CHAPTER 8

ROLLING STOCK

Chapter - 08

ROLLING STOCK

8.1 INTRODUCTION

The required transport demand forecast is the governing factor for the choice of the Rolling Stock. The forecasted Peak Hour Peak Direction Traffic calls for an Medium Rail Transit System (MRTS).

8.2 OPTIMIZATION OF COACH SIZE

The following optimum size of the coach has been chosen for this corridor as mentioned in Table 8.1.

Table 8.1

Size of the coach

	Length*	Width	Height
Driving Motor Car (DMC)	**21.64 m**	**2.9 m**	**3.9 m**
Trailer car (TC)/Motor Car (MC)	**21.34 m**	**2.9 m**	**3.9 m**

**Maximum length of coach over couplers/buffers = 22.6 m*

8.3 PASSENGER CARRYING CAPACITY

In order to maximize the passenger carrying capacity, longitudinal seating arrangement shall be adopted. The whole train shall be vestibuled to distribute the passenger evenly in all the coaches. Criteria for the calculation of standing passengers are 3 persons per square meter of standing floor area in normal state and 6 persons in crush state of peak hour.

Therefore, for the Medium Rail Vehicles (MRV) with 2.9 m maximum width and longitudinal seat arrangement, conceptually the crush capacity of 43 seated, 204 standing thus a total of 247 passengers for a Driving motor car, and 50 seated, 220 standing thus a total of 270 for a trailer/motor car is envisaged.

Following train composition is recommended:
3-car Train: DMC+TC+DMC

Table 8.2 shows the carrying capacity of Medium Rail Vehicles.

Table 8.2

Carrying Capacity of Medium Rail Vehicles

Particulars	Driving Motor car		Trailer car / Motor car		3 Car Train	
	Normal	Crush	Normal	Crush	Normal	Crush
Seated	43	43	50	50	136	136
Standing	102	204	110	220	314	628
Total	145	247	160	270	450	764

NORMAL-3 Person/sqm of standee area

CRUSH -6 Person/sqm of standee area

8.4 WEIGHT

The weights of motorcar and trailer cars have been estimated as in Table 8.3, referring to the experiences in Delhi Metro. The average passenger weight has been taken as 65 kg.

Table 8.3: Weight of Light Rail Vehicles (Tonnes)

	DMC	TC	3 Car Train
TARE (maximum)	40	40	120
Passenger			
(Normal)	9.425	10.4	29.25
(Crush @6p/sqm)	16.055	17.55	49.66
(Crush @8p/sqm)	20.475	22.295	63.245
Gross			
(Normal)	49.425	50.4	149.25
(Crush @6p/sqm)	56.055	57.55	169.66
(Crush @8p/sqm)	60.475	62.295	183.23
Axle Load @6 person/sqm	14.014	14.388	
Axle Load @8 person/sqm	15.119	15.577	

The axle load @ 6persons/sqm of standing area works out in the range of 14.014T to 14.388T. Heavy rush of passenger, having 8 standees per sq. meter can be experienced occasionally. It will be advisable to design the coach with sufficient strength so that even with this overload, the design will not result in over stresses in the coach. Coach and bogie should, therefore, be designed for **16 T axle** load.

8.5 PERFORMANCE PARAMETERS

The recommended performance parameters are:

Maximum Design Speed: 95 kmph
Maximum Operating Speed: 85 kmph
Max. Acceleration: 1.0 m/s^2
Max. Deceleration 1.1 m/s^2 (Normal brake)
More than 1.3 m/s^2 (Emergency brake)

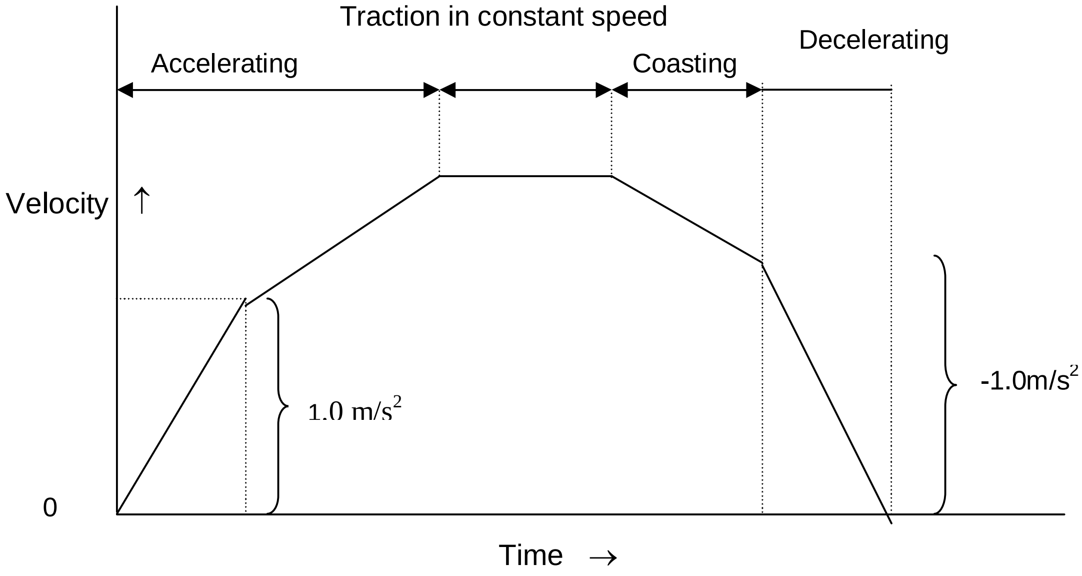

Fig. 8.1 : PERFORMANCE PARAMETERS

8.6 COACH DESIGN AND BASIC PARAMETERS

The important criteria for selection of rolling stock are as under:

(i) Proven equipment with high reliability
(ii) Passenger safety feature
(iii) Energy efficiency
(iv) Light weight equipment and coach body
(v) Optimized scheduled speed
(vi) Aesthetically pleasing Interior and Exterior
(vii) Low Life cycle cost
(viii) Flexibility to meet increase in traffic demand
(ix) Anti-telescopic

The controlling criteria are reliability, low energy consumption, lightweight and high efficiency leading to lower annualized cost of service. The coach should have high rate of acceleration and deceleration.

8.7 SELECTION OF TECHNOLOGY

8.7.1 Low life cycle cost

Low life cycle cost is achieved by the way of reduced scheduled and unscheduled maintenance and high reliability of the sub-systems. It is possible to achieve these objectives by adopting suitable proven technologies. Selection of following technologies has been recommended to ensure low life cycle cost-.

8.7.2 Car body

In the past carbon high tensile steel was invariably used for car bodies. In-fact almost all the coaches built by Indian Railways are of this type. These steel bodied coaches need frequent painting and corrosion repairs, which may have to be carried out up to 4-5 times during the service life of these coaches. It is now a standard practice to adopt stainless steel or aluminum for carbody.

The car bodies with aluminum require long and complex extruded sections which are still not manufactured in India. Therefore aluminum car body has not been considered for use. Stainless steel sections are available in India and therefore stainless steel car bodies have been specified. No corrosion repair is necessary on stainless steel cars during their service life.

Stainless steel car body leads to energy saving due to its lightweight. It also results in cost saving due to easy maintenance and reduction of repair cost from excellent anti corrosive properties as well as on improvement of riding comfort and safety in case of a crash or fire.

8.7.3 Bogies

Bolster less lightweight fabricated bogies with rubber springs are now universally adopted in metro cars. These bogies require less maintenance and overhaul interval is also of the order of 4,20,000km. Use of air spring at secondary stage is considered with a view to keep the floor level of the cars constant irrespective of passenger loading unlike those with coil spring. Perturbation from the track are also dampened inside the car body on account of the secondary air spring along with suitable Vertical Hydraulic Damper .The primary suspension system improve the curve running performance by reducing lateral forces through application of conical rubber spring. A smooth curving performance with better ride index is being ensured by provision of above type of bogies.

8.7.4 Braking System

The brake system shall consist of –

(i) An electro-pneumatic (EP) service friction brake
(ii) A fail safe, pneumatic friction emergency brake
(iii) A spring applied air-release parking brake
(iv) An electric regenerative service brake
(v) Provision of smooth and continuous blending of EP and regenerative braking

The regenerative braking will be the main brake power of the train and will regain the maximum possible energy and pump it back to the system and thus fully utilize the advantage of 3 phase technology .The regenerative braking should have air supplement control to bear the load of trailer car. In addition, speed sensors mounted on each axle, control the braking force of the axles with anti skid valves, prompting re-adhesion in case of a skid .The brake actuator shall operate either a tread brake or a wheel disc brake, preferably a wheel disc brake.

8.7.5 Propulsion System Technology

In the field of Electric Rolling Stock, DC series traction motors have been widely used due to its ideal characteristics and good controllability for traction applications. But these required intensive maintenance because of commutators and electro-mechanical contactors, resistors etc

The brush less 3 phase induction motors has now replaced the D.C. Series motors in traction applications. The induction motor, for the same power output, is smaller and lighter in weight and ideally suited for rail based Mass Rapid Transit applications. The motor tractive effort and speed is regulated by 'Variable Voltage and Variable frequency' control and can be programmed to suit the track profile and operating requirements. Another advantage of 3 phase a.c. drive and

VVVF control is that regenerative braking can be introduced by lowering the frequency and the voltage to reverse the power flow and to allow braking to very low speed.

For this corridor, three phase a.c. traction drive that are self-ventilated, highly reliable, robust construction and back up by slip/slid control have been recommended for adoption.

The AC catenary voltage is stepped down through a transformer and converted to DC voltage through converter and supply voltage to DC link, which feeds Inverter operated with Pulse Width Modulation (PWM) control technology and using Insulated Gate Bipolar

Transistors (IGBT). Thus three-phase variable voltage variable frequency output drives the traction motors for propulsion.

Recently advanced IGBT has been developed for inverter units. The advanced IGBT contains an Insulated Gate Bipolar Transistor (IGBT) and gate drive circuit and protection. The advanced IGBT incorporates its own over current protection, short circuit protection, over temperature protection and low power supply detection. The IGBT has internal protection from over current, short circuit, over temperature and low control voltage.

The inverter unit uses optical fiber cable to connect the control unit to the gate interface. This optical fiber cable transmits the gate signals to drive the advanced IGBT via the gate interface. This optical fiber cable provides electrical isolation between the advanced IGBT and the control unit and is impervious to electrical interference. These are recommended for adoption in Trains of MRTS.

8.7.6 Interior and Gangways

Passenger capacity of a car is maximized in a Metro System by providing longitudinal seats for seating and utilizing the remaining space for standing passenger. Therefore all the equipments are mounted on the under frame for maximum space utilization. The gangways are designed to give a wider comfortable standing space during peak hours along with easy and faster passenger movement especially in case of emergency.

Fig.8.2 Interior View of the Car

8.7.7 Passenger Doors

For swift evacuation of the passenger in short dwell period, four doors of adequate width, on each side of the coach have been considered. These doors shall be of such dimensions and location that all the passenger inside the train are able to evacuate within least possible time without conflicting movement .As the alignment passes through elevated section above ground, automatic door closing mechanism is envisaged from consideration of passenger safety. Passenger doors are controlled electrically by a switch in Driver cab. Electrically controlled door operating mechanism has been preferred over pneumatically operated door to avoid cases of air leakage and sluggish operation of doors.

The door shall be of Bi-parting Sliding Type as in the existing coaches of DMRC.

Fig.8.3 : View of the Passenger Doors

8.7.8 Air–conditioning

With heavy passenger loading of 6 persons/sqm for standee area and doors being closed from consideration of safety and with windows being sealed type to avoid transmission of noise, air conditioning of coaches has been considered essential. Each coach shall be provided with two air conditioning units capable of cooling, heating and dehumidifying and thus automatically controlling interior temperature throughout the passenger area at 25°C with 65% RH all the times under varying ambient conditions up to full load. For emergency situations such as power failure or both AC failures etc, ventilation provision supplied from battery will be made. Provision shall be made to shut off the fresh air intake and re-circulate the internal air of the coach, during an emergency condition, such as fire outside the train causing excessive heat and smoke to be drawn in to the coach.

8.7.9 Cab Layout and Emergency Detrainment Door.

The modern stylish driver panel shall be FRP moulded which give maximum comfort and easy accessibility of different monitoring equipments to the driver along with clear visibility .The driver seat has been provided at the left side of the cabin.

Fig.8.4 : View of the Driving Cab

An emergency door for easy detrainment of the passenger on the track has been provided at the center of the front side of the each cabin which has a easy operation with one handle type master controller.

8.7.10 Communication

The driving cab of the cars are provided with continuous communication with base Operational Control Center and station control for easy monitoring of the individual train in all sections at all the time .

Public Address and Passenger Information Display System is provided in the car so that passengers are continuously advised of the next stoppage station, final destination station, interchange station, emergency situations if any, and other messages. The rolling stock is provided with Talk Back Units inside the cars, which permit conversation between passengers and the drivers in case of any emergency.

8.7.11 Noise and Vibration

The trains will pass through heavily populated urban area .The noise and vibration for a metro railway become an important criteria from public acceptance view point. The source of noise are (i) rail-wheel interaction (ii) noise generated from equipment like Blower, Compressor, air conditioner, door, Inverter etc. (iii) traction motor in running train .For elimination and reduction of noise following feature are incorporated: -

- Provision of anti drumming floor and noise absorption material.
- Low speed compressor, blower and air conditioner.
- Mounting of under frame equipments on anti-vibration pad
- Smooth and gradual control of door.

- Provision of GRP baffle on the via-duct for elimination of noise transmission.
- Provision of sound absorbing material in the supply duct and return grill of air conditioner.
- Sealing design to reduce the aspiration of noise through the gap in the sliding doors and piping holes.

The lower vibration level has been achieved by provision of bolster less type bogies having secondary air spring.

8.7.12 Passenger Safety Features

(i) ATP

The rolling stock is provided with Continuous Automatic Train Protection to ensure absolute safety in the train operation. It is an accepted fact that 60-70% of the accidents take place on account of human error. Adoption of this system reduces the possibility of human error.

(ii) Fire

The rolling stock is provided with fire retarding materials having low fire load, low heat release rate, low smoke and toxicity inside the cars. The electric cables used are also normally low smoke zero halogen type which ensures passenger safety in case of fire.

(iii) Emergency door

The rolling stock is provided with emergency doors at both ends of the cab to ensure well directed evacuation of passengers in case of any emergency including fire in the train,

(iv) Crash worthiness features

The rolling stock is provided with inter car couplers having crashworthiness feature which reduces the severity of injury to the passengers in case of accidents.

(v) Gangways

Broad gangways are provided in between the cars to ensure free passenger movement between cars in case of any emergency.

Fig.8.5 : View of the Gangway

The salient features of the proposed Rolling Stock are enclosed as Attachment-I

Attachment I

Salient Features of Rolling Stock for MRTS

S.No.	Parameter		Details
1	**Gauge** (Nominal)		1435mm
2	**Traction system**		
2.1	Voltage		25 KV AC
2.2	Method of current collection		Overhead Current Collection System
3	**Train composition:**		
3.1	3 car trainset		DMC+TC+DMC
4	**Coach Body**		Stainless Steel
5	**Coach Dimensions**		
5.1	Height		3.9 m
5.2	Width		2.9 m
5.3	Length over body (approx)		
	- Driving Motor Car (DMC)		21.64 m
	- Trailer Car (TC)		21.34 m
	Maximum length of coach over couplers/buffers:		*22 to 22.6 m (depending upon Kinematic Envelop)*
5.4	Locked down Panto height (if applicable)		4048 mm
5.5	Floor height		1100mm
6	**Designed - Passenger Loading**		
6.1	Design of Propulsion equipment		8 Passenger/ m^2
6.2	Design of Mechanical systems		10 Passenger/ m^2
7	**Carrying capacity- @ 6 standees/sqm**		
7.1	Coach carrying capacity		
		DMC	247 (seating - 43 ; standing - 204)
		TC	270 (seating - 50 ; standing - 220)
7.2	Train Carrying capacity		
		3 car train	764 (seating - 136 ; standing - 628)
8	**Weight (Tonnes)**		
8.1	Tare weight (maximum)		
		DMC	40
		TC	40
8.2	Passenger Weight in tons @ 6 standees/sqm		@ 0.065 T per passenger
		DMC	16.055
		TC	17.55
8.3	Gross weight in tons		
		DMC	56.055
		TC	57.55
9	**Axle load(T)(@ 8 persons per sqm of standee area)**		**16 (System should be designed for 16T axleload)**
10	**Maximum Train Length - Approximate**		
10.1	3 car trainset		≈68

11	**Speed**	
10.1	Maximum Design Speed	95 Kmph
10.2	Maximum Operating Speed	85 Kmph
12	**Wheel Profile**	UIC 510-2
13	**Noise Limits (ISO 3381 and 3095 - 2005)**	
13.1	Stationary (Elevated and at grade)	
13.1.1	Internal (cab and saloon)	L_{pAFmax} 65 dB(A)
13.1.2	External (at 7.5 mtr from centre line of track)	L_{pAFmax} 68 dB(A)
13.2	Running at 85 kmph (Elevated and at grade)	
13.2.1	Internal (cab and saloon)	$L_{pAeq,30}$ 72 dB(A)
13.2.2	External (at 7.5 mtr from centre line of track)	L_{pAFmax} 85 dB(A)
13.3	Stationary (Underground)	
13.3.1	Internal (cab and saloon)	L_{pAFmax} 72 dB(A)
14	**Traction Motors Ventilation**	Self
15	**Acceleration on level tangent track**	1 m/sec^2
16	**Deacceleration on level tangent track**	1.1 m/sec^2 (>1.3 m/sec^2 during emergency)
17	**Type of Bogie**	Fabricated
18	**Secondary Suspension springs**	Air
19	**Brakes**	- An electro-pneumatic (EP) service friction brake- An electric regenerative service brake- Provision of smooth and continuous blending of EP and regenerative braking- A fail safe, pneumatic friction emergency brake- A spring applied air-release parking brake- The brake actuator shall operate a Wheel Disc Brake- Brake Electronic Control Unit (BECU) - Independent for each bogie
20	**Coupler**	Auto
	Outer end of 3-car Unit (except DMC cab front side)	Automatic coupler with mechanical, electrical & pneumatic coupling
	Front cab end of DMC car	Automatic coupler with mechanical & pneumatic coupling but without electrical coupling head
	Between cars of same Unit	Semi-permanent couplers
21	**Detrainment Door**	Front
22	**Type of Doors**	Sliding
23	**Passenger Seats**	Stainless Steel
24	**Cooling**	
24.1	Transformer	Forced
24.2	CI & SIV	Self/Forced
24.3	TM	Self ventilated
25	**Control System**	Train based Monitor & Control System (TCMS/TIMS)

26	**Traction Motors**	3 phase VVVF controlled
27	**Temperature Rise Limits**	
27.1	Traction Motor	Temperature Index **minus** 70 deg C
27.2	CI & SIV	10 deg C temperature margin for Junction temperature
27.3	Transformer	IEC specified limit **minus** 20 deg C
28	**HVAC**	- Cooling, Heating & Humidifier (As required) - Automatic controlling of interior temperature throughout the passenger area at 25°C with 65% RH all the times under varying ambient conditions up to full load.
29	**PA/PIS including PSSS (CCTV)**	Required
30	**Passenger Surviellance**	Required
31	**Battery**	Lead Acid Maintenance free
32	**Headlight type**	LED
33	**Coasting**	8% (Run time with 8% coasting shall be the 'Run Time in All out mode **plus** 8%')
34	**Gradient (max)**	3%
35	**Average Cost per car exclusive of taxes and duties at May 2011 Price level in INR Crores**	10.3

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