TRACK STRUCTURE

CHAPTER II

SLEEPERS

1.0 FUNCTION OF SLEEPERS

Sleeper is a component of track structure transversely placed, on which the rails are laid. The primary functions of sleepers are as under:

(1) To transmit the load to the formation below ballast.
(2) To hold the rails at the correct specified distance.
(3) To enable the rails to be seated at a cant of 1 in 20 either directly or over a bearing plate in case of wooden sleepers.
(4) To maintain the desired cross level between the two rails in the track with the help of ballast.
(5) To provide lateral and longitudinal resistance to the track with the help of ballast.
(6) To provide torsion resistance to the track frame with the help of rail/sleeper fastenings.
(7) To absorb the vibrations set up by the moving loads.

1.1 Requirements of an ideal sleeper

(1) Should be able to perform all the functions as indicated above.
(2) Assembly, installation, removal and renewal should be possible with ease.
(3) Should permit adjustment of gauge.
(4) Should have sufficient bearing area to avoid crushing of ballast.
(5) Packing should be possible with ease.
(6) Handling should be easy.
(7) Should have insulating properties for use in track circuited areas.
(8) Lastly, above all, should be economical and durable.

2.0 DENSITY AND SPACING OF SLEEPERS

Number of spacing of sleepers in the track is indirectly described as sleeper density. The sleeper density is designated in two forms.

(1) Number of sleepers per rail of standard length, or
(2) Number of sleepers per kilometer.

Sleeper density in the form of number of sleepers per rail of standard length is defined as (M+K) where M is the length of the rail in meters and (K) is a constant varying from 2 to 9 depending on the importance of the line.

From the number of sleepers as defined above, sleeper density can also be designated as number of sleepers per kilometer.

For a standard rail length of 13M on B.G a sleeper density of (M+4) would mean 17 sleepers per rail of 13m length or 1308 sleepers per KM.

Depending upon the density of the sleepers, the number of sleepers in a rail length is decided and their spacing is kept as uniform as possible except at and near the joint (Joint being the weakest link).

The sleepers on either side of the joint are spaced as close as possible duly taking into account the space required between two sleepers for packing and also making the joint to behave as suspended joint and not as a supported joint.

The next two sleepers, called shoulder sleepers, are so spaced as to maintain a uniform spacing of intermediate sleepers. (Fig. 2.1)

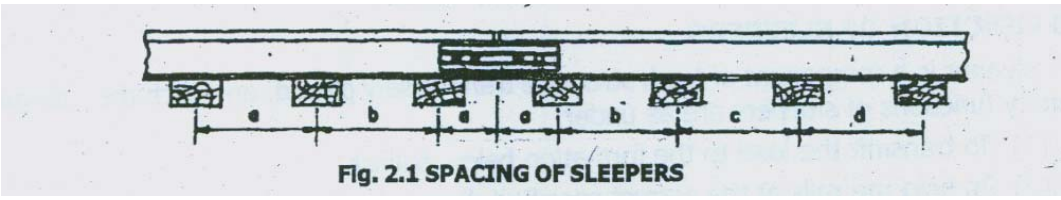

Fig. 2.1 SPACING OF SLEEPERS

The spacing (a) and (b) are standardized for a particular gauge and type of sleepers. The spacing (c) is then so adjusted to remain between 'b' and 'd' as to achieve the spacing (d) in whole centimeters.

Standard spacing for joint and shoulder sleepers

Gauge	Type of Sleeper	Sleeper spacing in cms			
		a	b	c	d
BG	Wooden	15	61	Between b & d	Equal in whole number of cm.
	Metal	19	61	-do-	-do-
MG	Wooden	12.5	58	-do-	-do-
	Metal	16.5	58	-do-	-do-

Standard sleeper spacing for BG track with 13 m. Rails with (M+4) and (M+7) density.

Sleeper Density	Type of Sleepers	No. of Sleepers per		Sleeper spacing in cms			
		Rail	Kms	a	b	c	d
M+7	Wooden	20	1540	15	61	64	64
M+4		17	1308	15	61	70	84
M+7	Metal	20	1540	19	58	63	68
M+4		17	1308	19	61	72	83

Note : (I) For long welded rails a uniform spacing of 65 cm. and 60 cm. are adopted for sleeper density of 1540 per km and 1660 km respectively. For short welded rails, sleeper spacing are arrived at based on the above principles, taking into consideration the increase or decrease of the length of short welded rails paved depended upon the System of welding, i.e. thermit or flash butt.

3.0 DIFFERENT TYPES OF SLEEPERS

The sleepers, which are in use on Indian Railways, are;

(1) Wooden Sleepers
(2) Cast Iron sleepers
(3) Steel Trough sleepers
(4) Concrete sleepers

3.1 Wooden Sleepers

3.1.1.Advantage and disadvantages of wooden sleepers are as under

Advantages

(1) Easy to manufacture

(2) Provide resilience

(3) Load distribution is uniform

(4) Handling is easy

(5) Less damage due to accidents

(6) Ideally suited for track circuited length

(7) Closer sleeper spacing at joints is possible.

(8) Ideally suited for MSP (Measured Shovel Packing) and Mechanized maintenance (Tie Tamping due to flat bottom..

Disadvantages

(1) Availability is reducing and cost is increasing day by day

(2) Life is less (10 to 15 years for durable hard wood sleepers)

(3) Liable to catch fire.

(4) Liable to decay due to attack by vermin and fungi.

(5) Scrap value is very low.

*Now Hon'ble Supreme Court has imposed ban on procurement of wooden sleepers. Railway has now started procuring Steel Channel sleepers to replace bridge timbers on bridges and concrete sleepers in other area.

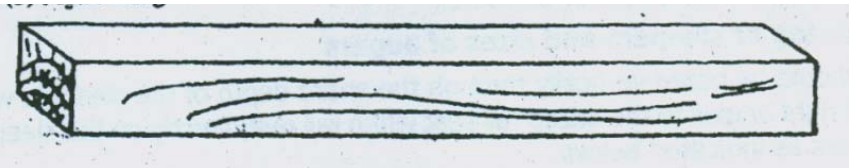

Fig. 2.2 WOODEN SLEEPER

3.1.2. Classification of wooden sleepers

Wooden sleepers are classified as treated (T) and untreated (U Category). Treatment is necessary to increase the service life for the species, which are naturally non-durable, e.g. deodar, chir, fir, etc. durable species like, teak, sal, rose wood, anjon, etc. are naturally durable species and hence need not be treated.

Service life of wooden sleepers varies with the type of timber, traffic density, etc. In the interest of both safety and economy, it is essential that wooden sleepers more than 5 years old in the track are thoroughly inspected every year. Experiences have shown that naturally durable wooden sleepers have a service life ranging from 10 to 15 years.

3.1.3 Standard sizes of wooden sleepers used on Indian Railways:

The size of wooden sleepers specified for different qauges are indicated in the Table (see figure 2.2)

Gauge	Size in Cm.	
	Track Sleepers 'U' & 'T'*	**Bridge Sleepers (U)**
BG	275x26x13	244(min)x26x15 or more
MG	183x21x12	167.6 (min)x21x13 or more
NG	153x18x12	152.5 (min)x18x12 or more

Note: The length of wooden sleepers (U) for points and Crossing varies from 275 to 488 cm, the section being 26x15 Cm for B.G, and from 183 to 427 Cm for MG the section being 21x13Cm.

3.1.4 End binding of sleepers

To protect the inner untreated portion of sleepers from being exposed to attack by insects/fungi due to shatter and splitting of sleepers in track, end binding of new and reconditioned sleepers should be done. For 'T' category of sleepers end binding of sleepers should be done before treatment. End binding is done using wire of hoop iron clips.

3.1.5 Adzing of sleepers

When wooden sleepers are used without bearing plates the rail seats should be adzed to an inward slope of 1 to 20 (to provide the cant to the rail) by using correct templates. It is also desirable to provide a recess of 3 to 5 mm deep on the adzed rail seats to accommodate the rail foot to restrict the lateral thrust being transmitted to the spikes and to protect the sleepers from getting spike killed early.

For treated sleepers and cutting, of recess, to provide even and plane bearing to bearing plates, and auguring should be done before treatment.

Note : *(1) No adzing is required for point & crossing sleepers.*

(2) Re-auguring, re-adzing or re-plaining of rail seats of 'T' category to suit other types of bearing plates should be avoided and if done, the exposed surface should be treatment with application of a coat of creosote.

3.1.6 Auguring of sleepers and sizes of augers

Hole should be bored vertically through the entire depth of the sleepers when bearing plates are used at right angles to the adzed rail seat when rail rest directly on the sleeper by using correct size of augers as indicated below.

(1) The size of auger used should be 4mm less than the dia of rail/plate screws for species having CSI(Composite sleepers index) values upon 63(925) in species like Chir, Deodar, Hallock, etc.

(2) The size of auger used should be 2mm less than the dia of rail/plate crews for sleepers with the CSI values of 63(925) and above for species like Teak, Sal, Gurjan, etc.(Higher values of Composite sleepers. Index indicated in brackets are related to the F.P.S units.)

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* U stands for Untreated and * T stands for Treated

3.1.7 Use of bearing plates on wooden sleepers

Use of bearing plates are considered a must on:-

(1) All 'T' category sleepers.

(2) All 'U' category sleepers on girder bridges.

(3) All 'U' category sleepers of points & crossings.

(4) All sleepers on sharp curves of radii less than 600m both for BG & MG track.

(5) All Sleepers of ash pits, examination pits and washing aprons.

(6) All sleepers of level crossing.

(7) All sleepers of SEJ (Switch expansion joint) and buffer rails in LWR (Long welded Rails) track.

3.1.8 Number of spikes/plate and rail \screw to be used at each rail seat should be as under

S. NO	LOCATION	NOs.
1	All joints, bridge, turn out, ash pits and examination pits	Four
2	Intermediate sleepers on curves for A, B. C and D routes of BG and Q,R and S Routes of MG	Three (Two on outside and one on Inside)
3	Intermediate sleepers at other Location not covered above	Two

Note: (1) Where ACB plates* are used on intermediate sleepers, especially for the purpose of arresting creep, the number of plate screws per plate should be four.

(2) Screws/spikes should be dipped into hot coal tar before fixing on the sleepers.

*ACB stands of Anti Creep Bearing Plate.

3.1.9 Laying of sleepers in track

Sleepers should be laid in track with their sap side upwards for 'U' category sleepers and heart side upwards for 'T' category of sleepers.

Inter mixing of 'U' & 'T' category of sleepers in the same stretch should be avoided, as this would invite premature through renewal of sleepers.

3.1.10 Dating of sleepers

The month and year of laying should be chiseled or branded on each sleeper for 'U' category sleepers. In this case of 'T' category sleepers, dating should be done in the treatment plant.

3.1.11 Precautions during Maintenance

(1) Where Mechanized maintenance is not introduced, through MSP in case of wooden sleeper track and joint MSP in case of Metal sleepers track with wooden sleepers at joints, should be resorted to, to avoid damage of the sleepers by beater packing.

(2) Spike killed sleepers should be reconditioned in situ by following the procedure as indicated below:

After removing the spikes/screws existing holes should be rebored to ensure that the existing holes are adequately scraped all around. The rebored and cleaned holes should then be plugged using tapered octagonal plugs, made from scarp hard wood sleepers, of slightly bigger size after

dipping in mixture of creosote and coal tar (Fig.2.3.). The new holes should be bored using correct size of the augur taking care that they are neither very near to the edge of the sleepers (not less than 40mm) nor close to the plugged hole (not less than 25mm). The spike/screw should be reinserted in new holes after dipping in coal tar only after plugging the old holes.

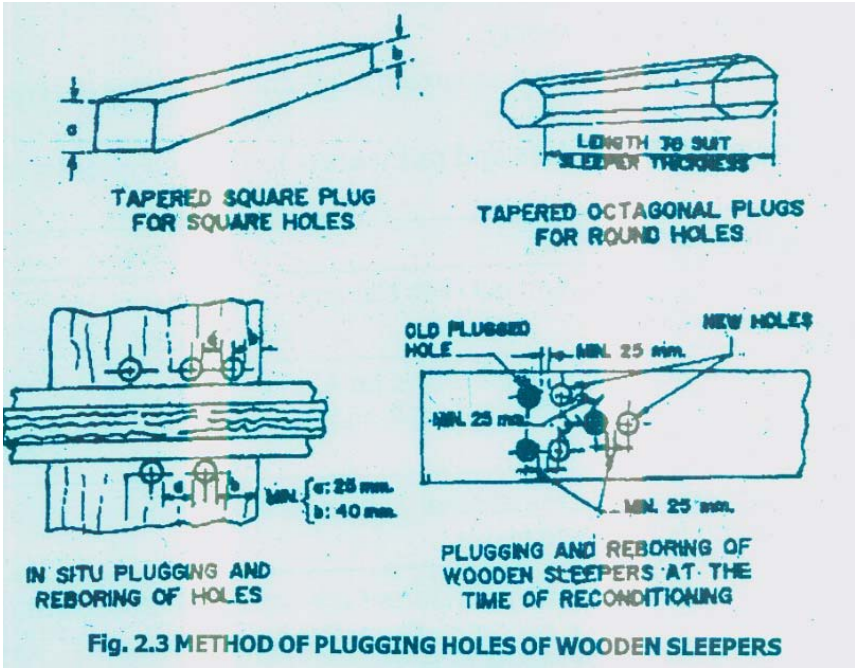


Fig. 2.3 METHOD OF PLUGGING HOLES OF WOODEN SLEEPERS

3.2 Cast Iron sleepers

There are two types of cast iron sleepers;

(1) Pot type (Fig.2.4)

(2) Plate type

Prior to standardization of CST-9 (Central Standards Trial no. 9) plate sleepers in 1935, pot type cast iron sleepers were in use for FF,BH and DH rails and still such sleepers are existing in some of the old/unimportant sidings in yards.

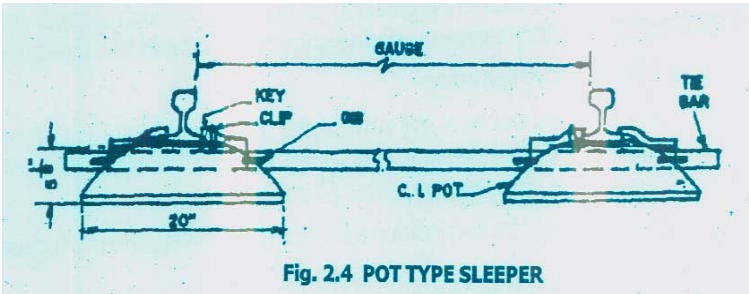


Fig. 2.4 POT TYPE SLEEPER

3.2.1 Components of pot type sleepers

S. No.	Component	No./Sleepers
1.	Cast iron pots	2 Nos.
2.	Mild steel Tie bar	1 Nos.
3.	Cotters	2 Nos.
4.	Gibs	2 Nos.

Shape of the pot was either elliptical or circular which were connected by a mild steel tie bar with the help of tapered cotters and gibs to from a complete sleeper. The rail seat on the bowl was cast to suit the type of rail (FF,BH,DH) and to enable its fixing by means of a special key (Wedge type or spring type).

A typical pot sleeper is shown below:

These sleepers have now become obsolete and no more pot sleepers are being procured on Indian Railways.

3.2.2 CST-9 Sleepers

After a series of trials, Central Standards Office standardised the ninth trial in 1935, called as CST-9 plate sleepers. Till recently, these sleepers were being extensively laid on Indian Railways. Thus long lengths of track with CST-9 sleepers were existing. However nowadays these sleepers are being replaced with PSC Sleepers.

3.2.2.1 Component parts of CST-9 sleepers:

S No.	Component	No. / Sleepers
1.	CST-9 Plates	2 nos.
2.	M.S Tie bar	1 nos.
3.	Cotters	4 nos.

Two plates are connected by means of a tie bar with the help of four tapered cotters to form a complete sleepers. The rails are fixed on to the sleepers by means of tapered keys. Sketch of a typical CST-9 sleepers is shown in Fig. 2.5

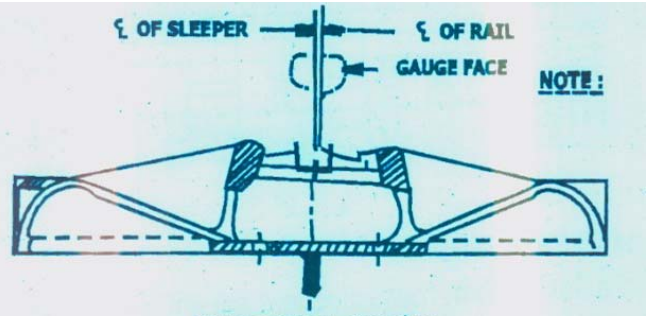


Fig. 2.5 CST-9 SLEEPER

3.2.2.2 Typical design features of CST-9 sleepers:

(1) A through tie bar (Fig. 2.6) which extends on outside of either plate connects the two plates and is fixed by means of four tapered cotters which permit gauge adjustment within certain limits by suitable alteration of the drive of outside and inside cotters.

(2) Rail seat is provided an inward slope of 1 in 20 to enable canting of rails when laid in track.

(3) Width of rail seat is only 114 mm along the rails with a recess 1.5mm deep in the central portion and a central slot across the rail which prevents the possibility of a rocking support in either direction.

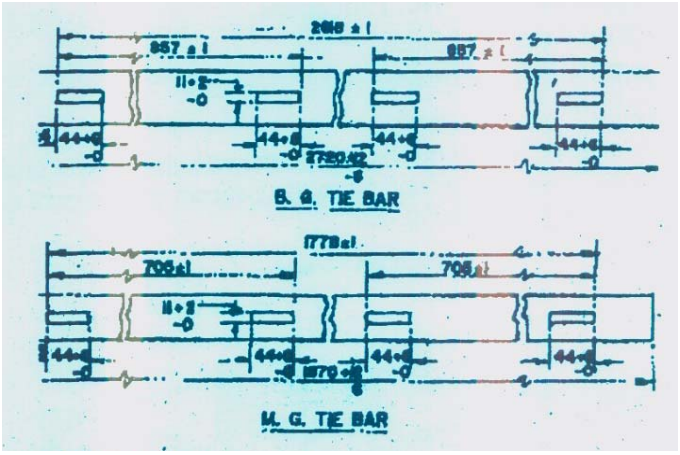
(4) A single two way tapered key is provided on inside of rail foot to fix the rail on each plate which has fixed jaw on outside.

(5) In case of reverse jaw type of sleepers the key is provided on outside instead of inside and 3 to 5 such sleepers, if provided, are equally distributed in a rail length (excluding joint and shoulder sleepers) serve as an anti-sabotage measure.(this make removal of rail difficult in as much as even if all the inner and outer keys are removed the rail cannot be taken out unless the reverse jaw plates are shifted after removing the cotters).

(6) The inner jaw (outer jaw in case of reverse jaw type sleepers) is provided with a double taper from centre to enable key being driven in either direction which is more effective in improving creep resistance depending upon the direction of traffic.

(7) At the bottom of the sleepers four shallow pockets tapering towards rail seat at four corners of each plate provide limited lateral stability due to keying up of the ballast in these pockets. While for additional anchorage a vertical keel (50mm deep) is provided along the rail.

(8) Designs have been standardized for 52 kg / 90R, 75R for BG and90R, 75R, 60R and 50R for MG rail sections. Approximate weight of each sleeper with all component parts is 102 kg. For BG and 58 kg for MG.



3.2.2.3 Limitation of CST-9 sleepers

(1) In absence of a flat bottom, these sleepers are not ideally suited for MSP and machanised maintenance.

(2) Not very suitable for use in LWRs due to limited longitudinal and lateral ballast resistance in service conditions, especially when fittings are loose, worn out or missing.

(3) The rail seat is having a very limited bearing area and wears out quickly and thus creates problems of falling keys and creep.

(4) In the event of different creep of two rails, the sleeper plates tend to become out of square due to flexible connection of the tie bar, resulting in defects like gauge kinks and distortion of alignment of individual rail.

Position of outer and inner cotters is so adjusted that a gauge within = 1.5mm can be achieved at the time of initial assembly by altering the extent of drive of outer and inner cotters by 12mm which enables a lateral shift of each CST–9 plates, to cater for various manufacturing tolerance. Further gauge can be adjusted in service to a maximum extent of + 10mm and –3mm. (inclusive of the initial alteration of key drive.) **These sleepers are now not being procured by Indian Railways.**

3.2.2.4 Precautions during assembly and linking

(1) Do not handle CST-9 sleepers in assembled position to avoid bending of tie bars.

(2) Ensure correct cotter drive and proper splitting of cotters to ensure their tightness and also to prevent their falling out due to vibrations. (Especially out cotters to guard against possibilities of gauge widening during service in the event of falling out of consecutive cotters).

(3) While driving cotters it should be ensured that the tapered face of the cotter is in contact with the tapered face of the CST-9 plate.

(4) Use only standard keying hammer, weight of which should not exceed 1.8 kg. In no case beaters should be used for driving keys.

3.3 Steel Trough Sleepers (Fig 2.7).

Steel trough sleepers are manufactured from special rolled sections which are subsequently, pressed in the form of a trough. In earlier design two lugs were pressed up on either side of rail seat and tapered keys

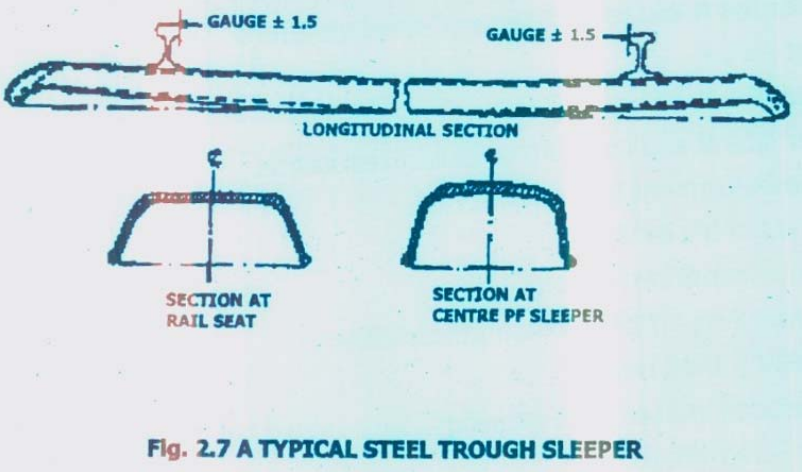


Fig. 2.7 A TYPICAL STEEL TROUGH SLEEPER

were used to fix the rail on to the sleeper. Alternatively bolt and clip type fastening were also used as shown in Fig. 2.8

In both the above designs the following difficulties were experienced.

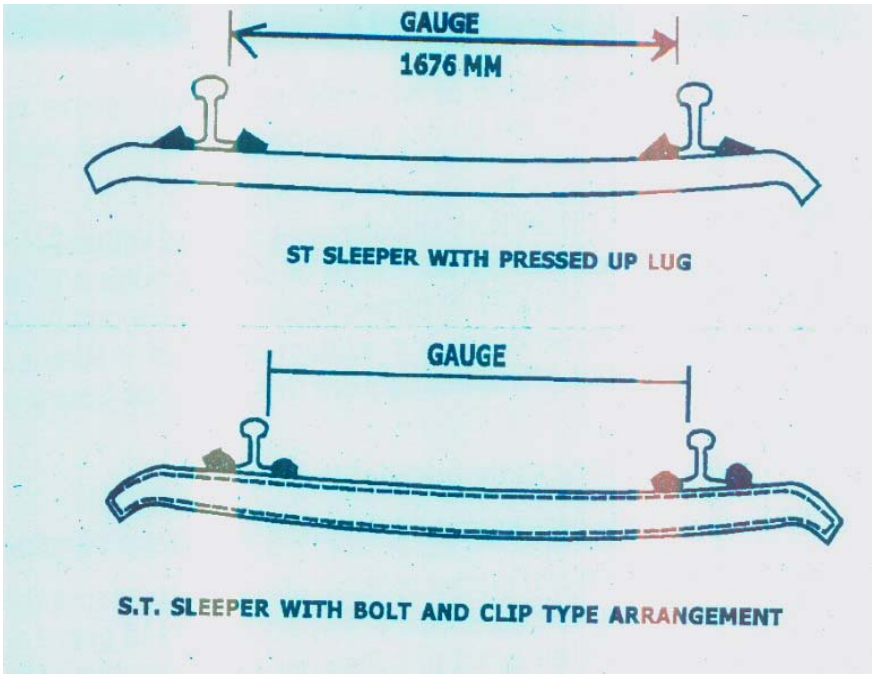


FIG.2.8 S.T. SLEEPER WITH DIFFERENT ARRANGMENTS FOR FIXING KEYS

(1) Cracking of the pressed up lug in service.

(2) Loosening of the nuts due to vibrations. Hence the design was modified with more effective fastening system consisting of loose jaws made from spring steel which were inserted in the holes on either side of the rail seat and rails were fixed by means of two way keys which could be driven in either direction and this design is now in use on Indian Railways.

3.3.1 Advantages & disadvantages of steel sleepers

Advantage

(1) Longer life

(2) Better lateral and longitudinal ballast resistance.

(3) Gauge adjustment is possible

(4) Easy assembly installation

(5) Less number of fastenings

(6) Manufacturing process comparatively easy.

(7) Suitable for LWR tracks.

(8) Can be used with elastic fastenings.

(9) Higher scrap values.

Disadvantages

(1) Liable for corrosion (calls for anti-corrosive treatment at the manufacturing stage).

(2) Unsuitable for track circuited sections.

(3) Not suitable near sea coast and platform lines.

(4) Cracks under rail seat.

3.3.2 Design features

(1) Special rolled section is thicker in the central portion.

(2) Edges are rounded off in the form of a bulb.

(3) Rail seat is canted to 1 in 20 slope while pressing the trough.

(4) The width of the trough is wide and flat at the rail seat.

(5) The ends are pressed in the form of a spade which improves the lateral resistance of track.

3.3.3 Component parts of S.T. sleepers

(1) Loose jaws …4 nos. per sleepers.

(2) 2 way keys …4 nos. per sleepers.

3.3.4 Precautions during laying & Maintenance

(1) Avoid use in coastal areas.

(2) Avoid use near ash pits, and platform lines where trains stop.

(3) Thorough inspection of sleepers in track is necessary for sleepers older than 15 years.

(4) Use only standard keying hammer (1.8kg) for driving of keys. Do not use beater for driving of keys to avoid over stressing of keys and over spacing of the spring steel loose jaw.

3.3.5 Problems during service

Elongation of jaw holes and wear at rail seats create problems of falling keys and excessive creep. These can be overcome by using over sized keys and / or liners. Experience has shown that trouble free life of ST sleepers in track is about 12 to 15 years.

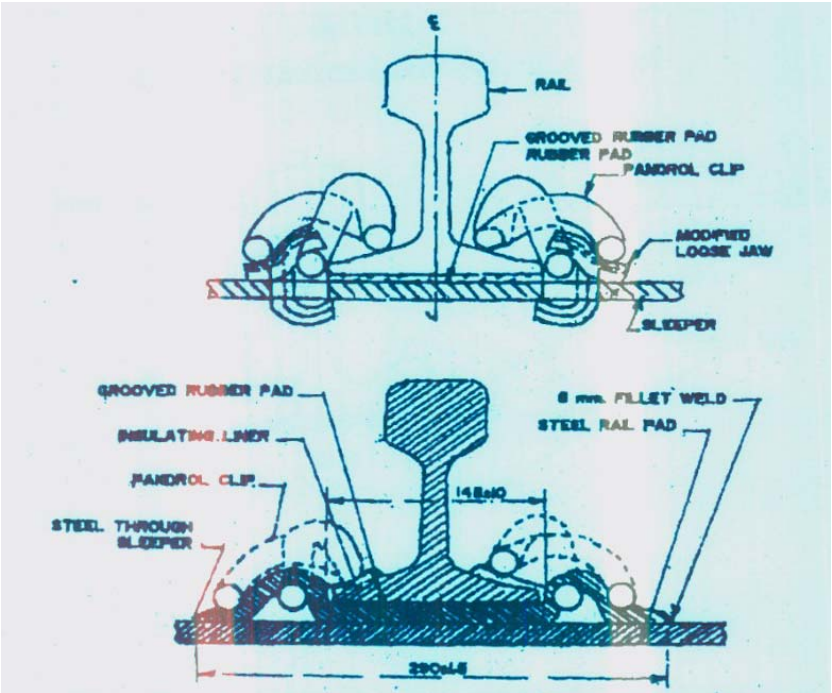


Fig. 2.9 MODIFIED VERSION OF ST SLEEPER WITH ELASTIC RAIL CLIP

3.3.6 Modified version of ST sleepers (Fig. 2.9)

There are two different methods of using elastic rail clips on St sleepers. By using modified loosed jaws in lieu of ordinary loose jaws, elastic rail cilps can be used after placing a rubber pad on rail seat. Alternatively, elastics rail clips can be used after welding a specially forged steel rail pad on the rail seat.

3.4 Concrete Sleepers (Fig 2.10)

The primary function of the sleepers is to transmit the axle load of rolling stock to the formation through the ballast and to maintain the gauge level and alignment parameters of the track. Another important requirement is to generate adequate longitudinal and lateral resistance of track for LWR. Due to increase in the axle load of the moving vehicles accompanied with the need for high speed trains, necessity of heavier track structure was felt. Further, due to reduction in availability of wooden sleepers need arose to develop of a sleeper design, having adequate electrical resistance from the point of view of track circuiting. Concrete sleepers are considered as the only alternative as these are expected to satisfy all the requirements.

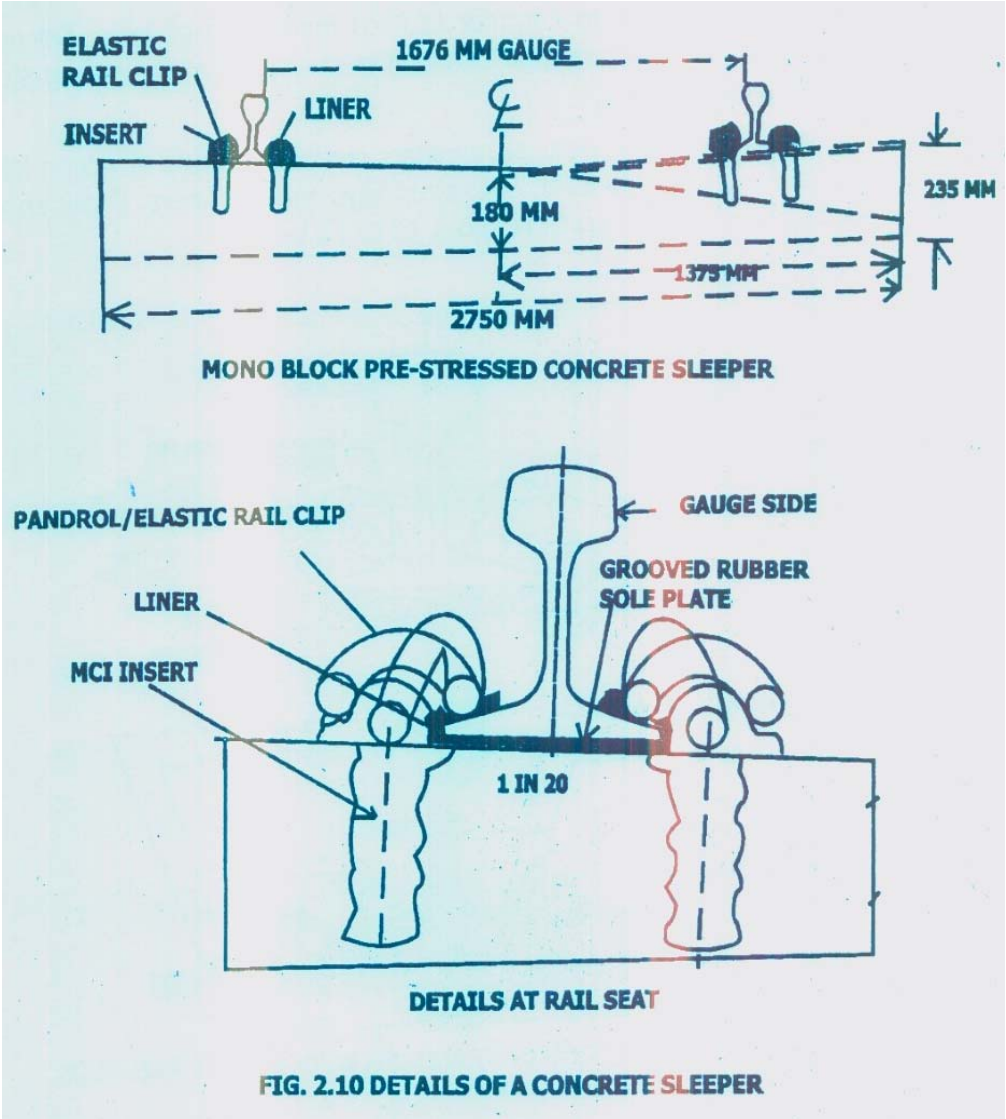


FIG. 2.10 DETAILS OF A CONCRETE SLEEPER

3.4.1 Advantages & disadvantages of concrete sleepers

Advantages

(1) Concrete sleeper being heavier than other types of sleepers provide longitudinal and lateral stability to the track and thus are suitable for LWRs.

(2) Concrete sleepers with elastic fastening provide a good maintainability of track with good packing retentivity.

(3) Because of their flat bottom these sleepers are ideally suited for mechanised maintenance.

(4) Due to their adequate electric resistance, concrete sleepers can be used in track circuited areas.

(5) They are not liable to damage by fire, pests attack or corrosion.

(6) The life of concrete sleepers is about 40 to50 years.

Disadvantages

(1) Due to their heavy weight, handling and laying of concrete sleepers is difficult. Normally mechinised method has to be adopted for handling, which involves heavy initial expenditure.

(2) At the time of derailments, the damage to concrete sleepers is very heavy.

(3) Scrap value of these sleepers is very low.

(4) These sleepers are not suitable for manual maintenance (beater packing)

3.4.2. Location where concrete sleepers are used

Concrete sleepers should normally be used only with LWR/CWR track. Hence the condition for laying LWR/CWR should equally apply for laying concrete sleepers. When concrete sleepers are used with fish plated track, provision of wooden sleepers at the joints and first shoulder is desirable.

3.4.3 Maintenance of concrete sleepers

(1) Heavy on duty track tampers should be used for maintaining track laid on concrete sleepers. For spot attention Measured shovel packing or off-track tampers may be used.

(2) Central binding of mono-block concrete sleepers would be avoided and to ensure this the central portion of the sleepers should not be hard packed.

(3) Both the ends of the concrete sleepers should be painted with an approved type of anti-corrosive paint periodically to prevent corrosion of the exposed ends of pre-stressing wires.

(4) The laying of concrete sleepers should be done by mechainsed means as for as possible.

(5) The elastic rail clip should be driven properly so that the leg of the clip is flush with the end face of the insert. Over-driving and under-driving should be guarded against by observations of the clips in position. Overdriving/under driving of the clips causes eccentric load on the insulators and results in their displacement and variation of toe load.

(6) A vigilant watch should be kept to ascertain that no creep is taking place in any of the portion of the concrete sleepers track or excessive movement near SEJs.

(7) Rubber pads: It must be ensured that the rubber pads are in correct positions. Whenever it is found that the rubber pads developed a permanent set, these should be replaced by new ones. Such examinations can be done at the time or distressing. Loss of toe load should be occasionally checked particularly, if any creep is noticed resulting in excessive movements of the SEJs.

(8) Insulating liners: Nylon/composite insulating 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.

(9) Measures to prevent corrosion and seizure of ERC with MCI inserts:

(a) Initial treatment

At the base depot, all the elastic rail clip and MCI inserts should be thoroughly cleaned. Grease to IS:408-1981 (specification for grease No. 'O' graphite) should then be applied on the central leg of the ERC and eye of the MCI insert and then the clip should be driven at the time of assembly.

(b) In service maintenance

All the elastic rail clips are to be taken out from the MCI inserts and are to be cleaned specially on the central leg. The eyes of the MCI inserts are also to be cleaned of may debris or rusted material. Cleaning of elastic rails clips may be undertaken by wire brush and emery paper and the surface cleaned before the grease is applied. The central leg of the ERC should then be applied with grease of approved quality. The eye of the MCI inserts should also be smeared with the same grease before the treated ERCs are driven back. This should be repeated every one year in corrosion prone areas. In other locations the frequency should be 2 years, and one half length in each gang should be greased annually.