CHAPTER

7

Sleepers

Introduction

Sleepers are the transverse ties that are laid to support the rails. They have an important role in the track as they transmit the wheel load from the rails to the ballast. Several types of sleepers are in use on Indian Railways. The characteristics of these sleepers and their suitability with respect to load conditions are described in this chapter.

7.1 Functions and Requirements of Sleepers

The main functions of sleepers are as follows.

(a) Holding the rails in their correct gauge and alignment
(b) Giving a firm and even support to the rails
(c) Transferring the load evenly from the rails to a wider area of the ballast
(d) Acting as an elastic medium between the rails and the ballast to absorb the blows and vibrations caused by moving loads
(e) Providing longitudinal and lateral stability to the permanent way
(f) Providing the means to rectify the track geometry during their service life.

Apart from performing these functions the ideal sleeper should normally fulfil the following requirements.

(a) The initial as well as maintenance cost should be minimum.
(b) The weight of the sleeper should be moderate so that it is convenient to handle.
(c) The designs of the sleeper and the fastenings should be such that it is possible to fix and remove the rails easily.
(d) The sleeper should have sufficient bearing area so that the ballast under it is not crushed.
(e) The sleeper should be such that it is possible to maintain and adjust the gauge properly.
(f) The material of the sleeper and its design should be such that it does not break or get damaged during packing.
(g) The design of the sleeper should be such that it is possible to have track circuiting.

(h) The sleeper should be capable of resisting vibrations and shocks caused by the passage of fast moving trains.
(i) The sleeper should have anti-sabotage and anti-theft features.

7.2 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 of the rail in metres and x is a number that varies according to factors such as (a) axle load and speed, (b) type and section of rails, (c) type and strength of the sleepers, (d) type of ballast and ballast cushion, and (e) nature of formation.

If the sleeper density is $M + 7$ on a broad gauge route and the length of the rail is 13 m, it means that 13 + 7 = 20 sleepers will be used per rail on that route. The number of sleepers in a track can also be specified by indicating the number of sleepers per kilometre of the track. For example, 1540 sleepers/km. This specification becomes more relevant particularly in cases where rails are welded and the length of the rail does not have much bearing on the number of sleepers required. This system of specifying the number of sleepers per kilometre exists in many foreign countries and is now being adopted by Indian Railways as well.

The spacing of sleepers is fixed depending upon the sleeper density. Spacing is not kept uniform throughout the rail length. It is closer near the joints because of the weakness of the joints and impact of moving loads on them. There is, however, a limitation to the close spacing of the sleepers, as enough space is required for working the beaters that are used to pack the joint sleepers. The standard spacing specifications adopted for a fish-plated track on Indian Railways are given in Table 7.1. The notations used in this table are explained in Fig. 7.1.

Table 7.1 Spacing of sleepers for a fish-plated track

Spacing of sleepers	*Broad gauge centre-to-centre spacing (mm)*		*Meter gauge centre-to-centre spacing (mm)*	
	Wooden	*Metal*	*Wooden*	*Metal*
Between joint sleepers (a)	300	380	250	330
Between joint sleepers and the first shoulder sleeper (b)	610	610	580	580
Between first shoulder sleeper and second shoulder sleeper (c) for sleeper density $M + 4$	700 (640)*	720 (630)	700 (620)	710 (600)
Between intermediate sleepers (d) for sleeper density $M + 4$	840 (680)	830 (680)	820 (720)	810 (640)

* Values within parentheses are those for sleeper density $M + 7$.

Now-a-days sleeper density is also indicated in terms of the number of sleepers/km. The sleeper spacing required for various sleeper densities is given in Table 7.2.

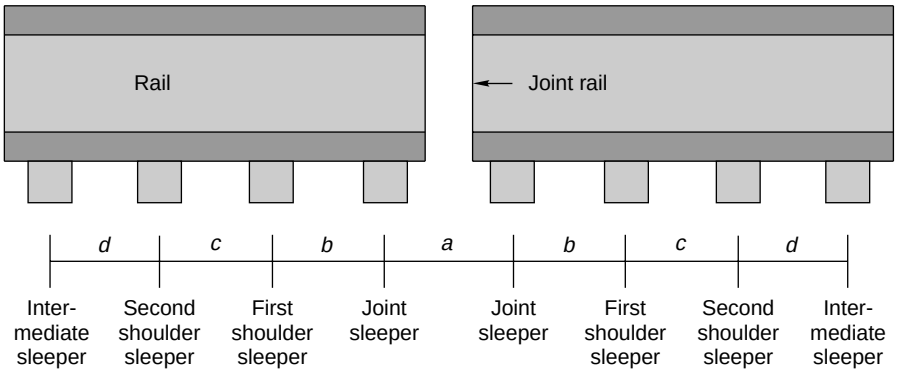

Fig. 7.1 Spacing of sleepers on a fish-plated track

Table 7.2 Spacing of sleepers for welded track

No. of sleepers per km	*Exact centre-to-centre spacing required as per calculation (mm)*	*Centre-to-centre spacing to be provided in the field (mm)*	
		LWR track	*SWR track*
1660	602.4	600	–
1540	649.3	650	660
1310	763.3	–	780

7.3 Types of Sleepers

The sleepers mostly used on Indian Railways are (i) wooden sleepers, (ii) cast iron (CI) sleepers, (ii) steel sleepers, and (iv) concrete sleepers. Table 7.3 compares the important characteristics of these types.

Table 7.3 Comparison of different types of sleepers

Characteristics	*Type of sleeper*			
	Wooden	*Steel*	*CI*	*Concrete*
Service life (years)	12–15	40–50	40–50	50–60
Weight of sleeper for BG (kg)	83	79	87	267
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

(*contd*)

Table 7.3 (*contd*)

Characteristics	*Type of sleeper*			
	Wooden	*Steel*	*CI*	*Concrete*
Type of maintenance	Manual or mechanized	Manual or mechanized	Manual	Mechanized only
Cost of maintenance	High	Medium	Medium	Low
Gauge adjustment	Difficult	Easy	Easy	No gauge adjustment possible
Track circuiting	Best	Difficult; insulating pads are necessary	Difficult; insulating pads are necessary	Easy
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
Suitability for fastening	Suitable for CF* and EF†	Suitable for CF and EF	Suitable for CF only	Suitable for EF only
Track elasticity	Good	Good	Good	Best
Creep	Excessive	Less	Less	Minimum
Scrap value	Low	Higher than wooden	High	None

* CF stands for conventional fastening.
† EF stands for elastic fastening.

7.4 Wooden Sleepers

The wooden sleeper is the most ideal type of sleeper, and its utility has not decreased with the passage of time. The wooden sleeper has the following features.

Specifications The size of a wooden sleeper should be economical. It should provide the desired strength to the sleeper as a beam as well as adequate bearing area. The depth of a sleeper governs its stiffness as a beam and its length and width control the necessary bearing area. The bearing length under each rail seat is 92 cm (3 ft) for a BG wooden sleeper, thereby giving an area of 2325 cm^2 under each rail seat. The sizes of sleepers used for BG, MG, and NG as well as the bearing area per sleeper are given in Table 7.4.

Table 7.4 Sizes of wooden sleepers and bearing areas

Gauge	*Size (cm)*	*Bearing area per sleeper (m^2)*
BG	275 × 25 × 13	0.465
MG	180 × 20 × 11.5	0.3098
NG	150 × 18 × 11.5	0.209

Wooden sleepers required for bridges, points, and crossings are of a thicker section—25 cm × 15 cm or 25 cm × 18 cm.

Composite sleeper index The composite sleeper index (CSI), which evolved from a combination of the properties of strength and hardness, is an index used to determine the suitability of a particular timber for use as a sleeper from the point of view of mechanical strength.

The CSI is given by the formula

$$\text{CSI} = \frac{S + 10H}{20} \tag{7.1}$$

where S is the figure for the general strength for both green and dry timber at 12% moisture content and H is the figure for the general hardness for both green and dry timber at 12% moisture content. The minimum CSI prescribed on Indian Railways are the following.

Type of sleeper	*Minimum CSI*
Track sleeper	783
Crossing sleeper	1352
Bridge sleeper	1455

Bearing plates are invariably used on sleepers with a CSI value of 82 or less. The CSI values for some of the timber species recommended by Indian Railways for making sleepers are as follows.

Sal	112
Teak	82
Deodar	63
Chir	54

Wooden sleepers have the following main advantages and disadvantages.

Advantages

(a) Cheap and easy to manufacture
(b) Absorbs shocks and bears a good capacity to dampen vibrations; therefore, retains the packing well
(c) Easy handling without damage
(d) Suitable for track-circuited sections
(e) Suitable for areas with yielding formations
(f) Alignment can be easily corrected
(g) More suitable for modern methods of maintenance
(h) Can be used with or without stone ballast
(i) Can be used on bridges and ashpits also
(j) Can be used for gauntleted track

Disadvantages

(a) Lesser life due to wear, decay, and attack by vermin
(b) Liable to mechanical wear due to beater packing
(c) Difficult to maintain the gauge
(d) Susceptible to fire hazards
(e) Negligible scrap value

At present wooden sleepers are being procured from the State Forest Departments. A detailed inspection of sleepers is done at the time of procurement to ensure that the sleepers accepted are of good quality and free from defects. The main defects normally found in sleepers are

(a) Centre heart
(b) Presence of knots, warps, wanes, and shakes
(c) Split ends
(d) Twisted or cross grains

The normal service life of wooden sleepers in India is only about 15 years as against a much longer service life obtained on other advanced railways. The weather conditions, particularly the rains, humidity, etc., are responsible for the shorter life-span of these sleepers in India. A committee was appointed by the Railway Board in the year 1972 to examine the measures for increasing service life and improving the utilization of wooden sleepers. The main recommendations of this committee are as follows.

(a) Sleepers should be procured in nominated sleeper depots of the Railways. The inspection of sleepers should also be done by the Railways in addition to the Forest Department.
(b) The net retention of creosote and fuel oil (in the ratio of 1:1) for the sleeper should be a minimum of 8 lb/ft^3.
(c) Bearing plates and elastic fastenings as well as modern methods of maintenance such as measured shovel packing (MSP) and mechanical tamping should be progressively used with wooden sleepers to avoid damage to the sleepers and ensure a longer life for them. Bearing plates should be compulsorily used when traffic density exceeds 20 GMT on BG routes and 5 GMT on MG routes as well as on joint sleepers and on curves of radius 1,500 metre and sharper curves.
(d) Spike-killed sleepers should be systematically reconditioned.
(e) Track depots should be organized in each railway to undertake the operations of end-binding, adzing, and pre-boring of sleepers.

7.4.1 Durable and Non-durable Types of Sleepers

Wooden sleepers may be classified into two categories, durable and non-durable.

Durable type

Durable sleepers do not require any treatment and can be laid directly on the track. The Indian Railway Board has classified particular categories of sleepers as the durable type. These are sleepers produced from timbers such as teak, sal, nahor, rosewood, anjan, kongu, crumbogam kong, vengai, padauk, lakooch, wonta, milla, and crul.

Non-durable type

Non-durable sleepers require treatment before being put on the track. Non-durable sleepers are made of wood of trees such as chir, deodar, kail, gunjan, and jamun.

If a non-durable type of sleeper is put onto the track directly without any preservative treatment, the sleeper will decay in a very short time. If, however, such sleepers are treated before use, they last longer and their life is comparable to that of durable sleepers. Fir sleepers, however, have not provided good service and their use has been restricted to only those trunk routes and main lines where traffic density is not more than 10 GMT [gross million tonne(s) per km/annum]. The primary service life of a wooden sleeper is approximately as follows:

	BG	MG
Durable	19 years	31 years
Non-durable	12.5 years	15.5 years

7.4.2 Treated and Untreated Sleepers

Wooden sleepers are also sometimes classified as hard wood and soft wood sleepers depending upon the origin or species of the wood of which these are made. Broadly speaking, timber produced from trees with broad leaves is known as *hard wood* and that obtained from trees bearing long leaves is considered *soft wood*. Some of the hard wood varieties also require treatment before being used in the track. As per the recommendations of the committee, the use of the terms 'durable' and 'non-durable' as well as 'hard' and 'soft' should be done away with to avoid confusion. The committee recommended that for simplification and rationalization, wooden sleepers should be classified in two categories:

(a) 'U' or *Untreated sleepers* comprising of all the sleepers made of wood from naturally durable species.
(b) 'T' or *Treated sleepers* consisting of the rest of the sleepers.

Treatment of sleepers

Indian Railways has set up four sleeper treatment plants at the locations given below for treating non-durable sleepers:

Dhilwan (Punjab) in Northern Railways	1923
Naharkatia (Assam) in North Frontier	1928
Clutterbuckganj (UP) in North East	1955
Olvakot (Kerala) in Southern Railways	1957

All these plants utilize the pressure treatment process and the preservative is forced into the wood under pressure using any one of the following three methods.

Full cell (Bethell) process In the Bethell process, a cylinder loaded with the charge for about 300–400 sleepers is first subjected to a vacuum of 55–60 cm of mercury for 20–30 minutes by means of a vacuum pump. Hot creosote oil is then forced into the cylinder at a pressure of 150–180 psi at a temperature of 180°F. This pressure is maintained for a period of 50–70 minutes till the desired amount of absorption is obtained. Thereafter, the pressure is reduced and the cylinder is drained off the creosote oil. A final vacuum of 55 cm of mercury is applied to free the timber of excess preservative. The whole process takes about 2–3 hours. This process is normally used when maximum retention of creosote oil is required for a particular type of sleeper such as that made of kail, deodar, fir, etc. At present this method is in use in Olvakot, Clutterbuckganj, and Dhilwan plants for various types of wood.

Empty cell (Rueping) process In the Rueping process, wooden sleepers loaded into the cylinder are first subjected to an initial air pressure of 3.5 to 5.25 kg/cm^2 for about 20–30 minutes. Afterwards, without reducing the pressure, hot creosote oil is forced into the cylinder at a temperature of 180°C to 210°C. The pressure is then raised to a value of 10.5–19.6 kg/cm^2 and maintained for a period of 20–30 minutes till the desired absorption is achieved. Finally, the pressure is released, the cylinder is drained off the creosote, and a final vacuum of 55 cm of mercury is created to drain off the excess preservative. The whole process of treatment takes about 2–3 hours per charge. This process is generally employed for treating porous timbers and is used in Dhilwan and Clutterbuckganj depots for chir sleepers. In this process, air in the cell is entrapped, thereby limiting the preservative to be absorbed by the sleeper to a certain extent.

Empty cell (Lowry) process In the Lowry process, the cylinder loaded with timber charge is filled and then subjected to a pressure of 180 lb, which is sufficient to ensure proper impregnation. The cylinder is then drained off and the timber subjected to a final vacuum of 55 cm of mercury for a period of 45 minutes or so. The air entrapped in the timber cells forces the excess preservative out. Preservative recovery is greater in this case than in the full cell process but is less than in the Rueping process. This process is used in the Naharkatia plant for very green species of timber.

Prophylactic treatment of sleepers Prophylactic treatment is given to the sleepers by using patent chemicals such as arsenic pentaoxide, copper sulphate, and potassium dichromate solution in water 1:3:4 wt (60%) to prevent infection at the forest head and in the treatment plant. This is necessary an as appreciable amount of time elapses in transferring the sleepers from the forest depots to the treatment plant.

Seasoning of sleepers

Wooden sleepers are seasoned to reduce the moisture content so that their treatment is effective. The Indian Standard code of practice for preservation of timber lays down that the moisture content in the case of sleepers to be treated by pressure treatment should not be more than 25%.

The seasoning of sleepers can be done by any one of the following processes.

Artificial seasoning in kiln This is a controlled method of seasoning the timber, normally used in the USA and other advanced countries, under conditions of temperature and relative humidity, which are in the range of natural air seasoning.

Boulton or boiling under vacuum process This is a process in which unseasoned wood is treated with hot preservative to remove the moisture content. This is adopted in the Naharkatia depot.

Air seasoning This is the method adopted extensively for the seasoning of wooden sleepers in India. The sleepers are stacked in the timber yard and a provision is made for enough space for the circulation of air in between the sleepers. The sleepers are stacked in any one of the following ways:

(a) One and nine method (Fig. 7.2)
(b) Close crib method
(c) Open crib method (Fig. 7.3)

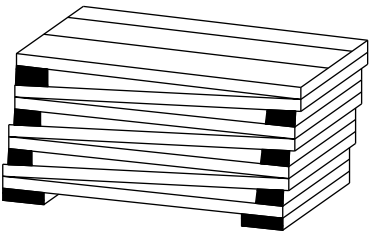

Fig.7.2 One and nine method

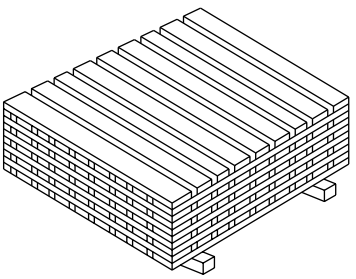

Fig. 7.3 Open crib method

Normally, the one and nine method is adopted on Indian Railways for stacking the sleepers. About 6 months are required to air season the timber fully by this method.

7.4.3 Laying of Wooden Sleepers

Great care should be taken in laying wooden sleepers. Untreated wooden sleepers should be laid with the sapwood side upwards and the heartwood side downwards so as to ensure minimum decay due to fungus, etc., attacking from below. More moisture would also percolate into the sleepers if laid otherwise. In the case of treated sleepers, however, the heartwood side is kept upwards and the sapwood side downwards. This is done because the sapwood side contains more creosote and is liable to less damage from vermin and fungus.

7.4.4 Adzing of Wooden Sleepers

In order to enable the rails to be slightly tilted inwards at a cant of 1 in 20, wooden sleepers are required to be cut to this slope at the rail seat before laying. This process of cutting the wooden sleeper at a slope of 1 in 20 is known as ‘adzing of the wooden sleeper’.

It may be pointed out that adzing or cutting of a wooden sleeper at a slope of 1 in 20 is done with great care, otherwise the slope will vary from sleeper to sleeper resulting in a rough ride. The adzed surface of a wooden sleeper is treated with

coal tar or creosote to ensure proper protection of the surface. Normally, adzing of a wooden sleeper is done only when bearing plates are not provided.

7.5 Steel Channel Sleepers

In view of the great shortage of wooden sleepers, steel channel sleepers have been developed by Indian Railways particularly for use on girder bridges. Steel channel sleepers can be used for welded plates, riveted plates, as well as open web girders.

Composite sleepers have been developed indigenously in India as a replacement for wooden sleepers. These are made from waste products such as used rubber tyres, and the manufacturers claim a lifespan of about 40 years for these sleepers. The Patel Group of Industries is one such firm that has developed these composite sleepers.

Composite sleepers are similar to wooden sleepers and use similar fittings. These sleepers are under trial and the results so far have been quite encouraging.

7.6 Steel Trough Sleeper

About 27% of the track on Indian Railways is laid on steel sleepers (Fig. 7.4). The increasing shortage of timber in the country and other economical factors are mainly responsible for the use of steel sleepers in India. Steel sleepers have the following main advantages/disadvantages over wooden sleepers.

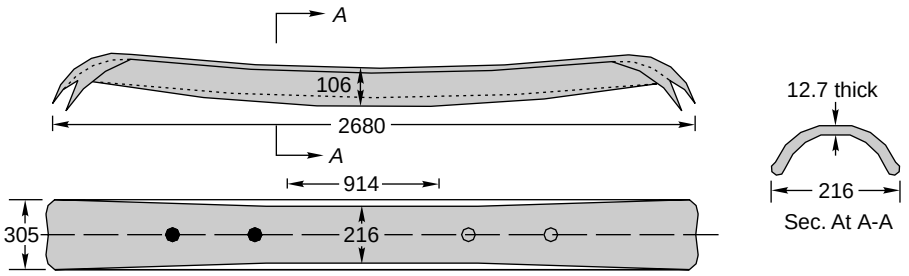

Fig. 7.4 Steel trough sleeper (BG 90 R)

Advantages

(a) Long life
(b) Easy to maintain gauge and less maintenance problems
(c) Good lateral rigidity
(d) Less damage during handling and transport
(e) Simple manufacturing process
(f) Very good scrap value
(g) Free from decay and attack by vermin
(h) Not susceptible to fire hazards

Disadvantages

(a) Liable to corrode
(b) Unsuitable for track-circuited areas

(c) Liable to become centre-bound because of slopes at the two ends
(d) Develops cracks on rail seats during service
(e) Design is rail specific

7.6.1 Design Features

The steel trough sleeper essentially consists of a rolled steel plate of about 2 mm thickness pressed into a suitable trough shape and the rail seat canted to 1 in 20. The ends of the rolled section are flattened out in the shape of a spade to retain the ballast. Two alternative types of sleepers have been designed for each rail section as per the following details.

1. In one type, the lugs or jaws are pressed out of the plate itself to accommodate the foot of the rail and the key (Fig. 7.5). There are several 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 sleeper design has been adopted. In this design, two holes are punched into either side of the plate to accommodate specially designed 'loose jaws' (Fig. 7.6). The rails are held with the help of two standard keys driven either into the pressed up lugs or into the loose jaws.

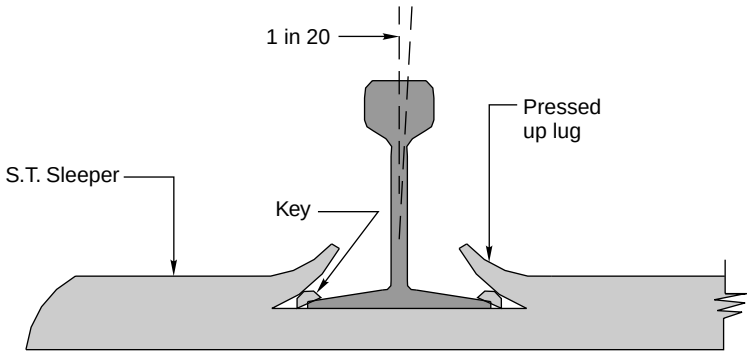

Fig. 7.5 ST sleeper with pressed up lugs

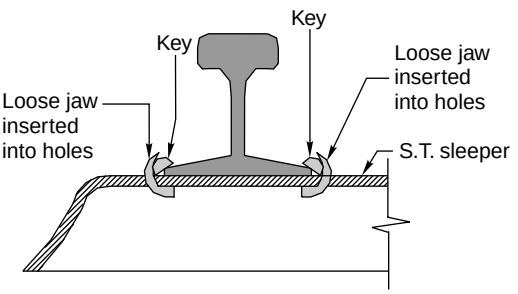

Fig. 7.6 Sleeper with losse jaws inserted into holes

The adjustment of the gauge to the extent of ± 3 mm is done by properly driving in the keys. In the double-line section, the keys are driven in the direction of the traffic. The approximate weight of a standard BG trough sleeper is 81 kg and that of an MG sleeper is 35 kg. The steel trough (ST) sleeper has an average life of about 50 years. It is an acceptable type of sleeper for use with long welded rails because of its lateral stability and its adaptability for use along with elastic fastenings.

7.6.2 Classification

All steel sleepers conforming to Indian Railways specifications T-9 are classified as first quality sleepers. The sleepers not accepted as first quality but free from the following defects are termed second quality steel trough sleepers.

(a) Inward tilt at rail seat beyond the limits of 1 in 15 to 1 in 25
(b) Sleepers with a twist
(c) Heavy scale fitting or deep grooves or cuts
(d) Deep guide marks at heads, blisters, etc.

All first quality sleepers are normally marked by a green dot. Sleepers that have been rejected as first quality sleepers on account of pipes, seams, and laps but are free from the defects indicated above are marked with a cross (×) in yellow paint at the centre. All other second quality steel trough sleepers are marked distinctly with a 15-cm-wide strip of yellow paint at one end. Sleepers that are unfit as second quality are given a distinct red paint mark to avoid mixing them up with first and second quality sleepers during loading.

7.6.3 Maintenance Problems

It has been noticed that the keys used to fix rails on steel sleepers tend to become loose due to the bending of the pressed up lugs or due to wear at the rail seat. The holes also get elongated during service. Special types 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 holding the correct gauge for oblong holes with loose jaws. Another maintenance problem with steel trough sleepers is that these tend to become centre-bound if due care is not taken while packing. The ballast is normally removed from the centre of the sleepers after packing so as to ensure that centre binding of the sleepers does not take place. Sometimes the alignment of steel sleeper tracks also gets affected by the overdriving of the keys.

7.7 Cast Iron Sleepers

Cast iron sleepers are being extensively used on Indian Railways and about 45% of the track at present consists of CI sleepers, which may be either pot type or plate type. The main advantages and disadvantages of CI sleepers over steel trough sleepers are the following.

Advantages

(a) Less corrosion
(b) Less probability of cracking at rail seat

(c) Easy to manufacture
(d) Higher scrap value

Disadvantages

(a) Gauge maintenance is difficult as tie bars get bent
(b) Provides less lateral stability
(c) Unsuitable for track-circuited lines
(d) Not very suitable for mechanical maintenance and/or MSP because of rounded bottom
(e) Susceptible to breakage

CI pot sleepers

Cast iron pot sleepers (Fig. 7.7) consist of two hollow bowls or pots of circular or elliptical shape placed inverted on the ballast section. The two pots are connected by a tie bar with the help of cotters and gibs; the gauge can be adjusted slightly [± 3 mm (1/8″)] by changing their positions. The rail is placed on top of the pots in a rail seat provided with a cant of 1 in 20 and is held in position with the help of a key. The pot sleeper suffers from the drawback that it cannot be used on curves sharper than 4° on BG. Most of the fittings are hidden and their inspection and maintenance is quite difficult. These sleepers have become obsolete now and are not being procured by the Indian Railways any more.

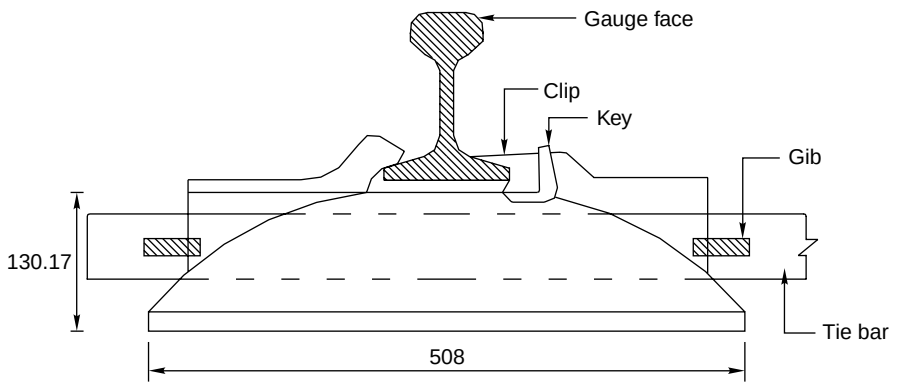

Fig. 7.7 CI pot sleeper (dimensions in mm)

CST-9 sleepers

The CST-9 sleeper is a standard sleeper and is being most extensively used on Indian Railways (IR). It is called CST-9 (Central Standard Trial-9) (Fig. 7.8) because it is the ninth of the series produced by the Central Standard Office. The sleeper is a combination of pot, plate, and box sleepers. It consists of two triangular inverted pots on either side of the rail seat, a central plate with a projected keel, and a box on top of the plate. The two CI plates are connected by a tie bar with the help of four cotters. The rails are held to the sleeper by two-way keys provided at each rail seat on the side of the gauge face. The gauge is adjusted to a value of ± 5 mm by altering the relative positions of the four cotters.

Table 7.5 Details of CST-9 sleeper (Fig. 7.9)

Rail	*Gauge*	*RDSO drawing number*	*Wt (kg)*	*A (mm)*	*B (mm)*	*C (mm)*	*D (mm)*
52 kg	BG	T-478 (M)	43.55	800	330	140	89
90 R	BG	T-478 (M)	43.55	800	330	140	89
90 R	MG	T-2366	–	700	300	132	85
75 R	MG	T-498 (M)	24.50	650	270	114	77
60 R	MG	T-10257	20.07	650	270	114	77
50 R	NG	T-438	–	533	228	108	69

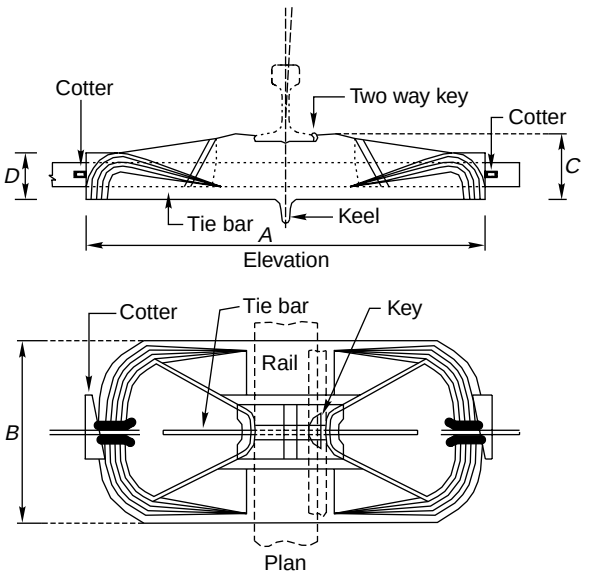

Fig. 7.8 CST-9 sleeper

The rail seat of a CST-9 sleeper is 115 mm wide along the length, and this narrow bearing tends to reduce the rocking of the sleeper under the wave motion of the rail. The sleeper is designed to provide a firm support to the rail and provides fairly good lateral and longitudinal stability to the rails. The dimensions of CST sleepers in use on IR are given in Table 7.5. The sleeper provides a bearing area approximately equal to the effective bearing area of a standard BG wooden sleeper, i.e., 5 sq. ft, for both the plates. CST-9 plates are also available with reverse jaws (T-443 type) to serve as an anti-sabotage measure; a few of these are provided in each rail length. Normally, three reverse jaw CST-9 sleepers are provided per rail to serve anti-sabotage purposes. The weight of a CST-9 sleeper assembly along with fastenings for BG is 102 kg and for MG is 58 kg.

The CST-9 sleeper is one of the most popular sleepers on Indian Railways at present. The sleeper has, however, certain limitations when combined with the modern track as mentioned in the following.

(a) As the sleeper does not have a flat bottom, it is not quite suitable for MSP and mechanical maintenance with tie tamers.
(b) The suitability of a CST-9 sleeper on LWRs, particularly on the breathing lengths, is doubtful because of rigid fastenings and the inability of the fastenings to hold the rail with a constant toe load.
(c) The rail seat wears out quickly causing the keys to come loose.
(d) The sleeper has only limited longitudinal and lateral strength to hold LWRs, particularly in the breathing length.
(e) Due to the use of less metal under rail seat, the shocks and vibrations are directly transmitted to the ballast, resulting in poor retention of packing (loose packing) and hence an increased frequency of attention.

CST-9 sleeper for MG

A new design of the CST-9 sleeper has recently been developed by Indian Railways for 90 R rails on MG lines as shown in Fig. 7.9.

CST-10 sleepers

The CST-10 sleeper is an improvement on the design of the CST-9 sleeper to 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 the following improvements.

(a) The rail is held with clips and double-coil spring washers instead of a fixed lug and key.
(b) An insulating liner is provided between the rail and the sleeper.
(c) A rubber pad is provided below the rail seat.

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

CST-11 sleepers

The CST-11 sleeper is an improvement over the CST-10 sleeper. A special shoulder is provided to accommodate the Pandrol clip instead of clips and double-coil spring washers. An elastic rubber pad is provided between the sleeper and the rail seat instead of the rail resting directly on the sleeper. The CST-11 sleeper has the potential of being used on the modern track. The sleeper, however, is still in the experimental stage and the results are not very encouraging at present. Its design details are shown in Fig. 7.10.

CST-12 sleepers

CST-12 sleepers are designed to suit the IRN-202 clip, instead of the Pandrol clip. In this case the casting is quite complicated due to the shape of the clip. No firm has undertaken the manufacture of this sleeper as yet.

CST-13 sleepers

The purpose of the CST-13 sleeper is to use the existing CST-9 sleeper with certain additions and alternations made in the local workshop. It consists of the CST-9

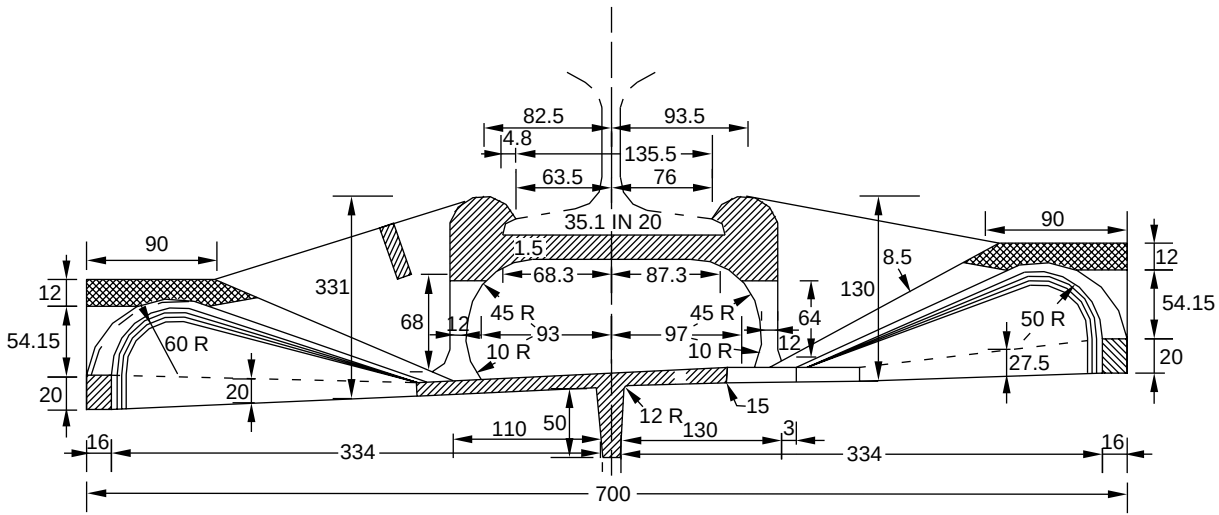

Fig. 7.9 CST-9 sleeper for MG (units in mm)

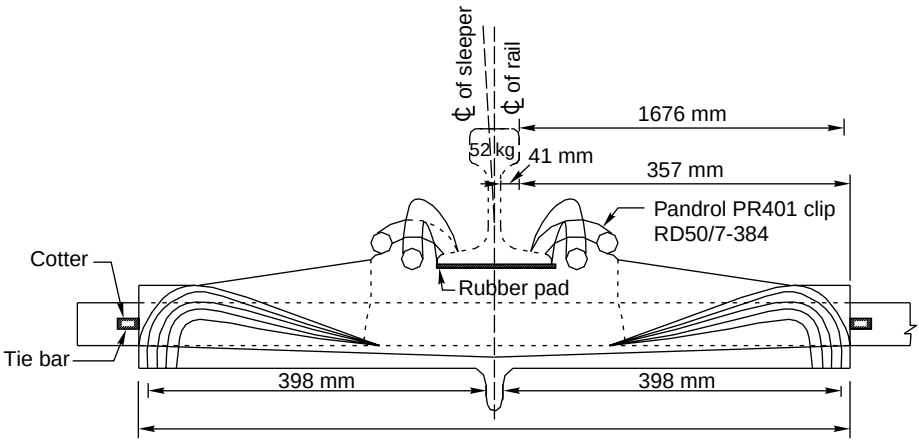

Fig. 7.10 CST-11 sleeper

plate with the rubber pad under the rail and an additional rubber head to fill the gap occupied by the key. The rail is fastened to the sleeper by a sigma clip, similar to the 'fist fastening' used on Swedish Railways. To reduce the cost of the sleeper, the inner cotter is dispensed with. No adjustment of gauge is possible in this sleeper. The CST-13 sleeper is still under trial.

7.8 Concrete Sleepers

The need for concrete sleepers has been felt mainly due to economic considerations coupled with changing traffic patterns. In the early days of Indian Railways, wood was the only material used for making sleepers in Europe. Even in those days, the occasional shortage of wooden sleepers and their increasing price posed certain problems and this gave a fillip to the quest for an alternative material for sleepers. With the development of concrete technology in the nineteenth century, cement concrete had established its place as a versatile building material and could be adopted suitably to meet the requirements 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 railway tracks. Monnier in fact designed a concrete sleeper and obtained a patent for it, but his design did not work successfully. The design was further developed and the railways of Austria and Italy produced the first concrete sleepers with a promising design around the turn of the nineteenth century. This was closely followed by other European railways, where large-scale trials of concrete sleepers were done mostly due to economic considerations.

However, not much progress could not be achieved till the second world war, when wooden sleepers practically 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, the modern track was born. Heavier rail sections and long welded rails came into existence. The necessity of a heavier and better type of sleeper that could fit the modern track was felt. These

conditions gave a spurt to the development of concrete sleepers and countries such as France, Germany, and Britain went a long way in developing concrete sleepers to perfection.

Development

The development of concrete sleepers that took place on various railway systems was mainly based on the following concepts of design.

(a) RCC or prestressed sleepers similar in shape and size to wooden sleepers
(b) Block-type RCC sleepers connected by a steel tie bar
(c) Prestressed concrete blocks and a steel or an articulated concrete tie bar
(d) Prestressed (pre-tensioned or post-tensioned) type of concrete sleepers

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

Advantages and disadvantages

Concrete sleepers have the following advantages and disadvantages.

Advantages

(a) Concrete sleepers, being heavy, lend more strength and stability to the track and are specially suited to LWR due to their great resistance to buckling of the track.
(b) Concrete sleepers with elastic fastenings allow a track to maintain better gauge, cross level, and alignment. They also retain packing very well.
(c) Concrete sleepers, because of their flat bottom, are best suited for modern methods of track maintenance such as MSP and mechanical maintenance, which have their own advantages.
(d) Concrete sleepers can be used in track-circuited areas, as they are poor conductors of electricity.
(e) Concrete sleepers are neither inflammable nor subjected to damage by pests or corrosion under normal circumstances.
(f) Concrete sleepers have a very long lifespan, probably 40–50 years. As such rail and sleeper renewals can be matched, which is a major economic advantage.
(g) Concrete sleepers can generally be mass produced using local resources.

Disadvantages

(a) Handling and laying concrete sleepers is difficult due to their large weights. Mechanical methods, which involve considerable initial expenditure, have to be adopted for handling them.
(b) Concrete sleepers are heavily damaged at the time of derailment.
(c) Concrete sleepers have no scrap value.
(d) Concrete sleepers are not suitable for beater packing.
(f) Concrete sleepers should preferably be maintained by heavy ‘on track’ tampers.

Design considerations

Two different concepts are being adopted by German and French Engineers in designing the section of a concrete sleeper. The Germans, having adopted a beam type sleeper, consider the sleeper as a rigid, stiff, and continuous beam supported on a firm and unyielding bed. The French engineers however, consider the sleeper as two separate blocks connected by a tie bar and resting on a resilient ballast bed. The former design is based on static loading, while the latter theory caters for a slightly 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 forces and factors considered in the design of concrete sleepers are the following.

(a) Forces acting on a sleeper
(b) Effects of the geometric form including shape, size, and weight
(c) Effect of the characteristics of fastenings used
(d) Provision of failure against derailments

Need for concrete sleepers in India

In India there has been a chronic shortage of wooden sleepers over the last few decades. Wooden sleepers of various species in India have a short life-span of about 15–20 years. In view of this drawback of wooden sleepers, cast iron and steel trough sleepers have been used extensively. The consumption of these metal sleepers at present is quite high and Indian Railways consumes about 40% of the entire pig iron production in the country. There is a need to reduce pig iron consumption by the Railways so that the iron can be made available in large quantities for defence purposes and other heavy engineering industries. In addition, higher speeds, welding of rails, and installation of long welded rails have recently been introduced in Indian Railways. A sleeper for a 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 totally lacking in these requirements. Both these considerations led to investigations for selecting a suitable concrete sleeper for use on Indian Railways.

Loading conditions adopted by Indian Railways

Concrete sleepers have been designed by the Research Design and Standard Organization (RDSO) wing of Indian Railways for the following different loading conditions.

BG sleeper

(a) 15 t vertical loads at the rail seat.
(b) Vertical load of 15 t at rail seats plus a reaction at the centre of the sleeper equal to half of the load under the rail seat.
(c) A vertical load of 13 t and a lateral load of 7 t directed towards the outside of one rail only.

The sleeper is designed to resist a bending moment of 1.33 t m at the rail seat and 0.52 t m at the centre of the sleeper.

MG sleeper

(a) Vertical loads of 10 t at the rail seats plus a reaction at the centre of sleeper equal to half of that under the rail seat.
(b) Vertical loads of 8 t at the rail seats with 4.5 t lateral force directed towards the outside of one rail only.

7.8.1 Types

The various types of concrete sleepers (prestressed, pre-tension, post-tension, and two-block) being manufactured by Indian Railways have been described in Table 7.6.

Table 7.6 Different types of concrete sleepers being manufactured by Indian Railways

Gauge	*Type of sleeper*	*Rail section*	*Standard drawing number*	*Sleeper design number*
BG	Mono block	60 kg	RDSO/T-2496	PDS-14
BG	Mono block	52 kg	RDSO/T-2495	PDS-12
BG	Mono block	60 kg/52 kg	RDSO/T-3602	Post-tension type
BG	Mono block	90 R/75 R	RDSO/T-2521	RCS-6
BG	Mono block	90 R	RDSO/T-2503	PCS-17
MG	Twin block	75 R/60 R	RDSO/T-3518	PCS-12
BG	Twin block	75 R	RDSO/T-153	PCS-11

Mono-block prestressed concrete sleepers with pandrol clips

The mono-block prestressed concrete sleeper (Fig. 7.11), which is similar to the 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 with a width of 154 mm at the top and 250 mm at the bottom and a height of 210 mm at the rail seat. A cant of 1 in 20 is provided on the top surface of the sleeper for a distance of 175 mm on either side of the centre line of the rail to cover the area of rail fittings. The sleeper is prestressed with 18 high tensile steel (HTS) strands of 3 × 3 mm diameter and 12 6-mm-diameter mild steel links. The initial prestressing of the steel is 100 kg/cm^2. The 28-day crushing strength of the concrete is normally not less than 525 kg/cm^2.

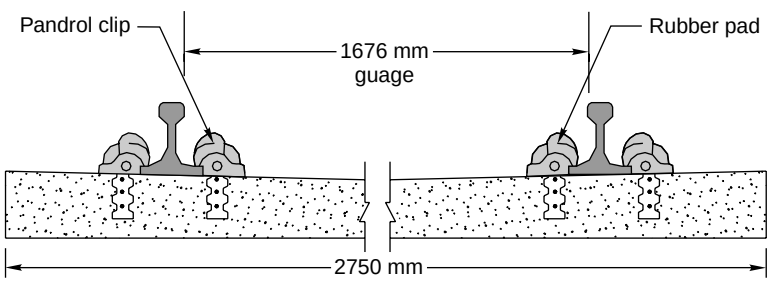

Fig. 7.11 Mono-block prestressed concrete sleeper

The rail rests on a grooved 130 × 130 mm rubber pad, with the grooves lying parallel to the axis of the rail. The fastenings provided for the 52-kg rail are Pandrol clips, which are held in malleable cast iron inserts as shown in Fig. 7.12.

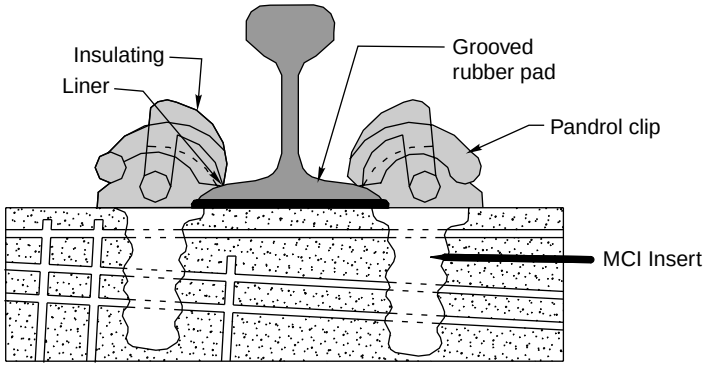

Fig. 7.12 Details at rail seat of a prestressed concrete sleeper

PCS-12 and PCS-14

PCS-12 is the latest type of prestressed concrete (PRC) sleeper for use on BG routes with 52-kg rails and elastic rail clips. For use with 60-kg rails and elastic rail clips, the PCS-14 sleeper has been standardized on Indian Railways.

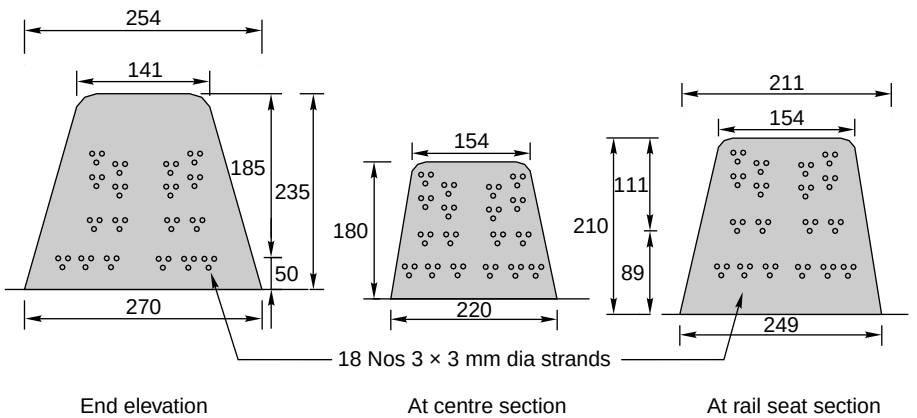

Fig. 7.13 PCS-12 mono-block concrete sleeper (units in mm)

The important dimensions of both of these types of sleepers are shown in Fig. 7.13 and listed as follows.

- Length = 2750 mm
- Weight = 267 kg
- Reinforcement: Eighteen 3 × 3 mm diameter strands
- Concrete is to be of controlled quality with a minimum 28-day crushing strength of 525 kg/cm^2
- Each strand to be tensioned with an initial tensile force of 2730 kg

Mono-block post-tension type of concrete sleepers for BG

The first factory in India for the manufacture of post-tension type of mono-block concrete sleepers was set up by Northern Railways at Allahabad in collaboration with M/s Dyckerhoff and Widmann (D&W) of West Germany. The factory, which started production in 1981, has a planned capacity of manufacturing 300,000 concrete sleepers per year. The salient feature of post-tension type of concrete sleepers are the following.

Size of sleeper

- Length = 2750 mm
- Width at centre = 160 mm (top)
  200 mm (bottom)
- Depth at centre = 180 mm
- Weight = 295 kg

Design features

- Initial prestressing force = 37 t
- Final prestressing force = 31 t
- Minimum concrete strength in 28 days = 550 kg/cm^2
- Minimum strength of concrete at the time of applying prestress = 450 kg/cm^2

The use of concrete sleepers using the post-tension method has not been successful on Indian Railways and its manufacture has since been stopped.

Mono-block PRC sleepers for MG (PCS-17)

A design for mono-block PRC sleepers (PCS-17) has recently been standardized for MG. The sleeper has a trapezoidal cross section similar to that of a BG sleeper. The concrete should have a 28-day compressive strength of 525 kg/cm^2. The salient features of this sleeper are the following (Fig. 7.14).

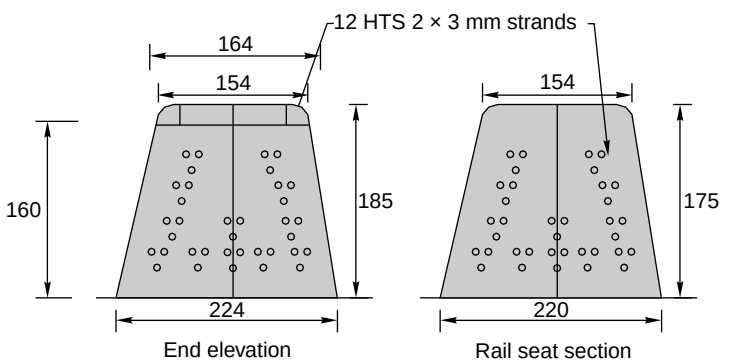

Fig. 7.14 PCS-17 concrete sleeper for MG (units in mm)

- Length = 2000 mm
- Weight = 158.5 kg
- Reinforcement: Twelve 3 × 3 mm diameter strand of HTS wire tensioned to initial force of 2730 kg

PRC sleepers can be used for 90 R rails with elastic rail clips and glass filled nylon liners (GFN 66) and on sole plates.

Two-block RCC sleeper for BG yards

A design for a two-block RCC sleeper for BG yards has been standardized by RDSO as per drawing number RDSO/T-2521 for extensive trials on Indian Railways. There is a general scarcity of wooden and CST-9 sleepers for use in BG yards and the new RCC sleepers will ease the situation in a big way. Some of the salient features of this sleeper are as follows.

- Considering low speeds in yard lines and less impact effect, the rail seat design load has been taken only as 10 t without any lateral thrust.
- Size at rail seat (top width × bottom width × depth) = 22 cm × 30 cm × 17 cm
- Overall length of the sleeper = 247.5 cm
- Weight of the sleeper = 170 kg
- Main reinforcement in each block
  - At top: Five 8-mm-diameter steel bars
  - At bottom: Two 8-mm-diameter steel bars
- The fastenings used are steel clips and a spring washer with screw fitted to a polythene dowel.

Two-block concrete sleeper for MG yards

Two-block concrete sleepers for use in MG yards have recently been developed. The sleeper consists of two cement concrete blocks, each weighting about 36 kg and consisting of an MS reinforcement of about 7 kg. The two RCC sleeper blocks are connected by an angle tie bar of 55 × 50 × 6 mm section and 1.5 m length. The rail is fixed to the sleeper block either by a clip and bolt arrangement or by polythene dowels and rail screws. A pad is provided below the rail seat to provide cushioning.

Mono-block versus two-block concrete sleepers

There are relative advantages and disadvantages of mono-block and two-block concrete sleepers. Some of these are enumerated below.

(a) Mono-block sleepers give better longitudinal and lateral stability to the track compared to two-block concrete sleepers.

(b) The mono-block concrete sleeper, being a monolithic concrete mass, is likely to have a longer working life compared to the two-block concrete sleeper connected with a tie bar. In the latter case, a tie bar is weak and has a comparatively shorter life due to corrosion, etc.

(c) The mono-block concrete sleeper requires heavy capital expenditure for its manufacture, being a prestressed reinforced concrete unit, compared to the two-block sleeper, which is an ordinary reinforced concrete sleeper.

(d) In a mono-block prestressed concrete sleeper, a crack that develops because of overstressing is likely to close down upon return to normal condition, whereas in a two-block sleeper, such a crack will continue to remain open.

(e) Mono-block sleepers are likely to become centre-bound unlike two-block sleepers.

(f) During derailments and rough handling the tie bars of two-block sleeper get deformed, thereby affecting the gauge.
(g) In a two-block sleeper, the two blocks are not likely to rest on the ballast in a way that each rail is properly inclined to the vertical, a feature which could affect the alignment and gauge of the track.

7.8.2 Sleepers for Turnouts

A railroad turnout is a mechanical installation that enables trains to be guided from one line of rail tracks to another. In this section we discuss sleepers and sleeper designs for turnouts.

Prestressed concrete sleepers for turnouts

Due to the acute shortage of wood, especially of long timbers required for points and crossings, it was felt necessary to develop PRC sleepers for use on turnouts in track-circuited areas. RDSO developed a PRC sleeper design with a rectangular cross section in July 1986 for 1 in 12 left-hand turnouts with a 7730-mm curved switch for use with 52-kg rails. These PRC sleepers for turnouts have been manufactured in the PRC sleeper factory at Khalispur, and these sleepers are on trial on Northern Railways at present. The salient features of these sleepers are the following.

(a) The sleepers have a rectangular cross section.
(b) There are 74 sleepers comprising 2l sleepers in switch assembly, 3 in intermediate sub-assembly and 18 in crossing sub-assembly.
(c) The sleepers are of varying lengths and design. There are 16 different turnout sleeper designs.
(d) These sleepers require the use of a number of fittings different from the existing standard fittings. The grooved rubber pads are of a standard 4.5 mm thickness, but of varying size.

New fan-type concrete sleeper for turnouts

The prestressed concrete sleepers discussed above are suitable only for 1 in 12 turnouts. RDSO has developed a new fan-type sleeper that can be used for 1 in 8.5 as well as 1 in 12 turnouts.

The new design of concrete sleepers has the following characteristics.

(a) The cross section of the sleeper in the new design is trapezoidal instead of rectangular as in the earlier design.
(b) The layout of the sleepers is fan shaped and the same design of sleepers can be used for right-hand as well as left-hand turnouts by rotating them 10° in a horizontal plane.
(c) Apart from approach sleepers, 54 concrete sleepers are used for 1 in 8.5 turnouts and 83 concrete sleepers are used for 1 in 12 turnouts.
(d) The concrete used has a 28-day crushing strength of 600 kg/cm^2.
(e) The sleepers are laid perpendicular to the main line on the switch portion. In the lead portion, sleepers are laid equally inclined to the straight and turnout tracks. In the crossing portion, the sleepers are laid perpendicular to the bisecting line of the crossing.

(f) The sleepers under the switch portion have dowels for fixing slide chairs with the help of screws. These sleepers are laid perpendicular to the main line and, therefore, can be used for both left-hand and right-hand turnouts.
(g) The mark 'RE' is provided on the fan-shaped PRC turnout sleepers at one end. The sleepers should be so laid that the end with the RE mark is always laid on the right-hand side.

Laying of the concrete sleepers on turnouts

The turnout locations where concrete sleepers are to be laid should have a clean ballast cushion of 30 cm thickness. Extra ballast should be available on the cess and the area should have good drainage. Depending upon the availability of space and various other site conditions, one of the following three methodologies or their combinations can be adopted for laying concrete sleeper turnouts.

- Assembling the turnout at the site and replacing it during the block period by means of either cranes or rollers.
- Carrying parts of the assembled turnout on dip lorries and replacing them during the block period.
- Replacing the existing turnout sleeper by sleeper except for the switch portion, which can be assembled as one unit.

The assembling and laying should normally be done using a crane of suitable capacity. After removing old turnout sleepers, the ballast bed at the level of the bottom of the concrete sleepers for turnouts should be evened out. Vibrating rollers should be employed to the extent possible for compaction of ballast bed.

Turnouts with concrete sleepers can be maintained in any one of the following ways:

(a) using points and crossing tamper,
(b) using off-track tampers with lifting jacks, or
(c) measured shovel packing.

In the case of emergencies such as derailments, when the sleepers may be damaged, temporary repairs should be carried out by interlacing wooden sleepers for permitting traffic with restricted speed. The damaged concrete sleepers are replaced by a fresh lot of turnout concrete sleepers as a permanent measure as early as possible. The wooden sleepers and any other damaged sleepers are replaced one by one with new turnout sleepers.

7.8.3 Manufacture

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 the concrete through bonds or through a combination of bonds and positive anchors. Bond transmission lengths and the losses in prestress vitally affect the design and determine the quality of manufacture. In the post-tensioned type of sleeper, the force is transferred only through positive anchors.

Mono-block prestressed

Mono-block concrete sleepers are generally manufactured by the 'long line method'. In this method, at a time, 30–40 moulds for casting concrete sleepers are kept in about 100–120-m-long casting beds. High tensile steel wires with diameters of 5 mm are anchored at the end block between the tension towers and moulds, and stretched by a specially designed tensioning method. The tensile stress in the wires should not exceed 70% of the specified minimum UTS (ultimate tensile stress). High-quality concrete, with a 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, preferably by steam. The wires are then destressed by Hover's method of destressing. The wires are cut and the line is released. The sleepers are further cured by submerging them into a water tank for a period of 14 days. Alternatively, the sleepers can also be steam cured.

Another method adopted sometimes for the manufacture of prestressed mono-block concrete sleepers is the short line method or 'stress bench method'. This process involves the use of short stress benches that accommodate 4–5 sleepers. The ends of the benches serve as anchor plates and comprise an iron frame to bear the initial prestressing force. The benches are on wheels and are mobile. The prestressing is done as in the case of the long line method. The concreting, vibrating, etc. is, however, done at a fixed place, the stress benches being moved into position one after another. This leads to better quality control in concrete mixing and compaction. Generally, after casting the benches are taken into steam chambers for curing with an overall turnround period of about 24 hours and a steam curing cycle of about 16 hours. This method of manufacture gives qualitatively better results and has been adopted by M/s Daya Engineering Works Pvt. Ltd, Gaya, and M/s Concrete Products and Construction Co., Chennai.

Prestressed mono-block concrete sleepers can also be manufactured by the individual mould method. This method is generally used when prestressing is transferred to concrete through bonds and positive anchorages in the case of pre-tensioned sleepers or only by positive anchors in the case of post-tensioned sleepers. The mould for the pre-tensioned type is designed to take the initial prestressing force and hence has to be sturdier than the moulds used in other systems. The moulds can adjust one to three sleepers, and as they move along the assembly line, various tasks, such as cleaning of moulds, insertion of high tensile stress wires, prestressing of wires, fixing inserts, concreting, vibrating, steam curing, and remoulding, are carried out on the manufacturing belt. This system involves a greater degree of automation, yields qualitatively better results, and requires the least amount of work force. In India, factories utilizing this technique have currently gone into production at Secunderabad and Bharatpur.

Two-block

The manufacture of two-block concrete sleepers is simple and similar to that of any other ordinary precast RCC unit. These sleepers are manufactured in a mould in which the necessary reinforcement and tie bar are placed in position. Concrete

of designed mix is then poured into the mould and vibrated. The mould is removed after the concrete is set and the blocks are cured in water for a period of 14 days.

Post-tension

Post-tension type of concrete sleepers were earlier manufactured in the concrete sleeper plant at Allahabad as per the design submitted by D&W of Germany, which was approved by the Railway Board. The specialty of this patent design of D&W lies in the use of high tensile steel rods bent into the U shape known as 'hair pins', slits, and nuts. This process also involved the instantaneous demoulding of the products.

The technology of post-tension concrete sleepers has become outdated over time. The sleepers manufactured in the concrete sleeper plant (CSP) at Allahabad have been quite uneconomical and their rejection rate has also been quite high. In view of this, the manufacture of concrete sleepers by the post-tension method has been stopped in the CSP at Allahabad since July 1995.

7.8.4 Testing

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

(a) The minimum 28-day compressive strength of the test cube should not be less than 525 kg/cm^2. Sleepers from occasional batches in which the minimum crushing strength falls below 525 kg/cm^2 but not below 490 kg/cm^2 may be accepted subject to their passing the increased frequency of testing for static bending strength.

(b) The minimum compressive strength of the test cube of concrete at detensioning should not be less than 370 kg/cm^2.

(c) The modulus of rupture should be as specified in the Concrete Bridge Code.

(d) The dimensional tolerance and surface finish of the sleepers should be checked using suitable templates and gauges.

(e) The cracking and failure moments of the sleepers 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

(f) For the abrasion resistance test, the concrete sleeper is subjected to a vibrating load under specified conditions. After 300 hours of operating time, the loss in weight due to abrasion should not be more than 3%.

7.8.5 Handling

Concrete sleepers weigh about 215 to 270 kg and about 6 to 8 persons are required to handle one sleeper. The mechanical handling of concrete sleepers is, therefore, desirable for safety purposes.

7.8.6 Prohibited Locations

Concrete sleepers, because of their heavy weight and rigidity of structure, are not suited to yielding formations, fish-plated joints, and places where uniform packing cannot be achieved. Concrete sleepers as such are normally laid at only those locations where LWRs are permissible. These sleepers should not be laid at the following locations:

(a) New formation in banks unless specially compacted
(b) Any rock cuttings, except where a minimum depth of 300 mm of ballast cushion has been provided
(c) Un-ballasted lines in yards
(d) Curves of radius less than 500 m
(e) Troublesome formations
(f) Near ashpits and other locations where drivers habitually drop ash
(g) At locations where excessive corrosion is expected
(h) On un-ballasted bridges and on arch bridges, where the height between the arch and the bottom of the ballast section is less than 1 m, and on slab bridges, where the ballast cushion between the bottom of the sleepers and the top of the slab is less than 300 mm
(i) With fish-plated tracks. Should be used only with long welded rails. Fish-plated joints on concrete sleeper tracks, where unavoidable, should have wooden sleepers at joints.

7.8.7 Laying

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

In the case of the mechanical relaying system, normally two portal cranes are used on Indian Railways and relaying is done using prefabricated panels. The existing rail panels are removed by gantry cranes, the ballast is levelled up, and prefabricated panels are then laid with the help of portal cranes. The following operations are involved.

(a) Preparation work at the site of relaying
(b) Pre-assembly of panels in base depots
(c) Actual relaying operation
(d) Post-relaying work

The full details of the manual relaying method as well as of the mechanical relaying system are given in Chapter 21.

7.8.8 Maintenance

The following points need attention in the maintenance of concrete sleepers.

(a) Concrete sleepers should normally be maintained with heavy on-track tampers. For spot attention, MSP or off-track tampers may be used. The size of chips for MSP should be 8 mm–30 mm as required

(b) Only 30 sleeper spaces are to be opened out at a time between two fully boxed track stretches of 30 sleepers length each in case a LWR track exists.
(c) Concrete sleepers should be compacted well and uniformly to give a good riding surface. Centre binding of mono-block concrete sleepers should be avoided, for which the central 800 mm of the sleeper should not be hard packed.
(d) Both ends of the concrete sleepers should be periodically painted with anticorrosive paint to prevent corrosion of the exposed ends of prestressing wires. In the case of two-block sleepers, the tie bars should be examined every year, and if any sign of corrosion is noticed, the affected portion should be painted with an approved paint.
(e) Mechanical equipment should be used for laying and maintaining concrete sleepers as far as possible.
(f) Wherever casual renewal of concrete sleepers is to be done, the normal precautions followed for LWR tracks should be taken.
(g) 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. Overdriving and underdriving should be guarded against, as these cause eccentric loading on the insulations, resulting in their displacement and in the variation of load.
(h) A vigilant watch should be kept to ensure that no creep occurs in any portion of the concrete sleeper track or there is no excessive movement near the switch expansion joint (SEJ).
(i) It must be ensured that the rubber pads are in their correct positions. Whenever it is found that the rubber pads have developed a permanent set, these should be replaced by new ones. Such examinations can be done at the time of destressing. Toe load can also be lost due to ineffective pads.
(j) Nylon or composite insulating liners used with Pandrol clips should be examined periodically for signs of cracking and breakage. Adequate care should be exercised when driving the clip at the time of installation to prevent damage.
(k) One of the biggest problems regarding the maintenance of a concrete sleeper track is that the elastic rail clips get seized with malleable cast iron (MCI) inserts not only during regular maintenance, but also during destressing, other incidental works, and derailments. The following remedial measures are suggested.
    (i) 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 elastic rail clip (ERC) and the eye of the MCI insert. These should then be driven into place at the time of assembly of the service pan.
    (ii) During service all the elastic rail clips must be taken out from the MCI inserts and cleaned with a wire brush and emery paper, specially on the central leg. The eyes of the MCI inserts must also be cleaned of any debris or rusted material. The central leg of the ERC should then be covered with good quality grease. The eyes of the MCI inserts should be smeared with the same grease before the treated ERCs are driven back. This has to be repeated every one year in corrosion prone areas. A maintenance checklist for concrete sleepers is given in Table 7.7.

Table 7.7 Maintenance checklist for concrete sleepers

Item	*Points for checking*
Location of concrete sleepers	▸ Concrete sleepers should normally be laid on a LWR/CWR track, first preference being given to high-speed routes and then to other routes. The track standard for the use of a concrete sleeper has been specified in chapter 5. ▸ Concrete sleepers should be used only at permitted locations. See section 7.8.6.
Sleeper spacing	▸ Spacing should be uniform, 60 cm for a sleeper density of 1660/km and 65 cm for a sleeper density of 1540/km.
Ballast section	▸ The specified ballast section for LWR should be followed. ▸ In two-block RCC sleepers, a 1033-mm-wide central trough should be provided to avoid corrosion of the tie bar.
Handling of concrete sleepers	▸ Preferably mechanized means such as gentry cranes should be used. In exceptional cases, manual handling should be done using sleeper slings and rail dollies, taking proper precautions to avoid damage to the sleeper.
Laying concrete sleepers	▸ Mechanical means, i.e., portal cranes with a pre-assembled panel should be adopted. ▸ Manual laying should be adopted only in exceptional conditions and that too with proper precautions.
Maintenance of concrete sleepers	▸ On-track tampers should be used for regular maintenance of long stretches. ▸ Off-track tampers such as Chinese tampers or measured shovel packing should be used for isolated or short stretches. ▸ In emergencies, a blunt end beater should be used for packing.
Maintenance of fastenings used with concrete sleeper track	▸ Overdriving or underdriving of Pandrol clips should be guarded against. ▸ It should be ensured that the rubber pad is in its correct position and renewed when these develop permanent set. ▸ Care should be taken while driving the clip into position to avoid damage to liners. Cracked liners should be replaced. ▸ At the time of initial laying as well as during service, all the MCI inserts and ERCs should be thoroughly cleaned and then grease applied on the central leg of ERC and the eye of the MCI insert.

7.8.9 Derailment

Derailment is a kind of accident that occurs when the wheels of a vehicle mount the rail head. It causes excessive damage to the track in general and sleepers in particular.

The following actions should be taken in the eventuality of a derailment on a track with concrete sleepers.

(a) When the damage to concrete sleepers is not extensive and it is possible to allow the traffic to pass at a restricted speed, suitable speed restriction should be imposed after assessing the damage to the track. Sleepers should be replaced as in the case of casual renewals while taking all precautions. After all the damaged sleepers are replaced, the affected portion as well as the portions 100 m on either side adjacent to it should be distressed, and normal speed should be restored after consolidation.

(b) When the damage to the concrete sleeper is extensive and the track is distorted in such a way that it is not possible to allow traffic to pass even at a restricted speed, the affected portion should be isolated by introducing buffer rails on either end of it. The distorted track should be removed and replaced by the track laid on single-rail panels using the available rails and sleepers. The section should then be converted into long welded rails using concrete sleepers, taking the usual precautions laid down in the LWR manual.

7.8.10 Concrete Sleepers on Indian Railways

Indian Railways is modernizing its track in a big way to meet the challenges of heavier traffic at faster speeds. The modern track consisting of long welded 52-kg/60-kg rails, concrete sleepers, and elastic fastenings can meet the above requirements.

Prestressed concrete sleepers are most economical and technically best suited for high speeds and heavy traffic density. They provide a stable track structure, which requires less maintenance efforts. Maintenance of concrete sleepers track should, however, be done using track machines only.

It has been proposed that concrete sleepers should be provided on all important routes of Indian Railways. Adequate capacity has been developed for the production of these sleepers to meet all the requirements of IR. During 2003–04, 8.86 million concrete line sleepers (highest ever production) and 3426 sets of concrete turnout sleepers were produced. The intake of wooden sleepers for main lines has been completely stopped and emphasis is being laid on using concrete sleepers on turnouts.

Indian Railways is the world leader in the manufacture of concrete sleepers and is presently manufacturing about 60% of the total concrete sleepers in the world. These concrete sleepers have a very bright future on Indian Railways.

Summary

Sleepers support rails and transfer the live load of moving trains to the ballast and formation. Wooden sleepers are the best, as they satisfy almost all the requirements of an ideal sleeper. Scarcity of timber has led to the development of metal and concrete sleepers. Concrete sleepers have high strength and a long life, and are most suitable for modern tracks. Indian Railways has developed designs for prestressed concrete sleepers and these are being extensively used on all important routes.

Review Questions

1. What are the requirements of sleepers used in a railway track? Give a neat sketch of a typical BG mono-block prestressed sleeper. What are its advantages and drawbacks?
2. List the various types of sleepers used on Indian Railways. Which one would you consider to be the best for modern tracks and why?
3. Enumerate the loading conditions adopted by RDSO for the design of mono-block prestressed concrete sleepers in India.
4. List the various types of metal sleepers in use on Indian Railways. Describe mono-block prestressed concrete sleepers with a neat sketch. What are the reasons for their ever-increasing adoption the world over?
5. Using a sleeper density of $N + 5$, determine the number of sleepers required for the construction of a 1800-m BG track. (***Ans***: 100)
6. Discuss the factors on which sleeper density depends. How is sleeper density expressed? Determine the number of sleepers required for the construction of a 640-m-long BG railway track, ensuring a sleeper density of $(N + 7)$. (***Ans***: 32)
7. Compare the characteristics of the different types of sleepers used in our country.
8. Compare the characteristics of wooden sleepers and reinforced concrete sleepers used on Indian Railways.
9. Explain the functions of sleepers and ballast in a railway track. Explain how the spacing of sleepers is determined. Give specific reasons for the necessity of regular maintenance of the ballast.
10. Draw a neat sketch of the prestressed concrete sleeper used on Indian Railways for broad gauge tracks. Give details of the location of wires and the seating and fastening arrangements.
11. What are the different types of sleepers used in the track on Indian Railways? Write down in brief the advantages and disadvantages of each type.
12. What are the advantages and disadvantages of steel trough sleepers? What is the function of tie bars in the case of cast iron pot sleepers? What is the relation between sleeper density and the width of ballast?
13. What is the difference between treated and untreated wooden sleepers? Describe briefly the use and methods of treatment of wooden sleepers being adopted on Indian Railways.
14. What are the loading conditions adopted by Indian Railways for the design of concrete sleepers? Discuss briefly the relative advantages and disadvantages of mono-block sleepers two-block sleepers.
15. What are the various methods of manufacture of concrete sleepers? Discuss briefly one of these methods on Indian Railways.
16. What is the future scope of concrete sleepers on Indian Railways? Discuss briefly the planning being done for the production of concrete sleepers in India.