Surveying

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Lecture - 2

Module - 11

Project Surveys

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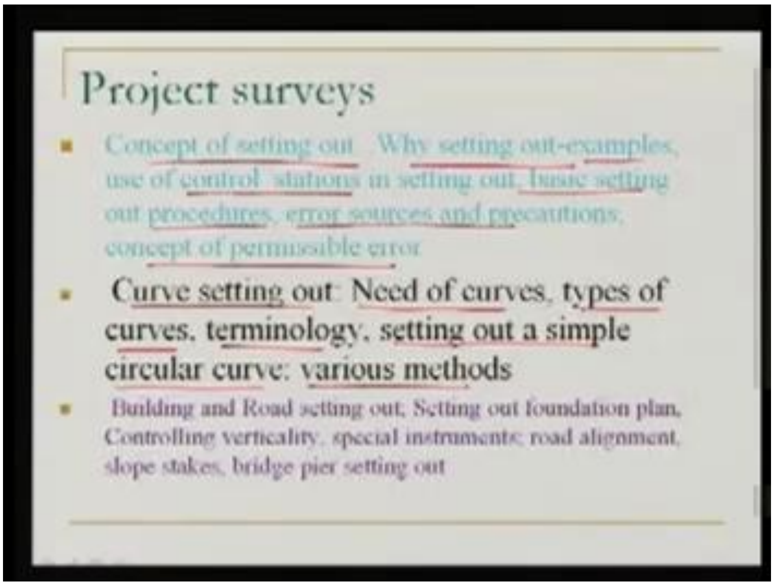

Welcome to this video lecture on basic surveying. Today, we are in module number 11 and we will be discussing the lecture number 2. In this lecture number 2, what all we will be covering? We will talk about the curve setting out. In our previous lecture, we have discussed the concept of setting out. Why we need it? And we had seen some examples, then also some basic setting procedures, the use of control points, error sources and concept of permissible error. Now, today in the curve setting out we will see why the curves are required? Of course, you should be, knowing it. Then some types of the curves, the terminology or the definition, which we use here. Then we will see setting out of a simple circular curve, what are the various methods?

So, now we go for curve setting out. To begin with first of all, we will discuss that why the curves are required? Think of some civil engineering projects for example, a roadway. In the road what happens? The road is coming here and it has to change its direction because the roads they do change the direction, because of many reasons. Now, when there is change of direction, we would not like the road to change its direction suddenly.

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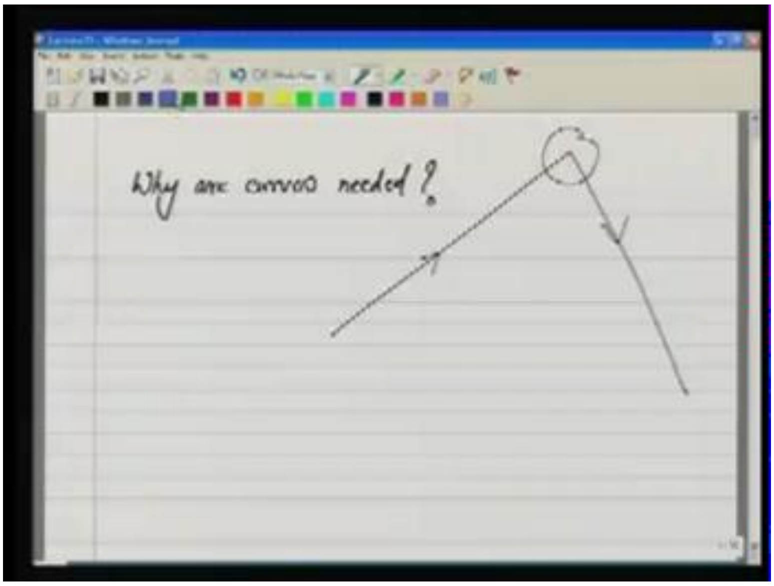

For example, if there is a road coming here and it goes like this. We need to change the direction. So, this is really not desirable we know for the obvious reasons. So, in this case what we will need to do? We will need to introduce a curve in between. So, that the change in direction is realised, but the change in direction is gradual. It is not direct you no sudden change that is something, which we need to avoid. So, this is true for the railways also this is true for oil and pipe lines or the canals or for varieties of applications. Where something is being is transported through a corridor and for changing the direction we need to provide the curve, in the particular structure. Also you might have in some for example, the buildings.

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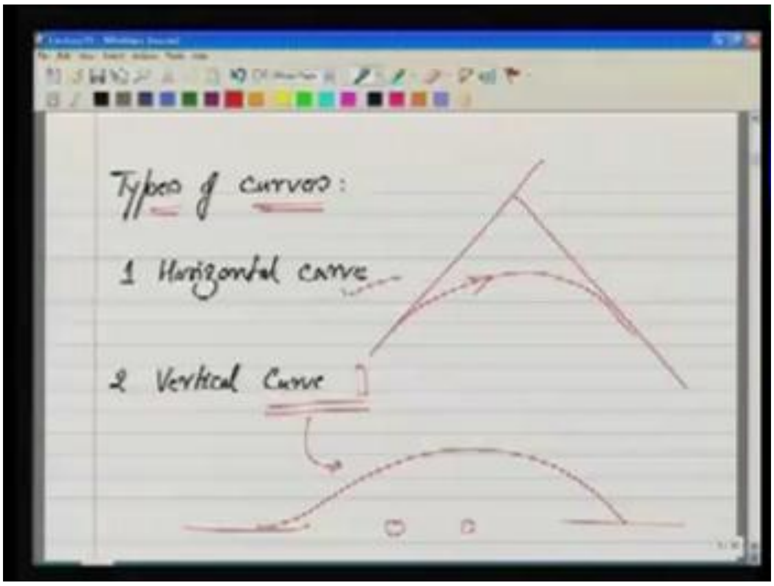

Many times the buildings, have got you know very beautiful curvilinear shapes. So, the architect has given the design like that. So, is the job of the site engineer to implement those curves there in the field? So, there also we need to set out the curves. What we will do now? We will look about the types of the curves. Well, very first type is horizontal curve. Horizontal curve means, the change in direction is in horizontal plane. The other possibility of the curve is vertical curve in case of horizontal, these two lines are horizontal. And this is how the, we need to introduce a curve in the horizontal plane. Now, in the case of the vertical curve we have a road segment here another road segment. And then in between we have for example, the railway line. We need to provide a fly over. So, this fly over is an example of the vertical curve so many times we need to provide these vertical curves also. And very often we will find many curves are combination of these 2 vertical and the horizontal curve put together. Well, next let us look about.

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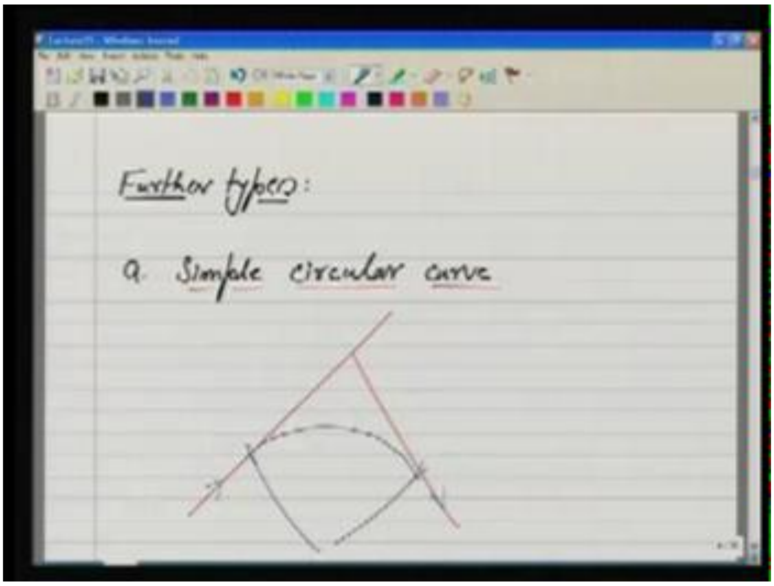

Some further types of the curve. Very first one is simple circular curve. Now, what is the meaning of this? The meaning is in between 2 tangents, because these are called tangents. The road which is approaching and the road which is leaving in between we have to change the direction. So, we have to provide a curve in between. If this curve is a circular is a part of the circle. So, we say this as simple circular curve in the otherwise case a curve could be a combined curve.

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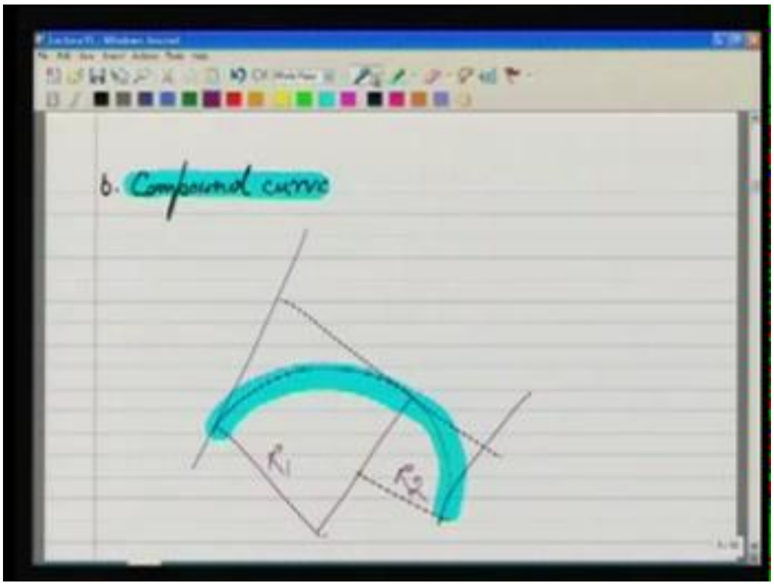

In case of combined curve, it is a combination of 2 curves. Here it is the first curve then the second curve start from here and both of these are with different radii. For example, here this is the tangent for this curve and the radius here is R 1 and the radius here R 2. So, this full curve if I highlight, it curve number 1 curve number 2. So, we have got 2 curves here, that is why we say this as compound curve. Well, next is the case of reverse curve.

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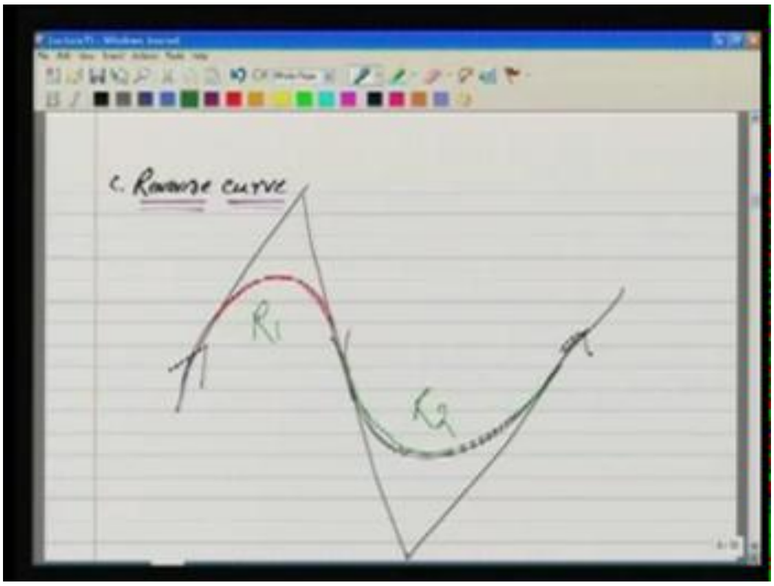

In the case of reverse curve what happens? We change the direction for example, like this. There is a road, which is approaching like this we need to change the direction. So, this curve is provided here this first curve. Then again we need to change the direction. Because the tangents are like this the road, first of all it is approaching in this direction then it is going out. Then Again we have to change the direction and finally, in order to go there. So, what we need to do? We need to provide one additional curve. So, that second curve is provided here. So, when these two curves of radius R 1 and R 2 they are provided and as well as they are their convexities are opposite to each other. So, we say this kind of curve as reverse curve. You might have seen these many times in field in actual application.

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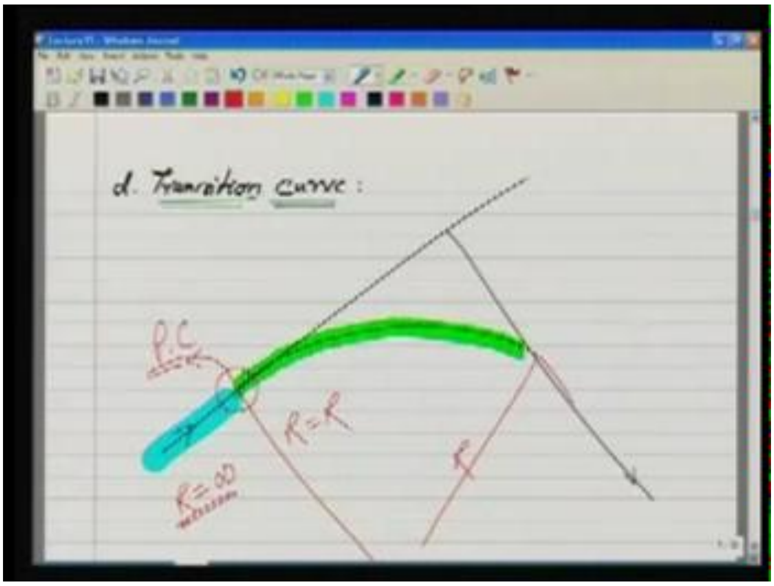

One more type and then very important one is the transition curve. Now, what is the meaning of transition curve? When you look at the curve, curves we are provided in order to change the direction smoothly. Now, let us take the example of a simple circular curve. What happens? In that curve this is the road which is approaching and that is the road in which direction we need to go. So, this is the road approaching and that is the road where we need to go. So, what we do in between we provide a curve and this curve is a part of circle and the radius is R. Now, over here if I highlight it over along this road when you are travelling? In your vehicle the radius here R is infinite, but the moment you start travelling, over here in the curve the radius becomes R is R.

So, what is there at this particular point, where the curve starts? Which we say point of curve also, at this particular point the radius is changing from R is equal to infinite to R is equal to R. So, there is sudden change in radius. So, what is the impact of that? If the radius is changing suddenly, if the radial acceleration you are sitting in the vehicle initially the radial acceleration is 0 you are moving in a straight line and suddenly you start moving in to a curve. So, there is sudden change in the radial acceleration again this is not comfortable to the passengers. Similarly, so what we need to do? We need to provide a curve which changes this radial acceleration from 0 value to a particular value.

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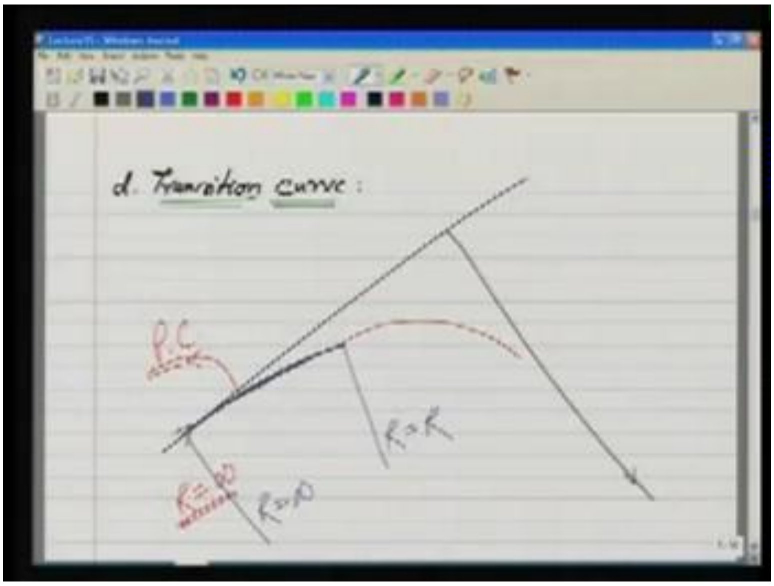

So, how it can be done in order to do it, what we can do? Because our idea is we want to provide a circular curve in between. However let us do it in this way I provide one extra curve and this extra curve has a property that at this point its radius is infinite while at this point the radii or radius of this curve is R. So, this is what is this curve doing? This curve is changing the radius from infinite to R value. So, now, the change in radius is gradual. So, this is why we say it as transition curve. So, this is for the comfort this is for the less wear and tear there in the vehicle. Now, let us look at some definitions, because before we go.

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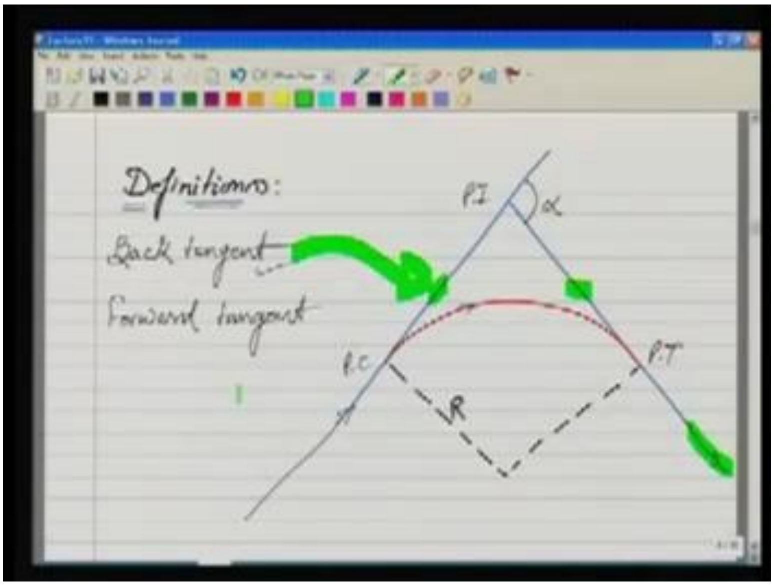

Into curve setting out, we need to we need to see these definitions. First of all what is a back tangent. Over here this is the road which is approaching and that is the road which is going out and in between a curve has been provided that is the curve. So, this curve or the circular curve, this circular curve here has a tangent. So, this tangent is called the back tangent while when the curve when you are leaving the curve. So, that is the direction of the leaving the curve. So, this tangent to the curve is called forward tangent.

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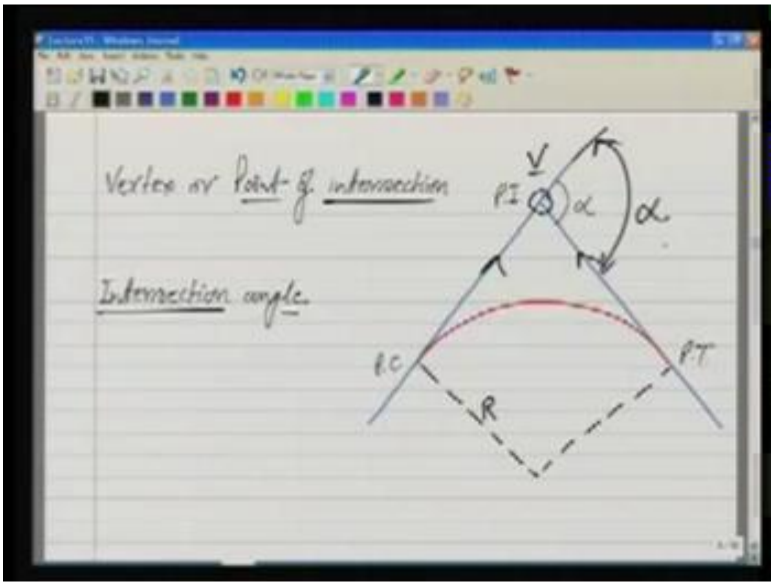

The point where these 2 curves intersect, because you can notice here that is the point where these 2 tangents are the, these 2 tangents they intersect is the vertex. It is recorded as V also or it is also called point of intersection then we define intersection angle as you can see this external angle here, is called intersection angle. We will need this intersection angle later on when we set out the curve.

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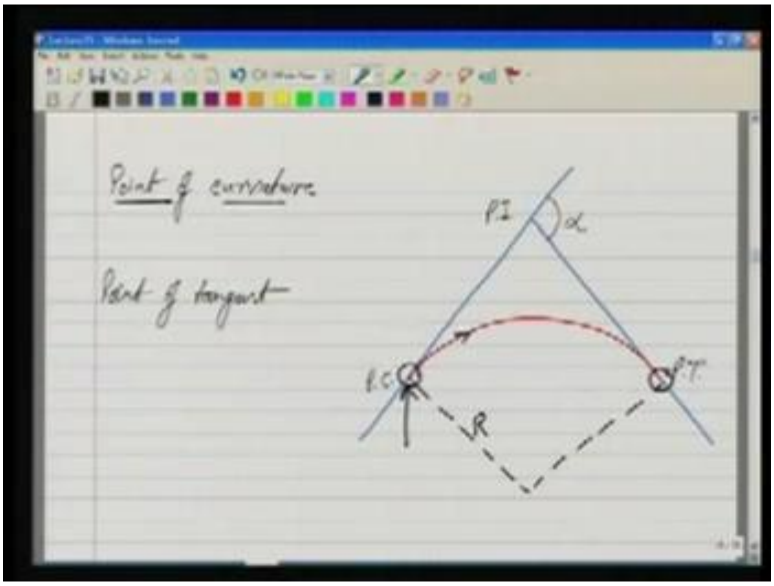

Next definition is point of curvature. What is the meaning here? The point of curvature means, the point where from the curve starts. So, that is the point from where our circular curve starts. So, this point we say as point of curvature. The curve terminates here and from here another tangent starts. So, we say this as point of tangent.

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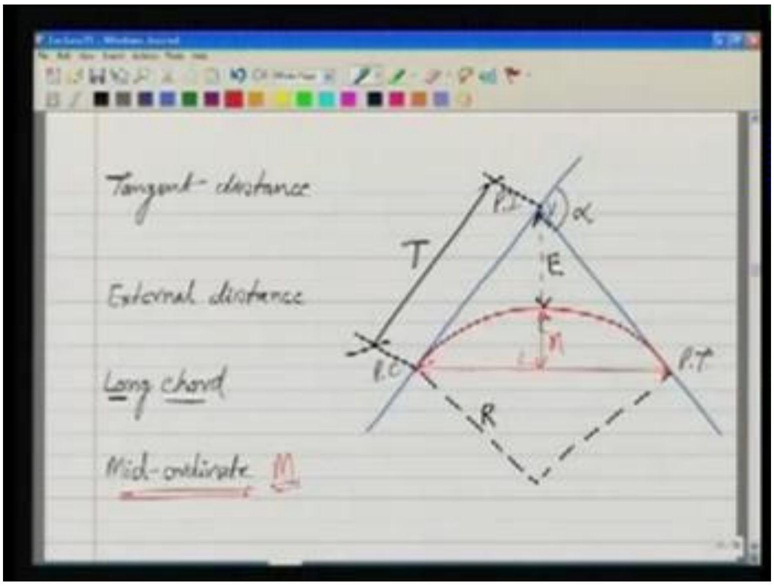

Then we have tangent distance, what is tangent distance? The distance from point of curve to vertex this distance is capital T we represent it like this. And this is called tangent distance. Then external distance is the distance from vertex to the middle point of the curve this is the external distance then we have got a term called long chord. Long chord is, I will show it by red colour here it should join point of curve and point of tangent. So, this is the chord on the curve. So, this is called long chord and we show it by capital L the mid ordinate, we will need all these in setting out the curve this is why we need to discuss this. This is M, M is mid ordinate.

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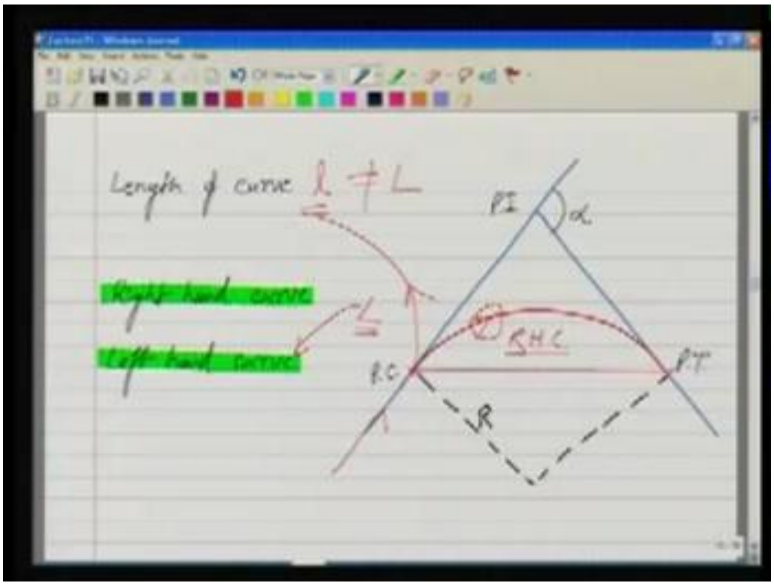

Well, the next is length of curve. Length of curve we write it as small l and this is the length along the curve. So, this is not equal to capital L because the capital L is long chord the distance along the chord. So, length of curve is distance along the curve then we also define right hand curve and left hand curve. What is the meaning? The meaning is if you are approaching a curve for example, we are approaching a curve here. Now this curve could have gone in this direction or in this direction. So, there are two possible ways. So, if it is going towards my left, we will say this as left hand curve while in this case this curve is going towards the right hand side. So, we will say it as right hand curve.

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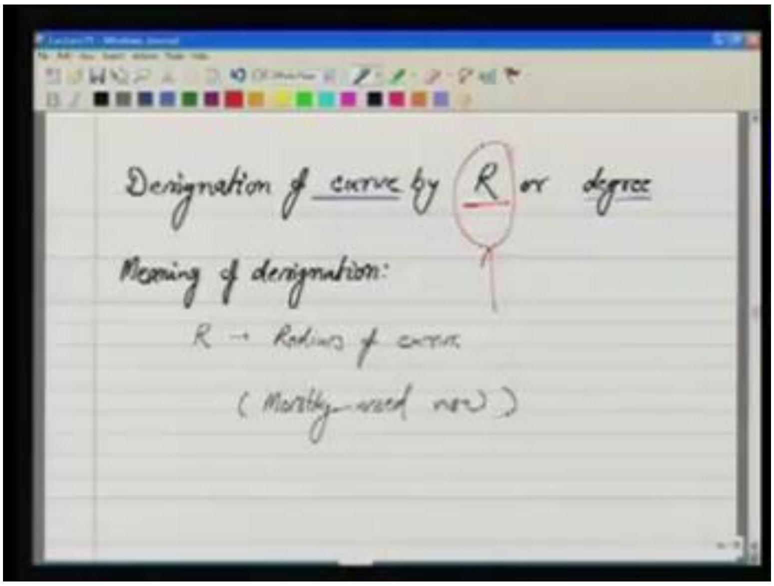

Now, some more definitions and this is regarding the designation, designation of a curve. Now, first of all, we will see what is the meaning of designation? You know whenever we are talking about a curve we need to say something about the curve. We can say about it is size about it is curvature. So, how can we do it? Well the very first possibility is about a simple circular curve we can say about its radius. What is the radius of the curve? So, radius is the one parameter which is used mostly in order to designate a curve. The second parameter, which was used earlier hum mostly and was useful in setting out the curve is also called degree of curve. So, radius of curve is very well understood and the curves are designated by their radius. Now, what is the degree of the curve? Now, the degree of the curve is.

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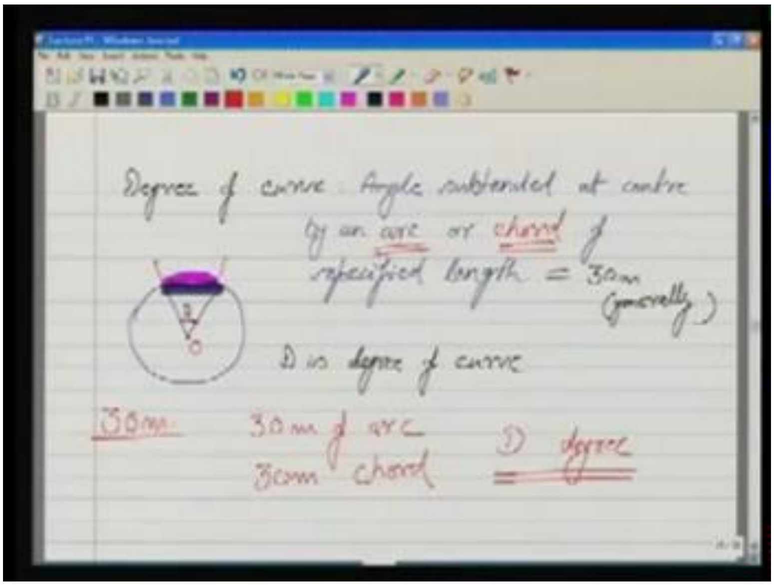

If for a curve let us say this is a little part here, I will highlight this, this is a circular curve here. Now, for the circular curve, because this circular curves of course, it is a part of a big circle and over here is the centre of the circle. For a given arc if I show that arc here for this given there is a chord now, for a given length of arc or chord. What we can say 30 meter of arc or we can say 30 meter of chord for any of these this, this distance is 30 meter either arc or chord. Whatever the angle made at the centre, that we represent as D and this is called degree of curve. So, this is also you know one way of designating a curve. So, the definition could be whether we have to ask whether the definition is for chord or whether it is for arc definition or chord definition.

So, we can designate a curve by its radius and as well as by the degree of the curve. Now, why we are using this 30 meter here? 30 meter is used because mostly earlier the chains or the tapes they are of 30 meter length. And whenever, we are setting out a large curve in setting out the chords that we take their out of 30 meter. So, that is why the degree is defined for a by this 30 meter, if it is defined by some other. Generally if there is no other information given you can assume it to be 30 meter and if some other length is used for example, 20 meter 10 meter then this information should be provided. So, accordingly we will understand, what is the relationship between degree of the curve and the radius? Well, some more terms here.

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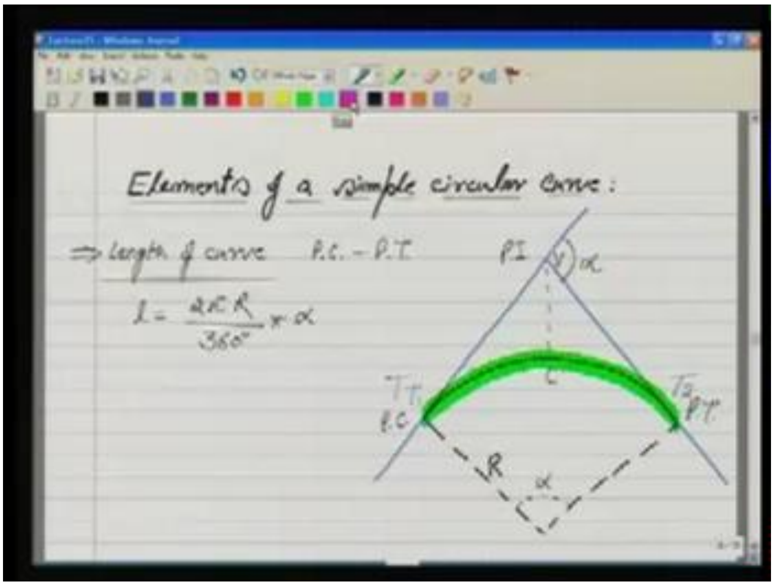

And these are we say elements of a simple circular curve what are the elements? The very first element is length of curve as we know the length of curve is starting from point of curve, to point of tangent these 2 points point of curve and point of tangent are also shown by T 1 and T 2 very often you will find it like that T 1 and T 2. So, this distance is length of curve. And you can very easily calculate that length of curve is given by two pi R by 360 into alpha in degree. What is the alpha? Alpha is the angle of intersection. So, very easily I am not going to derive all these formulae over here, but you can easily compute, that it should be like this.

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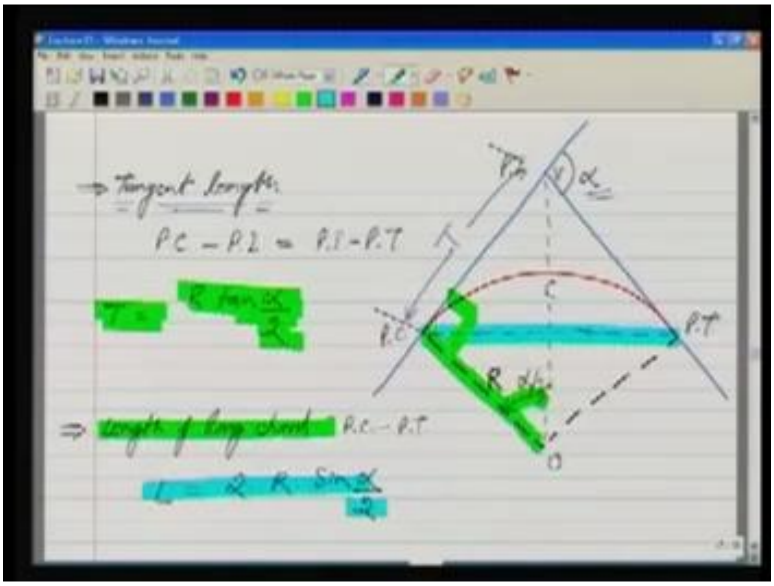

Then second element is tangent length. The tangent length we have discussed that it is this particular value, which we represent as T starting from point of curve to point of intersection. And this angle is Alpha so; obviously, this will be Alpha by 2 over here the angle is alpha by 2 and this is R the radius of the curve and this angle is 90 degree because it is tangent here. So, you can compute that this tangent length is R 10 alpha by 2. The other element of the curve is length of long chord. Now, what is length of long chord? Length of long chord is as for the definition is starting from point of curve to the point of tangent and of course, you can also compute this as L is 2 R sin alpha by 2 this is length of long chord.

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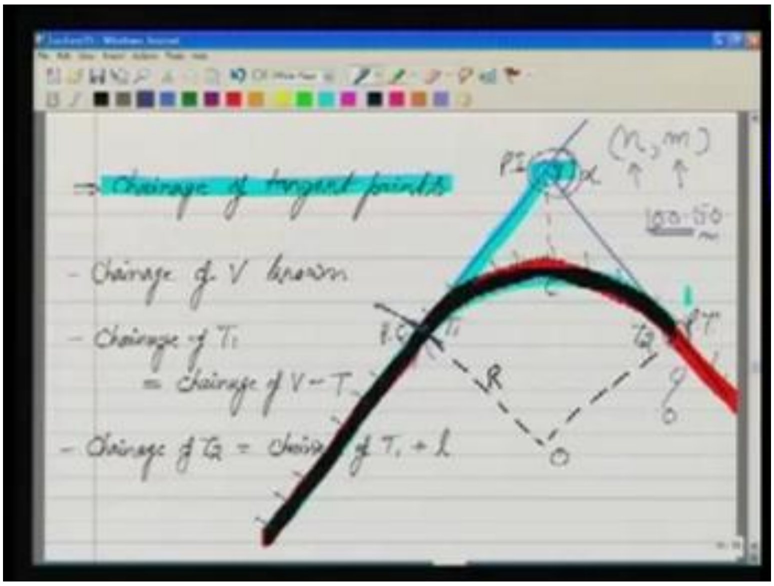

Then some things about the curves, because why we are discussing all these things, because we will need all these terms or the definitions, when we are setting out the curve. Because our main aim today is we want to set out a curve there on the field. So, before setting out we will have to do some computations. And all these things will be required there. Now, some additional things and these are chainage of tangent points. Now, before we discuss this, what is the meaning of chainage? Chainage as we have discussed before also in our, you know first few lectures when we are talking about the chain when you measure the distance using chain. Then we can say some distance there are 5 number of chains and 20 links. If the chain is 30 meter and each link is 20 centimeter well you know 5 chains and 10 links means certain distance.

This is how the distances are recorded, when you know still even if we are not using chain in the field now, still this chain word is continuing. Well, we are using the tape, so still for the tape also we say the same you know, distance along a length. What is the distance? At a particular point that, we say as chainage and generally over here, also we represent it as I am writing here. I will say the chainage as nm this is the chainage what is the meaning of this? They are n number of full tapes of lengths or chain lengths and m number of chain links.

We can write the distance, instead of nm also as 100.50 meter no problem. So, and this is also chainage, chainage means the distance along the chain or the length. Well, the chainage of v is known now, how it is known? The chainage of v how it is known we will see in a moment. If the chainage of v is known, we know the distance which we say tangent distance. So, chainage of v is known. So, we can compute very well the chainage of T 1 also. So, chainage of T 1 can be computed then what should be the chainage of point of tangent? Because we know the length of the curve the length of the curve we know about it.

So, finally, how about road is going the road is coming from here, then it is taking a curve. If I highlight by a different colour let us this is the road then it takes a curve and then it goes like this and then again joins the tangent. So, basically the chainages are being measured along the road that is distances are being measured along the road. Somehow, we know the chainage of point v this is how we can determine the chainge of point of curvature. And then you add the length of the curve you know the chainage of point of tangent and so on.

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Now, let us do the final thing the setting out. What I have done here? I have drawn a ground on my computer on my video screen. So, if you look at the video screen over here there is a road and this road start from a point A and goes to a point B. You can see the point B and point A and in between this black line is the road. Well; obviously, we can see this is the forest area and over here we have the water body and this is the terrain. Now, our road has to change its direction, because of the topography because of the limitations there and this road so far is on a map. Because you know we have planned this road on a map and while we are setting out the road we are setting out in small parts.

So, let us say we are setting out like this, and right now, we are interested in this curve. So, the road is a straight road here. The tangent here is this and that is the forward tangent and in between we have to set out a curve. So, this is something which is desired we want to do it. Now, at this stage what all is known number one which is known is the chainage of v. Now, how do we know the chainage of v? We know the chainage of v from our design, because we know the chainage of from the map from our design. That what will be the chainage of this particular point from here itself we know the angle alpha. Now, where is the angle alpha? If I highlight it, over here is the angle alpha. There is the angle alpha the intersection angle. We also know radius R how this R is being decided.

Now, radius in between 2 tangents we can fit the simple circular curves of different radii. Now, why should we choose a particular one; obviously, you know you can start thinking, there if the vehicles, which are negotiating the curve at very high speed the curve should have large radius. If the vehicles, which are negotiating the curve have got small speed you know not very large speed. We can provide even smaller or very high degree of curvature, will still the vehicle will not overturn. So, basically how this radius is decided? It will be decided based on the design speed on the curve as well as about the topography. Does the topography permit you to provide a particular radius or not? So, considering these things we decide the radius also beforehand. So, we know the radius also it is known to us.

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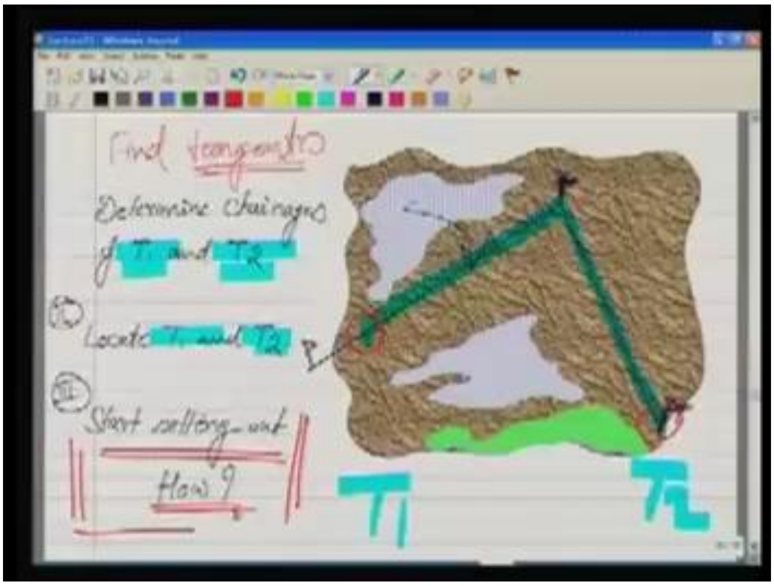

Then first of all we would like to find, where are tangents? You know we have the location of these tangents on our map. Always in any project you know we will make the map, in our map we have these tangents plotted. So, what we will do from the map? As we discussed in our last lecture we will take the references to the tangent and we will set out those tangents there on the ground first. So, the very first job that we do is setting out the tangent setting out means we have put some ranging rods there. So, we have ranging rods one over here at the point of intersection oh over here and over here these are the ranging rods. So, this is how by putting the ranging rods we have now, fixed our tangents. Then we will like to determine point, T 1 and T 2 the meaning is point of curvature and point of tangent. How do we do it? How do we locate it locating T 1 and T 2? Once we know this line we know how much we have to move in order to locate T 1.

So, T 1 is here, because this is tangent distance T, then we also move along this tangent to locate T 2. So, T 1 and T 2 are located, because we know we can do the computation for this distance. Once T 1 and T 2 are located let us say the T 1 and T 2 are located, T 1 T 2 are located here. Then we will have to start setting out. So, at the moment if you consider the ground, there in the ground what we have there in the ground? We have, we know the point of intersection is there T 1 is here and T 2 is here. This is the only information that we have the information about, because we can measure the angle of intersection alpha can be measured. So, we have also that in angle with us, we have also the radius the radius of the curve which we want to set out, because the tangent is computed from the radius information only. Now, there in the ground so far there is no curve only two tangents. So, we need to do something now. So that we can set out that curve, so what is that procedure? That we need to do in order to set out the curve, this is what we are going to see now, that how we can set out?

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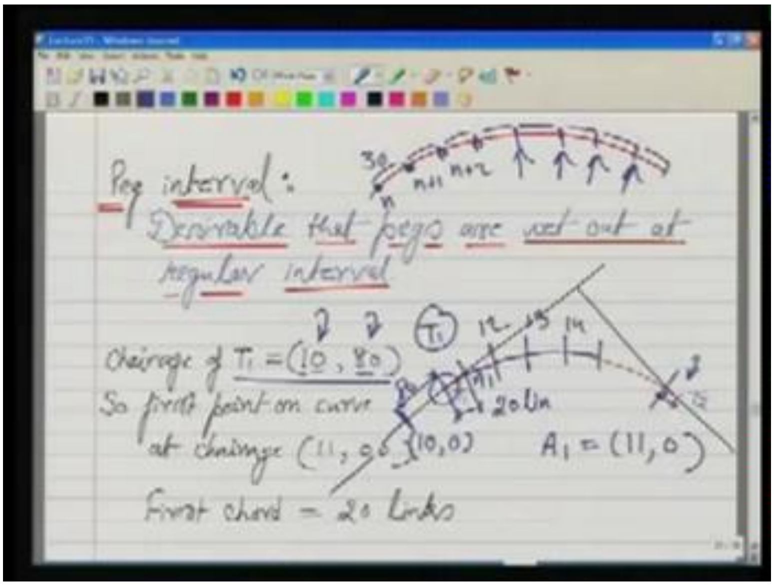

Now, before we set out, one more important thing and that is called peg interval. Well, before it is desirable that our pegs are set out at regular interval. What is the meaning of this? The meaning is if we have a curve and we want to set out this curve. So, definitely we will be setting out his curve, in some discrete points. So, what we want that the distance between these points should be uniform? And generally for large curves we would like to have it equal to a chain length or 30 meter. Of course, it depends upon the choice of the easier working in the field. Because for us smaller curve we will like to have these peg intervals smaller for very large curve, we would like to have these peg intervals large. So, the idea is we want to have these pegs at uniform interval also one more thing as we were discussing the chainage, we want to have these pegs at full chainages.

For example, the chainage is n then n plus 1 plus 2 we want to have these at full chainages. Because you know that is easy to work in the field there in the field when you are working, you are working with the layman. The workers were working there you know we want to provide them the facility. So, that they do not bother with much of computation rather using one full chain or full tape they start setting out the curve, they are not doing any computation there in between. So, that should be avoided and because of that reason what is desirable? The desirable thing is these pegs should be at full tape lengths or whatever the interval we have decided the peg interval this should be at full peg intervals everywhere. So, how it is ensured? Let us say the chainage of point T 1 here is 10 80 well what is the meaning if this they are 10 number of full chains 80 number of links that is the meaning of it. So, if I go backward here my tenth chain was complete here.

So, the chain is of this point is 10 0 10 full chains and 0 links now rest of this distance starting from a point here to point here this distance is equal to 80 links. So, this T 1 I do not want this T 1 to be my peg interval rather what I would like to do I would like to have my first peg interval at a point here which I say A 1. So, that the distance between T 1 and A 1 is equal to 20 links. So, by doing it, what we have achieved the chain is of A 1 is now 110. So, it is a full chain point, the next chain and next point next point next point, so that the chainsges, will be 12, 13 and 14 the chains no links there. So, they are the, this is how you know we decide the peg interval of course, depending upon the length of the curve our last chord. Because the last chord is this, which we are using or the last arc can be also smaller than one chain length. So, what we see here?

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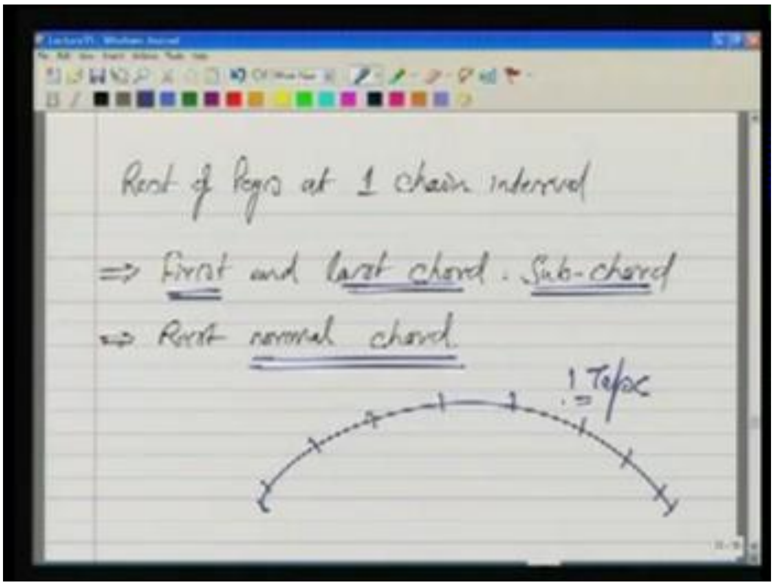

We see our first and last chord could be smaller. That is why we say them sub chord smaller than the full chain length or a full length of the chord, which we have taken and rest of them are the normal chord. Obviously, because the very first one was smaller the last one may be also smaller in between all separated by full interval or one chain we can say or one tape. So, this is why we give them the first and last as sub chord and the rest of them as normal chord. Well having understood this.

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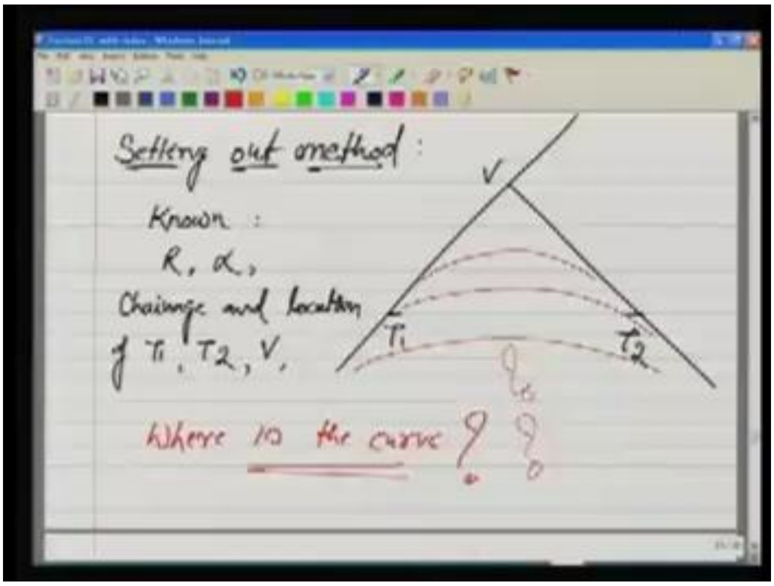

Now, we will go for setting out methods. So, now, we will see how to set out a curve? Now, what is known to us at the moment? We know there in the ground where the tangents you know we just discussed. The location of the point of intersection is known to us location of point T 1 that is point of curve we say that is known to us T 2 point of tangent that is also known to us. So, there on the ground we have these three ranging rods we can say. So, basically these 2 tangents are known to us, along with the point of intersection. What we can do? We can stand there at the point of intersection and measure the angle alpha. Exactly what is the value there in the field of that angle alpha?

So, now, that angle alpha is also known to us angle of intersection. Next as we discussed we have already taken a decision about the radius. What should be the radius of this curve? Depending the design speed, depending the topography the radius has been decided. So, these are the things which are known to us. Now, the big question is where is the curve? So, if you look here we need to answer this question that where is the curve is the curve here or is it here or is it here where is the curve. Then the other thing, I can stand on T 1 the point of curve now where should I go? If I stand at T 1.

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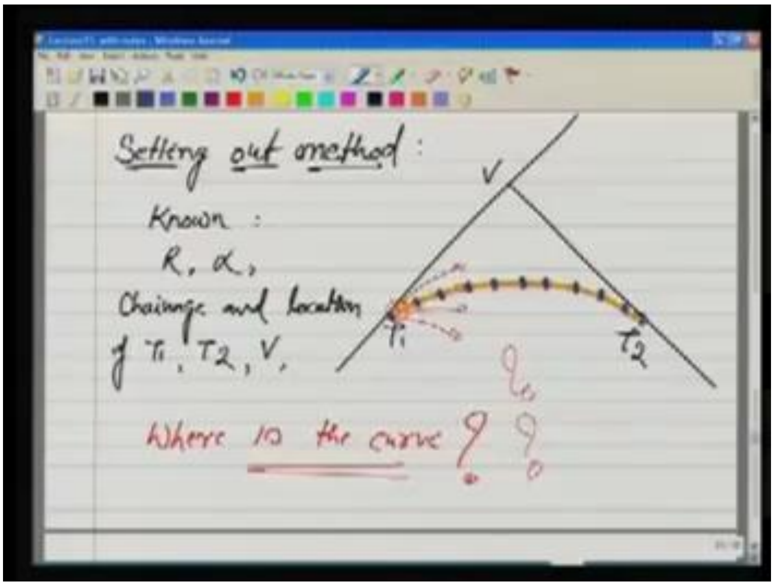

I am standing at T 1 and I want to move along the curve. So, which direction should I take what is the direction? So, that I am moving along the curve. So, these are the things which we have to take a decision on and finally, if we can do that we will be able to set out our curve. And of course, as we have discussed, we will set out our curves always in small chords. Now, what are the methods?

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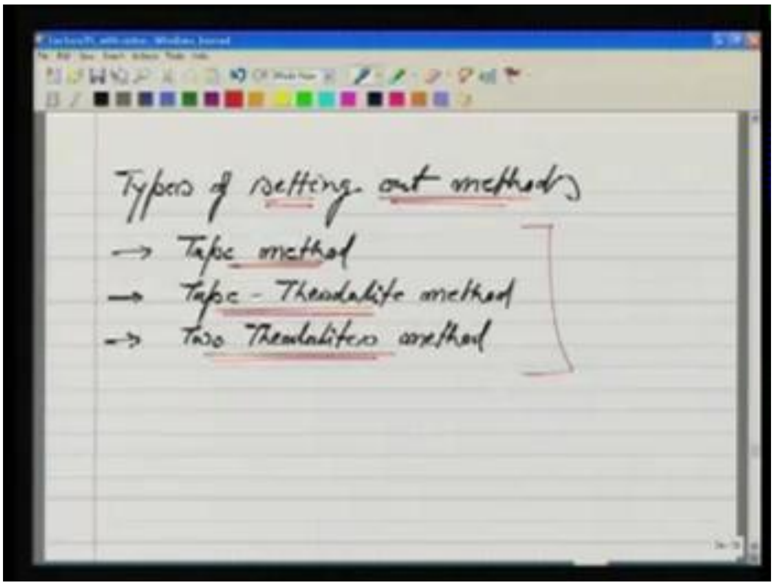

Let us discuss the methods for setting out the curve. These methods can be categorised as tape method, tape and theodolite method and finally, 2 theodolite method. Now, this is you know depending the application in our hand, what are the instruments available? Many times if you curve which you are going to set out is not a very important curve. You know that the design speed is less here the curve is small or it is not very important curve. Then we would not like to use very sophisticated instruments there rather we would like to just to use a tape or 2 tapes and by making use of 2 tapes we would like to set out the curve.

If the curve is sensitive, we want to set it out correctly in that case what is important in that case the important thing is that we should use better instruments the précised instruments. So, we may like to go for a tape and the theodolite and when I am saying tape I mean, we can also include the EDMI then if we have for example, let us say we want to do it very fast. There is a method we will which we will see in which we can use 2 theodolites together and we can set out a curve very fast. Also when I am saying ED tape or EDMI and the theodolite I mean total station, you know we can also set out the curve by the total station.

So, what we are saying here? We are saying couple of methods, very generic methods and these methods can be generalised can be made specific then depending the instrument which is available to you. So, it is absolutely depends upon the field, when you are working in the field what is the requirement in the field? What is the method which you should use? Once we discuss this methods you will learn that not all methods can be used in all cases. The topography of the field the, our movement the accessibility of the side this will also control the method. And of course, what are the instruments which are available to you the time the resources everything. So, let us discuss these methods 1 by 1.

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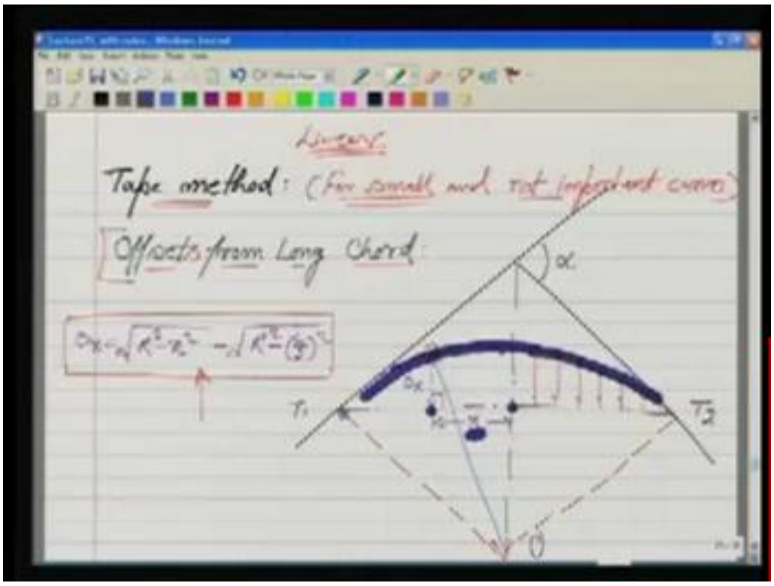

First of all, we say a method to be tape method. Tape method means, we are only taking linear observations, only linear measurements are being carried out and this is generally used for small and not important curves. In this tape method one method which is called offset from long chord I should write offsets off sets from long chord method now, what is this method? In this method over here is the long chord that is the long chord which we know about now, in this long chord, what we do? We measure some distance as I am saying x from the middle point. So, this distance x is measured here from the middle point here.

And at this x this point we erect a perpendicular that is the perpendicular and along the perpendicular we measure a distance equal to ox. And then this point will be on the curve. Now, what is the value of ox? ox is given as this I am not getting in to the derivation of this, because this is a very simple derivation. And you can arrive at this value very easily, but I will advice you that you please go through some text book or try to do this derivation yourself it is a very easy derivation, because that will help you to understand it. So, this method is offsets from long chord. We have done it for this x we can do it adequate intervals over here also. So, by doing that what we are doing? We are establishing the points on the curve and then joining these points, we will have our curve set out. So, this is how the curve can be set out.

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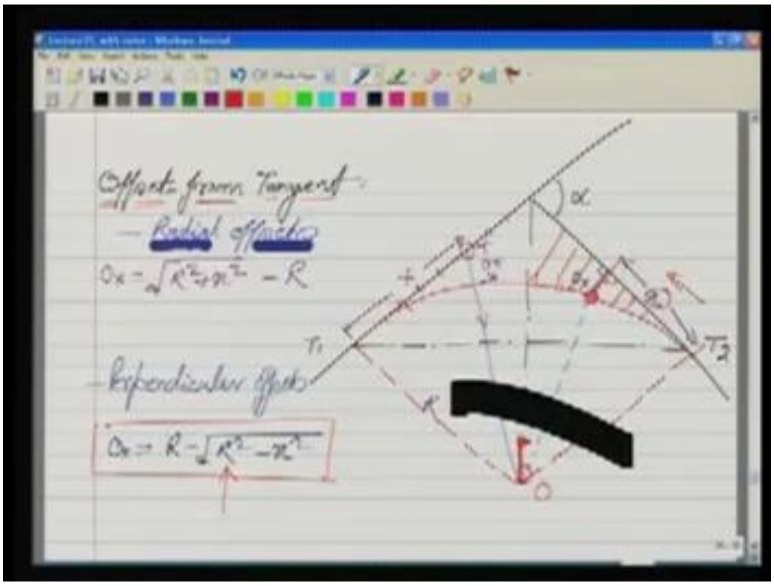

Well, in next method again this is a method, which we say tape method and in this case we will take the offsets from tangent. So, we are taking mind it please offsets from tangent. Now, our tangent is here, this is our tangent; we want to take the offsets from the tangent. So, what is the meaning of this? It is possible for us to walk along the tangent the ground permits this. The first method in this case is radial offsets, radial offsets means, if I am standing at any point here let us say we are standing here. It is possible, that I can see the centre of the curve we can establish the centre and I can look at the centre well arranging rod there and I can see the centre.

So, wherever, I move along the tangent from there I can see the centre. So, I have got a direction now, along this direction I measure a distance equal to ox at a distance of x. So, our x is this is x at the distance of x we measure a distance ox and this point will be on the curve. So, this ox is such that we can compute it, it ensures that the point is on the curve. So, what we can do? We can keep moving along and we can keep taking these off sets. Of course, in this case we should be able to see the centre; we should be able to draw a line along the centre. If it is not possible to the see the centre well the problem is we have for example, over there a building and it is not possible that we cannot see the centre. So, in that case what we should do? Well, we have to go for some other method and we can say another method, which is perpendicular offsets. Well in this case what we are doing? We are if I remove all of these in order to understand this perpendicular offsets now, we are moving along the tangent.

Let us do it here moving along the tangent at a distance of x at a distance of x here. I can erect a perpendicular this is the perpendicular, which I am erecting here. So, this perpendicular has a length ox and this ox is given by this. So, if at a distance of x, we move in perpendicular direction by a distance ox this point will be in curve provided we compute the ox like this. Again you can derive this why it is so? So, in this case it is not necessary for us to look at the centre. Because we are not able to see it there is a building or some wall or some other thing or jungle. So, we are erecting the perpendiculars at x and then we are setting out the curves. Similarly, this side also.

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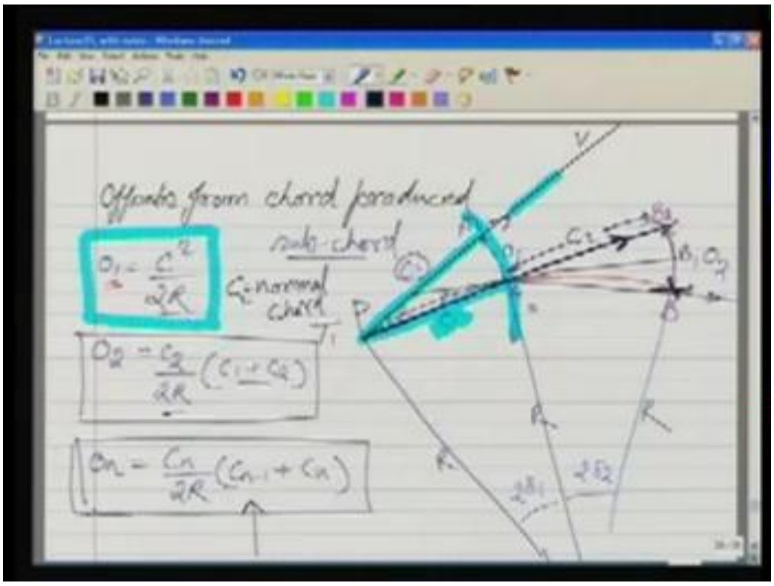

Now, here is another method and this method is offsets from chord produced. Now, So, far in our methods we are doing those for smaller curves. And also whenever we are discussing this you know all whenever we are working in the field we have to see whether our ground can support this method or not. Then these methods are not very accurate, because you know if our curve is large our offset from our tangent will become very large, measuring the distance erecting the perpendicular will become a problem. So, these methods are for not important curve as well as for small curves.

Now, here is a method, which is used very often for the curves in highways and over here. We do not have any angle measuring instrument only the tape, but the curve is very large. We cannot use any of those previous methods. So, what is this method in this method well there's the point T 1 and somewhere here is the point T 2 and it is our tangent. First of all what we do we take a chord equal to C 1 and C 1 is what C 1 is our sub chord. We know where from this sub chord is coming. So, we take the sub chord C one and we move along see right now we are moving along the tangent, we stretch our tape. So, that this distance is equal to C 1 from there I we take an arc. So, an the arc is taken like this and this arc ensures that this distance is also C 1.

Now, on this arc standing at the point A now, I am at A I want to cut a distance on that arc the distance should be such that, that the point which I get here should be on the curve. Now, how can we ensure it? This can be ensured by cutting a distance which is equal to O 1. Now, what is this O 1 will be this O 1 is given here. Again it can be proved very easily very easily we can find it we can prove it. So, what we did in this case? We moved or rather we took a distance C 1 along our tangent then we took the arc. And we standing at the point A 1 A 1 means standing at A 1 here we cut a distance equal to O 1 along the arc in order to get the point A.

So, this is how we get our first point A here and how much is O 1 O 1 is computed by C 1 square by 2 O R this can be proved very easily from this figure. Once we have done it our first point on the curve is known. Now, what next right now you just think you know we are standing now on the first point of the curve at the T 1 point. The previous point we had a direction with us that was the tangent direction, but standing at this point. Now, a, we do not have any direction we cannot erect our tangent there because we do not have a curve. So, if we do not know where the curve is we do not have any direction no tangent direction. So, what to do here? So, what we do this chord is extended further. So, it is being extend extended like this extended means there in the ground I have a ranging road at T 1.

I am standing at the point A and this particular direction I am taking it back. So, we can extend it by any method you know there is a ranging. So, we are extending it. So, I have extended then standing at A now, we have a direction the direction is AB 2 or a direction in which the chord is extended. So, standing at B we take a distance equal to C along this direction and this C is normal chord. We can write here it as C 2, also because the second chord. So, we take direction C and again we take an arc from this this direction this is the distance C 2 we take the arc here. Now, on that arc we cut a distance equal to O 2, what is this O 2? If you derive it you can find that O 2 is given by C 2 by 2 R and C 1 plus C 2 again this is a very easy derivation.

So, if we cut along this, if you cut along this a point here. So, this point B is on the curve. Similarly, now, what we will do? We extend this chord. So, this chord here is extended further, it extended further and same process is repeated. So, here is the general formula from any extended chord. So, what we are doing you know we are standing on a point in the curve, which has been just set out extending at that point the previous chord is being extended and from the extended direction. We are taking a distance for example, C 2 we took and an arc and then along that arc we are cutting a distance equal to as we have given here O 2. So, this is the general formula for this procedure. So, if we are following this, what we are able to do?

We are able to set the points all along the curve only by using length measurement. We are not using any angle measurement still. Now, let us look at a method one we have a tape with us and we have also the theodolite with us sometimes we will desire it like this you go you want to do your curve more accurately. Now, in the method we which we just discussed you know the method of extended chord, if you commit a mistake at any point what will happen rest of the points along the curve will be all shifted. So, you know we are establishing the points in an you know dependant way the point number n is dependent upon the accuracy of point n minus 1. So, that is the disadvantage there.

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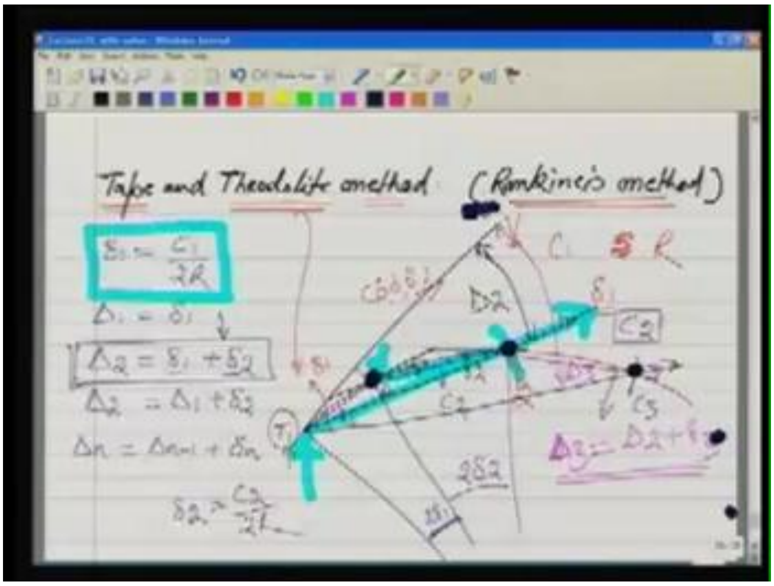

Now, over here in this method when we have a tape and a theodolite available with us, so we say this method as Rankine's method. Now, what is there in this method? Well, our T 1 is known to us we stand at T 1 with a theodolite. So, we are using a theodolite at T 1 point. We know this point V the point of intersection. So, I can align my theodolite in this direction. So, my theodolite can be aligned. So, that it is looking in this direction and we can set the angle or the reading to be 0 0 we know the meaning of it we can do that. Well, next if I have taken a chord of C 1 this is first sub chord. So, we can know the relationship now, if this is this distance is C 1 how much will be the angle here which we say as delta 1; delta 1 is the angle made by the chord. Let me highlight it made by the chord and the tangent that is the angle delta 1.

So, the relationship between this is delta 1 is C 1 by 2 R. So, once we have we know our C 1 the meaning is our normal chord our sorry sub chord. So, knowing the 1 we already know R we can find the value of delta 1. So, what we are doing? Now, standing at T 1 with the theodolite we have set this V point of intersection as 0 0 0 now, we are setting in our theodolite an angle equal to delta 1. So, we are setting that angle in our theodolite. So, the moment we have set angle delta 1 now, we are looking in the direction of this chord. So, we are looking in a direction which I am highlighting here in this direction. So, along this direction we cut a distance equal to C 1. So, our first point A is known on the curve. Well, next what we do?

We do not change the position of the theodolite the theodolite stands there only. From there now, theodolite if the next chord we have taken a decision now, our normal chord is let us say C 2. We can easily compute if it is C 2 and for C 2 let us say that is the C 2 and the angle over here is 2 delta 2. What is it is 2 del 2 and what is this del? It is the angle over here made by the tangents 2 and del 2 these are the angles and this length is this length is C 2. So, if it is. So, again we can have the relationship 2 is C 2 by 2 R. Now, my theodolite is set in such a way that it is looking at an angle equal to delta 2 which is del 1 plus del 2. Meaning the theodolite will look in this direction. So, this angle is delta 2.

Now, we can easily prove here that this delta 2 is equal to del 1 angle and del 2 angle easily this can be proved here. So, now, standing at point T 1, we have set out an angle equal to delta 2. Now, we are looking in which direction, we are looking in the direction over here I will highlight this direction we are looking now in this direction. This is the direction in which the theodolite is citing. And where are we standing? We are standing right now, at A with the tape we are standing at T 1 point with the theodolite, but we are standing at A with a tape. So, there is a person who is standing at A and there is a person at T 1 with the theodolite. So, from A we cut an arc of distance C 2 . So, this point second point which is B is established there.

Well, next again the step will be same we look again in a direction. So, that this direction is we will we look along this direction and this total angle I am showing you this by this proper colour here, it is delta three. How this delta 3 value will be known? Delta 3 will be delta 2 plus del 3 and we know how to compute del 3? So, we know that we have to look in this direction. And then how much we will cut from here from the point B because there is someone who is standing at point B over here he will cut a distance in this direction. Which is equal to this particular chord well we can say this chord to be C 3 generally all the chords will be same.

So, cutting that distance means you know we are citing to the theodolite. Now, someone is moving there taking an arc the moment is intersected, because we are citing through the theodolite. So, we are looking in one direction. Now, the moment or ranging rod which is taking that arc is bisected we will say that is the point on the curve. So, this is how the points on the curve means a point here then the next point then the next point and the next point and, so on will be established. Now, one thing important here over here all the angles are being measured independently, you can set out the angles independently. So, that way this method is better than this method is faster also, because it is we are making use of the angles here. It is also more accurate only 1 length measurement is there only 1 arc is being cut. So, this is our Rankine's method.

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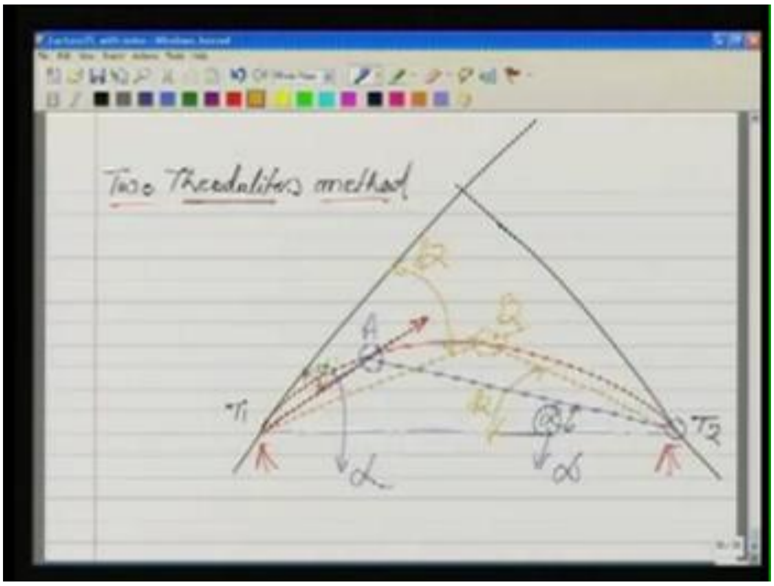

There is one more method which we say as 2 theodolite method. Now, in this case this is very easy or rather very fast method we can say, we put a theodolite at point T 1 also at point T 2. We know the characteristics of a circle and from by making use of that characteristics, what we do if I set an alpha here from the back tangent? So, I am looking now, my line of sight is in this direction. So, I am my theodolite is at T 1 and that is my line of sight. If I set a theodolite there is a theodolite T 2 and in that theodolite from the long chord I set the same angle. So, over here also it is alpha and over here also it is alpha and if I set the same angle here. They will intersect at this point and by the characteristics of the circular curve we know that this point has to be on the curve the circular curve. Similarly, I can do it for some other angle. So, what we are doing this angle for example, let us say beta. So, we will take the same angle here also beta.

So, ensuring that this point is also on the curve, so by taking these successive angles, you know one person is doing this angle measurement from the back tangent theta 1 theta 2, theta 3, theta 4. The other person is doing from the long chord from the T 2 point theta 1, theta 2, theta 3 and wherever these line of lines of the intersect. We are locating those points there on the ground and those are the points, which are on the curve. So, what we have seen today? We saw about the curve, why they are required? The elements of the curves and then also we saw how we can set out a curve in the field. There are more important thing about this excise is this is just theoretical back ground or the concept, but we need to do it in the field. If you have an opportunity to go to some laboratory go to the laboratory, take the instrument go to the field and set out the curve there in the field. So, we finish this lecture here.

Thank you.