A Major Project Report on

COMPARISON, TESTING AND STATISTICAL ANALYSIS OF PRESTRESSED CONCRETE SLEEPERS MANUFACTURED FOR INDIAN RAILWAY

Submitted in Partial Fulfillment for the Award of the Degree of

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By

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CERTIFICATE

This is to certify that **Mr. Puneet Kumar Swarnakar**, a student of final semester M.Tech (Structural Engineering), Department of Civil and Environmental Engineering, during the session 2010-2012 has successfully completed the project work on ***"Comparison, Testing and Statistical Analysis of Prestressed Concrete Sleeper Manufactured for Indian Railway "*** under my guidance and supervision and has submitted a satisfactory report in partial fulfillment for the award of the degree of Master of Technology.

The assistance and help received during the course of investigation have been fully acknowledged. He is a good student and we wish him good luck in future.

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Declaration

I Certify that

a. The work contained in this thesis is original and has been done by me under the guidance of my supervisor.
b. The work has not been submitted to any other Institute for any degree or diploma.
c. I have followed the guidelines provided by the University in preparing the thesis.
d. I have conformed to the norms and guidelines given in the Ethical Code of Conduct of the Institute.
e. Whenever I have used materials (data, theoretical analysis, figures, and text) from other sources, I have given due credit to them by citing them in the text of the thesis and giving their details in the references.

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ABSTRACT

A sound track is an important pre-requisite for the economic growth of the country. Concrete sleeper is the necessity of modern track all over the world to meet the challenge of higher speeds, higher density of traffic, higher axle load and long welded rails. Concrete sleeper is heavy, sturdy and capable of offering adequate lateral resistance to the track, where as wooden and metal sleepers were found to be lacking in fulfilling the requirements. Concrete is a versatile building material which can be moulded in any and size has made its impact in the field of railway engineering in the form of concrete sleeper and now a days India is in the position of producing more than one than one crore sleepers per annum after making its nascent beginning in 1969. The first experiment in production of concrete sleepers was made by Swiss Railway in 1904, French Railway in 1913 and German Railway in 1922. In India concrete sleeper are being manufactured by using either "longline method" or "stress bench method". Concrete sleeper provides greater stability, best suited for machine maintenance, track circuited area and avoids fire, corrosion, theft etc.

Sleeper, after rail, is the most important component of track superstructure in conventional track. Keeping track geometry, bearing loads acted from rail and transferring to the ballast is the main duty of sleeper. Their quality conditions have considerable influence on geometry quality. Moreover, track maintenance costs affected by this element due to their higher number. For this, in order to reduce operation & maintenance volume and, in the other hand, for more recognition of concrete sleepers used in Indian Railways, some studies and field investigations carried out on concrete sleepers and its results expressed as categorization of concrete sleeper failures. This project, evaluates effective factors and the reasons of their creation, while considering failures and conventional defects during sleeper service life (including production stage, transportation, construction and operation), and proposed some approaches for their reduction.

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CHAPTER-1

INTRODUCTION

1.1 Sleepers

Wooden, cast iron or R.C.C members which are laid transverse to the track alignment to support the rails and to transfer the load from the rails to the underlying ballast are called wooded sleepers, cast iron sleepers or R.C.C. sleepers respectively.

1.2 Functions of sleepers

Sleepers are transverse ties on which the rails are laid. The main functions of sleepers are as follows:

I. Holding rails to correct gauge and alignment.
II. Giving a firm and even support to rails.
III. Transferring the load evenly from the rails to wider area of the ballast.
IV. Acting as an elastic medium between the rails and the ballast to absorb the blows and vibrations of moving loads.
V. Providing longiludinal and lateral stability to permanent way
VI. Providing means to rectify the track geomentry during its service life.

1.3 Requirement of an ideal sleeper

A part from performing the functions as indicated in previous para, the ideal sleeper should normally fulfils the following requirements.

1 The initial cost as well as maintenance cost should be minimum .

2 The Weight of the sleeper should be moderate so that it is possible to handle the same.

3 The design of sleeper and fastenings should be such that it is possible to fix and remove the rails easily.

4 The sleeper should have sufficient bearing area.

5 The sleeper should be such that it is possible to maintain and adjust gauge properly.

6 The material of sleeper and its design should be such that the sleeper does not break or get damaged while packing below the sleeper.

7 The design of sleeper should be such that it is possible to have track circuiting.

8 The sleeper should be capable of resisting vibrations and shocks due to passage of fast moving trains.

9 The sleeper should have anti-sabotage and anti-theft qualities.

1.4 Sleeper Density and spacing of sleepers.

Sleeper density is the number of sleepers per rail length. It is specified as M+x or N+x where M or N is the length or rail in metres or yards and x is the number varying according to the following factors.

(i) Axle load and speed.
(ii) Type and section of rails.
(iii) Type and strength of sleepers.
(iv) Type of ballast and ballast cushion.
(v) Nature of formation.

In metric unit, if sleeper density is M+7 on a Board Gauge route and the length of rail is 13 meters, it means that 13+7=20 sleepers will be used per rail. Similarly in F.P.S. Units, if the sleeper density is N+3 on a M.G. route and the length of rail is 36 ft. or 12 yards, the number of sleepers used is 12+3=15 per rail length.

The Numbers of sleepers in the track can also be specified by indicating the number of sleepers per kilometer of track. e.g. 1540 sleepers per km. This becomes more relevant particularly in those cases where rails are welded and length of the rail does not have much bearing. This system of specifying number of sleepers per kilometer exists in many foreign countries and is lately being adopted by Indian Railways also.

Depending upon the sleeper density, the spacing of sleepers is fixed. The spacing is kept uniform throughout the rail length but is made closer near the joints because of the weakness of the joints and the impact of the moving loads on it. There is however, limitation to the close spacing of the sleeper as enough space is required for working the

beaters to pack the joint sleepers. The standard spacing adopted for fist planted track on the Indian Railway is given below in the table (fig 4.1)

Table 1.1 Spacing of sleepers at fishplated track

S. No	Spacing	Broad Gauge centre to centre spacing in cm		Metre gauge centre to centre spading in cm	
		Wooden	Metal	Wooden	metal
1	Between joint sleepers (a)	30	38	25	33
2	Between joint sleeper and the first shoulder sleeper (b)	61	61	58	58
3	Between 1st shoulder sleeper and 2nd shoulder sleeper(c) for sleeper density M+4 and M+7	70 (64)*	72 (63)*	70 (62)*	71 (60)*
4	Between intermediates sleeper (d) for sleeper density M+4 and M+7	84 (68)*	83 (68)*	82 (72)*	81 (64)*

The spacing is for sleeper density M+7

Notes: 1 The spacing for joint sleeper (a) and the 1st shoulder sleeper (b) will always remain the same as given above for all length or rails and all sleeper densities. The spacing (d) should be whole number of cm and spacing c should be between b and d.

2 In case of long welded rail on BG and MG the sleeper spacing is kept 65 cm.

1.5 Number of sleeper per kilometre

The sleeper density now-a-days is also indicated in terms of Number of sleeper/km. The sleeper spacing required for various sleeper densities is as given below.

Table 1.2 Sleeper Density

No of sleepers Per km	Exact centre to centre spacing required as per calculation	Centre to centre spacing to be provided in the field.	
1660/ km	60.24 cm	60 cm	_
1540/km	64.93 cm	65 cm	66 cm
1310/ km	76.33	_	78 cm

CHAPTER-2

LITERATURE REVIEW

2.1General

The general philosophy of different types of sleeper analysis is available in literature.

Grassie[2] has studied the effect of unsupported sleepers in increasing imposed forces on adjacent sleepers and Kerr[5] has described the effects of support hardness changes with sleeper type change (wooden to concrete). Gustavson[8] has also studied static & dynamic behavior of the sleeper. In these studies increase of imposed forces on sleeper due to existing of defect in superstructure have been mostly dealt with. This project took a glance look on concrete sleepers used in Indian Railways and collected& categorized all defects, appeared in them, in different stages including production, coupling (track panel), transportation, installation and maintenance.

In addition to categorization of concrete sleeper defects as well as deterioration, causes of the defects were also rooted and stated proportionate to their type. The first step to analyse a sleeper is to diagnose appropriate distribution of contact stress between sleeper and ballast and its changes to the time. In real conditions in railway superstructure it is very difficult to predict correct distribution of contact stress on a sleeper.

2.2 Sleeper Deterioration

Cope [9] has studied that sleeper design depend on weight and speed of trains, curve design limit and the type of fastening system. The combination of hardness of the rail and springiness of the ballast under the sleeper, leads to distribution of the wheel loads between several sleepers, so that even if the wheel is directly over a sleeper, only about half of the wheel load is actually transmitted to that sleeper.

2.2.1 Timber Sleepers

Zhang [17] has studied that timber sleeper deteriorate in terms of splits, base plate/rail cut, break, termite attack and fungal decay. Most deterioration modes are mainly dependent on the timber species and quality, in-factory treatment and environment factors such as climate condition and locality.

ROA [14] has done a survey of timber sleeper defects of Queensland rail revealed that fungal decay dominates sleeper deterioration, accounting for 53% of sleeper condemnations. Splitting and termites attack account for 23%, of which only 6% is caused by spike kill (2%) and rail cut (4%). Some sleepers (7%) also are rejected without apparent reason.

Wirth et al.[16] studied that one of the critical aspects to determine the condition of track with respect to sleepers is the dispersion of defective sleeper in the railway track. A section of railway track with 50% defective sleepers may still be safe to operate if the failed sleeper lies between two sound ones.

2.2.2 Concrete Sleepers

Powell[12] studied that cracking is one of the possible failure modes of concrete sleepers. Although decay at bottom edges and soffit of sleepers has not been a general trend, it has been evident on Queensland Rail's Goonyella to Hay point heavy haul line. The edges of sleeper are rounded by abrasion, soffit material is worn off to various degrees, and the area surrounding the sleeper forms a slurry hole.

Zhang[17] also studied that the attrition was considered to be a direct result of abrasion between the sleeper and ballast material which came about as a result of track pumping initiated by a localized track weakness.

Reiff[13] analysis under indecisive condition attrition of concrete sleepers could become a dominant deterioration model. Test at the facility for accelerated service testing (FAST) shows that Heavy Axle-Load Loop indicated up to two millimeters of abrasion can be produced by 51 MGT traffic and harder rail pads caused more abrasion than softer (rubber based pads).

2.2.3 Steel Sleepers

Dean and Kish [10] has got test results at FAST indicated that cracking of the fastener tabs has necessitated ateel sleeper replacement . possible reason for cracking included residual stress from the original bending of tabs, plastic deformation of tabs in service and fatigue bending stresses produced by combined vertical and lateral loads. It was suggested that problem could be overcome by improvement in design of the fastener system.

Jeffs and Mayhew[11] analysis that smaller sleeper spacing can avoid excessive strains in sleepers. Sleepers spaced at 600 mm are able to tolerate axle load up to 40 ton without strains exceeding the material's fatigue limit.

2.3 Maintenance of railway track

Simson[15] said that maintenance is one of the major issue in a railway track system. Any flaw in the component or usage may lead to deterioration. This cal lead to failure and huge loss to organization. It is very important to detect the causes for these and to find effective solutions to overcome related problems .

CHAPTER-3

COMPARISON OF DIFFERENT TYPES OF SLEEPERS

3.1 Different types of sleepers

The sleepers which are mostly in use on Indian Railways are

(i) Wooden sleepers
(ii) Cast iron sleepers
(iii) steel sleepers
(iv) concrete Sleepers.

3.2 Wooden sleepers.

Fig 3.1- Wooden Sleepers

3.2.1 Advantages and Disadvantages of wooden sleepers.

Wooden sleepers is the most ideal type of sleeper and its utility has not decreased with the passage of time. The wooden sleeper has the following main advantages and disadvantages.

Advantages

1 Cheap and easy to manufacture

2 Absorbs shocks and had has got good capacity to dampen the vibration thereby retains packing well.

3 Easy handling without damage.

4 Suitable for track circuited sections.

5 Suitable for areas having yielding. Formations.

6 Alignment can be easily corrected.

7 More suitable for modern methods of maintenance.

8 Can be used with or without stone ballast.

9 Can be used on bridges and ash pits also.

10 Can be used for gaunteletted track.

Disadvantages

1 Lesser life due to wear, decay and attack by vermin.

2 Liable to mechanical wear with beater packing.

3 Difficult to maintain gauge,

4 Susceptible to fire hazards.

5 Scrap value is negligible.

The C.S.I is given by the formula [80]

$$C.S.I=\frac{S+10H}{20}$$

Where

S is the general strength figure both for green and dry timber at 12% moisture content.

H is general hardness figure both for green and dry timber at 12% moisture content.

Minimum composite sleeper index prescribed on Indian Railway is:

Table 3.1 Minimum sleeper composite Index Prescribed

Type of sleeper	Minimum C.S.I.
Track sleeper	783
Crossing sleeper	1.352
Bridge Sleeper	1,455

3.3 Steel Through Sleeper

Fig 3.2- Steel Through sleeper

3.3.1 Advantages and Disadvantages.

About 27% of track on Indian Railway is laid on steel sleepers. The increasing shortage of timber in the country and other economical factors are mainly responsible for the use of steel sleepers in India. The steel sleepers have the following main advantages/ disadvantages over the wooden sleepers.

Advantages

1) Longer life
2) Easy to maintain gauge and lesser maintenance problems

3) Better lateral rigidity
4) Lesser damage during handling and transport.
5) Manufacturing process is simple.
6) Very good scrap value.
7) Free from decay and attack by vermin.
8) Not susceptible to fire hazards.

Disadvantages

1) Liable for corrosion
2) Unsuitable for track circuiting areas
3) Liable to become centre bound because of slopes at two ends.
4) Developes cracks at rail seats during service.
5) Can only be used for rails for which it is manufactured.

3.3.2 Design Features

The steel through sleeper essentially consists of a rolled steel plants of about 12 mm (1/2) thickness and pressed to suitable though shape and the rail seat canted to 1 to 20 the ends of the rolled Section are flattened out in the shape of a spade to retain the ballast. Two alternative type of sleepers have been designed for each rail section as per details given below:

1 In one type, the lugs or jaws are pressed out of the plate it self to accommodate the foot of the rail and the key (fig.4.4.a) There are a lot of maintenance problems with these pressed up lugs as they give way due to the movement of the keys as well as due to the vibrations and impact of the moving loads.

2 In order to obviate this defect, another design of sleepers has been adopted in this type two holes are punched in the plate on either side of the plate to accommodate specially designed ‘Loose jaws’ (figure 4.4.b)The rails are held with the help of two standard keys driven either in the pressed up luges or in the loose-jaws.

The adjustment of the gauge to the extent of +3 mm (1/8") is done by proper driving of the keys. In the double line section, the keys are driven in the direction of traffic. The weight of standard B.G. through sleeper is 81 kg. and that of M.G. sleeper is 35 kg approximately. The steel trough sleeper has an average life of about 50 years. It is an acceptable type of sleeper for use with Lone weled rails because of its lateral stability and its adaptability for use with elastic fastenings.

3.3.3 Classification of steel sleepers.

All steel sleepers conforming to Indian Rly specification T-9 are classified as first quality sleepers and sleepers not accepted as first quality and free from the flowing defects are termed as second quality steel through sleepers.

1 Inward tilt at rail seat beyond the limits of 1 in 15 to 1n 25
2 Sleepers having twist
3 Heavy scale fitting or deep groves or cuts.
4 Deep guide marks at heads and blisters etc.

All first quality sleepers are normally marked by a green dot. Sleepers which have been rejected from first quality on account of pipes, seams, and laps but are free from defects indicated about are marked by a cross (x) of yellow paint at the center of sleepers. All other second quality steel through sleepers are marked distinctly with a 15 cm wide strip of yellow paint at one end of the sleepers. The sleepers which are unfit for passing as second quality are given a distinctive red paint mark to avoid mixing up with first and second quality sleepers during loading.

3.3.4 Maintenance problems.

During maintenance it is noticed that the keys tend to become loose because of the pressed up lugs getting bent up or due to wear at rail seat. The holes also get elongated during service. Special type of shims and liners are provided in these cases to hold the gauge well. Mota Singh liner is a very effective type of liner used for oblong holes along with the loose jaw for holding correct gauge. Another maintenance problem with the steel trough sleepers is that these tend to become center bound if due care is not taken in packing. The ballast is normally removed from the centre of the sleepers after packing so as to ensure that

center binding of the sleepers does not take place. The alignment of steel sleepered track also gets affected sometimes because of over driving of keys.

3.4 Cast Iron Sleepers

Fig 3.3- Cast Iron Sleepers

3.4.1 Advantages and disadvantages of C.I. Sleepers.

Cast iron sleepers are being extensively used on Indian Railway and about 45% track at present consists of C.I. sleepers which may be either of pot type or plate type. The main advantages and disadvantage of C.I. sleepers over steel trough sleepers are as follows:

Advantage

1 Lesser corrosion
2 Lesser liable to crack at rail seat
3 Easier to manufacture
4 Higher scrap value.

Disadvantages

1 Gauge maintenance is difficult as tie bars get bent.
2 Provides lesser lateral stability
3 Unsuitable for track circuited lines.
4 Not very suitable for mechanical maintenance and or M.S.P. because or M.S.P. because or rounded bottom.

5 More susceptible to breakage.

3.4.2 C.I. Pot sleepers

These consist of two hollow bowls or pots or circular or elliptical shape, placed inverted on the ballast section. Two pots are connected by a tie bar with the help of cotters and gibs and slight adjustment of gauge + 3 mm (1/8") is done by changing their positions. The rail is placed on the top of pot in a rail seat provided with a cnt of 1 in 20 and is held in position with the help of a key. The pot sleeper suffers from the disadvantage that it cannot be used on curves sharpers than 4^{o} on B.G.most of the fittings are hidden and their inspection and maintenance is quite difficult. These type of sleepers has become obsolete now and are not being procured by the Indian Railways any more.

3.4.3 C.S.T-9 Sleepers

Fig 3.4- CST-9 Sleepers

Table 3.3 Types of CST-9 sleeper used

Rail	Gauge	RDSO Drg. No	Wt kg	A mm	B Mm	C mm	D Mm
52 kg	B.G.	T-478(M)	43.55	800	330	140	89
90 R	B.G.	T-478(M)	43.55	800	330	140	89
90 R	M.G.	T-2366	-	700	330	132	85

75 R	M.G.	T-498(m)	24.50	650	270	114	77
60 R	M.G.	T-10,257	20.07-	650	270	114	77
50 R	N.G.	T-438	-	533	228	108	69

This is the standard sleeper and is being most extensively used on the Indian Railway. It is called CST-9 (Central Standard Trial-9) because it is the 9th of the series produced by General standard office. The sleeper is a combination of pot, plate and box sleeper . It consists to two triangular inverted post on either side of the rail seat, a central plate. The two C.I. plates are connected by a tie bar with the help of 4 cotters. The rails are held to the sleeper by two way key provided at each rail seat on the gauge face side Gauge is adjusted to a value of 5 mm (3/16") by altering the relative positions of 4 cotters.

The rail seat of CST-9 Sleeper is 115 mm (41/2") wide along the rail length and this narrow bearing tends to reduce the rocking of the sleeper under the wave motion o the rail. The sleeper is well designed to give a firm support to the rail and provides fairly good lateral and longitudinal stability to the rails. The Sleeper provided bearing area approximately equal to the effective bearing area of standard B.G. wooden sleeper i.e. 5 sq ft for both the plates. The CST-9 Plates are available with reverse jaws (T-443 type) also to serve as an ant sabotage measure when a few of these are provided in each rail length Normally, 3 reverse jaw CST-9 sleepers are provided per rail to serve anti sabotage purpose: The weight of a CST-9 sleeper assembly along with fastenings for B.G. is 102 kg and for M.G. is 58 kg.

The CST-9 sleeper is one of the popular sleepers on Indian Railways at present. The sleeper has however certain limitations with the modern track as indicated below:

1 As the sleeper does not have a flat bottom, it is not quite suitable for M.S.P. and mechanical maintenance with Tie Tampers.

2 The Suitability of CST-9 sleeper on L.W.R. particularly on the breathing length is doubtfull because of rigid fastenings and inability of the fastenings to hold the rail with a constant toe load.

3 The rail seat also wears out quickly causing the keys to work out loose.

4 The sleeper has only limited longitudinal and lateral strength to hold L.W.R. particularly in the breathing length.

5 Due to less metal under the rail seat, the stocks and vibrations are directly transmitted to the ballast, resulting in (loose packing) poor retention of packing and hence increased frequency of attention.

3.4.4 C.S.T.-9 Sleeper for M.G.

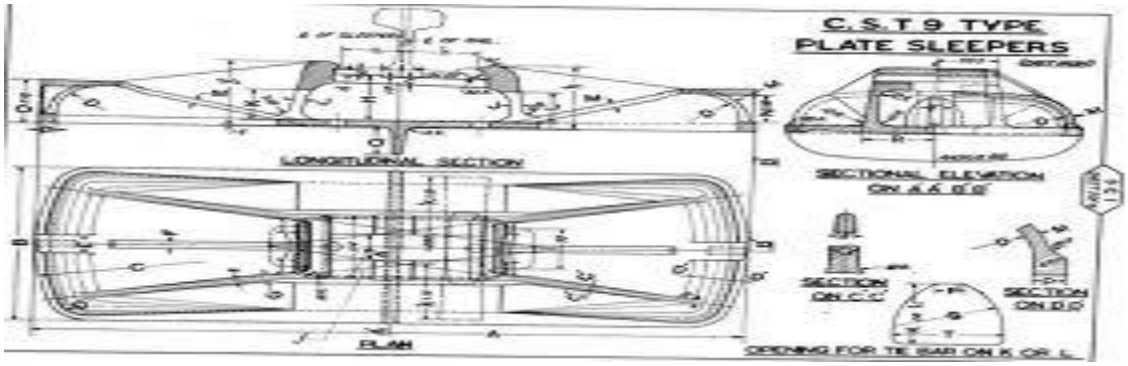

Fig 3.5- CST-9 Type Plate Sleepers

A new design has recently been developed by Indian Railway of CST-9 sleeper for 90 R rails for M.G.

3.4.5 C.S.T-10 Sleepers

CST-10 is an improvement on the design of CST-9 sleeper so that it can suit the requirements of a modern track. The basic design feature of this sleeper is the same as that of a CST-9 sleeper except that the following improvements have been made.

1 The rail is held with clips and double coil spring washers instead of a fixed lug and key.
2 An insulating liner is provided between the rail and the sleeper.
3 A rubber pad has been provided below the rail seat

CST-10 sleeper given certain amount of elasticity to the track by virtue of double coil spring washer. The sleeper however, has the limitation that it can not be used with the elastic fastenings.

3.4.6 C.S.T.-11 Sleepers

This is an improvement over the CST-10 sleeper A special shoulder has been provided to accommodate the pandrol clip instead of clips and double coil spring washers. An elastic rubber pad has been provided between the sleeper and the rail resting directly on the soeeper. CST-11 sleeper with pandrol clips and a rubbr pad the rail seat is a sleeper which has the potential of being used on the modern track. The sleeper, however, is still under experimental stage. The results are yet quite encouraging.

3.4.7 C.S.T.-12 sleepers

CST-12 sleeper has been designed to suit IRN-202 clip ,instead of pandrol clip. The casting in this case is quite complicated due to the shape of the clip. No firm has undertaken the manufacture of this sleeper as yet.

3.4.8 C.S.T.-13 sleepers

The purpose of CST-13 sleeper is to use existing CST-9 sleeper with centain additions and alternations in the local workshop. It consists of CST-9 plate having the rubber pad under the rail with additional head of rubber to fill the gap occupied by the key. The rail is fastened to the sleeper by a sigma clip, similar to "*Fist Fastening*" used on Swedish Railway. To reduce the cost of sleeper the inner cotter is dispensed with. No adjustment of gauge is possible in this sleeper. The sleeper is still under trial.

3.4.9 Cast iron sleeper with bitumen macadam filling

A new design of cast iron sleeper with bitumen macadam filling in the bowl, has recently been developed by Indian Railways Institute of advanced Track Technology. Important features of this sleeper are given below:

1 The sleeper consists of cast iron shell of 10 mm thickness weighing about 50-60 kg with bitumenous fill of about 40 kg in each bowl. Total weight of the sleeper is about 210 kg.

2 The sleeper being heavy and flat bottomed, has the following advantages:

a) The Sleeper provides better lateral stability and maintainability of track.

b) The sleeper can be a standard sleeper for welded track structure.

c) Sleeper can be well maintained by Tie Tamping Machines/ MSP as it is having flat bottom.

d) Though heavy, it can still be laid manually.

The design has been approved* by Railway board and trials are being conducted in Central Railway about its performance and behaviour in welded tracks with mechanized maintenance.

3.5 Concrete Sleepers

3.5.1 Evolution and History of Development of concrete sleepers.

The evolution of concrete sleeper has been mainly due to economic considerations coupled with the elements of changing traffic pattern. In the early period of history of railways, wood was the only material used for making sleepers in Europe. Even in those days, occasional shortage of wooden sleepers and their increasing price posed certain problems and this gave fillip to the quest for alternative material for sleepers. With the development of concrete technology in the 19th century ,cement concrete had established its place as a versatile building material and could be adopted suitably to meet the requirement of a railway sleeper.In the year 1877, Mr.Monnier ,a French gardener and inventor of reinforced concrete, suggested that cement concrete could be used for making sleepers for the railway track. Monnier in fact designed a concrete sleeper and obtained a patent for it, but this could not work successfully. The design was further developed and the railways of Austria and Italy produced first concrete sleepers with promising design around the turn of the last century This was closely followed by other European Railways where large scale trials were made mostly due to economic considerations. Much progress, however could not be achieved till 2nd world war, when the wooden sleeper pratically disappeared from the European market and their prices shot up. Almost at the same time as a result of extensive research carried out by French Railways and other European Railways, modern track was born. Heavier rail section and long welded rails came into existence. The necessity for a heavier and better type of sleeper which could fit in the modern track, was felt. These conditions gave a spurt to development of concrete sleepers and the countries like France, Germany and Britain went in a big way for development of these concrete sleepers to perfection.

3.5.2 Different concepts of Development

The development of concrete sleepers, that took place on various railway systems, was mainly based on the following different concepts:

1. R.C.C or prestressed sleepers similar in shape and size to wooden sleepers.
2. Block type R.C.C. sleepers connected by a steel tie bar.
3. Prestressed concrete blocks and a steel or an articulated concrete tie bar.
4. Prestressed pre-tensioned or post-tensioned type of concrete sleepers.

These four concepts of design form the basis of development of present day concrete sleepers.

3.5.3 Need for development of concrete sleepers in India.

In India there has been a chronic shortage of wooden sleepers over the last few decades. The wooden sleepers of various species in India have a short life of only about 15 to 20 years. In view of this cast iron and steel trough sleepers were used extensively. The consumption of these metal sleepers at present is quite high and the Indian Railways consume about 40% of entire pig iron production in the country. There is a need to reduce the pig iron consumption by the railways sothat the same can be made available in large quantities for defense purpose and for other heavy Engineering Industries. In addition ,the introduction of higher speeds, welding or rails and installation of long welded rails have recently been taken up in a big way by Indian Railways. A sleeper for long welded track has to be heavy and sturdy and should be capable of offering adequate lateral resistance to the track. Wooden and steel sleepers were found to be lacking in these requirements fully. Both these consideration led to the investigations for selecting a suitable type of concrete sleeper for use on Indian Railways.

3.5.4 Advantages and Disadvantage of concrete sleepers.

Advantages.

1. Concrete sleepers, being heavy ,lend strength and stability to track and are specially suited to L.W.R. due to the great resistance they offer to the buckling of track.
2. Concrete sleepers with elastic fastening provide a track which can maintain better gauge, cross level and alignment, it retains packing also very well.
3. The concrete sleepers, because of their flat bottom, are best suited for modern methods of track maintenance like M.S.P and mechanical maintenance which have their own advantage.
4. Concrete sleepers can be used in track circuited areas being poor conductor of electricity.
5. They are neither inflammable nor subject to damage by pests or corrosion in normal circumstances.
6. The life of concrete sleepers is very long, probably 40 to 50 years. Rail and sleeper renewals as such can be matched, which is a very big economic advantage.
7. The Concrete sleepers can generally be mass produced from local resources.

Disadvantages

1. Handling and laying of concrete sleepers is difficult due to their being heavy. Mechanical methods have to be normally adopted for handling which involve considerable initial expenditure.
2. The damages to concrete sleepers is very heavy at the time of derailment.
3. There is no scrap value for the concrete sleepers.
4. The sleepers are not suitable for beater pickings.
5. The concrete sleepers are preferably to be maintained by heavy “On Track” tampers.

3.5.5 Design considerations.

In designing the section of the sleepers basically two different concepts are being adopted by the German and French Engineers. The Germans, who have adopted a beam type sleeper, consider the sleeper to act as a rigid ,stiff and continuous beam supported on a firm and un-yielding bed. The French however, consider their sleeper, which consists of two separate blocks connected by a tie bar, as resting on a resilient ballast bed. In the former concept, the design is based on the static loading, while the latter theory caters for slight differential settlement of ballast support. As the calculations based on the latter theory are quite complicated and difficult, the sleeper design based on this concept has been evolved mostly on an empirical basis.

The factors considered in design of concrete sleepers may be enumerated as follow:

1. Forces acting on a sleeper.
2. Effects of the geometrical form including shape, size and weight.
3. Effect of the characteristics of fastenings used.
4. Provision of failure against derailments.

3.5.6 Loading conditions adopted by Indian Railways for Design of concrete sleepers.

The sleepers have been designed by research Design and standard organisation (R.D.S.O.) wing of Indian Railways for following different loadings:

3.5.6.1 B.G. Sleeper

a) 15 tonnes vertical loads at rail seats.

b) Vertical loads of 15 tonnes at rail seats plus reaction at the centre of sleeper equal in intensity to half that under rail seat.

c) A vertical load of 13 tonnes and a lateral load of 7 tonnes directed towards the outside of one rail.

The sleeper is designed to resist a bending moment of 1.33 tonne-metres at rail seat and 0.52 tonne-metres at the centre section of the sleepers.

3.5.6.2 M.G. Sleeper

a) Vertical loads of 10 tonnes at the rail seats.

b) Vertical loads of 10 tonnes at the rail seats plus a reaction at the centre of sleeper equal in intensity to half of that under rail seat.

c) Vertical load of 8 tonnes at the rail seats with 45 tonnes lateral force directed towards the outside of one rail only.

Table 3.4 Comparison of characteristics of different type of sleepers

S.No.	Characteristics	Wooden Sleepers	Steel sleepers	C.I. Sleepers	Concrete sleepers
1	Service life	12 to 15 yrs	40 to 50 yrs	40 to 50 yrs	50 to 60 yrs
2	Weight of sleeper for B.G.	83 kg	79 kg	87 kg	267 kg
3	Handling	Manual handling- No damage to sleeper while handling	Manual handling- No damage to sleeper while handling	Manual handling - Liable to break by rough handling	No manual handling -gets damaged by rough handling
4	Type of maintenance	Manual or mechanised maintenance	Manual or mechanised maintenance	Manual maintenance	Mechanised maintenance only
5	Cost of maintenance	High	Medium	Medium	Low
6	Gauge adjustment	Difficult	Easy	Easy	No gauge adjustment possible
7	Track circuiting	Best	Difficult	Difficult	Easy

			Insulating pads are necessary	Insulating pads are necessary	
8	Damage by white ants and corrosion	Can be damaged by white ants.	No damage by white ants but corrosion is possible	Can be damaged by corrosion	No damage by white ants or corrosion
9	Suitability for fastening	Suitable for CF & EF	Suitable for CF & EF	Suitable for only CF	Suitable for only EF
10	Suitability to track	Suitable for all routes *	Suitable for all routes	Not suitable for high speed routes	Suitable for high speed routes.
11	Track elasticity	Good	Good	Good	Best
12	Creep	Creep is excessive**	Less creep	Less creep	Creep is minimum
13	Scrap value	Low scrap value	Higher scrap value than wooden sleeper	High scrap value	No scrap value

- Also suitable for track circuiting level crossing and points & crossings
- Large number of anchors required to prevent excessive creep.
- CF stands for conventional fastening & EF stands for elastic fastening.

3.5.7 Types of concrete sleepers.

Various types of concrete sleepers (prestressed pre-tension concrete sleepers, post tension concrete sleepers and two block concrete sleepers) being manufactured on Indian Railway are given in the tabulated statement given below:

Table 3.5- Types of concrete sleeper

Gauge	Type of Sleeper	Rail section	Standard Drg. No.	Sleeper design No
B.G	Mono Block	60 kg UIC	RDSO/T- 2496	PDS-14

	Mono Block	52 kg	RDSO/T- 2495	PDS-12
	Mono Block	60 kg/ 52 kg	RDSO/T- 3602	Post tension type
	Mono Block	90R/75R	RDSO/T- 2521	RCS-6
M.G.	Mono Block	90 R	RDSO/T- 2503	PCS-17
	Twin block	75R/60R	RDSO/T- 3518	PCS-12
	Twin block	75R/60R	RDSO/T- 153**	PCS-11

3.5.8 Mono block prestressed concrete sleepers with pandrol Clips

Mono block prestressed concrete sleeper, which is similar to German B-58 type of sleeper, has an overall length of 2750 mm and a weight of 270 kg approximately. The sleeper has a trapezoidal cross section having width at top of 154 mm, at bottom of 250 mm and height of 210 mm at the rail seat. A cant of 1 in 20 has been provided in the top surface of the sleeper for a distance of 175mm on either side of the centre line of rail to cover the area of rail fittings. The sleeper is prestressed with 18 number high tensile steel strands of 3x3 mm diameter and 12 number 6 mm diameter mild steel links. The initial prestressing done of the steel is 65 tons/sq. inch.The crushing strength of concrete to be achieved in 28 days is normally not less than 525 kg./sq./cm (7,500 lbs/sq.inch).

The rail rests on a grooved rubber pad 130x130 mm with grooves parallel to the axis of the rail. The fastenings provided for 52 kg. rail are pandrol clips which are held in malleable cast iron inserts.

3.5.8.1 PCS-12 sleeper and PCS-14 sleeper

PCS-12 is the latest type of prestressed concrete sleeper for use on B.G. with 52 kg. rails and elastic rail clip. For use with 60 kg rails and elastic rail clips, PCS-14 sleeper has been standardised on Indian Railways.

The important dimension of both these sleepers are:

1. length 2750 mm
2. Weight 267 kg.

3. Reinforcement 18 number 3x3 mm dia strands
4. All corners to be rounded off to a radius of 5 mm unless otherwise specified.
5. Concrete is to be of controlled quality with a minimum crushing strength of 525 kg/sq. cm in 28 days.
6. Each strand will be tensioned with an initial tensioning force of 2730 kg.

Table 3.6-Quantity schedule for PCS-12 and PCS-14 sleepers

S. No.	**Item**	**Qty. reqd of various items for each sleepers of PCS-12 type or PCS-14 type**	**Drawing/ Specifications of each item for sleeper**	
1	Type of sleeper	One of PCS-12 or one of PCS-14	PCS-12 sleeper to drg. No RDSO/T-2495	PCS-14 sleeper to drg. No RDSO/T-2496
2	Reinforcement	18 nos 3 mm x3 mm dia HTS stands (total wt.8.217 kg)	HTS wire to IS:6006	HTS wire to IS:6006
3	Slope Plate	2 No rubber plate having total wt of 8.26 kg	IRS-T-37-82 Drg. T-2052	IRS-T-37-1982 Drg. T-2053
4	Liner*	4 No. glass filled Nylon-66 liners under each rail seat.	IRS spn.80 Drg.T-2505	IRS spn.80 Drg.T-3516
5	Inserts	$ No. SGI/SGCI inserts (total weight 6.8 kg.)	IRS T-32-84 Drg T-381	IRS T-32-84 Drg. T-2478
6	Elastic Rail Clips	4 No. elastic rail clips (total wt.4.0 kg)	IRS/T-31-84 Drg.T-1892	IRS/T-31-84 Drg.T-1892

3.5.8.2 Mono block post- tension type of concrete sleepers for B.G.

A factory for manufacture of post-tension type of mono Block Concrete Sleeper has been set up for the first time in India by Northern Railway at Allahabad in collaboration with M/S DYCKERHOFF & WIDMANN (D&W) of West Germany. The factory, which started production in 1981, has planned a capacity to manufacture 3,00,000 concrete sleepers per year.

Table 3.7- salient features of post-tension type of concrete sleepers

I	***Size of sleeper:***	
	Length of the sleeper Width of sleepers at centre Depth of sleeper at centre Sleeper Weight	2750 mm 160 mm (Top) 200 mm (Bottom) 180 mm 295 kg
Ii	*Design features:* Initial prestressing force Final prestressing force Min. concrete strength in 28 days Min. concrete strength of concrete at time of applying prestress.	37 Tonnes 31 Tonnes 550 kg/ cm^2 450 kg/ cm2
Iii	*Manufacture of sleepers:*	Details given in para 4.9.3

3.5.8.3 Reinforced cement concrete two block sleepers for use with IRN 202 clips for B.G. 90 rails

The sleeper is similar to French R.S. type of sleeper having its overall length as 2478 mm. The sleeper consists of two reinforced cement concrete blocks each weighing

approximately 90 kg joined by an angular tie bar 75x75x10 mm size each R.C.C. block is 722 mm long 295 mm wide and 251 mm thick The total weight of one assembly of concrete sleeper is about 125 kg.

The rails are held in position by I.R.N. 202 fastenings anchored in position by bolts which are housed in each block in the holes left in the concrete blocks. The bolts are fixed to the angle of tie bar and the nuts are tightened to press the clip against the rail seat. A rubber pad is also provided at each rail seat to absorb the shocks and dampen the vibrations. The sleeper is called RSC-2 sleeper, RSC-1 being the earlier version of two block concrete sleeper designed with conventional loose jaws and key type fastenings.

3.5.8.4 Mono Block PRC sleeper for M.G. (PCS-17)

A design for Mono Block PRC sleeper (PCS-17) has recently been standardised for M.G. The sleeper has a trapezoidal cross section similar to B.G. sleeper. The concrete of the PRC sleeper should have a compressive strength of 525 kg/ cm^2 in 28 days. Salient features of the sleeper are given below. (fig 4.12)

1	Length	=	2000 mm
2	Weight	=	158.2 kg
3	Reinforcement	=	12 no. 3x3 dia strand of HTS wire tensioned to initial fore of 2730 kg

The PRC sleepers can be used for 90 R rail with electric rail clips and GFN 66 lines and on sole plate.

3.5.8.5 Two Block RCC sleeper for B.G. yards

A design of two block RCC sleeper for B.G. yard as per drawing No. RDSO/T-252 has been finalised* by RDSO for extensive trials on Indian Railways. There is general scarcity of wooden and CST-9 sleepers for use in B.G. yards and the new R.C.C.

sleeper will ease the situation in a big way. Following are some of the salient feature of this sleeper:

1	Considering low speed in yard lines and lesser impact effect, rail seat design load has been taken as only 10 tonnes without any lateral thrust.	
2	*Size at rail seat* (Top width \x bottom width x depth	22 cm x 30 cm x17 cm
3	Overall length of sleeper	247.5 cm
4	Weight of sleeper	170 kg
5	Main reinforcement in each block	
	a) At top	5 Nos.8 mm dia steel
	b) At bottom	2 Nos. 8 mm dia steel
6	Fastenings	Steel clip & a spring washer with Screw fitted to a polythene dowel.

3.5.8.6 Two block concrete sleeper

Two block concrete sleeper for use in M.G. yards have recently been developed as per details given below:

1 RCS-12: Drg. No. RDSO/T-3518; suitable for 75 R and 60 R rails ,can be used for track circuited section with polythene dowels and rail screws.

2 RCS-11: Drg. No. RSDO/ T-153; suitable for 75 R, 60R and 50R rails .

The sleeper consists of 2 cement concrete blocks, each having a weight of about 36 kg. and having M,S. reinforcement of about 7 kg. in each block. The Two RCC sleeper blocks are connected by an angle tie bar or 55x50x6 mm section and length of about 1.5 metre long. The rail is fixed to the sleeper bolck either by clips and bolt arrangement or by polythene dowels and rail screws. A pad is given below rail seat to give cushioning effect.

The sleepers is still under trial for use in M.G. yards.

3.5.9 PRE-STRESSED CONCRETE SLEEPERS FOR TURN OUTS*

With the acute shortage of wooden sleepers especially of long timbers for points and crossing a need was felt to develop PRC sleepers for use on turn outs in track circuited areas.

RDSO accordingly developed a design of PRC sleepers having rectangular cross section in July 1986 for 1 in 12 left hand turnouts with 7730 mm curved switch for use with 52 kg rails. These PRC sleepers for turn out have been manufactured in PRC sleeper factory at Khalispur and these turn outs are on trial on Northern Railway at present.

Fig3.6 -PRC sleepers for turn outs

3.5.9.1 Salient features of PRC sleepers for turn outs.

1 The PRC sleepers have rectangular cross section.

2 There are 74 sleepers consisting of 21 sleepers in switch assembly, 35 in intermediate sub-assembly and 18 in crossing sub-assembly.

3 The sleepers are of varying length and design. There are 16 different designs of sleepers for the turn out as per table 4.1 given in the chapter Subsequently.

4 These sleepers require use of a number of fittings different from existing standard fittings. The grooved rubber pads are of standard 4.5mm thickness, but of varying size.

Table 3.8 details of 1 in 12 L.H Turnout for B.G. concrete sleepers.

S.No	Sleepers		Drawing Nos		Dimensions			Concrete
	Nos.	Total	From	To	Length in mm	Breadth in mm	Height in mm	Wt. in kg
1	2	3	4	5	6	7	8	9
1	1-2	2	T-2050		2750	250	210	361
2	2-4	2	T-2053	T-2054	3750	250	200	469
3	5-14	10	T-2055	T-2064	2750	250	190	326
4	15-21	7	T-2065	T-2067	2850	250	190	338
5	22-25	4	T-1992	T-1995	2950	250	210	387
6	26-29	4	T-1996	T-1999	3050	250	210	400
7	30-33	4	T-2000	T-2003	3150	250	210	413
8	34-36	3	T-2004	T-2006	3250	250	210	427
9	37-39	3	T-2007	T-2009	3350	250	210	440
10	40-42	3	T-2010	T-2012	3450	250	210	453
11	43-44	2	T-2013	T-2014	3550	250	210	466
12	45-47	3	T--2015	T-2017	3650	250	210	479
13	48-50	3	T-2018	T-2020	3780	250	210	496
14	51-53	3	T-2021	T-2023	3920	250	210	514
15	54-56	3	T-2024	T-2026	4070	250	210	534
16	57-59	3	T-2027	T-2029	4200	250	210	551
17	60-62	3	T-2030	T-2032	4360	250	210	572
18	63-65	3	T-2033	T-2035	4510	250	210	592
19	66-68	3	T-2036	T-2038	4660	250	210	612
20	69-70	2	T-2039	T-2040	4770	250	210	626
21	71-72	2	T-2041	T-2042	4880	250	210	641
22	73-74	2	T-2044	T-2044	4990	250	210	655
23	Approach	1	-	-	2750	250	216	264
24	Approach	1	-	-	2750	250	216	264
25	Approac	1	-	-	2750	250	216	264

	h							
26	Approach	1	-	-	2750	250	216	264

5 10 Nos. 9.5 mm dia 7 ply strand wires have been used in each sleeper.

6 The Volumetric content of concrete in 74 turn outs sleepers is approx. 12 cu.m.

Concrete sleeper for ordinary and other special location

These are listed as below:-

Table 3.9 Concrete sleeper for ordinary and other special location

S.No.	Location	Rail Section	Drawing No.	Remarks
1.	Ordinary	52 Kg	RDSO/T-2495	Pre-tensioned mono block
2.	Ordinary	60 Kg UIC	RDSO/T-2495	Pre-tensioned mono block
3.	Ordinary	52 Kg	RDSO/T-3178	Post-tensioned mono block
4.	Ordinary	60 Kg UIC	RDSO/T-4013	Post tensioned mono block
5.	Level crossing	60 Kg/ 52 Kg	RDSO/T-4148	For level crossing with 60 Kg UIC with 52 Kg check rail
6.	Switch Expansion Joint	60 Kg/ 52Kg	RDSO/T-4149	SEJ with 120 mm gap
7.	Curves	60 Kg UIC	RDSO/T-3670	Slack gauge upto 1681 mm can be obtained using liners of different thickness
8.	Curves	60 Kg UIC	RDSO/T-4170 & 4173	With 4 different sleepers for gauge 1675, 1677, 1679 & 1681 with normal liners
9.	Curves	52 Kg	RDSO/T-4174 & 4177	With 4 different sleepers for gauge 1675, 1677, 1679 &

				1681 with normal liners
10.	Cures (MG)	90 R	RDSO/T-4909 & 4913	Four different sleepers with gauge 1000 to 1008 mm
11.	Curves	60 Kg c/rail 52 Kg c/rail	RDSO/T-4183 RDSO/T-4186	Specially designed for Konkan Railway Line
12.	Ballast deck bridge	(a) 60 Kg (b) 52 Kg	RDSO/T-4088 RDSO/T-4097	With 52 Kg/90 R guard rail
13.	Rail joints (B.G.)	60 Kg	RDSO/T-4511	Main line sleepers to be used with ERC'J clip
14.	Rail joints (BG)	52 Kg	RDSO/T-4322	Main line sleepers to be used with ERC'J clip
15.	Rail joints (MG)	90 R	RDSO/T-4779	On main line sleeper, ERC MK-II clip in reverse position
16.	Shallow sleeper		RDSO/T-4852	For location with restricted headway
17.	For mixed gauge (three rail seat)	90 R	RDSO/T-4857	
18.	Turnout 1 in 12	60 Kg (fan shape)	RDSO/T-4218	Switch 4219, lead and crossing 4220
19.	Turnout 1 in $8_{1/2}$	60 Kg (fan shape)	RDSO/T-4865	Switch 4966, lead and crossing 4967
20.	Turnout 1 in 12	52 Kg (fan shape)	RDSO/T-4732	Switch 4733, lead and crossing 4734
21.	Turnout 1 in $8_{1/2}$	52 Kg (fan shape)	RDSO/T-4865	Switch 4866, lead and crossing 4867

3.5.9.2 Making of PRC sleepers

1 on the straight side stock rail shoulder of the sleeper, following marking is normally done:

Angle of turn out-direction of turn out- poundage of rail -section sleeper No. in the turn out. For example-1\12-LH-60-1 This will mean 1 in 12 turn out left hand for 60 kg rail ,sleeper, No .1 in serial order of use in the field starting from stock joint.

2 On the turn out side shoulder of the sleeper ,RDSO Drg. No. date of casting and set Number engraved or painted.

3 Special approach sleepers are designated by letter "A".Sleepers on which signalling gears are to be fitted are designated by letter "S"

3.5.10 Laying the concrete sleepers

The locations where concrete sleepers are to be laid should have clean ballast cushion of 30 cm thickness. Extra ballast should be available on cess and the area should have good drainage:

Depending upon the availability of space and various site conditions, one of the following three methodologies or their combinations could be adopted for laying of concrete sleepers turn out:-

a) Assembling at site and replacing during block period either by means of cranes or rollers.

b) Carrying parts of assembled turn out on dip lorries and replacing during block period.

c) Replacing existing turn out sleeper by sleeper except for switch portion which can be assembled as one unit.

The assembling and laying should be normally done using a crane of suitable capacity.

3.5.10.1 Compaction

After removal of old turn out sleepers, ballast bed should be made even at the level of the bottom of concrete sleepers for turn outs. Vibrating rollers should be employed to the extent possible for compaction of ballast bed.

3.5.10.2 Maintenance

The maintenance of turn outs with concrete sleepers should be done by means of either of the following:

1 by using points and crossing tamper,
2 by using off-track tampers with lifting jacks,
3 By measured shovel packing.

3.5.10.3 Attention during emergency like derailments

In case of emergencies like derailments, where damage to sleepers may take place, temporary repairs should be done by interlacing wooden sleepers for permitting the traffic at a restricted speed. The damaged concrete sleepers are replaced by fresh lot of turn out concrete sleepers as a permanent measure as early as possible. The replacement of wooden sleepers and any other damaged sleepers is done one by one with new turn out sleepers.

3.5.11 Manufacture of concrete sleeper

Prestressed Concrete sleepers can be of the pre-tensioned or post-tensioned type. In the case of pre tensioned sleepers, the force is transferred to concrete through bond or a combination of bond and positive anchors. Bond, transmission length and the losses in prestress vitally effect the design and determine the quality of manufacture. In the post tensioned type, the force is transferred only through positive anchors.

3.5.11.1 Mono block pre-stressed concrete sleepers.

The mono block concrete sleepers are generally manufactured by what is called the *"long line method*" in this method there are casting beds about 100 to 120 metre long in which 30 to 40 moulds exist for casting of concrete sleepers at a time. The steel wires, which are of 5 mm diameter high tensile steel wires, anchored at end block between tension towers and moulds and are stretched by a specially designed tensioning method. The tensile stress in the wires should not exceed 70% of the specified minimum U.T.S. High quality concrete, with pre- designed mix ,is then filled into the moulds. The newly laid cement concrete is thoroughly mixed and consolidated by means of high frequency vibrators. The concrete is then cured after about 3 hours preferable by steam. The wires are then destressed by means of "Hovers method of distressing". the wires are cut and the line is released. The sleepers are further cured by submerging into water tank for a period of 14 days. Alternatively, the sleepers can be steam cured also.

Another method which is sometimes adopted for manufacture of prestressed mono block concrete sleepers is short line method or '*Stress Bench method'* .This process involves the use of short stress benches which accommodate 4 to 5 sleepers .The ends of benches serve as anchor plates and comprise of an iron frame to take the initial prestressing force. The benches are on wheels and are mobile. The prestressing is done as in case of long line method. The concreting and vibrating, etc., are however at a fixed place, stress benches being moved in position one after another. This leads to better quality control in concrete mixing and compaction. Generally the benches after casting are taken into steam chambers for curing with an over -all turn- round period of about 24 hours with a steam curing cycle of about 16 hours. This method of manufacture has given better results qualitatively and has been adopted by M/s Daya Engineering work Pvt. Ltd. Gaya and M/s concrete products and construction Co. madras.

Prestressed mono block concrete sleepers can also be manufactured by '*Individual mould method*' The method is generally used where prestressing is transferred to concrete through bond and positive anchorages in case of pretensioned sleepers or only by positive anchors in the case of post- tensioned sleepers. The mould for the pretensioned type is designed to take the initial prestressing force and hence has to be strudier than the moulds

used in other systems. The moulds can take one to three sleepers and move along the assembly line, the various stages of work like cleaning of moulds, insertion of high tensile stress wires, the prestressing of wires fixing inserts, concreting vibrating ,steam- curing, demoulding, etc. being carried out on the manufacturing belt. This system involves a greater degree of automation, yields better results qualitatively requiring the least amount of work force .In India, the factories utilising this technique have currently gone into production at secundrabad and Bharatpur.

3.5.11.2 Manufacture of two block concrete sleepers

The manufacture of two Block concrete sleepers is simple and similar to that of any other ordinary precast RCC units. These sleepers are manufactured in a mould in which the necessary reinforcement and the tie bar are placed in position. The concrete of designed mix in then poured in the mould and vibrated The mould is removed after the concrete is set. The Blocks are cured in water for a period of 14 days.

3.5.11.3 Manufacture of post-tension concrete sleepers

Post-tension type of concrete sleepers are being manufactured in concrete sleeper plant Allahabad as per design submitted be D&W of Germany, which has been approved by the Railway Board/R.D.S.O.* The specialty in this patent design of D&W is in the use of high tensil steel road bent into U shape known as HAIR PINS and slits and nuts. This process also involves the use of instantaneous demoulding of the products.

The following are the details of procedure followed for manufacture of concrete sleeper in concrete sleeper plants at Allahabad.

1 Raw material viz coarse sand coarse aggregate of size 10 mm and 20 mm are moved with the help of loaders and dumpers from material stacking area and brought to the scraper. The materials are weighted and automatically fed in to concrete mixer.

2 Water is fed through an electromagnetic wager meter and cement is fed throught an electrically controlled cement scale, screw conveyor and feeding channel.

3 The concrete mixer mixer the various ingredients automatically in about 11/2 minutes. The concrete mix is discharged from the mixer to a reversible belt conveyor which feeds the concrete into a concrete distributor trolley running on a suspended frame with runway. The concrete distributor takes the concrete to be poured into the moulds in 4 layers.

4 The moulds are clean and core bare are inserted in them. These are tightened with the help of pneumatic tools. The moulds thus prepared are paced a trolley which takes them to the next position where M.C.I inserts are fitted. A host now lifts up these moulds and place them on another trolley. This trolley takes the moulds on to a vibrating table where the moulds are lowered and placed.

5 As the concrete distributor comes over the mould, the vibrators are switched on which vibrate the concrete in the mound at a frequency of 9000 RPM with a vertical force of 1.6 tonnes after the concrete is vibrated a compression beam from the top weighting 1.6 tonnes is lowered on the concrete. The compression beam is fitted with a vibrator. Hence the concrete if fully compacted with the vibrations from the top as well as below. After the concrete is fully compacted the moulds are lifted from the vibrating table with the help of a hydraulic device and are placed on a trolley. The trolley takes filled moulds on to a hydraulic demoulding table.

6 After the moulds are placed on demoulding table core bar extractor in brought near the mounds to pull the core bard out of the mould now the pallets are placed on the moulds and with the help of a hoist sleepers and demoulded instantaneously. The sleepers now rest on the pallets and the mould is free to be re-cycled again.

7 Another hoist lifts up the pallet along with sleeper and takes them to the heating stacks, Each heating stack can accommodate 40 sleepers there are 40such heating stacks in both production lines.

8 After steam curing the sleepers are lifted and placed on a trolley the pallets released are taken to be recycled again for use.

9 The sleeper placed on the trolley are taken to the prestressed line where hairpin rods are inserted and slit nuts are tightened at the either end along with anchor washers and back rests at the other end Necessary pre stressing force is applied with the help of pre-stressing jacks. The ends of the concrete sleeper are sealed after injecting the grout mortar. The sleeper is now ready which goes to the sleeper stacking area.

Approximately two lakh post tensioned concrete sleepers are being manufactured in concrete sleeper plant Allahabad per year presently and the production is bound to increase in near further to reach the planned capacity of 3 lakh concrete sleepers per year.

3.5.11.4 Testing of concrete sleepers

In addition to the control check exercised on the material and manufacturing process the concrete and the finished sleepers are subjected to the following periodical checks and tests:

1 Minimum compressive strength of test cube should not be less than 525 kg./sq. cm after 28 days in occasional cases when the minimum crushing strength falls below 252 kg./sq. cm, but it is not below 490 kg/cm^2 the sleepers from such batches may be accepted subject to their passing the increase frequency of testing for static bending strength.

2 Minimum compressive strength of test cube of concrete at detensioning should not be less than 370 kg/sq. cm.

3 Modulus of Rupture should be as specified in "Concrete Bridge code"

4 Dimensional tolerance and surface finish of sleepers should be checked by suitable templates and gauges.

5 The cracking moment and failure moment of the sleeper should be tested at the following sections by applying suitable loads.

a) Positive cracking moment at rail seat bottom.
b) Negative cracking moment at centre section top.
c) Positive cracking moment at centre section bottom
d) Failure moment at rail seat bottom.

6 For abrasion resistance test the concrete sleeper is subjected to a vibrating load under specified condition after 300 hours of operating time the loss of weight due to abrasion should not be more than 3%

3.5.12 Handling of concrete sleepers.

Concrete sleeper weight about 215 to 270 kg and about 6 to 8 men are required to handling one sleeper mechanical handling of concrete sleepers is therefore considered absolutely necessary.

3.5.13 Permitted locations for laying of concrete sleepers.

Concrete sleepers because of heavy weight and rigidity of structure are not suited to yielding formations fish plated joint and places where uniform packing cannot be achieved concrete sleepers as such are normally laid at only those locations where LWR is permissible concrete sleepers should not be laid at the following locations.

1) New formation in banks unless specially compacted.
2) Any rock cutting except where a minimum depth of 300 mm of ballast cushion has been provided.
3) Un- ballasted lines in yards.
4) Curves of radius less 500 meters.
5) Troublesome formations.
6) Near ash pits and other locations where drivers habitually drop fire.
7) At locations where excessive corrosion is expected.
8) a) on un ballasted bridges

   b) On arch bridge , where the height between arch and bottom of blast section is less than one meter.

   c) On slab bridge where the ballast cushion between the bottom of sleepers and top of slab is less than 300 mm.

9) concrete sleepers should not generally be used with fish plated track and should be used only with long welded rails fish plated joints on concrete sleepers track where unavoidable should have wooden sleepers at joints.

3.5.14 Laying of concrete sleepers

Concrete sleepers are heavy and as such manual handling of concrete sleepers is not only difficult but may generally causes damage to the sleepers in exceptional cases however, manual handling including manual laying of concrete sleepers is resorted to after taking adequate precautions.

In case of mechanical relaying system normally two portal cranes are used On Indian railways and relaying is done be pre-fabricated panels. The existing rail penels are removed by gantry cranes, ballast is levelled up and prefabricated panels are then laid with the help of portal cranes. Following operations are involved.

1 Preparation work at site of relaying.
2 Pre-assembly of panels in base depots.
3 Actual relaying operation.
4 Post relaying work.

3.5.15 Maintenance of concrete sleepers

1 Concrete sleepers should normally be maintained with heavy on track tampers. For spot attention, measured shovel packing (MSP) or off track tampers may be used. The size of chips for MSP should be 8 mm to 30 mm as required.
2 Only 30 sleepers spaces are to be opened out at a time between two full boxed stretches of track of 30 sleepers length each incase LWR track exists.
3 The concrete sleepers should be compacted well and uniformally to give a good riding surface. Centre binding of mono concrete sleepers should be avoided an I for that purpose the central 800 mm of the sleeper should not be hard packed.
4 Both ends of concrete sleepers should be painted with anti corrosive paints periodically to prevent corrosion of the exposed ends of prestressing wires. In

case of two block sleepers tie bars should be examined every year and if any sign of corrosion is noticed the affected portion should be painted with an approved type of paint

5 The laying and maintenance of concrete sleepers should be done by mechanical equipments as far as possible.

6 Wherever casual renewal of concrete sleepers is to be done normal precautions required for LWR track should be taken.

7 The elastic rail clip should be driven properly to ensure that the leg of the clip is flush with the end face of the insert. Over driving and under driving should be guarded against as this cause eccentric loading on the insulations and this results in their displacement and variation of the load.

8 A vigilant watch should be kept to ensure that no creep take place in any portion of the concrete sleeper track or there is no excessive movement near SEJ.

9 *Rubber pads*: it must be ensure that the rubber pads are incorrect position. Whenever it is found that the rubber pads have developed a permanent set, these should be replaced by new ones. Such examination can be done at the time of de-stressing loss of toe load can also be due to ineffective pads.

10 *Insulating Liners*: Nylon of composite insulation liners used with pandrol clips should be examined periodically for sign of cracking and breakage. Adequate care should be exercised while driving the clip at the time of installation to prevent damage.

11 *Special attention to seizure of elastic rail clips;* One of the biggest problem of maintenance of concrete sleepers track is that elastic rail clips get seized with MCL Insertsnot only en regular maintenance, but also during distressing other incidental works and derailments etc. following remedial measuresare are suggested.

a) *Measure to prevent corrosion and seizure of ERCs with M.C.I in sets*: at the base depot all the elastic rail clips and MCI Inserts should be thoroughly cleaned. Grease should then be applied on the central leg of the E.R.C and eye of the MCI insert and then the clip should be driven at the time of assembly of the service panel.

b) All the elastic rail clips are to be taken out during service from the MCI inserts and should be cleaned with wire brush and emery paper specially

on the central leg. The eyes of the MCI inserts are also to be cleaned of any debris or rusted materials The central leg of the ERC should then be applied with proper quality of Grease* The eye of the MCI Inserts should be smeared with the same grease before the treated E.R.Cs are driven back. This has to be repeated every one year in corrosive prone areas. In other locations the frequency should be 4 years and one fourth length in each gang should be greased annually.

3.5.16 Action in case of Derailments

1 When the damage to concrete sleepers is not extensive and it is possible to pass traffic at a restricted speed, suitable speed restriction should be imposed after assessing the damage to track. Sleepers should be replaced as in the case of casual renewal taking all precautions. After all the damages sleepers are replaced the affected portion and 100 meter on either side adjacent to it should be distressed and normal speed should be restored after consolidation.

2 When the damage to concrete sleeper is extensive and track is distorted in such a way that it is not possible to pass traffic even at a restricted speed, the affected portion should be isolated by introducing buffer rails on either end of the affected portion. The distorted track should be removed and replaced by track laid on single rail panels with available type of rails and sleepers The section should then be converted into long welded Rails by using concrete sleepers taking usual precaution as laid down in L.W.R. manual.

3.5.17 Mono Block sleepers versus Two Block concrete sleeper:

There are relative advantages and disadvantages between mono block and two block concrete sleepers and some to these are enumerated below:

1 Mono block sleepers give better longitudinal and lateral stability to the track compared to two block concrete sleepers.

2 Mono block concrete sleeper, being a monolithic concrete mass is likely to have longer working life compared to two block concrete sleeper connected with a tie bar. In the latter case a tie bar is a weak member and has comparatively lesser life due to rusting etc.

3 Mono block concrete sleepers requires heavy capital expenditure for its manufacture being a prestressed reinforced concrete unit compared to two block sleeper which as an ordinary reinforced concrete sleeper.

4 In mono block prestressed concrete sleeper crack developing because of overstressing is likely to close down on return to normal condition whereas in two block sleepers, such a crack will continue to remain open.

5 Mono block sleepers are likely to become centre bound unlike two block sleepers.

6 During derailments and rough handling etc. the tie bars of the two blocks get deformed affecting gauge.

7 The two blocks are not likely to rest on ballast in a way that each rail is at proper inclination to the vertical a feature which could effect the alignment and gauge of the track.

Table 3.10 Check list for concrete sleepers

	ITEM	POINTS FOR CHECKING	
1	Where to lay a concrete sleeper	i)	Concrete sleepers should normally be laid on LWR/CWR track in first preference on high speed routes and then on other routes.
		Ii	Concrete sleepers to be used at permitted location.
2	Sleeper sapcing	I	Spacing to be uniform viz 60 cm for sleeper density of 1660/km and 65 cm for sleeper density of 1540/Km.
3	Ballast section	I	Follow the specified ballast section for LWR as

			given in para 11.5.3 of chapter11
		Ii	In two blocks RCC sleeper provide a central trough of 1033 mm wide to avoid corrosion to tie bar.
4	Handling of concrete sleepers	I	Use preferable mechanised means like gantry cranes. In exceptional case, manual handling to be done using sleeper slings and rail dollies taking proper precautions to avoid damage of sleeper.
5	Laying of concrete sleeper	I	Adopt mechanical means i.e. portal cranes with pre assembled panels.
		Ii	Manual laying only in exceptional conditions and that too with proper precautions.
6	Maintenance of concrete sleepers.	I	Use of track tampers for regular maintenance of long stretches.
		Ii	Use off-track tampers like Chinese tampers of measured shovel packing for isolated or short stretches.
		Iii	In emergencies use blunt end beater for packing.
		Iv	Follow precautions as given in para 4.13.1
7	Maintenance of fastenings used with concrete sleeper track	I	Over driving/ under driving of pandrol clips should be guarded.
		Ii	Ensure rubber pad in correct position and renew when these develop permanent set.
		Iii	Care should be taken while driving clop to avoid damage to liners. Cracked liners should be replaced.
		Iv	At the time of initial laying, all the MCI inserts and ERCs should be thoroughly cleaned and then grease applied to IS 408-1981 on the central leg of ERC and eye of the MCI insert.
		V	During service, thoroughly clean ERCs and eye of MCI inserts and then apply grease to IS-408-1981 on the cleaned surface. This is to be repeated once

			a year in corrosion prone area and once in 4 years in other locations.

3.5.18 Scope and planning of concrete sleepers on Indian Railways

1 Scope of concrete sleepers : As per the present policy concrete sleepers are to be laid only on "A" categories of routes and only in such lengths that these can be packed with heavy "On track" machines. Presently track renewal are being done on "Need based" considerations and in view of this concrete sleepers are being planned only where sleeper renewal is due. Even with these consideration, the total requirement of concrete sleepers on a rough assessment comes to about 100 lacs sleepers per year.

It is felt that in order to get maximum advantage of heavy investment on track renewals, Indian Railways should have "Planned track renewals" instead of "Need based renewals" in the 1st phase all the Board Gauge Inter-city routes are proposed to be laid with concrete sleepers. The total length of six inter-city routes on Indian Railway is approximately 20,000 kms and the req uirements of concrete sleepers for these routes alone comes to roughly 300 lacs of sleepers.

Similarly for Metre Gauge routes proposal in under consideration to provide concrete sleepers for "Q" routes having a length of 5,000 kilometers approximately. The total requirement of concrete sleeper for M.G. is estimated to be 75 lacs.

2 *Planning of concrete sleepers*: There are 29 factories set up for manufacture of concrete sleepers on Indian Railway which are under regular production at present. In addition a large concrete sleeper factory with post tension system has been set up a Allahabad by Northern Railway with capacity to manufacture 3 lacs sleepers per year. Yet another departmental factory has also been recently set up by Northern Railway at Khalispur with installed capacity to manufacture 50,000 sleepers per year. A factory under public sector undertaking has also been set up by M/s Hindustan prefb Ltd. New Delhi with planned capacity of about 2 lacs sleepers per year. All these

concrete sleeper factories have produced about 35 lacs sleepers in 2000-01 and it is targetted to manufacture about 57 lacs sleepers (50 lack for B.G.and 7 lacs for M.G.) in next 2 to 3 years.

As far as Metre Gauge is concerned, the concrete sleeper have not been produced so for in a big way. The design of M.G concrete sleeper has already been finalized and approved by Railway Board Because of shortage of wooden sleepers of M.G. and also because of its necessity to improve the track structure on Important M.G. routes, it appears inevitable that production concrete sleepers is taken up for M.G. also in a big way

In view of this two departmental factories have already been set up on M.G. system; one at Sabarmati on western Railway and another at Garden rock in southern Railway.

Indian Railway are planning to further boost up the manufacture of concrets sleepers in order to take the challenge of moving faster and heavier traffic. It is planned to set up additional 17 concrete sleepers factories (14 for BG and 3 for MG) in phase I and another 14 factories (10 for BG and 4 for MG) in phase II so as to have total concrete sleeper factories on Indian Railway to the extent of 60 or so with these factories coming up the day is not far when Indian Railway will be manufacturing concrete sleepers to the turn of about one crore per year in forsseable future.

3.5.19 Economies in use of concrete sleepers.

The concrete sleepers are of recent origin in Indian and these have been introduced on Indian Railway mainly on technical considerations. With the introduction of these concrete sleepers the traditional track structure is completely changed. Indian Railway have only limited experience in the use of concrete sleeper and no data is at present available to compare the relative economies of the use of concrete sleepers via-a-vis other types of sleepers. It is felt that there may hardly be any direct economy effected because of introduction of concrete sleepers. There may be however some marginal economy in consumption of fuel become of better track geometry long term economies are, however, likely to accure appreciably because of longer life of rails and rolling stock on account of

better track structure and higher standard of maintenance. The life of concrete sleepers, which will be approximately 40-50 years may also synchronise with the life of rails resulting in economic renewal of rails and sleeper at one time. To what extent these saving will actually be affected is a question which only our further generation will be able to answer.

3.5.20 Development of new type of concrete sleepers

1 *Concrete sleepers for level crossing for 52 kg & 60 kg U.I.C. rails for B.G.** about 1300 sleepers have been manufactured on trial bases on Northern railway. The design requires to be improved by providing fixing arrangements of the check rails in the flared portion.

2 *Concrete sleeper on curves for* B.G. RDSO has evolved a concrete sleeper to drawing No RDSO/T-3670 for BG 60 kg rails to be used on curves with the development of concrete sleepers on curves, the RDSO is also examining the issue of laying of LWR and SWR on curves up to 4^o and 6^o on BG and MG respectively.

3 *Concrete sleeper for use at fish planted joint* : due to shortage of wooden sleepers a design of of concrete sleeper with suitable fastening system is under development which can be used for fish plated joint for B.G.

4 *Use of mono block concrete sleeper sharp curve:* The matter was considered by 63^{rd} track standard Committee and it was recommended that the concrete sleepers should be laid on curves up to 300 m radius of M.G. where no gauge widening is required.

CHAPTER-4

METHODOLOGY OF RESEARCH

4.1 Failures of Railway Concrete Sleepers During Service Life

Railway sleepers are the main structural elements of railway track. As well as pressure distribution and load transfer to the underlying layers, railway sleepers are in duty to maintain track gauge, grantee lateral stability of the track and contribute in better geometrical conditions of the track. Vertical, lateral and axial forces are applied to rail sleepers. These forces should be transferred to the underlying ballast layer within the admissible stress range with minimum disturbance of track quality and permanent deformation. In fact, no comprehensive approach is existed when dealing with sleeper pressure and load transfer mechanism of the track structure.

There are various assumptions concerning contact stress distribution between sleeper and ballast as well as bending moment diagrams of a sleeper which are show in figure

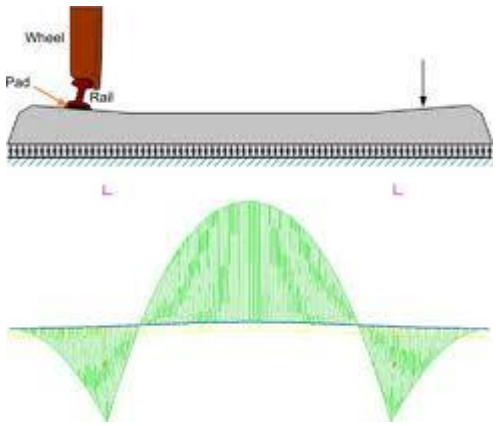

Fig 4.1 BM Diagram of a sleeper

To recognize main defects of concrete sleepers , life cycle defects of sleepers were primarily categorized as follow:

1. Deteriorations during manufacture and coupling (track panelling)

2. Deterioration during transportation and installation

3. Deteriorations during use.

Data collection for deterioration during production and coupling (panelling) carried out by optical inspection from plants producing concrete sleepers analyzing quality control reports, asking opinion of production experts. In this survey 1000 unusable defected sleepers in producing plant studied and their defects detected.

(1)Recognizing deteriorations during transportation and installation were also carried out through defected sleepers study in track laying workshops and analyzing QC reports.

(2)Deteriorations in operation time could be detected and categorized due to existing of monthly reports of supervising on track maintenance by supervising experts.

(3)5years report study and using engineers' opinions with maintenance experience and especially in different mountainous, plains and dry lands and etc. can give effective help to detect and diagnose these defects .In other sections detected deteriorations will be explained.

4.2 Detected Defects

4.2.1 Deteriorations during Production and Coupling (Panel)

Among causes of deteriorations during production and coupling, faults & defects related to primary material, concrete , processing, and unloading (evacuation) from the form, structural faults & defects like roll-plaque inclination, excess roll-plague cover, penetration of concrete sap, and/or other excessive material inside roll-plaque, penetration of water inside roll-plaque and its freezing in cold winter and/or existing of external material inside roll plaque can be mentioned. In spite of production process monitoring, unfortunately, happening of some of such a fault or defect may be assumed. The conventional deteriorations diagnosed in this stage are longitudinal crack, muscle crack, head zone crack, concrete decayed, concrete tear, and filling of roll plaque.

4.2.2 Defects during Transportation & Installation

Installation of sleeper or panel (coupling) carried out through different methods. Using Plattow crane and installing by panel laying method is conventional In Indian Railways. In this method proper distribution of ballast first layer is one of the factors prevent appearing of concrete sleepers defects.

Moreover, from other causes of defects ,plug cap fall down, improper depot, inaccuracy in loading & unloading the panel as well as improper pack, un-layering first ballast layer panel laying with ballast accumulation in sleeper center, sleeper broken due to incorrect primary loading, unloading and improper track laying can be mentioned. Defects &deteriorations observed in this stage include: chipped sleepers, bending cracks, cutting cracks, sleeper instable in fastening points.

4.3 Deteriorations during production and coupling

1. **Longitudinal crack**-This crack happened along sleeper longitudinal axle and in a distance between roll-plaques.

   Causes: un-greasing (un-lubrication)of sleeper muscle part, incorrect performance of screw driving machine, and incorrect vibration of the concrete inside the form, human faults such as incorrect positioning of roll-plaque ,incorrect mixing of concrete constituent material &components, the way of taking concrete inside the form ,fault in roll-plaque diameter size, unsuitable tamping ,entering of concrete sap ,rate of moment exerted on bolts during coupling, asymmetric displacement of coupling

2. **Muscle crack-** Emerge in concrete sleeper muscles area toward the main &horizontal axis. This crack appears at the time of exertion of prefabricate force and also when offloading sleeper from its form.

   Causes: The manner of exerting prefabricate force, the manner of bolts unscrew, no valvalin used inside forms.

3. **Crack in head zone-** This kind of track is diagonal and begins from prefabricate bolt holes point and terminate to (rail) seat.

   Causes: lack of concrete cover behind plaques, asymmetric infrastructure &tamping, improper processing, inaccuracy in exerting prefabricate force, inaccuracy in unloading (evacuate) sleeper, manner of bolts unscrew, wear of prefabricate rods.

4. **Decayed concrete-** These kinds of defect happen around concrete sleeper and are not detected before evacuation of sleeper from its steel mould.

   Causes: Improper concrete mixing plan, throwing concrete inside the form ,manner of vibrating concrete ,non-observance of steaming time, non-observance of steaming temperature, concrete solidity, inaccuracy in form typical oil rate.

5. **Concrete sleeper tear-** Due to damaging the concrete sleeper prefabricate system, torn sleepers are out of use completely and they are not repairable yet.

6. **Filled plug-** Due to plug breakage or cracking, usually this component filled by concrete sap or other material and defects emerge as a result of this phenomenon.

   Causes: nonstandard plug material ,plug crack, plug break, open-bottom plug(if plug not to be through),uncovering holes of plug, entering external material in panel site, concrete sleeper depot in free air and of snow & rain enter inside plug hole, manner of rail fastening unscrew for welding.

4.4 Defects during transportation & installation

1. **Chipped sleeper-** As from structure point of view it does not damage sleeper structure, chipped sleeper which (their chippness) has not exceed permissible limit, being accepted.

   Causes: Un-lubricated form bottom with special oil, inaccuracy in processing time and temperature,vibration rate, manner of unloading concrete sleepers from forms, transporting of sleepers withlifters to depot site, lifting of sleepers with catenaries cranes.

2. **Bending cracks-** Bending cracks in concrete sleepers appeared in sleeper center transversal &diagonal.

   Causes: Strikes touched to unload sleeper from the form ,concrete sleeper depot excessive altogether, sleeper transportation by lifters &cranes ,asymmetric panel transportation in site, ballast pollution and reduced track elasticity ,un-permitted load passing and increased

loading cycle, deficiency in drainage system and track solidity increase, improper infrastructure and insufficient compression ,asymmetric tamping ,jet- mud phenomena, inlaying ballast first layer.

3. **Cuttting cracks-** Cutting cracks usually appear in rail seat area and in a distance between plug holes transversally along rail longitudinal axis.
   Causes:, concrete sleeper depot excessive altogether, ballast pollution and reduced track elasticity ,un-permitted load passing and increased loading cycle as well as fatigue phenomena, deficiency in drainage system and track solidity increase, improper infrastructure and insufficient compression ,asymmetric tamping ,reduced ballast layer thickness .
4. **Sleeper instability in fastening point-** This kind of defect appears due to improper Screwing & unscrewing fastenings for welding, and result in un-monotonous stress distribution and due to load passing and weak sleeper conjunction with ballast under, concrete sleeper damaged.
   Causes: Inaccuracy in fastening screwing in panel site, plug diameter rate ,inaccuracy in correct fastening of rail clips after rail welding , bolts diameter rate ,external material falling down inside plugs, broken or cracked plugs ,manner of unloading panels, wheel defects and overwhelming strike effect, axle load value, climate(weather) changes and expansion & contraction cycles.

4.5 Defects during operation and maintenance

1. **Bending cracks-** Bending cracks in concrete sleepers happen in centre of sleeper transversal and diagonal.

Fig4.2- Bending cracks

Causes: shocks or strikes imposed on to take out sleeper from the form, excessive concrete sleepers depot (store) over each other, sleeper carried by lifter and crane, asymmetric transportation of panels in site, ballast pollution and reduced track elasticity, no permitted load cross over and loading cycle increase, deficiency in drainage system and track solidity increase ,improper infrastructure and insufficient compression.

2. **Sleeper breakage due to derailments-** Concrete sleepers break due to derailment considered as un-returnable defects and damages of concrete sleepers due to which these sleepers are not able to do their task in track any more.

Causes: manpower fault, existing impermissible defects in track or rolling stocks.

Figure 4.3 Sleeper breakage due to derailment

3. Cutting cracks- Cutting cracks usually appear in rail seat area and in a distance between plug holes transversally along rail longitudinal axis.

Fig4.4- Cutting Cracks

Causes:, concrete sleeper depot excessive altogether, ballast pollution and reduced track elasticity ,un-permitted load passing and increased loading cycle as well as fatigue phenomena, deficiency in drainage system and track solidity increase, improper infrastructure and insufficient compression ,asymmetric tamping ,reduced ballast layer thickness.

4.6 Deterioration or Defects during Operation

State of track maintenance has significant role in deterioration of track and its components. For this, track maintenance management, determining inspection cycles, cyclic inspections, defect detection , on time repairmen' has significant effect in track life increase as well as track life cycle costs reduction. Climate conditions including dry lands with flowing sand problems, is, of course effective in superstructure components destruction and deterioration.

Fig4.5 – Defects during operation

Pick or bade of regulator hit the sleeper and damage it, improper screwing &unscrewing the rail clips (fastenings) when welding, wastes fall inside sleeper plug and screwing the bolt without its cleaning, inaccuracy during ballasting and ballast deficiency during maintenance , improper tamping ,derailments and their effects of sleeper structure, sand keeping climate,(dry land and sand effects on track components specially on sleepers) , freezing during operation(melt & freeze cycle) ,sleeper twisting around their longitudinal axe , improper sleeper spacing and nonalignment of sleepers in track can be mentioned among the causes of such defects.

The main defects of this stage are: bending cracks, sleeper break due to derailment, cutting cracks, and sleeper instability in fastening area and sleeper damage in dry land.

4.7 Sleeper Defects Reduction Methods

According to the studies done in this research and identifying the reasons of the defects, the effective methods for reducing these effects in manufacturing, installation and operation stage are also studied. These methods are recommended for Indian Railways and, it is expected that by implementation of an appropriate quality control system and controlling the items described in this chapter, there would be a significant decrease in life cycle costs, specifically concrete sleepers.

Statistical analysis of sleeper defects in Indian Railway shows that the major quantities of defects occur in operation stage. Some of these defects can be prevented by works in manufacturing stage. After manufacturing stage, the most defects are manufacturing defects.

Among the studied statistical society, 1.2 % of manufactured sleepers had defects, which 0.3 % of them are used in secondary lines and the remaining (0.9 %) are discarded. In the case of operation stage defects, it is necessary to provide the statistical information of existing sleepers in Indian Railways. Statistical analysis of concrete sleeper defects shows that near 0.5 % of concrete sleepers are replaced by track maintenance contractor companies (private companies) because of the defects each year. Of course, it includes sleeper breakages due to derailments.

Because of the concrete sleeper vulnerability to derailment, near 0.15 % of concrete sleepers are replaced each year, which comparing to 0.35 % maintenance is a significant amount..

Table 4.1 Control steps in manufacturing and operational stage-

Control Item	Control Steps
Bar Control	1. Bar length , smoothness 2 Corrosion amount 3. Bar depot location
Mould condition	1. Mould appearance 2. Inside mould appearance 3. Inside mould defects
Mould lubrication	1.Mould lubrication quality 2 oil concentration in mould bottom 3 Greasing
Fastening (clip) and Screw bolt control condition	Mould top condition ,Screw bolt condition on the clip Screw bolt depot
Plate and Clinch condition	Plate appearance Symmetry of dimensions and clinch crack
Bolt condition	Appearance and diameter of tensional bolts Appearance and diameter of stationary bolts length
Bar condition	Amount of tension Bar arrangement Concrete cover over plate
Condition of material in batching mix	Time of materials mix Cement amount of the batch Proportion of stone materials mix Concrete slump Concrete distribution in mould
Condition of material behind batching	Waste in materials Dust in materials Warming the materials in cold weather
Vibration performance	Quality of concrete distribution in mould Bottom vibration period (2min)Trowel vibration period (30s)
Product Tracking	Production date on the sleeper
Bolt opening condition	Order of bolt opening from top to bottom

According to the importance of sleeper and its role in railway superstructure, identification of the

sleeper defects is the first step in increasing the efficiency of track and decreasing the maintenance costs. After identification of defects, surveying in order to find the reasons of that defect is the second major step. In this study, according to the kind of sleepers used in Indian Railway , the major defects of the life cycle of these sleepers are categorized in three groups :

1. Defects during manufacture.

2. Defects during shipping and installation.

3. Defects during operation or maintenance.

Statistical analysis shows that most defects occur in operation stage. After operation stage, most defects occur during manufacture and maintenance. Among the studied statistical society, 1.2 % of manufactured sleepers had defects, which 0.3 % of them are used in secondary lines and the remaining 0.9 % are discarded. In case of operation defects 0.35 % sleepers are replaced in current maintenance each year.

According to identification of concrete sleeper defects reason and using appropriate solutions to control them, it is expected to reduce the manufacturing defects, from 0.9 to 0.6 %.

CHAPTER-5

CONCRETE SLEEPER QUALITY CONTROL

5.1 Concrete Sleeper Plants on Indian Railway

Total Plants on Indian Railway= 82 nos.

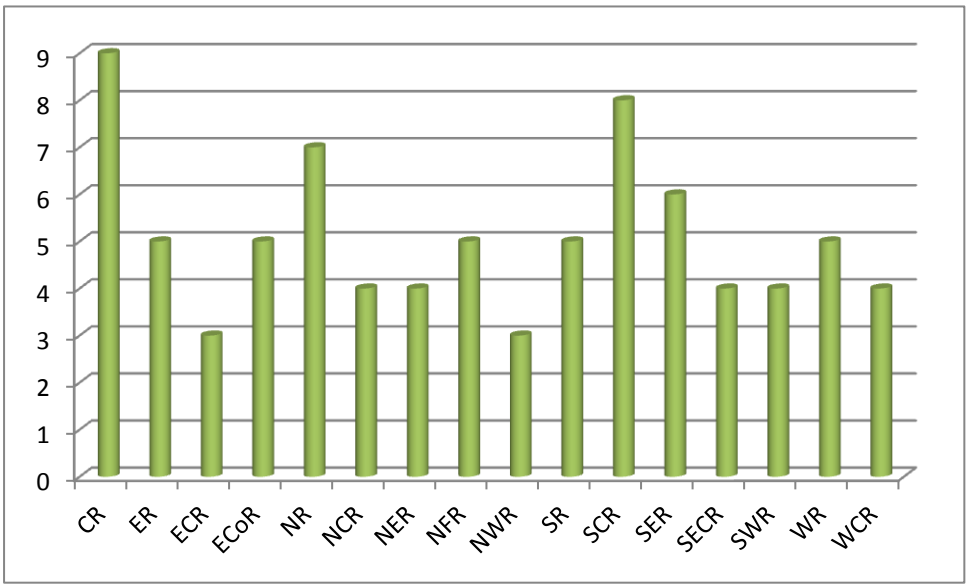

Fig 5.1 Concrete sleeper plants on Indian Railway

5.2 Maps Showing Location of Concrete Sleeper Plant

Fig5.2 Location of concrete sleeper plants

5.3 Specification and Drawings:-

There are following types of drawing is preferred-

- For main line sleeper: IRS: T-39
- For Turnout sleeper: IRS: T-45
- For main line sleeper-RDSO-T/2496
- For Turnout:

  1 in 8.5, 60 kg rail= T-4218

  1 in 12, 60 kg rail= T-4218

  1 IN 12 , 52 kg rail= T-4732

5.4 System of Quality Control-

- Quality check on Raw material
- Check on every process of manufacturing by Railway Official

- Inspection of product by Railway's official
- Periodical oversight inspection by RDSO

5.5 Role of RDSO-

- Initial development of plant
- During development of special type of sleepers
- Periodical oversight inspection
- Approval of quarry of aggregates

5.6 Initial development of plant

- Approval of layout plan
- Approval Mix design
- Approval of steam curing cycle
- Product inspection-
- Main line sleepers- 10000 nos
- Turnout sleepers- 10 sets of each design.

5.7 Product Inspection

Main Line Sleeper

- Release cube testing: 2 nos. of each steam chamber
- Compressive strength> 40 N/mm^2
- Water cured cubes: 3 nos. of each batch
- Compressive strength > 55 N/mm^2
- Flexural Beam Test: > 5 N/mm^2 (Weekly)
- Centre top = 60 KN
- Centre bottom = 52.5 KN (only during development)
- Rail seat = 220 KN

- Moment of failure = 370 KNS

5.8 Raw Materials

Table 5.1 Raw Materials

S. No.	Item	Source	Inspection authority	Procurement authority
1.	Fine and Coarse aggregates	Local but grading fitting with approved granulometric curve	Zonal Railway	Plant owner
2.	Cement (T-40)	BIS approved plant, Railway approved quality	Zonal Railway	Railway Board
3.	HTS (IS: 6006)	BIS approved firms	Zonal Railway	Plant owner
4.	SGCI Inserts	RDSO approved firms	RITES	Plant owner
5.	Water	As per BIS: 456 specification	Zonal Railway	Plant owner

Raw Materials

High strength Portland Cement

- Confirming to IRS/T-40.
- 53-S Grade as per BIS : 12269.
- The fineness > 3700 cm^2 / gm

Coarse Aggregates:

- 10 mm and 20 mm coarse aggregate are normally used.
- Receive from the local stone crushers.
- Conform to IS: 383-1970 and IS : 456-2000.

H. T. S. Wire

- Confirming to IS: 6006
- 3 mm X 3 ply HTS wire

Spheroidal Graphite Cast Iron Inserts

- Drawing No. RDSO/T- 381.
- The product must conform to the specification, IRS: T-46.
- Procured only from the RDSO approved Manufactures.

River Sand (Fine Aggregates)

- Sand is generally received from the local rivers.
- Silt content needs to be within permissible limit of 3%.

5.9 Manufacturing Process

Mixing of concrete:-

- Approved design mix of M-55/ M-60.
- Coarse aggregates CA1, CA2 and sand to be stacked in separate bins.
- Cement should be stacked separately.
- Quantity of water to be controlled with water meter.
- Provision of digital weighing platform close to weigh batcher- to cross- check of weight of cement.
- Accurate amount of materials by weight only.
- After due adjustment of moisture contents.
- Fully automatic weigh-batching plant.

5.10 Weigh- Batcher:-

Fig 5.3 Weigh Batcher

Mechanized and automatic clause no. 4.3.2 of IRS: T-39-1996 and IRS: T-45-1996, stipulated as under-

" Batching of different ingredient shall be done by weight only. A modern, mechanized or automatic weigh batcher shall be used for weighing aggregates and cement."

± 3 % accuracy as per IRS: T-39/1996.

The periodical calibration of weigh-batching plant.

Compensation of weight of aggregates for moisture content.

PLC (Programme Logistic Control) for logging-in the data of pre-defined mix and then facility of locking it.

Qualified operator- to be deputed to man the weigh-batcher.

Material to be automatically weigh-batched to be feed the desired weight of ingredients CA_1, CA_2, sand and cement into hopper.

The sequence of feed-

Coarse aggregate → Sand → Cement

All these are then poured in to the mixer.

Initially, the ingredients are mixed dry for about 20 to 30 seconds and then measured quantity of water is fed into the mixer.

Concrete Mix is prepared in high speed pan/ turbine type mixer in 1.5 to 2 minutes.

5.11 MANUFACTURING PROCESS

PREPARATION OF MOULDS

- Fabricated to accurate profile as per RDSO drgs.
- Use 8 mm or 10mm MS plates. End plates must be of minimum 10 mm thickness.
- Minimum nos. of moulds shall be 0.6 times of Daily production or 1.2 times the Shift production.
- Each mould needs to have proper marking as under :
    - RDSO Drg. No. RT – 2466 / RT – 4216,
    - Mould no. and corresponding Bench no.
    - Name of firm and year of manufacture.

TENSIONING OPERATION

- All strands to be pulled by hand before fixing wedges and barrels to avoid any differential slack or sag.
- Two jacks of 50 / 100 tonnes capacity shall be used for simultaneous pulling of all strands.
- In case of breakage of any strands during tensioning operation, full de – tensioning is done and re – tensioning done after replacing broken or slipped strands.
- Tensioning Register –
    - Bench no. / Line no.
    - Time of tensioning
    - Elongation at initial 50 kN and final force

MANUFACTURING PROCESS

TENSIONING OPERATION

Fig 5.4 Tensioning operation

- Strands are pulled simultaneously and load and extension is measured and recorded.
- In long line method , each wire is tensioned by desired load.
- Auto – cut provision
- Locking of HTS wires is done after achieving the required load.

CASTING OF CONCRETE

- Casting operation – manual , therefore better supervision.

- Casting to be done with fresh concrete.
- Fallen or dry concrete needs to be discarded.

Fig 5.5 Casting of concrete sleeper

- Vibrators of minimum 9000RPM to be fixed close to locations of rail seat to remove entrapped air.
- Indication of good preparation of moulds – No leakage of slurry through SGCI insert pockets and End plates.
- Moulds always placed over wooden batterns of 75 x 75 mm supports in bench for maximum advantage of vibration energy.

5.12 STEAM CURING

Fig 5.6 Steam curing

- Steam curing cycle – as per approved steam – curing cycle.
- Typical steam – curing cycle (11 1/2 hrs) is shown in the graph.

- Rate of rise in temp. not > 20 ^{o} C per hour.
- Recording of temperature – at interval of every half an hour.
- All steam chambers are fitted with dial gauge.
- Supply of steam – to begin after IST of the cement.
- 2 cubes to be put in each chamber for testing them for release strength.

5.13 PRODUCT INSPECTION

5.13.1 MAIN LINE SLEEPER

- Release cube testing : 2nos. of each Steam chamber
  Compressive strength > 40 N/mm^2
- Water cured cubes : 3 nos. of each Batch
  Compressive strength > 55 N/ mm^2
  Flexural Beam Test : > 5 N/ mm^2 (Weekly)
  Centre top = 60 kN
  Centre bottom = 52.5 kN (only during development)
  Rail seat = 220kN
  Moment of Failure = 370kN
- Dimension : 100% check
- Outer to Outer Gauge : with Go – NOGO Gauge
- Rail Seat : with Go-NOGO Gauge.
- Rail Seat Slope : Feeler gauge (0.075mm)
- Toe Gap : Three Pin gauge (8$\pm$ 1mm)
- Wind Gap : Four Legs gauge (1.2mm) – 10 %
- Concavity /convexity : Four Legs gauge (0.8)- 10%
- FTC

5.13.2 TURNOUT SLEEPERS

- Release cube testing : 2 nos. of each Steam Chambers Compressive strength > 50 N/ mm^2
  a) Flexural Beam Test : > 6 N/ mm^2 (Weekly)
  b) Sleeper top = 65 kN

c) Sleeper bottom = 85 kN

d) Moment of Failure = 160 kN (Sleeper bottom)

- FTC

Note : If above specified values are not obtained then follow SBT clause No. 5.3.7.4 of IRS : T – 45 -1996

- Dimensions : 100% check
- Centre line dimension along with X and Y dimensions:
  Format Booklet is to be filled up.
- Assembly Dimensions : Format is to be filled up
- Rail Seat : with Go – NOGO Gauge.
- Rail Seat Slope (Exit & Approach) :Feeler gauge
- Toe Gap : Three Pin gauge
- Wind Gap at Rail Seat : 1.2 mm (Max.) on width of 120mm
- Camber (50 mm Block) : not > 5mm

5.14 TYPICAL QUALITY ASSURANCE PLAN

- Quality plan insists on documentation of all processes in the suggested formats so that failure analysis can b done tracing back quality control exercised on different activities . A typical quality assurance plan is given as under :-
  - Part -1 : Minimum Essential Tests / Inspection– maintenance records.
  - Part -2 : Good Manufacturing Practices.

TYPICAL QAP – Part – I

Table 5.2 Min. Essential Tests / Inspection – maintenance records.

S. No.	Description	Characteristic Check	Specification eferance	Acceptance norms	Frequency	Format of records (Register No.)
1						

1.1	CEMENT					
		Fineness	IS : 4031 (Pt. – 2) – 1999	3700cm^2 / gm	-do-	Format – I
		Normal Consistency	IS : 4031 (Pt. – III & IV) – 1996	Needle reading 5 to 7 mm from bottom	-do-	Format - II
		IST	IS : 4031 (Pt. – 5)- 1996	60 minutes	-do-	Format- III
		FST	IS : 4031 (Pt. -3)- 1988	600 minutes	-do-	-do-
		7 days Mortar cube strength	IS : 4031 (Pt. – 6) - 1988	Not <37.5 MPa	-do-	Format –IV
		Soundness		Not > 5.0mm	-do-	-

S.No.	Description	Characteristic Check	Specification Reference	Acceptance norms	Frequency	Fomrat of record (Register No.)

1.4	WATER					
		pH value	IS:456-2000	Not <6 and not>9	Yearly	
		So4	-do-	<500 mg/l	-do-	
		Chloride	-do-	<500 mg/l	-do-	
		Quantity	IRS: T -39 IRS : T- 45	Sufficient for concrete, steam and	Daily	

				water curing		
1.5	SGCI INSERTS					
	Dimension	Jig to Drg. No. RT – 454 alt 9	IRS : T- 46- 1996 & Rly. Bd.'s letter dt. 11/08/03	As per RSDO's latest specifications	1% inserts randomly by SE/Works. AIE to check 20 inserts on random basis & make entry in register	Suitable format can be made by Plant
	Weight	Weight	-do-	1.55kg(-3%)		
	Soundness	2 kg Hammer test	-do-	1 % inserts randomly by SE/Works.		
	Rly. Bd's letter No. 98/Tk- II/22/11/17/Pt. Policy dt. 11/08/03					

S.No.	Description	Characteristic Check	Specification Reference	Acceptance norms	Frequency

1	RAW MATERIALS				
1.1	CEMENT				
	53- S grade cement	Procurement	IRS : T-40 IS : 12269-1987	BIS approved	Each consignment
		Stacking / Storage	IS : 4082-1967	Covered and properly ventilated room. Area = 2.5 T/m^2 Height of stack	Cement older than 3 months shall be used only after approval of AlE concerned.

				not > 8 to 14 bags. Storage = 2 months ' requirement	
1.5	SGCI INSERTS				
	Procuremet	Source & Validity of RDSO approval	IRS : T-46-1996	RDSO approved vendors Current validity of RDSO approval.	Each consignment.
1.5	SGCI INSERTS				
	Procurement	Source & Validity of RDSO approval	IRS: T-46-1996	RDSO approved vendors Current validity of RDSO approval	Each consignment.
	Heat No. & IC		-do-	Check Heat nos. & IC	-do-
	Physical	Weight	IRS : T-46-1996	1.55 kg. (-3%)	-do-
	Brinell Hardness	BHN	IS : 1500 -1983	170 -241 BHN	-do-
	Chemical	Phosphorous	IS : 228 (Part -3) - 1987	Not >0.12 %	-do-

SCHEDULE OF CALIBRATION

S.No.	Equipment	Frequency
1.	Aggregate Weigh Batcher	Once every week or after casting 2000 sleepers, whichever is earlier.
2	Cement Weighing Equipment & Water Meter	-do -
3	Dimension Checking Gauges	Once every 15 days or after inspecting 5000

		sleepers, whichever is earlier
4	15 cm concrete cube testing machine (2000KN capacity)	Once in 3 month

S. No.	**Equipment**	**Frequency**
5	Cement mortar cube testing machine (500 KN capacity)	Once in 6 months
6	Sleeper Static Bend Test machine (500 KN capacity	Once in 3 months or after testing 250 sleepers, whichever is earlier.
7	Pre-tensioning Jacks (500 KN capacity)	Once a month or after casting 5000 sleepers, whichever is earlier.
8	Proving Rings (2000 KN, 500 KN and 100 KN)	Once in 2 years

5.15 STATISTICAL ANALYSIS

In order to ensure quality of product on sustained basis, statistical analysis is carried out at the production site for following parameters:

- Release cube strength
- 15 days water cured cube strength.
- Flexural Beam strength
- SBT results

5.15.1 Case Study-I: Testing done on all plants:

- **Plant wise analysis: Sample size =44 mos.**
- **Sleeper-wise analysis: Sample size= 170 nos.**

Case Study-II: Testing done on one plant

- **Sample size= 85 nos**

Plant-wise analysis: Sample size = 44 nos.

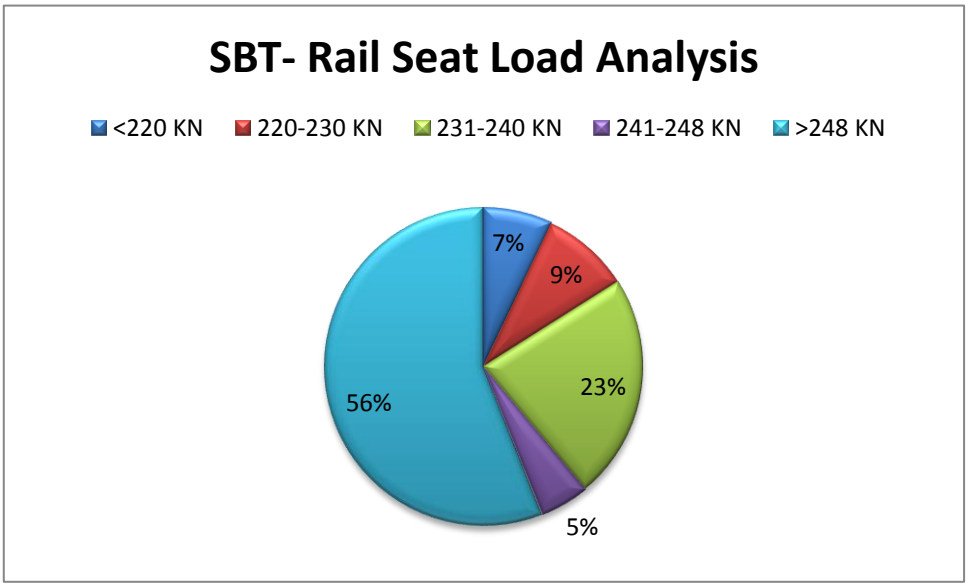

Fig 5.7 Plant wise analysis

5.15.2 Case Study-I Testing done on all plants

Sleeper-wise analysis: Sample size= 170 nos.

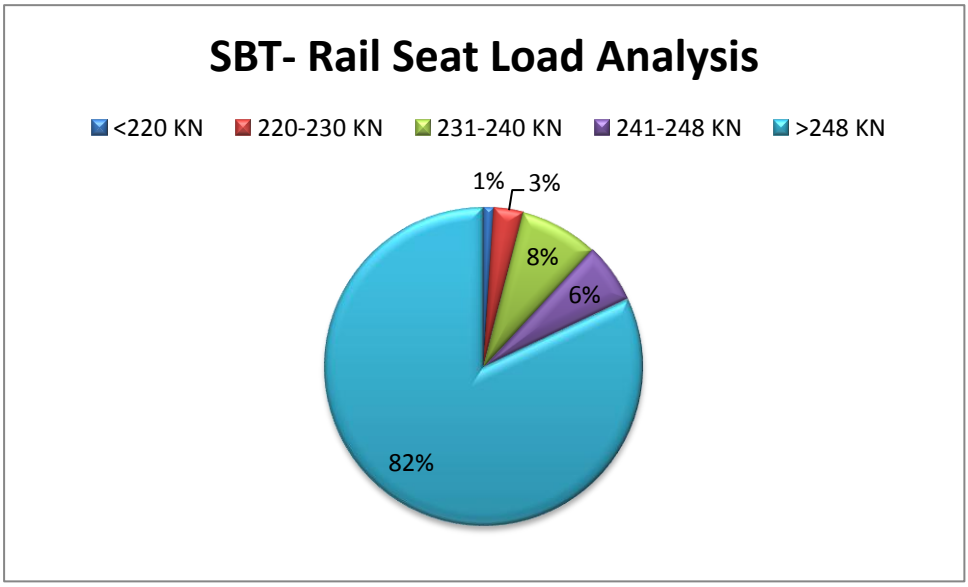

Fig 5.8 Sleeper wise analysis

5.15.3 Case Study-II Testing done on one plant

Sample size= 85 nos.

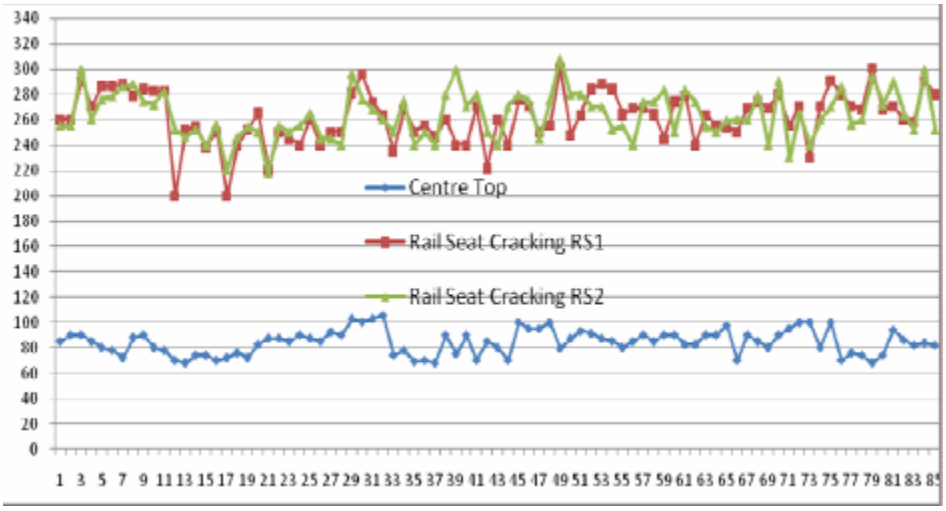

Fig 5.9 Testing done on one plant

CHAPTER-6

TRACK RENEWALS

Heavy track renewals are carried out on Indian Railways every year to keep the track safe and in good running condition and also to bring down the maintenance cost as low as possible. The cost of track renewals carried out on Indian Railways runs in several hundred crores. These track renewals consist of complete track renewal, through sleeper renewal and through rail renewal etc.

6.1 Necessity for Mechanised Relaying

A concrete sleeper weighs more than 200 kg. And therefore cannot be easily handled by manual labour unlike wooden or metal sleepers. Apart from being heavy, the concrete sleeper is brittle in nature and is likely to be damaged, if dropped from a height or handled roughly. The progress of conventional method or relaying is quite slow and the quality of the work is also not very high. On account of these considerations, the need for mechanized relaying has been increasingly felt particularly in view of the concrete sleepers being adopted in a big way on the Indian Railways.

6.2 Description of P .Q .R .S. Equipment

Indian Railways have procured some time back six sets of mechanical relaying equipment called P.Q.R.S. (Plasser Quick Relaying System) . These equipments have been manufactured by the firm M/s Plasser & theurer at a factory near Faridabad with 60% indigenous materials. Earth P.Q.R.S. equipment consists of:

(i)Four portal cranes
(ii)One sleeper layer
(iii)Ten hand gantries
(iv)Forty track jacks

The portal cranes and sleeper layer operate on an auxiliary track which has the following specification:

(i)The auxiliary track has 3.4 metre (11'-2") gauge.

(ii)The auxiliary track is supported on the wooden blocks or C.I. pots placed at 2 metre distance.

(iii)The auxiliary track and the track to be renewed have the same centre line.

(iv)The rails auxiliary track as well as that of main track should lie in one and the same plane.

6.2.1 Portal Cranes

The portal crane is a hydraulically driven 4 wheeled machine and is meant for carrying sleepers or track panels. The power for running and working of the portal crane is supplied by a Deutz diesel engine having for cylinders and developing 4 H.P. at 2000r.p.m the portal crane is of five tonnes capacity with a maximum lift of three metres and can accommodate four layers of concrete sleepers panels. Grippers are provided for lifting pre-assembled track panels. The crane are provided with hydrostatic brakes with hand levers on two wheels.

Fig 6.1- P.Q.R.S. Equipment

The portal crane has retractable legs with enables it to get loaded and unloaded from specially designed BFRs by its own power without any outside assistance. The portal cranes has been provided with a turn table also so that after getting loaded in BFR, it can turn in right had direction and get properly scated without any infringement to moving dimensions.

One crane can be used to lift a panel of 313 metre rail assembled on CST-9 sleepers. Two cranes, are however , able to lift a similar panel of concrete sleepers, which is comparatively heavier. One crane can normally lift concrete sleeper panel of 9.1 m length only because of the crane capacity being limited to 5 tonnes only. Indian Railways have recently acquired portal cranes of 9 tonnes capacity and one crane of this type can lift 13 metre rail panel having concrete sleepers.

Some important dimensions of old type of portal crane as well as new type of portal crane are given bellow:

6.2.2 Sleeper Layer

The sleeper layer moves on an auxiliary track having 3400 mm (11'-2") gauge. It is used for laying sleepers at correct spacing and alignment .the equipment is provided with a belt conveyor which handles the movement of 10 sleepers at time. The sleepers are taken by the belt conveyor from the rear to the forward side until the first sleeper has contacted the primary limit switch. This stops the conveyor belt and cause a sets a roller, on which sleepers rests to move forward the sleeper thus continues to roll forwards towards the sleeper laying till it reaches the fork and strike the secondary limit switch. As soon as sleeper is received by the sleeper laying fork the electronics feelers provided in the machine check the position of the sleeper on the sleeper-fork and accordingly cause the fork to move sideway to coincide the centre line of sleeper with the centre line of the track. This centering is done to ensure laying for all the sleepers in one line.

While the centering of the sleepers is being done, the sleeper laying-fork simultaneously moves down to its laying portion which is about 25 mm above the ballast top. When the sleeper layer has moved through the required sleeper spacing which the measured by an electronics device, the sleeper layer fork instantaneously works backward from down bellow and the sleeper falls on the ballast top in upright of the sleeper density.

6.2.3 Track Jacks

The track jacks are provided to support the service track at a inform level. These jacks are of the mechanical screw type with a vertical range of 85 mm and lateral range of 35 mm.

6.2.4 Hand Gantries

The hand gantries are of 1.5 tonne capacity and are provided with adjustable telescopic supports to suit variations. A travelling which is used for lifting the rail and placing them on the sleepers laid by sleepers layer. The rails can also be moved longitudinally in the lifted position with the help of rollers.

6.2.5 Relaying with P.Q.R.S. Equipment

Plasser Quick Relaying System (P.Q.R.S.) is well suited for carrying out Relaying work with concrete sleepers. The work is done by any of the two standards methods given in subsequent paragraphs:

6.2.6 Relaying with complete P.Q.R.S. Equipment including Sleeper Layer

In this method the track is dismantled at the site, panel by panel and loaded in the BFRs with the help of a portal crane. The concrete sleepers are also taken to site and laid with the help of a sleeper , layer. The rails, which are already unloaded at site, are then placed o0n the sleepers and linked. The portal cranes and sleepers layer works on the auxiliary track (3.4 metre gauge), which is laid in advance at the site of work. The various operations involved are as under.

A complete material train having the following rake is taken to site along with one locomotive at either end:

(1) Engine.

(2) BFR carrying 2 portal cranes.
(3) Empty BFRs for old panels.
(4) BFR carrying sleeper layer.
(5) BFRs carrying concrete sleepers.
(6) BFR carrying 2 portal cranes.
(7) Engine.

Note : (a) The number of empty BFRs (item iii) and the number of BFRs carrying concrete sleepers (item v) depend open the availability of block and the actual progress.

(b) One mobile workshop-cum van along with some emergency equipment i9s also taken to site along with the above rake.

(2) After the train has reached the site, the train formation is split in two parts with items (i) to (iii)on one side of the portion to be relaid and items (iv) to (vii) on the other side of this portion.

(3) The portal cranes are self unloaded from the BFRs on the auxiliary track. With the help of these two portal cranes, the sleeper layer is also unloaded from the BFR.

(4) The old track panels are lifted with the help of one or two portal cranes and loaded on the empty BFRs. As the old panels consist of rails laid on wooden or CST-9 or through sleepers, one panel can be easily lifted by one portal crane only.

(5) After the old track is removed, the ballast section is levelled up manually and brought to the required level.

(6) The concrete sleepers are then laid, one by one, at the requisite spacing and to proper alignment with the help of sleeper layer.

(7) The rails, which have been earlier unloaded at site, are then placed in position on the concrete sleepers with the help or rail gantries. The fittings and fastening are then provided to the newly laid track.

(8) The sleeper layer is loaded with the help of portal cranes in the BFR and the portal cranes are then self-loaded on to the BFRs.

(9) The block is then cleared as the new track is already linked.

(10) In case long welded rails or short welded panels are to be used, the track is first linked with the service rails and traffic allowed to pass on the same. When the track has sufficiently consolidated, the service rails are replaced by these L.W Rs. Or S.W.Rs. as the case may be.

In case there is difficulty of arranging two locomotives for the material train, the work can be managed even with one locomotives also by having material train formation as indicated below:

(i) Engine

(ii) BFRs carrying portal cranes

(iii) Empty BFRs for old panels.

(iv) BFRs loaded with concrete sleepers.

(v) BFRs carrying rails.

(vi) BFR carrying sleeper layer.

The progress of the work in the case is however, considerably reduced because of the longer leads the gantry cranes have to travel for lifting the concrete sleepers.

This method was tried on Indian railways, but the same has not been successful because of sleeper layer not efficiently function. The practice of relaying with complete PQRS equipment including sleeper layer is not being followed on Indian railways at present.

6.3 Relaying with Pre-fabricated Panels:

6.3.1. General

In this method, the sleeper layer is not required to be taken to site.Instead rail panels using concrete sleepers are assembled in a central base depot either using portal crane or with the help of a sleeper layer. For the sake of easy handling the Pre-assembled panels are of 9.1 metre length so that one portal crane of 5 tonnes capacity can handle one panel conveniently. These fabricated are loaded on BFR in 3 to 4 tier to form a PQRS Rake including empty BFRs. This PQRS Rake is taken to the site of work where the old panels are released and loaded into empty BFRs and new panels are laid in their places.

6.3.2. Composition of Rake

P.Q.R.S. Rake consist of following formation

(i) Engine

(ii) Coal wagon* (for recoupment of coal in engines)

(iii) Crew rest van*

(iv) Guard Brakevan*

(v) Mobile workshop-cum-rest Van*

(vi) BFR loaded with 2 portal cranes.

(vii) 6 to 8 BFRs for loading of released panels.

(viii) 2 empty BFRs for loading of released panels**.**

It may be noted that if the work is done in the direction of traffic, detention of P.Q.R.S. rake can be avoided.

6.3.3. Mode of working

The working of P.Q.R.S. equipment can be done in the following ways:

(a) Pulling method.

When engine leads in the direction of work and the work is done in the leading direction, it is called Pulling.

(b) Pushing method.

When engine is opposite to the direction of work is done in trailing direction, it is called pushing.

(c) Train Parting method.

In case of non availability of proper length of auxiliary track P.Q.R.S. rake is parted in two portions at site, and it is called 'Train Parting.' In this case, lot of time is wasted for parting and coupling and therefore this method is not very economical.

6.3.4 Sequence of operating:

(i) The auxiliary track is first laid at the location where relaying is to be done. The rails of the existing track to be relayed are also changed with 9.1 metre service rails in case of 9 tonnes of cranes.

(ii) A complete material train having the composition as indicated above and loaded with pre-fabricated panels is taken to the site of work after obtaining traffic block and power block in case of electrified section.

(iii) The portal cranes are then self-unloaded on the auxiliary track of 3.4 metre gauge.

(iv) The portal cranes are then utilised to lift two panels of 9.1 m of 13 m of existing track and load the same in empty BFRs. This is repeated second time so that four panels in existing track have been lifted and adequate working apace is available for the men to do spreading and levelling of ballast.

(v) The ballast bed is made up manually and levelled up to the prescribed level.

(vi) In the second round itself on return trip, the two portal cranes are utilised to lift two pre-assembled panels of concrete sleepers from the BFRs and lay them on the levelled ballast bed.

(vii) The procedure gets repeated so that in outer trip the two portal cranes lift two dismantled panels and place them in empty BFRs and on return trip, the portal cranes lift the two pre-assembled panels from loaded BFRs and lay them on the prepared bed.

(viii)The new panels are then linked up using fish plates, fitting and fastening.

(ix) The portal cranes are blocked back in BFRs and the block section is cleared. This method of relaying with prefabricated panels is quick and independent and is best suited under Indian conditions. It is possible to achieve with this method an average progress about 200 metres per effective hour of working by 9 tonne capacity portals. In a 4 hour gross block, a progress of about 0.6 to 0.8 kms of relaying can be obtained.

Sometimes only one portal crane is used for doing the track renewal work. In this case the sequence of operations will be the same except that output will be half in items of work done under para (iv), (vi) & (vii).

Base P. Way Depot

A suitable yard developed for receipt of concrete sleepers and other track components as well as for assembling of panels. Concrete sleepers are unloaded in the yard with the help of portal cranes and stacked at nominated place.

The base depot should ideally have 3 lines. A portion of two lines in the rear is used for stacking incoming concrete sleepers. A small siding of about 200 metres is also laid for stabling and repairing machine. The typical layout of basic depot is given in the figure.

Pre-assembled panels

For assembling of panels, concrete sleepers are laid by portal cranes almost at correct spacing and minor adjustment about spacing is done manually.

The rails in suitable lengths are then placed in position and fixed to sleepers with proper fittings and fastening. Assembled panels are then loaded in the relaying train in 3 of 4 tiers. Pre-assembled panels are now ready for actual relaying work.

6.3.5 Advantages/Limitations of relaying with P.Q.R.S. system:

Advantages:

(i) The damage to the concrete sleepers is avoided because of mechanised handling of the sleepers by P.Q.R.S. Equipment.

(ii) The work done is of better quality, as the track obtained has better alignment and the sleepers are laid to correct spacing.

(III) The concrete sleepers can be laid radially on curves with the help of P.Q.R.S. equipment, which is not possible in manual relaying.

(IV) No Pre-fabrications of panels is necessary as the work of laying the sleepers at the correct spacing and linking of track is done directly at site.

(V) The double handling of the concrete sleepers is avoided as the BFRs loaded with concrete sleepers are taken directly to the site.

(VI) The track can be packed with heavy 'on track' tie tempers immediately following the track relaying equipment, thereby giving by better quality of track and restoring the speed to normal in a laser time.

(VII) The requirement of labour is very much less, thereby not affecting the progress of works due to seasonal shortage of labour.

(VIII) The method many work out to be economical on a long term basis, particularly if long blocks are available and there is shortage of labour.

6.3.6 Limitations:

(i) An auxiliary track of 3.4 metres is to be lad in advance for operation of cranes and sleepers layer. This is quite a difficult job because this auxiliary track is to be laid in a block section, the position of which on goes on shifting every day.

(ii) As the concrete sleepers loaded in BFRs are directly taken to site, the rate of receipt of concrete sleepers has to synchronise with rate of progress of work. If this is not ensured, either there will be heavy accumulation of BFRs or double handling of concrete sleepers will have to be done by unloading them once and re-loading them again while doing the relaying work.

(iii) The equipment viz. Sleeper layer and cranes have to be kept constantly in good working condition; particularly the sleeper layer, which is single unit and is a sophisticated equipment, has to be kept in very good conditions. If this equipment fails due to some reasons, all relaying operations come to a standstill.

(iv) Blocks of long duration are required in order to make mechanised relaying an economical proposition. it is felt that laying of sleepers is a work, which can be done outside the block hours in a base depot.

(v) Heavy initial investment is involved as each P.Q.R.S. costs over Rs 15 lakhs.

It would be seen from the above that careful planning of men and material as well as availability of adequate and regular blocks are pre-requisites for the economical working of P.Q.R.S. equipment which sometimes become difficult to be ensured in actual practice.

6.4 Semi Mechanical Relaying System (SMRS)

Southern Railways has recently developed a new ‘Semi Mechanical Relaying System’ (SMRS) for laying of concrete sleepers. The method is particularly suited to Indian

conditions where on one side mechanical method of laying of concrete sleepers by PQRS system is very costly and on the other side manual system is crude and primitive and can damage a sophisticated concrete sleeper.

Following are the brief details of the new method:

(i) A special detachable ramp if 16 metre length, which is plane frame in plan, is indigenously manufactured with welded steel structural sections.

(ii) One end of the ramp is attached to the near head stock of a BFR wagon while the other end is attached with a single control wheel, running on ballast. On arrival of the SMRS special at the site, rear BFR provided with cleat arrangements for connecting the ramp is kept ahead of the first rail length to be relaid.

(iii) The first rail length is then dismantled, ballast levelled up and the ramp is slewed on to the ballast.

(iv) The front end of the ramp is then hooked and lifted by means of a pulley block fitted on a mini-portal on the BFR, and the ramp is fixed to the cleats on the BFR with two pins.

(v) The first sleeper is then slid manually along the ramp until it falls smoothly on the ballast at or near its final position.

(vi) The entire train formation is then moved forward approximately by 65 cm and the next sleeper unloaded. After unloading the sleepers for one rail length in the above manner, the rail end of the ramp is lifted either manually or by means le tripod with a pulley block and placed on a temporary support so that there is enough head room for men to go underneath and dismantle subsequent rail length of track. This process is repeated until as many panels as possible are relayed within the block period.

(v) With three similar sets of BFRs/coaching under frames, ramps and winches ,15 rail panels of 13m each could be conveniently laid in a block of two hours, which is normally the capacity of a PQRS machine.

In this new indigenous method, the concrete sleepers do not undergo any damage as fall is hardly 8cm. the method is quite economical and comparable progress as that o0f PQRS machine can be obtained with this method, utilising the same men power. The method is

particularly advantageous in special location like platform lines and ballasted deck bridges, where it is not possible to lay auxiliary track with PQRS system.

6.5 Track Renewal on European Railways System

In most of the European Railways, track renewals are done by using mechanical equipments. The following are some of the important methods adopted on the European Railways, particularly German Railways fo9r track renewal works:

(i) Method based on the use of Donelli portal cranes.

(ii) Method based on the use of Matisa gantry cranes.

(iii) Method based on the use of other portal cranes.

(iv) Method based on the used of Plasser High Speed Relaying train SUZ-2000 or SUZ-350.

All these methods have been developed by the European Railways in consultation with track machinery manufacturers viz. Matisa Donelli, Plasser & etc. The method (i), (ii) and (iii), referred to above, use cranes which run either on the normal track or on an auxiliary track to be laid. The exiting track is dismantled, lifted panel by panel by cranes, the ballast levelled up and new track with sleepers laid with the help of cranes, the following closely the track relaying machine are Tie Tamping machines to tamp the track so that the track can be restored to a minimum sped of 50 kmph after relaying. The average block requirement is 4 to 8 hours for these mechanical methods of track relaying and the average progress likely to be achieved is about 100 to 200 metres per hour of effective block.

6.6 Track Renewal method based on use of DONELLI Portal Cranes:

(a) General

The method is based on the use of a pair of self driving having portal cranes coupled by a chain beam for dismantling old track in 30m to 36m length panels, loading the same on empty wagons, picking up 60 new sleepers and laying the same at a fixed spacing. The two

portal cranes carrying a lifting beam run on an auxiliary track, having 3.28 metres gauge, and has got capacity of 14 tons each.

(b) Details of Donelli Portal Crane

The Donelli Crane consist of two portals carrying a lifting beam travelling on service rails. The capacity of the crane is 14 tonnes. The lifting beam has short chains with books at half sleeper apart. This spacing is adjustable as the chains are attached to clamps on a longitudinal beam. The rail clamps are operated by the crane operator from the control board and no man is necessary fixing the same to the rails.

(c) Preliminary works:

The following preliminary works are done:

(i) Spreading new rails; 120 feet long rails are unloaded at site by end unloading method.

(ii) Laying of auxiliary track at 3.28 metre gauge.

(a) Sequence of operations

The following is the sequence of main operations of the relaying works:

(i)***Dismantling old track:*** -The old track is gas cut in 30 metre panels and loaded in an empty wagons rake by means of Donelli crane.

(ii)***Levelling of ballast:***- The ballast is levelled by means of ballast plough or a bull dozer.

(iii)***Laying of new track:*** - After the ballast bed is levelled, the Donelli Crane picks up 60 nos. New PRC sleepers from the wagon, one in each hook and takes the sleepers down to the prepared ballast bed in 2 operations. A template is used to check the spacing of the sleepers.

The new rail, already unloaded are then placed on the new sleepers with the help of small gantries and the track is linked. The rail ends are joined by fish plates and special clamps.

(b) The track is subsequently aligned, ballast cleaned, mechanical tamping done, ballast suitably profiled by T.T. machines, ballast cleaner and ballast profiler.

(c) Out-put

The normal output with Donelli method is about 180 metres/hour. Each cycle of Donelli Crane for replacing 30 metres track takes about 10 minutes.

The machine, normally has the following blocks and output:

3 to 6 hours block	.....	500 to 800 metres
6 to 9 hours block	.....	800 to 1300 metres
Continuous operation of line (work for 10 hours period)	.....	1200 to 1500 metres

The method used by matisa gantry cranes as well as by other portable cranes are almost similar to the above and are therefore not proposed to be discussed hare.

6.7 Track renewal method based on use of 'Plasser High Speed Relaying Train SUZ-2000.

The above method, based on the use of 'Plasser High Speed Relaying Train, instead of. SUZ-2000, adopted by German Railways, is the most modern method of track relaying with mechanical Equipments. The relaying works is carried out with help of Plasser Quick Relaying Train which is about 600 to 800 metres long and has three essential units:

(i) A conveyor belt unit which removes the rails on which it has been travelling.

(ii) A grader which is trackless and levels and prepares the ballast bed dor new sleepers.

(iii) A second conveyor belt unit which travels on the new track, which it has just laid.

Moving at a speed of about 220 metres per hour, the SUZ-2000 is able to give a progress of about two kms per day in a block of 8 to 10 hours duration. All the operations in this method are, however, automatic and the method suffers from the serious limitation that if one unit fails due to any breakdown, the whole train just comes to a stop.

The cost of the train is likely to be in the range of 2 to 3 crores. It is debatable, however, to what extent such a sophisticated and costly but highly productive system of track relaying is suitable for Indian conditions at present. With ambitious track renewal programme of Indian Railways using concrete sleepers and LWR track, it may be worthwhile to go in for this highly productive system of track renewals by track relaying trains in a limited way.

6.8 Track Renewal Train (T.R.T.) for Indian Railways

Indian Railways have recently purchased two Track Renewal Trains (T.R.T.) of suitable design, which can carry entire track relaying work automatically with minimum manual efforts and can give an average output of about 200 to 250 Kms. Annually in a traffic block of 4 hours every day.

Track renewal trains purchased are of P-811 model and have been manufactured by Tamper corporation of U.S.A.

1. General Description of Track Relaying Train

The track relaying train is designed to replace simultaneously and continuously all operations involving replacement of rails and sleepers. The train is designed to carry out various multifarious functions such as removal of old rails, removal and stacking of old sleepers, levelling and compacting of ballast bed, placing new sleepers in position, laying of new rails and removal of released rails.

Fig 6.2 Track Relaying Train

The train consist of the following main units:

(i) **The main vehicle**. This consists of a sleeper handling vehicle permanently coupled to the power unit vehicle by a joint. The two form a standard railway vehicle unit which is self-powered when working or can be hauled by a locomotive or attached to train convey.

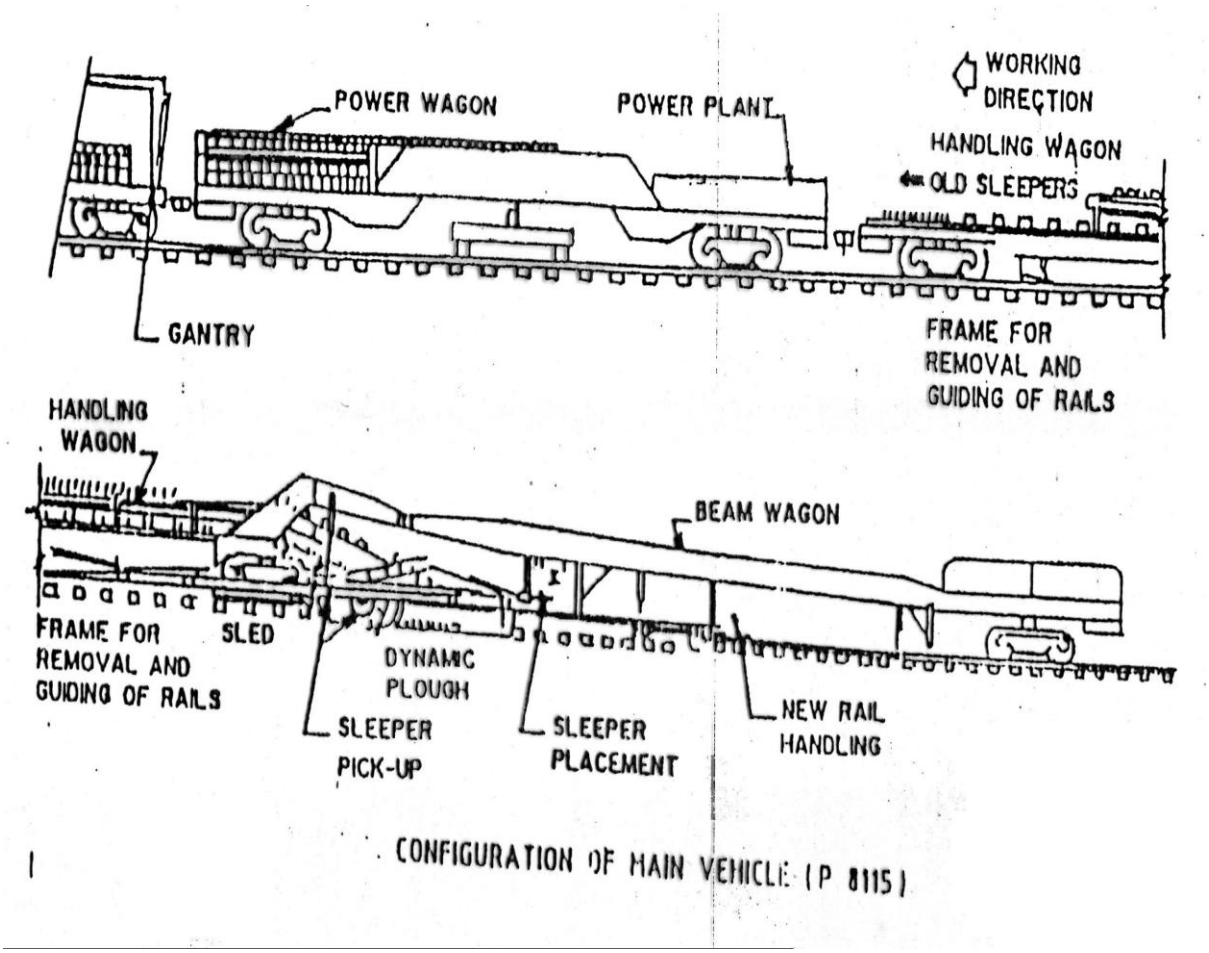

Fig 6.3 parts of Track Relaying Train

The sleeper replacement unit is suspended at the location of the ball joint between the two vehicles. This unit includes a triangular smoothing plough and a compaction plate to prepare the ballast bed for the reception of the new sleepers.

The sleepers handling vehicle is fitted with a guidance system which directs the old rails to the side of the track and with a number of conveyors to remove the old sleepers and to9 the replace them with new material. The power unit vehicle is fitted with a system to position the new rails and has a cabin which houses the power unit.

The main vehicle weighs about 110 tonnes and has an overall length of about 45 metres.

(*ii)Handling gantry*: The trains has handling gantry for the transport for old and new sleepers. The gantry weighs about 6.6 tonnes and has lifting force of about 20 concrete sleepers and can travel at a maximum speed of 15 kmph.

(iii)A set of B.F.R.: for the storage old and new sleepers. These are fitted with an inter-connecting rail track on which the handling gantry runs.

The renewal train cam be couple with a normal train and can have a speed up to 100 kmph. The train can, however, move independently with hydraulic drive its speed while working is maximum 720 m per hour.

3. Working programme

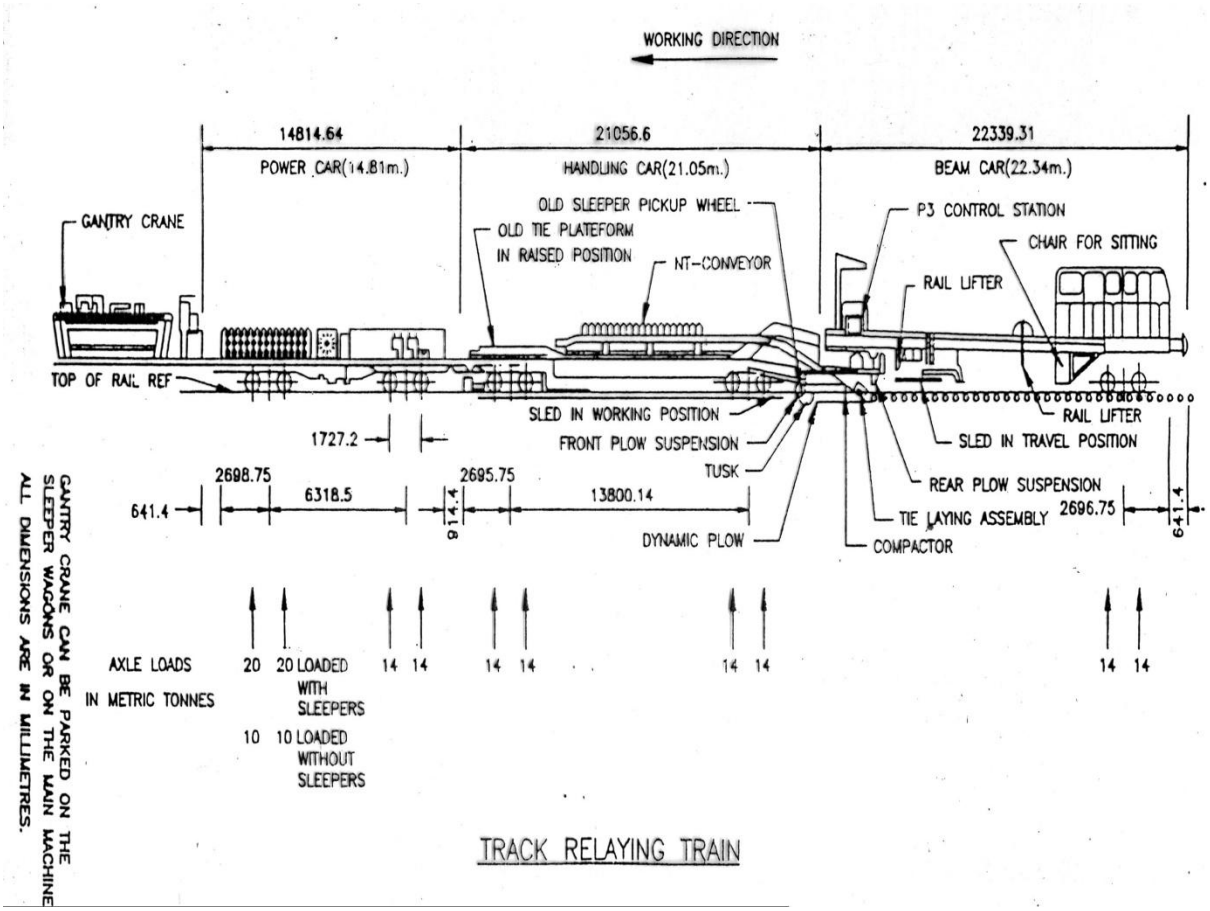

Fig 6.4 Working of Track Relaying Train

(i) **Removal of fastening***:* The fastenings of old rails to sleepers are removed in advance of track renewal work.

(ii) **Placement of new rails***:* The new rails are placed in advance on either side of the track duly welded or fish plated at a distance of 1.5 metres from the track.

(iii) **Positioning of the track:** The main vehicle is now positioned on the track to be renewed : The design of the machine is such that with help of ;guidance sled'. The machine is located in the track at three points : The front and rear bogies and the sled at the centre. The guidance sled rests on the old sleepers at the point made free by the removal of the old trains. This design ensures an accurate reproduction of the old track layout without the need for an external machine guidance system.

(iv) **Lifting of old rails** *:* The old rails which are already free from fastenings, are lifted and properly guided, with the help of 'Rail lifting and guidance frame.' The machine continuously lifts the old rails and deposits them on either side of the track.

This enables are ballast to be screened at the same time in necessary, while the rails are resting on the ends of the sleepers.

(v) **Picking up of old sleepers** *:* the old sleepers are picked up with the help of sleeper pick up system and these are placed upright on the conveyor system. With the help of chain conveyor belts, the old sleepers are carried and stored on the train in stack of 4 layers separated by dunnage with the help of handling gantry.

(vi) **Levelling & compaction of ballast bed** *:* Following the old sleeper pick up position is a vibratory plough and compacter. This plough levels the ballast ready to accept the new sleepers. The plough can be adjusted vertically to remove ballast as necessary. The plough can be remove up to 80 mm of ballast bellow the button of the sleepers, moving it to the shoulders.

A smooth track bed is thus made and compacted with the help of plough and computer.

(vii) **Laying of new sleepers** *:* The new sleepers are already stacked on the train in wagons. New sleepers are now placed automatically at a specified distance by using a wheel of specific circumference, the wheel sends a signal after each revolution to the sleepers spacing mechanisms giving accurate sleeper positioning (.10 mm). Because of the unique geometry of this mechanisms, the system ensures that sleepers are laid square and at specified distance.

When in curves, the mechanism is positioned at 90* to the inside rail which insures that the sleepers are always radial to the track.

Once the sleepers have been laid, rail pads are positioned correctly in the rail seats.

(viii) **Laying of new rails** *:* The new rails, which are already lying along the track, are then lifted and put in the position on the sleepers. The equipment is so designed as to cause minimum stress on the new rails while lifting.

*(ix)***Fixing of insulators and elastic rail clips** *:*

Attached behind the P 811 S machine is a wagon containing elastic rail clips and insulators. Two labourers place these adjacent to each sleeper. To additional labourer then position the rail clips and insulators in the correct position on the sleeper. Following this wagon is a clip applicator which fits the elastic rail clip into position, thereby, capturing the rail.

*(x)***Picking up of old rails** *:* The final operation is to remove the old rails. It is necessary prior to rail pickup to cut the rail into 39 metres length for proper handling. There wagons towed by utility vehicle (UTV), containing a mobile crane then pick up the old rails and place them onto the wagons for transporting to the depot.

4 Ancillary machines

The following Ancillary machines are also proposed to be procured to make the track renewal train fully automatic and complete all works independently:

(i) Lip cutting machine : To cut the lip of reserve jaw of CST-9 sleeper so that the rails can be taken off from the track without any problem.

(ii) A mechanism : for lifting the old released rails and loading them in the BFRS. This mechanism can follow the track renewal train.

(iii) Bolt tightening machine : which can handle the bolts and tighten/loosen as the case may be.

(iv) Clip applicator which can drive the portal clips.

5 Progress of work

The manufacturers claim that this train has a speed of laying 16 sleepers/ minute and can give an average output of 300 to 400 metres/hour. In an average block of 4 hours, each day, it is expected that this train will be able to give an average output of 200 to 250 kms per year.

CHAPTER-7

RESULTS AND DISCUSSION

Statistical analysis shows that most defects occur in operation stage. After operation stage, most defects occur during manufacture and maintenance. Among the studied statistical society, 1.2 % of manufactured sleepers had defects, which 0.3 % of them are used in secondary lines and the remaining 0.9 % are discarded. In case of operation defects 0.35 % sleepers are replaced in current maintenance each year.

According to identification of concrete sleeper defects reason and using appropriate solutions to control them, it is expected to reduce the manufacturing defects, from 0.9 to 0.6 %.

CHAPTER-8

CONCLUSION AND RECOMMENDATIONS

1. There is cope of improvement in quality-
    - SBT- Rail seat load can be enhanced from 220 KN To 230KN if not 240 KN.
    - More than 80% of the plant are already achieving these quality standard.
    - Improved SBT may enhance the fatigue life of the product.
2. Human interference can be done away by using computerization of activities-
    - In automatic weigh batching.
    - Using water meter for controlling w/c ratio.
    - In tensioning of strands.
    - Digital gauge and computer analysis of test data acquisition in the plant laboratory.
    - Calibration of all testing equipments.
3. Fabricated one piece pressed mould-
    - May help in eliminating failure on a/c of physical parameters such as gauge and rail seat slope.
    - Thicker size of flat plate i.e. 10 mm is desirable.
    - Use of lighter engineering material in place of heavier steel.
4. Level of supervision needs to be enhance.
5. Dedicated staff needs to be deputed for meticulous supervision in concrete sleeper plants.
6. Imparting minimum training say by RDSO.
7. "The Acceleration TRAP"

    Discouraging the multiplication of production capacity many-fold at the cost of quality because of shared manpower and laboratory testing equipments which is grossly inadequate for ensuring quality control on numerous activities in manufacturing of PSC sleepers. Thus advising concrete sleeper plants not to fall in "the Acceleration TRAP".

- Fresh investment in technology innovation.
    - Use of better quality of Boiler.
    - Energy saving will prove substantially economical in long run.

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