Transportation Engineering - II
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Lecture - 20
Crossing and Design of Turnout

Dear students, I welcome you back to the lecture series of course material Transportation Engineering – II. From the previous lecture, we have started discussing turnouts. As we have discussed the turnouts of the wheels allow the train to move or to change the direction. In the continuation of the same, we will be discussing some other features regarding turnout. We will be discussing about the crossings and the design of turnout specifically, in this lecture. So, the lecture has been outlined in the following manner.

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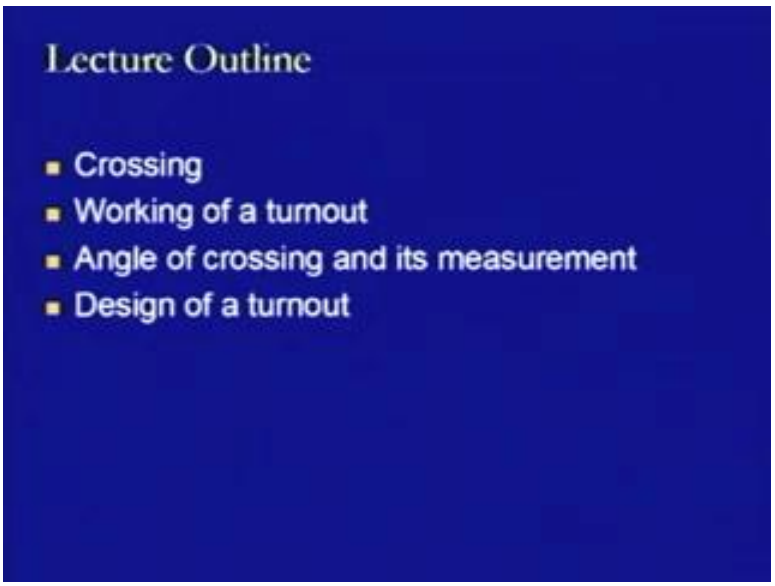

We will be discussing about crossings, we will be discussing about the working of a turnout; we will also look at the angle of crossing and the way it is measured and the design of a turnout.

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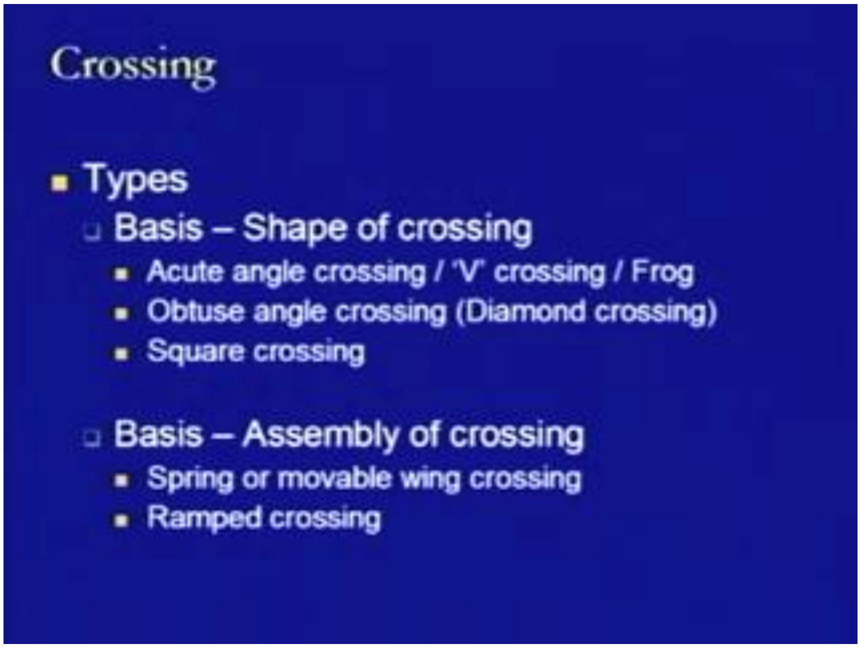

So, we start with crossing. We have already seen that in the case of a crossing, there are certain components, needs to be provided that is in the form of a combination of a point rail with a splice rail, a pair of check rails and the wing rails and the angle of crossing and with the combination of all these, then there are certain features which gets formed like ANC, that is actual nose of crossing, TNC, the theoretical nose of crossing and the throat. Now, here we will be looking at the different type of crossings which can be maintained, which can be created using these components, which we have discussed just previously.

Now, these types of crossings can be defined on the basis of the shape of crossing or there can be another way of defining it too. We will look at that one just after this one. In the case of shape of crossing, there are three types of the categories, the acute angle crossing which is also known as v crossing or a frog, an obtuse angle crossing which is also at times defined as a diamond crossing and a square crossing. In the case of acute angle crossing or V crossing or a frog, the splice rail and the point rail they are being placed in such a way that the angle being formed by the two is acute angle in this case, whereas in the diamond crossing there is an obtuse angle which is formed by the two types of the rail sections. In the case of a square crossing, what we find is that all the rail sections have been provided at an angle of 90 degrees with respect to each other.

Similarly, we can classify the crossing on the basis of the type of the assemblies being provided on the crossing. It may be defined as the spring or the movable wing crossing or classified as the ramped crossing. In the case of a spring or a movable wing crossing, the wing rails are provided with springs or there is a possibility of moving the wing rails in certain direction and that is why the reason due to which they are termed as the spring or movable wing crossing. In the other case that is the ramped crossing, no such arrangement is being provided and they are provided with ramp for certain movement. So, that is the basis of defining or classifying the crossings on the basis of shape and on the basis of assembly.

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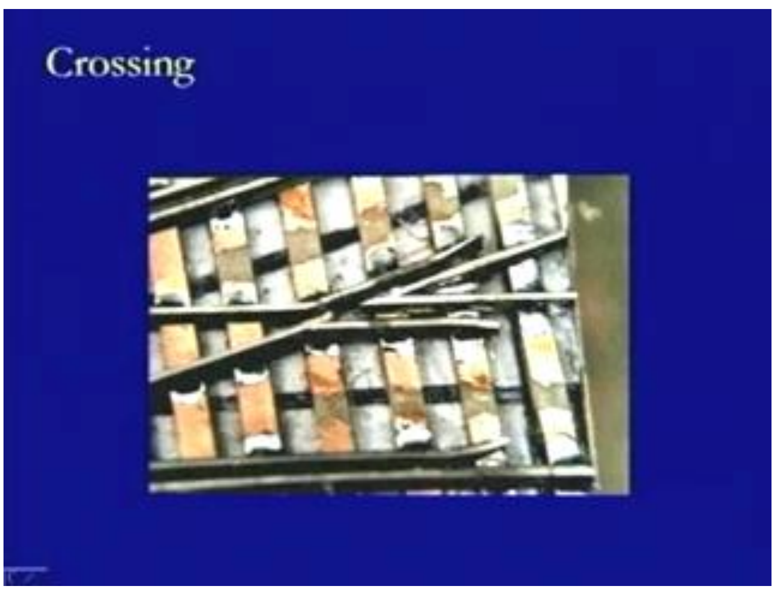

Now, this is the crossing which already we have seen previously too and here if we see that this is the V shape which is formed and if this angle is acute angle, then this is an acute angle crossing. But, if suppose, this gets flattened like this or it gets flattened like this, then it will be transferring into, transforming into a diamond crossing or an obtuse angle crossing, because this angle will become much bigger than 90 degree. Similarly, if this is being made at 90 degree, then we will be having square crossing. Then, on the basis of the movement of these wing rails in this direction or the flexibility of providing that movement using the springs, because of the lateral movement of the wheels which are coming at this location or striking the wing rail, then that is what is termed as the spring type of crossing, whereas if it is not being provided that way and there is just a sloping surface being provided within this section, then that is what is ramped crossing being provided.

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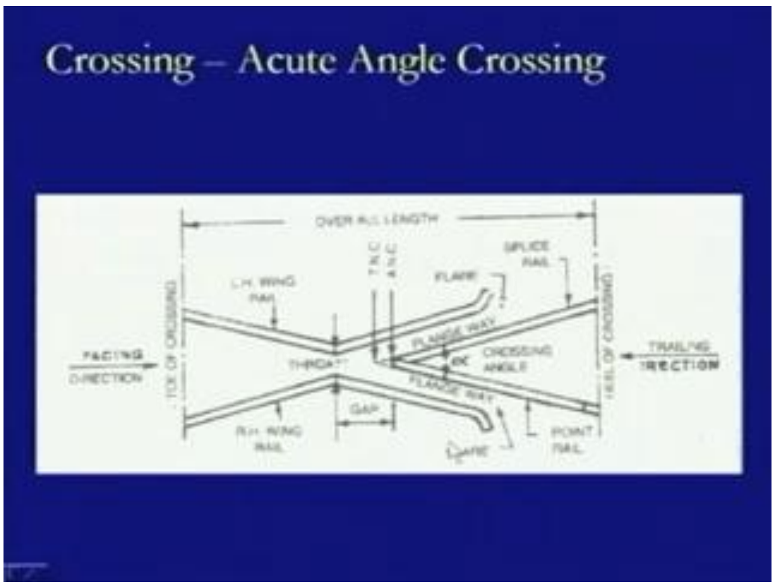

Now, in the case of acute angle crossing, this is another diagram which is trying to depict the same thing and what we see is that we have the two rail sections. This is one rail section and this is another rail section which are joining together at this location and this rail section is being cut here as we can see, whereas this rail section is going up to the end of this point and where it is being provided with a 6 mm thickness here. So, this is a point rail section and this is a splice rail section and in between these two, whatever angle is being formed is the crossing angle and because we are looking in the direction of the points from the crossings, then this is a trailing direction and this one will be the facing direction.

The overall length of the crossing is defined by taking certain length of these splice rails or the point rails along with some length or the straight section of the wing rails or the right hand wing rails which are provided at this crossing. The distance here has been defined previously too is the throat and where this is ANC and this is TNC that is the difference between the two. So, we have to look at these types of crossings or the similar sort of crossings or similar sort of terminologies, which needs to be used whether we are talking about the acute angle or obtuse angle or another type of crossing.

Now, we look at the obtuse angle crossing.

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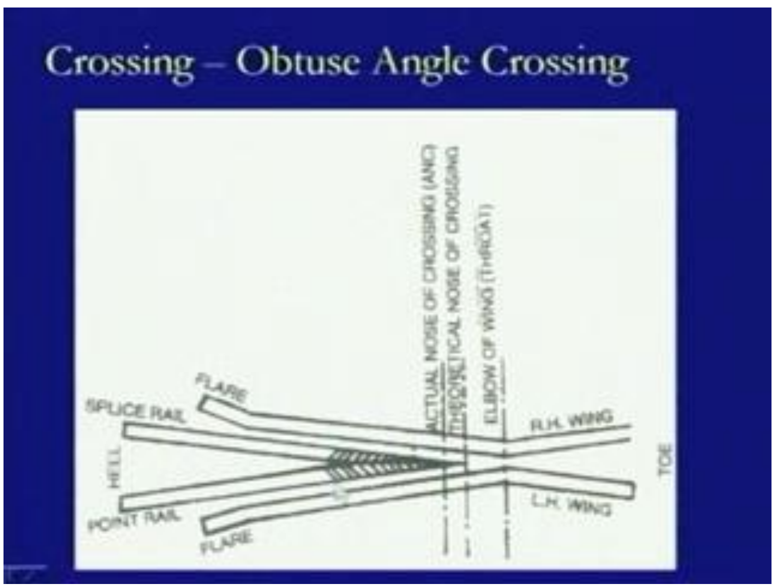

In this case, the obtuse angle crossing we just have a bigger angle which is formed and in that case that is what is this is actual nose and these all again are being shown in the same form with the throat.

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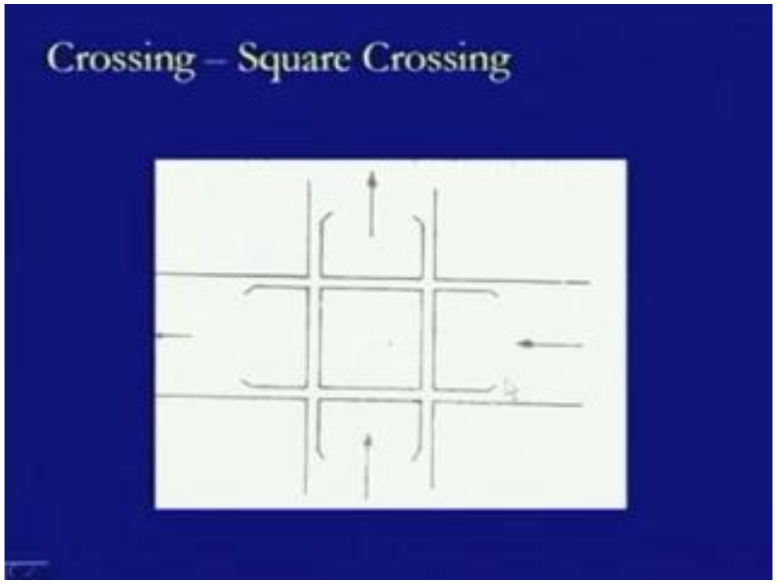

Whereas if we go to the square crossing, this is the diagram which depicts the square crossing, where everything is at 90 degree with each other and we have, this is crossing condition; so, we have the wing rail here and we have the wing rail here. What we can see is that at this location where the wing rails have been provided at this crossing, there is no check rail which is being provided on the other side. The reason being is that on this side also there is a crossing and because of the shape of this crossing, this check rail which goes along with this lead rail and comes back as a check rail, so they become opposite to each other and that is why there is no requirement of providing a check rail in this case. We have the wing rails being provided in all the crossings and in the center we have the straight section which is being connected in this form. So, this is square being formed here like this. So, on all the directions we find that we have the check rails, we have the wing rails on this side, this side, as well as this side. So, four pairs of wing rails are provided.

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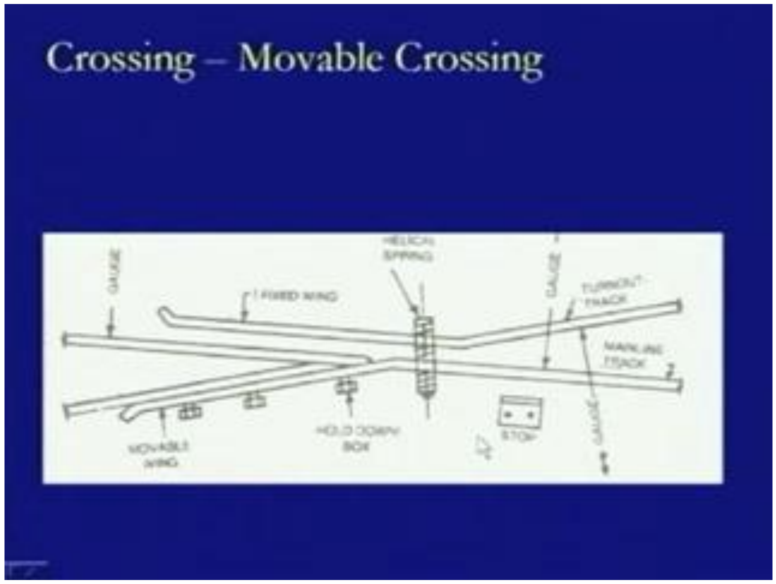

Now, we look at this one. This is a movable crossing, where the spring is located here. This is helical spring and with the help of this helical spring this has a tendency to move and this is a movable wing rail. It can be moved to this side or it can be touching this way. Now, what happens is that as we have seen in the previous diagram, where if this is provided in the way as been provided here like this, then the location will be something like this. This will be the location and because of this one, then there will a big gap between this face of the rail and this ANC.

So, so as to reduce this gap, so that there are no hazardous conditions getting created when the wheel is changing over from this rail section to this rail section, when it is moving in this direction like this, then this gap because it is now being maintained at a lower level, because of the movement of this wing rail in this direction and now it is touching this one and allowing a very small gap at this location, so that there is a smooth entry of the wheel from this side on this track and because we are not providing an operation in this direction, therefore even if this wing rail is touching this lead rail and closing the entry on this side is perfectly alright. So, this is what is the advantage of this spring type of assembly which is provided here and this is why this is known as the movable switch wing rail crossing.

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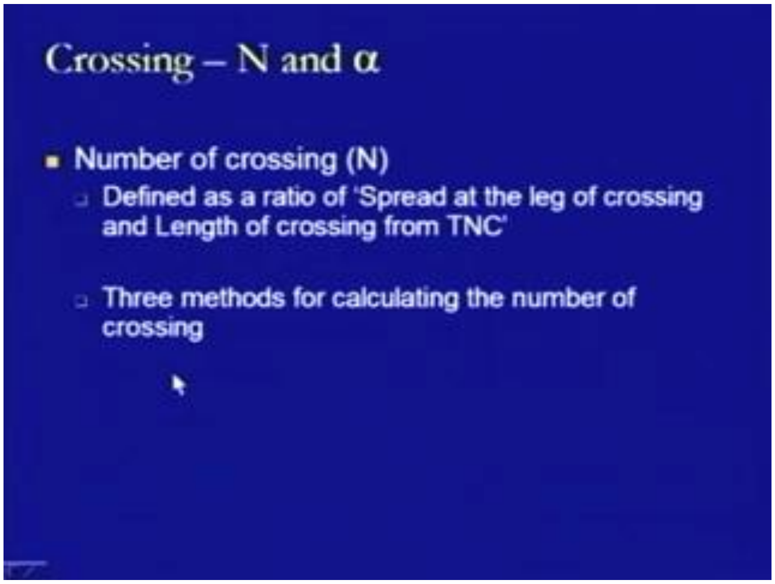

Now, we come to another condition, another thing which needs to be looked at. That is what is number of crossing. This number of crossing is having a correlation with the angle of crossing. Now, we have seen the angle of crossing in the previous diagrams, where the point rail and the splice rail, they were just crossing each other. So, if we look at that one and we find that angle of crossing, then on the basis of this angle of crossing we can also define the number of crossing and this is generally depicted or defined in form of N, capital N.

So, this is defined as a ratio of spread at the leg of crossing and the length of crossing from TNC. This is how it is defined. If we take the spread at the leg of the crossing, we have seen in the first diagram that is where the length of the crossing was shown and all of the features or components of that crossing were also indicated, in that case if we are interested to find out the spread, then this spread is to be seen at the leg of the crossing and with respect to that, then what is the length of the crossing starting from the theoretical nose of the crossing, then if we take the ratio of these two, then this is going to be defined as the number of crossing. There are three methods for calculating this number of crossing.

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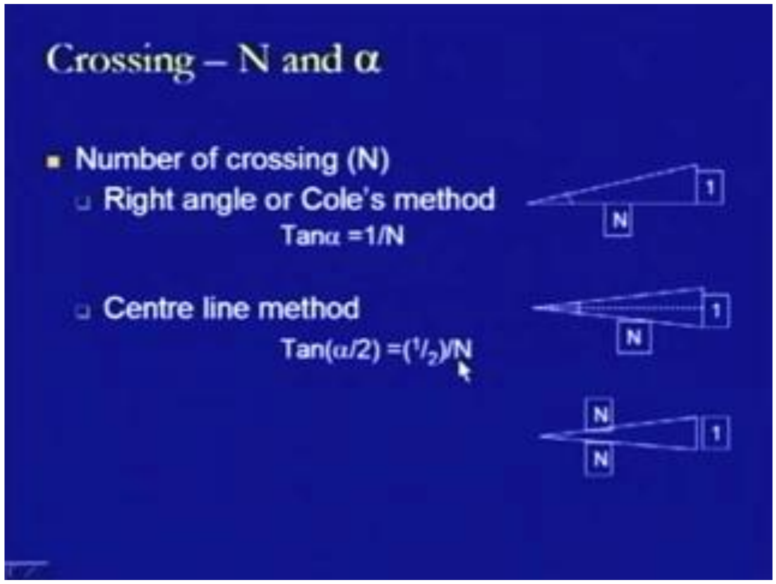

We will be looking at those three methods. The first method is the right angle or the Cole's method. This right angle or the Cole's method speaks in the form that if we have a crossing here, we have splice rail and a point rail being placed like this and there is this angle which is the angle of crossing that is alpha. Now, if we are moving a certain distance N and after moving that certain distance N, there is a unit distance available between the point rail and the splice rail, then we can define this angle of crossing. Here, in general case, this distance, unit distance 1 was taken as 1 feet. So, if we are moving a distance in feet and then we are getting a distance of 1 feet between the point rail and the splice rail, then that is going to define us with the angle of crossing and here in the case of this right angle or Cole's method, it will be defined in terms of tangent of this angle alpha. That is angle of crossing is nothing but this is 1 divided by N.

In the other case, we have the center line method and this case of center line method as you see in this diagram instead of having this sort of a geometry, where the thing was at 90 degree, here we have this point rail and this splice rail again being shown in this form and then, we are dividing this angle of crossing by 2 and so, this is a center line. So, if we have this centerline, if we move along this center line here and then while moving along this center line we get say, half of the feet on this side and half of the feet on this side, so that it constitutes total 1 feet distance between the point rail and the splice rail at this distance which is being moved horizontally in this way, then this is how we are going to define in the center line method the number of crossing and in this case, it will be defined as because we are taking in this one, this we are considering as a triangle now, so this becomes alpha by 2 and this distance will also become half instead of 1. So, we have this as half, this is an angle as alpha by 2 and the distance moved from this point to this point remains N. So, therefore this is tangent of alpha by 2 is ~~half multiplied~~ half divided by N. So, that is how we can find out the value of this N, because we know the angle of crossing.

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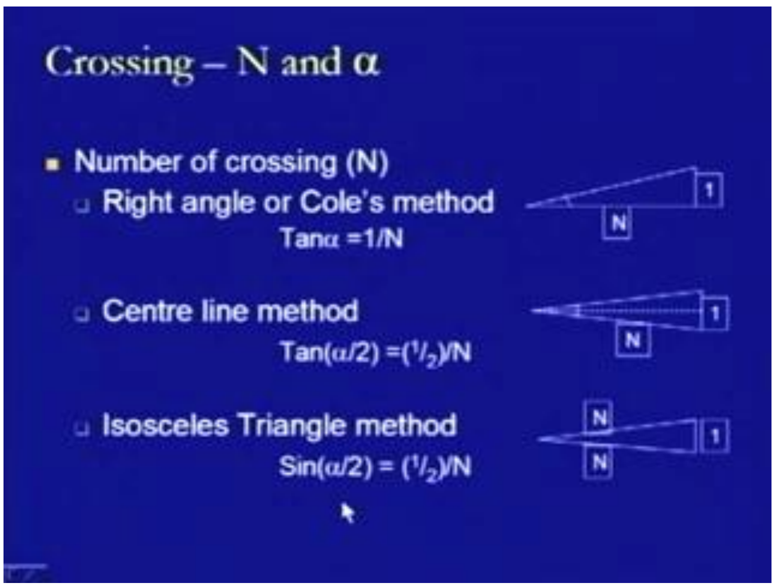

The third way of finding out the number of crossing is the isosceles triangle method. In this isosceles triangle method, what we are doing is that we assume that the triangle which is formed by the combination of a point rail and a splice rail is isosceles triangle and therefore, the length here and the length here is same. So, once we have this angle alpha and we are moving along this side or this side, then we are moving a distance N and when we move a distance N in this way, then the distance being maintained between the splice rail and the point rail, again if it becomes unit that is if we are moving certain feet in this direction and this becomes 1 feet that is how it was taken, then this value, we will be taking this value of N, if it comes something like 12, then it is the value of N is equals to 12. If it is coming eight and a half, then it is taken as eight and a half. If it is coming as 16, then it is taken as 16 and this is the way by which we can define it easily.

Here again, if you are interested in computing the value, then we can compute the value using this way. That is again if we make a center line here and then we have alpha by 2, alpha by 2 angle, then sin of alpha by 2 will be half divided by N. So, that is how in the case of isosceles triangle method we can compute the value of N. So, these are the ways by which it can be done. But in general, what happens is that if you are taking this distance with respect to a unit distance being maintained between the two types of the rail sections, then that distance itself gives us the value of N and that is how we find out the value of N in the field.

So, what we will do in the field is that if there is a turnout and we are interested to find out the angle of the crossing, then we will just start moving some distance and we will keep on checking that at what particular point we are getting away from the one side of the rail section by a distance 1 feet and then, at that particular point whatever distance we have moved already is the value of number of crossing. So, depending on the requirements, depending on the type of the data which is available to us, we can compute this angle of crossing or the number of crossings, so as to be used in the design of turnouts. These are the three ways which are more widely used throughout the world.

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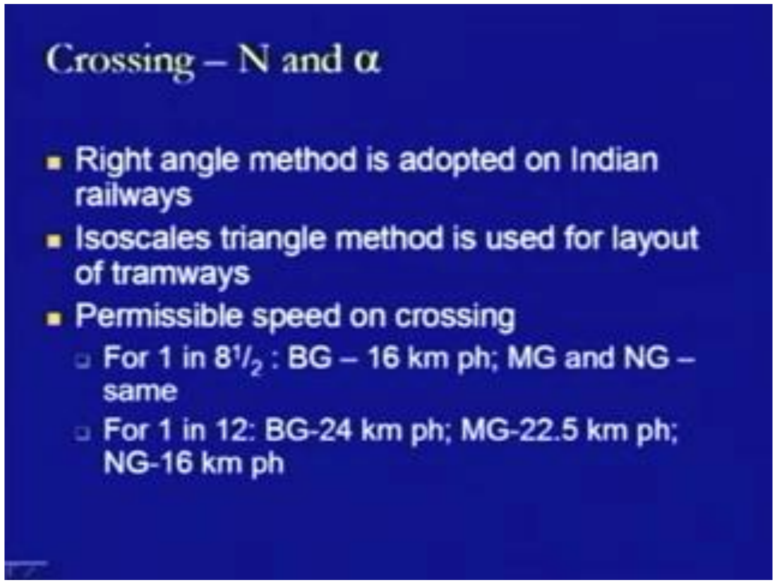

In the case of the Indian railway condition, we are using right angle method. This is in general adopted for finding out the value of N or alpha or correlation between these two. The isosceles triangle method is used for the layout of tramways. This is another type of movement system which is provided and this has been provided previously at certain number of locations. Even in India too we have the trams in Mumbai very, very late, where you can see in the early time period when the train systems were devised and we have these in the Kolkata too. So, in those locations where we have provided such type of tracks for the tramways, then isosceles triangle method has been used and the permissible speed on the crossing is one another aspect which needs to be seen, because if we are looking at a higher speed turnouts or the higher speed crossings, then in that case the turnout or the crossing has to be flatter and if it is going to be flatter, then we have to see that the value of N will keep on increasing.

So, we have to look at that what is the permissible speed which is being provided, which is being approved for that track and then, on the basis of that one, we can find out that what type of crossing or what angle of crossing or the number of crossing can be provided. Now, in the case of different type of crossings which are available, in terms of the value of N that is like has been shown here for 1 in eight and a half, the value of this speed is being given as 16 kilometers per hour for broad gauge and in the case of meter gauge and narrow gauge also it remains the same value. Whereas, if it is being made further flatter that is now it is having a value of 1 in 12, then in that case the broad gauge can have a value of 24 kilometers per hour, whereas meter gauge can have a value of 22.5 kilometers per hour and the narrow gauge can have a value of 16 kilometers per hour.

Similarly, if we keep on increasing the value of this N that is we go to 1 in 16 or 1 in 20 or 1 in 24 likewise, then we can keep on increasing the speed of the track. That is the permissible speed of negotiating that crossing or negotiating the turn out will keep on increasing and in the case of high speed facilities, generally we are interested to provide the value of this crossing as minimum of 1 in 16 and now a days when we are looking towards the speed where we are interested to maintain a speed as high as 250 kilometers per hour, then we have to go to further flatter type of crossings or turnouts. So, in that sense we have to look at 1 in 20, 1 in 24 size of the turnouts which are also being under studied and probably in some point of a time we are going to provide them, if high speed facilities have to be provided.

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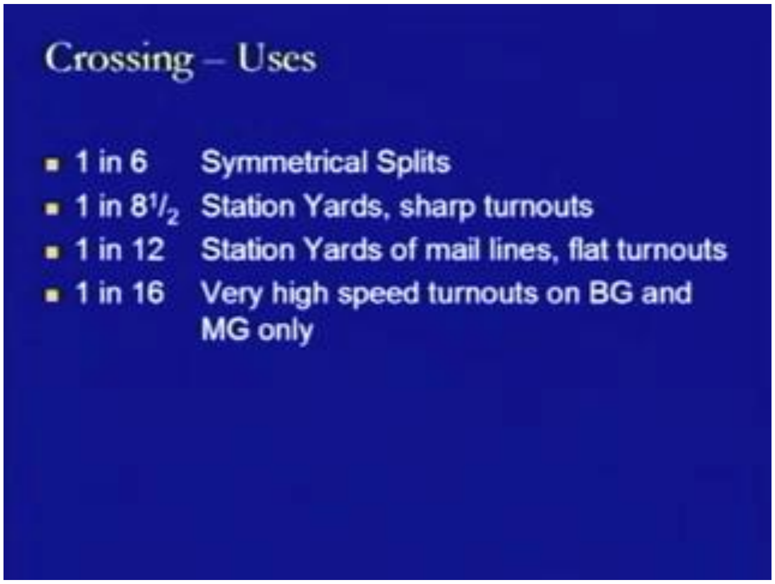

Then, we will just look at the uses of the different type of the crossings which can be provided. It is again, the crossings have been defined using the value of N that is number of crossing. Here, when we are looking at this one, this is 1 in 6 that is 6 is the number of crossing. So, this is being provided for this symmetrical split of the tracks. Where the two tracks which are diverging from each other, they are diverging at the same angle with respect to the profile of the main tracks in either direction, in both of the directions. So, that is what is symmetrical split condition, whereas the 1 in eight and a half is in general provided in the station yards or it is provided on sharp turnouts, where we have to negotiate the curve at lesser radius.

Then, 1 in 12 is provided in the case of the station yards of the mail lines or in the flatter turnouts and because, as I have discussed previously too, more is the flatter more is the speed. In the case of 1 in 16, we are providing it on very high speed turnouts on broad gauge and meter gauge only. We are not providing this type of crossings in the case of narrow gauge, because we are not maintaining such very high speeds in the case of narrow gauge.

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Now, we will be looking at some of the standard details of the turnouts. Under these standard details we will be looking at type of the crossing, the switches, the permissible values of speeds. We will look at this one and that is how we can define that what is going to be the correlation and how we have to take one value with respect to another value. Here, when we are looking at 1in eight and a half type of the turnout, then here the crossing has been defined in the terms of its number by 8.5, whereas it will translate into an angle alpha that is the angle of crossing in the form of that is as we have taken the right angled method on the Indian railways, then it is tangent of alpha is equals to 1 divided by N and using this equation, we can be clear that N is taken as 8.5. So, if we put the value in this one and find out the value of alpha, then this will come out as 6 degrees 42 minutes and 35 seconds. So, this is the standard value of the angle of crossing, if it is 1 in eight and a half type of crossing.

Similarly, in this case, the switch angle will also be defined and this switch angle as we have discussed previously is the angle between the tongue rail and the stock rail and this way out by which we can compute this value depending on whether we are considering the thickness of the tongue rail at the toe or we are not considering the thickness of the tongue rail at the toe, we can find out this value of angle beta and this angle beta in this case, where we are talking about 1 in eight and a half type of turnout, comes out to be 1 degrees 34 minutes and 37 seconds and here the permissible speed in kilometers per hour is 10 for the straight switch and if we are changing the value of switch angle from zero degrees to 47 minutes and 27 seconds and then it can be 25 kilometers per hour even for the curved switches. So, it depends on how we are defining. If we are making this angle in this form that is the sort of a kink which is going to be created, because of the angle is reducing, then there are chances that we can provide a better permissible speed or a half permissible speed as compared to the normal condition and that is what we look here. It is increasing from10 to 25.

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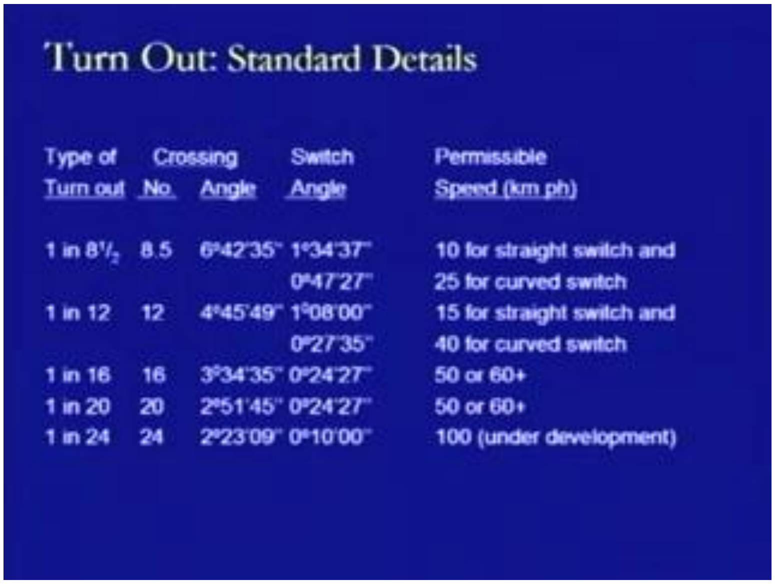

Similarly, if we look at this one, this is 1 in 12 type of turnout and as we have seen that this 12 is nothing but this is the number of crossing and for this number of crossing that is if we take again tan alpha equals to 1 divided by 12, then we have the value of alpha as 4 degrees 45 minutes and 49 seconds and in this case, again we can have a switch angle as 1 degrees 8 minutes and 0 seconds and it will translate into permissible speed of 15 kilometers per hour for a straight switch and if you are having a switch angle as zero degrees 27 minutes and 35 seconds, then it will be translating into a permissible speed of 40 kilometers per hour for the curved switches.

Then, if we look at this one that is where we are having a value of turnout as 1 in 16 which translate N to 16 and the alpha angle will be 3 degrees 34 minutes and 35 seconds and the switch angle may be zero degrees 24 minutes and 27 seconds and the permissible speed can be 50 or 60 or more than that that is the value which can be there and this is how we are getting that if we change one of the component, like if we are changing the switching angle or if we are changing the crossing angle or if we are changing the number of crossing, then this is how we are increasing the speed on different crossings.

1 in 20 is another case which is just shown here. In this case this angle keeps on reducing and we reach here to 2 degrees 51 minutes and 45 seconds and this, at this type it remains the same. This is reaching towards the minimum condition where it can be zero degrees 24 minutes and 27 seconds and the speed again can be maintained to higher side that is 50 or 60 kilometers per hour.

For 1 in 24 it will be, you can see the switch angle and the angle of crossing, angle of crossing is 2 degrees 23 minutes and 9 seconds, whereas the switch angle is zero degrees 10 minutes and 0 seconds and here we can go up to a speed of as high as 100 kilometers per hour. But then, this is the section which is under development, under study and the experiments are going on to examine the technical viability of providing this type of a turnout and obviously this type of a turnout if we are in a position to provide, then it will allow us go to the higher speeds of something like 250 or 300 kilometers per hour. So, that is why this is one of the important types of turnout which we are looking for.

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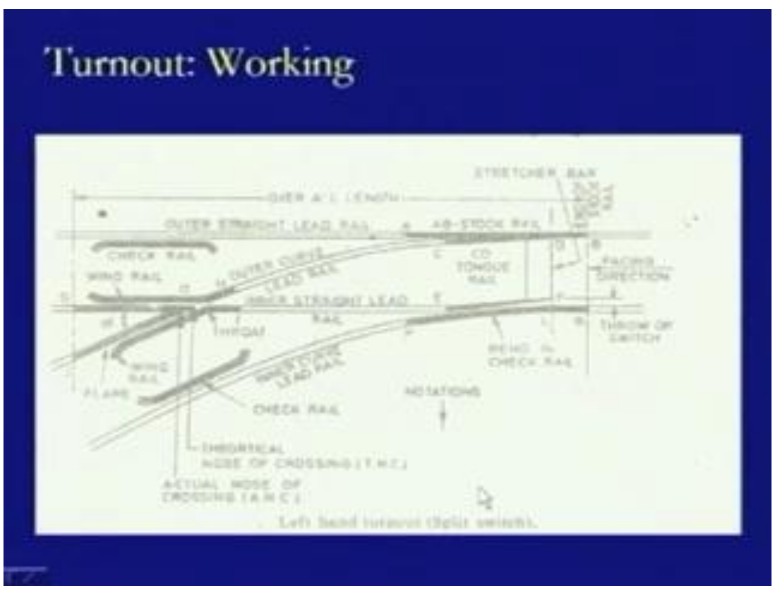

Now, when we are talking about the turnout and we have been discussing about the different components of a turnout and we have also discussed about the crossing, its definition, its types and then how we are going to define the crossing and the permissible speeds and angle of crossing and correlation with the number of crossing, another important thing which comes is how this turnout or crossing combination works and this is one of the important aspects which we need to understand. As we have seen in this diagram, previously when we have discussed about the various components of any turnout and what we have seen is that it is a combination of a pair of straight lead rails, the pair of curved lead rails with the pair of the wing rails or a pair of the check rails, set of point rail and splice rail and a pair of tongue rails and a pair of stock rails, the tongue rails being connected by the stretcher bars. So, these are the stretcher bars by which they have been connected.

Now, we understand that the turnout is the device which is providing us an opportunity, so as to turn the direction of the train. If we look at that and we assume that there is a train which is coming from this facing direction, this is the main track and this is another track which is diverging out of the main track, so if we look at this facing direction and train coming from this direction, now it is going to depend upon the way these tongue rails or the points or the switches are operated.

Now, if we are interested to take the train to the curved section, then what is to be done is that the wheel should come to this curved lead rail. So, they should negotiate the curve this one or this end, this one. So, if they have to come on this one if we provide the way by which it is being shown in this diagram that there is some distance which is being maintained here that is what is the throw of the switch, whereas at this location the tongue rail is just abutting with respect to the stock rail. So, the wheel which is coming on this wheel on this rail, this wheel will come to this location and it will shift from this main track line to the tongue rail.

So, it will be shifting this to this tongue rail like this and it will start negotiating or it will start moving on this tongue rail in this form and as soon as this starts moving on this tongue rail and then further on the outer curved lead rail, then similar is the condition which will happen here, because in this side we have taken this tongue rail away. Therefore, there is a gap being maintained and the wheel which is coming on this main rail section it will remain on this stock rail, it will not be coming negotiating the tongue rail here. So, it will be negotiating because of this gap being maintained between the tongue rail and this tongue rail and it will keep on continuing on the stock rail.

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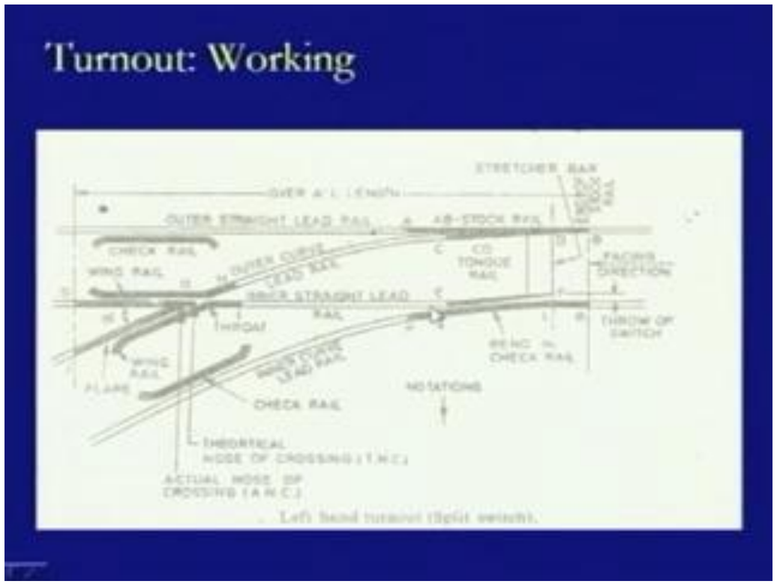

So, now it is moving on the gauge face of this stock rail and the gauge face of the tongue rail on this direction, at this particular location, whereas it will be moving on the gauge face of this outer curve lead rail and the gauge face of the inner curve lead rail in this location and that is how it will be negotiating a curve like this and will come to this location, where the wheel will negotiate a gap which is provided here and there will be a little jerk which we can observe while we are sitting in the train also and due to this little jerk, it will negotiate and will strike here and because of this 6 mm thickness being provided here, it will be able to get accommodated and if at all it gets deflected either in this direction, then in that case this wing rail will take care of it and it will not allow the wheel to move further away and will respond it back by the repulsive force condition.

So, that is how the wheel will come back on this lead rail and it will negotiate this lead rail. Whereas, the wheel which is moving on this inner curve lead rail will continue to do so and here as a precaution we have provided this check rail, as been shown here.

Because, if there is any impact or any jerk which has got created at this location because of the movement of wheel from this outer curve lead rail to this straight section rail or we can say that this stock rail, then there is a chance of the wheel base moving in this direction and if it happens, then this is being controlled at this location. But, if at all there is a chance of moving the wheel base in this direction, then this check rail will not allow this wheel to move in this direction and therefore, it will be maintained within this gauge. Otherwise, if it moves in this direction and it strikes here and tries to negotiate this one, then there will be a derailment of the train.

Now, let us look at another type of operation which can be performed using the same turnout. Here, we are not interested in taking a turn and we will like to move a train in the straight forward direction. So, in that case, how we are operating over these points and switches? Here what we will be doing is that this tongue rail will be shifted in this downward direction in this diagram. When we shift this tongue rail in the downward direction using the stretcher bars and its connectivities through the cabin, then the downward tongue rail will get connected to the stock rail on this side, whereas the upward tongue rail will be having a distance between the stock rail and the tongue rail maintained as a throw of the switch.

Now, if there is any train or rolling stock coming from this facing direction, then the wheel which is negotiating this outer straight lead rail will not be moving on the tongue rail because of the throw of the switch here and will continue moving on this straight lead rail only. Whereas, in the downward direction on this side what will happen is that, as there is no throw of the switch it is being maintained at zero level, therefore the wheel which is coming from this direction will negotiate on this downward tongue rail and then, after this one, it will come to the inner straight lead rail and then at this location where the crossing is being provided, it will negotiate this gap and will go on continuing on the inner straight lead rail and this is how the train will be moving in the direct straight direction, instead of taking a turn in the curved section towards this left hand side. So, that is how the turnout works, in the case of making a turn in one direction or keeping the train in the forward direction. I hope that this has become clear to you that how by using the points and the switches you can operate this turnout and we can facilitate the change in the direction or we can just eliminate the change in the direction and allow the train to move in the forward direction only.

Now, we come to the design of the turnout. There are three methods of design of any turnout and we will be looking at all those three methods and how we design using those three methods. The first method is the Cole's method.

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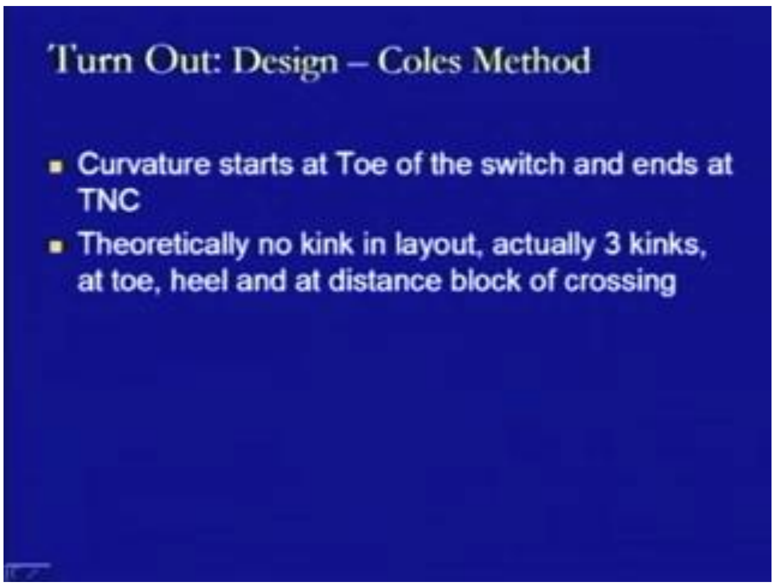

In the Cole's method, the main ideology is as we have seen in the case of the turnout that we have the curved section, we have the tongue rail section and we have the crossing section, where the wing rails and the check rails have been provided. So, what we have to design is the overall length of any turnout which comprises of the straight sections, the curved sections and the tongue rail sections and if we look in this sense, then we have different points of changeovers, whereas in the case of the crossing we have the heel of the crossing and the toe of the crossing and in the case of the point or the switch, again we have the heel of the switch and the toe of the switch.

In this case, the curvature of the curved lead rail, it may be starting from the theoretical nose of the crossing and then, it goes along and may be ending somewhere around the toe of the switch. So, either way we can define it. So, this is what is the basis of the Cole's method. So, the curvature is the starting, may be at the toe of the switch and ends at TNC. The toe of the switch means where the tongue rail is having a thickness of 6 mm, not the thickness of equivalent to the head of the rail. So, up to that point we are assuming that there will be a curvature.

Now, theoretically when there is a curvature from TNC up to the end, then there should not be any kink in the layout. But, what happens is that it is being observed that in actual, there are three locations where the kinks will be remaining - a location at the toe of the switch, at the heel of the switch and at a distance block which is provided at the crossing and all these three locations there are chances that the kink is being formed and due to this kink, there will remain certain form of discomfort or the chances of the jerks coming up when the rolling stock moves or negotiates these kinks.

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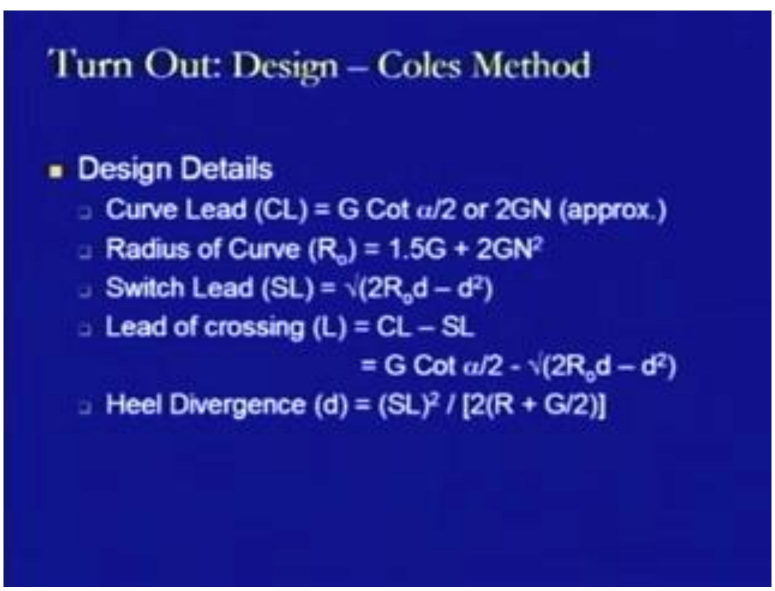

Now, when we design in this case, then what we are getting is that we have to find out certain values. The one value is termed as the curve lead. The curve lead is a distance in the horizontal direction which is to be provided, so that the curve lead can be provided in its complete length. So, the horizontal distance corresponding to the curved section of the turnout is known as the curving and here, because we are looking at this curve which is stating from TNC that is the theoretical nose of the crossing and goes up to the toe of the switch, then this curve lead will go up to that location. That is it includes not only the curved section, but also will be including the tongue rail section and can be given by, it is abbreviated as CL and can be computed as G cot alpha by 2 or approximately it can be computed as twice of the multiplication of G and N, where G is the gauge phase. That is if it is a broad gauge, then it is 1.676 meters and similarly, like we can, we can have the value of meter gauge and narrow gauge and alpha is the angle of crossing which we have already seen, which is the angle between the point rail and the splice rail and otherwise if it is defined as N, then N is the number of crossing, as been seen it is eight and a half, 12, 16, 20 and so on.

Another design detail is the radius of the curve and this radius of the curve can be computed as 1.5 G plus twice of G and square of N, this multiplication being taken at this point. So, this is what we are taking. Here, this is the radius of curve R naught, where again all these vales remain the same as been defined previously. Then in this case, we can also compute the switch lead, where if we are taking the switch lead and this is related to the distance in which the tongue rail is moving and as we are we taking it in the form of that, there are chances of the three kinks remaining in this overall section in this Cole's method. So, the switch lead will be computed with respect to the distance in which the tongue rail is available and this is computed as the under root of the value of that total value taken together as 2R naught small d minus square of the d, where R naught is being computed in the previous step and d is the heel divergence and the lead of crossing that is the crossing which is being provided and that is going to be nothing but the difference between the curve lead and the straight lead and this if we use the same formula as we have already seen will be nothing but G cot alpha by 2 minus under the root of twice of R naught d minus d square taken together.

In this case, the heel divergence d can also be computed if it is not been given and there we have been given with certain other values like switch lead, then it is nothing but the square of the switch lead divided by twice of R plus G by 2. That is how we can compute this value, but most of the time we know that the heel divergence is to be provided on any of the broad gauge for certain conditions then we can use that value and as we have computed the value of radius of curve, then we can find out the switch lead and this is a very easy calculation as far as the curve lead is concerned, because the gauge is always known to us and as soon as we have fixed the type of the crossing, then we can easily compute the value of curve lead.

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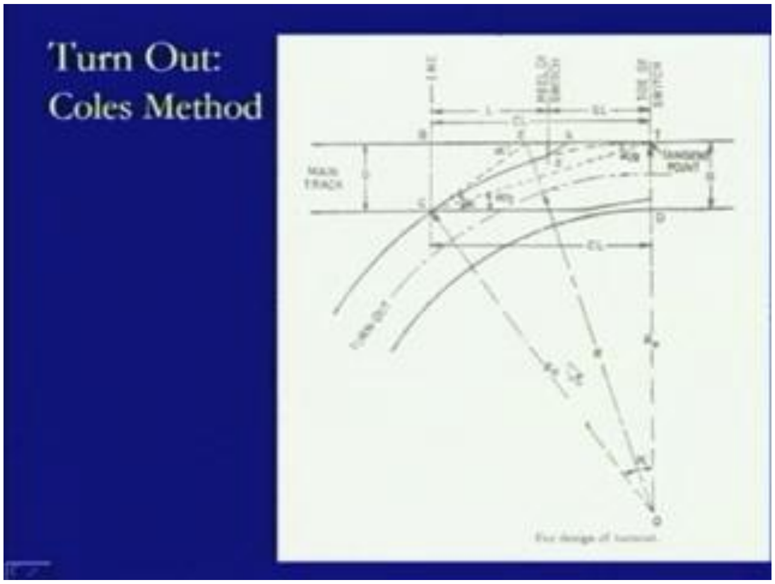

Now, this is the diagram which tries to depict the same thing. What we are interested here is that the Cole’s method assumes that the curve is starting here. This is the theoretical nose of the crossing. We have this crossing here like this and this is the angle alpha that is the angle of crossing. This is gauge, G. So, this the same gauge here also and we have the turnout in this direction. So, where curve is starting from this location as for this method and it keeps on going like this and it ends at this location, which is the toe of the switch. This is what is the basis of ideology of calculations in the Cole’s method.

Now, as far as the kinks are concerned which we have discussed, there are three locations where the kinks are getting formed. One location is here, where the theoretical nose of crossing is being provided. Then, this is another location which is the heel of the switch. Up to this section in general, this remains as a curved section and then after that this tongue rail is provided which is straight in section. So, that is why at this particular location there is a formation of a kink and then, the next one gets formed at this location, because of the thickness of the tongue rail being provided. So, this is another location of the kink. So, we have one kink, two kink and the three kinks. So, three kinks will be there.

Now, here when we are talking, because we are taking the curve from this location to this location, therefore the curved lead will be with respect to the horizontal distance being moved from one location to another location and that is what is between this point C and this point that is toe of the switch. So, this is what is the distances curved lead and this is we have computed as approximately twice of G into N. Then, here this is the switch and this is the tongue rail and therefore, with respect to this one whatever is the horizontal distance which we are taking is termed as the switch lead. That is the lead distance related with the switch. So, this is this distance and on the basis of this one, the lead distance here will be computed as nothing but as the difference between these two values computed that is the value of CL and SL and this is how we can define it.

As far as the radius is concerned, this radius we are computing here is with respect to this curve which is provided here like this. So, if you are computing this value, this is what is R naught. So, this R naught value we have already seen how we can compute this one, but what we are interested in is the center line profile of the turnout. So, therefore the value of R will be nothing but R naught minus half of the gauge length. So, if this is the gauge, then this is half of the gauge, so therefore, if we subtract half of the gauge from this value we are going to get the value of R and that will be the center line profile of this curved track.

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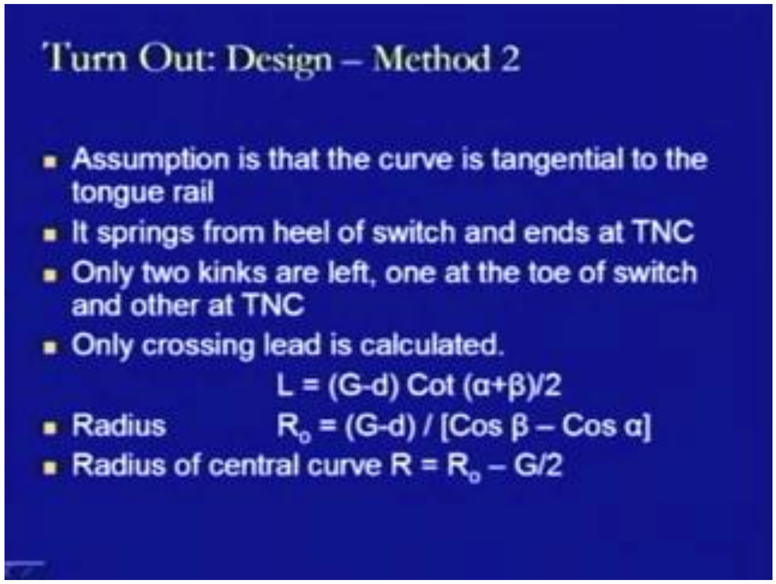

Another design method is having an assumption that the curve is tangential to the tongue rail. It says that it is starting obviously from the TNC, but as it comes towards the points or it comes towards the switches, then it becomes tangential to the tongue rail. So, it means the curve will be having its distance between the ANC and heel of the switch and it springs from the heel of the switch and ends at TNC. That is what I have already mentioned and in this case, because the curve is going from this point of end TNC to the heel of the switch, we have the two kinks.

One is at the toe of the switch and other at the TNC. So, we have to look at these two, because we are trying to provide a curved section to the heel of the switch and if we can eliminate these two kinks, then it becomes further more easier way of the movement on this type of a track or turnout and only crossing lead is calculated. What we find is that this becoming probably a little easier in this form, because TNC distance or related distance with respect to tongue rail is not required to be computed in that sense and this crossing lead is calculated as L is equals to G minus d taken in bracket multiplied with cot of alpha plus beta divided by 2, where G is again the gauge distance, d is the heel divergence, alpha is the angle of crossing and beta is the angle of switch and if we take these together, we can compute the value of L.

Similarly, we can also compute the value of radius that is R naught and this will be given by G minus d divided by cos of beta minus cos of alpha and then, the radius of the central curve, R that is the center line profile of the turnout will be the similar as we have computed in the previous case and it will be equivalent to this R naught minus G by 2, because R naught is the radius with respect to the outer curve of the turnout.

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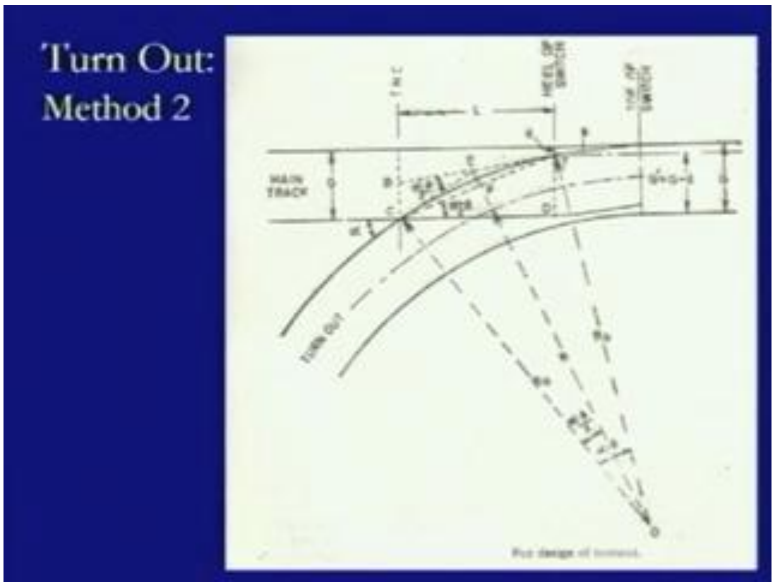

We will look at this diagram which tries to define this method. Here, in this one we have this as again the gauge and this will also remain the same gauge G. This is angle of crossing alpha. Then, the curve is starting from this point, again the TNC and is ending at the heel of the switch that is this location. This is the toe of the switch. So, it is not going up to the toe of the switch as in the case where we have used it in the previous condition and because this toe of the switch is there and this curve is tangential to this one that is why we are using this angle beta here, which is the angle of switch that is the angle between the tongue rail and the stock rail.

So, once we have this one, then at this distance, at this location where the heel of the switch is being located we are providing the distance block and due to this distance block, there will be heel divergence as we have discussed in the previous lecture. So, this heel divergence will be nothing but the distance between the one face of the rail with respect to the similar face of another rail. So, if we are talking about this side, then from the outer side of this one towards the inner side of this one, we will be having the distance and that is what is the d value and if we remove this d value we are left with the gauge condition as G minus d. Therefore, this distance remains as G minus d and this is what is being taken into calculation and then, we have the angle here. We can see this is angle alpha minus beta by 2, because this is being drawn from this tangent as well as from this tangent. This is the angle between the two tangents.

Similarly, if we join this point with respect to this point and go by the geometry of the triangles and the angles being formed on the either side, then this angle will come out to be alpha plus beta by 2. So, we have this distance as G minus d. This angle is known as alpha plus beta by 2. Therefore, we can compute this distance, this one using this triangle and that is what we have done in the case of the equation of finding the value for L. That is L is the crossing lead here and again as I have defined in the previous method, this is the horizontal distance being moved along the curve. So, this curve starts here and here, so this is the horizontal distance.

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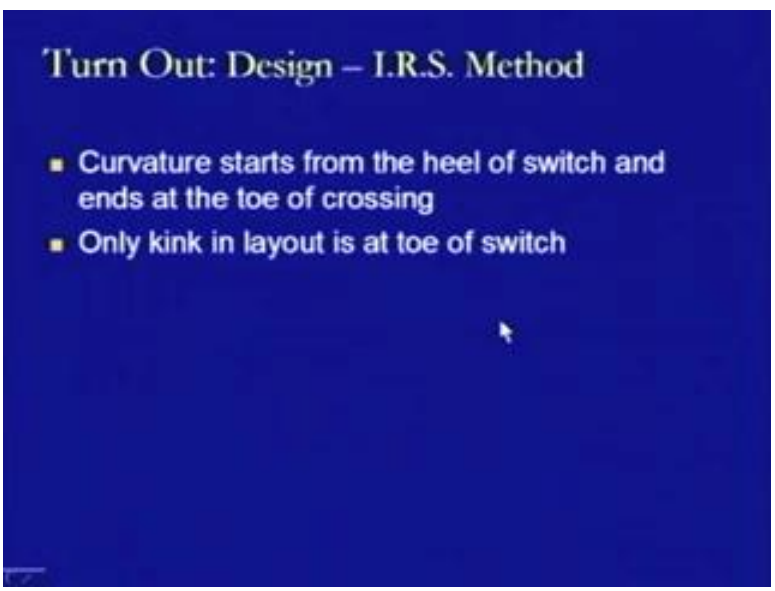

Now, we come to another method that is Indian railway specification method, I.R.S method mostly used on Indian railways. Here, in this method, the curvature is assumed to start from the heel of the switch and it ends at the toe of the crossing and only one kink is there that is at the toe of the switch. That is we are reducing the kinks slowly and slowly and making the operation smooth.

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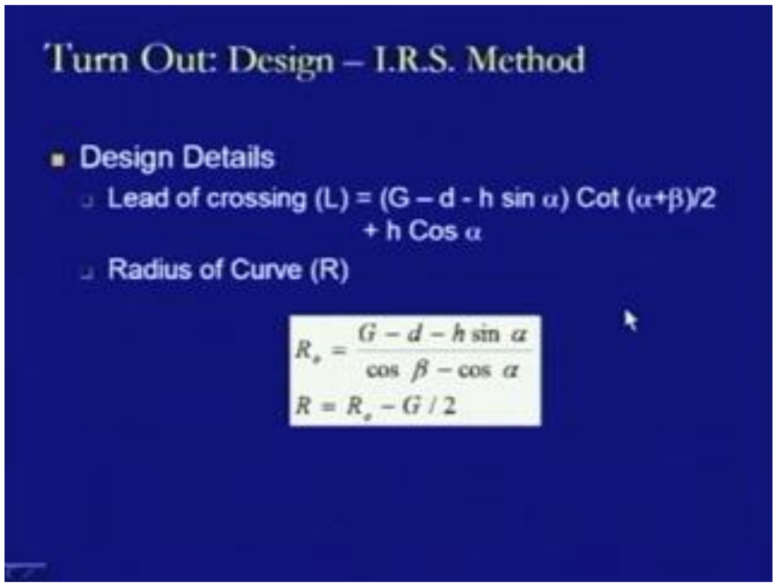

Here, this is how we are computing the value of R naught and R that is G minus d minus h sin alpha divided by cos beta minus cos alpha, whereas R is R naught minus g by 2. Here, h is the distance which is moved from the TNC and then after that distance only the curve is starting. So, this is what is the design detail and the lead of the crossing will be defined as G minus d minus h sin alpha. This is multiplied with cot of alpha plus beta by 2 and is totally added to h cos alpha and the radius of curve as we have seen here.

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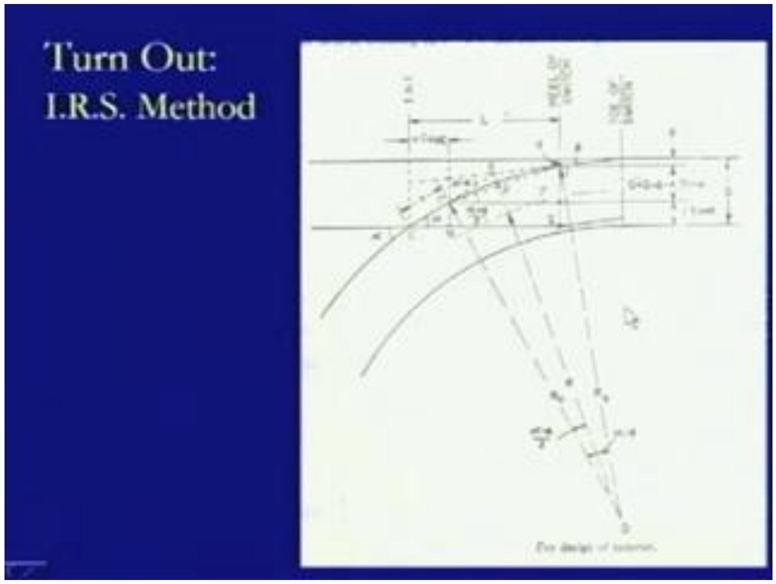

Then, in this diagram what we see is that this is the TNC and we are moving a distance h. Here, this is distance h and then, the curve starts from this point and goes up to this point. So, only one kink is being left here and again the same type of thing remains. We have this as G, that d is also there. So, we have G minus d and then, because this is a straight section being used here, so we have x sin alpha. So, we are left with only this much distance which is G minus d minus x sin alpha and this is being used in the computation.

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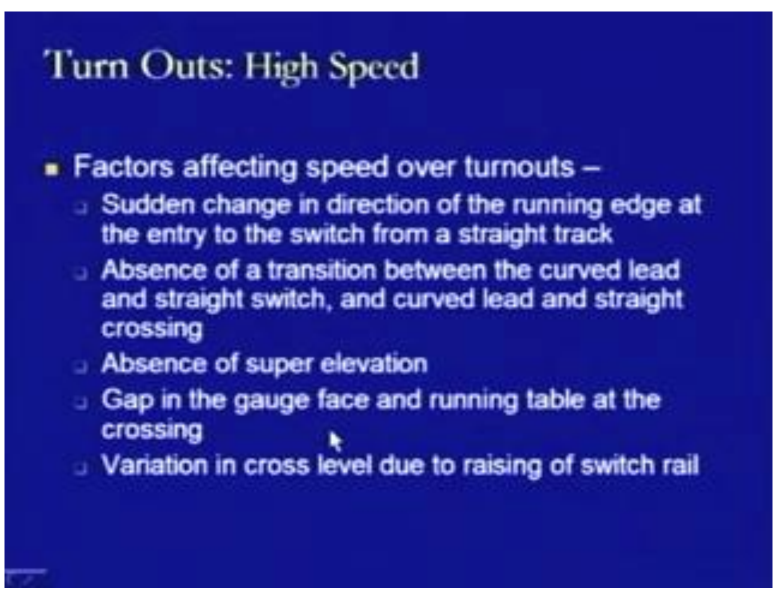

Now, we come to the turnouts being provided for the high speed and we look at the factors which affect the speed over the turnouts. There is a sudden change in the direction of the running edge at the entry to the switch from a straight track. This is one of the things need to be taken care of. The absence of the transition between the curved lead and the straight switch and the curved lead and the straight crossing, this is another factor which creates an effect on the speed which can be attained over the turnouts. The absence of super elevation, the gap in the gauge face and the running table at the crossing, this is another thing and that is why we have the movable wing rails being used at some time, the variation in cross level due to the raising of the switch rail. So, these are some of the factors which create its effect and the speed gets limited or permissible speeds have to be seen.

Now, we come to another aspect that how the sleepers are provided on points and crossings. There are two types.

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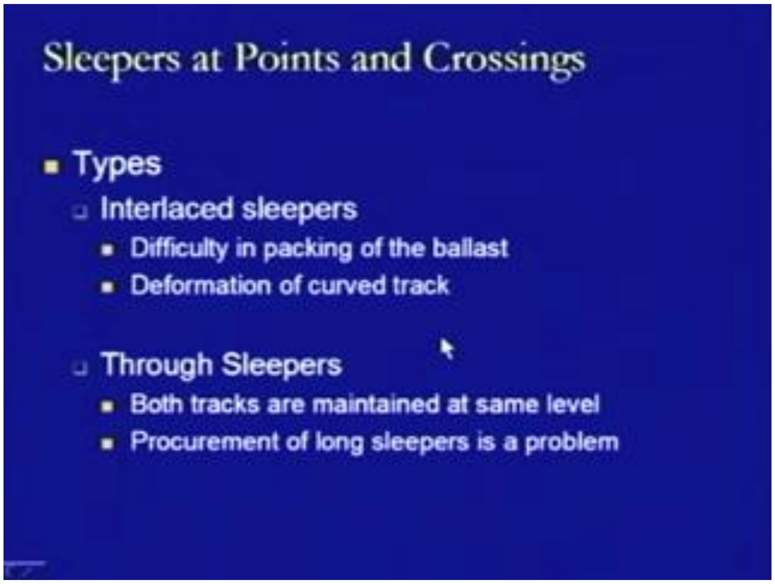

The interlaced sleepers - the interlaced sleepers are the sleepers which are provided in one track and then, they are being combined together from one track to another track in a form that they are coming alternatively for both the tracks. What happens in this case is that they create a difficulty in the packing of the ballast. We will be looking at the diagram of this one and it will become further clear from there and there are chances of deformation of the curved track. Whereas, in another case that is through sleepers, both the tracks are maintained at the same level and the sleepers are provided starting from one track and they keep going across the other track also and the procurement of long sleepers of this size is a problem in this case but otherwise there is no problem of packing or deformation.

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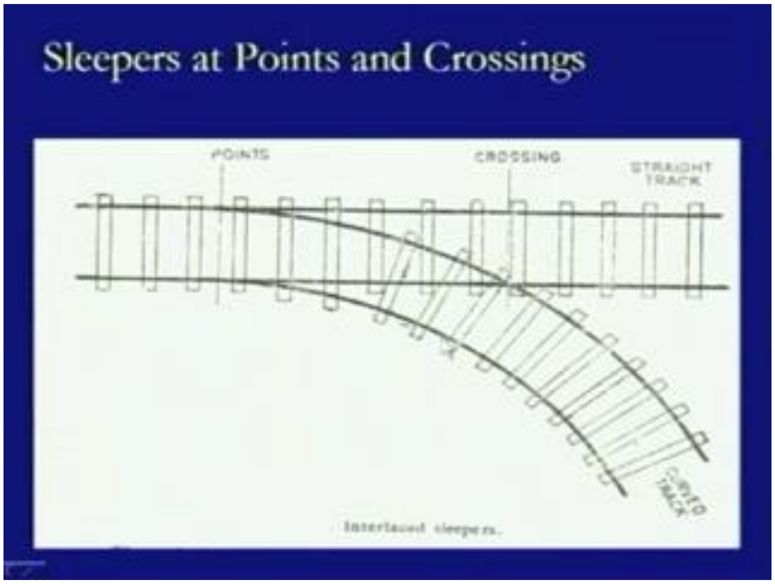

We will look at this diagram. This is the interlaced sleeper, where the sleepers are provided for this track and the sleepers are also provided for this track and then this sleeper is coming in between the other two sleepers. That is the problem of packing. You cannot pack the ballast in this area.

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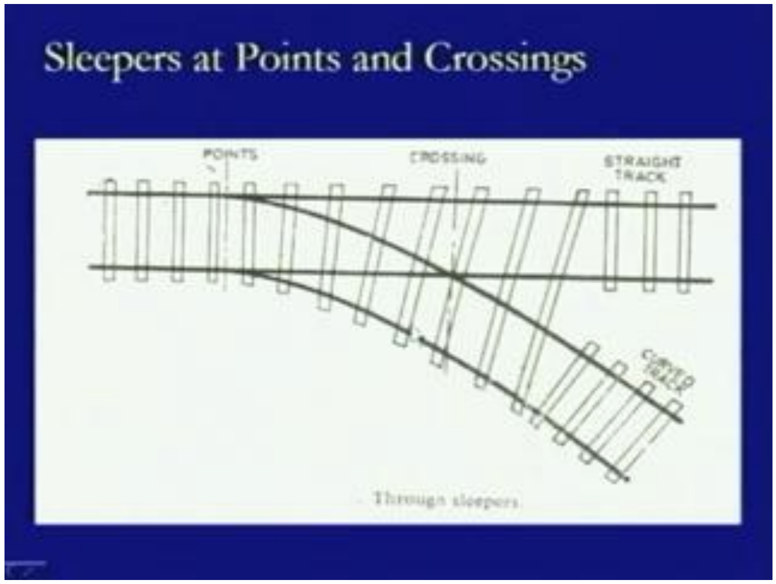

Then, this is another diagram, where the through sleepers have been shown and what we find is as we go forward like this up to the end of the crossing this size of the sleepers are required and that is what is a problem in this case. But then, this is a better way of providing the sleepers as compared to the previous one.

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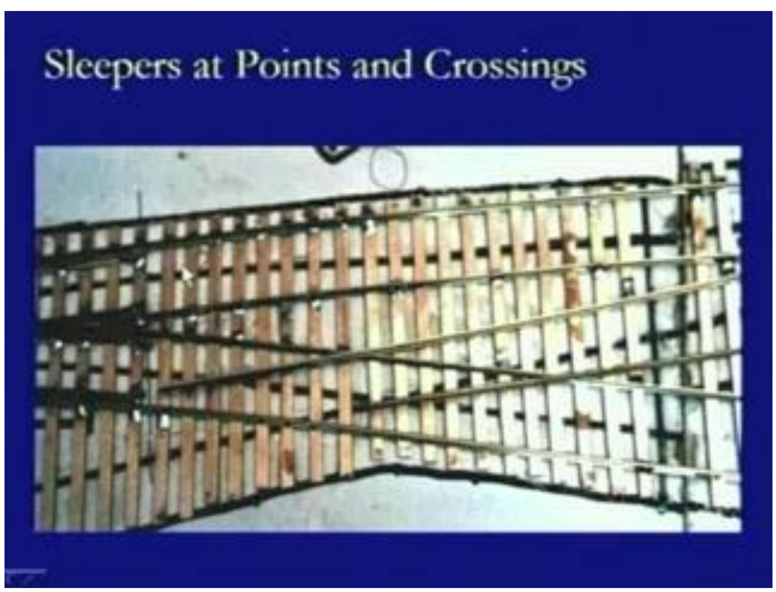

This is another figure, another photograph, where the tracks have been shown and you can see these through sleepers have been provided all the way. So, what we have discussed in the today's lecture is the design features related to the turnouts and the way the crossings can be defined on the basis of their shape or on the basis of the movable parts. This is one of the aspects which was supposed to be understood. Another one is the one which we will be discussing in the coming lecture related to the various types of the crossovers which can be provided for the junctions. We stop at this moment and we will be meeting in the next lecture; till then, bye, bye.

Keywords: *Crossings, Working of a Turnout, Angle of Crossing, Design of a Turnout*