method is chosen for review here.

According to MAPI's theory, economic life ends at the point when the sum of the yearly depreciation value and yearly maintenance costs reaches its minimum.

Fig. 4-2-1 illustrates the relationship between these factors.

The mean annual cost S for n (the number of years) can be determined as follows:

$$S = \frac{C}{n} + \frac{\int f(n)dn}{n}$$

where $f(n)$: annual cost of maintenance

C : initial construction/procurement cost of rolling stock

According to the MAPI's theory, the following condition is required to minimize S.

$$\frac{dS}{dn} = 0$$

Therefore, $nf(n) - \int f(n)dn = C$

It can be concluded that the economic life of rolling stock depends upon $f(n)$, the annual cost of maintenance. In general, however, it is difficult to calculate $f(n)$.

Meanwhile, as shown in Fig. 4-2-2, it can also be concluded that the time at which the shaded area becomes equal to the initial rolling stock construction/procurement cost marks the end of economic life. This is because the total rectangular area represents $nf(n)$ and the nonshaded area represents $\int f(n)dn$.

Generally speaking, the increase of $f(n)$ is sluggish from just after construction/procurement until the middle age of the rolling stock, but $f(n)$ suddenly begins to increase sharply at the last stage of economic life. This period correspond to life limit. The last stage refers to the period during which heavy repairs of principal components are increasingly required.

Based upon the experience of the Japanese National Railways (JNR), the following phenomena and requirements are evident during this last stage.

(Carriage)

(1) Corrosion of such body parts as beams and pillars becomes remarkable, requiring patching or partial replacement of each part.

(2) Due to heavy corrosion, a lot of repair on the side plates is required.

(3) Thinning and cracking of the underframe occurs, requiring patching or local replacement.

(4) Outer or interior furnishings require all-round replacement.

(Wagon)

Similar to (1), (2), and (3) of (Carriage).

In accordance with the above concepts, the approximate lifetime of the two relevant BR rolling stock types can be inferred as follows.

Carriage	35 years
Wagon	45 years

Furthermore, individual usage and environment must be checked to determine serviceability of individual rolling stock. With this view, the following inequality may also be a significant factor in determining rolling stock life:

$$\frac{\text{irregular maintenance costs}}{\text{extended time for longer life}} > \frac{\text{construction costs} \times 0.9}{\text{average life}}$$

where irregular maintenance costs exclude ordinary maintenance costs, and extended time refers to the overhaul period.

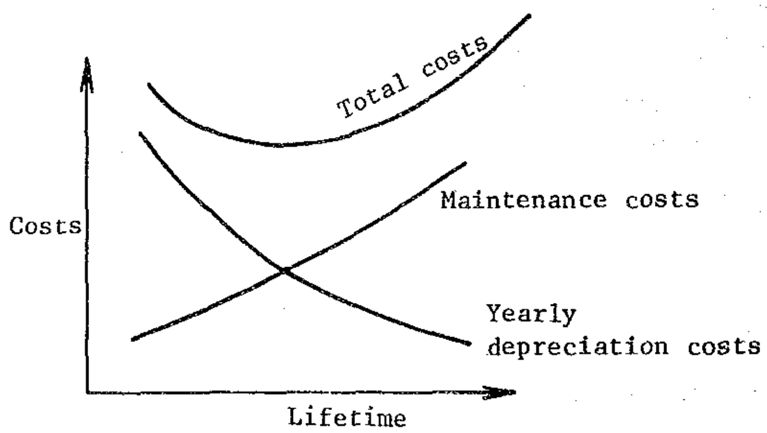

Fig. 4-2-1 Relation between Lifetime and Cost

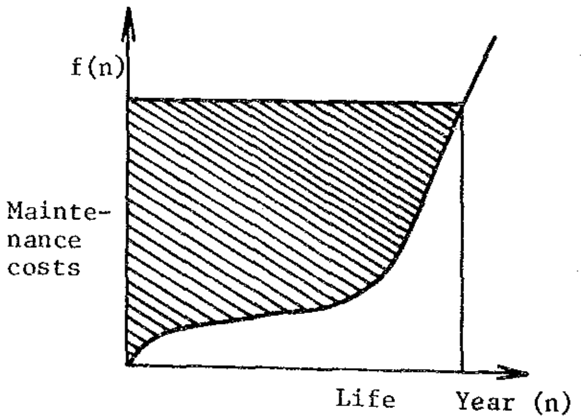

Fig. 4-2-2 Characteristics of Maintenance Cost

4-3 Types of Rolling Stock to be Constructed

The principal types of rolling stock in the existing rolling stock are listed in 4-1. As can be seen in Table 4-1-2, Table 4-1-3, and Table 4-1-4, there is a very large variety of rolling stock types. Part of the rolling stock is constructed domestically in Bangladesh, but their number is very small. Most of the units are imported from such foreign countries as Japan, Germany, Korea, India, and Pakistan. As a consequence, even rolling stock of the same type have distinct interior finishings, or use different parts and components.

When considering the construction of new rolling stock, it is necessary to screen the wide variety of types and to standardize as much as possible. This should be done by considering the interchangeability of parts and the ease of procurement of parts.

4-3-1 Carriages

New carriages should be constructed consisting principally of Third Class (T), Second Class (S), Third Class with Luggage and Brake Vans (TLR), and Luggage Vans (L), by considering Tables 4-1-2 and 4-1-3. Examples of the particulars and outer view of the MG carriage are shown in Table 4-3-1 and Fig. 4-3-1. The completely rivetted Pahartali (PHT) type bogie will be used for the time being. Such improvements as adoption of the coil-spring and hydraulic-damper suspension system or pneumatic spring suspension system (advantageous from the standpoints of high-speed operation and passenger comfort) will be considered in the future, in accordance with track conditions.

Examples of the particulars and outer view of the BG carriage are shown in Table 4-3-2 and Fig. 4-3-2. Type-64 bogie (which is used in many of the existing carriages) will be used for the time being. In reality, it is necessary to evolve from the partially rivetted construction to the all-welded construction with stamped steel plates, in order to achieve such improvements as reduction of construction costs and reduction of weight. Of course, it is necessary to consider the future adoption of a suspension system consisting of pneumatic springs in higher class vehicles, in the same way as in the case of the MG carriages.

Table 4-3-1 Principal Particulars of MG Carriages

Type	T	S	TLR	L
Seating capacity	68	68	28	
Loading capacity tonne			7	14
Tare weight tonne	29	29	26	25
Length over couplers mm	18,700			
Max. height mm	3,300			
Max. width mm	2,700			
Length overhead stocks mm	17,300			
Distance between bogie centres mm	12,400			
Wheel base mm	2,000			
Wheel diameter mm	720			
Max. speed km/h	90			
Brake system	Fully automatic vacuum brake			
Coupling device	Center buffer coupler			

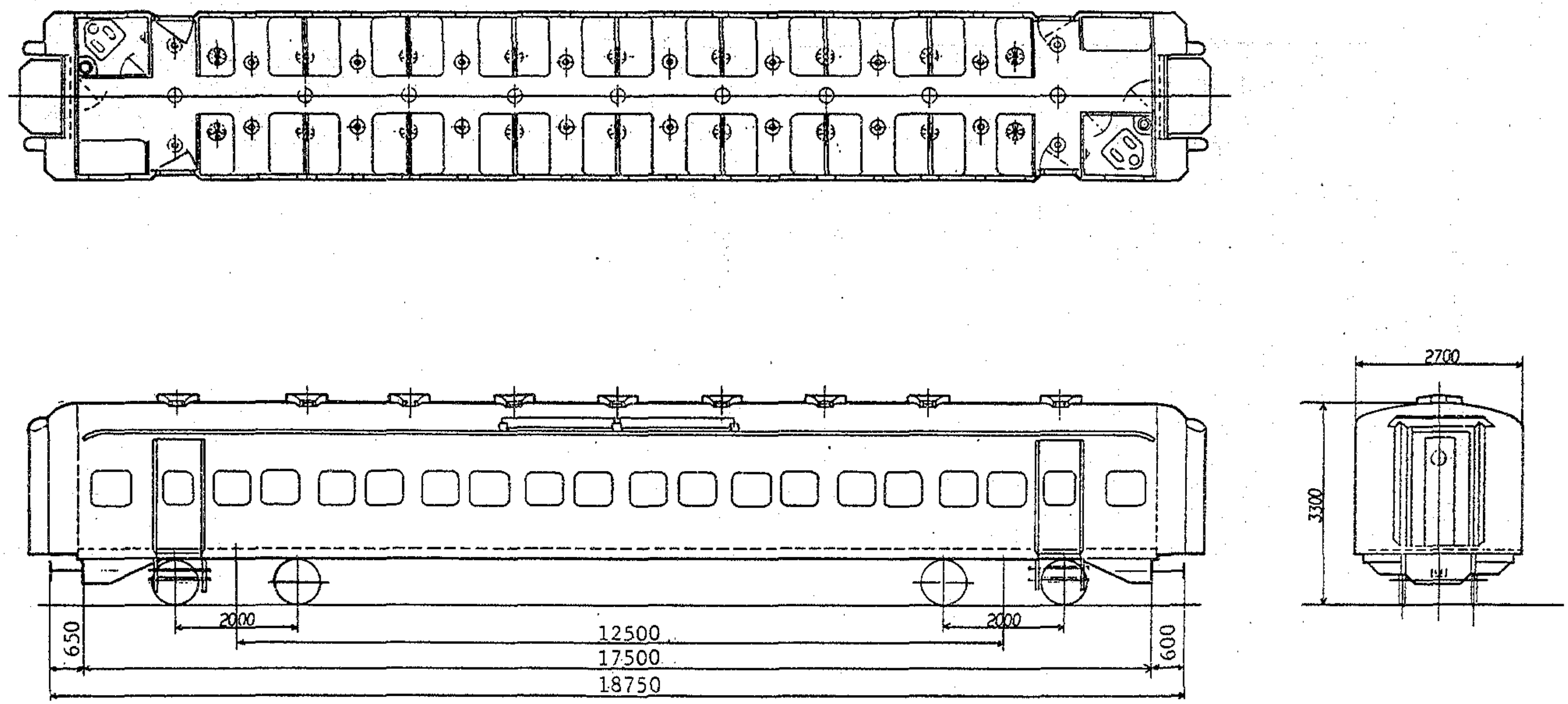

Fig. 4-3-1 Third Class Carriage (MG)

Table 4-3-2 Principal Particulars of BG Carriages

Type		T	S	TLR	L
Seating capacity		104	79	44	
Loading capacity	tonne			9	28
Tare weight	tonne	41	41	38	37
Length over couplers	mm	22,600			
Max. height	mm	3,800			
Max. width	mm	3,200			
Length overhead stocks	mm	21,300			
Distance between bogie centre	mm	14,600			
Wheel base	mm	3,000			
Wheel diameter	mm	1,090			
Max. speed	km/h	120			
Brake system		Fully automatic vacuum brake			
Coupling device		Independent drawgear and side buffers			

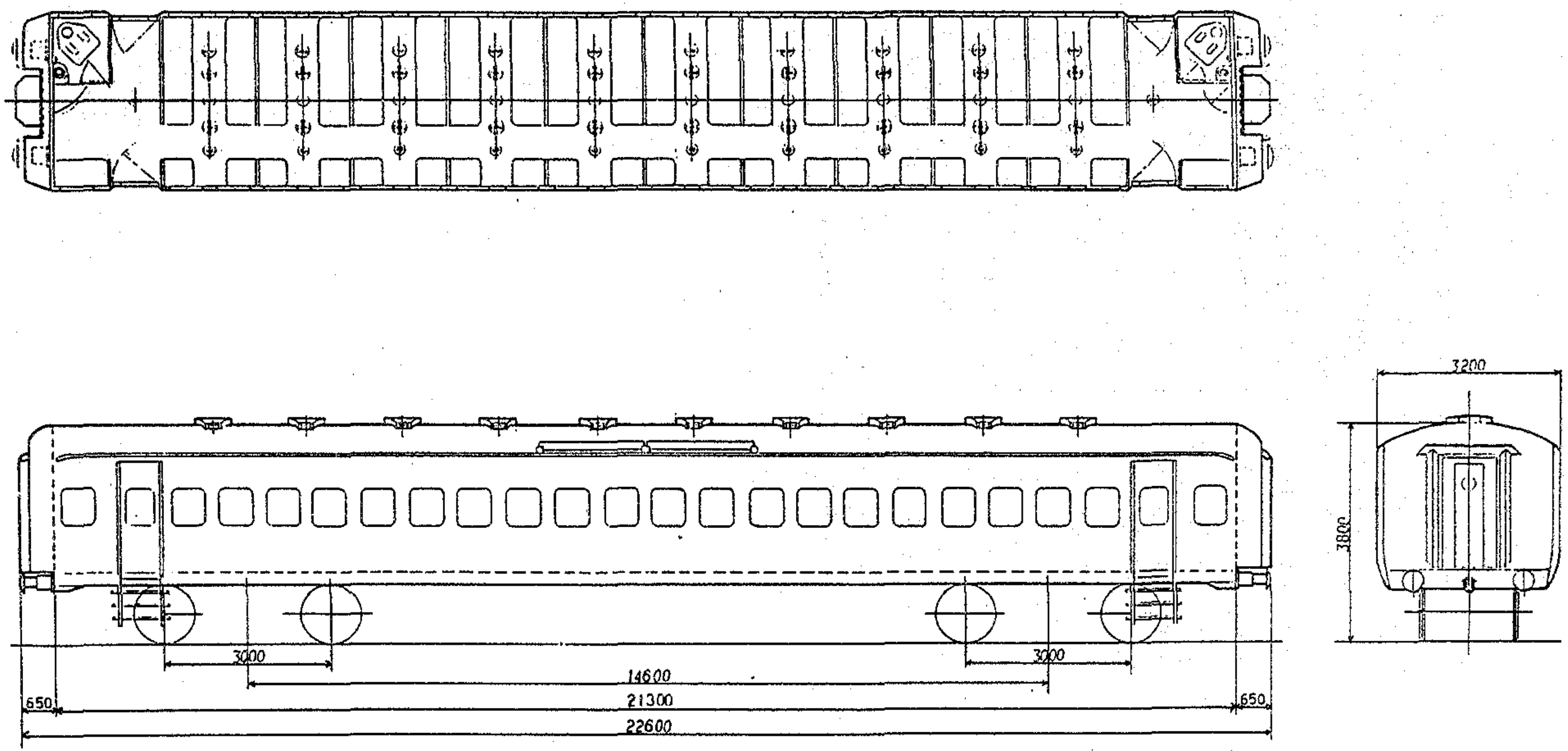

Fig. 4-3-2 Third Class Carriage (BG)

4-3-2 Wagons

As can be seen in Tble 4-1-4, Covered Wagons and Open Wagons account for the absolute majority of goods wagons. It is presumed that the types of goods wagons to be constructed in the future will consist principally of these two. The four-wheeled or bogie construction will be selected in accordance with the types of goods to be transported, the maximum operation speed of the trains, and other relevant factors. This study is conducted by assuming that five types of goods wagons will be newly constructed: flat wagons aimed at coping with the future containerization of goods transportation, in addition to the four types mentioned before (four-wheeled covered wagons (C), bogie covered wagons (BC), four-wheeled open wagons (KC), and bogie open wagons (BKC)).

Particulars and drawings are shown in Table 4-3-3 and Fig. 4-3-3 for MG wagon and in Table 4-3-4 and Fig. 4-3-4 for BG wagon. Chevron spring bogie will be employed, in view of its simple structure and easy maintenance. As an alternative for Chevron spring bogie, conventional type bogie using coil springs or laminated springs will be employed as carriages.

Table 4-3-3 Principal Particulars of MG Wagons

Type		C	BC	KC	BKC	Flat wagon
Loading capacity	tonne	20	35	18	28	36
Tare weight	tonne	7	15	6	13	13
Length over couplers	mm	7,700	12,500	7,700	12,500	14,300
Max. height	mm	3,300	3,300	2,200	2,200	1,800
Max. width	mm	2,700	2,700	2,700	2,700	2,700
Length overhead stocks	mm	6,500	11,200	6,500	11,200	13,100
Distance between bogie centres	mm		7,900		7,900	9,400
Wheel base	mm	3,600	1,600	3,600	1,600	1,600
Wheel diameter	mm	720				
Max. speed	km/h	60				
Brake system		Fully automatic vacuum brake				
Coupling device		Centre buffer coupler				

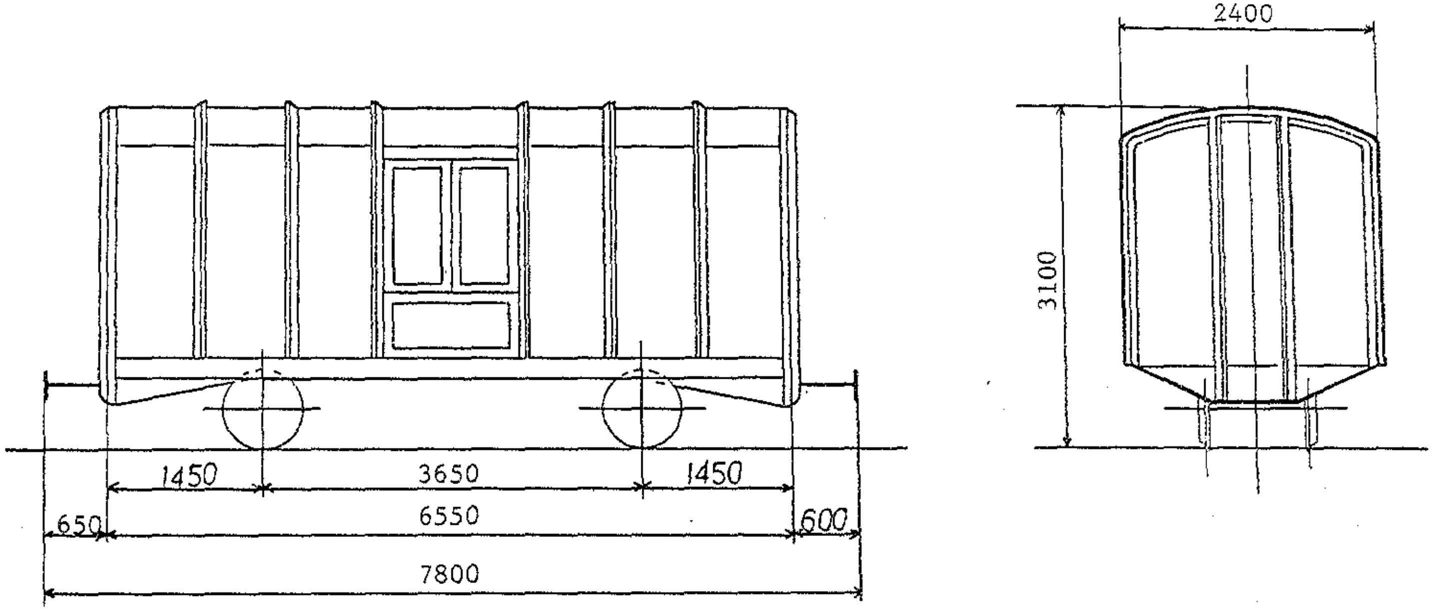

Fig. 4-3-3 Four-wheeled Covered Wagon (MG)

Table 4-3-4 Principal Particulars of BG Wagons

Type		C	BC	KC	BKC	Flat wagon
Loading capacity	tonne	22	43	22	34	43
Tare weight	tonne	11	21	10	17	21
Length over couplers	mm	9,100	14,900	7,200	14,900	14,900
Max. height	mm	3,700	3,700	2,700	2,700	2,000
Max. width	mm	3,000	3,000	3,000	3,000	3,000
Length overhead stocks	mm	7,900	13,700	5,900	13,700	13,700
Distance between bogie centres	mm		10,000		10,000	10,000
Wheel base	mm	4,800	1,800	3,500	1,800	1,800
Wheel diameter	mm	1,090				
Max. speed	km/h	60				
Brake system		Fully automatic vacuum brake				
Coupling device		Independent drawgear and side buffers				

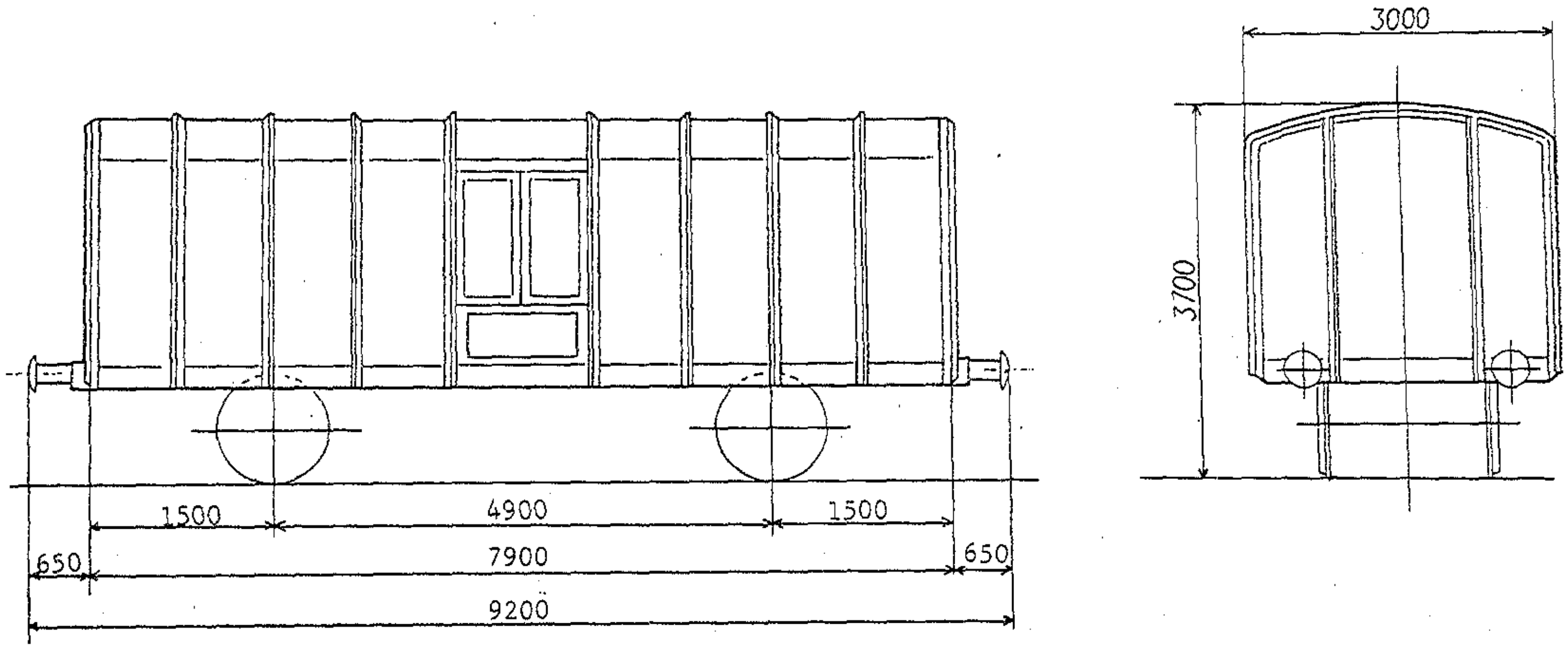

Fig. 4-3-4 Four-wheeled Covered Wagon (BG)

4-4 New Rolling Stock Required

The quantity of new rolling stock to be constructed is obtained by adding the number of vehicles required to cope with the transportation demand obtained in 3-5 and the number of vehicles required to replace the obsolete ones.

The quantity of rolling stock obtained from the transportation demand is shown in Table 4-4-1.

In this study, the quantity of new rolling stock required is calculated for the 1982 to 2019 period by fitting it with the demand forecast. The new plant is assumed to start operation in 1992. In the meantime, considering the past record regarding the matter, it is assumed that 90 cars/year of carriages and 610 wagons/year of wagons will be procured, either from existing workshops or by importation.

The age groups of the rolling stock as shown in Table 4-4-2. (According to the BR document "Answers to the Questionnaire on the Diesel Locomotive Project.")

The term "unit" in Table 4-4-2 means four-wheeled wagon. The number of carriages is expressed in terms of bogie vehicles by dividing these figures by two. The number of wagons is expressed in terms of four-wheeled wagons by leaving the number of units unchanged. The age groups of the existing rolling stock are shown diagramatically in Figs. 4-4-1 and 4-4-2.

Carriages have passed the economic life limit of 35 years, and 950 wagons the economic life limit of 45 years. Therefore, replacing obsolete vehicles is an important problem. In the present study it is assumed that obsolete rolling stock will be replaced, in accordance with the following line of reasoning.

(1) The number of carriages to be scrapped will be adjusted to permit life prolongations up to 15 years, by considering the fact that there are rolling stock in use surpassing the economic life limit by 15 years or more.

(2) The number of wagons to be scrapped will be adjusted to permit life prolongations up to 5 years, by considering the fact that there are rolling stock in use surpassing the economic life limit by 5 years or more.

Table 4-4-1 Rolling Stock Required to Cope with Transportation Demand

(Car)

Year	Carriages	Wagons
1982	1640	20522
1987	2347	22511
1992	3054	24500
1997	3204	26514
2002	3353	28529
2007	3502	30543
2012	3651	32558
2017	3801	34572
2020	3890	35780

Note: Number of wagons converted into Four-Wheels

Table 4-4-2 Age Group of Carriages and Wagons

(Unit)

	MG Carriages	BG Carriages	MG Wagons	BC Wagons
Over 45 years	161	85	741	209
41 - 45	29	9	81	111
36 - 40	6	5	166	706
31 - 35	95	7	1,793	217
26 - 30	166	8	2,025	754
21 - 25	284	NIL	2,614	977
16 - 20	580	100	3,522	232
11 - 15	226	36	339	194
6 - 10	402	176	2,295	500
Up to 5 years	506	398	1,830	1,216

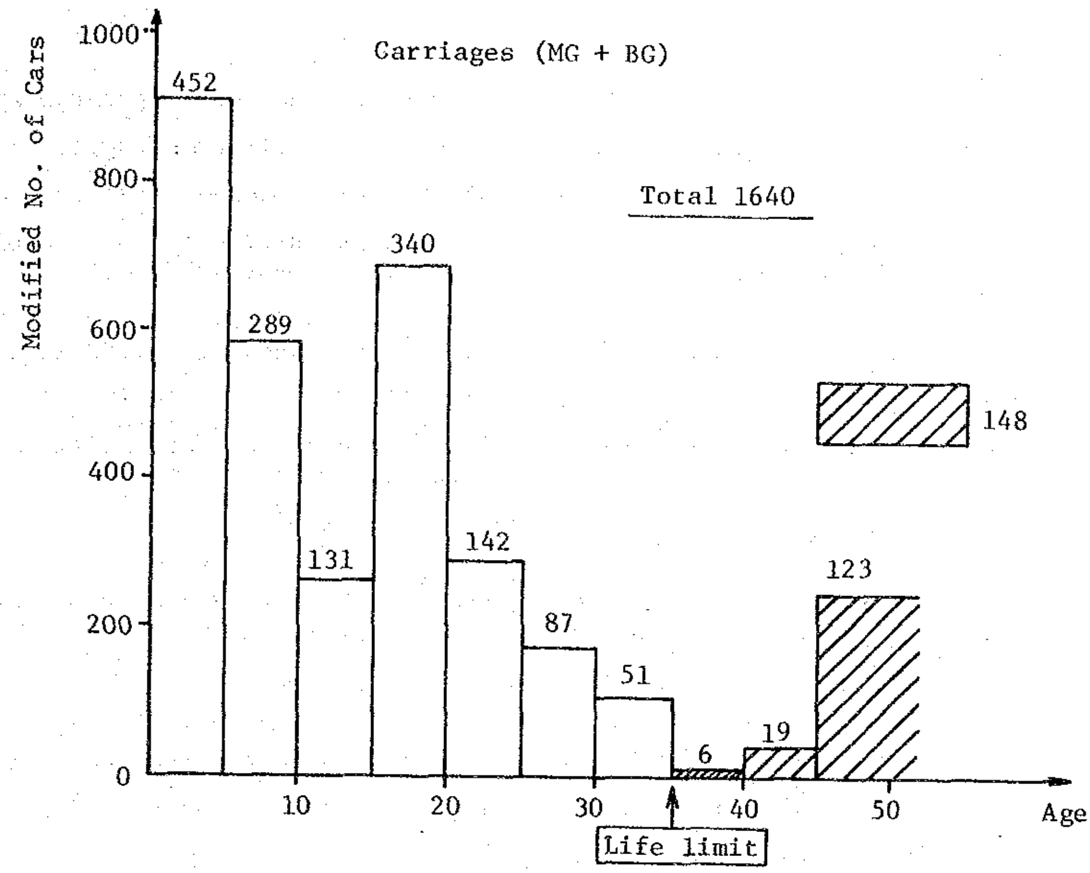

Fig. 4-4-1 Age Group Distribution of Carriages (MG + BG)

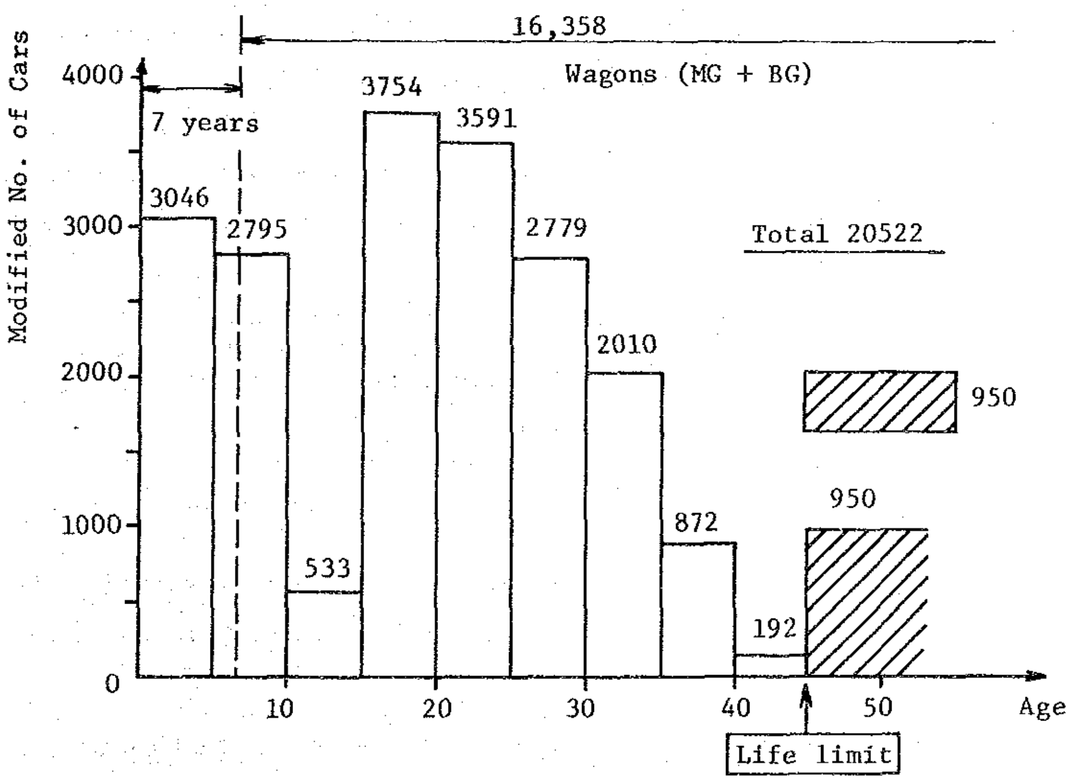

Fig. 4-4-2 Age Group Distribution of Wagons (MG + BG)

4-4-1 Carriages

1,910 carriages will be replaced between 1982 and 2019. Because all of the 1,640 carriages existing at the present time will be scrapped, and 270 new carriages to be introduced by 1984 will be scrapped. (Since their economic life is 35 years, 90 cars/year will be procured unit the new plant operation.)

The number of additional carriages to be introduced from 1982 to 2019 is calculated as follows: 3,890 carriages will be required in 2020 (forecast based on transportation demand), and 1,640 carriages were existing in 1982.

$$3{,}890 - 1{,}640 = 2{,}250$$

Therefore, the quantity of rolling stock to be introduced from 1982 to 2019 is calculated as follows.

$$1{,}910 + 2{,}250 = 4{,}160$$

Of that total, 90 cars/year will be introduced in the 1982 to 1991 period. Therefore, the quantity of rolling stock to be constructed anew from 1992 on is calculated as follows.

$$4{,}160 - 90 \times 10 = 3{,}260$$

The quantity of rolling stock to be built in the new workshop is called x cars/year. It is assumed that production will be increased gradually, with (x - 40) cars in the first year beginning in 1992, (x - 30) cars in the second year, (x - 20) cars in the third year, (x - 10) cars in the fourth year, and x cars in the fifth year (and thereafter). Under these circumstances, the quantity of rolling stock to be built from 1992 to 2019 is calculated as follows.

$$24x + (x - 40) + (x - 30) + (x - 20) + (x - 10) = 28x - 100$$

Setting this quantity equal to the required quantity of rolling stock (3,260 cars), we have the following relation.

$$28x - 100 = 3{,}260$$

$$x = 120$$

Therefore, 120 rolling stock cars/year are to be constructed. The carriage introduction plan drawn up based on this quantity is shown in Table 4-4-3.

It is assumed that shortages, if any, will be convered through improvements in efficiency or through the adoption of two shifts (after a certain point).

4-4-2 Wagons

Some 16,358 wagons are to be replaced from 1982 to 2019. This is the number of rolling stock that are seven years old or over in 1982 and will exceed the economic life of 45 years by the end of the period. (Fig. 4-4-2)

The quantity of additional rolling stock to be introduced in the 1982 to 2019 period is calculated as follows. The quantity required in 2020 is 35,780 units, and the quantity possessed in 1982 is 20,522 units.

$$35{,}780 - 20{,}522 = 15{,}258$$

Therefore, the total quantity of rolling stock to be introduced from 1982 to 2019 is given by the following expression.

$$16{,}358 + 15{,}258 = 31{,}616$$

If the quantity of rolling stock to be introduced from 1982 to 1991 is assumed to be 610 units/year, the quantity to be manufactured from 1992 on is calculated as follows:

$$31{,}616 - 610 \times 10 = 25{,}516$$

The quantity of rolling stock to be built in the new workshop is called y cars/year. It is assumed that production will be increased gradually, with (y - 400) units in the first year, (y - 300) units in the second year, (y - 200) units in the third year, (y - 100) units in the fourth year, and y Units in the fifth year (and thereafter). Under these circumstances, the quantity of rolling stock to be built from 1992 to 2019 is calculated as follows.

$$24y + (y - 400) + (y - 300) + (y - 200) + (y - 100) = 28y - 1{,}000$$

Setting this quantity equal to the required quantity of rolling stock (25,516 units), we have the following relation.

$$28y - 1{,}000 = 25{,}516$$

$$y = 947$$

In view of these considerations, it is assumed that wagons will be built at a rate of 900 units/year. It is expected to be possible to expand production with the same equipment and the same number of workers, in view of the characteristics of this kind of rolling stock. The wagon introduction plan drawn up based on this quantity is shown in Table 4-4-4.

Table 4-4-3 Carriage Introduction Plan

Years	Required quantity of carriages	Carriages to be introduced	Carriages to be scrapped	Increment	Quantity of carriages possessed
	1,640				1,640
1982 ∿ 1986		450	123	327	
	2,347				1,967
1987 ∿ 1991		450	19	431	
	3,054				2,398
1992 ∿ 1996		500	6	494	
	3,204				2,892
1997 ∿ 2001		600	139	461	
	3,353				3,353
2002 ∿ 2006		600	451	149	
	3,502				3,502
2007 ∿ 2011		600	450	150	
	3,651				3,652
2012 ∿ 2016		600	452	148	
	3,801				3,800
2017 ∿ 2019		360	270	90	
	3,890				3,890

Table 4-4-4 Wagon Introduction Plan

Years	Required quantity of wagons	Wagons to be introduced	Wagons to be scrapped	Increment	Quantity of wagons possessed
	20,522				20,522
1982 ∿ 1986		3,050	1,061	1,989	
	22,511				22,511
1987 ∿ 1991		3,050	953	2,097	
	24,500				24,608
1992 ∿ 1996		3,735	1,829	1,906	
	26,514				26,514
1997 ∿ 2001		4,735	2,720	2,015	
	28,529				28,529
2002 ∿ 2006		4,735	2,721	2,014	
	30,543				30,543
2007 ∿ 2011		4,735	2,720	2,015	
	32,558				32,558
2012 ∿ 2016		4,735	2,677	2,058	
	34,572				34,616
2017 ∿ 2019		2,841	1,677	1,164	
	35,780				35,780

CHAPTER 5 PRODUCTION PLANNING

5-1 Plant Scale

The recommended scheme of manufacture in the proposed project is to establish an integrated plant, comprising the full-scale installations for producing carriages and wagons, and its auxiliary facilities.

The following economies of scale are expected to derive for an integrated plant compared with a scheme for two manufacturing plants (one for carriages/wagons and the other for wagons only).

(1) Plant installation economy

Savings in land, building, facility, railway siding, and other investments.

(2) Staffing economy

Avoiding duplication of senior engineers, middle management, and skilled and semiskilled workers.

(3) Materials economy

Merits due to the purchase of raw materials in large quantities, with savings in the stocking of raw materials and spare parts.

(4) Management expense economy

Elimination of salaries and expenses for overlapping administrative and service departments.

These factors yield a lower plant cost and a lower fixed cost of production for the proposed scheme than the scheme for two separate plants. Accordingly, the manufacturing plant for carriages and wagons, having the proposed production capacity described in 5-2, should be integrated. That is, it should not be split to achieve feasibility.

5-2 Precondition for Production Capacity

It is presumed that the number of rolling stock to be produced is as follows:

Carriages	120 cars/year
Wagons	900 units/year

Though several types of carriages and wagons will actually be produced, to simplify the feasibility study, the types are limited to the third class carriage and the four-wheeled covered wagon (all-welded) that are expected to be produced largely in Bangladesh Railway.

Both carriages and wagons are to be manufactured for BG and MG at the rate of 25 to 75.

5-3 Standard Production Process

Generally speaking, a standard production process is designed, taking into consideration production technology level, as well as facilities, equipment, and jigs. In the future, the standard production process is considered to be changeable, in accordance with the actual situation (in terms of improved technology and facilities, as well as the types of carriages and wagons to be produced).

5-3-1 Standard Process for Carriage Manufacture

The standard process for carriage manufacture is shown in Table 5-3-1.

5-3-2 Standard Process for Wagon Manufacture

The standard process for wagon manufacture is shown in Table 5-3-2.

5-4 Phased Transition of Production Scale

For a large-scale carriage and wagon manufacturing plant such as proposed, immediately full-scale production should not be attempted for reasons explained in this section.

It will take a long time to acquire a considerable number of qualified engineers and skilled workers required for the manufacture of carriages and wagons. Moreover, a phased investment in facilities and equipment is advisable from the viewpoint of investment efficiency. It is, however, necessary to meet the demand as much as possible, considering the BR situation. It is also necessary to acquire modernized production know-how for the manufacture of carriages and wagons, so as to accomplish a smooth transfer of production technology. For the reasons mentioned above, a phased production method should be adopted.

5-4-1 Phased Production

Because Bangladesh Railway has a history of rolling stock repair technology and carriage and wagon assembly, its staff has acquired technological experience. But the production of carriages and wagons was and still is too small, compared with the proposed production. Accordingly, the experienced staff is limited to a small group. The manufacture of rolling stock requires a wide variety of technologies, including designing, production, and engineering. Recently there has been remarkable progress in technology, with tests and trials being made one after another at an extremely rapid pace. It is, therefore, indispensable to guide and train workers systematically and efficiently, so that they understand the rolling stock and pertinent technologies.

It is also necessary to increase the number of engineers having advanced technological knowledge and experience, and to acquire engineers having knowledge of carriage and wagon design.

For all these reasons, the percentage of domestic production should be allowed to grow gradually. This should be done by starting domestic production with a Semi-Knocked Down (SKD) phase then proceeding to Complete Knocked Down (CKD) and Raw Material (RM) phases as the technical level rises.

(1) Production scale for carriages by phase

The production scale for carriages by phase is shown in Table 5-4-1. It is of great importance for Bangladesh Railway to establish a modernized and rational production system so as to achieve domestic production of carriages that meet its demand without importing complete carriages in general use. To smoothly achieve this object, the production scale by phase is required to be in harmony with the training programme for personnel required. Accordingly, the manufacturing work of the carriage is divided into four categories; Ⓐ, Ⓑ, Ⓒ, and Ⓓ. Category Ⓐ includes carbody assembly and final assembly; Ⓑ sub-assembly or block assembly of side, end and roof structures and underframes, etc.; Ⓒ fabrication of members and parts including such works as gas cutting, shearing and pressing. For the first full year domestic production work will be limited to category Ⓐ for the production of 80 carriages.

For the second full year domestic production work will be limited to categories Ⓐ and Ⓑ. In this case, however, workload will be limited to half of the total quantity of 80 carriages with respect to Ⓑ in consideration of staffing capacity of skilled and semi-skilled workers as well as qualified supervisory personnel.

For the third full year the scope of domestic production will be extended to Ⓐ, Ⓑ and Ⓒ for the production of 100 carriages. In this case, however, the workload will be confined to half of the total quantity with respect to category Ⓒ except for categories Ⓐ and Ⓑ. For the fourth full year, full-fledged domestic production of 110 carriages excluding bogies will be started. In addition, from the fifth full year onward completely full-scale domestic production system for 120 carriages excluding bogies will be established in terms of both quantity and quality that satisfy the demand. In this feasibility study it is presumed that for the first three years principal materials and components including steel plates are imported.

(Carriage)

Table 5-3-1 Standard Production Process

Days			110						Remarks
			18	28	12	17	25	9	1	
Process			① Members & parts fabrication	② Block assembly	③ Body structure assembly	④ Painting	⑤ Interior & exterior equipments installation	⑥ Inspection	⑦ Trial running test	
Production process			· Gas cutting · Shearing · Pressing · Fabrication of formed materials & plate materials, etc.	· Underframe · Side structure · Roof structure · End structure · Partition structure, etc.	· Overall assembly of each structure through welding	· Shot blast for body structure · Anticorrosion painting · Outside panel final painting, etc.	· Interior panel · Ceiling panel · Doors & other equipment · Piping & wiring · Outfitting	· Final body inspection · Weighing · Max. moving dimensions check · Watertight test · Function test · Others	· Performance test · Running test · Vibration & ride quality test	
Phase	I	Year 1			←	———	———	———	→	
		2		← Half of total Number of carriages →	←	———	———	———	→	
	II	3	← Half of total Number of carriages →	←	———	———	———	———	→	
		4	←	———	———	———	———	———	→	
		5	←	———	———	———	———	———	→	
	III	6	←	———	———	———	———	———	→	
		7	←	———	———	———	———	———	→	
		8	←	———	———	———	———	———	→	

Table 5-3-2 Standard Production Process

(Wagon)

Days			70							Remarks
			24	22	7	4	6	6	1	
Process			① Members & parts fabrication	② Block assembly	③ Body structure assembly	④ Painting	⑤ Equipments installation	⑥ Inspection	⑦ Trial running test	
Production process			· Gas cutting · Shearing · Pressing · Fabrication of formed materials & plate materials, etc.	· Under frame · Side structure · Roof structure · End structure, etc.	· Overall assembly of each structure through welding	· Shot blast for body structure · Anti-corrosion painting · Final painting	· Brake equipment & other parts fitting · Piping, etc.	· Final body inspection · Weighing · Max. moving dimensions check · Watertight test · Function test, etc.	· Performance test · Running test	
Phase		Year								
	I	1								
		2		Half of total Number of wagons						
	II	3	Half of total Number of wagons							
		4								
		5								
	III	6								
		7								
		8								

Table 5-4-1 Transition to Domestic Production

(Carriage)

Category	Division	Description	Phase I: Year 1	Phase I: Year 2	Phase II: Year 3	Phase II: Year 4	Phase II: Year 5	Phase III: Year 6	Phase III: Year 7	Phase III: Year 8	Remarks
Domestic production	Ⓐ	· Final assembly · Car body assembly	Ⓐ	Ⓐ	Ⓐ	Ⓐ	Ⓐ	Ⓐ	Ⓐ	Ⓐ	
Procurement	Ⓑ	· Block assembly · Side structure · End structure · Roof structure · Partition structure · Underframe etc.	Ⓑ	1/2Ⓑ 1/2Ⓑ	Ⓑ	Ⓑ	Ⓑ	Ⓑ	Ⓑ	Ⓑ	
Procurement	Ⓒ	· Members & parts fabrication · Gas cutting · Shearing · Pressing · Fabrication of formed materials & plate materials	Ⓒ	Ⓒ	1/2Ⓒ 1/2Ⓒ	Ⓒ	Ⓒ	Ⓒ	Ⓒ	Ⓒ	
Procurement	Ⓓ	· Bogie · Bogie frame · Bolster · Others	Ⓓ	Ⓓ	Ⓓ	Ⓓ	Ⓓ	1/5Ⓓ 4/5Ⓓ	1/2Ⓓ 1/2Ⓓ	Ⓓ	
Number of carriages to be produced			80	80	100	110	120	120	120	120	

From the fourth full year onward the feasibility study is based on the assumption that materials and parts, except for commercial parts and special items that are not domestically procured are not imported.

On the other hand, category Ⓓ, that is, domestic production of bogies will be partly started in the third phase on the basis of the production technology and the quality control that are acquired through the experiences of domestic production of carriages excluding bogies. From the third full year in the third phase onward, full-fledged domestic production will be expected provided that required technology is acquired. In this case, commercial parts such as wheel-sets, roller bearings and springs, etc. are required to be imported.

(2) Production scale of wagons by phase

The production scale of wagons by phase is shown in Table 5-4-2. Basic points of view toward the wagon production system are the same with wagons as with carriages. In case of wagons, however, it is necessary to take into consideration the concept of mass-productive system, compared with the production of carriages. Consequently it is considered to be advisable that the same four-category method consisting of Ⓐ, Ⓑ, Ⓒ and Ⓓ as in the production of carriages is adopted. In conclusion, for the fourth full year full-fledged domestic production of 800 wagons (units) will be started. In addition, from the fifth full year onward completely full-scale domestic production system for 900 wagons (units) will be established in terms of both quantity and quality that satisfy the demand.

Table 5-4-2 Transition to Domestic Production

(Wagon)

Category	Division		Description	Phase I, Year 1	Phase I, Year 2	Phase II, Year 3	Phase II, Year 4	Phase II, Year 5	Phase III, Year 6	Phase III, Year 7	Phase III, Year 8	Remarks
Category	Domestic production	(A)	· Final assembly · Car body assembly	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)	
	Procurement	(B)	· Block assembly · Side structure · End structure · Roof structure · Underframe etc.	(B)	1/2(B) / 1/2(B)	(B)	(B)	(B)	(B)	(B)	(B)	
		(C)	· Members & parts fabrication · Gas cutting · Shearing · Pressing · Fabrication of formed materials & plate materials	(C)	(C)	1/2(C) / 1/2(C)	(C)	(C)	(C)	(C)	(C)	
		(D)	· Bogie · Bogie frame · Bolster · Others	(D)	(D)	(D)	(D)	(D)	1/5(D) / 4/5(D)	1/2(D) / 1/2(D)	(D)	
Number of wagons to be produced				500	600	700	800	900	900	900	900	

5-5 Domestic Production Plan

5-5-1 Outline of Other Industrial Concerns

The principal industrial concerns in Bangladesh are all semigovernmental. Bangladesh Steel and Engineering Corporation is considered to be closely concerned with the production of carriages and wagons, and is composed of 27 limited industrial companies, including Bangladesh Machine Tools Factory, and Chittagong Steel Mills.

At present, a considerable quantity of materials, parts, and consumables that are locally produced are used in the construction of carriages. However, commercial components such as wheelsets, roller bearings, springs, brake gears, and coupling devices are imported from abroad. In addition, whole-set bogies and carriage underframes are now imported, but will be domestically manufactured at the time of full-fledged production at the proposed manufacturing plant. For reference, the results of a questionnaire are shown in Table 5-5-1.

Utilization of domestically produced materials and parts is roughly shown in the Table 5-5-1.

5-5-2 Rate of Transition to Domestic Production

The domestic production plan is broadly classified into two categories; the whole car body without bogies and the bogies. The former is to be accomplished in the last year of Phase II for the total number of carriages and wagons produced annually; the latter is to be accomplished in the last year of Phase III for the bogie.

Accordingly, in the last year of Phase III, the total annual production of carriages and wagons will be handled domestically.

For reference, the planned rate of transition to domestic production is shown in Table 5-5-2.

5-6 Transport of Rolling Stock

BG rolling stock (both domestically produced in the Chittagong area and imported) is transported from the Chittagong area to the Saidpur area (MG track) as described below.

Table 5-5-1 Utilization of Domestically Produced Materials & Parts (1/3)

Materials & parts	Local	Imported	Remarks
(1) Cast steel			
• Vacuum brake cylinder	30∿40%	the rest	
• Center pivot	- do.-	- do.-	
• Draft gear stop	- do.-	- do.-	
• Others	- do.-	- do.-	
(2) Whole set of bogies	-	Yes	
(3) Stainless steel parts			
• Wash basin	Yes	-	
• Lavatory, bathroom wall & floor	Yes	Yes	
• Others	Yes	Yes	
(4) Alminium parts & sections			
• Window frame	Yes	Yes	
• Window blind	Yes	Yes	
• Others	Yes	Yes	
(5) Rubber products			
• Hose	Yes	-	
• Vestibule diaphragm	-	Yes	
• Weather strip	Yes	-	
• Rolling seal	Yes	-	
• Other rubber products	the rest	5∿10%	
(6) Consumables			
• Electrodes	Yes	Yes (special)	
• Gas	Yes	-	
• Paint	Yes	-	
(7) Electrical goods			
• Cables	Yes	-	
• Axle generator & accessories	5∿10%	the rest	
• Fans	Yes	-	
• Lamps	Yes	little (high watt)	

Table 5-5-1 Utilization of Domestically Produced Materials & Parts (2/3)

Materials & parts	Local	Imported	Remarks
(8) Bolts & screws			
· Bolts	Yes	few (special size)	
· Screws	Yes	-	
(9) Coupling device			
· Screw & link couples	-	Yes	
· Draft gear	-	Yes	
(10) Commercial goods			
· Wheels and axle	-	Yes	
· Spring	5∿10%	the rest	
· Roller bearing	-	Yes	
· Brake gear	-	Yes	
· Others	Yes	Yes	
(11) Steel			
· Plate hot-rolled (SS41 equivalent)			
t 1.6 m/m	Yes	-	equivalent thickness
t 2.3 m/m	Yes	-	
t 3.2 m/m	Yes	-	
t 4.5 m/m	Yes	-	
t 9.0 m/m	Yes	-	
t 12 m/m	Yes	-	
· Plate cold-rolled (SS41 equivalent)			
t 1.2 m/m	-	Yes	equivalent thickness
t 1.6 m/m	-	Yes	
t 2.3 m/m	-	Yes	
· Angle (JIS equivalent)			
· L50 m/m × 50 m/m × 4.5 m/m	Yes	-	
· L65 m/m × 65 m/m × 8 m/m	Yes	-	
· L90 m/m × 90 m/m × 6 m/m	Yes	-	
· Others	Yes	-	

Table 5-5-1 Utilization of Domestically Produced Materials & Parts (3/3)

Material & parts	Local	Imported	Remarks
(11) Steel (continued)			
· Channel (JIS equivalent)			
· [150$^{m/m}$ × 75$^{m/m}$ × 6.5$^{m/m}$	Yes	–	
· [180$^{m/m}$ × 75$^{m/m}$ × 6.5$^{m/m}$	Yes	–	
· [200$^{m/m}$ × 100$^{m/m}$ × 9$^{m/m}$	Yes	–	
· Others		Yes	{ special sections
· Bars ϕ4 ∿ 12$^{m/m}$	Yes	–	
· Flat bars 50$^{m/m}$ × 6$^{m/m}$	Yes	–	

Table 5-5-2 Rate of Transition to Domestic Production

Item	Phase / Year	I: 1	I: 2	II: 3	II: 4	II: 5	III: 6	III: 7	III: 8
Number of rolling stock to be produced	Carriages	80	80	100	110	120	120	120	120
	Wagons	500	600	700	800	900	900	900	900
Rate of transition to domestic production	Bogies excluded	45%	60%	80%	95%	100%			
	Bogies included	40%	50%	70%	80%	85%	90%	95%	100%

Note: Rate of transition to domestic production is roughly determined based on the workload with production of 120 carriages (MG) and 900 wagons (MG) as cent per cent with respect to two cases (bogies excluded and bogies included).

5-6-1 Carriages

The body of a BG carriage was transported using MG dummy bogies specially made for this purpose. Bogies of a BG carriage were transported on the MG wagon.

5-6-2 Wagons

A BG bogie wagon was transported by the same means as used for the carriage. A four-wheeled wagon was separated into body and wheelsets, and these were carried on separate MG wagons.

Recently, however, Bangladesh Railway has begun unloading BG rolling stock directly onto a BG wagon ferry barge at Mongla-port, which then carries them to the BG track at Khulna.

CHAPTER 6 CONSTRUCTION PLAN

6-1 Site Selection

6-1-1 Proposed Sites

As stipulated in the Scope of Work agreed upon between MOC and JICA, the sites for the Study are, for the new workshop, Kumira and Parbatipur, for the expansion of the existing workshop, Saidpur.

Kumira is located approximately 23 km north of Chittagong city, alongside the main railway line of meter gauge between Chittagong and Dhaka. Two sites are proposed in this area; one on the north side of Kumira Railway Station (hereinafter referred to as Kumira North) and one on the south side of the station, the present site of the Kumira scrap yard (hereinafter referred to as Kumira South).

Parbatipur (pop. 19,000) is a rural town on the west side of the River Jamuna, located at the junction of the meter gauge line entering from the eastern region and the broad gauge line running from Khulna to Dinapur. Two sites are proposed at Parbatipur as well, with one on the north side of Parbatipur Railway Station (hereinafter referred to as Parbatipur North) and the other on the south side of the station (hereinafter referred to as Parbatipur South).

The town of Saidpur is approximately 15 km north of Parbatipur. It is well known for its traditional railway workshop with over eight thousand employees. Dual gauge (MG and BG) track connects the workshop to the main railway line. The track between Parbatipur and Saidpur is also dual gauge, carrying MG/WG carriages and wagons.

Surveys for each of the five proposed sites were completed during the site survey period. The following items have been chosen as criteria for the establishment of carriage and wagon manufacturing plant. Fig. 6-1-1 - Fig. 6-1-5 show the above-mentioned five sites.

Table 6-1-1 Proposed Sites

Site Names		Location	Area (m^2)	Shape	Remarks
Kumira	North	Area in front of Kumira Station	Approx. 93,000	Approximate Rectangle	Former Brick Factory Site
	South	Approx. 600 m South of Kumira Station	Approx. 100,000	Approximate Rectangle	Presently Scrap Yard Site
Parbatipur	North	West Northwest of Parbatipur Station	Approx. 140,000	Rectangle	Near Diesel Workshop
	South	Southeast of Parabatipur Station	Approx. 525,000	Rectangle	South of Fertilizer Store
Saidpur		West Side of Saidpur Workshop	Approx. 69,000	Tapered Rectangle	In Vicinity of Store

6-1-2 Land

(1) Area

A land area of at least 250,000 square meters is required to support the establishment of a carriage and wagon manufacturing capacity of 120 carriages and 900 wagons, as described in 4-4. As shown in Table 6-1-2, the areas of the Saidpur site and the two proposed sites at Kumira are too small to allow adequate and efficient production. By comparison, both proposed sites at Parbatipur have markedly larger areas of approximately 525,000 square meters (south side) and approximately 140,000 square meters (north side). These are roughly three or four times the size of the Kumira sites. However, if privately owned land could be obtained at Kumira (e.g. land north of the proposed north side site or land west of the proposed south side site) the proposed north side and south side sites can be enlarged to approximately 110,000 squre meters, and 135,000 square meters respectively. They would then grow to approximately one third of the proposed sites at Parbatipur.

The site at Saidpur is the smallest. At 69,000 square meters, it is roughly one seventh of the existing Saidpur Workshop area. (110.34 Acres)

Table 6-1-2 Comparison of Proposed Site Area

(Unit m^2)

Place	Kumira		Parbatipur		Saidpur
	North	South	North	South	
Railway owned area	93,000	100,000	140,000	525,000	69,000
Private land	20,000	36,000	-	-	-

In addition, proportionately more space will be required if the administration determines a need for housing colony installations and related facilities.

The Parbatipur sites are larger than the Kumira sites. However, the land ares required for housing colonies must be considered. It may be said that less area will be required for housing colonies at the Kumira site due to its proximity to Chittagong city.

(2) Site Conditions

A complete evaluation of the proposed sites requires an assessment of the improvements necessary before construction can begin. The following observations were made.

1) Kumira North: There is the foundation of an old brick factory in the central area and a tank currently being used by the BR tuberculosis sanatorium.

2) Kumira South: There is a BR's scrap yard. The building area is not so large.

3) Parbatipur North: 50% of the site area is a tank, and a public road crosses the site diagonally. A grave yard is located at the northeast corner of the site.

4) Parbatipur South: The entire site is farm land.

5) Saidpur: Almost the entire area of the proposed site is a tank.

The remains of the factory and scrap yard do not constitute an unrasonable hinderance, but a tank requires much earth work for the construction of a plant.

(3) Embankment

In order to prevent the flood damage so often observed in Bangladesh, the level of the ground should be kept at least as high as railway track level. The approximate heaping height necessary for each proposed site is shown in Table 6-1-3. Significant differences can be noted but they are not conclusive.

Table 6-1-3 Data for Site Embankment

Site	Kumira		Parbatipur		Saidpur
	North	South	North	South	
Heaping height	3 - 4	(15%)* 2	(50%) 3 - 4 (50%) 1 - 1.5	1 - 1.5	4

(Unit in m)

* For the privately owned proportion, it is 4 - 5 m.

(4) Earth Bearing Capacity

Regarding the earth bearing capacity, the Kumira sites have priority with value of 7 - 8 ton/m^2, while the value of other sites ranges around 4 - 5 ton/m^2. These values mean that each site is available for plant construction.

(5) Land Cost

The price of land depends almost exclusively upon its surrounding circumstances, commercial potential and purchase conditions. Kumira is near Chittagong city and it is said that land costs at Kumira are several times those of the proposed sites in the western region.

(6) Environment Conditions

At Kumira the proposed sites are surrounded by farms along the trunk road. A high school adjoins the site of Kumira North.

At Parbatipur North, there is the Central Diesel Workshop and its housing colonies on the opposite side of the railway track. The Central Diesel Workshop (BACK SHOP) is also under construction at a site near Parbatipur North. The Parbatipur South site is surrounded by vast fields and a few fertilizer warehouses.

The Saidpur site is partially surrounded by several farms and homes.

6-1-3 Transport

(1) Access by Railway

Track can easily be installed from the Kumira Station Yard to the Kumira North site. The Kumira South site already has incoming track presently used for the scrapyard.

Similarly, at the Parbatipur North site, an incoming track can easily be laid from the north point of the rail line. The incoming track for the Parbatipur South site starts directly from the Parbatipur Station Yard.

For Saidpur, an incoming track can be installed from the shunting yard of the Workshop.

There is no significant difference in railway access among the proposed sites.

(2) Access by Road

The Dhaka Trunk Road runs almost directly alongside the west side of both Kumira sites. The Parbatipur North site has an approach by trunk road from the east side and the Parbatipur South site has a trunk road adjacent to its west side. A 4 m wide road passes the site at Parbatipur.

No significant difference was found among the sites in terms of road access.

(3) Transport of BG Rolling Stock

As described in 6-1-1, there is a dual gauge track (i.e. MG/BG) between Parbatipur and Saidpur. This eliminates difficulties in the transport of MG rolling stock on the BG line in the western region. On the contrary there is no BG line alongside the Kumira sites; special means are required to ttansport BG rolling stock. A common method is the use of a dummy bogie, which is only temporarily used to transport a car body on different gauge lines. Four wheeled wagons are laid wholly on the flat car especially equipped for them.

Also required are restrictions in train operations. Rolling stock with dummy bogies must be operated with utmost caution at reduced running speed (under 15 km/h). Attention must be paid to the dynamic behaviour of the rolling stock concerning the clearance between structure gauge on the ordinary lines and car body, and to the stability of rolling stock on the barge used for crossing the river as well.

Indeed, this is not the most efficient means to transport, but BR has had experience in such transport, especially with the transport of imported BG rolling stock and BG rolling stock constructed at the Pahartali Workshop in Chittagong.

This is one of the more relevant items with respect to site selection.

6-1-4 Utility Resources

(1) Electric Power Supply

Chittagong is a hilly area. There are some hydraulic power plants in that area which can provide enough electricity for the Kumira site.

A 33 kV trunk line belonging to Power Development Board (PDB) runs alongside the Parbatipur South site. Both Parbatipur North and Parbatipur South would have no difficulty providing electric power for both plant operation and housing colony needs.

Although the Saidpur workshop presently has its own power plant and feeds electricity to the Saidpur workshop, its capacity is not ample. Expansion of the workshop for this project will require a new substation, connected to the PDB supply.

(2) Heat Resources

In a rolling stock manufacturing plant, most heat is consumed for the following purposes:

- Annealing of manufactured components in the furnace
- Heating of parts to be forged in the furnace
- Boiling for phosphate treatment
- Room heating and use for gas ranges in offices and canteen

For these purposes, natural gas will be recommended as the best source of heat from the viewpoint of controlability, cost, curtailing foreign currency outlays, installation of specified facilities for storage and cleanness of burnt air. However these priorities are not necessarily definitive, the plant can be operated using oil without serious deficiencies.

A comparison of the proposed sites reveals: at the Kumira sites, natural gas can be provided with relatively little difficulty, at Parbatipur and Saidpur, oil, coal or electricity can be supplied instead of natural gas. It is said that natural gas service will be provided to Parbatipur in future.

Consequently, no significant differences among the proposed energy resources of the proposed sites have been noted.

(3) Water Resources

For rolling stock manufacturing, water is consumed in the plant for cooling air compressors, water showers in the painting booths, cleaning after phosphating, quenching for body strain reforming, generation of acetylene gas, water-proof testing etc. Water must also be supplied to the hydrants, canteens, toilets and showers both in the factory and colony areas as well.

Roughly 1000 - 1500 m^3 of water to be used daily in the factory and colony area. This quantity is equal to the volume of thirty four - fifty 30 ton tank wagons. For the Kumira sites, no ground water is available, although well digging was attempted several times at several locations. This is one of the serious shortcomings of these sites.

If this defect is compensated by a water pipeline extending approximately 12 km from Fouzderhat, several pumps connected in a cascade mode will be required.

The extreme pipeline length will cause high resistance to water flow. Moreover installation of water pipeline entails high initial expenditures and heavy maintenance to maintain the system. Such a pipeline might interfere with plant operation.

On the contrary it is said that the sites at both Parbatipur and Saidpur are able to provide enough water for plant operation and daily needs.

6-1-5 Manpower Recruitment

The major industry of Bangladesh is agriculture, although there are some shipyards, steel mills, railway workshops and a variety of other industrial operations. This figure is much more conspicuous especially in western inland region.

To operate the carriage and wagon manufacturing plant on the aforesaid scale in Bangladesh, approximately over three thousand employees will be required. The recruitment of skilled workers on such a large scale will be a sizeable task.

However transferring skilled workers from existing railway workshops will be possible to a certain extent. Such will be an efficacious solution if not a perfect one. Transfers occasionally result in an increases in housing colonies.

Descending from general to particulars, the Kumira sites are not located in the outskirts of the City of Chittagong but not so far away from the city. This gives the sites an advantage especially in recruiting skilled workers. On the contrary, both Parbatipur sites and the Saidpur site have less skilled local workers available for recruitment.

However, this deficiency can be compensated for by the transfer of the workers from the conventional Saidpur Workshop, where carriages are now manufactured on a much larger scale than at the Pahartali Workshop near Kumira.

Judging from the above-mentioned prospects, the Kumira sites have recruitment advantages overall, but it can be mentioned that this is not a crucial factor. Since skilled workers are of great importance, the establishment of a rather long term training plan would remove some of the uncertainty surrounding the Project.

6-1-6 Procurement

Imported raw materials or components which are to be gradually changed over to domestic production will be transported from Chittagong to Kumira, or from Khulna and/or Chittagong to Parbatipur or Saidpur. A steel mill is located in Chittagong and the Machine Tool Factory is located at Joydebpur near Dhaka.

Some components may be provided by the Pahartali Railway Workshop to Kumira and by the Saidpur Workshop to either Parbatipur or to the new Saidpur Plant respectively. Furthermore, the Central Diesel Workshop (BACK SHOP) will be able to assist the plant at Parbatipur with parts or components supply if necessary.

In conclusion, it is difficult and hardly significant to discriminate the fine difference in procurement potential at each site. However one could maintain that the Kumira sites are somewhat superior to the other sites.

6-1-7 Introduction of Updated System

It can be said with certainty that the newly established plant should be controlled and operated much more efficiently and modernly. This seems to require the physical isolation of the new plant from any conventional workshops. Accordingly, the expansion of the Saidpur Workshop can hardly be adopted as a suitable plan for this project.

6-1-8 National Development Plan

Establishment of a carriage and wagon manufacturing plant is the prominent project not only in the railway field, but also in the whole Bangladesh industrial field. Accordingly this project will greatly influence the up-lift of the local area.

The GOB in line with its goal of a "happy and prosperous country" is attempting a balanced development of all areas of the country with special emphasis on the least developed area.

The Dinajpur District is certainly less developed than Chittagong District. Throughout the northwest region overall, there are fewer heavy industries. The GNP per capita is considerably less in the northwest region than in the southeast region.

Table 6-1-4 GNP Comparison by Region

Region	GNP per Capita (Taka)
Northeast	2831
Northwest	2623
Southeast	4802
Southwest	2704

(as of 1981/82)

To make the imbalance in development smaller is a great concern and interest to the GOB. It depends upon the governmental policy whether great importance is attached to this project.

6-1-9 Cost Estimation

The construction cost and production cost evaluation plays a significant role in the site selection. A rough comparison of the construction cost and production cost of each site has been done towards this end. The site selection study should review a variety of aspects including such quantitative factors as costs and abstract factors which cannot be quantified, such as the overall impact of the project on the national development plan.

For site selection a rough estimation, even for the quantitative factors, is adequate since precise cost estimates would lose their significance in the overall consideration of all factors. More detailed estimation will be undertaken at the preliminary design and detailed design stages.

To compare the construction cost, we calculated the construction cost differences among the proposed sites in terms of additional land acquisition outlays, embankment and foundation costs and expenses incurred for water supply, fuel store construction and labour (construction). The results are shown in Table 6-1-5.

Table 6-1-5 Cost Differential of Each Site

Site	Kumira		Parbatipur		Saidpur
	North	South	North	South	
Sum of the Cost to be varied with site location (Mil. Taka)	300	230	175	120	220
Cost Differential (Mil. Taka)	180	110	55	0	100

The construction cost of the Kumira North site is the highest, and that of the Parbatipur South site is the lowest. Cost differential for these two sites is approximately 180 million Takas, approximately 15% of the total Parbatipur South site land and building construction cost.

Differentials in the working capital requirements among the sites are negligible. As labour costs are the key variable, the relatively uniform

BR wage scales accounts for the similarity in operating costs among the sites.

6-1-10 Conclusion

The specific features of each major factor related to site selection were investigated and compared from 6-1-2 to 6-1-9.

In addition to the above, such factors as the availability of communication facilities and local effluent treatment requirements could have been considered, but they were considered to be of minor significance.

Among five proposed sites, the Saidpur site is too small to establish the plant and too adjacent to the existing workshop to introduce up-dated system in it. The Study Team concluded that the Saidpur site is not adequate for this Project site.

Excluding the Saidpur site, the following Table 6-1-6 shows the merit and the demerit of each proposed site by key factor.

Table 6-1-6 Proposed Site Evaluation

Site	Kumira		Parbatipur	
	North	South	North	South
Land Area	Δ	Δ	o	o
Water Supply	Δ	Δ	o	o
Embankment	Δ	o	Δ	o
Cost Differential	Δ	Δ	o	o
Transport of Product	Δ	Δ	o	o
Recruitment	o	o	Δ	Δ
Effect on Up-Lift	Δ	Δ	o	o

Legend [o : Good ; Δ : Poor]

Judging from technical and cost comparison, the Study Team recommends the Parbatipur site especially South site as the most appropriate site for this Project, and GOB agreed that further study on feasibility be conducted, taking Parbatipur South, as the site for the plant.

Fig. 6-1-1 Proposed Site "Kumira South"

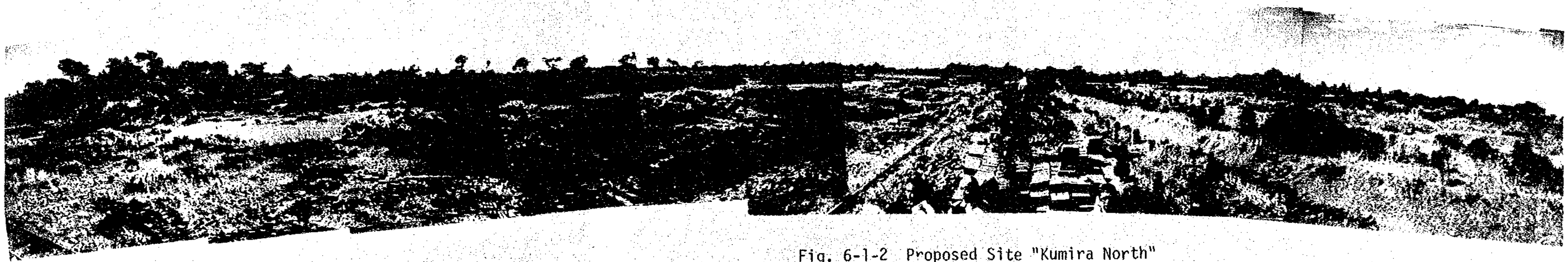

Fig. 6-1-2 Proposed Site "Kumira North"

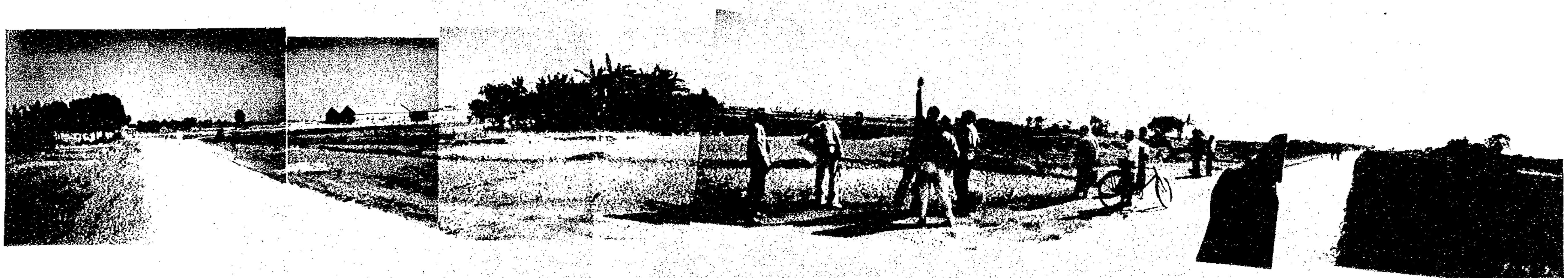

Fig. 6-1-3 Proposed Site "Parbatipur South"

Fig. 6-1-4 Proposed Site "Parbatipur North"

Fig. 6-1-5 Proposed Site "Saidpur"

6-2 Site Preparation

6-2-1 Topography of the Project Site

(1) Site Description

As proposed in the Interim Report, the project site was selected at Parbatipur South. The site is rougly square, 800 m east-west and 850 m north-south, having an area of 680,000 m^2. It is adjacent to Parbatipur station to facilitate the construction of a sidding to the plant.

The plant site is rectangular (380 m × 630 m, north-south; 239,400 m^2), avoiding a one-storey warehouse on the northwest corner and extending to a road near power transmission lines.

The housing site located next to the plant site has an area of 200,000 m^2 and can be arranged in any shape.

(2) Embankment Volume

Since the flood level at the site is 109.5 m above sea level according to level survey maps (Fig. 6-2-1), filling of 1.5 m on the average will be required.

6-2-2 Subsoil Conditions

Since the surface layer (GL to 1.5 m) has a bearing capacity of only 4 to 5 ton/m^2, most permanent structures will require pile foundations. The bearing layer is assumed to be 16 m below GL in a sand layer which lies below a clay layer of GL to 8 m (see Fig. 6-2-2). If 400 mmϕ piles are used, the bearing capacity of each pile, including friction force, is estimated at 40 tons in accordance with AIJ standards.

A more precise survey is recommended in the detailed design stage.

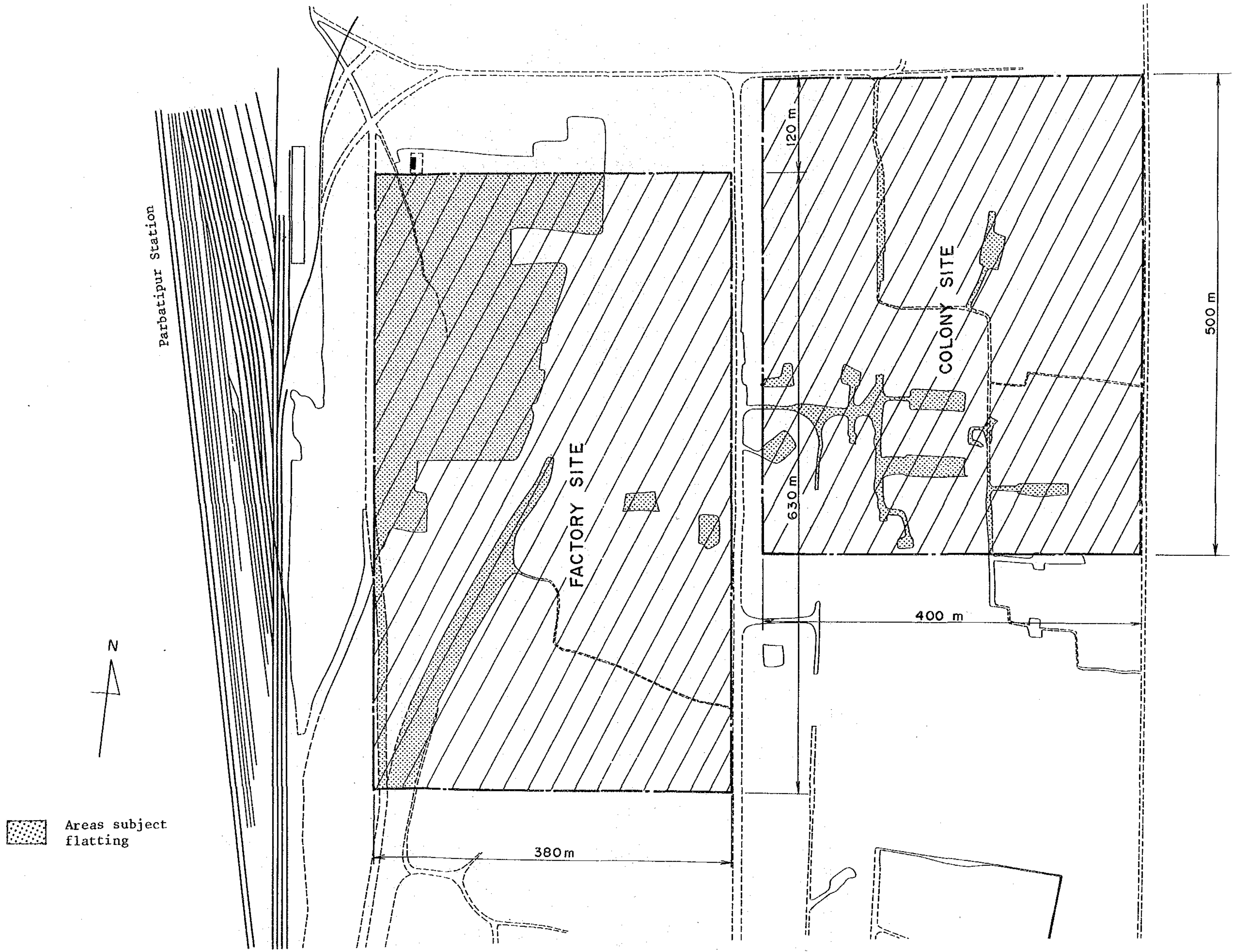

Fig. 6-2-1 Topography of Parbatipur - South

BANGLADESH RAILWAY AT PARBATIPUR

BORE LOG FOR BOREHOLE NO. H.S.-2

R. L.: +35°3 m DIAM OF BORING: 12 cm

DEPTH IN METRE	DATE OF BORING	SOIL STRATA ENCOUNTERED	LOG	S.P.T. RESULTS BLOWS/FT. PENETRATION (140 LBS, HAMMER, 30° FREE FALL)	AT
3.50		Lt. grey SILT with clay		2	1.0m
				4	2.0m
				4	3.0m
4.50		Lt. grey very fine SAND, traces SILT		[illegible]	4.0m
5.50		Lt. grey SILT; traces v. fine sand & clay		7	5.0m
8.20		Brownish grey SILT with clay		8	6.0m
				9	7.0m
				9	8.0m
12.00		Lt. grey (occasionally brownish grey) fine to med. SAND, traces SILT		13	9.0m
				13	10.0m
				18	11.0m
				20	12.0m
23.00				24	13.0m
				30	14.0m
				37	15.0m
				37	16.0m
				35	17.0m
				37	18.0m
				40	19.0m
				42	20.0m
				44	21.0m
				39	22.0m
				42	23.0m
30.15				54	24.0m
				38	25.0m
				39	26.0m
				45	27.0m
				45	28.0m
				47	29.0m
				49	30.0m

16.0 m (length of pile)

Fig. 6-2-2 Soil Column Map