"Maintenance Practices for High Speed Routes on Indian Railways"

Under the kind guidance
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1.0 Introduction

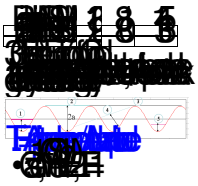
The increasing movement of people and products at the local, regional and national level has placed extreme demands on transportation systems. The railways are the backbone of the transport system. In the present scenario of competition, to save energy and to protect environment from the pollution, various Railways have endeavored to promote their services.

Japanese Railways and European Railways have already constructed high-speed rail (HSR) network on which trains operate up to 300 km/h. Indian Railways have rightly embarked on introduction of trains at higher speeds on existing network and construction of dedicated corridors for very high-speed operation.

Indian Railways has done first time speed trial for Shatabdi train at 150 km/h between New Delhi-Agra. Integrated Railways Modernization Plan (2005-2010) envisages running of passenger trains at 150 Km/h on Delhi-Howrah and Delhi-Chennai routes and develop a world class high speed passenger corridor fit for running 250 to 300 km/h train.

High speeds will place new requirements on the standards and quality of construction and maintenance of track and bridge infrastructure. Since goods train will not be permitted in these routes, therefore, the maintenance system will certainly be different than what exist at present in IR.

In this project efforts have been made to define the maintenance system to be adopted. Also, the maintenance tolerances for high speed routes have been suggested in accordance to comfort criteria & safety.



2.0 Definition of High speed

As per UIC:

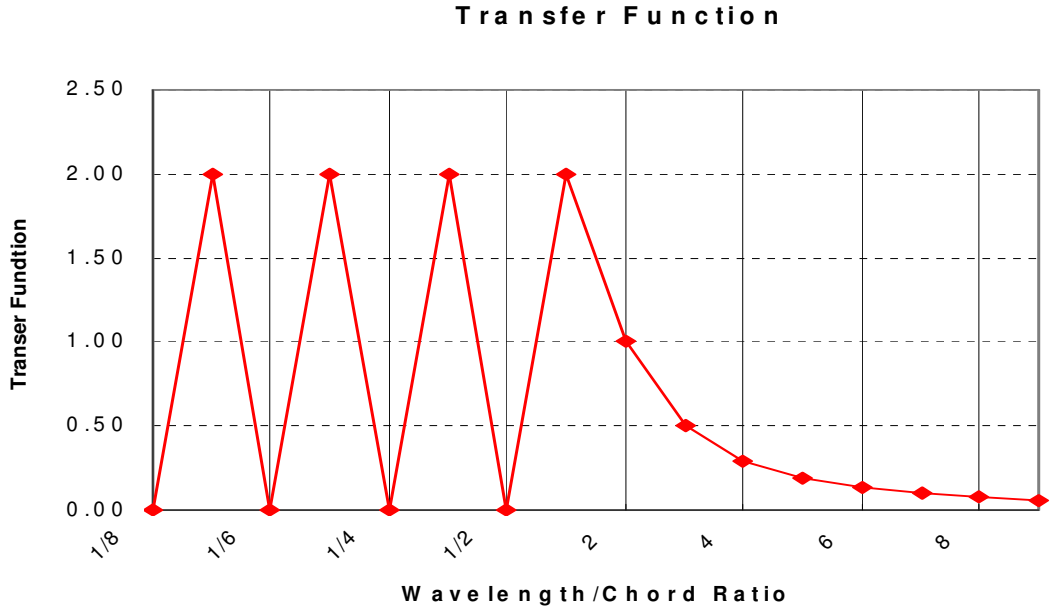
- As regards infrastructure, - A line is described as a “high speed line” when it is a new one designed to enable train operation at speeds above 250 kmph throughout the whole journey, or at least over a significant part of the journey.

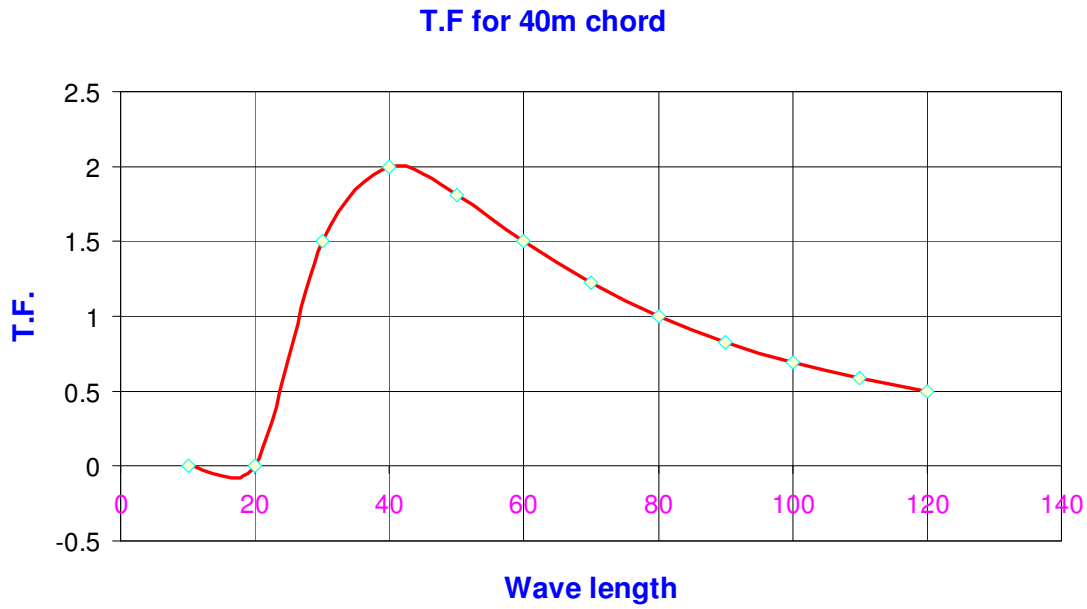
- In case of upgraded conventional lines, speeds of 200-220 kmph can be considered high speed if it results in substantial reduction in journey time.

2.1 Passenger Train Speeds in India

Train	Speed in Kmph		
	Max	Average	Trial
Shatabdi Exp (NDLS-AGC)	140	95	160

- Case 2, When L=λ , T.F.=2
- Case 3, When L=2λ ,T.F.=0





High speed routes carriage are designed for natural frequency of 1 Hz. i.e large wavelength .

Since $v = f * \lambda$

where, v= velocity in m/s

f= frequency in Hz
λ = wavelength in m

(a) For high speed v=250 kmph & f=1Hz

λ = 69.45 m

(b) For high speed v=300 kmph & f=1Hz

λ = 83.33m

Hence, track defects of wavelength 70-80 m are prone to create resonance.

To control longer wavelengths, most foreign high-speed railroads either use a 30 or 40 m chord or inertial principle of measurements. These longer chord lengths allow measurement of anomalies with wavelengths up to 90 m. A 40 m chord was adopted by Japanese Railways after increased speed on Tokaido line. JR research and testing indicates a strong correlation between car body motion at high speed and track geometry limits based on 40 m mid chord offset.

4.0 Organizational Set up

It is proposed that jurisdiction of field officials shall be as given below:

- DEN : 600 TrKM.
- ADEN : 300 TrKM.
- SE (P.way) : 150 TrKM.
- JE (P.way) : 75 TrKM.
- JE (P.way) /spl : One with each MMU
- Key Man : 5 KM.

5.0 Maintenance Activities:

The following maintenance activities are identified:

1. Through packing/Tamping
2. Slack attention:
   - A- attention to bad spots generally on approaches of bridges, level crossing and at turnouts.
   - B- packing of glued joints, welded joints.
   - C- attention of switch expansion joints (SEJ).
   - D- minor rectification of alignment.

3. Casual renewal of track components.
4. Systematic overhauling.
5. Ballast profiling.
6. Emergency repairs viz.rectification of rail /weld fractures etc.
7. Distressing of LWR tracks.
8. Transportation, loading and unloading of P.Way material.
9. Ultrasonic testing of rails.
10. Lubrication of elastic rail clips.
11. Patrolling
    A- Hot weather patrolling.
    B- Monsoon patrolling.
    C- Cold weather patrolling
    D-Security patrolling
    E-Key man daily patrol
12-manning caution and speed restriction boards.
13-Tree cutting for improved visibility.
14-Lubrication of rails and joints
15-Resurfacing of switches and crossings
16-Pre monsoon attention to drains /waterways
17-Pulling back of creep and gap adjustment
18-Attention to level crossings
19-Periodic deep screening
20-Rail welding
21-Rail cutting /drilling and chamfering
22- Minor cess repairs

6.0 Maintenance System

The maintenance system which is being currently used in IR should be revised as follows:

Revised 3-Tier system –

1. On track machines (OMU).

2. Mobile maintenance unit with mobile maintenance gang.(MMU)
3. Gangs for patrolling & outsourcing of misc. activities.

Also, the functions of each tier are tabulated below for high speed routes:

6.1 Assignment of Activities

Activity	Tier	Remarks
TTM works-Pre & post tamping	OMU & MMU	Ballast profiling by BRM
Reconditioning of P& Xing, tamping tools	Out sourcing	
Casual welding	MMU	
Casual Renewals of rails & sleepers	MMU	
Slack attention	MMU	By using MPT
Lubrication of ERC	Out sourcing	Once in 2 years
Deep screening & shoulder screening	OMU	BCM & FRM
Loading, leading & Unloading	MMU	
Pre monsoon attention & cleaning of drains	MMU & outsourcing	
Destressing of LWR & Welding	Out sourcing	Welding at destressing site

7.0 Mechanized maintenance

7.1 On track machines

For mechanized maintenance, it is very essential to have a dedicated fleet of tack machines. The following machines are required for maintenance activities:

1. Deep screening by BCM-802/RM900
2. Shoulder screening by FRM
3. Tamping by CSM-3X/CSM in design mode-Plain & curved track
4. Tamping by UNIMAT-4S in Design mode- Point & Crossing
5. Consolidation by DGS
6. Ballast profiling by BRM-USP-5000
7. Grinding of rail top by KR24-M14 or GWM-150
8. Formation treatment by AHM-800/R or RPM/200R
9. Picking up rails/ sleeper by UTV

7.1.1 Frequency of Machine work

The frequencies of deploying track machines for various maintenance activities are highly inadequate for high speed routes. Since the permissible tolerances are very difficult to maintain without use of machines, therefore it is necessary to revise the frequency of deploying machines. The following frequencies are suggested for high speed routes:

Machine	Output per effective hour	Min block hours	frequency
CSM	2000 Sl	2:30 Hrs	Once in a year
UNIMAT	One set T/O	2:00 Hrs	Once in a year
BCM	125M	4:00 Hrs	Once in 5 year
Rail grinding m/c	12km/day	3:00 Hrs	Once in a year
UTV&MPT	One with each SE(P.Way)		

7.2 Mobile Maintenance unit (MMU)

The existing MMU-I&MMU-II has been merged and also the activities of MMU are redefined.

(i) Need based spot tamping
(ii) In situ rail welding
(iii) Casual renewals and repairs except planned renewals
(iv) Replacement of glued joints
(vi) Rail cutting /drilling and chamfering
(vii) Permanent repairs to factures
(viii) Creep or gap adjustments involving machines
(ix) Loading/ unloading of materials
(x) Any other functions assigned

The following equipments should be available in MMU:

Equipment type	Details
Communication equipment	• walkie talkie • portables field telephones
Rail cutting / drilling equipment	• disc cutter • rail cutting machine

	• rail drilling machine • 6-chamfering kit
Rail welding equipment	• Mobile FB welding equipment • Weld trimmer • Rail profile grinder for welded joints
Safety and protection equipments	• Warning system • Red banner flag • Red hand signal flag • Green hand signals flag • Detonators
Rail tensors-	• hydraulic/mechanical
Safety and protection equipments	• Warning system • Red banner flag • Red hand signal flag • Green hand signals flag • Detonators
Gas cutting equipments with accessories	
Material handling equipment	• Rail dolly • dip lorry

The MMU will be rail mounted only and capable to run at a speed of 100 kmph, so that for any maintenance activity, time taken for reaching site and leaving the site should be minimum. One multi purpose tamper (MPT) to be provided with each SE (P.Way) with a jurisdiction of 150 Km single line can be used as MMU. The mobile maintenance gang comprises of 20 men has to move along with MPT.

7.3 Track Patrolling

(i) Key man daily patrol
(ii)Hot/cold weather patrolling
(iii)Mansoon patrolling
(iv) Watching vulnerable locations

8.0 Track tolerances

For high speed routes it is very necessary to know the limit of track parameters in the form of tolerances, so that track can be maintained accordingly.

8.1 Existing Track Tolerances in IR

The track tolerances for operation of passenger trains at a maximum speed of 160 km/h with WAP3 locomotive on Mark-IV bogie and coaching stock with IR-15 bogie coaches has been done by RDSO is described below :

Track Parameter	Standard Deviation	Maximum peak Exceedences
Unevenness (Base 9.6m)	5.00 mm	15 mm
Alignment (Base 9.6m)	3.5 mm	10 mm
Twist (base 4.8m)	3.0 mm	09 mm
Gauge	2.3 mm	08 mm

8.2 UIC Maintenance Tolerances

Type Class →		IV	III	II	I	0
Speed Range Km/h → Acceptance Parameter↓		>250 to 300	>200 to 250	>120 to 200	>80 to 120	<80
Gauge (mm)		±2	±2	±2	±3	±3
Cant (mm)		±2	±2	±2	±3	±3
Top (mm)	Chord 10m	2	3	3	4	5
	Chord 20m	3	4	5	-	-
Alignment (mm)	Chord 10m	2	3	3	4	5
	Chord 20m	3	4	5	-	-
Twist	(0/00)	1	1	1	1.5	1.5

8.3 Proposed track tolerances for high speed route in IR

Track Parameter	Standard Deviation	Maximum peak Exceedences
Unevenness (Chord 40m)	3.00 mm	5 mm
Alignment (Chord 40m)	2.00mm	5mm
Twist (base 4.8m)	2.0 mm	5mm
Gauge	2.00 mm	5 mm

9.0 Track monitoring

Track monitoring is basic requirement of any system of maintenance. The following mode of track monitoring required for high speed routes:

9.1 Manual Inspection of Track

(i) Daily patrolling –by key man
(ii) Footplate/ Last vehicle inspection – by JE/SE/AEN/DEN
(iii) Inspection of P&Xing, Curve, LWR, Track on Bridges – by JE/SE/AEN/DEN

9.2 Track recording car

Track geometry is measured with the help of micro-processor bases Track Recording Cars (TRC). The frequency of TRC run in high speed route should be once in month. Also, TRC should have Micro Processor facility for conversion of measurements of AL & UN in to chord of 40 m. The results of electronic TRC should be analyzed by computers (TMS/MIS).

The following limits are suggested for track maintenance activity in terms of TGI recorded by TRC.

TGI <50	–urgent maintenance
50 to <80	–planned maintenance
80 to 100	– need based attention
>100	- no maintenance

9.3 Oscillograph monitoring system

The Riding quality and accelerations (lateral & vertical) are to be monitored by Oscillation Monitoring System (OMS). For high speed routes vertical & lateral accelerations should not be more than. 0.1g. Also, the riding index is limited to 3.25.

9.4 USFD Testing

Although rail testing is being done by USFD & eddy current at manufacturing plants and FB plants will be used for high speed routes.

Since defect generation rate will be more in high speed track and AT welds will be still used in exceptional circumstances. Therefore, USFD testing becomes very important.

The use of modern equipment such as SPURT car, Laser based USFD testing (developed by TTCI, USA) will be essential. The out put of data loggers with USFD Machines shall be used in analyzing the results by computes programmes like TMS/MIS.

Since AT weld can be used in exceptional circumstances, therefore hand probing of AT welds should be continue.

9.4 Rail Profile measuring system – to decide requirement of grinding of Rails

9.5 Rail stress measuring system - to decide requirement of de-stressing of LWR

10.0 Important Aspects

For proper implementation of mechanized maintenance, the following aspect must be ensured:

(i) Fixed Corridor blocks
(ii) Imprest for petty repairs: Track machines, T&P etc.
(iii) Spare parts: Critical items of machines like tampimg tools, hydraulic valve etc.
(iv) Reconditioning of tamping tools- out sourcing
(v) Non-core P-way works: out sourcing (de-weeding, cess repairs, drain work)
(vi) Availability of Survey equipment & surveyor: Total station, precise level

10.1 Need of fencing along the track

- Ensure Fencing –to prevent trespassing
- Out sourcing of security patrolling to prevent tress passing and damage to fencing

10.2 Level Crossings

- No Level Crossings to be permitted in high speed routes
- Exceptional cases-only manned &interlocked can be permitted

11.0 General problems & remedial measures

Item	Problems	Remedy
UTS Rails	Corrosion	Metalising
	Distortion of top profile	Grinding of rail top
	Handling of UTS rails	Use of UTV
PSC Sleeper	Seized ERC	• Periodical greasing • ERC Extractor
	GR pad	• Replace periodically • Use Elastomeric pads
Formation	Weak	• Formation treatment by machine • Formation treatment by cut & fill method
	Soil erosion	• Turfing • Pitching
	Slope failure	• Rail pilling
Cutting	Drainage	• Periodical cleaning of drains
	Boulder falling	• Detection mechanism by providing sensors for clear visibility • Wire netting
Curves	Versine variation in transition	• Frequent inspection • Attention by design mode tamping
P&Xing	Wear	• Reconditioning
	GR pad under Xing	• Provide horn • Use elastomeric pads • Spare availability
Bridges	Channel sleeper fittings	• Regular tightening of hook bolts • Replacement of crushed GR pads under rail • Use of elastomeric pads under rail

12.0 Conclusions

1. Track defect (AL&UN) of longer wavelength is more crucial for high speed. Therefore, TRC must be able to record track defects accordingly.

2. Mechanized maintenance system must be adopted with a fleet of on track machines.

3. Multi purpose tamper can be used as MMU vehicle and it must be provided to every SE (P.Way) @150km.

4. Outsourcing of certain activity like reconditioning, distressing of LWR is necessary.

5. Directed track maintenance should be adopted.

6. Track man should be used only for patrolling.

7. Mobile maintenance gang to be part of MMU.