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**GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS**

**INTRODUCTION OF TRAINS AT SPEED UPTO 160KMPH ON
NEW DELHI-HOWRAH & NEW DELHI-MUMBAI CENTRAL
ROUTES**

**REPORT NO
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**RESEARCH DESIGNS & STANDARDS ORGANISATION
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Preface

This report is based on inputs provided by Bridges & Structures, Carriage, Electric Loco, Geo Tech Engg., Motive Power, Signal, Telecom, Testing, Traffic, Track Design, and Track Machine & Monitoring & Traction Installation Directorates of RDSO. The report has been revised after incorporating the fresh inputs from TI, Bridge & Structures, Track and Signal Directorates During Core Group Meeting, held on 28.11.2008, 02.01.09 and 22.06.09. Run time has been simulated once again after incorporating time loss due to additional restrictions coming in course on curves due to rising of speed.

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Introduction of trains at speeds up to 160kmph

1. Introduction:

- 1.1 During the 28th GCM, CRB had desired that a detailed study shall be made for firming up of technology and infrastructure improvement required for operation of trains at 160kmph speed. It was decided that RDSO should pick it up as a mission or project, give priority attention and come out with final detailed recommendations.
- 1.2 Accordingly, a multidisciplinary initiative was launched by RDSO. Studies pertaining to various issues were carried out. Based on these studies, a number of items have been identified as requiring action in this report.
- 1.2.1 In this connection recommendations made in previous studies viz RDSO's Report No. R-50 of 1994 are considered to be still valid. Experience gained in processing New Delhi- Agra section for raising the speed to 150 kmph, particularly the points raised by Commissioner of Railway Safety provided useful inputs.

2. The Issues:

The entire subject has been broken into various subheads like motive power, carriage, track, signaling etc. These are discussed below, in detail:

2.1 Running Time

- 2.1.1 Simulation studies were carried out in order to judge saving in running time on account of proposed speeding up of trains upto 160Kmph. These studies were carried out for New Delhi-Howrah & New Delhi-Mumbai Central routes considering operation of trains with 1/2/WAP5 locomotives and 18 LHB Coaches using existing permanent and temporary speed restrictions. The details are indicated in table below:

Section	Length Km	No.of Locos	Max. Speed Kmph	Total Running Time (Minutes)	Notes
NDLS-BCT	1385	1	130	898	No.of stoppages=4 Stoppage time=31min. Total speed restrictions=111 Nos. (Perm=74, Ty=37nos.)
		1	160	832	
		2	130	875	
		2	160	790	
NDLS-HWH	1450	1	130	936	No.of stoppages= 5 Stoppage time= 27min. Total speed restrictions=126 Nos. (Perm=81, Ty=45 nos.)
		1	160	870	
		2	130	901	
		2	160	815	

In order to refine simulation studies further, time loss because of additional restrictions coming in course on curves due to raising of speed was considered. For this, Track Dte. had collected list of such curves and curve- wise details of additional restrictions which has been incorporated in calculation of run time :

Simulation of Running Time on New Delhi- Howrah Section

Loco	H.P.	No. of EOG Coaches	Max. Speed (Km/H)	Time Taken (Minutes)
WAP 5	5400	18	130	936
			160	870

Note:

- Total section length
New Delhi –Mumbai section = 1450 Km.
No. of Stoppage stations are 5.
- Total stoppage time is 27 minutes for New Delhi – Howrah section
- Total speed restrictions are 126.
- Permanent speed restrictions and temporary speed restrictions considered are 81 and 45 respectively.

Simulation of Running Time on New Delhi – Mumbai Section

Loco	H.P.	No. of EOG Coaches	Max. Speed (Km/H)	Time Taken (Minutes)
WAP 5	5400	18	130	936
			160	870

Note:

- Total section length
New Delhi – Mumbai section = 1385 Km.
No. of Stoppage stations are 5.
- Total stoppage time is 31 minutes for New Delhi – Mumbai section
- Total speed restrictions are 111.
- Permanent speed restrictions and temporary speed restrictions considered are 74 and 37 respectively.

2.1.2 Considering additional permanent speed restriction on account of curves at increased speed, the gain indicated in above table would get reduced. The effective gain on account of speeding up is likely to be about one hour for each route.

2.2 Issues connected with Locomotives:

2.2.1 WAP5 Electric Locomotive is cleared for operation at a maximum speed of 160 kmph vide RDSO's speed certificate no. SD.WAP5.11 dated:19.6.1997 and amendment dated 23.10.2006. Similarly, WDP4 diesel locomotive with 4000HP is also cleared for 160kmph speed vide RDSO's speed certificate no.

SD.WDP4.11 dated 5/7-3-2002 and amendment no. SD.WDP4.11 dated 28-2/3-3-2003.

- 2.2.2 To eliminate nuisance of sound, dust and high air pressure specially in confined locations at speed of 160Kmph, air conditioning of cab is required. Two WAP5 and six WDP4 locomotives have been provided with cab air conditioning, more can be provided enabling regular operation of trains. Railway Board had earlier issued instructions to DLW/CLW to provide cab air conditioning on WDP4/WAP5 locomotives.
- 2.2.3 The cattle guard for 160 Kmph operation has been designed for WAP5 locomotive There have been significant number of cases of cattle run over involving WAP-5 locomotives while working high speed trains at 130 km/h however, there has been no case of derailment of loco/train. The details of damages in locomotives due to cattle run over has been collected from AGC division and GZB shed which has been forwarded to motive power directorate to review the design of cattle guard if necessary. The WAP5 locomotives have to be provided with modified design of cattle guard for 160 Kmph operation.
- 2.2.4 WAP5 gives a balancing speed of 160kmph on level track with 18 LHB coaches as per Report no. MT-283. For operation with more than 18 coaches and considering the ruling gradient/curvatures obtained on the proposed sections double heading may have to be done for both WAP5 and WDP4 locomotives.

2.3 Issues connected with Carriage:

- 2.3.1 LHB EOG coaches and Generator van are cleared for regular operation upto a maximum speed of 160 kmph vide RDSO's speed certificate no.MC/LHB/Coach dated 19/20-3-2003 and MC/LHB/Coach dated 20-3-2003 respectively. These air-conditioned coaches are running in Shatabdi and Rajdhani Express trains. They can also be introduced in long distance trains at 160 kmph. It is not desirable to permit non-air conditioned coaches for speeds more than 120 kmph due to dust ingress and air blast. Thus, LHB, Self generating Non-AC Coaches, though developed and capable, are not recommended for 160 Kmph operation.
- 2.3.2 Better maintenance facilities are required for maintenance of high speed trains. Railway Board had issued instructions, in June 2004, to set up the following facilities at the Maintenance Depots for maintenance of high speed trains (more than 140 kmph):
- Well lighted all weather covered area for under gear examination and maintenance of sub-assemblies.
 - Boundary wall for safety and security of the rake and the facilities.
 - Automatic washing plant at entry point
 - Wheel profile measurement and re-profiling system.
 - In situ wheel changing facility.
 - Automated and instrumented maintenance system in lieu of existing system based on visual inspection.
 - A separate bay with capacity for lifting and change of complete bogie will also be required.

- Platform for attention to roof mounted AC equipments.

To begin with the additional facilities may be provided in the existing carriage sheds. As more and more trains at 160 kmph are introduced, it will be desirable to have separate maintenance facilities for high speed coaches.

- 2.3.3 Better braking system is required in high speed trains particularly when there is a requirement of running longer trains. Rolling stock should be provided EP brakes to improve better controllability of the train and limiting emergency braking distance and coupler force.
- 2.3.4 Oscillation trials of coaches fitted with air springs in their secondary suspension has shown better stability & riding index. LHB type coaches with FIAT bogie having air springs in its secondary suspension should be used in high speed services.
- 2.3.5 Only HOG/EOG coaches should be used as SG version for 160 kmph is not available as of now.
- 2.3.6 The coaches should preferably have crashworthy features for better occupant protection although it is not mandatory in terms of vehicle dynamics characteristics of the coach.
- 2.3.4 **CBC with Draft Gear** : Locomotives identified to haul passenger services should be provided with H type tight lock coupler and modified draft with pre-load. Coaches should be fitted with AAR'H' type tight lock CBC with draft gear having pre-load in the range of 30-35 KN or better available draft gear. These couplers are already in service.

2.4 Issues connected with Track:

- 2.4.1 Considering the superiority of suspension of these rolling stocks, a speed of 160 kmph can be permitted on track structure with 60 Kg/90UTS rails ,PRC sleepers at 1660 sleeper density on 300 mm ballast cushion on routes having annual GMT of 5 or more, even though the dynamic augment values for the vertical load for locos and coaches at 160 kmph are yet to be evaluated. This track structure is desirable in order to keep frequency of maintenance of track under control. However, on routes with less than 5 GMT, the speed of 160 kmph can be permitted on 52Kg/90UTS rails ,PRC sleepers at 1540 density and 250 mm ballast cushion as an interim measure with provision of close monitoring of deterioration in track geometry and necessary remedial actions.
- 2.4.2 **Turnouts** consisting of ordinary fixed heel curved switches on PSC sleepers are fit for speeds up to 160 Kmph while negotiating mainlines based on accelerations recorded during oscillation trials of these rolling stocks. Turnouts with Thick Web Switches (TWS) shall be preferred on such routes. RDSO has already developed the drawings and specification for such switches. Railway Board has initiated action on procurement. Provision of Thick Web Switches will also facilitate provision of clamp lock for ensuring direct holding of closed tongue rail to stock rail. Thick web switches should be provided on the track where speed is 160 kmph.

- 2.4.3 Existing **Switch Expansion Joints** (SEJ) on PSC sleepers are fit for speeds up to 160 Kmph, considering accelerations recorded during oscillation trials of these rolling stocks. RDSO has developed two designs of modified SEJs with the help of industry. Their superiority has been established through field trials. Railway Board have recently issued directives for use of modified SEJs on 'A' routes vide letter no. Track/21/2007/0600/7 dt:6-5-2008. Improved SEJ should be provided on the track where speed is 160 kmph.
- 2.4.4 Existing **Bridge Sleepers**, both Wooden and Steel Channel, are fit for speeds up to 160 Kmph, considering accelerations recorded during oscillation trials of these rolling stocks. The performance of composite sleepers is being monitored and no conclusion has been reached so far regarding their superiority.
- 2.4.5 All through fencing of track is essential to prevent trespassing and to eliminate instances of cattle run over, which may lead to derailments which will be more serious due to high speed. To begin with, fencing can be provided in stretches to be identified by the Zonal Railways as prone to trespassing/cattle crossing. Zonal railways should also provide subways at suitable location to avoid trespass and ensure effectiveness of fencing provided. Suitable design of fencing will be advised to Zonal Railway by RDSO.
- 2.4.6 The **track geometry standards** depend upon interaction of rolling stock with track. LHB coaches and WAP5/WDP4 locos have already been tested for speeds upto 180 kmph on track maintained to C&M-1 Vol 1 standards. Thus, track to this standard is considered suitable for running of trains at 160 kmph.
- 2.4.7 **Frequency for track recording**/ monitoring may have to be increased to take care of faster deterioration of track. Para 606 of IRPWM (Advance Correction Slip No. 83) prescribes the frequency of track recording to be followed on different routes. Higher frequency of once in two months has been prescribed for routes with speeds above 130 kmph. This frequency shall be adequate till a large number of high speed trains are introduced on a section based on the experience accumulated.
- 2.4.8 Stretches of **existing weak formations** (where permanent/temporary speed restriction is imposed), if any, will have to be rehabilitated/strengthened first.
- 2.4.9 **Formation at bridge approach** also required to be strengthened to avoid settlement and jerks at formation to bridge transition.
- 2.4.10 A study on present infrastructure on New Delhi-Howrah and New Delhi-Mumbai Central routes is placed at Annexure-1.

2.5 Issues connected with Bridges

- 2.5.1 Existing IRS provisions for bridges are for a maximum speed for 160 kmph for passenger trains. Coefficient of Dynamic Augment as given in Bridge Rules is valid for speed up to 160 kmph. Further, before introduction of speed up to 160 kmph for passenger services, bridges will have to be monitored for resonance

tendency, during COCR. Bridges having resonance identified by COCR will have to be covered with suitable SR to check the tendency of resonance.

- 2.5.2 Where maximum permissible speed for any class or classes of trains or rolling stock is proposed to be raised, application accompanied with certificates specified for track, bridges, etc. to the Commissioner of Railway Safety for sanctioning the same is required to be submitted by the zonal railways concerned in terms of Para 1307 of Indian Railways Permanent Way Manual (IRPWM).

2.6 Issues connected with Signaling & Telecommunication:

- 2.6.1 Requirement of signalling for introduction of high speed trains upto 160Kmph as per Standard-IV interlocking provided in SEM are given as below –

- Multiple aspect colour light signalling with two distant signals or automatic signalling.
- Electrical operation of points and means for locking both switches.
- Electrical means for lock detection and independent switch detection by signals.
- The interlocking between signals and points by electrical or electronic means (PI/RRI/EI).
- Complete track circuiting of running lines.
- Means for verifying complete arrival of train by provision of Block proving by axle counter (BPAC), where automatic signalling is not provided.
- Provision of Train protection and Warning system (TPWS) is a desirable feature.
- Provision of Clamp lock on points is a desirable feature.

- 2.6.2 Though provision of Train protection and Warning system (TPWS) is a desirable feature as per SEM, it is considered necessary in view of passenger safety in train operation at high speeds and also considering CRS view for provision of TPWS for running Shatabdi trains at 150kmph.

- 2.6.3 While considering the application of NR for introduction of 150 kmph train on New Delhi-Agra section, CRS Northern Circle had opined that **Train Protection Warning System** is a pre-requisite for operation of a high-speed train. CRS had further opined that it is not safe to go ahead with operation of 150 Kmph train pending completion of this work. Therefore, TPWS needs to be planned for operation at 160Kmph.

- 2.6.4 There are a few cases of Signal Passing at Danger (SPAD) in almost all sections, even at lesser speeds. Any SPAD case for high speed train can be disastrous. The issue was also discussed in the CBRR held in RDSO on 30.3.05. Additional Member/ Signalling expressed the view that when it comes to passenger safety, even the requirements prescribed as desirable shall be given the status of mandatory. Thus, provision of a suitable system to prevent driver from passing signal at danger is considered a necessity. This can best be provided by Train Protection Warning System.

- 2.6.5 Another desirable requirement of Standard –IV Interlocking is **Means for directly holding closed switch rail to corresponding stock rail** and preventing the points from being unlocked during the passage of the train (clamp lock). Such clamp locks have been successfully developed for Thick Web Switches. In case of ordinary curved switches, efforts to design clamp lock have not succeeded due to the following factors:
- 2.6.5.1 Tongue rail of conventional switches is thin and therefore lacks the stiffness required for fixing of clamp lock arrangement.
- 2.6.5.2 The design of clamp lock requires both switches to move independently which is not feasible in the case of curved switches having stretcher bars.
- 2.6.5.3 Required JOH (Junction of Heel) clearance for high speed running of trains cannot be obtained with 115 mm switch opening of conventional layouts.
- 2.6.6 Considering this requirement as mandatory for all the turnouts in the facing direction on main line in the section, these shall be provided with thick web switches. All switches in the section may be replaced with thick web switches in a programmed manner.
- 2.6.6 Electrical operations of points and means for locking both switches, means for lock detection and independent switch detection by the respective signals is a mandatory requirement under Standard – IV Interlocking. This makes provision of **Panel Interlocking/Electronic Interlocking** an essential requirement.
- 2.6.7 **Emergency Braking Distance** trials of WAP5 loco with 18 LHB coaches have been conducted at 160kmph. As per results, contained in report No. MT-283 of March, 2001, EBD is less than 1200m on level track. There should be either second distant signal or automatic signaling to meet the requirements of braking distance for high speed trains.
- 2.6.8 Where **automatic signaling** is not provided, means for verifying complete arrival of train by provision of **Block Proving by Axle Counter (BPAC)** is necessary on high density routes and for stations provided with central panel interlocking as per provision of SEM.
- 2.6.9 Current status of Balance works on concerned Railways is given below:

Route	Railway	Balance provision of PI/RR1	Balance provision of BPAC	Provision of Clamp lock on Pt. machine	Provision of TPWS
NDLS-BCT	NR	NIL	NIL (Provided with Auto Signaling)	Provided between Jn. Cabin to Palwal on Main line only	Not provided
	NCR	NIL	NIL (Provided with Auto Signaling)	Provided in Palwal-Mathura section only	Work is in progress in Palwal-Mathura section by IRPMU.
	WCR	NIL	NIL	Not provided	Not provided

Route	Railway	Balance provision of PI/RR1	Balance provision of BPAC	Provision of Clamp lock on Pt. machine	Provision of TPWS
	WR	1 station	Auto Signaling in progress at balance 25 block sections. Balance BPAC available.	Not provided	Not provided
NDLS-HWH 'A' Route	NR	NIL	NIL (Provided with Auto Signaling)	Not provided	Not provided
	NCR	90 stations	100 block sections	Not provided	Not provided
	ECR	5 stations	68 block sections	Not provided	Not provided
	ER	8 stations	76 block sections	Not provided	Not provided

2.6.10 Reliable train radio **communication between driver and guard** and between driver and nearest station and/or control office at a high speed of 160Kmph and above can only be achieved by Mobile Train Radio Communication System (GSM-R). However, the communication arrangement with 25 Watt VHF set may be continued up to 160 Kmph as the system has been tested at 150 Kmph on Shatabdi Express trains in NDLS – Agra Section and can meet the requirement at 160 Kmph also. The same may be verified during the trial at a speed of 160 Kmph. Mobile train radio communication (GSM-R) already sanctioned as pilot project in HWH-MGS-NDLS section may be commissioned on priority for achieving reliable communication. In NDLS–Mumbai section, GSM-R may also be sanctioned & provided on priority.

2.7 Issues connected with Level Crossings:

2.7.1 As per existing instructions, **Level Crossings Gates** are required to be manned, provided with telephone but not necessarily interlocked on High Speed Rajdhani routes. For 160 kmph train operation, interlocked gates are desirable. With large number of interlocked gates in the block section, there may be gates where signals cannot be taken off when the train enters the section. This will result into train's inability to achieve 160 kmph speed. Optimisation by provision of ROB/RUB, interlocking and closing of certain gates having lesser road traffic through diversions may have to be done. This will be necessary when frequency of 160 kmph trains increase. For introduction of 1 or 2 trains existing system for Rajdhani routes may suffice.

2.7.2 Issue of provision of hangers (frills) in the lifting barrier at level crossings was considered in detail. Scooters and cycle rickshaws, usually, cross the level crossings from below the closed lifting barriers. They do so at their own risk,

despite obstruction. It has been the experience that where ever scooter/ rickshaw traffic is heavy, the frills are broken in no time by miscreants. Otherwise they find alternate way to cross through the closed gate. It is dangerous and sometimes leads to the trespasser being overrun. Number of such instances is reported regularly.

After considering all the aspects the committee feels that the existing instructions that frills are not mandatory are sufficient.

- 2.7.3 The visibility at level crossing should be as laid down in IRPWM/Railway Board's instructions. All requirements pertaining to level crossing as laid down in IRPWM/Railway Board's instructions should be fulfilled to ensure safety at level crossing. Drainage of the level crossing and adjoining track should be in good condition.

2.8 Issues connected with Traction Installation:

- 2.8.1 The OHE shall be swiveling type of cantilever having tension in the conductors regulated automatically, with a presag of 50/100 mm.
- 2.8.2 Tension in contact wire and catenary wire should be increased from existing 1000 kgf to 1200 kgf, in case a large number of trains are to run at 160 kmph. For introduction of 1 or 2 trains in a section at 160 kmph, existing level of 1000 kgf tension is considered to be adequate.
- 2.8.3 Cantilever in the section shall be BFB steady arm (RI No.2390) with 25mm drop bracket assembly (RI No.2360).

2.9 Other General Issues:

- 2.9.1 Special medical standards and frequency for PME for Drivers of High Speed trains will have to be laid. Stringent psycho testing of drivers, will be required.
- 2.9.2 System of exchange of signal by driver/guard with station staff, at speeds of 160 kmph, from AC Loco/ Brake van will need similar dispensation as given to guard of Rajdhani Express in respect of exchange of all right signal by way of provision in SR initially. With the availability of improved Communication, a new system, based on these lines, both for driver and guard may be adopted.
- 2.9.3 COCR at 160 kmph shall be carried out.

3 Recommendations:

- 3.1 WAP5 and WDP4 locomotives and LHB coaches are recommended for operation of train at 160kmph on New Delhi-Mumbai and New Delhi-Howrah routes.
- 3.2 Respective Zonal Railways on these routes shall study the requirements spelt out in this report and take initiatives for preparing the sections, enabling COCR and regular operation of trains at 160Kmph speed including obtaining CRS sanction.
- 3.3 Railway Board has issued instructions, in June 2004, to set up certain facilities at the Maintenance Depots for maintenance of high speed trains. To begin with the additional facilities may be provided in the existing carriage sheds. As more and more trains at 160 kmph are introduced, it will be desirable to have separate maintenance facilities for high speed coaches.
- 3.4 Track structure for 160 kmph operation shall be as follows:

Component	Annual GMT < 5	Annual GMT equal or more than 5
Rails	52kg/90UTS	60kg/90UTS
Sleepers	PSC 1540 per km	PSC 1660 per km
Ballast cushion	250mm	300mm
Blanket	Thickness as per type of embankment soil	
Subgrade soil	Minimum CBR value of 5% and elastic resilient modulus of soil >25MPa	



- 3.5 Track tolerances as specified in C&M 1 Vol 1 can be adopted for operation of trains at 160Kmph speed with WAP5/WDP4 locomotive and LHB coaches.
- 3.6 All through fencing of track is recommended to prevent trespassing and to eliminate instances of cattle run over.
- 3.7 Provision of clamp type lock along with thick web switches in facing direction on main line points: –
- In the sections where trains are already running at 150Kmph with the stipulations that clamp type locks along with thick web switches shall be provided in a programmed manner, speed can be raised to 160Kmph. However the works of provision of clamp lock along with thick web switches shall be expedited.
 - In other sections where train at 160Kmph are to be introduced, provision of thick web switches along with clamp type lock in facing direction on main line shall be ensured.



- 3.8 Provision of Train Protection Warning System: –
- a) In the sections where trains are already running at 150Kmph, the speed can be raised upto 160Kmph with the same stipulations with which 150Kmph speed was introduced.
 - b) In other sections where trains at 160Kmph are to be introduced, provision of Train Protection Warning System shall be provided before introduction of 160Kmph.
- 3.9 To meet the requirement of electrical operations of points and means for locking both switches, means for lock detection and independent switch detection by the respective signals, provision of Panel Interlocking/Electronic Interlocking becomes an essential requirement.
- 3.10 To meet the requirement of braking distance for high speed trains, either second distant signal or automatic signaling shall be provided.
- 3.11 Where automatic signaling is not provided, means for verifying complete arrival of train by provision of Block Proving by Axle Counter (BPAC) is necessary on high density routes and for stations provided with central panel interlocking as per provisions of SEM.
- 3.12 The OHE shall be swiveling type of cantilever having tension in the conductors regulated automatically, with a presag of 50/100 mm. Cantilever shall be BFB steady arm (RI No.2390) with 25mm drop bracket assembly (RI No.2360). For introduction of 1 or 2 trains in a section at 160 kmph, existing level of 1000 kgf tension is considered adequate, this shall be increased to 1200 kgf before increasing the frequency of high speed trains.
- 3.13 Reliable train radio **communication between driver and guard** and between driver and nearest station and/or control office at a high speed of 160Kmph and above can only be achieved by Mobile Train Radio Communication System (GSM-R). However, the communication arrangement with 25 Watt VHF set may be continued up to 160 Kmph as the system has been tested at 150 Kmph on Shatabdi Express trains in NDLS – Agra Section and can meet the requirement at 160 Kmph also. The same may be verified during the trial at a speed of 160 Kmph. Mobile train radio communication (GSM-R) already sanctioned as pilot project in HWH-MGS-NDLS section may be commissioned on priority for achieving reliable communication. In NDLS–Mumbai section, GSM-R may also be sanctioned & provided on priority.
- 3.14 Minimization of level crossings by provision of ROB/RUB, interlocking and closing of certain Level crossings may have to be done.
- 3.15 RDSO has developed two designs of modified SEJs. Their superiority has been established through field trials. This should be the preferred type of SEJ to be provided in a planned manner before frequency of 160 kmph train operation is increased.

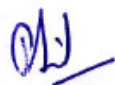

- 3.16 LHB, Self generating Non-AC Coaches, though developed and capable, are not recommended for 160 Kmph operation.
- 3.17 Locomotives cab and guard brake van air-conditioning are desirable for trains running at and beyond 150 kmph. These could be introduced after making necessary amendments in GR for exchanging all right signals.
- 3.18 Stringent psycho testing of drivers will be required.
- 3.19 One round of detailed inspection of bridges & bridge approaches to be carried out before introduction of 160Kmph.

4. Conclusions :

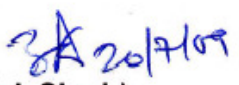
- 4.1. Indian Railways' track, consisting of 60Kg/90UTS rails laid on PRC/ST sleepers with 1660/Km sleeper density and 300mm ballast cushion on routes having annual GMT of 5 or more and 52 Kg/ 90 UTS rails on PRC/ST sleepers with 1540/Km sleeper density and 250mm ballast cushion on routes having annual GMT less than 5, maintained to C&M-1 Vol. I Standards is fit for introduction of trains consisting of LHB coaches, hauled by WDP4 or WAP5 locomotives, at 160 kmph.
- 4.2. Sections which are cleared for 150 kmph can be used for 160 kmph train running with the same stipulations with which 150 kmph speed was introduced. On all other sections, certain requirements which are to be fulfilled before introduction of these trains, as discussed above, shall be ensured.


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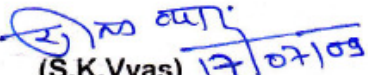

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TRACK STRUCTURE ON NEW DELHI-HOWRAH ROUTE

Rail	Howrah-Pradhan Khunta		Pradhan Khunta-MGS		MGS-GZB		PWL-MTJ		Total	%
	Up	Dn	Up	Dn	Up	Dn	Up	Dn		
90R	0	0	0	0	0	0	0	0	0	0
52/72	0.95	4.05	0.25	0	0	0	0	0	5.25	0.17
52/90	35.55	0.86	10.15	0	113.55	305.21	13.41	34.09	512.82	17.03
60/90	210.82	242.2	397.19	414.18	643.57	451.91	71.11	50.44	2481.4	82.43
60/110	0.88	1.09	8.3	0.7	0	0	0	0	10.97	0.36
Total	248.2	248.2	415.89	414.88	757.12	757.12	84.52	84.53	3010.5	100
Sleeper										
PSC	247.06	246.75	412.315	411.315	755.36	755.36	84.53	84.53	2997.2	99.76
Steel	0.07	0.45	0.45	0.7	1.76	1.76	0	0	5.19	0.17
CST-9	0	0	0	0	0	0	0	0	0	0.00
Wooden	1.07	1	0	0	0	0	0	0	2.07	0.07
Total	248.2	248.2	412.765	412.015	757.12	757.12	84.53	84.53	3004.5	100
Sleeper Density										
1540/km	38.92	9.17	218.62	33.29	113.55	305.21	12.54	33.05	764.35	25.41
1660/km	209.28	239.03	195.32	380.66	643.57	451.91	71.99	51.49	2243.3	74.59
Total	248.2	248.2	413.94	413.95	757.12	757.12	84.53	84.54	3007.6	100
P&C										
52kg 1 in 12										
PSC	0	0	24		1	5	8	11	49	100
Steel	0	0	0		0	0	0	0	0	0
Wooden	0	0	0		0	0	0	0	0	0
TWS	0	0	0		0	0	0	0	0	0
Total	0	0	24		1	5	8	11	49	100
60kg 1 in 12										
PSC	98	106	427		301	292	18	20	1262	98.21
Steel	0	0	0		0	0	0	0	0	0.00
Wooden	0	0	0		3	2	0	0	5	0.39
TWS	0	0	0		0	0	10	8	18	1.40
Total	98	106	427		304	294	28	28	1285	100

ANNEXURE-1 (Page 2)

TRACK STRUCTURE ON NEW DELHI-MUMBAI ROUTE

Rail	MTJ-PWL Section		BCT-NAD Section		NAD-MTJ Section		Total	%
	Up	Dn	Up	Dn	Up	Dn		
90R	0	0	0.4	0.15	0	0	0.55	0.02
52/72	0	0	4.06	8.23	71.74	12.41	96.44	3.64
52/90	13.41	34.09	47.56	136.3	0	12.7	244.06	9.22
60/90	71.11	50.44	634.49	535.69	473.04	516.67	2281.44	86.22
60/110	0	0	7.2	13.33	0	3	23.53	0.89
Total	84.52	84.53	693.71	693.7	544.78	544.78	2646.02	100
Sleeper								
PSC	84.53	84.53	688.6	687.62	544.78	544.78	2634.84	99.58
Steel	0	0	2.6	2.14	0	0	4.74	0.18
CST-9	0	0	0	0	0	0	0	0.00
Wooden	0	0	2.5	3.94	0	0	6.44	0.24
Total	84.53	84.53	693.7	693.7	544.78	544.78	2646.02	100.00
Sleeper Density								
1540/km	12.54	33.05	307.01	385	30.26	15.43	783.29	29.60
1660/km	71.99	51.49	386.69	308.7	514.52	529.35	1862.74	70.40
Total	84.53	84.54	693.7	693.7	544.78	544.78	2646.03	100.00
P&C								
52kg 1 in 12								
PSC	8	11	94		21	17	151	251.67
Steel	0	0	0		0	0	0	0
Wooden	0	0	33		1	2	36	60
TWS	0	0	34		0	0	34	56.67
Total	8	11			22	19	60	100
60kg 1 in 12								
PSC	18	20	827		193	205	1263	84.94
Steel	0	0	0		0	0	0	0.00
Wooden	0	0	0		0	0	0	0.00
TWS	10	8	31		10	4	63	4.24
Total	28	28	1019		203	209	1487	100.00