Surveying
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Module – 6
Lecture - 3
Triangulation and Trilateration

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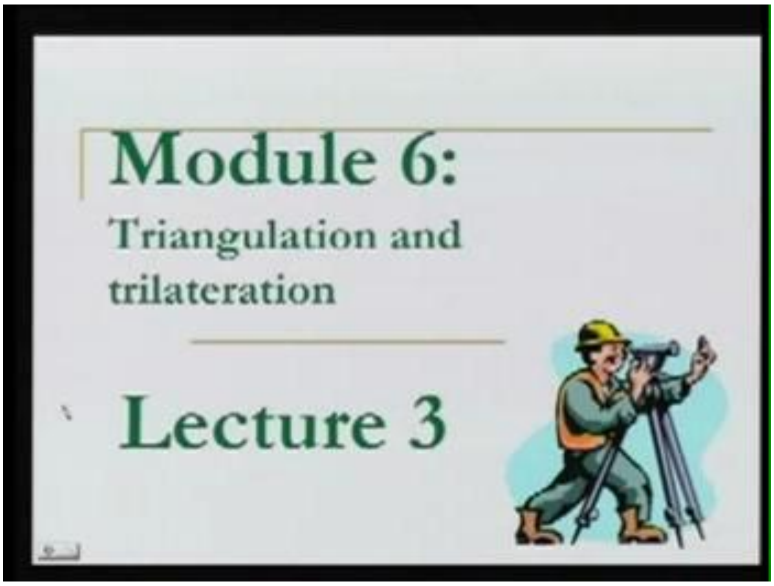

Welcome to this another lecture on basic surveying. Today, we are talking about this module 6, and we are in lecture number 3.

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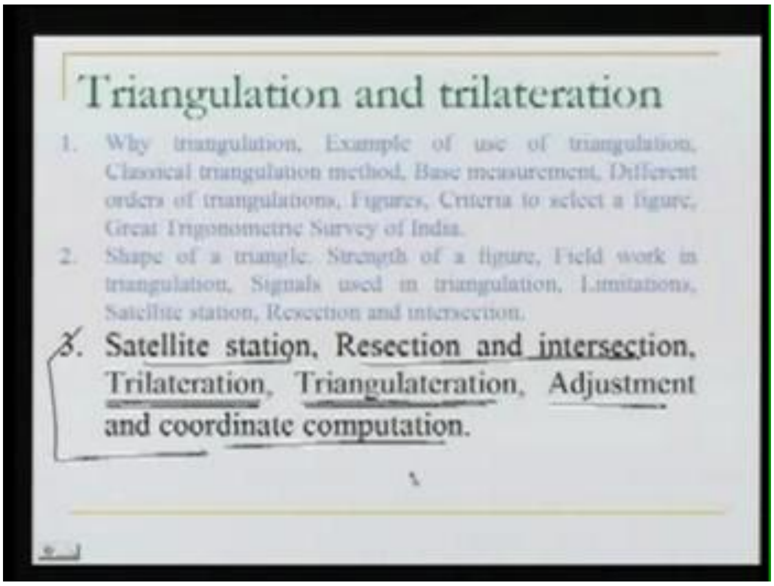

In lecture number 3, we will be talking about the satellite station, resection and intersection. Then, will go to another method of establishing the control that is trilateration. We will go for one more method that is called triangulateration. Finally, we will see something on adjustment and coordinate computation.

What we have done so far, we have talked about in our last lecture the basic thing, the shape of a triangle. Why the shape is important? We found it graphically. We found it also mathematically by some analysis that if in a triangle, the angles are between 30 and 120, the error propagated in computation of the rest of the lands because as we know the triangulation is a network of triangles, where all internal angles are measured. One length which is called the base length is also measured. Now, starting from this base length, all internal angles we compute the other lengths.

So, in this process, the error which is introduced in the angle measurement again gets introduced in the computation of those lengths. So, we say this process to be the error propagation or may be the scale error. So, we saw that the scale error in computation of those lengths through a chain of triangles will be less if our angles are well conditioned. So, that is also very important thing which we should keep in mind. Then, we saw also about the various signals which we used in the field, the towers. Many times we have to use the towers in the field. So, we looked into those aspects also.

So, now today we will begin with satellite station. The satellite station is required in triangulation, when? For example, let us say what is the triangulation? As I draw here, we keep forming a chain of triangles. This could be any other figure also, not only triangles, there is quadrilateral or centered figure.

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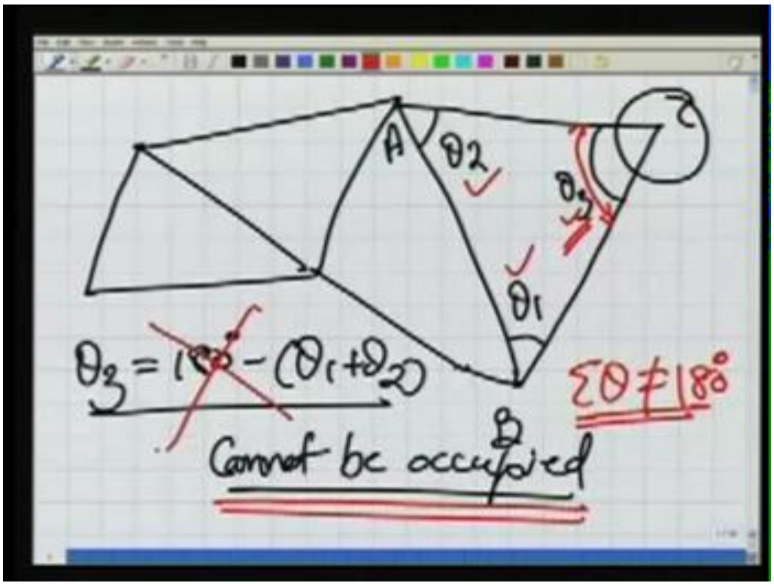

Let us say, we are at some distances A and B and from this A and B, we are trying to see in a direction. As I will highlight towards this direction, we are trying to say in this direction and over here our station, the actual station where we can put our instrument is not visible may be or may be something, which is more visible or we want to take that as a station. This is more important point. We want to take something, which is here.

Let us say C as our station and we bisect that C, so that we can also measure our angles at B and A. We prefer to bisect the C because it forms my triangle A, B, C as well as conditioned triangle also. May be this C is very nicely visible, but there may be a problem later on after visiting that place or may be beforehand also. You knew it that C has some problem and then, the C cannot be occupied. It cannot be occupied. What is the problem? Well the problem will be if you have measured the angle theta 1 theta 2, you can still get the value of theta 3. So, how will you get this theta 3? Theta 3 you will find by 180 minus theta 1 plus theta 2, but should we go like this.

We have been talking all through that this is not the right way of getting theta 3 because in that case if there is some error in measurement of theta 1 or in theta 2, large errors, it can go unnoticed. We cannot determine that, we cannot find it. We should have a way out, so that kind of errors can be located. So, for that reason what we desire? We want to measure this theta 3. Also, independently we want to measure theta 1, theta 2 as well as theta 3. All three angles measured and in that case, if all three angles are measured, we will find sigma theta is not equal to 180 because of those measurement errors. The observation errors, but the condition in this case C cannot be occupied. So, what to do? Somehow we want to get this value of theta 3 which is independent of theta 1 and theta 2. We do not want to use this relationship rather you want to do it by some other method. Now, the solution of this is given by satellite station.

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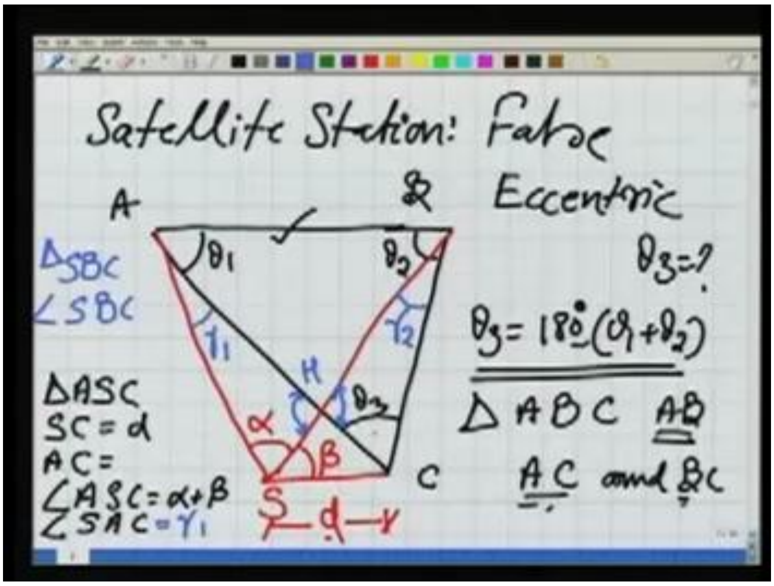

This is also called many times false station or eccentric station. Now, how we proceed in that case? Well, those A and B as we have seen previously also are here A and B, where we can measure the angles. Our C is somewhere here. Let us say we had occupied or as you can see in this diagram, this is our measured base length. We are starting from the base length, and we go through this chain of triangles. So, by knowing all these angles, we are in this length. We are able to compute this length. So, this length is known. So, length AB is known to us as well as we have measured angle here and angle here.

Well, we are not able to measure the angle at this point. This is for example theta 1 theta 2. What is the value of theta 3? That is something, which we want to determine. Well, what is done in that case is, we take one more station which is very near to see, so that this station S can be occupied as well as from S, we can measure the angles to A, B and C. For example, the angles which are being measured at S are alpha and beta. Well, these angles can be measured as well as the distance. As C, this distance d can also be measured. So, this is the condition for this satellite station. We locate the satellite station somewhere around our C because C can be any high range tower, or may be a spire of something, you know something which we cannot occupy, but we can bisect.

Well, having done this establishing, this S measuring d measuring alpha and measuring beta. Now, what we are trying to do? We are trying to reduce these measurements alpha beta and d using these alpha, beta and d. We want to determine. Now, using this alpha, beta and d, we want to determine an independent value of theta 3 which is independent of theta 1 and theta 2. Well, what is the procedure for that? The procedure for that is first of all, we will get an approximate of theta 3 which is as usual we will find by 180 minus theta 1 plus theta 2. This is the first approximate value of theta 3. Once we have determined this theta 3, this is the first approximate value using the triangle A, B and C and as well as this known length AB. AB is known to us.

What I can do? We can compute lengths AC and BC. This is by using the sin rule. Now, I can compute the length AC and BC. Well, once the length AC and BC had been computed, the next step we are going to the triangle let us say AS and C in triangle ASC. I know SC because this is measured, this is equal to d and I know AC. Well, this is computed. Having known these two as well as the angle ASC, this angle is alpha plus beta. Having known all these, I can apply the sin rule again and I can compute the angle SAC. The angle SAC if I show it by different color here, this angle. So, I to write this angle for example, let us say gamma 1. So, I can compute angle gamma 1.

So, in computing this angle gamma 1, what I am doing? I am making use of alpha and beta and d which are kind of independent measurements, and then theta 1 and theta 2. Similarly, we should go to the triangle SBC. You can also compute the angle SBC. So, the SBC angle is here. You can also compute this angle. Similarly, this is let us say, gamma 2, fine. We have determined this angle. Once we have determined this angle, I can now easily find the angle over here and this point as H. So, working in the triangle SA and H, I can find this angle. So, I know the value of the angle here. So, I can write this angle H.

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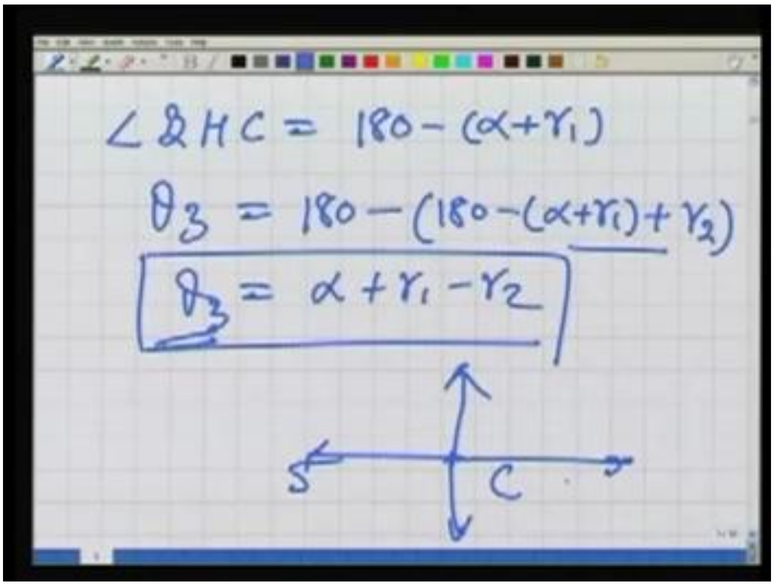

If I go to the second slide B, angle BHC that is equal to 180 minus alpha plus gamma 1. You can check it also whether we are writing the correct thing or not because this angle H AHS is 180 minus alpha plus gamma 1. So, similarly this angle also. Well, if you know this angle BHC, I can now compute the value of angle ACB or theta 3 directly now. So, the theta 3 can be now computed. So, theta 3 will be 180 minus 180 minus alpha plus gamma 1 plus gamma 2. So, this entire thing can be reduced to alpha minus gamma 1 minus gamma 2. Well, what we have found here? If you can check, just solve it. You will find. It should be plus. We found a value of theta 3, which has some influence of our first approximation, but at the same time, this theta 3 has also influence of alpha, beta and d. So, this is how we can determine an independent value of theta 3 which we will then treat as an independent measurement hence on.

Now, in this case, our S was located towards left of C, but there are many more possibilities. Our S could be here, S could be here, or S could be here and depending where the S is, whether the direction accordingly the computations can be done. Now, we will see one important thing of the triangulation and that is intersection.

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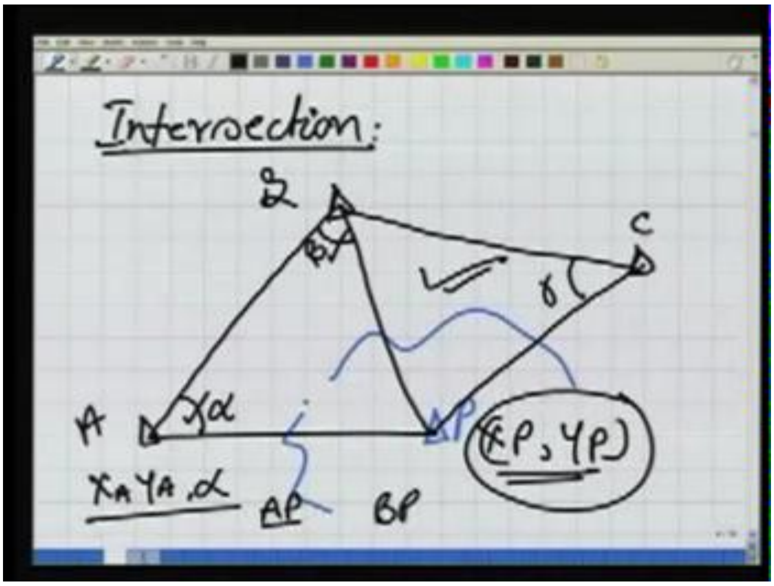

Now, what is the meaning of this? The meaning is in triangulation. For example, here we establish the stations in the field. These stations are for example, A, B and C. After we have done the triangulation, we know the coordinates of these stations. The meaning of intersection is if we are moving somewhere in the field, for example let us say I am somewhere here. And I am moving here or let us say at this point, there is a temple and we want to determine the coordinate of the temple, but because you can see the temple, you cannot occupy it or may be for some reason. If this is a water body, you cannot go to this area, but you can see this particular tower of the earth. So, it is possible for you to intersect this, but not stand on this.

So, in that case our aim is to determine XP YP. What are the coordinates of this point P? So, what we will do? We will make use of intersection in order to compute those coordinates. The meaning is I will stand at A and from A, I will measure let us say the angle alpha. This is possible triangle. The triangulation station A is our station. We can measure angle alpha. Similarly, I will go to let us say B and from B also, I will measure the angle beta. Once I have done it, now using the coordinate of A XA YA and the angle alpha, I can write the equation of line AP. Similarly, for B, I can write the equation of line BP.

Now, solving these equations for their intersection where these two lines intersect, I can compute the coordinate of P. So, what we are doing? This way we are computing the coordinates of a point which we cannot occupy. Well, right now what we have done? We have measured only alpha and beta. These two angles if there is some error in measurement of alpha is there, any check yes we can go for a check. Let us say I also occupy C and from this C, I measure the angle gamma by bisecting B and P. So, what I can do? I can repeat the same set of calculation in this triangle also, or maybe I can solve the problem now about the BC square. So, I will have the coordinates of point P. So, this is called the method of intersection. Next which is similar to it, but slightly different, we will see a method called resection.

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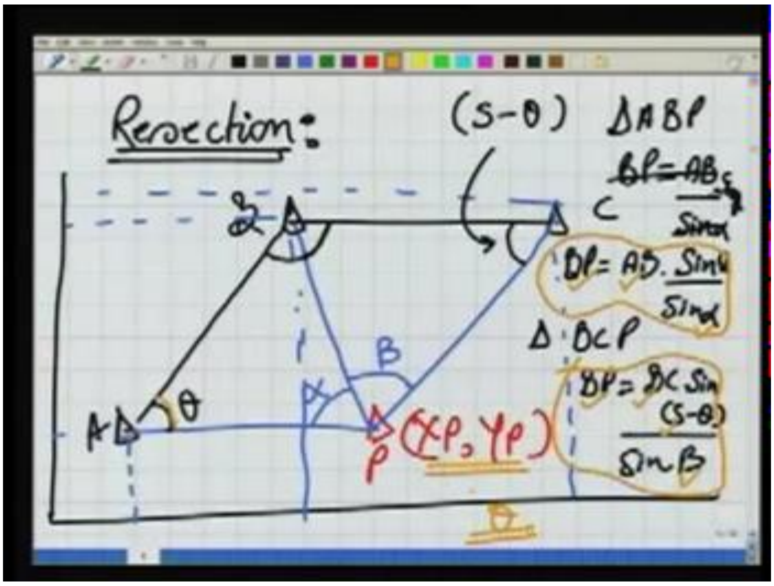

This is called method of resection. Now, what is this resection? The resection is slightly different. The same set of A, B and C are our triangulation stations. We know their coordinates. So, if we know their coordinates, that means, we have a coordinate system and in that coordinate system, I know their coordinates. Let us say C is there in this coordinate system. I know these coordinates. Let us say you are wandering there in the field somewhere, you are just wandering in the field somewhere here, and by standing at a point, you are standing somewhere. For example, let us say over here and by standing at this point and taking observations to A, B and C, you want to determine where you are. This point is P. So, XP YP, this is what you want to compute

So, now the situation is different. You are not taking observation from A, B or C rather you are taking observation where you are standing on some field. You want to know what the coordinate of this point is. So, how to do that? Again in this case, you will be measuring the angles. For example, I can measure the angle APB. Let us say, this angle is alpha. Then, I can also measure the angle BPC. This angle is beta. When I am saying the angles, I mean you are measuring the angles in the horizontal. Well, having known these two angles, can we determine the coordinates of XP and YP? Now, this is a very simple problem.

One solution of this could be though you can solve it by many methods, one solution of this could be if this angle is let us say, theta. So, within this figure A, B, C and P, I can write this angle as S minus theta. Now, what is S? Here S is sum of you know 360 minus alpha minus beta minus the angle here that is S. So, I can write this angle as S minus theta. So, S is the constant. You can find the value of S.

Well, having done this, what I can do? I can write now in triangle ABP for length BP by using the sin rule, I can write for BP as because I know the length AB. AB length is known to me because I know the coordinates of A and B. So, I can compute this length. So, AB by sin of alpha, the alpha is been measured multiplied by for BP, BP by sin into and over here it will be sin of theta. So, if I write it again, it will be BP is AB sin of theta by sin of alpha.

Similarly, in triangle BCP, I can now again write for BP. Again by using the sin rule, I can write here BP is BC sin of S minus theta. This divided by sin of beta. Well, in this equation number 1 and number 2, BP is same. The left hand side is same. So, I can equate these two. If I equate these two, the only unknown because we know AB, we know BC, we know S, we know alpha, we know beta. The only unknown will be theta which you can compute. So, once you know the value of theta, having known this you can compute these coordinates of XP, YP. Well, now what we will do? We have seen the triangulation so far. We have seen the application of the triangle, triangulation also or may be some more things like what do we do by the resection there, what do we do by the intersection there, all those things we have seen.

Now, we are going to talk about one more aspect of establishing the controls that is called the trilateration. As in the case of the triangulation, we understood that triangulation is done in order to establish a control network in the field. Now, why we did the triangulation, what are the basic aim for that? It is because we have to measure only single length. While we can measure all the angles and the computations can be done, the coordinates can be generated. We also discussed this thing that measuring length was difficult in earlier times when the EDMI was not there. That is why we will only measure a single length, but measuring angle is easier. You do not have to go and traverse the length. You have to just stand on a point, bisect the targets and the angle is known to you. So, because of this reason, the triangulation was very much in practice, but now because of the EDMIs are available and with the EDMI, the electronic distance measuring instrument, what you can do is, you can measure the lengths very accurately and very fast.

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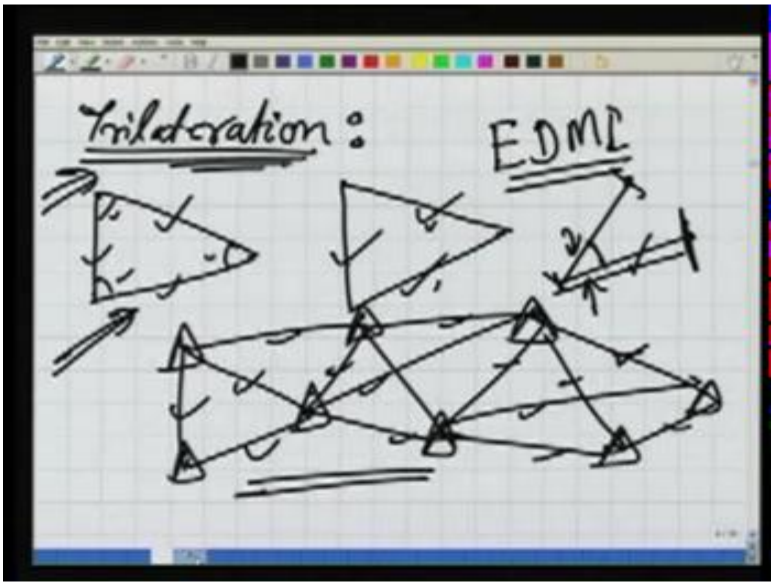

So, something comes to the mind. Cannot we use EDMI to establish control network again by using the same chain of triangles? So, what we will do here in this case, instead of measuring in case of triangles, we are measuring one length and three angles. Cannot we do one more thing that we measure all three lengths. Well, my triangle is solved. I know all three lengths because ultimately in triangulation also in order to compute the coordinates, what you did? We made use of these angles for computing the lengths. Finally, we are computing these lengths there.

So, this kind of triangulation figure, where all lengths are measured, the figure could be anything. We will talk about that in a moment, but all the lengths are measured here. This is called trilateration. So, this is another method of establishing control in surveying. Now, what we will do? We will compare our trilateration with triangulation where these tend together because measuring distance with EDMI is very easy. You can measure these distances very fast. The number of the observations which you have to take is less than in case of the angle because in case of the angle, you have to measure this angle alpha, you have to bisect here, you have to bisect here and then, you have to measure. Then, you will know the angle, but in this case, also you have to take the reading, this reading and this reading, but in the case of the EDMI as we understand so far what you have to do in order to know this length, you have to just bisect the target here, and the length will be known.

Similarly, in order to know this length, you have to bisect the target here, and then length will be known. So, it was considered earlier that this trilateration because the distances will be measured very fast and it can be a better method of establishing the control. So, now we should try to see whether it is really or not whether this triangulation is really a better method or triangulation is the better method, or can we go for figure where both angles as in this case three angles as well as three lengths are measured. Which one is better? So, we will try to see these things now. So, what we will do? We will start with advantages of trilateration.

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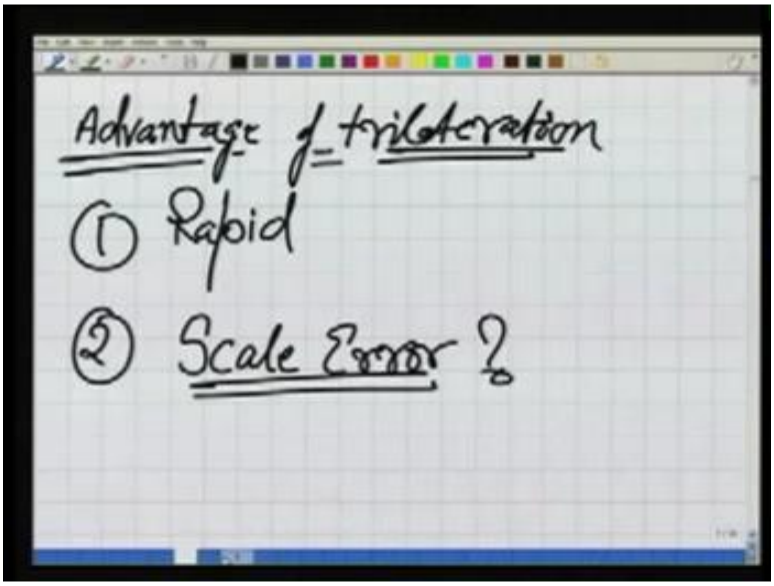

Number one advantage that we can site is it is rapid because straight away you are measuring the distances. In the case of triangulation, we would compute those, but here we are measuring them directly. So, it may be considered to be the rapid method. Number two, a very important thing is it can control scale error. Now, what is scale error? Let us see this first.

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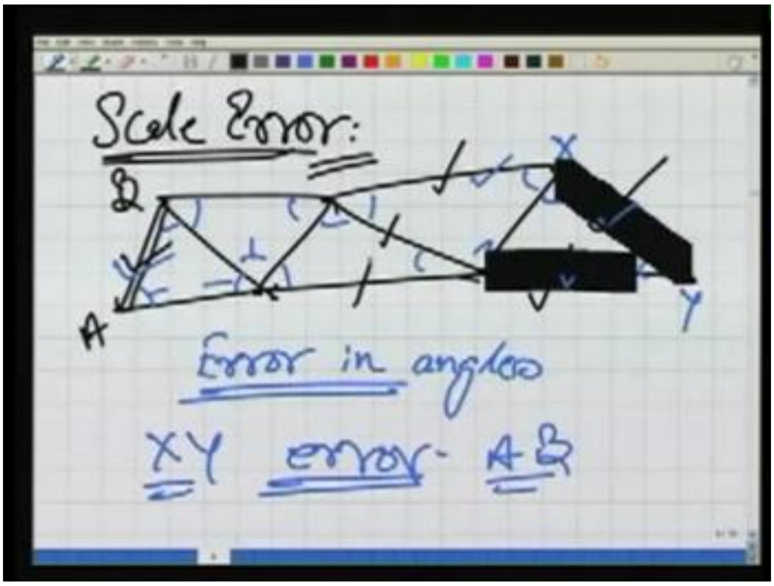

The scale error is as we know in any network of triangles; we start from a measured length which is called the base length. Let us say it is AB. Then, we have all these angles measured and knowing this length and all the angles, we would compute the other lengths. We have also seen that error in angles because all the angles, which we are measuring here with this, or this or this have some error and this error propagates.

Propagate means when we are computing the length here, let us say this is length finally XY. So, in computing this length XY, we will have some error which is a result of the error in our initial AB as well as the important thing as well as my angles are how much is the error in the angle. We know now in computing XY will have some error, and this error is because of the error in AB as well as the errors in all these angles, all these angles here. Not only the errors in the angles, it also depends upon what the size of the angle is because we are making use of sin rule. We have seen that all. Already we have seen how the error propagates, how it depends upon the size of the angle, but whatever the case we know in case of triangulation, there will be some error finally in computing our length. So, this error we say the scale error.

Now, in the case of the triangulation for a trilateration, what we are doing? We are measuring these lengths directly. We are not computing these. So, there is no question as such of scale error. So, this scale error is controlled. What we will see? After seeing these advantages, we will see now some disadvantages.

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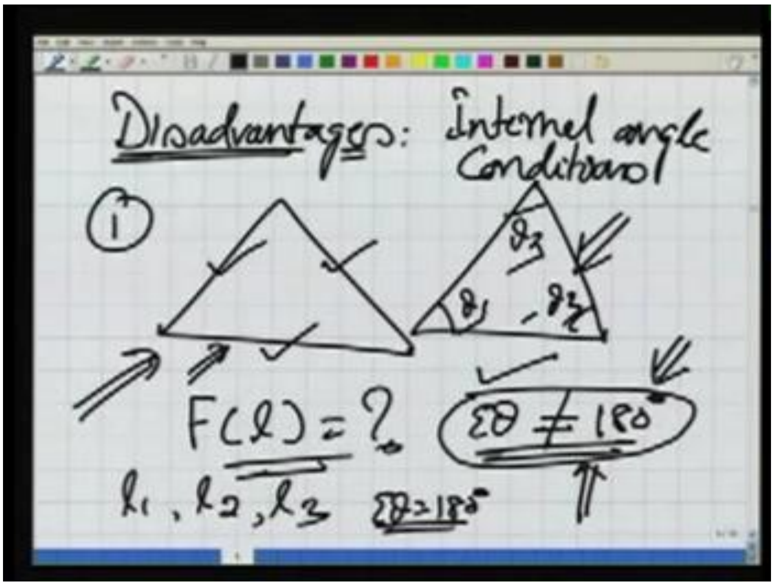

Disadvantages of trilateration we are starting with number one. In case of trilateration, you are measuring these three sides. In case of the triangulation, we measure these three angles. Now, in case of this triangulation, we can say this theta 1, theta 2 and theta 3. So, sigma theta should be equal to 180 degrees. Our observations in the triangulation should satisfy this condition there. Any similar condition, geometric condition for the length also. Can I say something? Will you know any kind of relationship? We say a function of these lengths. Can I say it that they should follow some relationships? We cannot whatever the lengths we have measured l 1 l 2 and l 3, whatever they will always form a triangle. Always the resulting angles will sum to 180 degrees, but this is not.

So, here in case of triangulation, this sum of three angles theta 1, theta 2, theta 3 will not be equal to 180 degrees because my theta 1, theta 2 and theta 3 has some errors in them. So, in case of the triangulation, we have a way out of adjusting these errors because we know there is an error, but in case of trilateration even if error is there, we do not know. So, in order to reach conditions like this, the trilateration figure becomes very complex. A simple triangle like this has one geometric condition. The sum of these three angles should be 180 degrees, but this is not. So, in a simple figure like this in order to have a similar geometric condition in trilateration, also our figure will become complex. So, this is one disadvantage of trilateration that our figures will become more complex, or rather we can say our internal condition; internal angle conditions are not there. These are not there as in case of the triangulation.

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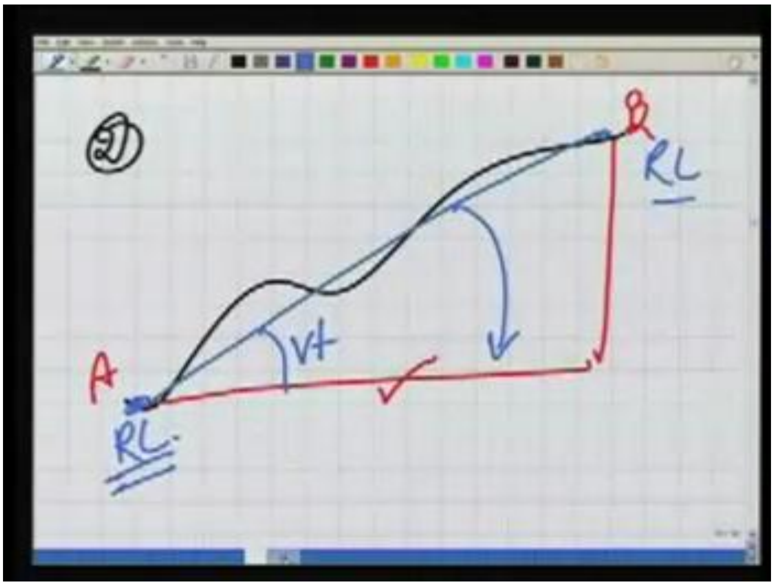

Well, the second disadvantage is as we know in trilateration we measure the distances. If we have a hill like this, and we are interested in knowing the horizontal distance between these two points B and A. In triangulation, we do measure the horizontal angles, we do not measure the angles in a sloping plane rather we measure the angles always in a horizontal plane, and this is how the theodolite is made. So, directly there by the computations, we compute the horizontal length, but in the case of trilateration, we are measuring the sloping distances. So, this sloping distance which has been measured needs to be finally reduced to its horizontal component. How can we do it? Either we should know the RL, the reduced level of these two points or I should know the vertical angle, Vt. So, in order to do it, again we end up taking some extra measurements, either the vertical angle or the heights of these two points, and then only this job can be done. So, this is another problem.

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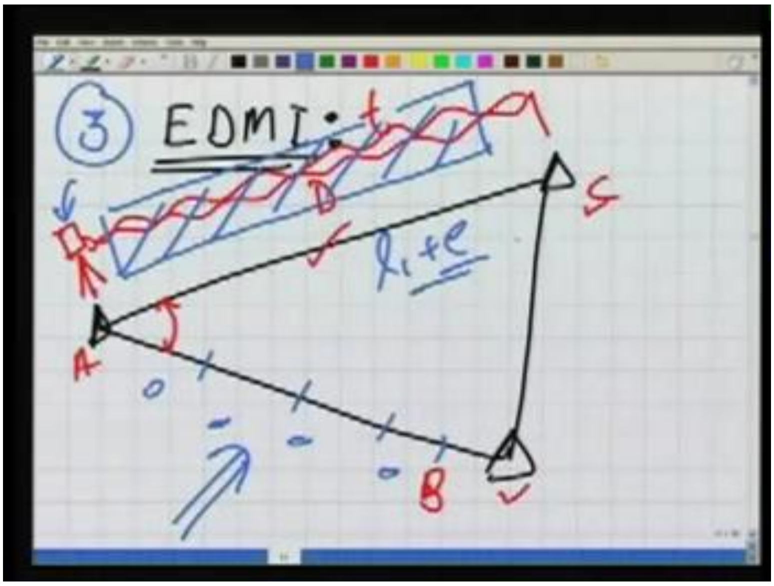

Then the third problem with the trilateration is because we are using here EDMI for the measurement in case of a triangle, our length of this side could be of order of 2 kilometers, 3 kilometers, 5 kilometers, 10 kilometers. We know it in case of triangulation. We have seen that. Now, in case of triangulation, what we did if we are at A, we put our theodolite at A and then, we bisect the target at B and target at C, and we know the angle CAB, but in case of EDMI, I am measuring the distance AC. How we are measuring the distance? We are putting our EDMI here, and our reflector here, and the electromagnetic waves are sent to the target, and then it will be reflected back and reaching here. So, by measuring the time of travel, we know the distance.

So, we have seen this principle of EDMI before in one of our lectures, and we know the accuracy of EDMI will depend upon how accurately we can represent the atmosphere in between this column here in the instrument. Because once the instrument is actually making the computations, we should input the actual atmospheric conditions because this is what on which the C will depend the speed of light. So, we should not use the C for vacuum. No we cannot. We have to use it for the actual atmospheric conditions. Now, measuring those actual atmospheric conditions across this length of 2 meters is not a possible task. We cannot do it. So, because of that reason, there will be some error again in these length measurements.

Another disadvantage of trilateration, while in the case of the triangulation, we are measuring only one single length. We can take all the precautions. We can try to measure that length you know in small parts, or may be 100 times and or maybe we can also sample our atmosphere in between, so that we know this length to the best possible accuracy. So, this is not possible in case of trilateration because you cannot do this thing for all the lengths of the network.

Now, we will see that what all field work is involved in trilateration. You can guess it also now very well because you have seen the field work, which is required in case of triangulation, and generally the field work is nearly same.

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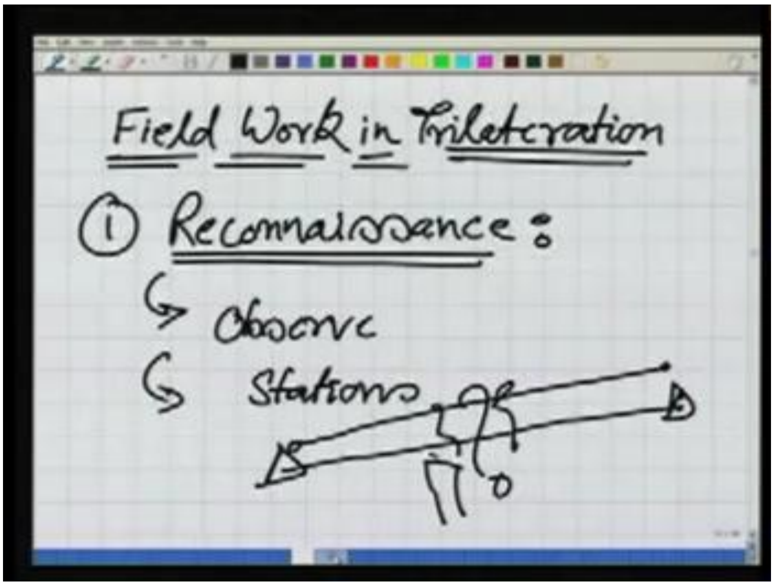

So, the very first step in trilateration will be Reconnaissance survey. The meaning of this is the most important part of any survey because your proper planning will govern the work later on in the reconnaissance survey. What you do? You observe your area through may be using some previous maps or by visiting the area by talking to people, and then you establish your trilateration stations. When you are establishing these, and if your triangles are very large, intervisibilty is the problem, then again over here you would like to go for some kind of towers, so that you can measure the distances. So, you will observe the stations.

Well, in observing these stations, in establishing these, again some of the things, which should be made or rather we should ensure these now that I will select these two stations for trilateration taking care that in between. They are not any kind of hottest spots in the atmosphere or maybe there is no industry here because if there is an industry, the atmospheric condition over here in between will be different. We cannot sample it. Also, we should ensure that the line of sight or the laser pulse which we fire from the earth which goes to the other target, it should be away from the ground. It should not grace the ground. So, these are the things which we should keep in mind in establishing our stations. At the same time, we know that we have to go for a figure.

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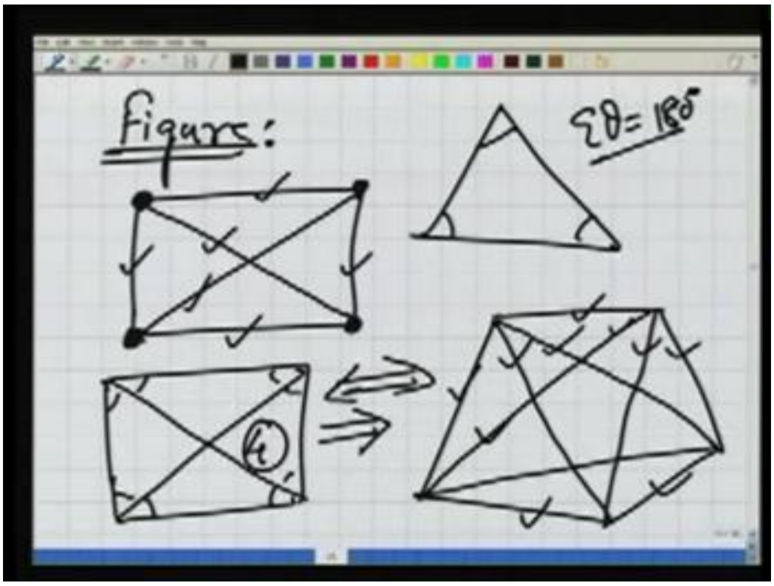

As in the case of triangulation here, also we have to make a triangulation figure in the field. So, what kinds of triangulation figures are possible here? Now, here the figures which are generally adopted are the base quadrilateral, where you are measuring all these lengths. Then, also the corresponding figure, one more figure could be and this is an important observation. Important in the sense as we discussed earlier also that triangulation by measuring the angles provides better geometric condition for our checks for adjusting the angles which is not. So, in trilateration in order to have the same kind of internal checks or geometric conditions in our observation, our figure will become more complex.

One example here is in triangulation if we have a figure of this quadrilateral where you observe only these eight angles, and we have here four conditions, the condition means we will talk about these conditions later on, but condition mean as the condition here in case of triangle is sigma. Theta should be 180 degree in a simple triangle. There is one condition. So, here we have four conditions in a base quadrilateral. If we do trilateration, we will have to make a pentagon and in this pentagon also, we will have to observe all 10 lengths. If you observe all these 10 lengths, you have taken the measurements, 10 measurements here then these two will have near same number of internal conditions. So, what we see here our figure becomes more complex in order to have the same number of internal conditions, and we will see this when we will be talking about the adjustment. Why these internal conditions are important? We have looked into it also a little bit so far in our lectures. So, we can go for figure like this that many researchers, they have suggested that the best figure.

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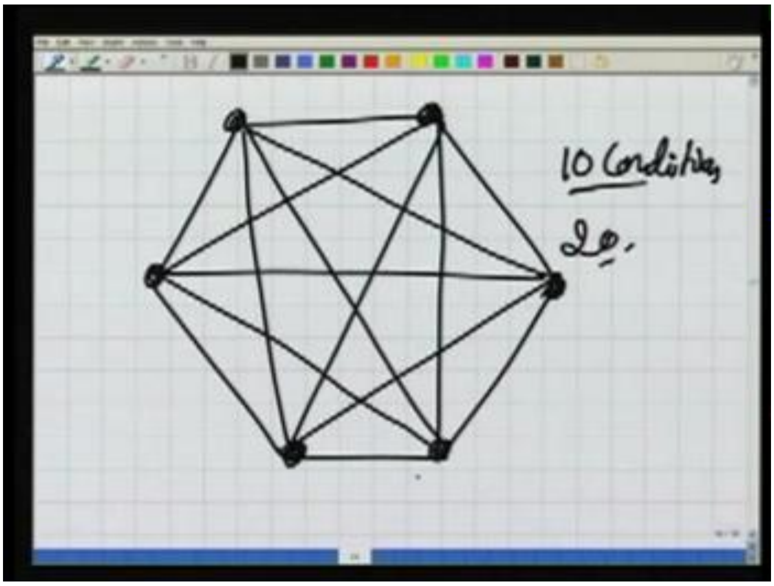

In trilateration is a hexagon with all the sides measured, all possible sides, whatever you can think of, all these are measured here. That is the best figure. This is what is there and it has 10 conditions and 20 observations. So, we will need to go for this kind of figure in order to have good geometric conditions in our trilateration figures. Well, having selected whatever the figure we are going for, these are the ideal cases. Not always this is possible. So, whatever the figure we have chosen, the next step will be of course measuring the lengths or distances.

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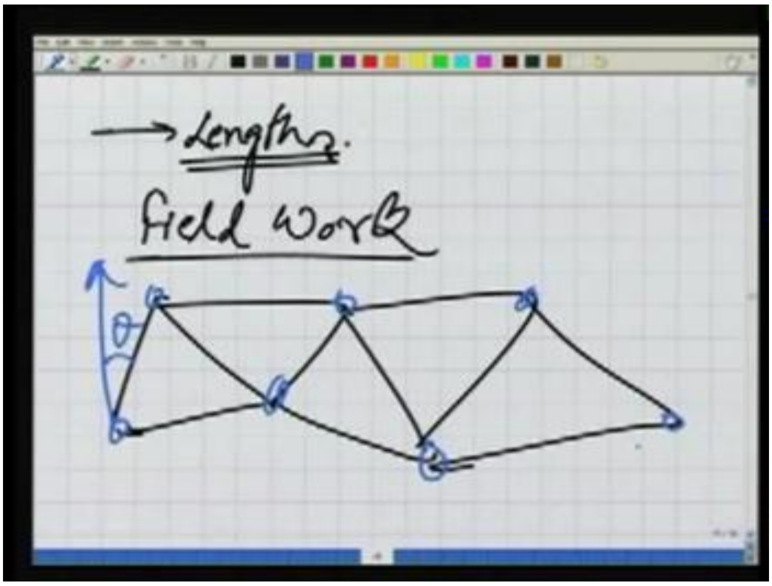

We are measuring the distances, the sloping distances and the vertical angles, and we are reducing these vertical or the sloping distances to the horizontal equivalent or the horizontal component. So, this is actually the field work. One more thing that we do again as in the case of triangulation, we will also observe bearing of one line that is theta because we will have to observe this bearing in order to compute these coordinates. So, all these things will be involved in doing the triangulation in field. Next what we will see? We will see how we can go for computation and adjustment.

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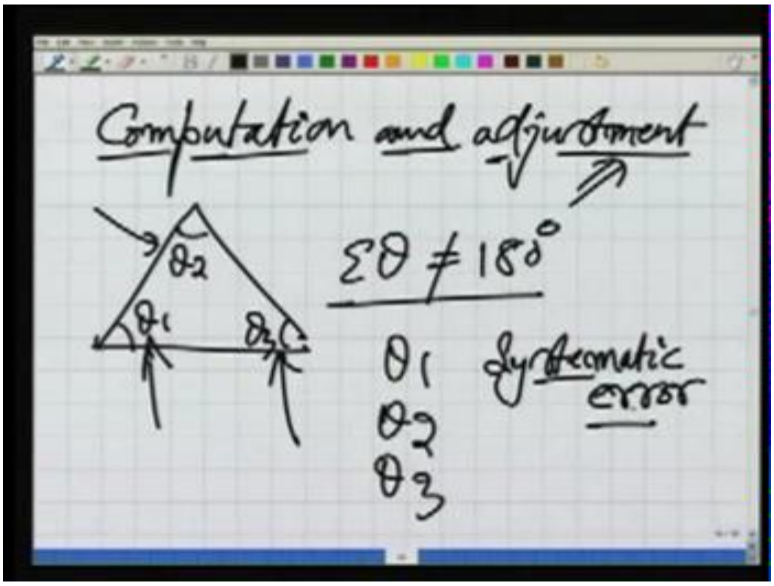

So, right now we will only see the concept of adjustment. First this is important. What is it? What do we do in this, and the actual methods of adjustments, we will see later on. Well, for a simple case if there is a triangle for which we have observed theta 1, theta 2, theta 3, all these three have been observed. Obviously, sigma theta will not be equal to 180. We know it because all these observations will have some error, but the condition in the field says that sigma theta should be 180. So, what we try to do? We try to adjust these errors. We try to find what the amount of corrections is which is required to this angle.

What is the correction which is required to this angle? If we know in our angles we have some systematic error, we know already about the systematic error. If there is some systematic error in our angles, we will eliminate it by writing the physical model, so theta 1, theta 2, theta 3, if the systematic error is there, we will first eliminate that, even after eliminating systematic error.

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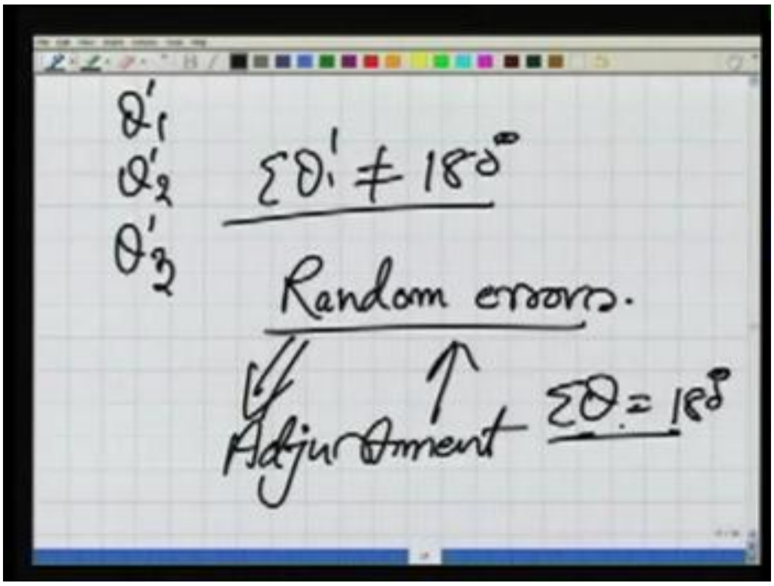

Let us say, I write it as theta 1 dash theta 2 dash theta 3 dash. Still sigma theta dash will not be 180 because we have in our angles, the random errors which cannot be eliminated by writing a physical model because we do not know where these errors where. So, what we do is the adjustment procedure. What we are talking about is done for these random error, we adjust it, so that our condition sigma theta 180 is satisfied because this is what is there in the ground.

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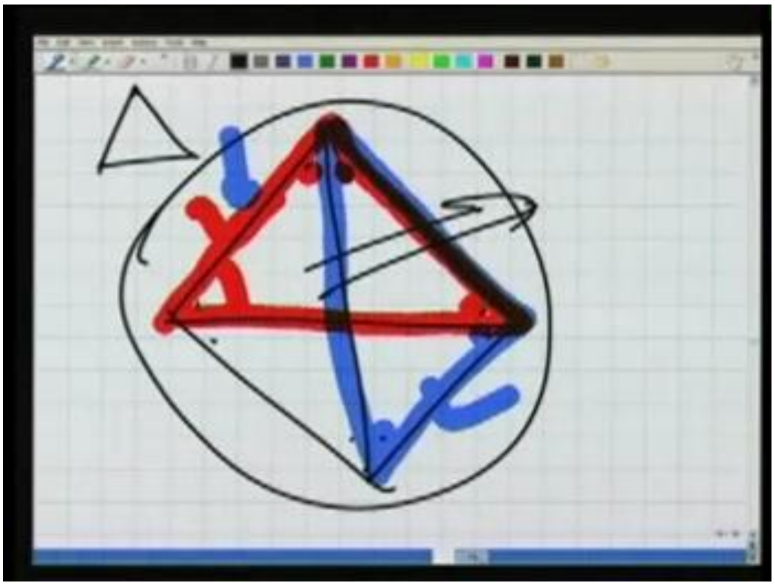

Well, that was a simple case of a triangle, but we may have let us say a figure like this. We have all these angles are measured. Now, there will be many more conditions here. There could be a condition. The sum of all if I highlight it sum of all the angles within this triangle should be 180 as well as sum of all the angles within this triangle should be 180. If I first adjust my red triangle, I adjust this one. I change this angle, this angle, this angle, this angle and then, I do it for the blue one. I again change this angle, this angle. Now, again this angle has been changed. If I change, adjust it for blue, the red will not be adjusted. If I adjust it for red, the blue will not be adjusted. Similarly, there are many more triangles here.

So, what we do? We go for a method in which we take all these observations together. We keep this everything as one system and by least square; we adjust all these angles, so that all the conditions within this figure are satisfied. So, this is adjustment.

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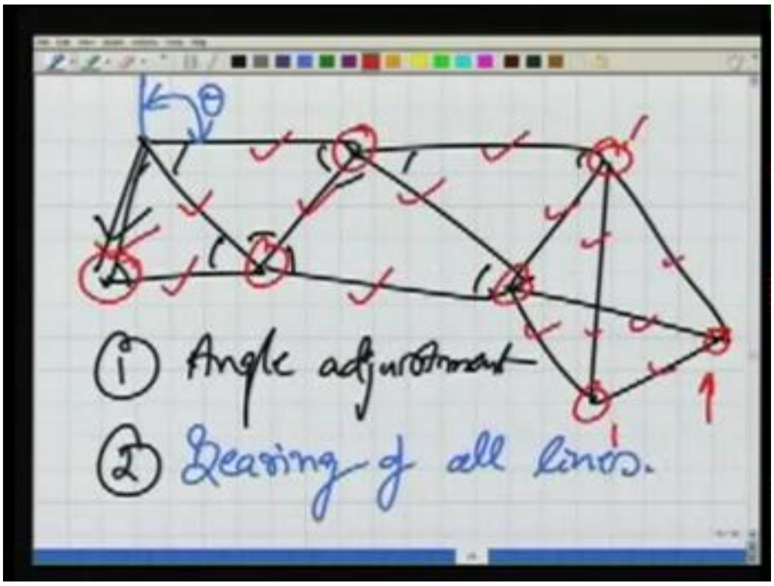

Now, in our computational adjustment first of all let us say in case of triangulation, we have done a triangulation where this length is known. First of all, these angles are adjusted. Now, the figure could be anything. We may have some base quadrilaterals also there. So, first of all, all the angles are adjusted, angle adjustment. Number 2 step in the computation is starting from the bearing of an unknown line. Now, the angles have been adjusted. We have measured the bearing of unknown line. What we will do? We will compute the bearing of all lines. Once the bearings of all the lines in the triangulation figure has been computed, our next step will be, we will start from a known line and will start computing these lengths. Having computed all the lengths again by the best possible route, what we will do is the strongest route. What we will do? We will compute the coordinates.

So, if I know the coordinates of my initial station which we can assume, or we can take from some national reference or national system, I know now the coordinates of all other stations here and this is where the computation of triangulation is.

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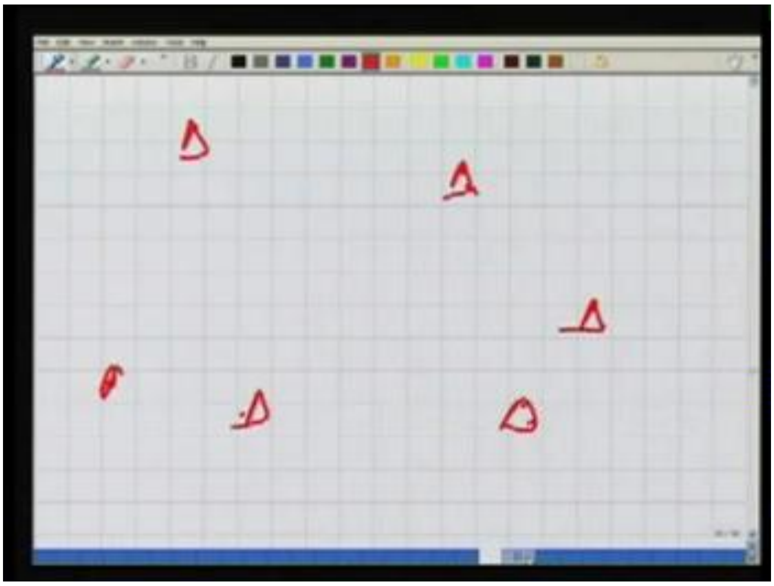

Over our end product at this stage, a map where all these points are the triangulation stations and we know their coordinates. This we can use later on. Now, this procedure how we do it in case of trilateration?

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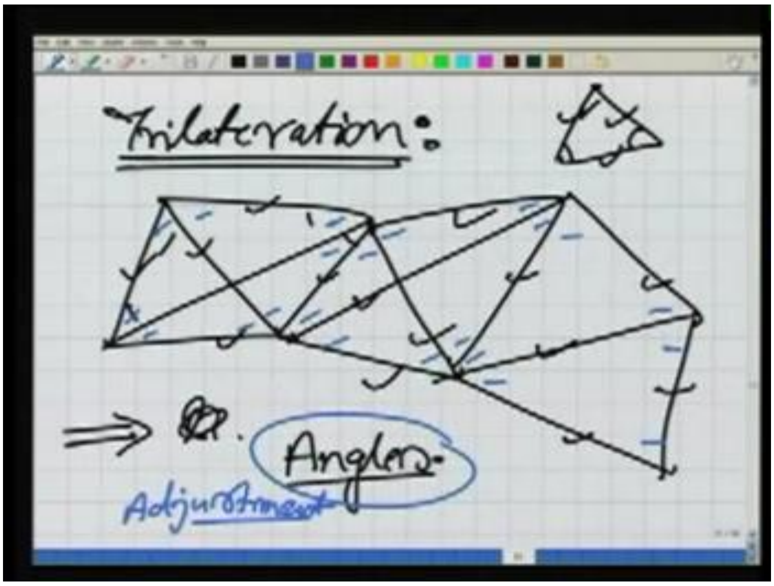

In case of trilateration, number one because trilateration means we have these complex figures. May be let us say simple chain like this, where all these lengths are observed. What we do? We start because we have to go for the adjustment. So, the procedure generally which is followed is using these lengths. You know whatever the length we have observed, what we do? We compute the internal angles. First of all, we compute the internal angles using the cosine rule. So, in any triangle using these three sides, I can compute the angles. After computing the angles, we put those angles say inside.

So, all the angles are computed. So, we know these angles which are computed angles and then, later on for these computed angles, we go for the adjustment as in the case of the triangulation. So, after computing these internal angles, using the lengths, the procedure is nearly same as in case of the triangulation. We adjust those angles and then, we again after adjusting our lengths, sorry the angles, we compute the corrected lengths and then, we compute the coordinates. Now, we will try to see one more aspect of establishing control network and that is called triangulateration.

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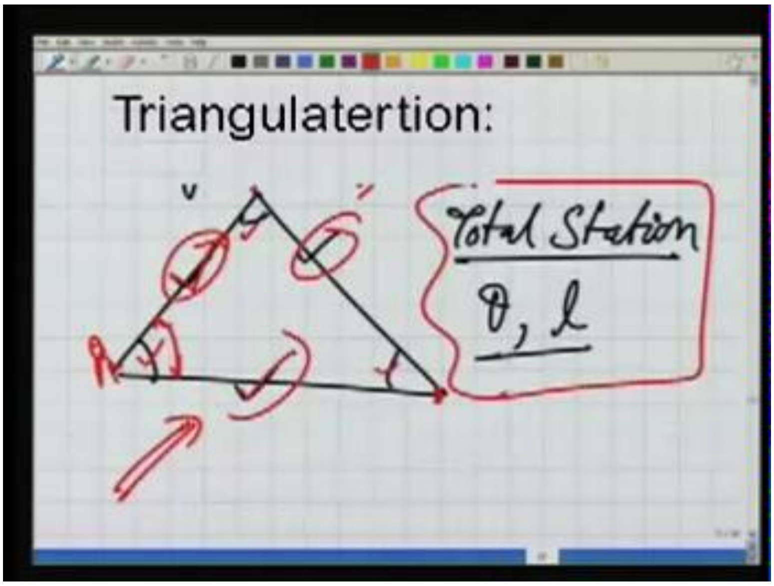

Now, as the name is there in this case the idea is, we will be measuring all the lengths as well as all the angles. Now, we have an instrument, which is called total station. We have seen this instrument also, and it is possible with the total station that you can simultaneously measure the angles as well as the lengths.

For example, if you are standing here, you can measure the sloping distance to this point as well as you can measure the sloping distance to this point. At the same time, your total station is giving you a horizontal angle; a total station is also giving you the vertical angle. So, making use of this, we will say of course if in a figure we have all the angles measured as well as all the lengths measured, our figure is very strong figure. There is a lot of redundancy in the figure.

So, now, with the availability of the total station, if we are going for very precise survey, we are going to establish a very precise, very accurate controlled network. We would like to go for triangulateration. Now, at this stage we have gone through almost all the steps of triangulation and trilateration. I will not say you know in a very comprehensive way, but something, which is limited within the scope of this video lecture series. What we saw here starting from triangulation, then trilateration, triangulateration, all these are the methods of establishing control whether it is vertical control or horizontal control. More importantly it is the horizontal control.

In case of the triangulation, we are measuring the angles, all the angles in the triangulation figure and only one or two lengths, but in the case of the trilateration. As we saw today we are measuring all the lengths in a network and by using these observation which we are doing in the field by taking you know eliminating the errors which are possible in the field, what we do is, we do computation and at the end of the computation, what we get is the coordinates of all our control points or stations. Now, these coordinates or the control points can be used later on for varieties of purposes as we will see later on when we talk about the plane tabling. How we can make use of these coordinates in plane tabling because in plane tabling, we will make use of this network.

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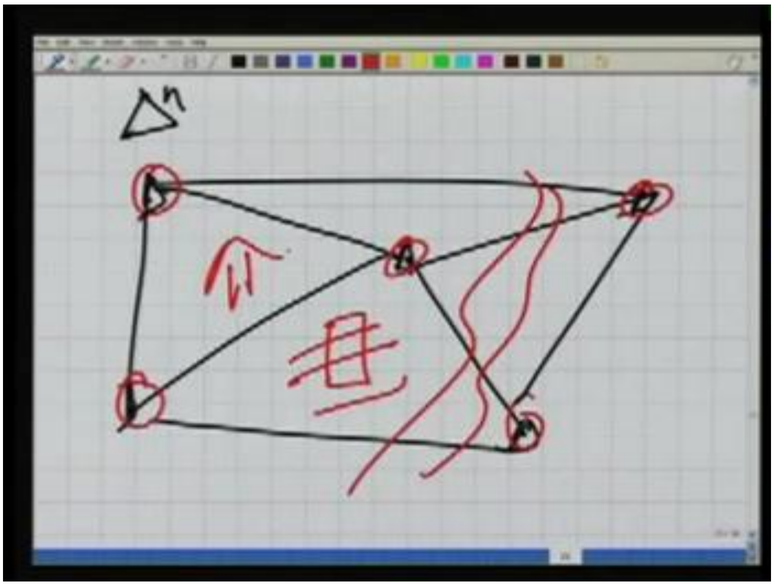

Let us say there is a big network here, and these distances are of the order of 1 kilometer. Now, I want to make the map here. I want to fill the details in my map because so far in my map in drawing sheet, I have only these stations plotted and nothing else. Now, I want to plot the other things, where the roads are there, the houses are there. I want to plot everything. So, for this plotting, we will go for one more method which is called plane tabling and then, we will make use of these control points or control networks. Otherwise, also when we began talking about this triangulation, we saw some application of the triangulation. So, we finish this triangulation here.

Thank you.