PROJECT REPORT ON

STRENGTHENING OF FEEDER ROUTES FOR RUNNING OF 25T AXLE LOAD TRAINS- REVIEW OF WORKS INVOLVED

COURSE No.623
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CHAPTER-I

INTRODUCTION

1.0 BACKGROUND : Most of the IR network had been constructed during the times when India was under British rule and even in the post independence era, the country was witnessing Hindu rate of growth, i.e., the economy was growing at a rate of around 3.5%. The expansion of the rail network grew marginally. The growth in the traffic had been catered for by taking up line capacity works, eliminating operational bottlenecks, improvement in track structure & utilizing unused capacity of existing lines. But since the 90s, the traffic has been showing the growth in double digits as evident from the following table:-

TABLE 1.0 GROWTH IN RAIL FREIGHT TRAFFIC

Years	Freight Traffic (Million Tonnes)	Growth (MT)	Average Annual Growth (MT)
1950-51	73.20	--	--
1960-61	119.80	46.60	4.66
1970-71	167.90	48.10	4.81
1980-81	195.90	28.00	2.80
1990-91	318.40	122.50	12.25
1999-00	456.42	138.02	13.80
2000-01	473.50	17.08	17.08
2001-02	492.50	19.00	19.00
2002-03	518.74	26.24	26.24
2003-04	557.39	38..65	38.65
2004-05	585.35	27.96	27.96
2005-06	668.00	82.65	82.65
2006-07	726.00 (Target)	58.00	58.00

1.1 From the freight traffic carried by the Railway in the past years, it is seen that the growth in the earlier decades was lower. Up to 1980, the average growth rate was less than 5 Million Tonnes per annum, whereas in the remaining period of the 20th century the growth rate of traffic had been around 13 Million Tonnes per annum. The increased traffic had been carried by way of improvement to the rolling stock, innovation in operation and other policy initiatives.

1.2 In the 21st century, the economy is growing at a very fast pace. The X plan which started in 2002-03 has projected growth rate of more than 8% in GDP. Growth in GDP during 05-06 is around to be 8%.

1.3 With the growth of GDP @ 8%, the transportation demand is expected to grow @ 12-14%. This implies that the transport capacity needs to be doubled every 7 to 8 years. In the past, IR had handled the growth in the traffic as follows:

- i) Enhancing the through put of the existing lines.
- ii) Increase in permitted axle loads.
- iii) Execution of traffic facilities works.
- iv) Improving the standard of maintenance.
- v) Improving the signaling

vi) Emphasis on doubling/multiple lines.

All the above efforts & similar efforts had resulted into improvement of the operating parameters e.g., the turn around time of wagons have reduced to 5.5 days.

1.4 Seeing growth in traffic MR has declared a target of 726 MT in 06-07 on the floor of parliament & the internal target has been fixed as 740 MT.

1.5 CONSTRAINTS BEFORE IR: The constraints before the railways are as follows:

i) Golden quadrilateral & diagonal routes, which constitute about 16% of the network but carry 65% of the freight, are highly congested, e.g., the line capacity utilization on Bombay - New Delhi route & New Delhi - Howrah route is 115% to 160%
ii) At present same track carries passenger & freight trains, i.e., mixed traffic conditions, resulting into lower average speed of goods train (which is at present approx 25 Kmph) resulting in lower output.
iii) Lesser capacity of wagons.
iv) Lesser axle load restrictions on existing routes.
v) Moving dimension restrictions on existing routes.

1.6 SOLUTION : Considering the above constraints, following improvements in the system is envisaged in order to meet the challenge of increasing freight traffic:-

1. *To expand the Railway network capacity.*
2. *To increase the average speed of goods trains.*
3. *To increase the capacity of freight stock.*
4. *To increase the axle load.*
5. *To improve the service by reducing the running time.*

The above improvements in the system can be achieved by going for a separate line exclusively for the freight traffic with improved standards like; higher axle load & increased moving dimension. Accordingly, the concept of '*Dedicated Freight Corridor*' has been envisaged. The alignment of such corridor has been envisaged mostly along the golden quadrilaterals with certain diversions as per the need of the traffic. In the 1st Phase, construction of Eastern and Western corridors at an estimated cost of Rs.22,000 crore has been included in the Railway Budget 2006-07.The proposed routes of the Eastern & Western corridors are as under:-

Eastern Corridor will start from Ludhiana to Sonnagar via Ambala, Saharanpur, Khurja and Allahabad. The primary feeder routes from Sonnagar to Durgapur via Gomoh, Sonnagar to Tatanagar via Garhwa Road and Barkakana to Bokarro via Chandrapura are proposed to be upgraded in order to carry heavier trains of coal and steel traffic. It may be further extended up to the ports in West Bengal as per traffic needs.

Western Corridor will start from Jawaharlal Nehru Port and routed via Vadodara, Ahmedabad, Palanpur, Jaipur and Rewari to Tughlakabad and Dadri. The feeder routes connecting ports of Gujarat are proposed to be upgraded to carry heavier trains.

Both the corridors would be joined by a link between Dadri and Khurja.

CHAPTER-II

DEDICATED FREIGHT CORRIDOR

2.0 The concept of dedicated freight corridor, its need has been explained in the Chapter I. Since the feeder routes are related to the Dedicated freight corridor, these corridors are discussed in brief in this chapter.

2.1 AIM OF DEDICATED FREIGHT CORRIDOR

The dedicated freight corridor will help railway immensely in achieving the following objectives:

i) Create Rail Infrastructure To Carry High Levels Of Freight thus Increase IR's Share In Freight Market
ii) Increase Throughput By Higher Axle Loads, Moving Dimensions, Track Loading Density, Improved Pay Load/Tare Ratio.
iii) Speed Up Freight Train Operations, Achieve Higher Productivity Through Better Utilization Of Railway Assets.
iv) Reduction In Unit Cost Of Transportation, Inventory Costs and greater customer satisfaction.
v) Relieving Existing Rail Corridor for additional passenger traffic.

2.2 DEDICATED FREIGHT CORRIDOR

i) During budget discussion in April '05 Hon'ble MR informed Parliament about importance of double line dedicated freight corridors on Golden Quadrilaterals and its diagonals.
ii) Hon'ble PM had announced on 15th Aug. '05 that Dedicated Rail Freight Corridor would be developed.
iii) RITES carried out Feasible Study and Preliminary Engineering cum Traffic survey & submitted report in Dec. '05.
iv) Hon'ble MR has proposed in Budget Speech '06 to construct Dedicated Multimodal High Axle Load Freight Corridors with computerised control on Western and Eastern routes at an estimated cost of Rs.22,000 crores.

2.2.1 EASTERN CORRIDOR

i) 1st phase from Ludhiana to Sonnagar via Ambala, Saharanpur, Khurja and Allahabad.
ii) Length 1232 Kms., costs Rs.10,000 crores
iii) From Ludhiana to Khurja single line and from Khurja to Sonnagar double line.
iv) Corridor will be extended upto ports in West Bengal as per traffic needs.

2.2.1.1 Feeder Routes of Eastern Coridor:

i) Sonnagar-Garwa Road-Barkakana (311 Kms)
ii) Patratu-Gomoh including PD Branch Line (128 Kms)
iii) Sonnagar-Gaya-Gomoh (249 Kms)
iv) Gomoh-Pradhankhunta (39 Kms) including Kusunda-Telumari (4.5 Kms), Katrasgarh - Nichitpur, Pradhankhunta - Pathardih Links (24 Kms)
v) Pradhankhunta-Asansol-Andal including coal branch lines (75 Kms)
vi) Andal-Sainthra-Pakur (151 Kms)
vii) Chandrapura-Dhanbad (36 Kms)

viii) Bhojudih-Mahuda-Gomoh (44 Kms)
ix) Aligarh-Harduaganj (15 Kms)
x) Kanpur-Paricha (198 Kms)
xi) Mughalsarai-Unchahar via Janghai, Phaphamau (205 Kms)
xii) Varanasi-Sultanpur-Utratia-Rosa (558 Kms)
xiii) Zafrabad-Tanda (99 Kms)
xiv) Ludhiana-Beas-Govindwal Sahib (112 Kms)
xv) Rajpura-Dhuri-Bhatinda (Lehra Mohabbat) (173 Kms)
xvi) Sirhind-Rupnagar-Nangal Dam (104 Kms)
xvii) Hissar-Bhatinda-Suratgarh (298 Kms)

TOTAL 2823.5Kms.

The map of the eastern corridor and its feeder routes is shown in Fig.2.2.1

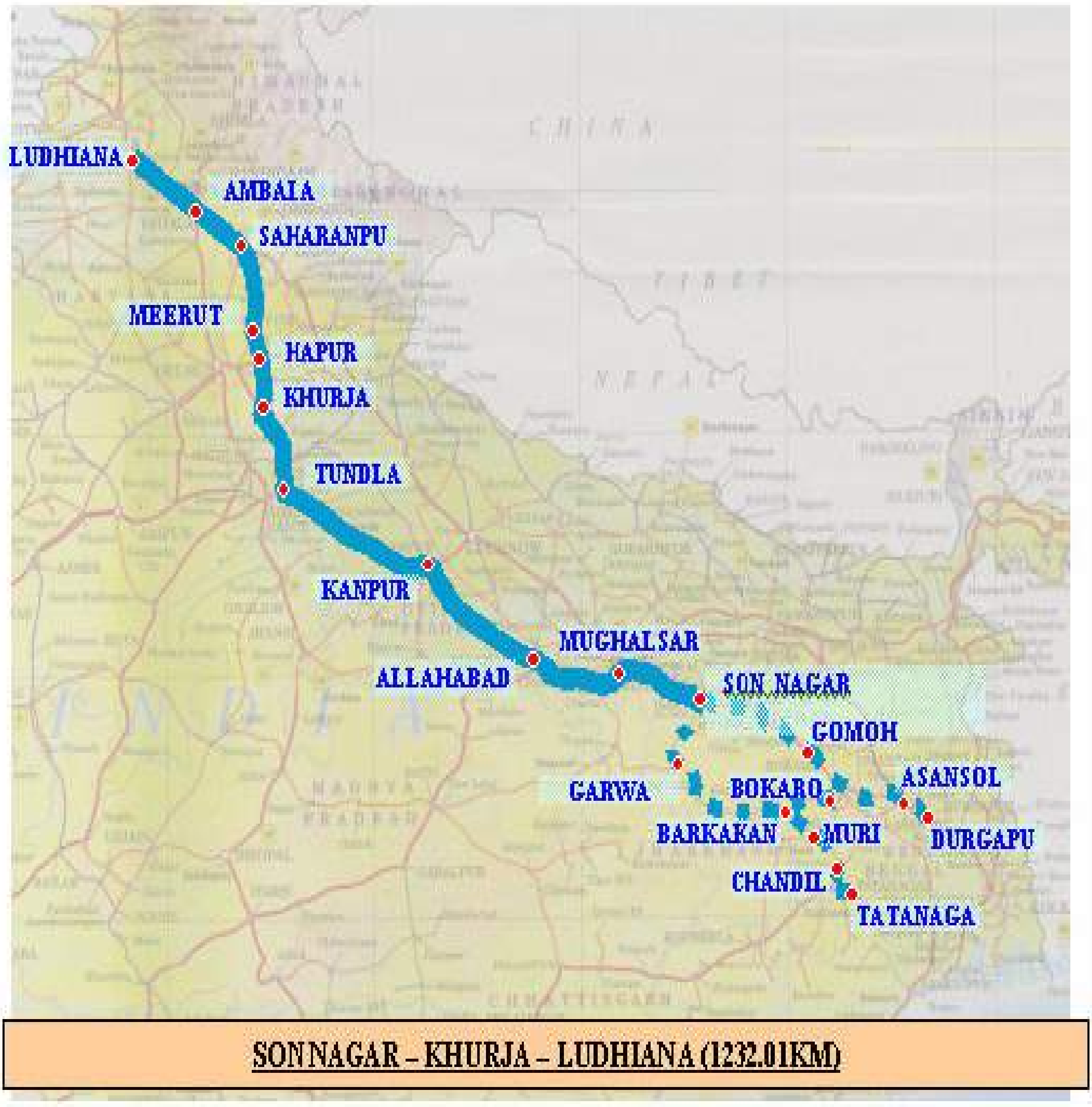


FIG 2.2.1 Eastern corridor and its feeder routes

2.2.2 WESTERN CORRIDOR:

i) From Jawaharlal Nehru Port to Dadri via Vadodara, Ahmedabad, Palanpur, Jaipur, Rewari, Tuglakabad.
ii) Length - 1490 Kms. Double Line. Costs Rs.12,000 crores.
iii) Route via Ahmedabad, Palanpur, Rewari selected as it will connect to Gujarat ports at Mundra, Kandla and Pipavav and offer more traffic.

2.2.2.1 Feeder routes of Western Corridor:

i) Pipavav-Surendranagar-Viramgam-Mehsana (395 Kms).
ii) Kandla Port-Gandhidham-Palanpur (312 Kms)
iii) Mundra Port-Gandhidham (66 Kms)
iv) Viramgram-Samakhiali (182 Kms)
v) Hazira-Surat (40 Kms)
vi) Ludhiana-Hissar-Rewari (348 Kms)
vii) Mumbai Port-Wadala-Kurla-Diva with connectivity with DFC (36 Kms)

Total route length of western corridor 1379 kms.

The western corridor and its feeder routes are shown in Fig.2.2.2.

FIG 2.2.2 Western Corridor and its feeder routes.

CHAPTER-III

EXPERIENCE ON INDIAN RAILWAYS OF HEAVY AXLE LOADS

3.0 Indian railways have been increasing the axle loads on its routes gradually as can be seen from the loading standards adopted in the bridge rules. The experience has been narrated in the subsequent paragraphs.

3.1 Indian Railway has been carrying the freight trains mainly through Box N Wagons with the axle load of 20.32t. Most of the lines on IR has been designed with the RBG & BGML standards which are lighter loading standard as compared to 25t axle load.

3.2 The beginning has been made by taking up the pilot project to increase the payload of the Box N Wagons by 8 tonnes which combined with 2 tons loading tolerance is called as CC+8+2 loading.

3.3 For this a pilot project for running of higher axle load wagons has started w.e.f. 15.05.05 on identified iron ore routes. Initially the pilot project was for one year but it has been extended to 30.06.07. The routes identified are mainly iron are routes as follows:

i) 15 routes as per Rd's Lr. No.2003/CE.II/75/5 Vol-1 dtd.04.05.05.
ii) 6 routes as per Bd's Lr. No. 2003/CE.II/75/5 Vol-2 dtd.01.06.05.
iii) 6 more units are identified in routes.
iv) 3 more routes i.e. Guntakal-Somalkot-Kakinala, BNDM-514-RIG-KDL & 554-SBP have been identified for running of CC+8+2.
v) 4 more routes are indentified vide Rly Bd's Lr. No.2005/CE.II/75/Pt. dtd.09.05.06.

Thus total 34 routes have been identified by the bd. for running of CC+8+2 loaded axle wagons.

3.4 Since introduction of (CC+8+2)t axle load is a milestone towards allowing 25t axle load, case study of the sections of CKP division, allowing (CC+8+2)t axle load have been given indicating the impact on the track before the introduction of (CC+8+2)t & after the introduction of the same.

3.5 Geography & traffic of CKP area:-

3.5.1 Chakradharpur division in South Eastern Railway loads Iron ore to the tune of 7,500 FWW per day. Out of 7,500 FWW, 4000 FWW are for steel plants like SAIL/Rourkela, SAIL/Bokaro, IISCO/Burnpur & TISCO/Tatanagar. Remaining 3500FWW are for domestic market and export .

3.5.2 Loading points of Iron ore are concentrated in two areas known as Dongaposi area and Kiriburu area as shown in the map (Fig.3.5).

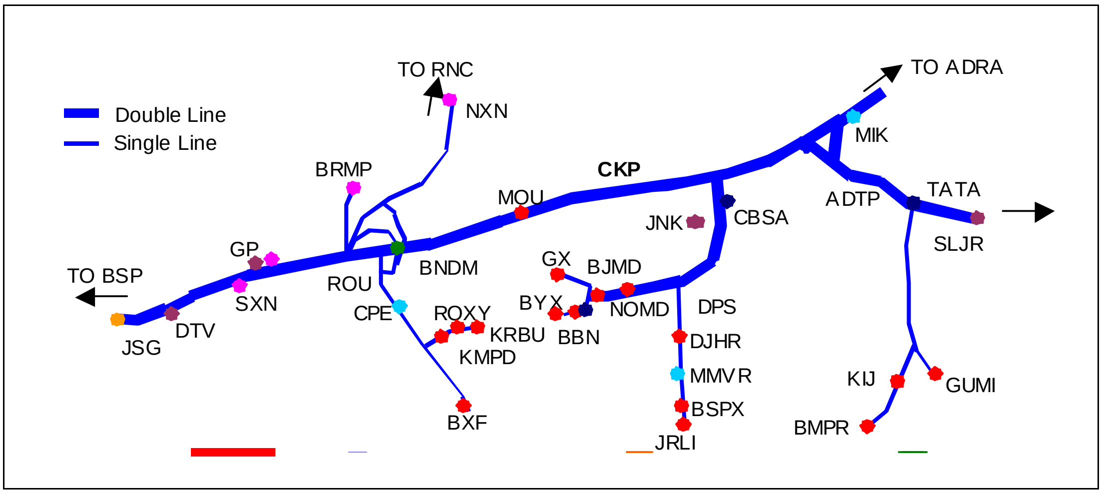


FIG. 3.5 Loading Points of CKP division.

TABLE 3.5.1 LOADING STATIONS/SIDINGS OF CKP DIVISION

	IRON ORE		STEEL	SPONGE IRON	CEMENT	FLUXES	FOOD GRAIN	OTHERS
	GX	BXF	BNDM	MMVR	SLJR	GP	JSG	CBSA
	BJMD	ROXY	TATA	MIK	JNK	SXN		BBN
	BBN	KMPD		CPE	GP	NXN		
	BYX	KRBU			DTV	BRMP		
	NOMD	GUMI						
	DJHR	KIJ						
	BSPX	BMPR						
	JRLI	MOU						
TOTAL	16 Nos.		2 Nos.	3 Nos.	4 Nos.	4 Nos.	1 Nos.	2 Nos.

3.5.3 65% of Iron ore loading originates from Dongoaposi area. Remaining 35% is from Kiriburu area.

3.5.4 CC+8+2t load was introduced in CKP division from 15.05.2005 on routes given in table 3.5.2.

TABLE 3.5.2 LIST OF SECTION OVER WHICH CC +8+2 T AXLE LOAD WAS ALLOWED OVER CKP DIVISION

SNo.	Routes
1.	Gua Barjamda-Rajkharswan-Sini-Chandil
2.	Bondamunda-Sini-Adityapur
3.	Bolanikhadan-Barajamda
4.	Bondamunda-Barsuan
5.	Bimalgarh-Kiriburu
6.	Padapahar-Banspani
7.	Bondamunda-Nawagaon
8.	Jharsuguda- Bondamunda
9.	Bondamunda-Birmitrapur

3.5.5 Patterns of failure on Rajkhharswan-Sini dn line (Part of Bandamunda - Sini dn line) before the introduction of CC+8+2 (from DEC 03 to MAR.05)

3.5.5.1 With normal axle load traffic, following defects were detected in the rails during the period fromDec03toMarch05.

Fig.3.5.2: Fractured Rail Piece with Kidney Flaw

Table 3.5.3 Details of defects found in the rail before the introduction of CC+8+2 t axle load.

S.No.	Name of Defect	No. of defects		
		GFC/USFD	Normal USFD	Total
1.	IMR	11	11	22
2.	OBS	26	45	74
3.	OBS(W)	8	12	20

Some of the photographs of defective rails broken by ***JIM CROW*** are shown below:-

Photograph of IMR detected on 21.1.04 between RKSN-MMV (Dn) at Km.290/28-30

Photograph of IMR detected on 21.1.04 between RKSN-MMV (Dn) at Km.290/28-30

Fig 3.5.3: Kidney Flaws detected before the introduction of (CC + 8 +2) t axle loads.

3.5.6 Effect of CC+8+2t axle load on the tracks:-

During the CC+8+2t movement fromMay'05 to Mar'06, the USFD testing with "*shifted probe*" showed the following results in Sini-Rajkharswan section:-

Table 3.5.4: Details of defects found in the rail after the introduction of (CC + 8 + 2) t axle load

S.No.	**Name of Defect**	**No. of defects**		
		GFC/USFD	**Normal USFD**	**Total**
1.	IMR	23	22	45
2.	OBS	205	177	382
3.	OBS(W)	149	23	172

The above case study proves the fact that with introduction of CC+8+2t, on 60 Kg rails, the no. of defects have increased. The defective rails were broken with "JIMCROW " to see the type of defect. All such broken rail pieces showed presence of kidney flaws in the rails. The photographs are shown in the following pictures:-

3.5.6.1 IMR DETECTED ON 09-07-2005 IN RKSN-MMV Dn Line at Km 289/16-14

The particular of the location are as follows:

S. No.	Description	Remarks
1.	Rail Section	60 kg 90 UTS of 1996 laid in 1996.
2.	Sleepers	PSC
3.	Clean Ballast Cushion	250mm
4.	Sleeper Density	1660 Nos./Km
5.	Whether LWR/SR	LWR
6.	Straight/Curve	Straight
7.	Level/Gradient	Level
8.	Traffic Density	68.19 GMT
9.	Total GMT Carried	613 GMT
10.	Last USFD	April-05(Normal + shifted probe)
11.	Last distressing done	Nov 2003
12.	Last machine packing	June 2005

The IMR was removed on 10.07.05. It has been observed that the flaw was a kidney flaw as evident in the picture below:-

The IMR was removed on 10.07.05. It has been observed that the flaw was a kidney flaw as evident in the picture below:-

Fig 3.5.4 Kidney Flaw occurred at km 289/16-14

3.5.6.2 <u>IMR DETECTED ON 09-07-2005 IN RKSN-MMV Dn Line at Km 289/4-6</u>

The particular of the location are as follows:

S. No.	Description	Remarks
1.	Rail Section	60 kg 90 UTS of 1996 laid in 1996.
2.	Sleepers	PSC
3.	Clean Ballast Cushion	250mm
4.	Sleeper Density	1660 Nos./Km
5.	Whether LWR/SR	LWR
6.	Straight/Curve	Straight
7.	Level/Gradient	1 in 250 falling
8.	Traffic Density	68.19 GMT
9.	Total GMT Carried	613 GMT
10.	Last USFD	April-05(Normal + shifted probe)
11.	Last distressing done	Nov 2003
12.	Last machine packing	June 2005

The IMR was removed on 10.07.05. It has been observed that the flaw was a kidney flaw as evident in the picture below:-

The IMR was removed on 10.07.05. It has been observed that the flaw was a kidney flaw as evident in the picture below:-

Fig 3.5.5 Kidney Flaw occurred at km 289/4-6

3.5.6.3 IMR DETECTED ON 09-07-2005 IN ADTP yard Dn main line at km 253/26-28

The particular of the location are as follows:

S. No.	Description	Remarks
1.	Rail Section	52 kg 90 UTS of 1995 laid in 1995.
2.	Sleepers	PSC
3.	Clean Ballast Cushion	150mm
4.	Sleeper Density	1660 Nos./Km
5.	Whether LWR/SR	LWR
6.	Straight/Curve	Straight
7.	Level/Gradient	Level
8.	Traffic Density	27.07 GMT
9.	Total GMT Carried	340 GMT
10.	Last USFD	May-05 with Normal probe)
11.	Last distressing done	Oct 1997
12.	Last machine packing	June 2002

The IMR was removed on 10.07.05. It has been observed that the flaw was a kidney flaw as evident in the picture below:-

The IMR was removed on 10.07.05. It has been observed that the flaw was a kidney flaw as evident in the picture below:-

Fig 3.5.6 Kidney Flaw occurred at km 253/26-28

3.5.6.4 IMR DETECTED ON 09-07-2005 IN RKSN-MMV Dn Line at Km 287/4-2

The particular of the location are as follows:

S. No.	Description	Remarks
1.	Rail Section	60 kg 90 UTS of 1996 laid in 1996.
2.	Sleepers	PSC
3.	Clean Ballast Cushion	250mm
4.	Sleeper Density	1660 Nos./Km
5.	Whether LWR/SR	LWR
6.	Straight/Curve	Straight
7.	Level/Gradient	1 in 200
8.	Traffic Density	68.19 GMT
9.	Total GMT Carried	613 GMT
10.	Last USFD	April-05(Normal + shifted probe)
11.	Last distressing done	Nov 2003
12.	Last machine packing	June 2005

The IMR was removed on 12.07.05. It has been observed that the flaw was a kidney flaw as evident in the picture below:-

The IMR was removed on 12.07.05. It has been observed that the flaw was a kidney flaw as evident in the picture below:-

Fig 3.5.7 Kidney Flaw occurred at km 287/4-2

3.5.7 Comparison of defects in rail before and after CC+8+2t

The comparison of generation of defects in rails after introduction of CC+10 load in the year 05-06 and 04-05 is shown in the graph below:-

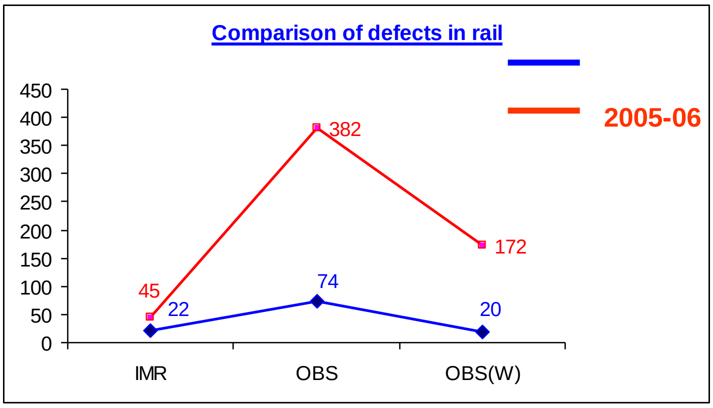


Fig: 3.5.8 Comparison of defects before and after the introduction of CC+8+2 t axle load

3.5.8 Problems at Loading Points

Loading Line No.7 at BXF.

Loading Line at BXF.

Apart from causing other problems these loading points, have no weighing facility, therefore, we are unaware of the total weight being ferried on the existing rails from the loading points.

However, these rakes are weighed at electronic in-motion weigh bridges after covering a considerable distance. But by that time, even if overloading is detected, nothing is done to correct it.

In CKP division, there are railway electronic in-motion weigh bridges at 3 stations namely Bimalgarh, Jaroli & Dongoaposi. Inspite of electronic in-motion weigh bridges random sample checks have time and again proved that over loading takes place on a regular basis. Some of the results show alarming trend. These are mentioned in table 7.1:-

7.1

Srl. No.	Date of weighing	Weigh bridge	No. of wagons found overloaded	Maximum load of any of the wagon (In ton)	Over load beyond CC+10 (In ton)
1.	05.02.06	DPS	21	111.10	19.80
2.	08.02.06	BUF	40	105.50	14.20
3.	02.03.06	BUF	25	108.90	15.00
4.	03.03.06	JRLI	16	122.60	31.30
5.	15.03.06	BUF	28	104.60	5.80

From the above it can be seen that even after permitting the overload up to 8t, the tendency to overload is not curbed & there is overloading to the extent of 14 tonnes to 40 tonnes above the carrying capacity of the wagons.

3.6 Implication on Bridges

The loading standard for bridges are as follows:

Table3.6.1 Loading Standard of Bridges

Std. of loading	Year	Maximum axle load (t)	Trailing load/t/m	Remarks
BGML RBG MBG HM	1933 1975 1989 1995	22.9 22.9 25 t 30 t	7.67 (t/m) 7.67 (t/m) 8.25 (t/m) 12 (t/m)	DHlocos DHlocos DHlocos
BoxN Wagons	-	20.32	7.59 t/m	As per the axle spacing of the BOXN wagons.
CC+8+2 BoxN Wagons	2005	22.82	8.52 t/m	--Do--
25t BoxN wagons	2006	25 t	9.0 t/m	--Do--

Note:

i) Though the axle load of CC+8+2 wagons are less than 25t, the trailing load intensity is more than 8.25 t/m as given in MBG loading, at the axle spacing of Box N wagons.

ii) BOBs / BOBX & BOBY are other wagons with axle load of 22.9t already running on K-K line of East Coast Railways and Badajamda-Asansol Ssction of SE Rly & E Rly in a closed circuit operation, but there loading intensity is less than the Box N Wagons with 22.9t axle load due to different axle spacing, since trailing load is dependent on the type of wagon. In BOXNHA & BOX wagons. trailing load is lesser train that of BOXN with CC+8+2 load. Therefore, they are not as detrimental to bridges as CC+8+2 loading.

3.7 In view of the above experience, it is necessary that instrumentation is carried out for checking the actual over stressing of the bridges, if any, due to running of heavier axle loads.

3.8 From the experience of the running of (CC+8+2) t wagons, it is concluded that strict discipline is required to be observed to prevent the overloading of wagons beyond (CC+8+2)t.

CHAPTER-IV

EFFECT OF RUNNING OF 25 T AXLE LOAD TRAINS ON FEEDER ROUTES

4.0 Based on encouraging results of the running of CC+8+2 t loaded trains, it has been decided to run 25t axle load trains on Banspani-Daitari & Durg Dallirajhara sections of East Coast & SEC Railway respectively.

4.1 The feeder routes of DFC as mentioned in ChapterII are also required to be strengthened for 25t axle load. To determine the scope of the work for making these existing track fit for 25t axle load, it is necessary to understand the effect of 25t axle load on various components of track which are discussed in the subsequent paragraphs:-

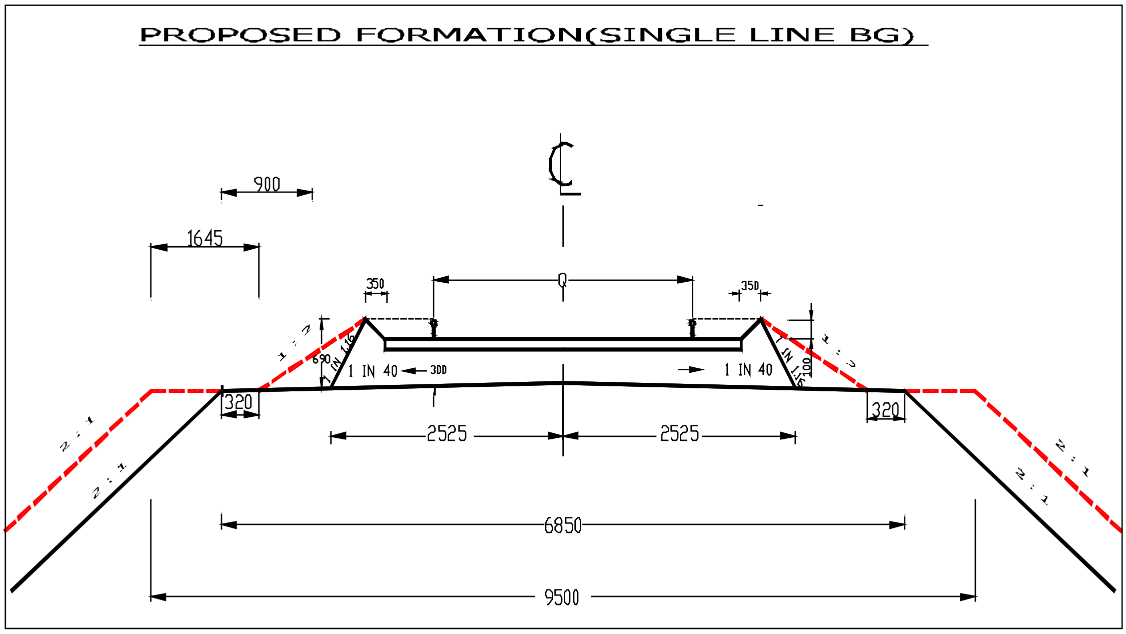
4.2 EFFECT ON FORMATION

4.2.1 The formations on the core routes of Indian Railway were constructed decades ago, without any consideration to the soil strength and its geotechnical requirements. Due to phenomenal increase in axle loads, traffic and speeds during the recent years, large lengths of formations have started showing signs of distress and instability and their lengths are likely to increase with increase in axle loads. The only solution lies in providing a well-designed blanket layer as per Specifications of blanketing material, which stipulates different thickness for blanketing materials, as per axle loads and geo-technical classification of the sub grade soil.
However providing blanket is an arduous task from two considerations:
(i) Naturally available material as deposit rarely conforms to the specifications. As per study conducted by RDSO only 23 % of the samples tested in different Railways conformed to the specifications. In SouthCentral Railway out of 172 Nos. samples tested during year 2000- 01 only 20 % were found to conform to the required specifications.
(ii) Providing blanket and is proper compaction to desired Dry Density, under traffic is very difficult.
4.2.2 Therefore to overcome the first part problem, blending of naturally available soil with sand/ quarry dust/ stone chips is being done in many Railways. However the problem still remains in mixing the various components in designed proportions and ensuring a homogenous material to be provided as blanket layer. Recently Northern Railway has devised a blanket material by mixing 10 mm stone chips with quarry dust, carrying it in wet condition to avoid segregation. A similar strategy will have to be adopted on the routes carrying heavier axle loads, depending upon the materials locally available. For providing the blanket under traffic different methods have been tried on different Railways. Some of them are listed below:
(i) By using Rail cluster, CC cribs, aluminum alloy girder (with 3 Hrsblock duration on Wadi- Nalwar section of SCR)
(ii)By blocking the line for blocks of long duration (under 8 Hrs traffic block on Chittapur- Malkaid Road section of SCR) and providing blanketing layer.
(iii)By suspending the line / resorting to single line working on double line sections and providing blanketing layer.
The relative implications of these schemes are discussed in Table below:

Table 4.2.1. Comparison of the various methods of Formation treatment

S.No.	Item of comparison	Blanketing under traffic with short duration blocks using aluminum alloy girder	Blanketing under traffic with longer blocks (8 Hrs)	Blanketing under complete closure of line
1.	Progress of work	10-15 m/day	30-40m/day	No limit depends on themachinery deployed
2.	Direct Cost	Rs. 35 lakhs	Rs.30 Lakhs	Rs. 20 Lakhs
3	Quality of work	Satisfactory-problem is ensuringcompaction in short duration- not very effective	Better	Very Good as Vibratory rollers can be deployed for required compaction
4.	Safety of traffic	Requires good supervision with adequate measures for protection of traffic as girders remain after block	Relatively less asno girder being used – confined to only attention to track for safe passage of trains	NIL as the work is carried out under complete closure of line.

From the consideration of direct cost, quality of work and safety of running traffic, it will be desirable to carry out the work under complete closure of line. However, on the routes carrying heavy traffic complete closure may not be possible. It will therefore be desirable to attempt for the spells of 7-8 Hrs duration block, using vibratory rollers so that the desired degree of compaction is achieved in minimum number of passes, preferably 3-5. Such vibratory rollers have been used with success on Northern Railway. Again, rather than follow the instructions of RDSO uniformly throughout the section, in this matter, it shall be worthwhile to take the decision of Upgrading the formation only after identification of data from GPR studies / Visual Inspections. Proposed formation profile is shown in Fig 3.5.9:



The extra width of formation is required to reduce the pressure in the embankment and earth. In addition to this it will help in exerting lateral support to the track structure. Available cess width will also increase even after providing milder slope to the ballast profile.

4.3 Effect on Ballast :

4.3.1 Components of the track structure affect each other in a way so as to behave like a composite system. By increasing the rail size, other components viz, sleeper, ballast, and fittings, the structure does not behave in a composite manner and therefore, the results are never realised to the true potential.

4.3.2 The function of ballast is to transfer and distribute the load from sleepers to larger area of formation, to provide elasticity and resilience to track for riding comfort, to provide effective drainage, to provide necessary longitudinal and lateral resistance to track and to provide means for maintenance of alignment and unevenness. Increasing axle loads will require increased depth of ballast cushion. As per Railway Board's letter No. 95/W1/Genl/0/39 dated: 9.10.96, the depth of ballast cushion for various axle loads and speed upto 100 Kmph, is as follows:

4.3.3 As per Para 263 of IRPWM Minimum Ballast Profiles/Sections/Depths of Cushion in case of where 22.1 t Axle load rolling stock is nominated to run shall be 350mm. While it is possible to provide the increased cushion, it is the optimum utilization of ballast that needs to be given a thought.As of today, there is no scientific basis for arriving at the ballast cushion. GPR methods may be employed to arrive at scientific values and cause saving of money.

4.3.4 On Indian Railways the condition of ballast is either assessed by visual inspection of level of fouling or in its manifestation as rail/ weld failures. The Ballast is deep screened once in ten years. However as the ballast ages, it absorbs increasing amount of energy on account of moving traffic, which results in rounding of particles and soiling of ballast due to attrition and abrasion. The ultimate result is decrease in the resilience and increased track modulus, which ultimately reflects in increased load on rail, sleepers and fastenings. According to studies conducted by ERRI D182, the properties of ballast material become markedly poor at soiling level of 50- 70%. This could therefore be taken as one of the criteria for evaluating the useful life of ballast. The study further indicates that a certain distance should be maintained from soiling level of 50% to 70%, as the soiling is very uneven. The final suggestion being to start ballast cleaning activities, when soiling level reaches 30% to 40%. This makes ballast soiling a desirable parameter to monitor.

4.3.5. 1 J P Hyslip & E T Seli, S S Smith and G R Oleoft, have reported of Ground Penetrating Radar (GPR) being employed to assess conditions in railway track substructure (ballast, subballast, and subgrade) and to produce quantitative indices of substructure condition for use in track maintenance management efforts. GPR surveys have been conducted on over a combined 100 miles of track, including mainline and freight tracks. Results of these surveys have shown the ability of GPR to distinguish between the different substructure layer conditions to determine areas of trapped water and fouled ballast.

4.3.6 The railway GPR equipment is mounted on a hi-rail vehicle and includes multiple sets of 1-GHz air launched horn antennas suspended above the track that permit fast survey travel speeds and high resolution measurements to a depth of 4 to 6 ft (1 to 2m). The antenna configuration and surveying procedures are deployed to reduce the influence of sleepers and rail. Antennae are located at both ends of the sleepers as well as in the center of the track, so the variations of conditions laterally across the track are seen.

4.3.7 The GPR method requires transmitting pulses of radio energy into the subsurface and receiving the returning pulses that have reflected off interfaces between materials with different electromagnetic properties. Antennae are moved across an area with a continuous series of radar pulses, giving a profile of the subsurface. Reflections of the GPR pulse occur at boundaries in the subsurface where there is a change in the materialproperties. Only a portion of the pulsed signal is reflected and the remaining part of the pulse travels across the interface to again be reflected back to the receiver from another interface boundary. The time the pulse takes to travel through the layer and back is controlled by the thickness and properties of the material. The travel time between upper and lower boundaries of a layer can be used to calculate the layer thickness employing a known velocity.

4.3.8 The majority of track substructure problems are associated with one or more of the following:
_ Poor drainage of ballast, subballast and subgrade.
_ Fouled ballast (causing rapid loss of surface of track after maintenance).
_ Subgrade failure or deformation (from progressive shear failure or excessive plastic deformation).
_ Subgrade attrition
_ Subgrade excessive swelling and shrinking (expansive clays).
_ Longitudinal variation of the condition and behavior of the track substructure.
_ Unstable embankments.
_ Inadequate amount of crib and shoulder ballast.

4.3.9 Each of these substructure problems can be defined in terms of one or more of the following condition *indicators* of the ballast, subballast and subgrade:
_ Layers – thickness, lateral and longitudinal extent, deformation with time.
_ Water – trapped water, moisture content, change with time
_ Composition – fouling condition, gradation, density/consistency, Ground penetrating radar (GPR) has the ability to provide a rapid, nondestructive
measurement technique for evaluating these key substructure condition indicators. Further, the fouling condition of the ballast can also be analysed by scattering textures of the GPR scans, thereby removing ad hoc and subjective assessment for periodicity of deep screening.

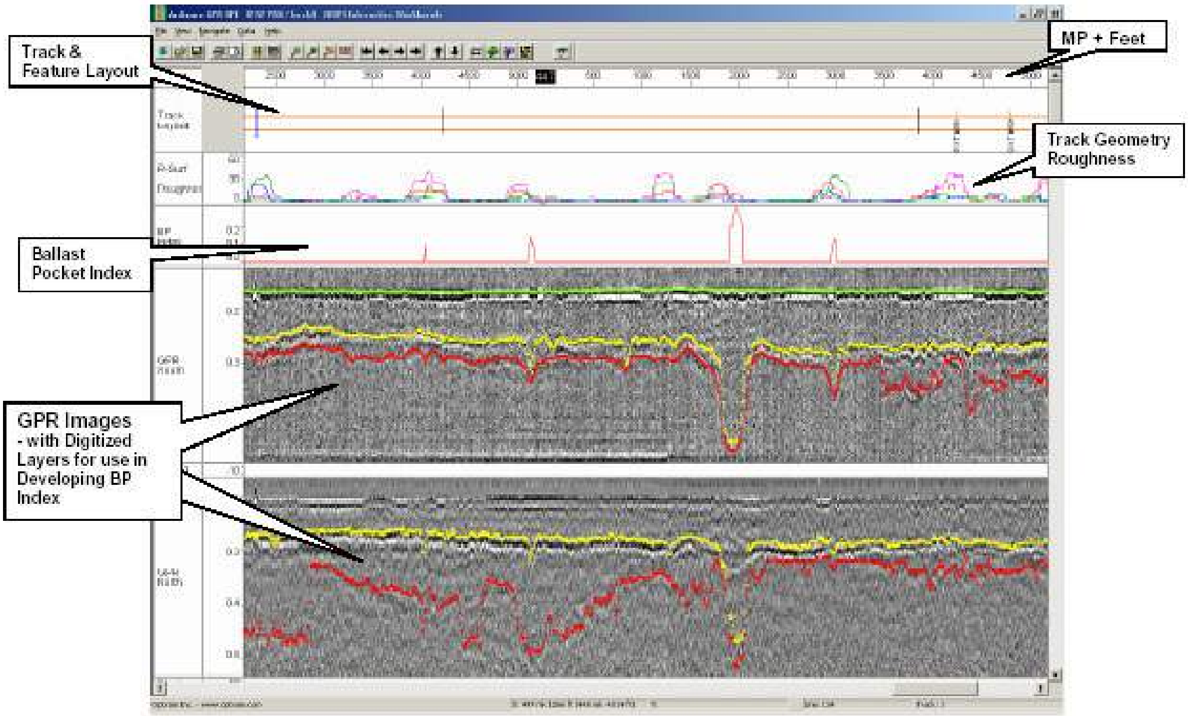


Fig.4.1 GPR method of assessing the condition of ballast.

An example of a condition index based on GPR information is depicted in the ORIM screen grab in Figure 4.1. The above figure shows two parallel longitudinal GPR profiles along a 1.5-mile (2.4 km) section of heavy tonnage freight main line. The images, shown with the digitized layer boundaries, indicate ballast pockets that have developed in an embankment under the influence of heavy axle load traffic. Ballast pockets are load-induced depressions in the subgrade surface directly under the sleeper. A Ballast Pocket Index ("BP Index") was derived to indicate where the ballast pocket condition has developed. The BP Index matched withthe track layout and track geometry data, and review of Figure 4.1 reveals that many of the geometry rough spots are being driven by the ballast pocket problem. A common remedy to minimize the continued development of the ballast pocket is to drain the ballast pocket with a cross-drain (essentially a ballast-filled trench) excavated perpendicular to the track. GPR can delineate the bottom of the pockets to ensure that lateral drainage is put at the most effective location, i.e., at the lowest point of the ballast pocket.

Through Ballast renewals (TBR) form a major chunk of track renewal estimates, an intelligent management of ballast condition through GPR will not only result in optimum utilization of ballast life by monitoring soiling levels but also help in identifying the spots requiring ballast renewal, the problem areas in sub grade and providing right solutions.

4.4 Effect on Sleepers :

4.4.1 The primary function of a sleeper is to transmit the load of rolling stock to the formation through ballast, while maintaining the gauge, cross-levels and alignment. On Indian Railways the sleeper has been standardized to 60 Kg PSC mono block sleeper. Rational design of sleeper is difficult as the load on rail seat, which govern the design of a sleeper, is dependent on a number of factors like dynamic wheel load, sleeper spacing, condition of track expressed as track modulus and bending stiffness of rail. The design of sleeper has therefore been evolved on the basis of simplified loadings and extensive field trails on the sleepers so designed. The present design of 60 Kg PSC mono block sleepers has been evolved for an axle load of 22.5 tonnes.

To understand the implications of increasing axle load on this sleeper, it is necessary to know the load transferred at rail seat by the axle load, which is given by the following expression:

$W=QS\,(U/64EI)^{0.25}$

Where W = Load transferred at rail seat of the sleeper
Q= Static wheel load
S= spacing of sleepers
U= Track Modulus
E= Modulus of elasticity of rail section
I = Moment of inertia of rail section.
The static wheel load so worked out is increased by 150 % to account for dynamic wheel load.

4.4.2 For the axle load of 25 tonnes, the value of static wheel load at rail seat for 60 kg rail section with a spacing of 65 cm, (sleeper density = 1540 cm) with a track modulus of 183.7 Kg/cm/cm for first 4t and 419.17Kg/cm/cm for the remaining, works out to 5.7 tonnes, which is not much different from the design static load of 6 tonnes taken for design of concrete sleepers. Hence the present design of 60 Kg PSC mono block sleepers will suffice for the increase in axle load to 25 tonnes..

It can be seen from the above equation that the static wheel load will decrease by 7.69 %, if the sleeper spacing is decreased from 65 cm to 60 cm and it will decrease by 8.32 %, if the rail section is changed from 52 Kg to 60 Kg. Thus the amount of reduction in rail seat load is nearly the same if the sleeper density is increased or rails are upgraded to higher section.
Should the need arise therefore to increase the axle load on existing track, same can be done by varying the sleeper density without changing the rail if residual life of 52 kg rails is still there.

4.5 Effect on RAILS

4.5.1 The rail is the single most expensive element of the track structure accounting for nearly 40 % of the cost of track.. The failure of the rails will affect safety and its premature failure will result in increased track maintenance cost. The cost of rail maintenance can be minimized when the rail is ultimately removed for loss of railhead, as opposed to any other cause such as fatigue.

4.5.2 The IRS standard for most mainline tracks is 52kg/m 90UTS (really 51.89kg/m,), and it allows 25-ton axle loads. For sections with heavy traffic, the newer IRS standard rails are 60kg/m (really 60.34kg/m). Although rails allowing 22.5t or 25t loads are in place, as a matter of operating procedure goods wagons are currently [5/05] restricted to 22.9t axle load. For running of goods wagon with 25 t axle loads, their design/stresses are to be checked.

4.6 RAIL STRESSES:

On Indian Railways, Rail stresses are calculated by theory of “Beam on Elastic foundation (BOEF) treating rail to be continuous beam supported on closely spaced elastic supports. The effect of stiffness and yield ability of tie (sleepers), ballast and roadway is represented by a single factor called ‘Track Modulus’, which is load per unit length of rail, required to produce unit depression on the track. The calculations takes into consideration the factors like effect of adjacent wheel, speed effects (parasitic motions of pitching, bouncing, rolling and hunting etc.), leading wheel effect, eccentricity of vertical load, effect of lateral loads and wear on rails. It can be concluded from the above that both 52 Kg and 60 Kg/90 UTS rails with sleeper density of 1540 Nos/KM on LWR track are fit for the speeds upto 65 Kmph.

4.7 RAIL WHEEL CONTACT STRESSES:

4.7.1 The contact between rail and wheel flange should be theoretically a point. Hertz theory explains that in practice the elastic deformation under high axle load results in deformation of steel of wheel and the rail creating an elliptical contact area. The dimensions of the contact ellipse are determined by the normal force on the contact area, while the ratio of the ellipse axes a and b depends on the main curvatures of the wheel and rail profiles. Inside the contact area a pressure distribution develops which in a cross section, is shaped in the form of a semi-ellipse, with highest contact pressure occuring at centre.

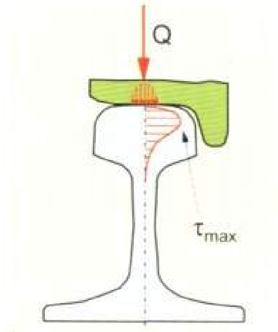


Figure 5.18: Shear stress distribution in rail head

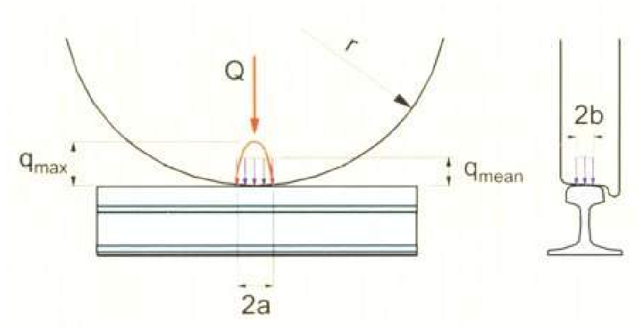


Figure 5.19: Assumed contact distribution between wheel and rail according to Eisenmann

Fig.4.2 Shear stress distribution at railhead

4.7.2 The concentrated load between wheel and rail causes a shear stress distribution in rail head as shown in figure above. The contact problem is most serious in case of high wheel loads or relatively small diameters. Eisemam has devised a simplified formula to calculate the maximum shear stress in railhead, which is as follows.

τ_{max}= 4.13 $\sqrt{(Q/R)}$

Where τ_{max}= maximum shear stress in railhead.

(kg/mm2)

Q= Wheel load + load due on loading on inner rail due to curves. (kgs)

R= Wheel radius (mm).

Since the problem is one of fatigue strength, the permissible shear stress is restricted to 30% of UTS, which works out to 21.60 kg/mm2 for 72 UTS rails and 27.00 kg/mm2 for 90 UTS rails. The important derivation from the above formula is that the maximum shear stress increases, with increase in axle load. It also increases with increase in curvature of track as increased super elevation results in increased on-loading of inner rail, when a goods train ply on a mixed traffic route. The shear stress also increases with wearing of wheel, as the wheel radius decreases with the wear of wheel. Thus it may appear that the problem of increased axle loads can be solved with increase in the wheel diameter but this is not possible as increase in wheel diameter will mean less carrying capacity because of restricted overhead clearances. Therefore the only way to keep the maximum shear stresses within the permissible limits is to use the rails with higher UTS.

4.7.3 The contact stresses for BOXN would be as under:

Table 4.7.1 Contact stresses for BOXN

Wagons	**Wheel load Q (Tonnes)**	**Worn wheel diameter (mm)**	**Contact shear stress (kg/mm2)**
BOXN	12.5	813	21.91

For 72 UTS rail the maximum allowable shear stress will workout to 21.6 kg / mm2 and for 90 UTS rails, it will be 27 kg/mm2. It therefore implies that 90 UTS rails will be required for running 25 t of axle load and 72 UTS rails have to be replaced by 90 UTS rails.

4.7.4 In the above deviation the effects of uneven loading and increased wheel loads in monsoon, especially due to wetting of iron ore carried by wagons during rainy season are not considered. Both of the above situations are not uncommon. The above situations will result in increase in Q and consequently the contact shear stresses may increase beyond permissible values. If the permissible stresses are exceeded there will be plastic flow of metal at contact and development of cracks in railhead will take place. These cracks grow gradually due to combined effect of contact stresses with the entrapment of water or lubricant resulting is surface breaking. If allowed to grow, they have potential go subsurface and cause a failure by combining with already present defect. Another implication is that if the surface cracking is severe, the substantial amount ultrasonic waves transmitted will be reflected from these surface defects making it impossible for the rail section to be reliably inspected for full depth. The most prominent defects with the heavy haul are Rolling Contact Fatigue defects predominantly the Gauge Corner Fatigue.

4.7.5 The maximum shear stress is developed not on the contact surface but at a depth of 5-7mm below the railhead. It therefore implies that use of head hardened rails will be effective only if such hardening increases the UTS upto the depth of 6 mm or more from the railhead. It is interesting to know the effect of surface hardening and lubrication in context of maximum shear stresses. If wear is not dictating the life of rail, as on head hardened rail / lubricated rails, the maximum repetitive shear stress will always occur at same point, thereby increasing propensity of fatigue failure and shelling. On the other hand if the rail is allowed to wear, the point of occurrence of maximum shear stresss will gradually shift downwards making it less prone to shear fatigue failures or shelling. Therefore, it is paradoxical to say whether the use of head hardened rails / lubrication of rails will actually enhance or reduce the life of rails with heavy haul. Tests at Facility for Accelerated service Testing (FAST) have also shown that higher wear rates of rail not only reduce surface defects but also suppress the internal defects i.e. detail fractures and shelling.

4.8 RAIL GRINDING:

4.8.1 A better solution will therefore be to do rail grinding on heavy haul routes. Such grinding will remove the plastic deformation on railhead thereby removing the surface cracks before they propagate uncontrollably into the rail section. It also helps in progressively lowering the point of maximum shear stress thereby increasing the life of rail and preventing generation of s bsurface cracks due to fatigue. American rail roads are now adopting preventive grinding programmes aimed at minimizing the occurrences of internal rail defects, before they have form in rails. This new, more scientific approach to rail profile grinding have proved to extend the rail surface life. Rail grinding programs are primarily intended to:

(i) Shift the wheel loads from the gauge corner of rail running surface by asymmetrical grinding pattern

(ii) Prevent areas of high localised contact stresses by grinding the corrugated profiles more conforming to wheel geometry, thereby distributing internal stresses more uniformly, into the rail cross section and

(iii) Grinding at predetermined intervals and rates shifts the critical internal stresses, thereby not allowing time for micro cracking and subsurface failure to occur. Grinding of rails using LORAM SX-11 rail grinder has been done on Kottavasla – Kiramdul line.

4.8.2 The normal pattern wear on the curved track with heavy haul traffic is pronounced side wear on outer rail, gauge face corner defects and flattering of rail head due to plastic flow of material on inner rail. The problems of wear aggravates with increase in curvature. Premature renewals have been reported on KK line of EC Railway, on wear considerations, due to plying of loaded BOBs wagons. In world Railways asymmetric grinding is carried out to over come this problems. In this type of grinding wheel / rail contact point is shifted towards the inside of the low rail. This give better steering of the wheel set by which flanging is prevented or at least reduced, thus lessening the problems of side wear, severe corrugation and shelling.

4.8.3 The grinding not only makes the operation of heavy haul safer but also brings about a long-term economy. It has been demonstrated on Sweden's iron ore line, the Malabanan, that by preventive grinding over a period of 3 years, the Rolling Contact Fatigue defects were considerably reduced. The Malmbanan is claimed to be Western Europe's only heavy haul line insofar as it carries fairly long trains with relatively high axle loads of 25 tonnes and relatively high annual tonnage of about 23 GMT. The line suffered from the problem of RCF defects like spalling, shelling and head checking. These defects were primarily observed on the high rail of curves and in switches and were a cause of considerable concern. A preventive grinding strategy was adopted where the rate of metal removal was about 0.20 mm
across the railhead after every 23 GMT. By adopting this preventive grinding, the cost of rail grinding and rail decreased by more than 30 %. The principal savings came from the purchase of rails, which declined, by two thirds over the period 1997-99, from over 6 million crowns to about 2 million crowns, while the cost of grinding remained constant at about 5 million crowns. Thus the Railway was not only less expensive but also safer.
Thus it can be concluded that the Grinding will be effective strategy both in terms of safety and long term economy, for the heavy haul routes as it helps in prolonging the life of costliest component of track, the rail.

4.9 RAIL FATIGUE LIFE:

From the analysis of bending stresses and contact stresses it may though appear that 52 Kg 90 UTS rail may suffice the requirements of increased axle load, but in practice, the above stresses coupled with thermal stresses and residual stresses set up cyclic stresses. From the theory of fatigue, it is evident that such cyclic stresses may result in failure of material at a stress level lower than what would normally require for failure. Allan M Zarembski compared the rail life based on wear limits to rail fatigue life for different axle loading environment and found that in lighter axle loading environments, rail wear is dominant mode of failure while in heavier axle load environments, the fatigue emerges as dominant replacement criterion. (Fig. 4.9.1).

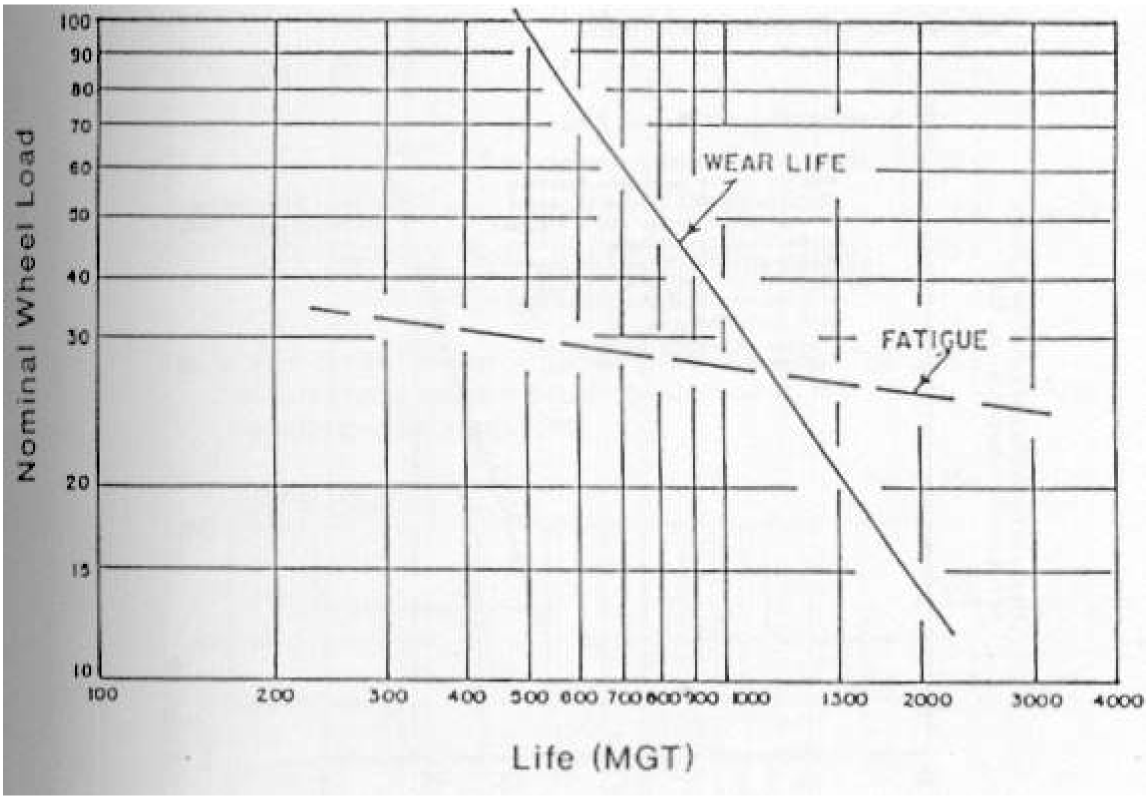


FIG 4.9.1 Rail Fatigue Life vs Wear 136 RE Rail

4.9.2. AREA Bulletin No. 685, Vol 83 reports of study made by Dr. Allan.M.Zarembski on the effects of increasing axle loads on tangent track on a continuous welded track. Two independent studies were conducted to determine the fatigue life of rails with different axle loads. The first study involved the study of rail defect data to obtain the probability distribution curves. Analysis of rail defects have shown that the probability of their occurrence is a function of tonnage (MGT) and it follows Weibull Distribution. The cumulative defect data was found to have linear relationship with the accumulated MGT when plotted on Weibull's scale. The defect datas collected from two mining railroads operating with different axle loads and compared with those of a mixed railroad. The results have shown that heavier axle loads have resulted in a more severe occurrence of rail defects. (Fig.4.9.2)

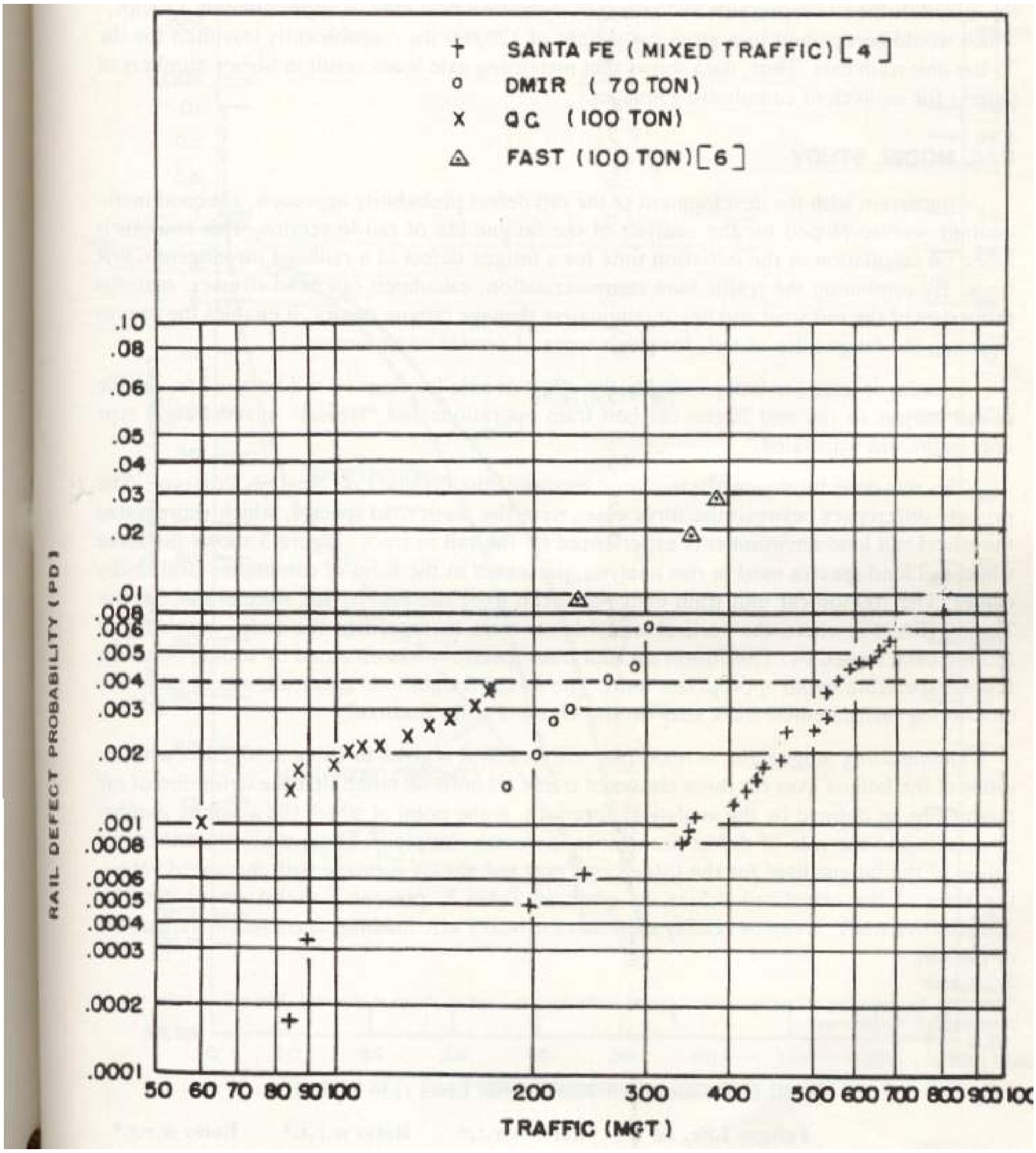


Figure 4.9.2: Cumulative Probability Distribution

The second study was the analysis of the rail life under fatigue. The effect of traffic load, calculated rail head stresses (Bending, contact, thermal and residual stresses), material properties of rail steel were analysed using the cumulative damage fatigue theory which postulates that every increment of stress beyond the fatigue strength of material causes fixed amount of damage. The fatigue lives of rails were then calculated for different types of service environment.

4.9.3 The study had two conclusions:

i) An increase in axle loading will result in decrease in the fatigue life of rail, measured in terms of cumulative MGT and reduction occurs for both heavier as well as lighter sections.

ii) When the axle loads are increased from 27.5 tonnes to 33 tonnes (corresponding to 70 tonnes and 100 tonnes freight cars), the resulting decrease in life of rail was found to be 40 %.

4.9.4 Thus under Indian Railways context, it can be said that with increase in axle load upto 25 tonnes, 52 Kg/m, 90 UTS rail may even though be permitted from the considerations of bending stresses and contact stresses, however, in the interest of long term economy and from fatigue considerations, it will be more appropriate to use a heavier section of 60 Kg/m if further increases in Axle loads are imminent.

4.10 EFFECT OF TRACK GEOMETRY AND CURVATURE:

4.10.1 Dynamic effects of 22.5 tonnes axle loads have been reported in ORE 161 studies for different speeds, track quality and radius of curvatures. The track quality was expressed in terms of standard deviation of vertical profile and alignment. Track with standard deviation. less than 1 mm was considered to be very good that with 1-2 mm good and more than 2mm moderate.

4.10.2 The important results of the above studies are:

i) The Dynamic wheel force (DSQ) increases with the increase in speed and a poorly maintained track will have most pronounced effect, where increase in the wheel force can be upto 22 % of axle loads for speed ranging between 60 to 100 Kmph. and track quality

ii). The lateral rail- wheel force (Ya) increases with increase in curvature and deterioration of quality of maintenance.

iii). Stability of track depends upon the total lateral track load especially that part which is present over a length of at least 2 m. This lateral load referred to as _Y2m increases with increase in curvature. For the lateral stability of track, its limiting value can be ascertained
from Prud'homme's equation implying thereby that _Y2m _ 0.85 (10+ Q/3) which works out to 73.38 KN for axle.

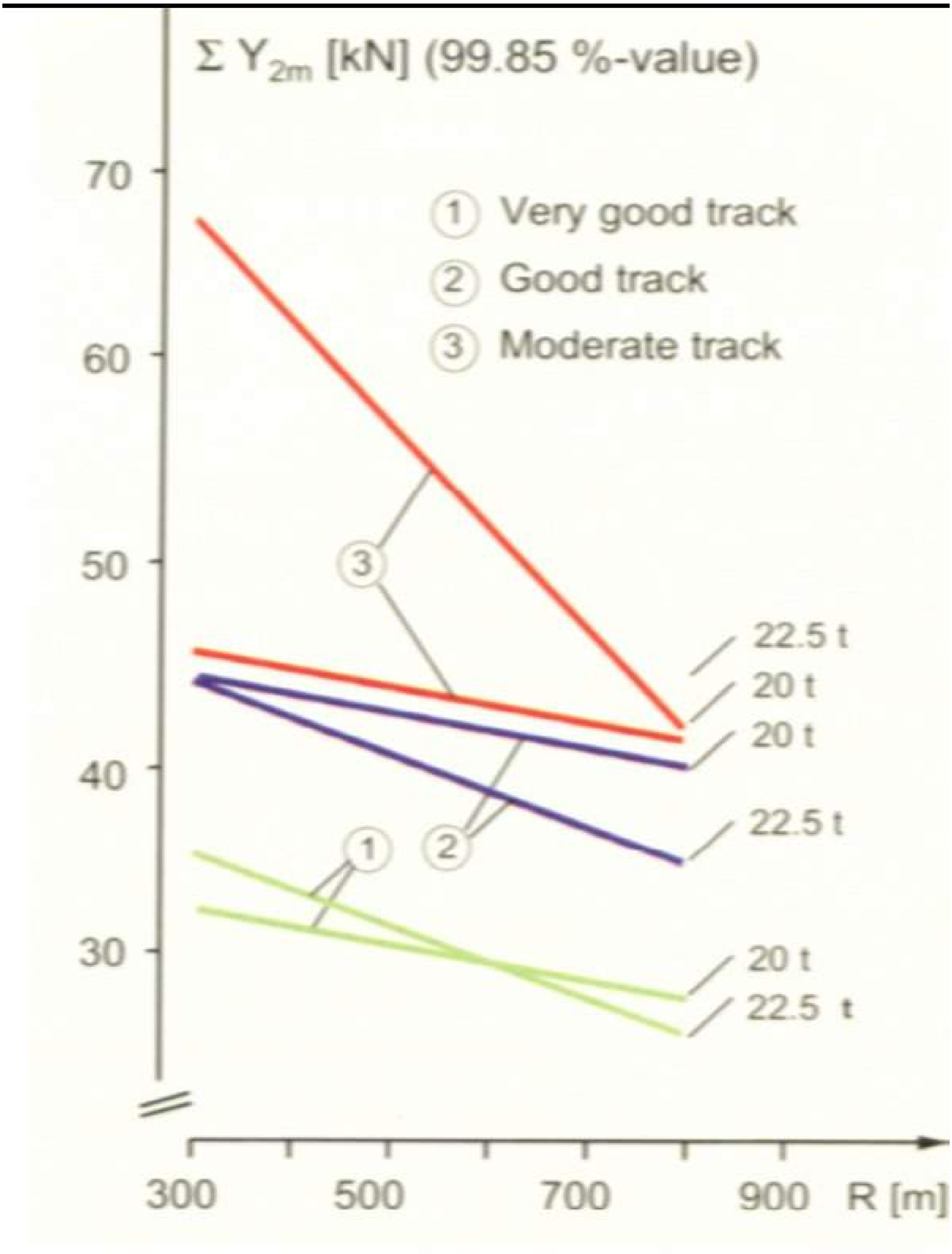


Figure 4.8: Dynamic lateral track load in curves

Fig: 4.10.1. Dynamic Lateral load in curves

From the figure above it can be observed that the lateral force $\sum Y_{2m}$ increases with increase in curvature and deterioration of quality of track maintenance. Though it is not possible to apply the above studies directly to Indian Railway conditions because of difference in rolling stock and track, but it gives a fair insight into the disturbances in geometry caused due lateral forces on sharp curves. On Indian Railways the standard deviation above 2.0 for alignment and unevenness (as reported by track recording car) is considered to be maintenance tolerances. From the figure above it can be seen that the Prud'hommes limiting value is likelyto be reached for cures sharper than 400 m radius.

Thus the curves in general and with radius sharper than 400 m in particular will require a greater care of track geometry with increase in axle loads.

4.11 EFFECT OF WHEEL FLATS:

4.11.1 The largest loads applied to the track from vehicles are those, which arise from irregularities on wheel such as wheel flat. ORE 161.1/RP 3 reports of the tests carried out on flat tyres measuring the effects of speed, size, sleeper type and axle loads. The results reveal:

i). The forces at frequencies above 500 Hz referred to as P1 forces increases continuously with speed, while the forces at frequencies below 100 Hz, referred to P2 forces are more of less independent of speeds. The P1 forces have bearing on wheel rail contact stresses. This force, which causes most of damage to rails and concrete ties, increases with increasein speeds.

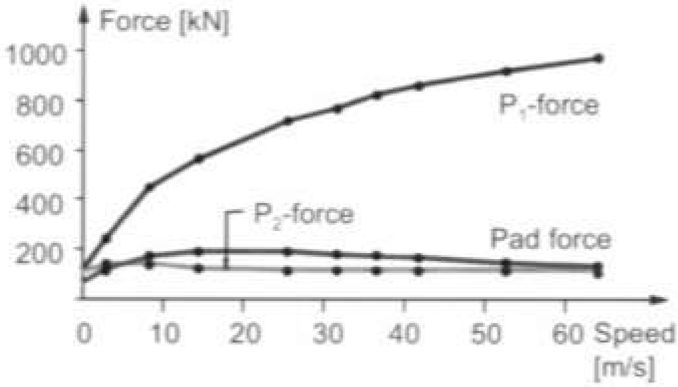
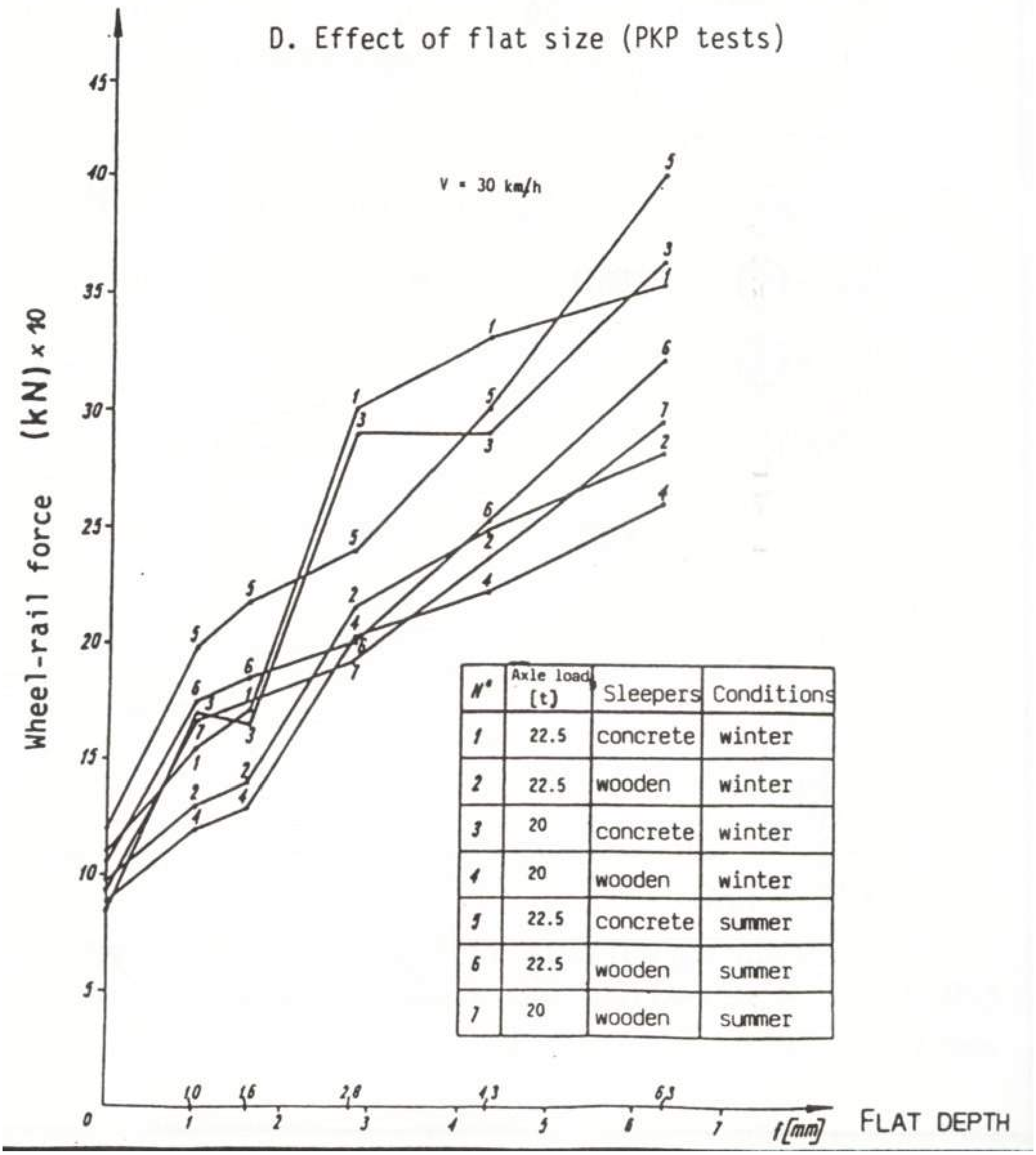


Fig 4.11.1: Relationship between Force and Speed

ii). Increase of axle load from 20 t to 22.5 t (12.5%) caused the increased wheel flat force of the order of 0 to 6 %. Hence if go from 22.5t to 25t the increase the increase in wheel flat force will be of the order of 12%



N°	Axle load (t)	Sleepers	Conditions
1	22.5	concrete	winter
2	22.5	wooden	winter
3	20	concrete	winter
4	20	wooden	winter
5	22.5	concrete	summer
6	22.5	wooden	summer
7	20	wooden	summer

Fig.4.11.2 Relationship between Flat size and Wheel force

iii). The relationship between the flat size and force is almost linear.

iv). The increase in Dynamic wheel force is more for concrete sleepers than for timber sleepers.

4.11.2 Studies have also revealed that movement of wheels with flats can generate dynamic forces, as high as six times the normal static load, in extreme situations. The Dynamic forces increase with increase in speed and axle loads. On Indian Railways, the effect of rail/ wheel defects and vehicle suspension, on static wheel load, is represented by a speed factor which can assume a maximum value of 1.75 for locomotives and 1.65 for wagons. However the studies conducted by ORE shows that the dynamic loads can increase upto 6 times static wheel load and further by 6% due increase in axle loads.

Such occasional high loads may result in higher rail stresses reducing the fatigue life of rails and causing fracture of rail/welds in extreme cases. The problem assumes alarming proportions incase of thermit welds (which have the impact strength of 7-10% of parent rail) in LWR territories, during winter season, when the full tensile stresses are present in rail section. Spate of weld failures due to running of flat tyres under these conditions, is not uncommon.

4.11.3 According to UIC leaflet 510-2, flats on wheel with diameter of 1000- 630 mm should be restricted to a length of 60 mm and a depth of 0.9- 1.4 mm. On Indian Railways, the permitted sizes of wheel flats are 50mm for locomotives and coaching stock and 60mm for goods stock. This would imply that on a Goods stock with a new wheel diameter of 1000 mm
(BOBs or BOY wagon), depth of flat tyre can be 0.9 mm (602/8X500) and it can go upto 1.0 mm, when the tyre is worn out and reaches condemning limit of 906 mm. Thus though the situation on Indian Railways is not any different for World Railways, so far as the permitted size of wheel flats are concerned, it is sincerity of detection and enroute detachments of wagons with flats, which leaves much to be desired. It is felt that the role of detecting staff at C&W depots and train passing staff at station and in control offices should be clearly defined for detection, reporting and detachments of wagons with wheel flats, as has been done for Hot axles and the cases of non compliance should be viewed seriously. It is understood that the Railways in collaboration with IIT/ Kanpur are developing the means to measure the impact force generated on account of a wheel flat to objectively identify a wheel flat so that its detection and enroute detachments are done on a scientific way rather than on subjective assessment of train passing staff. The technology provides Audio-Visual signal to station staff in the event of passing of Flat Wheel of a running train against the present system of listening to sound. The system generates two levels of alarms depending upon severity of the
impact force. The system has been installed at Ajgain Station on Kanpur – Lucknow Section and data generation with full trainloads has commenced since 25th June, 2002. Another possible solution could be use of more flexible rubber pads, which has potential of reducing the impact loads from the rail anomalies (engine burn, battered welds, joints) as well as from the irregularities of wheel as wheel flats. The effect of tie pad stiffness on high- impact wheel/ rail loads were investigated by field and laboratory measurement and also by analytical simulations by F.E.Dean, D.R.Ahilbeck, H.D.Harrison and J.M.Tuten to determine the factors that led to development of hairline cracks under rail seats on concrete ties laid a few month back to about two years ago. The important conclusions of their study are:

i). The substitution of a more flexible pad can definitely reduce the rate of occurrence of impacts with the potential to cause crack in ties. The pad should have an approximately linear load deflection characteristic of about 1 million pounds per inch (17900 Kg/mm)

ii). The long term stability of pad should be evaluated through track and laboratory tests appropriate for the specific service environment,

iii). Only detecting and turning the wheels, which cause the severe impact, can ensure Long-term durability of concrete ties.

4.12.0 EFFECT ON BRIDGES

4.12.1 ARCH

With limiting value of deflection as 1.25 mm and spread as 0.38 mm as criterion, it is considered safe for all practical purposes to allow axle loads up to 30 tonnes with 60 kmph speeds with proper physical condition of arch being assured. Utmost, an additional arch ring can help fixed with proper skew back on strengthened abutment/pier. (ME Technical instruction No. 4)

4.12.2 Other Bridges

Instrumentation of Bridges is being planned and shall be soon carried out with the help of M/s Pixel Networks, a Mumbai based Company, which has tied up with IIT Mumbai and has carried out works of similar nature in the past. Instrumentation in track is being planned with M/s Vinay Sharma & Associates, a Chicago based firm, who have wide experience in delivering online instrumentation for assessing the wheel loads, dynamic augments and extents of stressing in rails. Efforts are also on for procuring Instruments like the Vibration signature Analyzer as is existing in KRCL. Divisions are being directed to procure the NDT (Non Destructive Equipment) equipment for bridges and conduct physical inspection of all
the bridges on these routes, in addition to the existing annual cycles of maintenance.

4.13 MAINTAINABILITY OF TRACK:

4.13.1 Various studies have been conducted for the analysis of cost on Heay Haul lines and increase in maintenance cost with increased axle loads. Two such studies are reproduced here to appreciate the increase in the maintenance cost:

4.13.2. *Findings of the AAR Panel on 100-ton cars*

In 1981, an AAR panel of distinguished railroad engineers compared the expected impacts of 80-ton loading cars (20 t axle load) on well-maintained tangent track with 132-pound (60 Kg rail) continuous welded rail to the expected impacts of 263,000-pound cars (100-ton loading cars) on the same track. The panel concluded that rail life would be 1.5 to 2.1 times greater
using the 80 tons cars, while tie and ballast lives would be 1.0 to 1.4 times greater under the lighter loads. The panel's report also noted that the impacts of heavier 100-ton cars would be much greater on light rail and poorly-maintained track. However, these effects were not quantified.

4.13.3*Findings of the* Ahlf *Study of 100-Ton Cars*

Robert (1980) developed an economic-engineering model of maintenance of way and structure (MW&S) costs using reported Class I railroad maintenance expenses and work load measures (such as gross ton miles). He classified each MW&S cost element into one of three categories:

1) Fixed costs;
2) Costs that vary in relation to the mechanical actions of the track under load; and
3) Costs that vary with rail life.

The costs of ballast, Sleepers, and track surfacing events were included in Category 2 (costs that vary with track mechanical action). Rail deflection was used as an indicator of the mechanical actions of the track under different axle loads and track support conditions. Ahlf concluded that: (1) 39 percent of MW&S costs vary with track
mechanical action, (2) 17 percent of MW&S costs vary with rail life, and (3) Industry deployment of 100-ton cars will reduce rail service life by about 50 percent.

CHAPTERV

WORKS REQUIRED TO BE DONE IN FEEDER ROUTES FOR MAKING THEM FIT FOR 25 T

5.1 Following are the works to be done for raising the axle load to 25 t from track point of view.

- From the consideration of Bending stresses and contact stresses, though 52 Kg/ 90UTS rail section will suffice in SWR track, (Annexure – I, II), but with the heavier axle loads, fatigue life of rail is shortened (Ref Annexure-I). It will therefore,be appropriate to continue using 52 Kg / 90UTS rails to avoid premature renewals, rail being the costliest component. However, wherever possible, track should be upgraded with 60 kg 90 UTS , especially so in LWR. Wherever the CTR work is sanctioned with 52 kg rails on feeder routes, they are to be carried out with 60 kg rails through material modification as done by Northern Railways. While 72 UTS rails are to be changed on priority and on out of turn basis. The planned track renewal is to be proposed as per the following track structure:

Table 5.1: Proposed Track Structure for 25 t axle load

S.No.	Component	Minimum Standard(Proposed)
1.	Rail	60 kg 90 UTS
2.	Sleeper	PSC with 1660Nos./Km
3.	Ballast cushion	300 mm clean
4.	Turnout	Fanshaped with thick web switches.

- Preventive Rail Grinding at predetermined intervals will not only increase safety but it will also be a cost effective solution for prolonging the life of rails on Heavy Haul Routes.

- Wheel flats are to be given a serious consideration in terms of detection and enroute detachments. The permissible limit for Flat wheel may be reduced to bring down the contact stresses. Role of train Examining staff of C&W and in control office should be clearly defined and non-compliance should be viewed seriously, till the time equipment for objective assessment of flats and their impact are developed and put to use. Further, there should be an Increase in frequency of testing schedules for Load boxes.

- 60 Kg Monoblock PSC sleepers, 1660 Nos/ Km, will suffice for increase in axle loads upto 25 tonnes .
- Increased ballast cushion as stipulated in Board's letter dated: 95/W1/Genl/0/39 dated: 9.10.96 may be provided. It will be desirable to monitor the fouling levels with Ground Penetrating Radars, as is being done on World Railways, to optimize the life of ballast.

- Blanketing as per RDSO Specifications will have to be provided. The right strategy is to use the blended material and provide the same in the traffic block of reasonably long duration 6-8 Hrs, so that desired degree of compaction is achieved, with less number of passes, by using vibratory rollers.

- The cost of maintenance of track with increase in axle load from 20t to 25 t was found to have increased by 30% to 50%, depending upon the track quality.

- As an alternative strategy, use of lightweight wagons, Wagons with high Pay Load to Tare ratio and increased number of axles (3 -axled bogie) may also be thought of.

- Superior material in Bushes, Pads, and Lubricants should ebe used so as to reduce the inventory costs.

- In track, 1 m Long Fish plates should be used in unavoidable Joints, Supporting all the AT welds should be done on wooden blocks, frequency of USFD should be Increased, Improved Rubber Pad and ERC designs, Gapless SEJs developed by Rahee Industries and Approved by RDSO should be used.

- Introduction of SH/DH WAG7 Locos instead of WAG6/ WAG5A, WAG5B, WAG5C Consist Locos.

- There should be an increased Focus on all cases of Stalling and each case should be scrutinized for avoiding asset failure in future.

- Instrumentation and Increased inspections of all assets should be done to collect sufficient data so as to take better managerial decisions.

- Mechanised maintenance should be introduced alongwith revised track maintenance standards to avoid frequent failures and to ensure safety.

5.2 Works to be done to prevent over loading:

Besides strengthening the track, parallel stringent actions are required to be taken to prevent overloading. Following strategy is to be adopted regarding this:

i)Installation ofelectronic weigh bridges at originating loading points.
ii)Installation of in motion weigh bridges
iii) Analysis of weigh bridge results both at originating point and in motion and stringent punitive action to be taken for overloading.
iv) Detachment of overloaded wagons en route.
v) Installation of WILD equipment on the lines of that installed at Ajgian station of LKO-CNB section of Northern railway.This system will have the following capabilities:

a)Recording the axle loads for all the axles (including the dynamic component of the load). This can be used to calculate the values of CDA, if the wagons are pre weighed in static condition. This also helps in detecting wheel flats, if any.
b) Trigger mechanism, for starting recording for every train and switching it off after pas sage of train.
c)on site data recording and transmission facility. The data is transmitted to off site server where it is analysed and the results are available on line.

5.3 Works to be done for bridges

Instrumentation for condition monitoring of bridges for various parts and will consists of:

i) Measurement of strain
ii) Measurement of Deflection
iii) Measurement of longitudinal forces at bearings

iv) Measurement of tilt of piers/abutment
v) Measurement of settlement of foundation
vi) Measurements of accelerations.

Instrumentation will report the overstressing of any member, if any. Based on this information, the strengthening of the concerned member can be decided more objectively. The residual fatigue life of member can also be revised accordingly.

CHAPTER VI

CASE STUDY OF THE WORKS UNDERTAKEN BY THE NORTHERN RAILWAY FOR MAKING THE FEEDER ROUTES FIT FOR 25T

6.0 Works taken up by zonal railways for 25t axle load

As per the requirement discussed above, the details of the work identified by NR are discussed in this chapter to make the feeder routes in its jurisdiction, fit for 25t.routes.

6.1 The seven routes are as follows:

1	LDH-HSR	205.44 TKM
2	MGS-UCR (Via JNH, PFM)	205.00 TKM
3	BSB-SLN-UTR-RAC	558.00 TKM
4	ZBD-TD	99.00 TKM
5	LDH-BEAS-GOI	112.00 TKM
6	RPJ-DUI-BTI	173.00 TKM
7	SIR-RPAR-NLDM	104.00 TKM

6.2 Action to be taken

Action needs to be initiated in terms of the instructions issued vide Railway Board's letter No. 2005/CE-II/TS/2 dated 13.04.2006 for seven feeder routes of NR. As per this letter, Board has desired as follows:

i) The Railway should form a core group under Pr. CE to draw an action plan for up-gradation to these feeder routes.

ii) Required proposals should be developed quickly and action taken to include these works in W P 2007-08.

6.3 Action taken so far by the railways

Track Renewal works amounting to Rupees 1147.16 Crores have been identified for Up-gradation of above feeder routes. Broad details are as under:-

1 New proposals of track renewal works, : Rs. 856.25 Crs.

2 Material modification to the works of track renewal sanctioned with lower track structures,: Rs. 291.0 Crs.

6.4Action Required

For up-gradation of the identified routes for carrying 25 T axle loads, inputs will be required from all the departments like C&W, Power, S&T and Operating. The necessary inputs need to be identified by the respective departments, quantified in physical and financial terms and packaged in suitable proposals which can be discussed and finalized for submission to Railway Board for W P 2007-08, in time.

6.5 Modifications of the routes already sanctioned works

The preferred track structure for 25t axle load is 60 kg 90 UTS rails on 1660 Nos per km sleeper density with 300 mm ballast cushion will be applicable for 25t axle load operation. Track renewal on some of the stretches on identified routes is sanctioned with 52 kg rails and 1540 PRC sleepers per km which are the stipulated standards on these routes. Details for identified routes are as follows:

Table 6.1 Details of identified feeder Routes in NR

S.No.	Route	Track length pertaining to N.Rly. (TKM)	Already sanctioned work
1	LDH-HSR	205.44	10.00 Km CTR
2.	BSB-SLN-UTR-RAC	558.00	20.17 km TSR
3.	ZBD-TD	99.00	85.88 Km TRR
4.	LDH-BEAS-GOI	112.00	33.89 Km TSR
5.	SIR-RPAR-NLDM	104.00	16.96 Km CTR
			15.20 Km TSR
			7.99 Km CTR
			9.60 Km TSR
			1.56 Km TRR

To avoid duplicity of works with higher standards, instructions were issued to the divisions to execute the works already sanctioned on these routes with sleeper density@1660 per km with immediate effect and to process the material modifications as follows:

Table No. 6.2 Abstract cost for upgradation of feeder routes to DFC

						Cost of Rs. in Lacs			
S No	Route	Track length pertaining to N.Rly.	Already sanctioned work	Proposed Quantity		Unit cost	Unit	Approx cost	Remarks
		TKM	TKM						
1	LDH-HSR	205.44		CTR-	178.40	101.94	TKM	18186.10	New propo
			CTR-10.00	TRR-	10.00	71.60	TKM	716.00	Material modificatio
				ISD-	10.00	1.72	TKM	17.20	Material modificatio
			CTR-17.04	TRR-	17.04	71.60	TKM	1220.06	Material modificatio
				ISD-	17.04	1.72	TKM	29.31	Material modificatio
2	MGS-UCR (Via JNH,PFM)	205.00		CTR-	40.84	101.94	TKM	4163.23	New propo
			CTR-67.62						No proposa required
			CTR-74.09	TRR-	74.09	71.60	TKM	5304.84	Material modificatio
				ISD-	74.09	1.72	TKM	127.43	Material modificatio
			TSR-22.45	TRR-	22.45	71.60	TKM	1607.42	New propo
3	BSB-SLN-UTR-RAC	558.00		CTR-	207.06	101.94	TKM	21107.70	New propo
			CTR-164.78						No proposa required
			TSR-63.81	TRR-	63.81	71.60	TKM	4568.80	New propo
			TSR-6.54	TRR-	6.54	71.60	TKM	468.26	New propo
				ISD-	6.54	1.72	TKM	11.25	Material modificatio
			TRR-115.81	TRR-	115.81	71.60	TKM	8292.00	Material modificatio
				TSR-	115.81	31.74	TKM	3675.81	New propo
4	ZBD-TD	99.00		CTR-	64.26	101.94	TKM	6550.66	New propo
			TRR-34.74	TRR-	34.74	71.60	TKM	2487.38	Material modificatio
				TSR-	34.74	31.74	TKM	1102.65	New propo
5	LDH-BEAS-GOI	112.00		CTR-	33.51	101.94	TKM	3416.01	New propo
			TSR - 42.47	TRR-	42.47	71.60	TKM	3040.85	New propo
				ISD-	42.47	1.72	TKM	73.05	Material modificatio

			TRR - 26.59	TRR-	26.59	71.60	TKM	1903.84	Material modificatio
				TSR-	26.59	31.74	TKM	843.97	New propo
			TRR - 9.43	TSR-	9.43	31.74	TKM	299.31	New propo
6	RJP-DUI-BTI	173.00		CTR-	74.21	101.94	TKM	7564.97	New propo
			CTR - 43.25	TRR-	43.25	71.60	TKM	3096.70	Material modificatio
				ISD-	43.25	1.72	TKM	74.39	Material modificatio
			TSR - 5.18	TRR-	5.18	71.60	TKM	370.89	New propo
				ISD-	5.18	1.72	TKM	8.91	Material modificatio
			TRR - 50.36	TRR-	50.36	71.60	TKM	3605.78	Material modificatio
				TSR-	50.36	31.74	TKM	1598.43	New propo
7	SIR-RPAR-NLDM	104.00		CTR-	50.76	101.94	TKM	5174.47	New propo
			CTR-24.95	TRR-	24.95	71.60	TKM	1786.42	Material modificatio
				ISD-	24.95	1.72	TKM	42.91	Material modificatio
			TSR-24.80	TRR-	24.80	71.60	TKM	1775.68	New propo
				ISD-	24.80	1.72	TKM	42.66	Material modificatio
			TRR-3.49	TRR-	3.49	71.60	TKM	249.88	Material modificatio
				TSR-	3.49	31.74	TKM	110.77	New propo
Total cost on account of Material modification								29090.02	
Total cost on account of new proposals								85625.97	
TOTAL COST								**114715.99**	

Table 6.3 Abstract cost for upgradation of Feeder Routes to dedicated freight corridor					
S No	**Route**	**Track length pertaining to N.Rly.**	**Approximate cost in Crores**		
		TKM	**New proposals**	**Additional for material modification**	**Total**
1	LDH-HSR	205.44	181.86	6.43	188.29
2	MGS-UCR (Via JNH,PFM)	205.00	57.70	8.32	66.02
3	BSB-SLN-UTR-RAC	558.00	298.2	11.12	309.32
4	ZBD-TD	99.00	76.54	3.30	79.84
5	LDH-BEAS-GOI	112.00	76.00	3.26	79.26
6	RJP-DUI-BTI	173.00	95.34	9.73	105.07
7	SIR-RPAR-NLDM	104.00	70.61	3.56	74.17
TOTAL COST		**856.25**	**45.72**		**901.97**

CHAPTER VII

CONCLUSION

From the discussions of the previous chapters, it can be concluded that Indian Railways can carry 25t axle load traffic with enhanced cost of maintenance. However, the point of concern is the prevention of overloading. Overloading has to be curbed in the loading lines itself as it will be detrimental to the track and bridges.

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ANNEXURE-I

Stress Calculation for Rails in case of axle load being 25 Tons.

Analyse for 52.00 Kg

Sleeper spacing= 60.00 cm Ixx Worn) Zc(worn) Zt(worn)=

Ui= 75.00 kg/cm/cm 52.00 1942.20 241.65 256.95

Ue= 300.00 kg/cm/cm 60.00 2749.50 301.95 339.66

Assume 5% worn Rail

Ixx (Worn)= 1942.20 cm4 (52 Kg) 2749.50cm4 60 Kg

Zc(worn)= 241.65 cm4 (52 Kg) 301.95cm4 60 Kg

Zt(worn)= 256.95 cm4 (52 Kg) 339.66cm4 60 Kg

BOEF Application

X1(i)= 94.18 cm 1942.20 241.65 256.95

X1(e)= 66.59 cm

Wheel Arrangement

Axle Load = 25.00 T

Wheel Load = 12.50 T

Wheel Spacing

W1->W2 170.00 cm

W2->W3 482.00 cm

W3->W4 170.00 cm

Speed Effect= 43.00 % (As per RDSO's report No. C-100 for 60 kmph speed)

Live Wheel Load= 17.88 T

BM Coeff. From Master Diagram with X1(i)

170.00 -0.20

482.00 0.00

652.00 0.00

822.00 0.00

BM Coeff. From Master Diagram with X1(e)

170.00 -0.20

482.00 0.00

652.00 0.00

822.00 0.00

Effect of Adjacent Wheels

Due to Initial load of 4t

W1 W2 W3 W4

W1 4.00 -0.80 0.00 0.00

W2 -0.80 4.00 0.00 0.00

W3 0.00 0.00 4.00 -0.80

W4 0.00 0.00 -0.80 4.00

3.20 3.20 3.20 3.20 3.20

Final

W1 W2 W3 W4

W1 13.88 -2.78 0.00 0.00

W2 -2.78 13.88 0.00 0.00

W3 0.00 0.00 13.88 -2.78

W4 0.00 0.00 -2.78 13.88

11.10 11.10 11.10 11.10 11.10

Max Dynamic Wheel load = 14.30T

Max BM = 330.90 T-cm

Stresses due to Vertical loads

Bending in Head= 13.69 kg/mm2
Bending in Foot= 12.88 kg/mm2
Eccentricity of Vertical Loads - Effect Timoshenko
Torque = 21.45 T-cm
_Stress on top= 7.53 kg/mm2 52.00 0.04 0.02 10.60 108.25 53.32
_Stress on Bot = 5.30 kg/mm2 60.00 0.03 0.02 12.36 141.63 68.39
Eccentricity of Lateral Force
Hy= 3.97 T
Moment = 21.02 T-cm 0.04 0.02 10.60 108.25 53.32
_Stress on top= 7.38 kg/mm2
_Stress on Bot = 5.19 kg/mm2
Lateral Def lection under load - stresses Allowable Stress 72 UTS 90 UTS
BM= 59.50 T-cm SR 30.00 36.20
_Stress on top= 5.50 kg/mm2 SWR 24.25 30.25
_Stress on Bot = 11.16 kg/mm2 LWR 19.25 25.25
Results
CombinedStresses
19.04 Top Kg/mm2 24.14 OKAY FOR SWR 72 UTS
24.14 Bottom Kg/mm2 24.14 OKAY FOR LWR 90 UTS
The values taken from C-100 are for BOX type bogie, which was too rigid, and hence impact may be larger. Current BOXN wagons having
CASNUB bogies may have to be trial tested for speed factor.
Allowable stresses of the rails are very much conservative. We can control the impact factor and run trains although effect on stresses is not pronounced.

ANNEXURE-II

Stress Calculations for Rails in case of axle load being 25 Tons.

Analyse for 60.00 Kg

Sleeper spacing= 60.00 cm Ixx Worn) Zc(worn) Zt(worn)=

Ui= 75.00 kg/cm/cm 52.00 1942.20 241.65 256.95

Ue= 300.00 kg/cm/cm 60.00 2749.50 301.95 339.66

Assume 5% worn Rail

Ixx (Worn)= 1942.20 cm4 (52 Kg) 2749.50 cm4 60 Kg

Zc(worn)= 241.65 cm4 (52 Kg) 301.95 cm4 60 Kg

Zt(worn)= 256.95 cm4 (52 Kg) 339.66 cm4 60 Kg

BOEF Application

X1(i)= 102.73 cm 2749.50 301.95 339.66

X1(e)= 72.64 cm

Wheel Arrangement

Axle Load = 25.00 T

Wheel Load = 12.50 T

Wheel Spacing

W1->W2 170.00 cm

W2->W3 482.00 cm

W3->W4 170.00 cm

Speed Effect= 43.00 % (As per RDSO's report No. C-100 for 60 kmph speed)

Live Wheel Load= 17.88 T

BM Coeff. From Master Diagram with X1(i)

170.00 -0.20

482.00 0.00

652.00 0.00

822.00 0.00

BM Coeff. From Master Diagram with X1(e)

170.00 -0.20

482.00 0.00

652.00 0.00

822.00 0.00

Effect of Adjacent Wheels

Due to Initial load of 4t

W1 W2 W3 W4

W1 4.00 -0.80 0.00 0.00

W2 -0.80 4.00 0.00 0.00

W3 0.00 0.00 4.00 -0.80

W4 0.00 0.00 -0.80 4.00

3.20 3.20 3.20 3.20 3.20

Final

W1 W2 W3 W4

W1 13.88 -2.78 0.00 0.00

W2 -2.78 13.88 0.00 0.00

W3 0.00 0.00 13.88 -2.78

W4 0.00 0.00 -2.78 13.88

11.10 11.10 11.10 11.10 11.10

Max Dynamic Wheel load = **14.30** T

Max BM = **360.94** T-cm

Stresses due to Vertical loads

Bending in Head= 11.95 kg/mm2
Bending in Foot= 10.63 kg/mm2
Eccentricity of Vertical Loads - Effect Timoshenko
Torque = 21.45 T-cm
__________ ____ 6.40 kg/mm2 52.00 0.04 0.02 10.60 108.25 53.32
__________ ______ 4.10 kg/mm2 60.00 0.03 0.02 12.36 141.63 68.39
Eccentricity of Lateral Force
Hy= 3.97 T
Moment = 24.52 T-cm 0.03 0.02 12.36 141.63 68.39
__________ ____ 7.32 kg/mm2
__________ ______ 4.69 kg/mm2
Lateral Deflection under load - stresses Allowable stresses 72 UTS 90 UTS
BM= 59.50 T-cm SR 30.00 36.20
__________ ____ 4.20 kg/mm2 SWR 24.25 30.25
______s on Bot = 8.70 kg/mm2 LWR 19.25 25.25
Results
CombinedStresse s
17.07 Top kg/mm2 **18.74** **Okay for LWR** 72 UTS
18.74 Bottom kg/mm2 18.74 **Okay for LWR** 90 UTS
The values taken from C100 are for BOX type bogie which were too rigid and hence impact may be larger. Current BOXN wagons having CASNUB bogies may have to be trial tested for speed factor. Allowable stresses of the rails are very much conservative. We can control the impact factor and run trains although effect on stresses is not be pronounced .