Transportation Engineering -II
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Lecture - 11
Sleepers

Dear students, I welcome you back to the course material lecture series of transportation engineering 2. In today's lecture we will be discussing about sleepers. As we have seen sleeper is one of the component of the railway track. We have already discussed about the one another component of the railway track, that is, rail and associated features with rails like creep in rails, wear or failures of rails, or the joints in the rails. So in today's lecture we will be discussing about the sleepers; the different types of sleepers, sleeper density, sleeper spacing.

First of all we will try to look at the different functions which any sleeper will be imparting. Sleepers try to hold the rails section to correct gauge and alignment. This is on the basis of different fixtures or fastenings which are used to control or keep hold of rail sections. So this is the very first prime important function of the sleepers. The gauge should be maintained and as far as possible alignment should not get distorted. Another aspect they should able to provide firm and even support to the rail sections. The rail sections have been placed at the top and if they are not being supported then they are going to sink into the ballast cushion. So that should not happen, they should have a wider area by which they keep remained in the floating condition in the ballast cushion medium and that is how support system is devised.

They should be able to transport the load to a wider area of ballast. As we have seen the concentration of loads as we go from the top to the bottom keep on reducing. They are heaviest at the top and that is why the heaviest sections have been provided as the rail sections but as we come to ballast section the strength capabilities of the ballast section taking the unit area quite less as compare to the rail section. Therefore there is a need of transferring the load to a wider area so that that load remains within the capacity of load taking of those sections. This is another important respect that it should be able to transport the load as a concentrated load which is coming from the rail track sections to the ballast section. It should act as an elastic medium, that is, it should be able to absorb the blows or the vibrations which are coming from the rolling stock movement over the rail sections. If it is not elastic in nature then the deformation will keep on increasing and finally the track will become irregular in shape or it will be higher amount of settlement of certain locations. So as soon as the load has been removed it should come back to its normal condition.

The longitudinal and lateral stability permanent way should also be there, this is another aspect. As we have seen in the case of rail sections not only there has been movements of the forces which are acting in the longitudinal direction but there are other forces which are acting in the lateral direction too and all those forces which are acting either of the direction are going to be transported finally to the sleepers.

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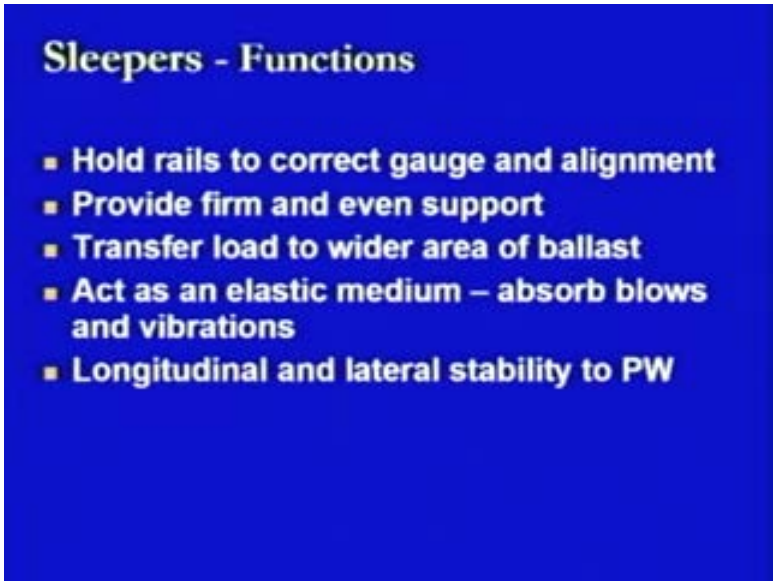

If the amount of these forces is quite large then the sleepers will come out of their position and will be moving either along with the rail sections or they will just loose this strength which they are going to impart to the overall track structure. So this aspect of stability both directional stability should be maintained. They should be means to rectify track geometry, we should be able by just doing some exercises with the sleepers we will able to rectify the track geometry or the deformation which have distortion which have caused into the track geometry. So based on all these functions which we have seen we are going to look at certain requirements. The very first requirement is always remains with respect to the cost. The cost, initial cost as well as the maintenance cost of the sleeper should be minimum, they should be moderate weight, they should be easy to handle, this is of course related to each other. If the weight is quite low then obviously that is the easiest condition to handle the sleepers but then in that case the stability or the stiffness of the track will not be bear. Therefore at least they should be of moderate weight or they should be heavy weight but at the same time the structure should be such that they are easy to handle.

Fixing and removing of fastenings should also be easy this is again related to the type of the material being used at the same time the type of the design being used so that if we have to remove or if we have to fix the fastenings that should not be difficult job. Sufficient bearing area should be there to all the sleepers so that they can transfer to the load to the wider area of the ballast cushion. The maintenance should be easy and the gauge adjustment should be possible using the sleepers. Further the track circuiting there also be possible. Now, slowly and slowly we are moving towards the electrified track condition. Therefore, this is another important concentration on requirement of the sleepers.

They should be able to resist shocks as well as the vibrations. If they are not in a position to resist shock and vibrations then obviously they will get crushed and if they are going to

get crushed the maintenance requirements will increase, the periodical maintenance will increase, the cost will also increase. At the same time they should be anti sabotage type or anti theft qualities should be there, this is important as far as those locations are concerned which are removed or which are inaccessible or where the vision cannot be maintained thorough out the time period. So if they are anti sabotage or anti theft type then the safety of the track will be maintained or the safety of the operation will also be maintained.

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Now we have seen at the different types of requirements in the function of the sleepers. We are going to look at the type of the sleepers; the one type of the sleeper is the concrete sleeper. These concrete sleepers have very large life period something like 50 years or even more than 50 years also nowadays. The lend strength and stability to the tracks because of their size, because of their weight. They maintain the gauge as well as the cross level and alignment in the better form as compared to the other type of the sleepers and this is again being governed by the structure by the weight component of these type of the sleepers because they are quite heavier in section. Therefore, they remain in position throughout and that is how they are in a position to maintain the gauge cross level and alignment in a better way and at the same time they are also providing doing the circuiting of the track and their chances of less damage in the case of concrete sleepers compare to the other type of the sleepers.

Now, another type of the sleepers which has been in use from the very old time is the wooden sleepers and this wooden sleeper most of the time it has the size of around 275 by 25 by 13 centimeters and it has quite low service life and this life is somewhere around 15 years only. Another type of sleepers is steel sleepers and this case again the life is comparable to the concrete sleepers, is as high the 50 years. Then we have the C.I the cast iron sleepers. In this case one sort of a sleeper which is extensively in use is the CST 9 sleeper which is abbreviated as a central standard trial 9 sleeper.

Now we are starting with the different type of the sleepers. We will be starting with the older version of the sleepers that is the wooden sleepers which have been in use. There are certain advantages of using a wooden sleeper; one thing is they have been in cheap in the older days where there was a lot of wood available around but nowadays we may not say that it as cheap as it has been relatively in the older years. They are easy to manufacture and easy to handle. This is one of biggest advantage of using the wooden sleepers. They also have good dampening effect because of the properties of the wood this is coming that whatever shocks are coming or whatever vibrations are coming they have possibilities, they have the changes that all these types of shocks will get damp because of the property of the wood.

Then they are also suitable for track circuiting because of again they are nomenclature because of the characteristic of the wood. Their suitable for yielding formations, bridges, ash pits etc which are provided with, without stone ballast and the correction to the alignment is also easier in the case of wooden sleepers because if at all the rails have to be displaced from their location at which they have been fixed to the wooden sleepers, that is, easier to do because we can insert the fixtures or the fastenings at some other location easily as compared to other type of materials like concrete but at the same time there are certain disadvantages too in the case of wooden sleepers. They are liable to mechanical wear, whatever mechanical devices are used they have all likelihood that they can penetrate the wooden sleepers and when they penetrate the wooden sleepers then this is type of the wear which may happen to those wooden sleepers.

They are having a shorter life period this is due to decay or this is due to the different types of the wear which can take place or it is also due to the attack of the vermin. This is one type of disadvantage which is not there in the other cases of the sleepers. Maintenance of gauge is little difficult in this one because of the loosening effect of the fixers or the fastenings which have been inserted in the wood. As the loads or as the vibrations keep on coming or as the impact keeps on coming these fixers or the fastenings start becoming loosened out and if they are getting loosened out then it has effect in terms of maintaining the gauge. The susceptible to fire hazards, again one of the characteristic of the material itself. They have the very less scrap value, this is one another aspect or disadvantage because as soon as it has completed its life its span so they will be take a out and some other sleepers will be provided but at that time there is the sleeper which have been taken out which are not going to pay back some amount in an handsome form.

Further we have sizes as we have seen the sizes 275 by 25 by 13 centimeter cube that is the normal conventional size of the wooden sleepers but in the case of bridges the cross sectional areas is increased by some amount and here the depth of the sleeper is increased and instead of 13, it may be 15 and 18. So the cross sectional area will become 25 by 15 or 25 by 18. Then they have some categories of wooden sleepers based on the type of the treatment to be provided or do not be provided. There is durable type of wooden sleepers. These wooden sleepers do not require any treatment and they have little higher service as compared to the other type of the sleepers and they are designated as U type of wooden sleepers. The another one is non durable type of sleepers where the treatment is required before the placement and obviously they have shorter period of service life which is

around 12.5 years and they are designated or indicated as T. T is for treated and U is for untreated, treated and untreated conditions respectively.

Then in the case of the wooden sleepers as wood has been taken directly from the any of the tree and then as soon as it arises it has some amount of moisture. So as in the case of other wooden structures seasoning has to be done in the case of wooden sleeper. So this seasoning is nothing but in this case it is treated such that the amount of moisture contained in the sleeper is reduced. So the moisture content to be treated by pressure treatment should be more than 25 percent and there are different ways available by which the seasoning of the wooden sleeper can be done. This is artificial seasoning in kiln, boulton or boiling under vacuum process.

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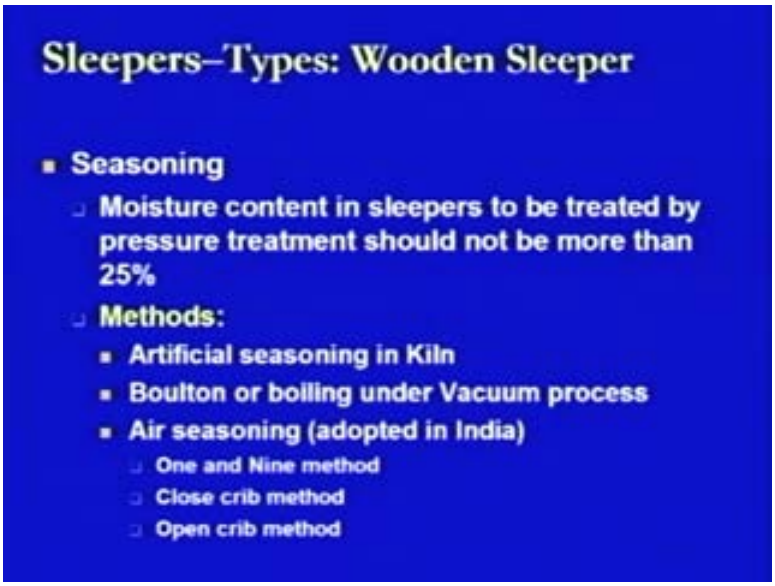

Air seasoning, air seasoning is being adopted in India. There are different ways by which the air seasoning can be done like one and nine method, close crib method, open crib method. In the case of crib method it is form of the number of sleepers which have been placed at some distances from each other and then there is another layer of sleepers which is placed at top of this layer but at perpendicular to the previous layer. So this is how this crib method is used and depending on the distance between the two sleepers it is turned as the close crib method or open crib method whereas in the case of one and nine method it is sort of jig jag condition where one layer is being laid out and then there is another layer which starts from the same level at which the previous layers has been laid but towards the other end where it is being perpendicular to the previous layer there is another one sleeper being provided so that the layer becomes tilted. So that type of method is turned as one and nine method and it has the flexibility of seasoning the wooden sleeper from all the sides whereas in the previous cases they are not going to seasons from th**e** bottom side where they are in contact with other sleepers. So that is the advantage of one and nine method and this is one method which is mostly used or adopted in India.

Now in the case of wooden sleepers so as to look at their strength characteristic or determine the suitability of that particular timber for use, one index is found out that is known as the composite sleeper index. In this case it is a combination of the general strength at 12 percent moisture content designated as S and H that is the hardness value. This hardness value is taken again at 12 percent moisture content and the formula is that is CSI that is composite sleeper index equal to S plus, 10 H divided by 20 and the values of these composite sleeper index they are different for different location. In the case of track sleeper this value is being prescribed minimum as 783 whereas for crossing sleepers it is being prescribed as 1352 as minimum again and for this sleeper it is 1455. So more strength is required towards the bridge sizes or towards the crossing sizes compared to the normal condition of track.

Now I am coming to another type of sleepers that is the steel sleeper. This is one photograph of steel sleeper which you must have seen. This is the type of the sleeper which are covered like this the shape goes this way and again this way. This is the real section which is placed at the top of steel sleeper. Here this steel sleeper mostly uses in steel rolled sleeper which is nothing but rolled steel plate 12 mm in thickness and they are pressed to suitable trough shape where the rail seat canted to 1 in 20 provided. So at this point there is rail seat provided at a gradient of 1 in 20 and the ends flattened out to retain ballast. So what is being done is at this end of this sleepers is being made like this.

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Now the advantage of doing this is whatever ballast section is being placed at this level will not go out as soon as the loads are transferred from the top. So this is how it will contain the ballast below the sleeper. So this is the way by which it is done. This is another diagram where the over all section of the steel trough sleeper is being shown. This is like vv section where the rail is being placed, one here another is being placed here and has been told that there is a canted of 1 in 20 being provided at this side. Similarly, there is cant 1 in 20 being provided at this location and this is the gauge of this

track, this is steel trough sleeper. This is another photograph by another where it is being shown that this is steel sleeper and the steel sleeper is being jointed to this rail section using certain fastenings. These are the types of the jaws which have been provided here by which this is the clamp using these jaws and the clamps this rail section is kept in place on these steel trough sleeper.

So we have 2 type cases in this one; one is the steel trough sleeper with pressed out lugs and other one is the steel trough sleeper with loose jaws. In this case of these 2 will be looking at this one. This is pressed out lugs steel trough sleeper where this is the steel sleeper in which grooving is being made like this. So this metal is coming out in this direction here this metal is coming out in this direction and this is termed pressed out lugs. Within this area rail is being seated and then it is fitted towards the position using the keys at this position as well as the keys at this position. So they have sufficient strength so as to keep the rail section into position. At the same time whatever cant is to be provided as 1 in 20 is being maintained at this bottom level. This is another case we have the loose jaws condition is shown this is loose jaws being provided here as well as here and again this rail section is being placed, is being hold up using the keys between the rail sections and the loose jaws. So this is another type of the steel trough sleeper.

Some of the advantages of steel trough sleeper they are having the longer life, they are better in the lateral rigidity. They are free from the decay and fire hazards, this is the metal property. They have good scrap value again a metal property because in the case of wooden sleeper as we have seen they do not have any scrap values. So even if they have completed their life they are going to provide some monitor value. There are lesser damages during handling and transportation. This is again a metal characteristic only as compared to the wooden sleeper as we have seen previously where the chances of damages are much more as compared to this one and based on all these things they are less maintenance problems in the case of the steel sleepers and they are also easy to maintain gauge.

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There are some disadvantages too. We will look at these disadvantages; the very first one is they liable to corrosion. Previously, we have seen that they are certain location like the coastal area, or the canal areas, or the locations where some of the industries have been provided where the affluence are coming which have corrosive in nature. So if we are providing the steel sleeper of those locations then they are liable to get corroded and if they are getting corroded then the life span will get reduced. They are unsuitable to track circuiting because of the chances of related to the electric current is being passed to the metal. They become centre bound due to sloping ends as we have seen in the case of the sleepers. There are 2 types of conditions as far as the defluxion are concerned; one is the center bound sleeper and the other is the ends bound sleeper. In the case of the center bound sleeper because of the sloping ends what happens is they have changes of more of defluxions are taking place at the center locations as compared to the hand locations and they are also rail specific.

As we have seen in the case of the rail there are 3 types of the rails double headed rails, bull headed rails and flat footed rails. So depending on the rail section we are using there are certain fastenings which need to use. So it is not at whatever is grouping being need in the steel sleeper we can see it any of the structure in that one. So the rail structure is to be used along with some fastenings which are specific to rail as well as the steel track sleeper. There are tendencies of developing the cracks at rail seat and this is the weakest point in the structure because the sleeper itself of sheet type it is 12 mm thickness that is why further as we have made grooving in that one. So this becomes weakest zone and this the reason why there can be development of cracks at this locations.

Now we come to another category of sleepers. This another category of sleeper is CI sleepers or cast iron sleeper. In this case we have again different type that is one is CI pot sleeper. This CI pot sleeper is not suitable for curves sharper than 4 degrees. This is one case as far as its use is concerned then the another thing is fittings are hidden and

therefore the maintenance become difficult. So if we have to change any of the fitting, then the first of all, the pot sleeper has to be removed and then only those fittings can be changed. So that is the one of the biggest disadvantage in using the CI pot sleepers. This is one of the diagrams of pot sleeper where this is the rail section being shown here and this is the inverted pot being placed at the ballast cushion. This is the ballast cushion so this is the pot being placed like this. One thing which may happen is that the ballast will go inside the sleeper. So there is sort of packing of ballast within this sleeper but another aspect is this sleeper is to be connected to another sleeper on other side. So this is the section which is shown here it comes out on this side like this, this is the bar. This connecting bar will go to the other sleeper and this is how they are going to be connected.

This is one thing, another thing is that this sleeper has to be connected to the rail sections using different features have been shown like this here and they are finally going to be connected somewhere inside that is the reason why the maintenance is little difficult in this type of the sleeper. This is another diagram of CI sleeper where the further details have been shown. What we can see is this is inverted pot like this and then this is placed where the rail is being seated, so this is the chair of the rail is being provided and so to keep these rails section into place again the keys have to be used. So we are using this key so as to keep in place the cup, so key and cup arrangement is there whereas at this location it is being hold up like this one. So this is the section of the rail which has been provided, it is fine to maintain some pressure at the put of the rail section. Then here we have this tie bar, this bar is going from this one sleeper to another sleeper on the other side of the gauge and obviously this is being connected with the pot and the other fixers by using zebu at this location or at location too.

So, the another type of CI sleeper is CST 9 sleeper. CST 9 sleeper is the name which comes from central standard trial 9 sleeper. This name is coming from the different number of test which has been carried out in the laboratories of railways where they have tried different type of sections or different type of designs related to the cast iron sleeper. So in this section this is the ninth trial which has been you can say successful trial and further after this ninth trial again some more trails are going on like 11,12,13 and likewise but still at most of the section we are using this CST 9 sleeper. Now this CST 9 sleeper is sort of combination of pot sleeper plate and the box type of a sleeper. So all the things have been mixed together to form this type of sleeper this is CST 9 sleeper, they can be termed as triangular inverted pots. The central plate is provided with the projected keel and there is a box which is provided on top of the plate. So this is the combination of 3 things which are used in the formation of CST 9 sleeper. Then it has the tendency of reducing, rocking of the sleepers under the rail wave motion.

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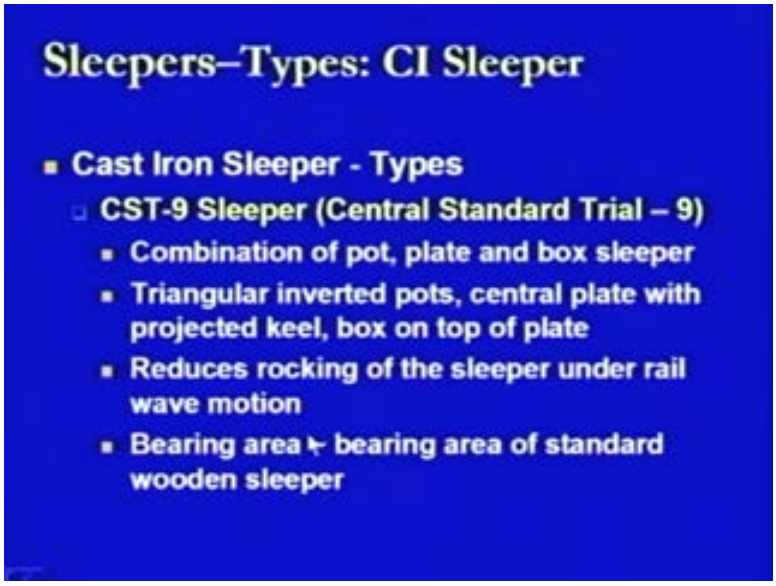

Now as we have seen that there are so many fixtures which have been used it is a sort of a little complicated design which is being used so it helps in reducing the rocking behavior of the sleeper because of the moving revolving stock and one advantageous condition with the CST 9 sleeper are basically the CST sleepers is that they have wider area through which the loads can be transferred from the rail section to the ballast cushion sections at the bottom and the bearing area is approximately of the same stature as been provided for wooden sleeper. So this is one of the biggest advantage in the case of the CST 9 sleeper. Further, in this case of CST 9 sleeper they are not suitable for mechanical maintenance with the tie tampers. This is again because of its design, because of the different type of the fastenings fixers which have been used and that is why the mechanical maintenance cannot be done because the tie tempers are used in the mechanical maintenance, they are mechanical devices, they are automatic sort of devices and they can do the maintenance by itself but then in case of CST 9 it is not possible.

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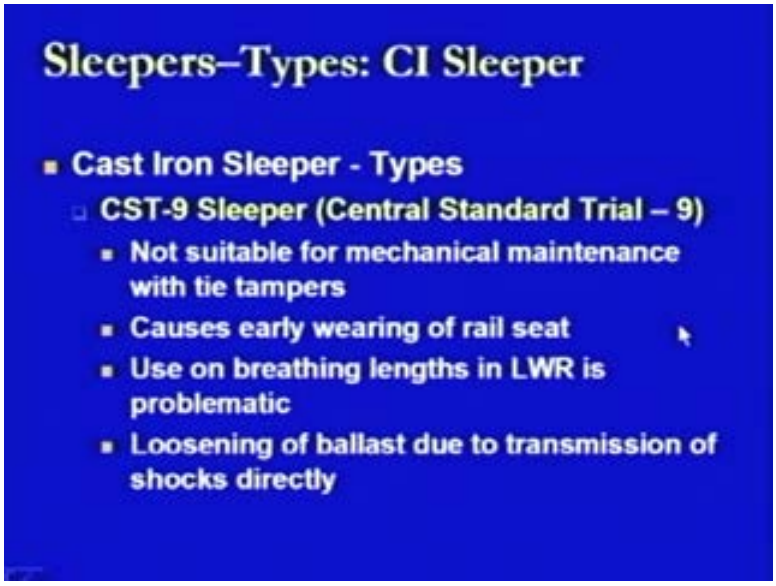

Then they cause early wearing of the rail seat. This is one of the disadvantages of CST 9 sleepers. The use of breathing lengths in LWR is problematic, this is another problem related with use of CST 9 sleepers and loosening of ballast due to transmission of shocks directly and in the case of the previous one where we had seen that they are having turning at the ends and that is why they were be in a position to retain the ballast section where it is sort of locking of the ballast section was possible but in these cases there is the loosening of ballast section because of the loads and in this ballast may go out and therefore they are periodical packing of ballast section is to be done.

This is one of the diagram of a CST 9 sleeper, in this case what we have seen is there is inverted triangular plate which is being used then there is a flat plate condition which is used here and sort of cup is being placed on this side. So this is the elevation of the CST 9 sleeper. In this one the rail section is being placed here so the grooving is being made and we are using at two ways key which is inserted at this location. So that this rail section can be placed and maintained and hold out at its level and then in this case again we are using the tie bar and these tie bars are joined to this triangular plates by using quarters at this location or at this location. So these are the type of the sleeper which have been used probably you have also seen these type of sleepers being provided. There is a very thin bar which is used to connect this sleeper with another sleeper on other side of the rail track that is based on the gauge. This is the plan of the same one and here this is the rail section is being placed and this is the key being inserted in this one and this is how we find the shape of this, this is inverted condition is being here, this is the slanting going down in this direction and slanting going down in this direction. So the box type of the structure is being placed in this one, the triangular structure is being placed in this one and plate structure is placed on the other side. This is the combination of different things and then at the bottom of this one there is the key is being provided, the idea to hand this is that it tries to maintain because it gets inserted into the ballast cushion. So this is how it

will remain into its position at that ballast cushion level. So this is what is diagram of CST 9.

So now we look at some of the advantages of the CI sleepers. In the case of CI sleepers they are less corrosion prone as compared to the steel sleepers, they are less liable to crack at the rail seat because by strength of these sleepers have been increased by using different type of fittings, that is, triangular shape or box shape structure which have been used in the construction of this sleeper and then they are easy to manufacture. They have higher scrap value compare to the other type of sleepers but there are some disadvantages, the disadvantages are that there is the difficulty in the maintenance of the gauge, there is lesser lateral stability in these type of sleepers and they are unsuitable for track circuiting as we have seen in the case of steel sleepers too and they are also unsuitable for mechanical maintenances because the space being provided or the type of the design which is being used in the formation of the sleeper is so complex that it is not possible. They are susceptible to breakage at those locations where the different type of the structures have been combined with each other that is the plate or triangular or box structure which has been combined together.

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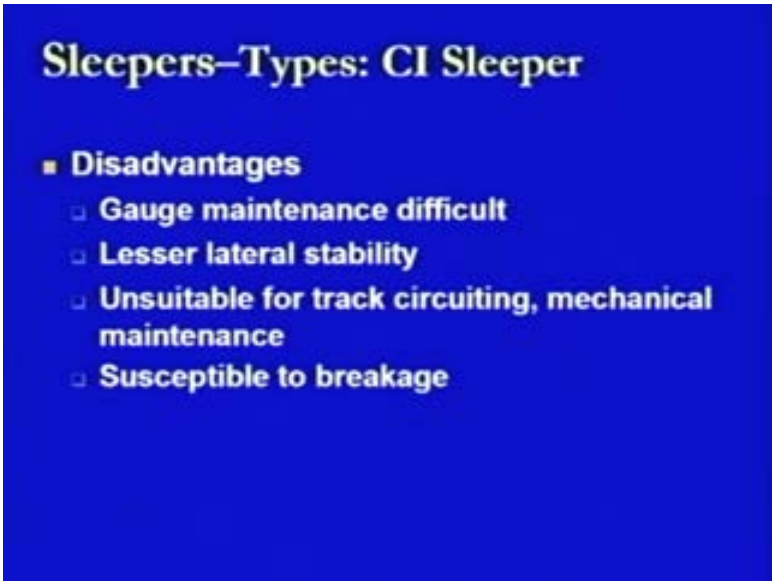

Now we come to another category of sleepers these are the concrete sleepers. In the case of concrete sleepers we have different type of loading conditions. So we are looking at first of all for what design these concrete sleepers are being taken up. The loading condition remains like they should have the vertical load at rail seat equivalent to 15 tonnes, so they are going to design for 15 tonnes vertical load at the rail seat level, this is the load. Then another category, another condition which needs to be satisfied is that this 15 tonnes along with the reaction at the center of sleeper which is equivalent to the intensity of half of the load that is the under the rail seat is to be considered. So that is another loading condition which is to be considered and the third condition is that this vertical load is reduced to 13 tonnes whereas the lateral load is taken as 7 tonnes. So this

is another combination of the loading vertical load with the lateral load and the final loading condition is of the banding moment where the bending moment is taken as 1.33 tonnes meters at the rail seat and taken as 0.52 tonnes meters at the centre of the section. So these are the 4 condition for which the concrete sleepers have to examined or tested and once they comes out satisfactory under these testing conditions for these different loading conditions then they are used on the track. So this is one aspect related to the design of the concrete sleepers.

Another factor which needs to be taken into consideration as far the design is now on basis of this we can see that the forces which are acting on any of the section or any of the sleeper the various forces as we have seen in the loading conditions or vertical loads, or the lateral loads, or the type of the banding moments which will be there. There is also a fact of geometrical form of the shape of the sleepers and this is to be taken in the form of what is the overall shape? What is the size? And then what is the weight of that sleeper?

Obviously, the shape or the size they are going to govern especially the bending moment because the point at which the lateral load is acting the point at which the vertical load is acting then if you go for the calculation of the bending moment may be at the rail seat or at the location then the distance will come into consideration. So that is why the geometrical forms have their effect and then the weight is the another aspect because this weight is going to add on to the vertical loads which is coming from the rail seat and this weight is not only it is going to create a resistance to the vertical load because if it is going to increase then it will be having the more stresses or resistances offered to those loading conditions. Then characteristic of fastenings which are provided between the sleepers and the rail section. So what type fastenings have been provided? Whether they are the conventional type of the fastenings being used or they are the elastic fastenings being used. These are the 2 types of the fastenings which are generally used in the permanent ways, so to look at what fastenings we are using. Mostly in the case of concrete sleepers we use elastic fastenings and provision of failure against derailment because if there is a derailment then obviously it is going to just damage the concrete sleepers and therefore in that condition the only remedy is to just to renew the sleepers.

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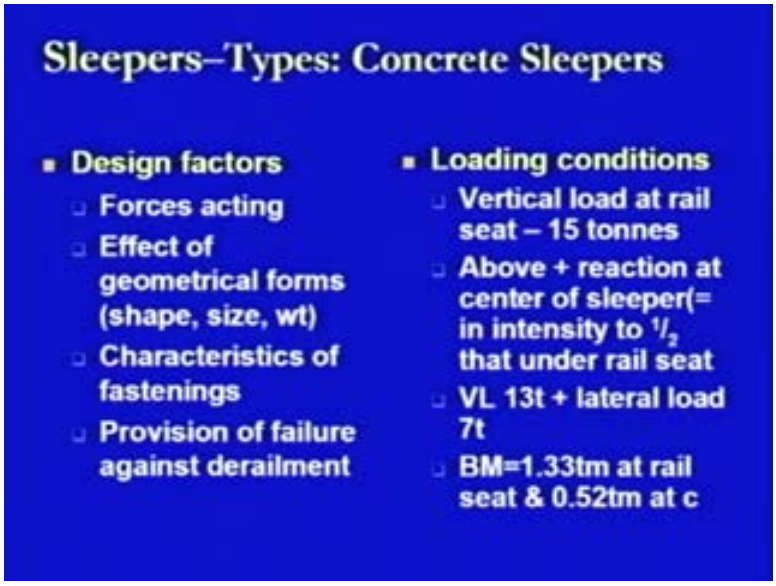

Therefore, what are the provisions which we taken against derailment against failure of such type, that is another important aspect which is to be taken into consideration while it designing the concrete sleepers.

Now some of the advantages of concrete sleepers they are being heavy they lend strength and stability track, they are suitable for LWR due to resistance to buckling because they are quite heavy so that is why they are able to provide those resistances, they maintain the gauge alignment and the cross levels as we have seen this is again coming because of their heaviness because of the weight of the concrete sleepers. The track circuiting is possible in this case as in the case of wooden sleepers whereas in the previous 2 cases, that is, the steel sleepers and the CI sleepers is not possible. The corrosion or the damage due to pests fire hazard all these 3 conditions are not there in the case of concrete sleepers. They are not going to be affected by the corrosive conditions; they are not going to be affected by the fire hazards and by the pests. They have longest life expand even more than 50 years. The better mechanical maintenance is possible in the case of concrete sleepers as compared to the previous sleepers because of the easiness of the design of the concrete sleepers, and the local resources can be used for making of forming the concrete sleepers, that is the another advantage. Whereas in the rest of the cases what is to be done is that they are rolled out sections or they are sections which have been need in the workshops, so they have to be done in there and then they are taken to the sites.

At the same time some disadvantages are also there; One thing is because of they are heavy weight the handling and laying is difficult, heavy damages are there in case. There is a derailment because of again the material property the concrete is of such thing that if gets removed then there is it loses their strength. So if there is any derailment damage being caused then whole of the concrete sleepers has to be removed and replaced. There is no scrap value again in this case as being seen in the wooden sleeper condition too whereas in the previous conditions we would we are getting bigger higher scrap value.

They are not suitable for beater packing, beater packing is again sort of mechanical devices where we have to beat the ballast cushion which is being provided on the side of the sleepers, that is, what is the packing of the ballast is there. So it is not suitable for that because of chances that if beater is hitting the concrete sleeper then the concrete sleeper may get damaged. The cost increases due to use of mechanical handling procedure so this one another disadvantage in the case of concrete sleepers though the mechanical handling is possible but than it is increasing the cost, we have seen because of the heavy loads or heavy weights of these types of sleepers we cannot do it manually or by using manual labor.

This is one type of sleeper which is being shown in this diagram. This is another type of the sleeper. We will be looking at these two types of sleepers, that is, the mono block sleepers or the twin block sleeper condition. This is one track bear the mono block sleeper is being provided, what we found is that this is the sleeper comes like this then section is being reduced at this point. Here is the section is more thicker, here at this location the section is the less thicker. The reason behind is that whatever loads are coming they are going to dispose through the area, certain area in this section. So we have some distances up to this point after which the section has been reduced in this one and this is again is increased as we come towards the other rail sections. So this is mono block concrete sleeper, they are trapezoidal section, the cant of 1 in 20 is being provided for 175 mm from center line of rail and initial pre stressing is done at value of 65 tons per square inch that is already they have been pre stressed the stressing is being done before they are laid, so this is the amount by which it is being done. They have crushing strength at the hand of 28 days as 525 kg per square centimeter and pandrol clips are provided so as to join the rail section where the concrete sleepers. So here at all these locations whatever we have seen they are the fixers, they are fastenings which have been used so has to join to this rail section with the concrete sleepers and generally this fastening is the pandrol clips which is being used.

This diagram what we are seeing is in this photograph this is the twin black RCCS concrete sleepers. Here this is again the section being shown like this. This is the depth of the concrete section below the rail seat and this is how it is being reduced so as to seat the rail section here and then it being joined in both sides by using some fixers which has been shown here or here or here and in this case again two blocks have been used. One below the rail section and another below the rail section, they have been joined together using the bars. So we have the tie bar which is being used here like this they are tie bars which have been placed here this level.

Now there are certain locations in which the concrete sleepers should not be used. One is the new troublesome formations the concrete sleepers should not be used unless until they have stabilized, it is sort of condition which we have seen in the case of a LWR or CWR. The rock cuttings without ballast cushion, that is the another area where if there are the rock cuttings have been provided and the track is directly being laid on those rock cuttings then in that case the concrete sleepers should not be used. If they have to be used in the ballast will also be used. Then unballasted lines in yards again in those conditions the concrete sleepers should not be used. Curves of radius less than 500 meters, whatever we are seeing this is another condition which we have seen in the case of LWR, the LWR

is also prohibited. Then location of excessive corrosion; they are condition if the reinforced sleepers have been used and twin block sleepers have been used. The 2 sleepers have been connected using the tie bars. Un-ballasted arch slab bridges are there then those locations are also not being used or in those conditions we are the fish plated tracks are used. So instead of this if the validate joints are being used then we go for the concrete sleepers.

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Now we come towards a sort of comparison at the point of comparison between the different types of the sleepers which so far we have discussed. What we have discussed is on the basis of course of sleepers. The cost is going to be lower in the previous case compared to the concrete sleepers. The life is highest in the case of concrete sleepers as compared to the other sleepers, the weight per sleeper is to be examined and this is mush higher in the case of the concrete sleepers as compared to the wooden or CI sleepers or steel sleepers. The ratio is being something like around 1 is to 4. Then, maintenance cost is lower in the case of concrete sleepers compare to the other sleepers because of chances of decays, corrosion or wears is less. Handling is easier both in the case of wooden sleepers as well as in the case of the steel sleepers but in the rest of the cases in the case of concrete sleepers because of the heavy load it is a more difficult.

Track fittings, more track fittings are required in the cases where the steel sleepers or the CI sleepers have been used. In the wooden sleepers simple fittings are being used whereas in the case of concrete sleepers we already insert the fitting while the manufacturing is being done of those ones of the grooves as required to fit in provided so normal fittings will be required but one thing is here in this cases that the fittings in the case of the concrete sleepers they are elastic in nature whereas in the case of wooden sleepers or steel sleepers they are both may be elastic or conventional in nature. Elasticity of the track is another point where the comparison can be made. Then another point is laying and relaying of the different components of the track along with the sleepers that

whether it is a possible to lay and relay the sleepers easily or not. In the case of the wooden or the concrete sleepers looks a little easier as compared to other one. Then the rigidity of the track is more rigid in the case of concrete sleepers as compared to the other one.

Suitability of the track is another aspect needs to be looked at that is what are the locations here this type of sleepers can be used. We have already seen in the case of advantages disadvantages of the different sleepers when we have discussed them. The suitability aspect can also be taken care of track circuiting is possible in the wooden concrete sleeper but in other two cases is not possible. Gauge adjustment again is much better in the case of concrete sleepers. Now we look at another aspect related to sleeper that is sleeper density. The sleeper density is defined as the number of sleepers per rail length and the mathematical abbreviation for this one is defined as M plus x, where m is rail length and x is the number which varies from 4 to 7.

So if we have a rail length as 13 meters then and if we take the number as 4, then 13 plus 4 means 17. It means they are 17 sleepers to be provided below 13 meter length of the rail section.

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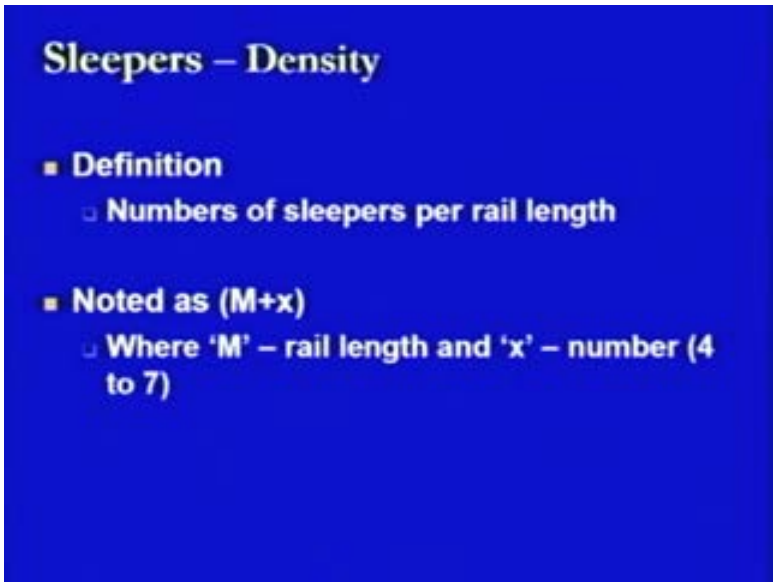

So this is the sleeper density for that case. Then this sleeper density depends on certain factors. The factors are the axle load; if the axle load is increasing the sleeper density should also be increased. If their higher speed then we required to just the resist the augmented conditions of the different loads which are coming, so therefore again the sleeper density needs to be increased in this case. If the lower rail section have been provided the sleeper density can be increased again but if the higher have their sleeper density may reduce. Then the type of the sleeper which is being provided, if heavy sleepers have been than sleeper can be reduced. What is the thickness of the depth of the ballast cushion or what is the type of the ballast is being used, that is, another factor

which may define the sleeper density or the number of sleepers we should be provided because it is going to depend on the load taking capacity of that ballast.

Similar is the case for formation level because formation level is the final level up to which the loads are going to transfer. So if it is weaker in section than in taking load then more of the sleepers is to be provided at the top of ballast cushion. The next point, the next aspect related to sleeper is the spacing of sleepers. Now the sleepers are defined in different forms as we see in this diagram. This is the rail section, this is another rail section, the joint is being provided at this point. Any sleepers which is provided at adjacent to this joint at this side, or at this side is known as joint sleeper whereas any sleeper after this one that is the first sleeper which is provided after this one is known as first shoulder sleeper. Then the next sleeper which is provided is known as second shoulder sleeper. Any sleeper provided after the second shoulder sleeper is termed as intermediate sleeper. So this is how the sleepers are designated and then in this case whatever the distance available in these sleepers designated as a, b, c and d respectively.

So we have look at the values of these a, b, c and d. This is the case of fish plated track. So in this case what we see is the spacing of the sleepers is being defined here for 2 cases that are wooden and metal. In the case of between joint sleepers that is distance 'a' it is given as 30 centimeter for wooden and 38 centimeter for metal. Then between the joint sleeper and the first shoulder sleeper it is 61 centimeter in both the cases. Between the first shoulder sleeper and second shoulder sleeper it is 70 or 72 centimeters if the sleeper density is M plus 4 and it is 64 or 63 if the sleeper density is M plus 7.

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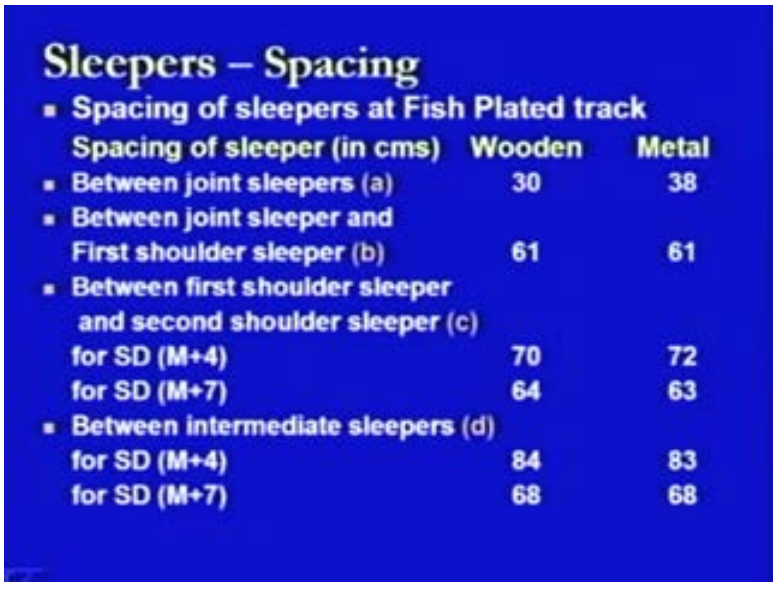

Between the intermediate sleepers this is 84 or 83 if the sleeper density is M plus 4 whereas it is 68 centimeter if the sleeper density is M plus 7. Similarly, in the case of the welded track value is defined in terms of 1660 per kilometer length and the spacing is 60 centimeter in this LWR section. If it is 1540 per kilometer than the spacing is 65

centimeter in LWR and 66 centimeters in SWR and if it is 1310 then the spacing is 78 centimeters in SWR condition.

So what we have discussed today is the different aspects related to sleepers, their functions, their requirements, different type of the sleepers, their advantages and disadvantages of the comparison and finally the sleeper density and the sleeper spacing. All these things are part of the design features of permanent way.

This is one of another component which we have discussed today in this lecture. We stop at this point and I say good bye to you.

Thank you.