Higher Surveying
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Module - 9
Lecture - 33
Field procedures for hydrographic Surveying

Hello everyone, welcome back in the course of Higher Surveying and we are in the lecture 2 of module 9, ok. In the last lecture of the hydrographic survey we have learned that what is the importance of the tide, ok? First of all we learn that why should we measure the 3D coordinates of the terrain which is under the water, right. And that is what we said the hydrographic survey is very very important for many reasons.

Now, we then learned that the depth of the water which is the height of the water above the river bed or sea bed varies with time, because of the tides and tides are created by the combined effect of sun and moon gravitation, ok. There when we see that the height of the tide is basically decided by the moons gravity field and the earth gravity field. And when they are in balanced state, when the gravity of the earth and the gravity force of the moon both are under equilibrium then that equilibrium point decides the height of the tide, ok.

So, then we see that why the variation in the tides occur as the movement of the moon is around the earth changes, fine. Then we have realized what is the frequency of the tides, it could be daily, it could be fortnightly, it could be monthly or it could be annually, semi annually and it could be at the interval of 19 years. So, different, different aspects we have learned about the recurrence of the tides, ok.

Then we looked into the terms like string tide and neap tide, fine. I hope that you are able to recall all this thing. Later, we have decided that later we have discussed very briefly that how to establish the horizontal and vertical control for the hydrographic survey.

Later on, we see that once we collect the 3 D data using sounding operations and the plane metric position methods, we will be preparing the two products, one is nautical chart and another is hips off metric curve, ok. So, that is what we have discussed in our last lecture, ok. In this lecture, we are going to talk about how to perform the survey or

the how to collect the 3 D information of the river bed or seabed in the given situation, ok.

The most important aspect here is we first of all separate two surveys, one is vertical survey and other is horizontal survey. Or I should say that horizontal positioning and vertical positioning are separated, because you know that depth of the water or the vertical position of a point which is below the water level is to be measured by some instrument that can penetrate through the water. It could be a mechanical instrument like sounding pole or a lead line, right. Or it could be some kind of acoustic instrument like echo sounder, so that is the vertical positioning.

On the other hand, if we talk about the horizontal positioning, horizontal positioning is obtained with the help of conventional surveying method or maybe modern methods. However, the observations are to be taken on the surface of the water, well. So, see that this is the location x y on which I will take the sounding. So, x y location has to be known in order to make the sounding position, the some measurement of the sounding very relevant, fine.

So, in this lecture we are going to discuss mainly about the horizontal positioning methods, ok. And these methods are decided by the given situation or the circumstances at the field site, fine. So, let us dive into the lecture.

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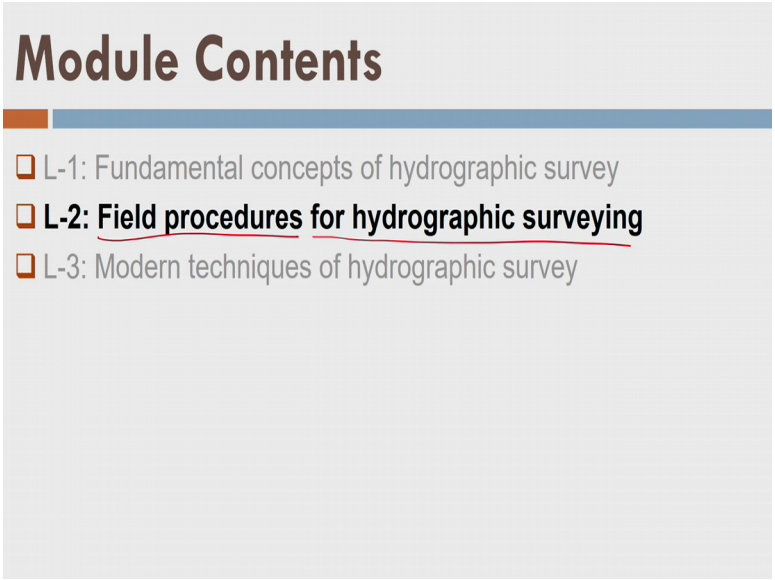

So, this is our second lecture what we call them the; what we name it as a field procedures for hydrographic surveying. So, these are the books.

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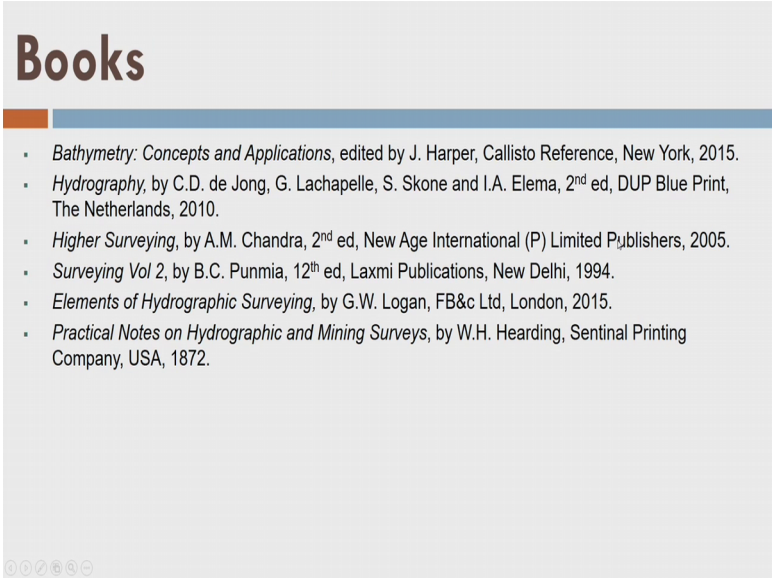

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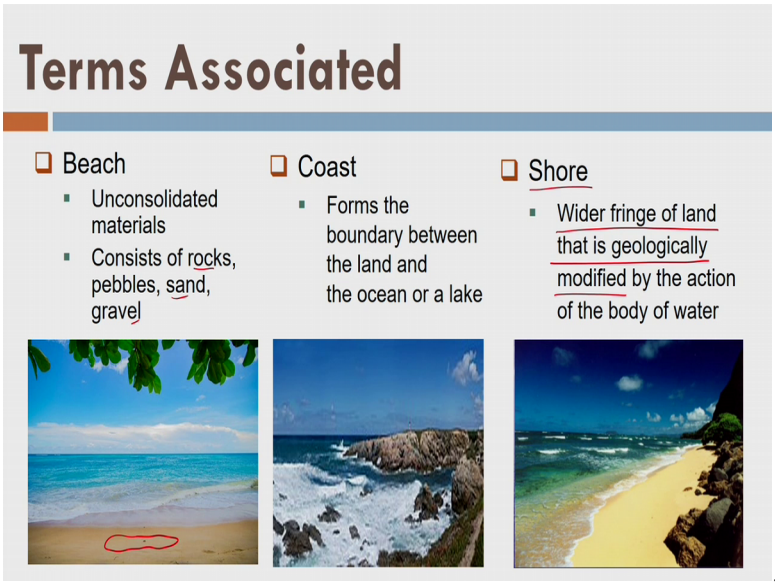

And now, before we start this lecture let us first look into the simple terms. You might have used three terms like beach, coast and shore or shoreline, many a times, though what is the difference? And is this is the difference important for us? In fact, yes; when we use these terms technically especially in the context of hydrographic survey we should be very very careful, ok.

Let me first define what is beach, ok. Many of the times, we go to the beach to enjoy to for the purpose of recreation. So, the beach consists of the unconsolidated material, fine. As shown in the figure here, this is the kind of unconsolidated material lying over there, right it could be sand, it could be rocks, it could be pebbles, it could be gravel whatever right, but it is a unconsolidated which means, the water can penetrate through it; that means, the voids between these particles are not filled by the water, rather it is filled by the air. So, any part of the place near to a sea which is like that we should call it beach.

What about the coast is just like a reference line which is permanent in nature that means, it could be a form line created by the rocks, natural rocks or it could be a form line created by the artificial structure, but it is permanent in nature.

It cannot be changed by the movement of the water; that means, water cannot cover it or water cannot change it or water cannot displace it, fine. So, I hope that you are very - very clear about what is coast.

And secondly, when we use the term coastline; that means, the line created by the coast it is called coastline. Or sometimes, you might have heard the word coast guard. So, coast guard they stay on the coast. Now last term is there; that is called shore. What is the shore or shoreline, ok? If you see the movement of the water, what will happen? Water try to reach to the land and try to disturb some of the feature on the land surface. For example, it try to first of all disturb the available sand, right it try to changes the island shapes.

Shore is the wider fringe of the land that is geologically modified; that means, if there are some small rocks they are moved, but again they are brought back by the water. And that is why the line which is created by such a phenomena is called shore line. The shore line is not a kind of fixed thing, it is kind of time changing phenomena or rather at certain time, it is visible in certain position, maybe it will be changing with time. So, after few days, few hours, few months, if you come that will change. And. So, all the rocks which are affected by water is geologically, we call them it is a part of the shoreline. I hope you got the idea, what is shore, what is coast and what is the beach? So, now, let us go forward in the lecture, ok.

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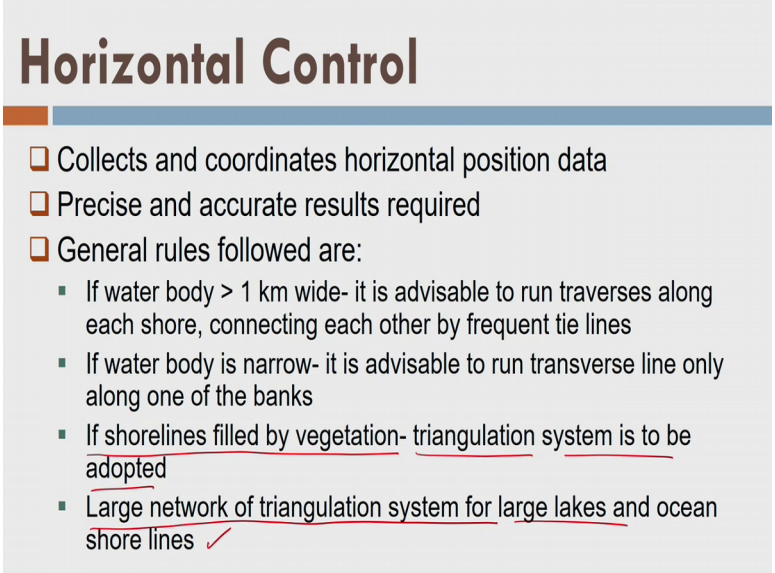

The horizontal control, we have defined last time also. And again we are redefining it, it collects and coordinates the horizontal position data; that means, it will collect the x ray position. As well as, it will ensure that if this is the x 1, y 1, it is x 2, y 2 this is, this is x 3, y 3, there should be in coordination to each other right; that means, if they are in same reference frame they should talk to each other. They should have some relationship between each other. And that relationship should represent my the correct topographic information of the river bed or sea bed. It should be precise and it should be accurate,. Then what are the general rules, we should follow?

The first rule is, if the width of the water body is more than 1 kilometer, ok. So, in that case, what should we do? Let us say there are two shorelines on one bank and another bank. So, the two banks and we have two shorelines and the overall width of the water body is more than 1 kilometer, fine.

So, what do we recommend that we should conduct this survey from both the sides; that means, we should draw the lines from both the line, both the sides and we try to conduct the survey. Further, we say that use some common tide lines and connect both of a survey, right. What will happen? The check lines or tie lines will ensure that the quality of the data in both forces are of same nature. And that is a reason the two data can talk to each other or two data can be synthesized in a one data form. And then, we get the complete data set of the water body that is the idea here, but what about my water lake or the water body is the width of the water body is less than 1 kilometer, ok.

In that case, we recommend that start a survey, the horizontal positioning basically from one shoreline only. One more thing here, if shoreline filled by the vegetation then triangulation system should be adopted. At the same time, if large network of triangular system for large lack and ocean shorelines should be adopted, fine.

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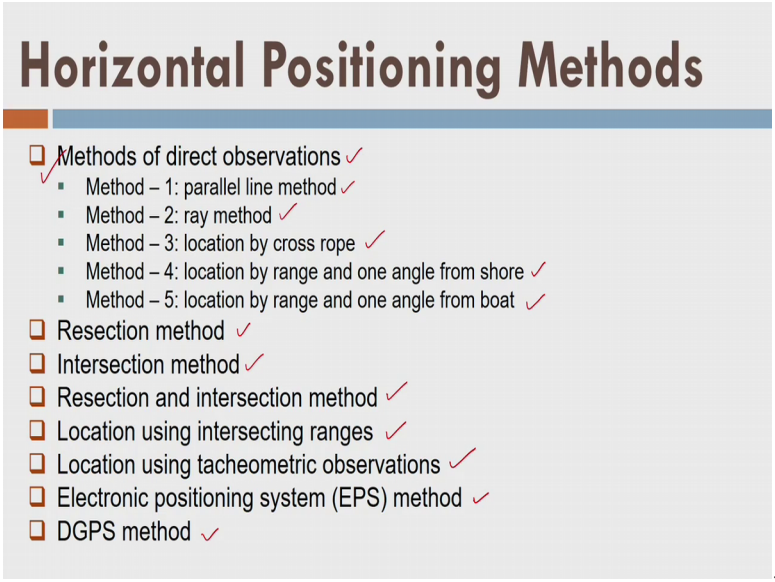

Now, let us start with the horizontal positioning methods. The first method is so, we have categorize those methods into different categories or we have classified them,. This classification is not available in the books, but this only our understanding, we have done it.

So, first is the method of direct observations; that means, we are observing the point x y by direct observation. It could be an angle measurement, it could be a coordinate measurement, it could be a distance measurement; that means, we are not deriving it by some calculation. Rather, we are saying that ok, let us make this position and maybe polar coordinate system or Cartesian coordinate system, but measure it directly. And then, we can later on derive some information, but our observations are very very direct at the point.

So, first method is parallel line method, then we talk about ray method, then we talk about location by cross rope, then location by range and one angle from shore and location by range and one angle from boat. Then we will talk about resection method, intersection method and combination of resection and intersection method. Further, we

will talk about location using intersecting ranges. Then we talk about tacheometric observations then EPS method and finally, the DGPS method or a differential global positioning method or differential GPS method.

So, let us start with our direct observations. So, this is our first direct method where we observe the position of the sounding location by direct observation; that means, we are observing maybe angle or distance, but we are observing it directly from an instrument and we are recording it.

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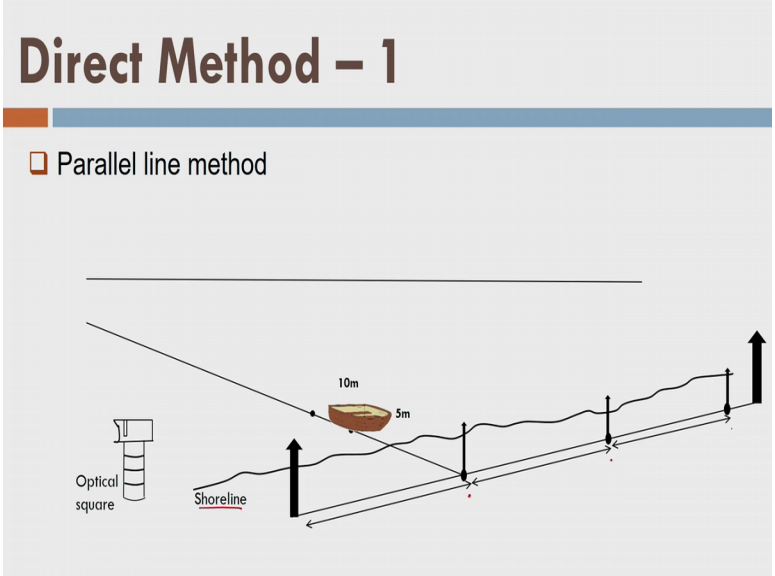

So, let us look into this method and this method is parallel line method, ok. In the parallel line method, you can see there is a shore line and there is some line which is appearing as a horizon to me; that means, it could be an another bank of the river or water body, fine.

So, now, we first lay down a reference line on the shore line and these are my reference marks show in the screen. Then this distance between the two reference mark is divided into equal intervals, like this, fine. So, after dividing into the equal interval let us, let us mark these points here, like this. On this point we will put now on this point, we want to establish the perpendicular lines or the survey lines or our range lines, right.

So, what do we do? What do we do here? We take an optical square like this and we put on these points one by one. And using the optical square, we draw the survey line or the

range lines which are perpendicular to the reference line. So, this is my first survey line, which is in transverse, which is in transverse direction to the reference line. Now, what do we do here basically, we stretch a float line, float line let me tell you about float line.

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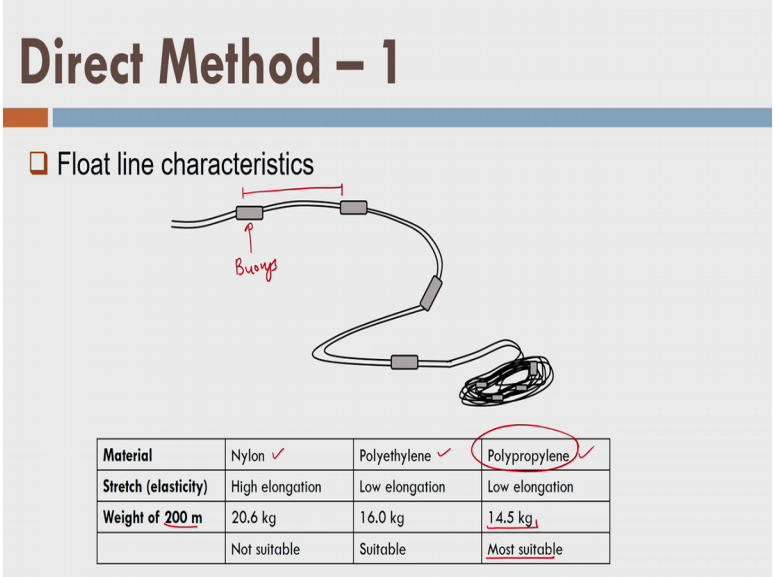

So, what do we do here? We basically take the float line and one end of this float line is tied at the reference mark. Remember, we have mark three reference on the screen. So, one of the reference mark where, I am drawing the I am putting this optical square. So, there itself, we make a peg or make, we make some kind of knot here. And with the help of some nail and with the help of this nail, what do we do, we take the float line which is shown here in the screen which is a kind of graduated line right and it is having buoys.

So, what do we do here, we take a float line which is shown here in the screen. And we stretch between the reference mark that we have already marked on the shore line, on the reference line. And we take we stretch it across the river, there since the length is almost 200 meters. So, we can cover up to the 200 meter length, right.

Now, what happens here, this float line is having the buoys, what you call here or their floating bodies that is why this float line always remain on the surface of the water, even it is visible also very clearly. Since, these buoys are marked or these tags are marked at a regular interval. And so, this float line is my graduated float line; that means, I know what is the distance between these two tags, ok?

Now, what happens is using since, we have stretched this float line across the river. And now, we are moving from one end to another end; that means, from the shore line to the next end in the river or water body, ok. At every, this location where buoys are there. Since, it is starched in a straight line, so, I am measuring the distance x with the let us say the x distance or maybe the y coordinate on the graduated float line. And I am already have along the one distance called x or maybe y, whatever so, you can have. If you call the range or the distance along the float line as y then you can call the distance along the reference line as x, right.

So, I will show you what does it mean, fine. So, after that what do you do? You move your boat along this float line. And at each, each and every tag point, you will take the sounding observation. Well, the sounding observation can be taken with the help of echo sounder or with the help of sounding lead line or with the help of sounding pole or with the help of sounding pole, well. So, all three methods are possible with us; however, since if that is depth of the water bodies, less we prefer sounding pole. If depth is little more than let us say 8 meters or 6 meters, we would prefer to have the lead line,. I hope you got the idea or if depth is still more what do we do, we will take the echo sounder.

So, it depends the choice of the instrument depends on us for the sounding. So, for the sounding purpose, the choice of the instrument depends on us right and the depth of the available water body, fine. So, if you see here that there are three type of material are there available nylon, polyethylene and polypropylene. Most appropriate is polypropylene here you can see that the total weight of the 200 meter line is only 15 kg or close to 15 kg. So, it is more suitable so, it is very lightweight basically, fine.

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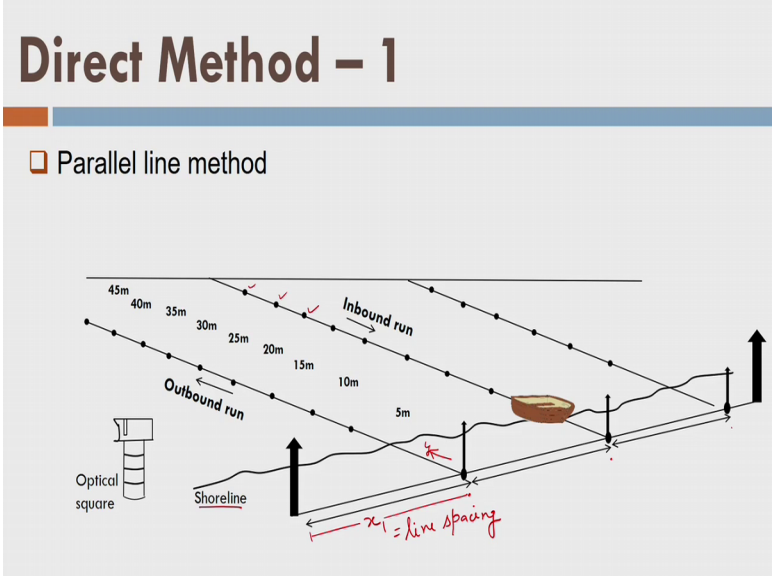

So, now we have seen that this is the point. So, this is my distance x here from here to here or I can call it x 1. So, now, I will measure my y along float line, right. So, let us see this is the situation here at 5 meter, I will take my sounding and that at 10 meter, I will again take my sounding observation and so on. I repeat this process like this along the line. So, I am taking the observations here. Next observation is 15 meter and next observation of sounding at 20 meter at 25 meter and so on; I keep on repeating this observation, well.

So, once this line is finished or I completed this line then this boat will be turned on the, on to the next line like this. And so, we will come back and we will observe these points also; that means, we are observing the sounding at these points also, every point. And now, we will repeat this process for the rest of the survey line or in lines, fine. So, that is a process in the parallel line method; that means, we have divided the whole area of interest or the river body into parallel lines. And we are observing the sounding readings as well as x y position, right at regular interval. So, I am getting a very nice grid of data x y z. So, each point is representing my x y and z, x and y are measured, x is measured on the reference line, let us say y is measured along the float line and z is measured using some sounding instrument, fine.

So, that is a kind of mechanism, we always follow in each and every data measurement; that means, how to measure x y. So, measurement of x y could be different, different

techniques; however, when we measure the z, we have the one sounding instrument with us fine, ok.

So, now if you see this run when boat comes from the offshore to ensure a towards the shoreline, it is called in bound run like this. Similarly, when boat goes away from the shoreline towards the offshore, we call it outbound run like this, fine, I hope you got the idea. So, we will repeat this alternate outbound run and in bound run to cover the whole area of interest. So, like this, we will collect data on these points.

Now, you can understand very easily that we are developing the data x y z, we are observing, we are taking the measurements x y z and each and every tag of the float line or maybe, we have pre decided that what should be the distance, right. So, this is x 1 is nothing, but my line spacing and you can see here that we have assumed that we have done this job at very regular interval; that means, my line spacing is very - very regular and my points are also placed very regularly. So, I am getting a rectangular grid.

Here you can imagine what are the assumptions, we are making, we are making one assumption that there is no wind current that is why, it is very easy to stretch the straight float line. Also, the float line is test with the help of sometimes other boat or if the riverboat is very small, we stretch the float line with the help of some other anchor on the other bank.

So, there are two methods possible fine. So that means, one boat is touching and another boat is moving in order to take the observations. So, that is a method, what do you call parallel line method, ok. First of all, since the float line is straight and it is not moving which means there is no wind, current and there is no water current; that means, the body water body is very calm, very stable, right, ok. I hope, this you got the idea here what is the meaning here, right. And by this, we can collect very ness data in minimum time. So, this method is very efficient under given circumstances where there is no wind current and there is no velocity current or the water current.

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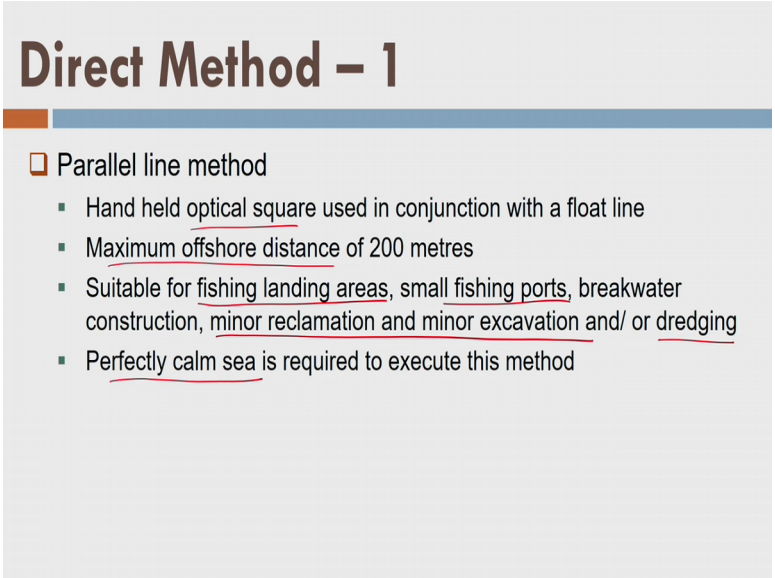

So, now you can see that hand held optically square used. And then the maximum allowed distance is 200 meters; that means, the length of the float line is 200 meter. So, if I stretch one float line so, that is the maximum length, we permit in case of parallel line method, ok. What is the reason? Reason is that I want to collect some data which is very - very dense at very regular interval near to the shore line and not away from that. And secondly, the assumptions of low water current and the no wind velocity is appropriate there, right. And that is why this method is very much restricted up to 200 meter only from the shoreline or I can say from the some jetty or so on, ok.

So, it is only suitable for the fishing landing areas small fishing ports some breakwater construction and minor reclamation and minor excavation or small dredging purposes, right. And perfectly calm sea is required I think I have repeated all the things again for you, fine.

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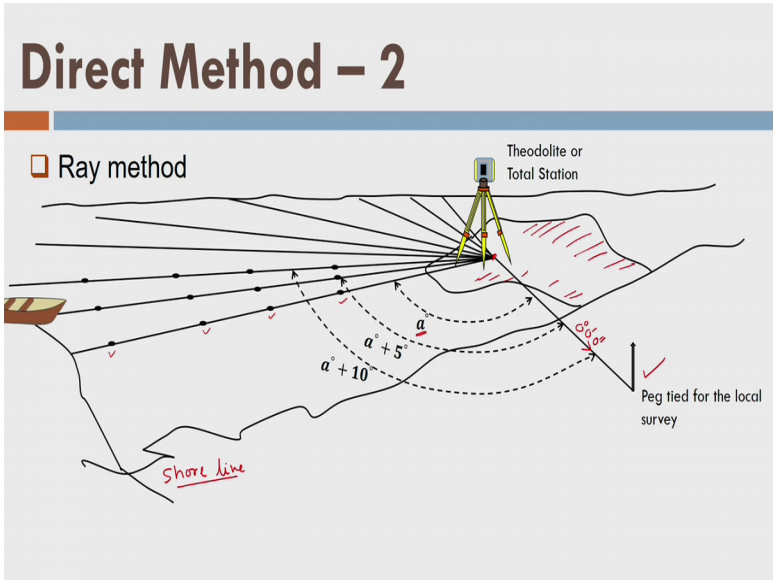

Now, let us look into the ray method this is another method, right. Let us in case of parallel line method I assume that there is a long shore line and we are stretching one the reference line between two reference mark. Now imagine, that it is not possible to establish another reference mark that is only possible to establish one reference mark, why? Because, there could be any reasons; that means, on depending on the field situation sometimes the there is no place to establish the reference mark or, or there is no way to refer the reference mark with our topographic survey.

So, in order to connect my hydrographic survey with topographic survey, I need to have some control stations which are well visible to me. And let us say, this only one station is possible to use and this post position, this location is this one. So, what will I do now? In this case and let us say this is the area which is acceptable by a surveyor, right this is a kind of land area.

Now, at this point, let us say this is the point where he will establish his total station or theodolite. Then you will he will orient his theodolite or total station towards this line; that means, it is 0 degree 0 minute 0 second line or it is my 0 reference line.

Now, I will first, we will spread a line here and this is my shore line here, right. So, you can see here, we will stretch one survey line here like this. And let us say this angle is my a degree, fine then what we will do again? We will observe the point like this at a regular

interval. And we will measure the sounding like this, right and again we will come back to the same position back to the my this point.

Now, you can observe here that we have observed few points here, fine. And they are also regular at regular interval,. Now, we have collected at least couple of points along the real line and that is why it is called ray method, ok? What is next? We will spread or we will understand another real line at a plus 5 degrees; that means, we have doing some increment by 5 degrees.

Now, again we will repeat the same process like this,. And so, we collect these points,. What is next? We will come back and then next time we will have 5 degree increment like this and again we will collect these points, fine. So, now, you can understand how easy the ray method is where there is only one surveyor is controlling the complete survey, fine.

Again this line for example, this any real line can be stretched with the help of float line or even we can use their total station or theodolite to measure these distances, but the issue here is since we are measuring these points at a regular interval, I need to have some device which can provide me the data at regular interval and that is why the float line is the best solution here. So, it is spread the float line maybe with the help of some anchor on other bank or with the help of a boat another boat. So, another boat is stretching the float line. And at one end on this point it is anchored at this point here and then boats are moving, fine.

So, now you are measuring the x y position with the help of float line and you are at every such a point where you are observing x y, you are also measuring the sounding position or the sounding measurement, fine. I think this is the very standard method. Now I can use any instrument for sounding, but we always do it, right. So, that is why we say it is not a, it is not a pseudo 3 D surveying, it is a perfect 3 D survey we are, we are, we are measuring x and y position. And we are measuring the sounding position, fine. So, 3 D data is collected always simultaneously. Although, we have separate the see we have separated the vertical and horizontal survey here, but still we are measuring the three data simultaneously, fine.

So, now, in the coming slides whenever we make this dot here saying that we are taking measurement it means we are taking all three measurements x y and z, fine. So, that is

my ray method which is another direct method, because we are observing the distance as well as the angle. So, let us say at a degree angle I have observed 1 2 3 4 points here, right. So, I know the distance along this ray what are the regular distances of these points. So, I can now make the map and mark those points.

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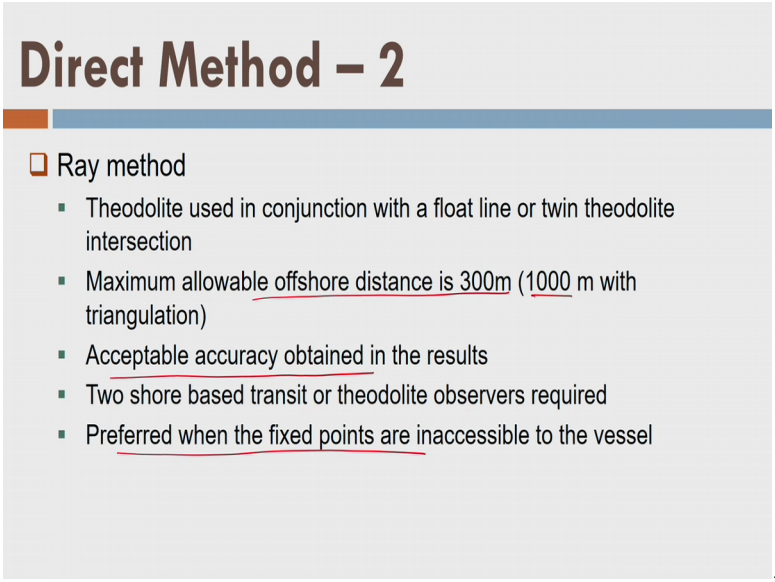

Ray method here, the maximum offshore distance is 3 meter or in case of triangulation, it is 1000 meter. Here, in case of ray method that acceptable accuracies are obtained ok, fine. So, as I have already discussed, it is preferred when the fixed points are inaccessible; that means, only fix one fixed point is accessible. And so, we are using some kind of small line area and now we are doing it, then we do the ray method, ok.

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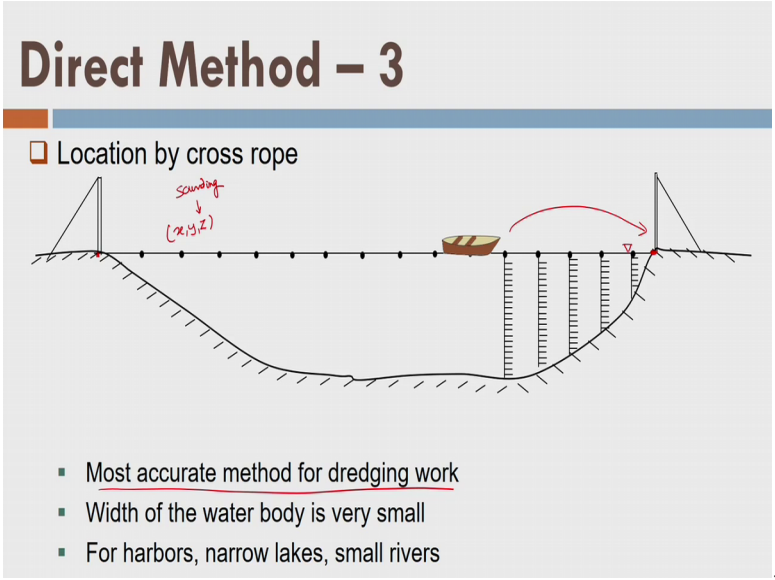
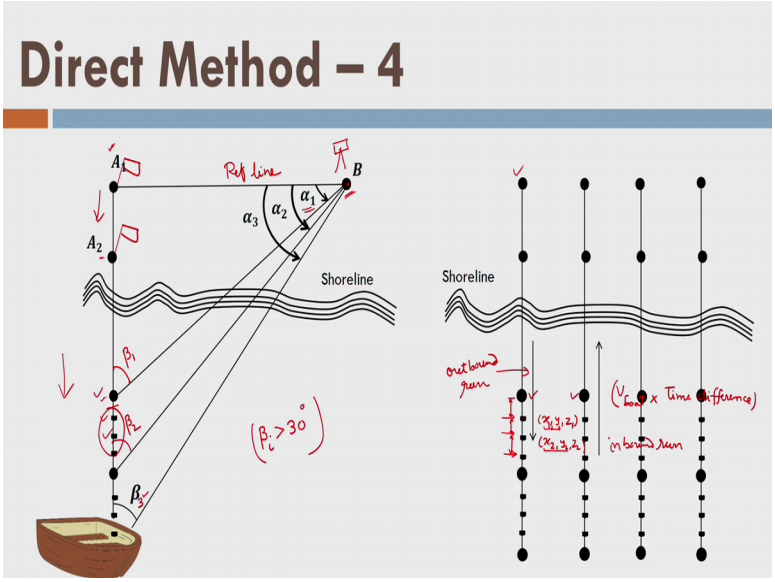


There is a third direct method is called location by cross rope, ok. What is this cross rope? Let us say that water body is very very small 8 meter, 10 meter, 20 meter something like that. So, across this water body, we can stretch a rope, ok. And which is also graduated rope; that means, it is like a float line, although float line is needed when we want our reference line or our range line or our survey line to float over the water. So, right now, the requirement is not like that, fine.

Now, we are stretching the rope and this is my water level here, fine. So, boat is there also right, ok. So, we have a starch or let us say float line across to this point and this point, fine. Now what to do next, along this float line or rope, we will take the observations like this at a regular interval like this. So, you can see here, that we are measuring the x y position for each point here. At the same time, we are taking the z by sounding.

So, now we repeat for the whole of these points, right. So, my boat will be definitely reaching here. And again we will take another section and we will repeat this thing, ok. So, it is the most accurate method for dredging work. Suppose, there is a dredging; that means, someone is we want to do some kind of dredging or we want to deepen our channel. So, we should use this location by cross rope method.

So, width of the water body is very - very small here, fine for the small rivers. And we can say the small channels, we should use this method; that means, if we can stretch a straight float line a starch rope across the two banks.



Let us say direct method 4, fine. Let us assume a situation where I have a point B which available in shore line and we have another point A 1 or right. So, what I plan now, I plan to acquire the data along this line which is marked here, fine. So, boat will be moving along this line and it will be collecting the data at certain points fine. And then, we will be measuring the angle of the boat or boat as a target and we will be measuring the angle from point number B, right.

So, let us see into the animation what does it mean? So, let us say at point A 1, we have a flag; that means, we establish a flag that is a kind of a reference mark. And again in order to align the line, this line our out bound turn we have marked A 1 and A 2. So, A 1, A 2, let us say they are two ranging rods are put there or two flags are there. So, they are basically indicating one straight line.

Now, if we move along this straight line what will happen from the boat, one surveyor can observe that the his location ranging rod 1 and the ranging rod 2; that is A 2 and A 1 are in straight line. So, he can ensure that he is moving in a straight line, ok. At the same time what happens is, we put a total station or theodolite at point B. And then we observe the angle of the boat at B saying that the point A 1 is a reference line, I shown I shown here. So, this is my reference line, fine.

So, now we are marking on this side also the same thing here, technically. So, this is my outbound run. And now, boat is moving that is my first point. So, we have measured an angle alpha 1, here. And we have also measured the distance from A 1 or maybe A 2 fine, ok.

Now, we are not stretching any float line remember, right. So, basically what we are doing now, it is more interesting part that how to measure the distance along this line right, because once we measure distance along this line we can mark the position of the boat, because we are measuring two positions one is angle alpha and one is distance along A 1 A 2 line.

So, then boat will go to the next position and again from this position to this next position, we are measuring the time,. Let us say that we are having a clock and measuring the clock, we are measuring the time and using let us say every 5 second or 10 second or may be every 30th second, we are measuring the sounding. So, this position is my sounding position, this is an another sounding position and they are at a regular time interval fine; that means, my boat is moving at a constant speed. And there is beauty of this method; that means, I am measuring the distance with the help of time measurement and the speed of the boat that is V into T, right.

So, now we has measuring, we are measuring this distances from this point, from this point to this point. And later fine at the same time, I measuring the angle alpha. And so, by this distance measurement and angle measurement I am fixing the position of the boat, I hope you can easily understand, this is very easy method. So, this angle is my alpha 2 and we will repeat this process. So, like this so, we will also have some more, you see the time, time basically the measurement of the sounding; that means, I am noting down here x y z. This is the x 1 y 1 z 1, here x 2 y 2 z 2 and x 2 y 2 is basically calculated will be later by the this distances.

So, basically we are measuring this distance here, this distance here, this distance here and so on. And in order to measure these distances, we are using clock; that means, speed of the boat into time difference fine ok, all right.

So, now let us see this angle is alpha 3, fine. We should take care always that the angle which is here called beta, let us called the beta 3 here angle is beta 2 and here angle is beta 1. So, my beta should always be more than 30. So, let us call beta I. So, any angle

beta should be more than 30 degree. So, as to create the good or we say that well condition triangle, fine. I hope you got the idea and you are able to recall the basic surveying concepts also, now, fine.

So, this is my direct method 4 where I am observing one angle from the shore and distance from the boat,. So, here I assume that the speed of the boat is fixed; that means, there is no wind current, there is no water current again these assumptions are valid here. So, now, this is my inbound run here and this was my outbound run here ok. So, we repeat this process like this.

Now, in this case, if you go back just in the previous slide; so, these are the positions which are noted down by the angle observation and not these positions here, ok. So, now, what we do? Let us say we take every 10th reading for angle observation. So, between these 10 readings what we will do the nine readings are taken without the angle observation, but there we have observed the time interval. And we move, we are moving in a straight line and that is why, we know that we can always find out the angle with the help of theodolite by interpolation process. So, this is the process, it is explained in the slide, you can read it yourself, ok.

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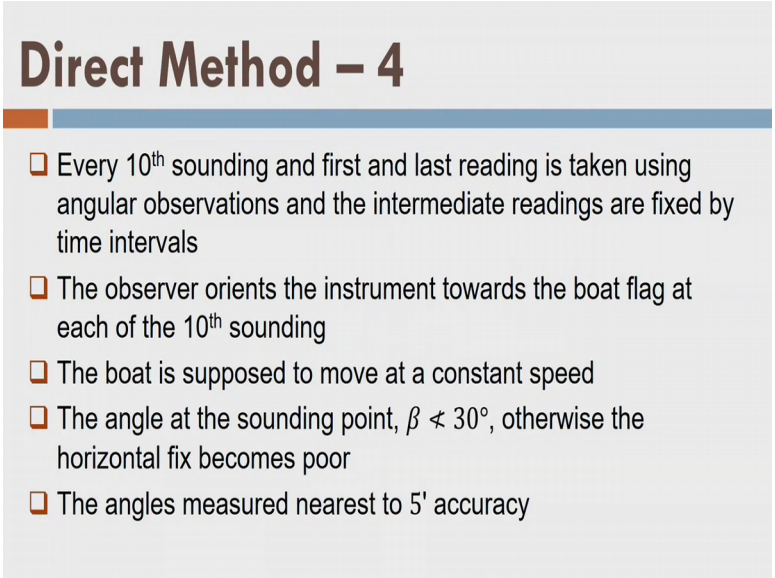

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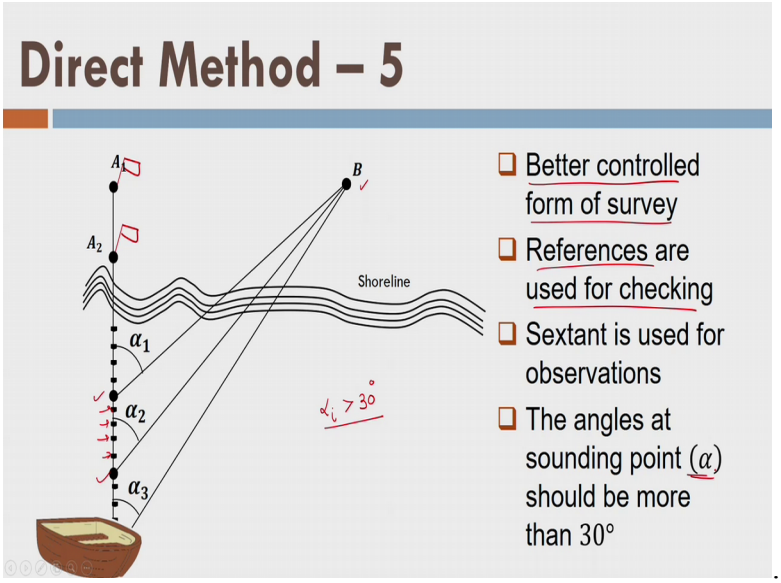

So, direct method 5, so, we have seen a method in the previous slides that we are measuring some angle from point B; that means, I am putting the total station or theodolite at point B and I am observing it, ok.

Now, understand that why ca n not I? Means take the observations from the boat itself ok; that means, I am not only measuring the time and the speed of the boat which is speed of the boat is constant. So, I am only measuring the time a survey or who is in the boat is measuring the time fine by means the time. And he is also now measuring the angle to point B; that means, B is my kind of reference point A 1 is also a reference point. So, there is a reference line between them, fine.

But now, we are saying that we will stretch a line using A 1 A 2, because A 1 A 2 there in one line, right. And then we will move our boat like this and then we will measure the time ticks in order to measure the distance from point A 2 or maybe point A 1. Now, in addition to that we will measure the angle like this. So, this may alpha 1 angle. So, I move to next point now. So, in the boat again, I have observed the distances with the using the time ticks or the time interval I have observed and again I have observed this angle alpha 2 here, fine

Now, we can see that we are measuring the alpha angles at certain interval maybe 10^{th}, reading every 10th reading, we are observing [noise. What about the intermittent reading, intermittent readings are obtained with the help of so, for the intermediate intermittent

readings. We are taking only the distance measurement using the time and assuming that the boat is moving with a constant speed.

Now, we can see here very clearly that once we do this kind of observation, in order to find out the angle values for the intermittent points, I will be using some kind of interpolation. So, similarly this is a last point to demonstrate, this is my alpha 3 angle here, fine. So, we should again be careful that my alpha I angle should always be more than 30 degree for the well condition triangles that are formed between point A 1 B and the boat, right.

So, I hope that you can understand the difference of the method 4 and method 5. In case of method 4, we have 1 percent over B and 1 percent and one surveyor in the boat; that means, there were 2 percents coordinating among each other. Now, we do not have that problem, the surveyor is in the boat the whole survey team is in the boat and we have marked point A 1 and B 1 and A 2.

Now, using our own sextant instrument, we are measuring the angles alpha 1 alpha 2 and alpha 3 at regular interval. Let us say every 10th reading and intermittent readings are measured or the distances are measured between the two points. Let us say this point and this point. So, all these readings are measured with the help of time, time interval or the watch, fine. I think you can now understand that better control form of survey is this. And the references are used for checking fine a sextant is used and the angle again alpha should be more than 30 degree.

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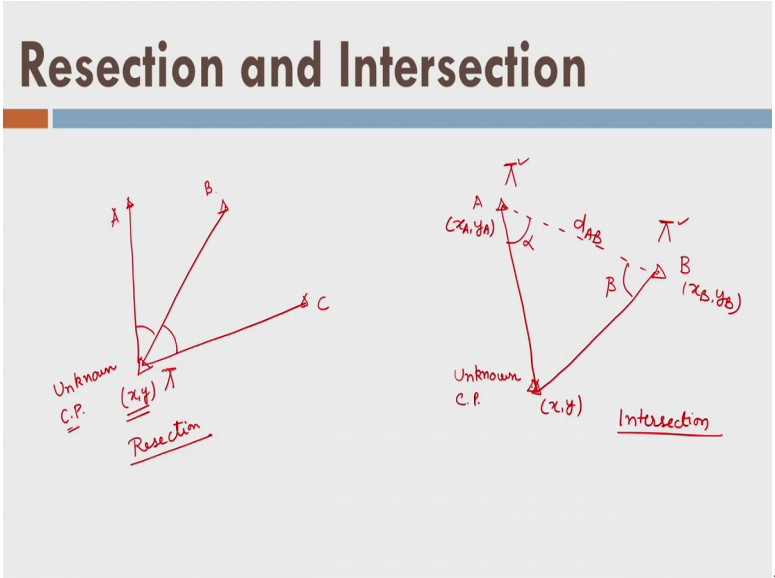

Now, let us look into the other possibilities and other possibility is the resection and intersection. What is resection and intersection? I just repeat it for you or we can recall it. Remember there is a point which is an unknown point that I want to establish as a control point. And hence here, we have A, it is control point, B this is another control point and C this is another control point. So, now, from this point I want to find out let us say x and y. So, I can measure these distances and these angles also, fine.

So, by this five measurements, I can find out the position x y and this process is called resection; that means, I am determining the unknown control point, right by observing from the unknown control point to the known control point. So, my A, B, C are known control point.

On the other hand, if I say let us say there is point A which is my known control point and B this is another known control point. And there is unknown point D; this one is my unknown control point, ok. So, what if I put the total station or my theodolite over here? And then I observe these distances from here and from here. Moreover, this distance is known to me, because we know what is my x A y A and what is my x B y B, fine. So, this distance is let us say d AB is known to me and also we observe this angle alpha and beta.

So, now I can fix this point, fine and I can find out the coordinate of x y, coordinate of unknown point as x y. So, this process is called intersection. So, in intersection, we have

observations from A and B known control points. And in case of the resection I have observations from the unknown control point, here.

So, now we are using the same methods for the purpose of hydrographic surveys also. So, here my unknown point is the point where we are taking the sounding or it is a boat position; however, what are my known points the points which are in the shore which are permanent nature or which are control points on the shore or on the coast.

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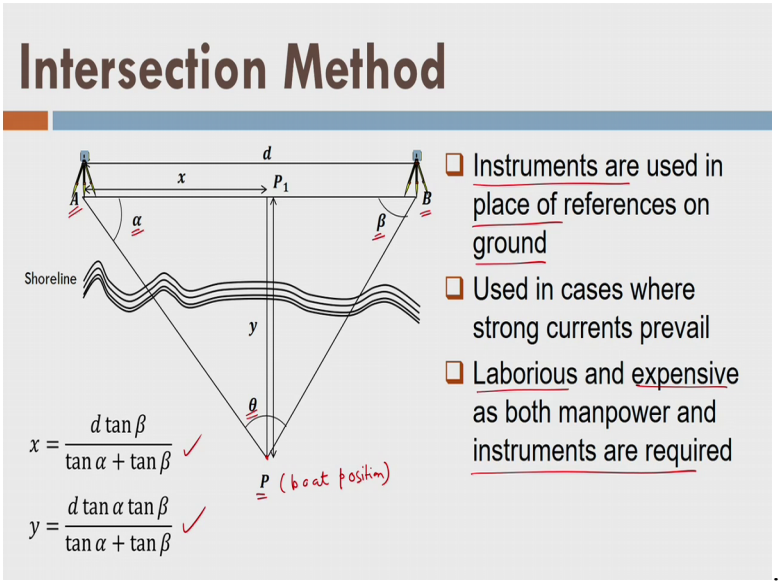

So, let us look into the intersection method here. So, we have, we see here let point A and point B are my known control points from where I measuring the position of the boat that is my B, here. So, it is my boat position at a given instant right. So, this distance d is known from the map or may be from the field itself. Then what will I do? I will measure this angle alpha and angle beta for the current position of the boat. So, there is a person in the boat who will raise the flag and on the flag, we will take the observations from position A and position B or control point A and control point B. So, we have measured angle alpha and beta since we know the distance d I can find out the coordinate of point P by x and y and x and y given by this formula by these formulas,.

Now, we can see here that how accurate this method is, because there is no control or we have the very high control at point A and point B, because we are using some instrument like theodolite or total station. And we are measuring the angle which are not affected by any vibration of the boat or which are completely independent.

Moreover, we will also measure the angle theta here at the boat and remember the theta is measure to ensure the triangles A B and P is well conditioned triangle fine, ok. Later on, if you find that theta is less than 30 degree, we will reject that particular observation. So, you got the idea now, fine. So, here we can see that instruments are used in place of references on ground surfaces. And then even if there is strong current is there. In that case what will happen boat will maintain for few seconds or few minutes in second position, right. That boat can be that boat can perform this action for few seconds or few minutes.

Now, during that time as I told that a person surveyor who is in the boat he will raise the flag. And using that flag position, we will be measuring we will be measuring the angle alpha and beta right. So, we will be the instrument at point a and b they will be targeting that reference flag which is raised by the surveyor who is in the boat.

So, it is very laborious and expensive as well as, but it is at the same time it is very very accurate also. So, when accuracies are very high or the demand of accuracy is very very high or at the same time if the wind currents are very high or the water currents are very high, in that case we should use this intersection method.

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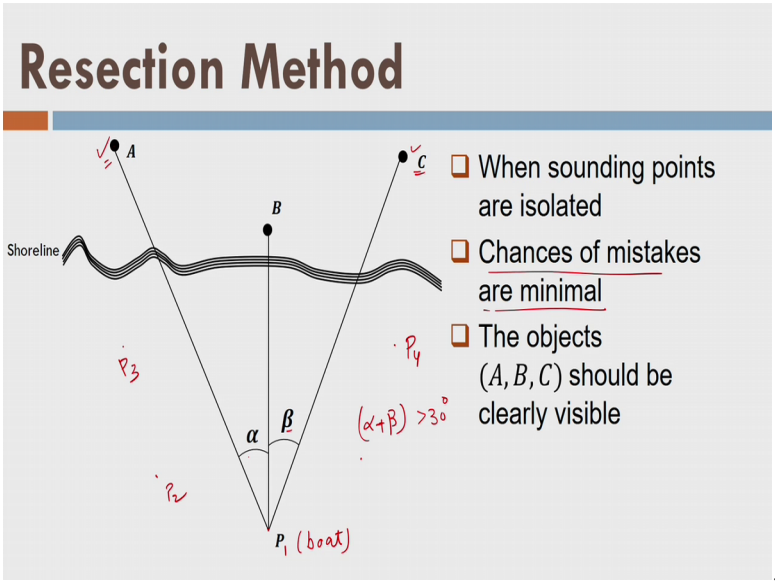

Now, look into the resection method, in case of resection what happens is we are at point P in the boat, in the water and from point P there is a one surveyor team. And that is observing the distance L angle alpha and beta to the permanent mark C and A, ok. What

does it mean? I know the coordinate of A and C in the map and they are on the shoreline, they are permanent in nature. So, I am making this point B, as my reference point and around that point B, I am measuring to angle alpha and beta by citing A and C from the boat and so, I am using this extent here, fine.

So, this method is my resection method. As we know, the distance between A and B as well as distance between A and B and C, all distances are known I can find out the position of P at a given instant where we observe. And so, this method is equally intelligent, intelligent method at the same time, it is accurate also.

Moreover since, these are only the permanent reference marks. So, the complete survey team is in the boat. So, we do not need much of the survey team or the small team of survey surveyors will also be good. So, this method is little more independent that intersection method or it is less laborious. So, chances of mistakes are minimal here.

Secondly, we should be careful enough here that the angle alpha plus beta should be more than 30 degree for the condition of well triangle, well conditioned triangle. Here when even the points are isolated; that means, these points, this point, this point, this point are to be observed. So, let us say P 1 so, we have P 2, P 3, P 4 and I need to perform some observations on all these points resection method is one of the good method like intersection method, fine.

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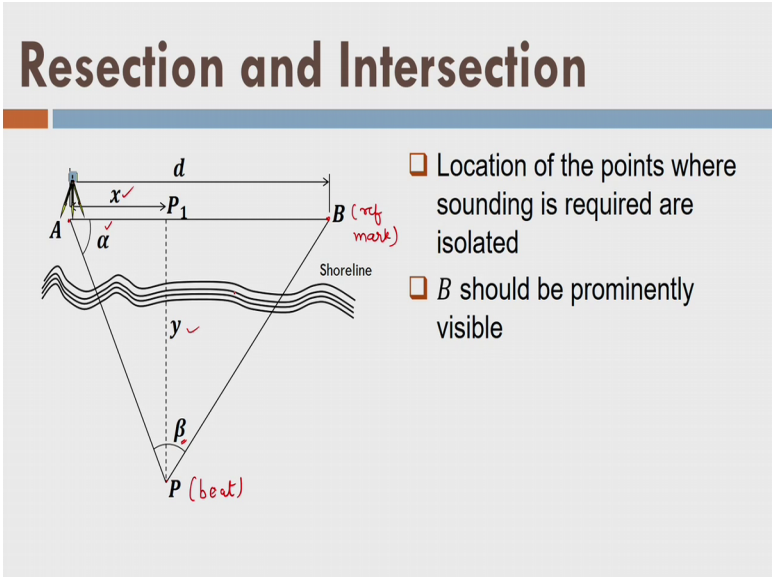

Now, let us make the combination of resection method and intersection method. In this case, what happens is that there is a point P here where the boat is located, ok. And now, here at point A and point B is there point P is kind of reference mark, fine. So, at point A, we are establishing or we are setting up our instrument straight total station or theodolite. And then, we measure the angle at A to the boat for the current given position of the boat.

And we also know the distance D, so, using distance D and the angle alpha and angle beta which is measured at the boat. We can determine the position of boat P that is my x y location. Again this method is equally good like resection and intersection method. And it is combination of resection and intersection fine by the using the same formula, you can find out x and y what we have used in the intersection.

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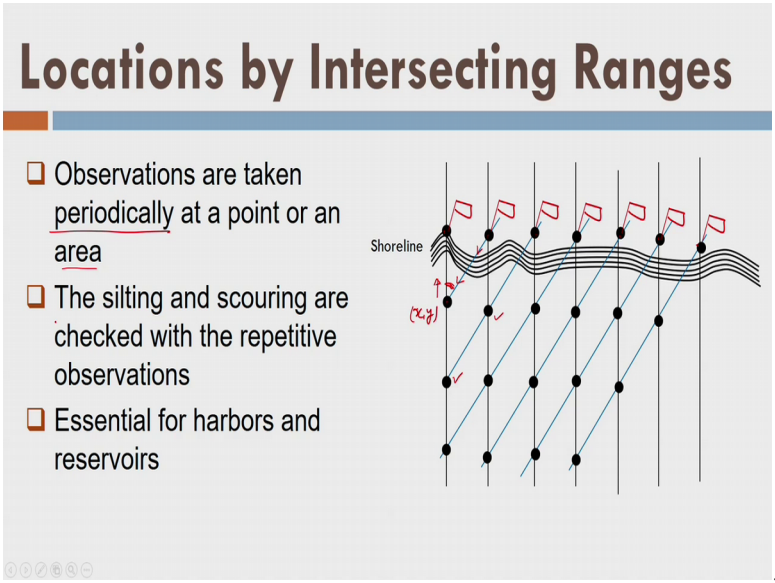

Now, locations by intersecting ranges what does it mean here you see along the shoreline, if you put a points like this, fine. Now what we will do, we will put a flag on first point here and then we will put another flag here and then we will move our boat in certain direction. So, I know what is this angle. So, let us say, I have observed this point here, ok. How to observe this point? So, since there is a flag here as soon as the boat which is moving along this direction, it comes in this direction. It will stop and uptake observe the x and y position here, ok.

Now, you have got the idea since here this angle is fixed, here. So, I can always find out what is these position x and y. So, I will repeat this process, let us say this is flag and boat is moving parallel to the last previous line and so we determined. So, we determine these two points also, ok. So, this is the next flag and we move parallel to this and we determine this points. And so now, we are getting the points at a regular interval or in a regular grid session. So, let us keep on doing this thing like this like this and so on. So, this method is called locations by intersecting ranges.

So, observations are taken periodically at a point or an area the silting and scouting are checked with respect to the, ok. Now, let us say this method is creating a regular grid and what I want to do here I want to check whether is there any silting or scouring, ok. For that purpose, I need to check the whole area in a very regular grid fashion or in a regular format. And for that purpose this method is useful, fine I hope that you are getting into the hydrographic survey now.

So, basically for the reservoirs where wind currents or harbors where which are very near to the port right where we expect they should not be in scouring we generally follow this method in order to ensure that if is there any scouring or silting has happen because that is going to affect the available draught of water at certain period at a certain point of time.

So, now we have measured let us say all these points, let us look into the tacheometric observations. And how do we use the tacheometric observation in order to find out the position? And remember one thing that now, we have already said that I think when we observe the position x y on a water surface, we will always observe the depth. So, sometimes even, if you say that let us measure, let us take some observation. So, it means that we are taking the sounding also, right, ok. So, let us look into the tacheometric observations.

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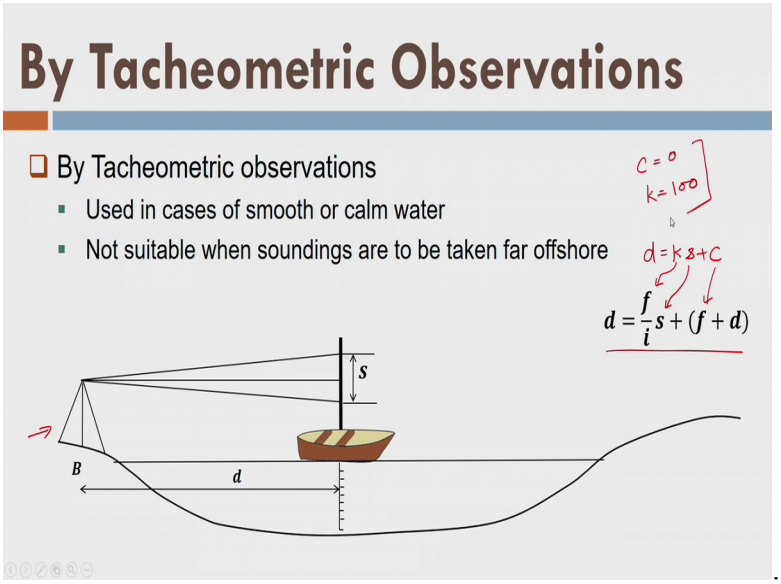

Where we are using the logic of tacheometer, you might have used tacheometer for your basic surveying, where we say the distance D is given by k s plus C where s is my stuff intercept. So, we are going to use the same logic here, fine.

So, let us see this is my tacheometer put on point B here. And now this is a boat having an stuff as shown in the figure. So, now, this is my stuff intercept here s fine. So, this is my sounding observation. So, this is the depth d here, ok. So, this is the distance d. So, this is my location of the point, ok. Now what happens is as we move the boat, ok. So, this is the formula, I use you remember d is equal to k s plus C, where this is my s, this is my K here and C here for the calibrated instrument. We know that K equal to 100 and C is equal to 0 is always taken, right C and K values are decided after the calibration. So, in general these are the values, we take, ok.

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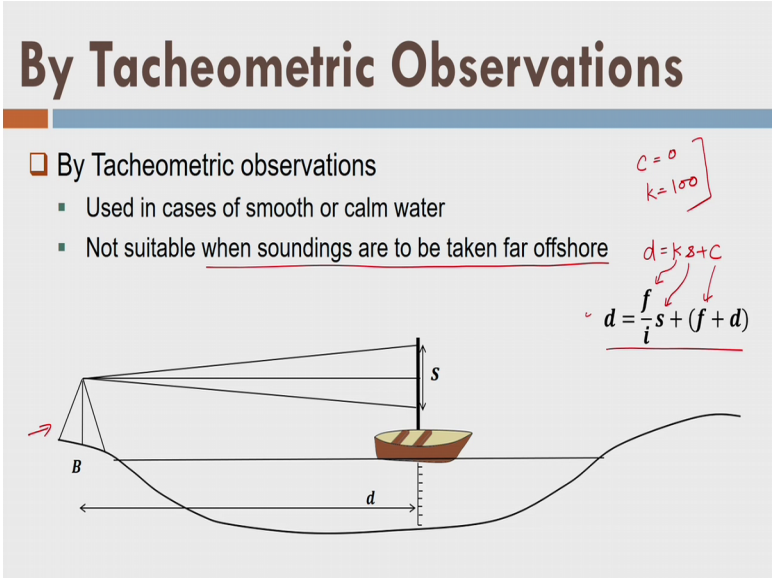

So, now what will we do next, let us move the boat like this and in this position again I will measure the staff intercept which is increased now. And so, my depth of the sounding is,. So, I can find out the distance. So, now, I can find out the next distance, let us say the distance again for this position. And at this position also, we will observe the sounding measurement like this, fine.

So, this is the distance d here which again I will calculate by this formula. So, now, you can see in this case, we can perform the sounding or by observing x y position by the distance using tacheometer and the sounding by the sounding instrument. So, now, we are preparing some kind of section data here, right. So, this is the, this is this method is called tacheometric observation method,.

Now, this is not suitable when soundings are to be taken far the offshore again it is usable only when we want our survey to be performed very near to the shore or near to the point where which is very close to the shore line.

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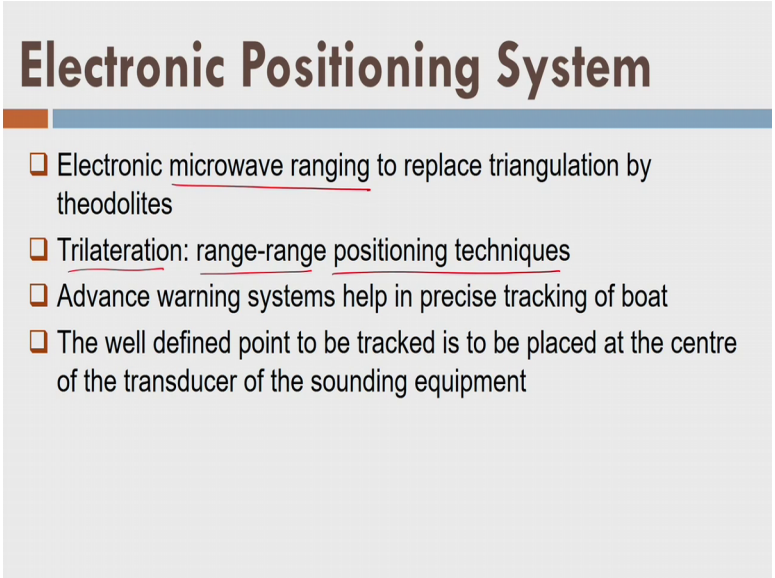

Now, there is the next method is electronic positioning system what is electronic positioning system. So, far we have talked about positioning like GPS, global positioning system, but what is electronic positioning system. Well, before the GPS, there were many systems in place which are based on radio detection or microwave detection. So, electronic positioning system is basically microwave ranging system, right which uses the logic of triangulation by theodolites.

So, basically it replaces the triangulation method by distance measurement or what you call the trilateration. So, we major range and range positioning technique. So, generally so, this method is now superseded by global positioning system or what we call is GPS.

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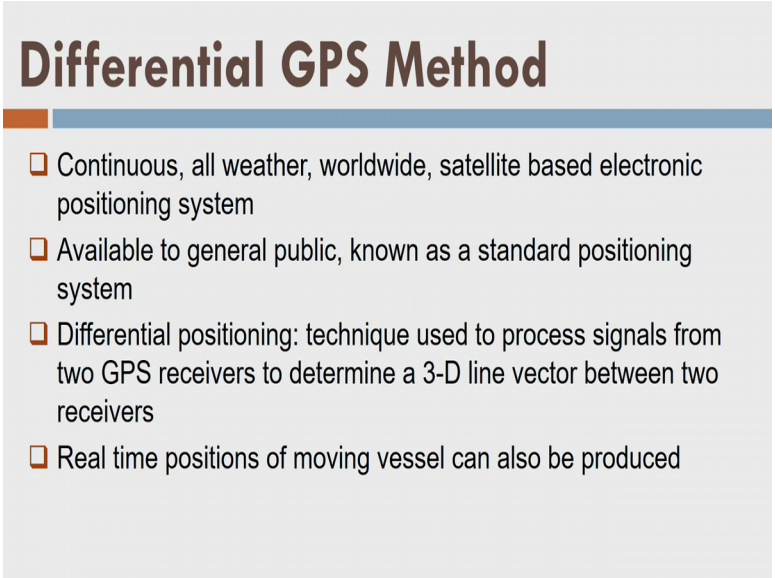

So, now, we are using a differential GPS, because of the differential GPS. What happens is, I will come to know the exact position x and y of my vessel or the boat well.

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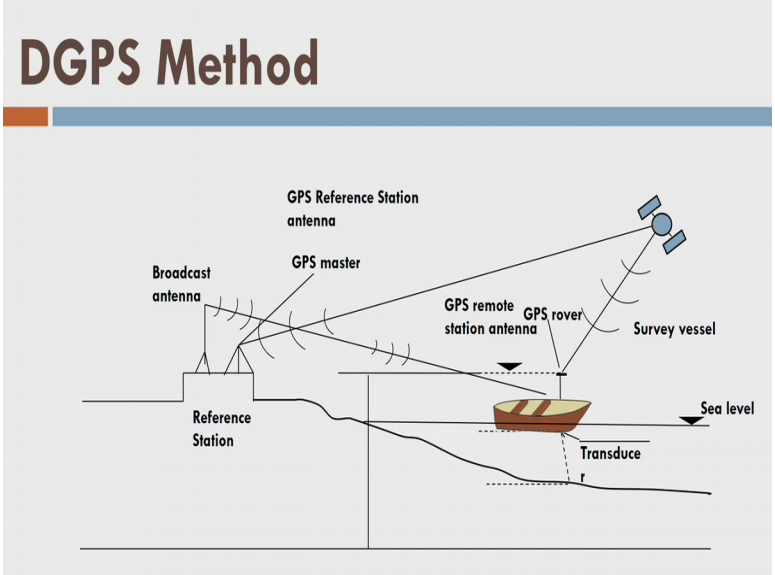

So, there is a GPS mounted in the boat and that is my rover. And there is a base station, we have established on the shoreline anywhere, fine. Generally, we take a permanent station. So, that if we repeat the survey, we can come to know what are the changes that happened over the time in some of the positions in the sea that means, let us say if I try to observe that there is some kind of hazard like tsunami or there was some kind of

earthquake. So, what are the changes that happened in the sea or the seabed? In that case, if I use a permanent station, right that will be more useful for us.

Moreover, if I want to do some kind of (Refer Time: 55:27) detection; that means, over the period of time what is happening? Maybe a point, it is subjected to a lot of currents within the sea and so, it is being silted again and again for some reason. So, if you take a permanent base station or a station which is permanent in nature and we establish our base again and again on that point, what will happen? Every time, I will measure the my vectors which are from the same base station or the same reference position and that will give me more confidence while locating some of the obstructions.

So, anyhow DGPS method is a current state of the art technology and which has superseded all other methods. So, if DGPS is available to you, it is always necessary to use, it is always advisable to use.

Moreover, I would like to say one thing here that GPS is going to measure the position only x and y again, but we need to measure the depth of the water by the sounding only well, that is very clear to us. Moreover, here I would like to tell, because of the small vibrations, in the boat what will happen, you need to put some kind of tilt correction with the G GPS. And that is the best thing here with the GPS, because GPS is going to give me very highly accurate x y position ok, but these positions I should not meet wrong, because of the vibrations of the boat that will create some kind of corrections.

And so, we need to have a, a tilt sensor. If you read the specifications of the DGPS these days, most of the DGPS which are high end generally more than 500 channels. They are coming with the tilt sensor for the tilt correction and these can be used even for the hydrographic surveys, but always consult this aspect with your manufacturer of the DGPS instrument whether can instrument is sensitive enough to use for the hydrographic survey. So, that we can apply the tilt correction be careful on this part.

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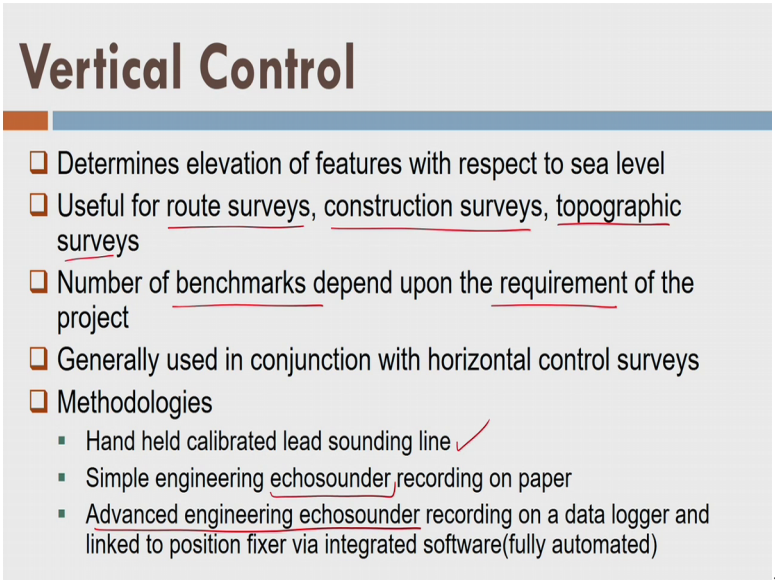

Now, we so, far we have finished our vertical, horizontal positioning survey; that means, we have look at it our x y. Now, we have said every time that we are measuring the soundings that vertical depth at each and every point on the vertical surface wherever, we have measure x and y.

Now, what about the vertical control how can we establish the vertical control? First of all, we take and permanent reference mark. And there we use the bench which we use as a benchmark which is available on the shoreline or coast. Now, using that we are trying to connect our sounding instrument observations. So, that we can determine the sea surface or the water body surface in a certain vertical reference frame. I hope you got the idea and that is why we call it vertical control establishment, fine.

So, it is very useful for the route surveys construction surveys and topographic surveys. So, we establish the number of benchmarks depending upon the requirement of the project. It is always in conjunction with the horizontal survey, we do not, do we? Do not separate here the horizontal and vertical survey, right.

So, now as we have already seen how to use the lead sounding line and we also use the echo sounders for the depth measurement. And then we also, use the advanced engineering eco sounder; that means, automated system sometimes less automated systems, but ecosounder is more or less. These days are completely automated or we say that we need the minimum human intervention for the echo sounders, but at the same

time we can also use lead line or we can also use the sounding pole, well. Sounding pole has a limitation of 5 to 8 meter length. So, that is why it is somehow preferred only for small depths of level of 5 meter or maybe 6 meter, but the moment we go for higher depths, we should go for lead line or if you can afford you should go for the ecosounder. So, that is my vertical control for the hydrographic survey, fine.

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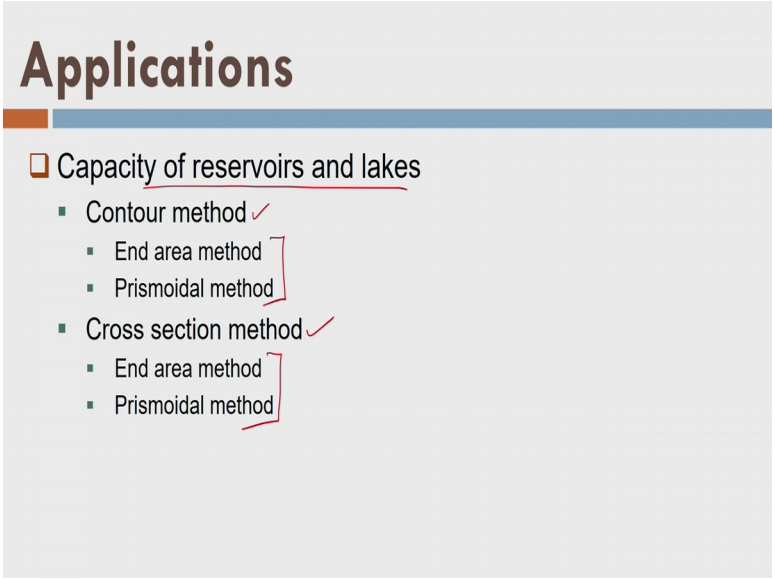

So, here let us look into the applications means let us say, we have acquired the data, ok. Let me tell you one thing since echo sounder itself is a big area. So, we are going to consider them in the next lecture, but here we assume that we have observed x y and z positions.

Now with this observation what can we do? We can have some applications. First is we want to find out the capacity of the reservoir and lakes and that is the most important application. So, first we look into those applications. So, there are two methods, one is contour method and another is cross section method,.

In case of contour method, again we have two methods end area method and prismoidal method and here also we have same two methods. So, let us look into these two methods and then we will go for the next lecture, ok.

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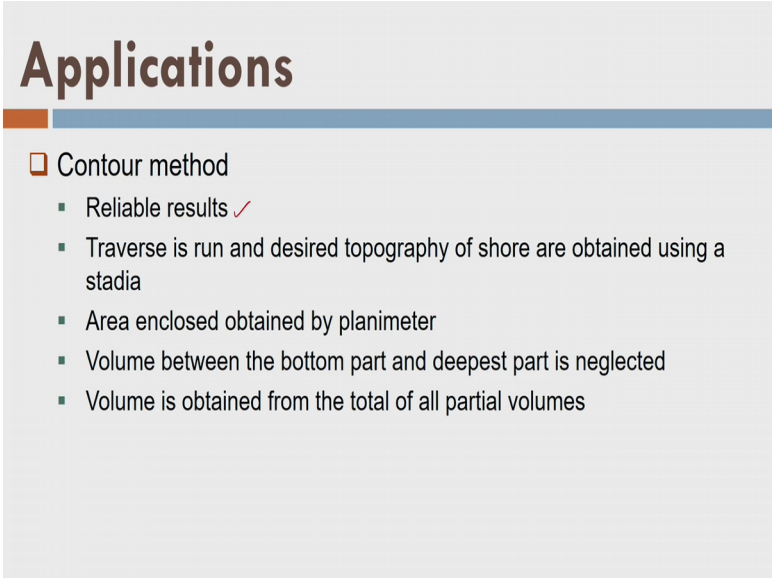

So, contour method is very very reliable method, because it gives you reliable results. So, what we do, instead of reading the slide for you, you can read it yourself, but I will explain the method.

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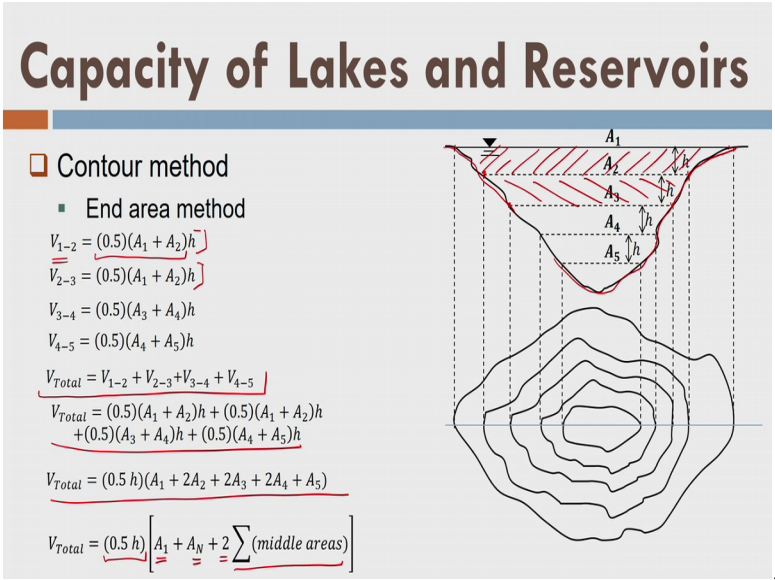

So, that is my end area method. So, what do we do basically? We take the some map here, fine. And now, we draw a section here which is required where we required to measure the flow or maybe velocity of the water.

Now, what do we do? We develop a section by projecting these lines. And now, we got this section here as shown here by this line fine, this complete section is there ok, fine. Then what we will do? We will divide this whole section into equal interval of the contours, let us say h, h and so on, ok.

Let us say on the map, we measure this A 1 area using planimeter. Similarly, I measure A 2 area at this level and so on, fine or we measure this level A 1, A 2, A 3 from our hydrographic survey; that means, we have derived this section from the hydrographic survey. Now, we have divided this section into different, different levels and at each level I am determining the area which is planimetric area A 1, A 2 and so on.

Now, by using the simple mathematics I can write the volume between section 1 and 2. So, I can say here so, that area average of the area into height that is my volume of the water. Similarly, I can write for each section, for this section like this and so on. I will repeat this process and finally, I will add all the values here. And so we got this formula. And now, if you make it total here this formula will come and there we write that first area and Nth area plus 2 times. All the middle areas into 0.5 times h, h is my let us say contour interval or the vertical interval of this method, fine that is my end area method.

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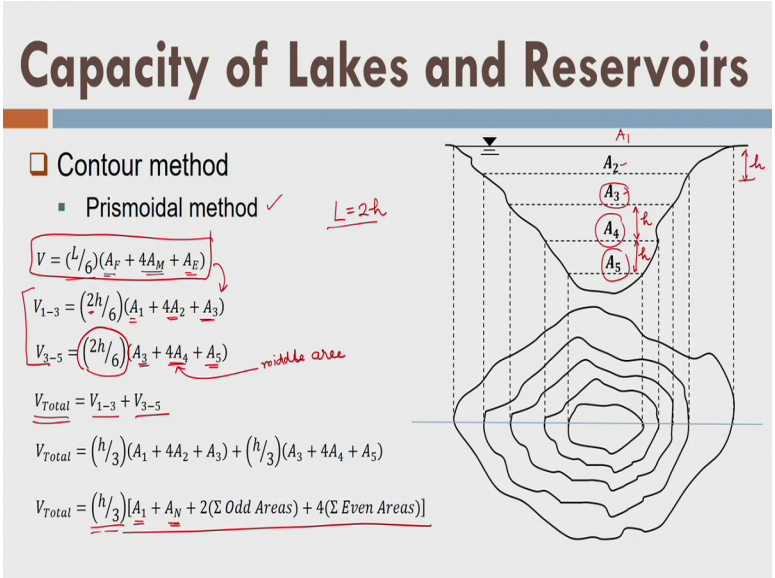

Let us come to the contour method where we are going to discuss the prismoidal method. Here, we can see the formula L by 6 A first area, A end area and the middle area 4 times. So, this standard formula for the prismoidal method where L is nothing, but the distance

and the distance between the two sections A 1 and A 2 and so on. So, now, the distance is h. So, we are dividing h into two parts h by 2 and h by 2. And now, we are saying that L is equal to my 2 h fine,ok.

What does it mean? It means that I am considering three sections at a time the middle section at middle one is first mid first section middle section and the end section, ok. The distance between the first and the middle section is h and the distance between middle and the end section is else also h. And that is why this length between the first and the third section or first and the end section is 2 h. So, L is my 2 h here, fine.

So, now I use this formula and there I put L equal to 2 h here. And then let us say there are three areas for example, A 1 here then A 1 A 2 A 3. So, I put A 1 plus 4 A 2 plus A 3 by this formula here, fine and then 2 h by 6. Similarly, when I consider 3, 4 and 5 section; that means, this one, this one and this one.

So, this is my h, this is my also h here, fine. So, basically this is the h interval or what you call is contour interval fine. So, again I am using this 2 h by 6, here. And then A 3 plus 4, A 4 A 5. So, here A 4 is nothing, but my middle area, fine.

Now, in since we have covered all the areas from A 1 to A 5 in two calculations. So, the total volume is given by V 1 3 plus V 3 5. And so, if we do it the summation, I will get finally, this formula that is A 1 and it is the Nth areas, ok. Now, we have shown you the total formula. Now imagine that instead of five areas we have total number of N areas A 1 A 2 A 3 and up to A N. So, what we will do? We will take the contour interval h fine and then this areas are separated by the contour interval,ok on the section area.

Now, you can imagine that I will take a A 1 that is my first area the AN is the last area. And in between area I will divide into the odd areas and even areas. So, A 2, A 4, A 6, they are my even areas A 3, A 5, A 7. And so, on they are my odd areas then I will use this formula straight away, right. So, that is my prismoidal method.

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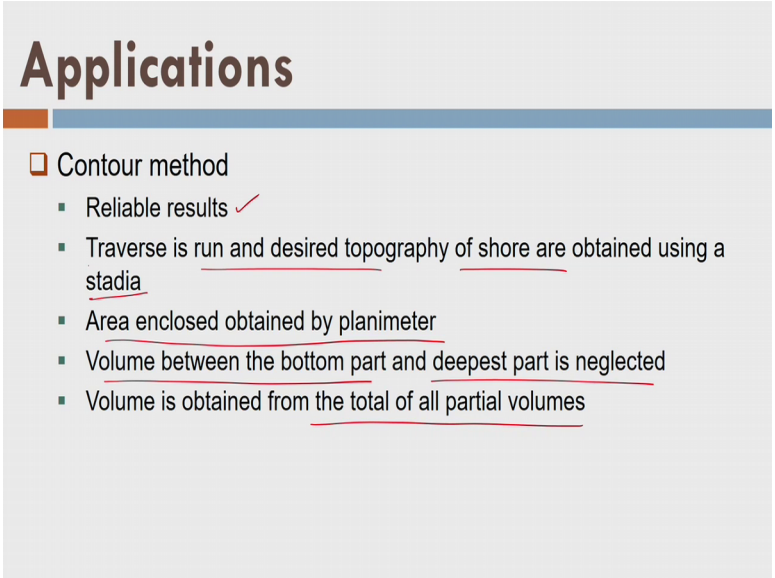

So, the cross section method, it has the moderate degree of precision. And so, the contour method is very much reliable here, ok. We can see here that traverse is run and desire topography of the shore are obtained using a stadia; that means, techeometric area includes obtained by a plainmeter; that means, on a map if I have the area overall area, right. So, what will I do? I will do the map and then I will draw the sections. At different sections what will I do? I will take the planimeter and make the area of the particular section that is horizontal section at the certain, at a certain elusion level, fine.

That volume between the bottom part and the deepest part is neglected here, fine be careful. So, total volume is nothing, but after neglecting the first and the last. So, we have the partial volumes here, fine. So, we make the summation of the partial volumes and that is my total volume, but this method is much accurate here.

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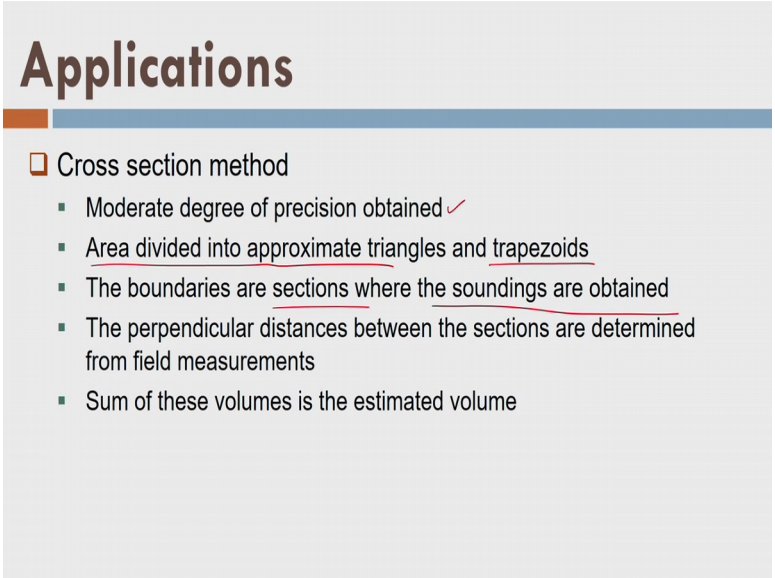

Next method is my cross section method, in cross section method it is moderate degree of precision is obtained. So, area is basically divided into approximate triangles and trapezoids, fine, the boundaries are sections where the surround soundings are obtained, ok. So, I have calculated my sounding positions, right. And so, I have prepared the sections here. So, now, you can read it yourself. So, instead of reading slide for you I am going to explain you what is my method. In cross section method again we have the prismoidal method well.

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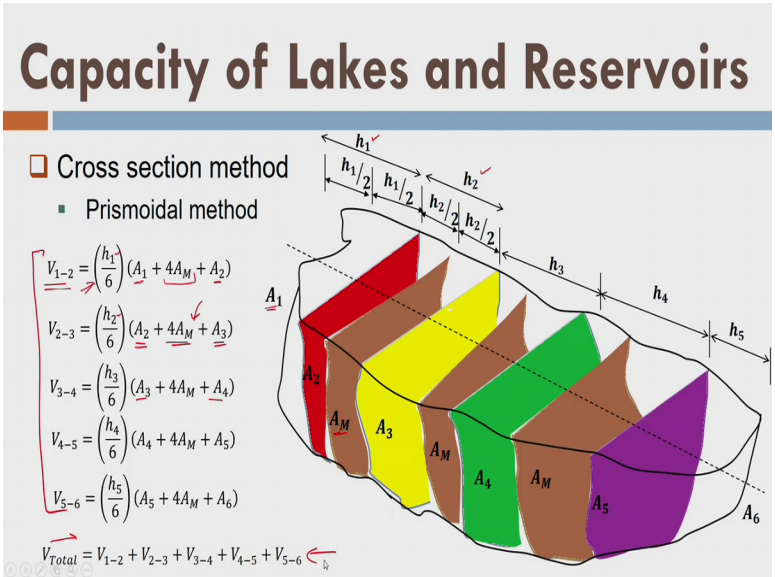

So, here we are saying that again this arrangement of the sections are same, ok. So, let us see this is my h 1 section which I measured in the field. This is my h 2 section which is nothing, but a distance between A 2 and A 3 here, fine. And this is my AM here. AM means the middle area that I determined between A 2 and A 3 by some intersection scheme, ok. Intersection could be let us say the average or intersection could be some different value; that means, it depends on your interpolation scheme.

So, let us say I have with respect to my middle area, I have some first area as well as end area; that means, the cross section area of the two sections which are address into the middle area, I have observed, ok. So, basically observe A 1 A 2. And so, on then we calculate the middle areas, the middle cross section areas by interpolation scheme.

So, let us say, we have complete data now with us, fine. So, you can see here this is my h 1 and if I divide by h 1 by 2 h 1 by 2. Now I want to use the prismoidal method. So, let us say if I write remember, we wrote one formula L by 6 where L was equal to two times h. Here you can see the two times h is nothing, but I can see here that h 1 itself is equal to 2 h, why? Because I am using 1 A 1, ok. Then I am using A 2. And then I am estimating the middle area between the two sections A 1 and A 2 and that is why my h 1 is divided into two parts 2 h 1 by 2 and h 1 by 2. So, basically h 1 is equal to L, fine.

So, now we estimate the middle area between A 1 and A 2 and we put it here. Similarly, for A 2 and A 3, we put it here. That and this AM is nothing but in this term it is the middle area or the intersection area obtained by the intersection of A 2 and A 3, fine. And similarly, I repeat this process, here I am putting h 1, the distance between the A 1 and A 2. Here I am putting h 2 the distance between the A 2 and A 3 and so on, you can see all this thing.

And finally, after doing this calculation, we make this summation here in this formula. And this is my prismoidal method here.

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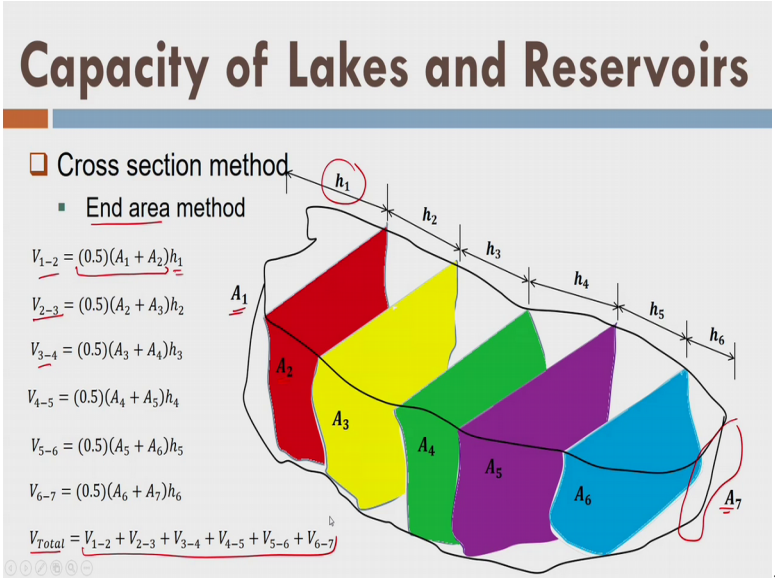

So, what let us demonstrate the end area method here? So, let us say this is my water body. And. So, this is my area A 1 which is on the left hand side of the water body. This is my cross section area, so, this distance is h 1 from some reference point. And then this is my area A 2, this is distance h 2 and again this is my area A 3 and so on. So, now, I am showing you all this, fine.

So, now finally, I have A 7 area which is at the end here, something like this, some kind of area. And similarly, A 1 is also there, ok. So, what are my formulas now? So, these are my formulas again by end area method; that means, I take the average of the two areas, let us say A 1 and A 2, fine. And then I will multiply by this height h 1 or this distance h 1. Similarly, I will repeat the whole process and finally, I get the total volume of the water by summation, this is my end area method for the cross section method.

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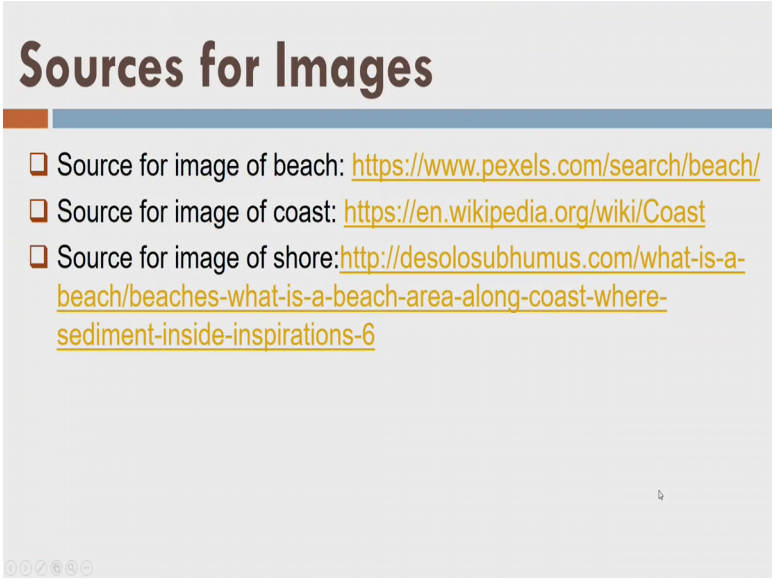

So, now we have taken some of the images from some sources like Wikipedia. And so, we are here, we finished our lecture 2. And in the third lecture, we will look into the operation, operations of the eco sounder for the sounding measurement or the vertical depth measurement of the water surface or the depth of the sea bed, so.

Thank you very much.