Higher Surveying
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Module – 9
Hydrographic Survey
Lecture – 32
Fundamental concepts of hydrographic survey

Hello everyone. Welcome back in the course of Hire Surveying. And today we are in the new module hydrographic survey. This is module 9 or second last module of the course. So, what about the hydrographic survey? Why do you want to learn the hydrographic survey? First of all, I would like to tell you might have heard 2 terms; hydrographic survey and mathematics survey.

In case of hydrographic survey we collect the information of the seabed or the topography underwater surface ok. So, we are collecting 3D information for that surface which is under the water. At the same time if I collect some additional information; for example, the type of vegetation on the seabed or the material available there or any other information which is relevant to maybe geophysical survey or which is relevant to any other aspect of my of our exploration we call it mathematic survey.

So, mathematics survey contains the hydrographic survey also fine. So, in this course this module is about only hydrographic surveys fine. So, let us go ahead you might be surprised that why do we need the hydrographic survey, where we collect the 3D information on the surface of the sea bed which is under the water on the river bed.

Let me tell you one simple example that we are talking about the river navigation now, because most of the settlements and the cities are developed on the banks of the river. For example, Ganga, Brahmaputra or Yamuna maybe Krishna and Godavari, we are also example are good example in south India, fine.

So, use that now we want to look for methods, where we can use the rivers in order to transport people or in order to transport some material. Well, for that purpose I need to have some place what we call as jetty or the bank, where a ship can be park, or a river vessel can be parked or the vessel or boat can be parked.

And from that place it will start roaring in the river and it needs to navigate through the part which has enough depth of water to support the buoyancy of the vessel right. And that is a reason we are looking for a 3D surface data of the river bed or sea bed.

A similar example is good enough to explain you why do we need the seabed 3D theta, because we want to navigate from one country to another country or maybe one sea coast to another sea coast across the ocean. Well, it is very much important, because it will allow us to transport a heavy material using vessels or ships, fine. I think that is a good reason for you to understand that we need the hydrographic surveys.

So, let us go ahead in this lecture. So, this lecture it is based on the fundamental concepts of hydrographic survey. Moreover, so, we have total 3 lectures in this module on hydrographic survey. So, the first lecture is about fundamental concepts of hydrographic survey; which we are going to address today fine.

So, these are the books again few of the books are very, very expensive. So, once you join some library or once join some institute library in order to avail such fact books and make the note, but again I say that these 3 lectures of this module are sufficient enough to create a good knowledge for you; however, if you need more knowledge you should refer these books ok.

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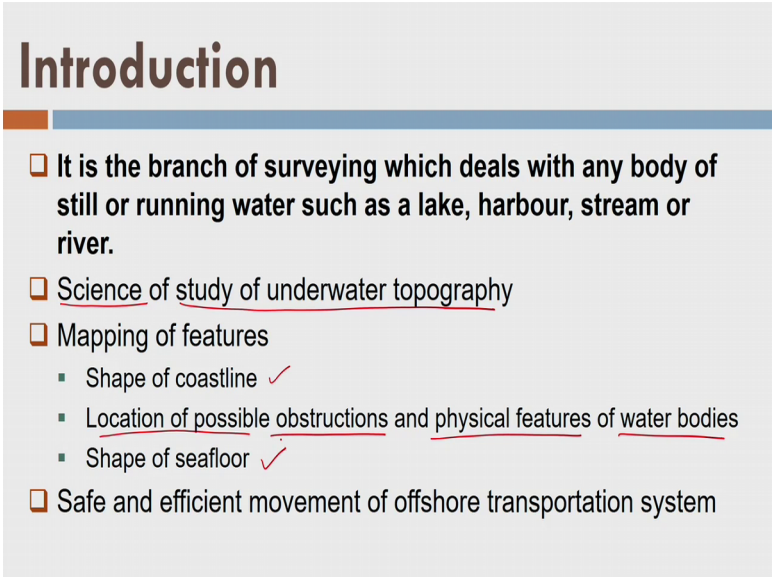

So, let me introduce this hydrographic surveys formally. So, it is the branch of serving which deals with anybody of still or running water such as lake harbour stream or river, but we can also include sea. So, then it is the science of study of underwater topography.

Well, that we have already said. So, in this hydrographic survey we map the features like shape of the coastline. We also find out what are the locations of possible obstructions and the physical features of water bodies, and then we try to map the shape of the sea floor. The purpose of doing this that is we want to ensure that safe and efficient moment of off shore transportent system. And that is the purpose we have already discussed slightly.

But now you may be little surprised that what do you want to do the measurement of the complete river or complete seabed ok. So, let me explain you the reason ok. You might have heard that there is a tides in the sea ok. And it is because of the interaction with the interaction or surface with moon and sun well. That is the kind of understanding we have already developed from our 6th and 7th standard, ok.

Now, the idea here is because of the tide what happens water level rises right. And because of that there is a change in the water level. Moreover, such tight also creates some change in the shape of the as a underwater bodies. For example, there is some un consolidate material located in the sea that will be shifted because of this water level rise or maybe nowning of the or maybe the lowering of the water level.

On more over we need to understand that if water level is high how can we take advantage of that? At the same time if water level is low, we should suspend some of the activities.

But for suspending some of the activities like shipping or rowing a boat we should know what is the water depth available at low tide right. Now you got the idea that why do we need the hydrographic survey, fine. And what should be the time interval so, we should do it very frequently or less frequently or at yearly basis or so.

So, let us try to understand those things with a fundamental concept of the tide that, why tides are visible or why do we experience the tides.

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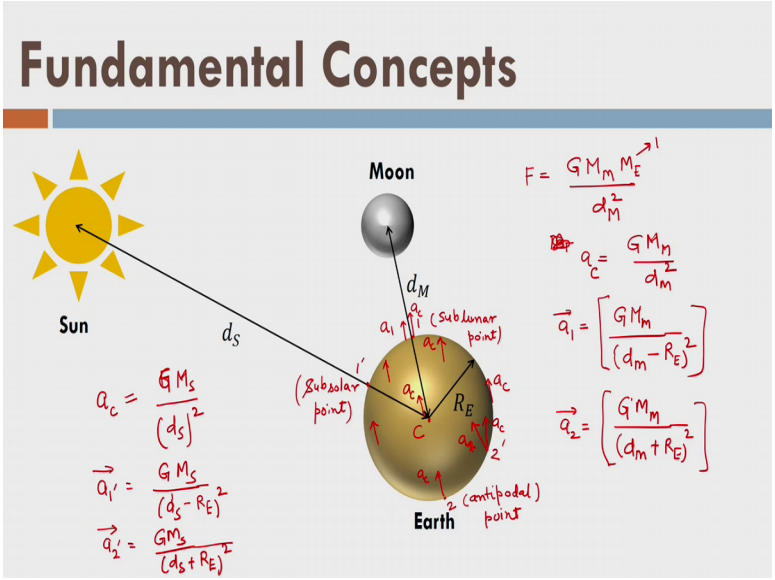

Now, we are showing the 3 planets sun, moon and earth. So, earth is shown with this radius R E and there is a moon and the sun. So, because of the attraction force between moon and earth and between sun and earth we have the tides.

So, let us try to understand, what does it mean. So, let us say this is the distance between sun and earth, and this is the distance between moon and earth. So, these distances are indicated by d S and d M now for the earth let us say a distant point of earth, if I write the force that is acting between moon and earth, I can right like this. Remember, the rule of the Newton, the Newton's first law of gravitation I can right here.

So, let us say mass of the moon and then mass of the earth divided by d M square. Here if I assume that mass of the we are talking about the mass, a unit mass here on the earth, then I can write the acceleration like at the center of the earth as G M M divided by d M square ok.

In a similar session I can write the acceleration for the sun, let us say at the center of the earth this acceleration caused by the mass of the sun and the distance between the sun and earth it is this. We agree with this idea?

Well now, you can observe very easily if I talk about the sun and if I talk about the moon and earth interaction, there is a point here fine, and there is a point here. This point for example, if I call it point number 1, it is called sub lunar point. And corresponded this

corresponding to this sub lunar point, this point which is opposite by 180-degree longitude, it is my anti pole or antipodal point, right.

Now you can see that point 1 is much closer to the moon compared to the point 2 which is farthest from the moon. And if I just say this is center c here to the center compared to the center, the point 1 should have higher acceleration, and point 2 should have lower acceleration, fine.

So, can I write the acceleration at point 1 with this sublunar point as my G M M divided by d M, which is center to center distance, minus radius of the earth square. I hope you agree with that and similarly I can write here a 2 is equal to G M M divided by d M plus R square.

I hope you agree with that, these 2 formulas at least fine. Similarly, I can write the same formulas like a 1 and a 2 so, if I declare this point is a 1 the point number one, or call it one dash and call it the point 2 dash here; which is subsolar point here, and the antipodal point that is 2 dash corresponding to the subsolar point, fine? Ok, let us say right 1 dash equal to G M of sun, and then d S minus R E square and similarly if I write a 2 dash equal to G M mass of sun and d S minus plus, sorry R E square, like this ok.

So, we know that these are the acceleration values a 1, a 2 and they are the vectors also fine. And they are basically working on the points different points on the surface of the earth. Now what is the problem here? Or what is the conclusion here?

So, if I try to draw this acceleration values of a c, then a c will be towards the moon like this at each and every point, because I can see that earth is my point mass fine ok. And so, the acceleration a c is same at each and every point as if earth is a point mass fine. I hope you agree with that ok.

At the same time now the force acting because of the moon they are working on the surface here. So, here at point 1 it is my a c and it is my a 1 right. This is my a c and this is point a 1. Similarly, at any other point I can mark this direction towards the moon; that means, this is my a c here and if I draw the direction towards the moon, this point this is my a right.

So, basically this is direction now. So, we know that there are some differential forces are acting on the surface of earth. One because of the center to center distance between moon and earth, and another is on the surface of the earth because of the moon gravitation; that means, there are 2 forces working on the surface of the earth. One is because of the gravity of the earth and one is because of the gravity of the moon.

Now, what is the consequence of that? Ok let me tell you one thing, the same things happening for sun also. Since I am not marking it here, it does not mean that it is not happening. It is happening with sun and earth interaction also; that means, a point on the surface of the earth is attracted by moon as well as it is also attracted by the gravity of the earth. Well, so, let us go ahead with this idea.

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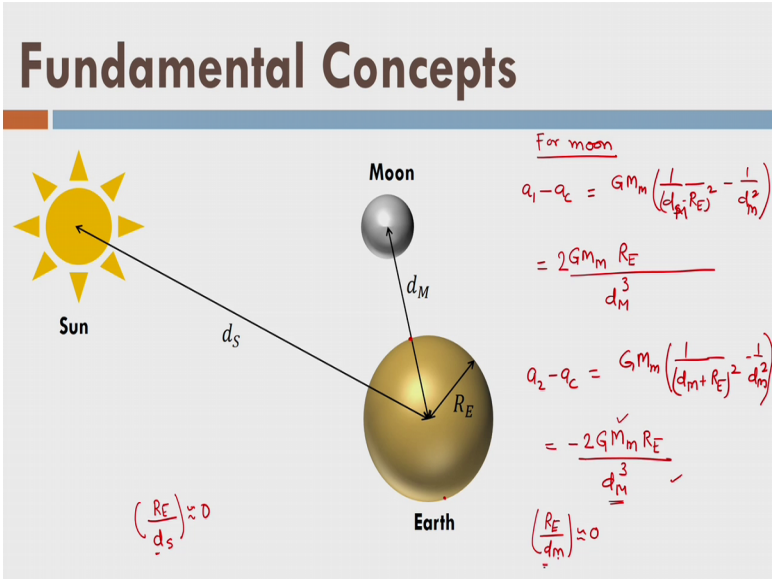

So, this is a given here situation.

Now, if I for the moon if I want to find out what is the differential force at a point. So, a 1 minus a c let us say at this point and what about this point? And let us try to make it. So, it is G M M 1 upon d S minus R E square minus 1 upon d, I am sorry it should be d M d M square, fine?

Now, we can find out that this one if you take the multiplication and everything, you will get a expression; where d M cube will be there, and this is the expression we will get ok. At the same time if you take a 2 minus a c for the moon only, we are talking about again

you can write G M M, then 1 upon the m plus R E whole square minus 1 upon d M square.

So, here we will get minus 2 times G M M R E divided by d M cube here ok. The similar relationship I can also write for the sun where this mass will be replaced by the mass of the sun and this distance will be replaced by the d S. Here we have taken one approximation that the radius of earth the ratio of radius of earth to the distance d M is approximately 0. And try to derive this one yourself we will get this one right.

Similarly, here if we derive such formulas we have to take an assumption that the radius of earth the ratio of radius of earth to the distance between sun and earth center to center is approximately 0. Because this radius of earth is very small compared to this distance, and similarly here also ok.

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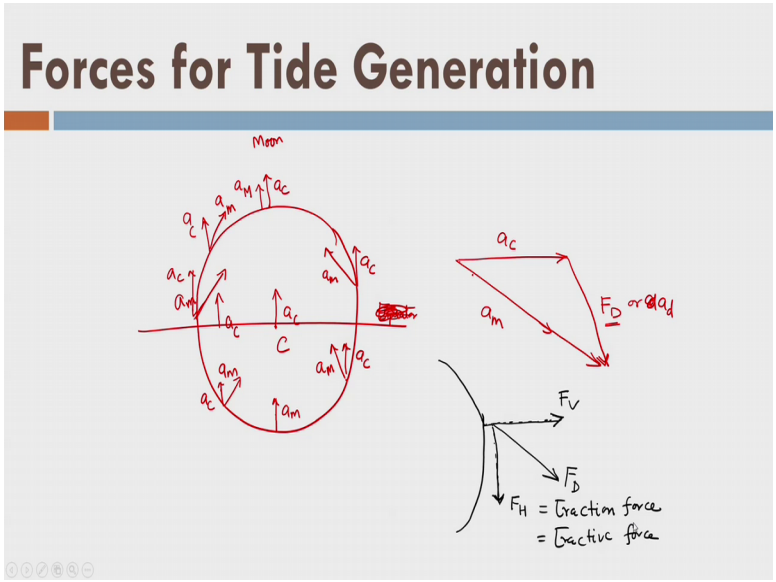

Now, what are the forces for tide generation? How tide is generator generated, we have learned that what are the forces working on this one, ok.

Now, you can imagine that there are some forces on the surface of earth, let us see because of the moon ok. So, here there is force here working like a c, a c at each and every point and at the same time if there is a moon here, then what will happen? There will force a c that is because of the gravity, the center to center interaction between moon and the earth so, this my center c.

But at the same time there is another force working here called a 1 or I call it a M now fine. So, directions a M at each point is towards the this towards the moon. So, like this like this, and like this, what about the a c? A c is like this here at this point if I draw a c is like this and this is my a M and so on so forth.

Now, here am will be like this. So, you can see here a c here and am is this one. So, this is my a c. Well, the direction vectors are not showing in proportion to the force value, but just their indications. Now if I just make a vector sum I can see here that this is the for example, at any point 1 is a c here ok, and there is one a M here. So, the resultant force since it is higher force if I just consider the top half let us say it is my equator, the moon is like this for example, or do not say.

So, let us so this is my resulting force called F D or a d the exhalation is a d here fine ok. Now you can understand that it is the vector sum, this force is vector sum of 2 forces working here or 2 differential force is right. So, this force is causing the tide, how? we will see now?

But before that so, if I resolve this force F D which is working in this direction, fine in to the horizontal and vertical component. So, vertical component will be like this, which is perpendicular to the surface of earth, and one force will be like this which is tangential to the surface of the earth at this point, like this, fine.

So, this is my F H ok. So, the importance of this F H and F V is very, very critical in terms if I want to understand the tides ok. Now first of all we should understand that since at this point this is my gravity direction and force is working like this, ok. What about this force and this force is called F H is called traction force or tractive force, fine.

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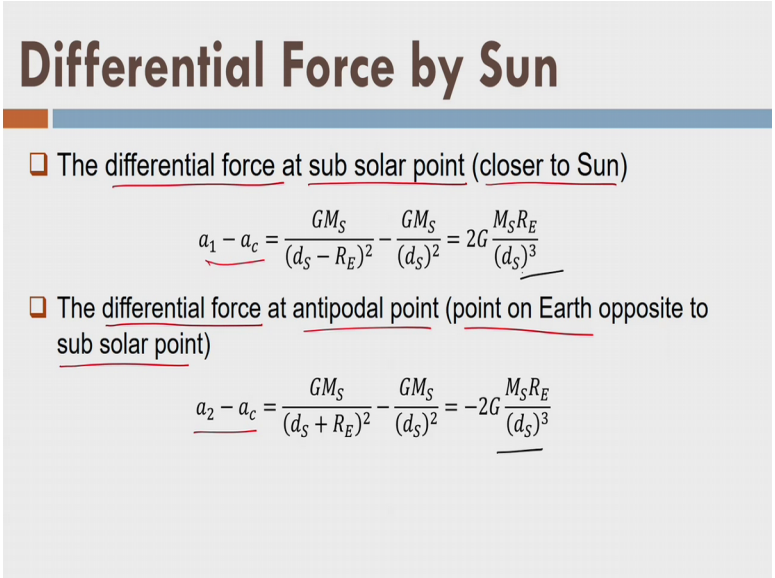

So, if I just go ahead explain this thing here, we have already explained these 2 things right. So, that differential forces at the sub solar point and closer to this one. And similarly away from the sun antipodal point fine, these are the acceleration acting here, ok.

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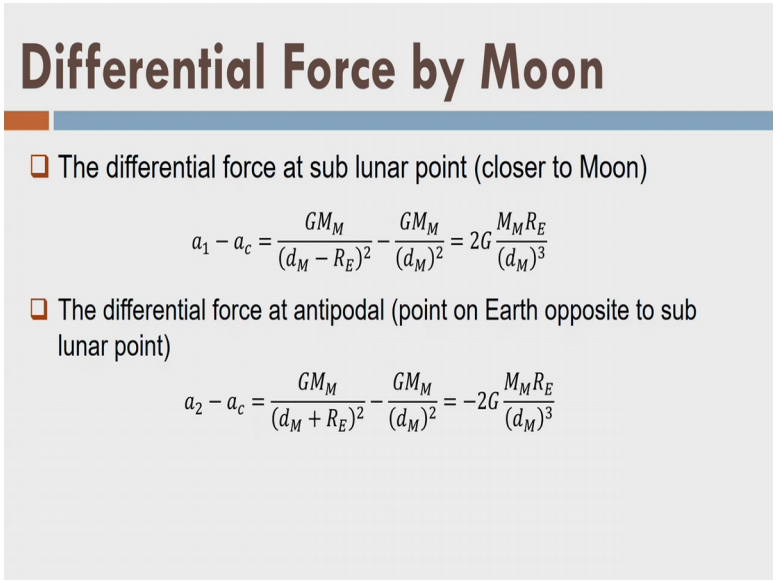

Similarly, for the moon, we have written like this. So, you can check yourself these derivations.

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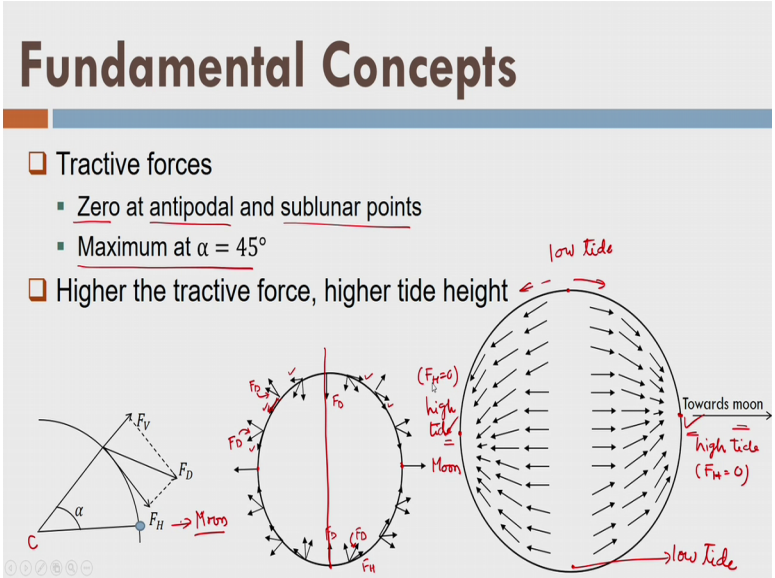

Now, we have said that there is an tractive force working on the surface of the earth ok. What is the tractive force? Basically the vertical force which is working, but particular to be surface of earth at that point is not going to cause any tide. It can change something, but it is not going to cause any tide ok.

Now, if you look at the forces which are horizontal or which are tangential to the surface of the earth on water, what will happen? They will bring the water like this, why because, you can see your on the screen that this is the force; suppose this is the moon here on this direction, what will happen? This is the horizontal force here, this is the horizontal force here, this is your horizontal force here and horizontal force here right.

So, we have resolved this F D into 2 values. Here this is my F D, this force, this force and we have resolved it, and here there is only F D working in this direction here F D. So now, you see there is F D here this force you have resolved into 2 forces one is F H and one is F V.

So, you can see here that the half part of the earth where water is located, the tractive force or the F horizontal it is bringing the water towards the one point and which is closer to the moon, fine. I hope you agree with that, and in order to make the equilibrium again on the surface of earth what is happening? The 50 percent of the water in the other part which is opposite to the moon, it is going in other direction.

So, there is a point which is closer to the moon and there is a point which is exactly opposite to the moon on the surface of earth. So, 2 points here is now water is accumulating at 2 points, fine. You can see here the tractive forces are bring in the water here. And as a result what happens? Because of these tractive forces a sea level will experience a rise in the water level, because water is brought from the other places to one place, ok.

The same thing happened. So, this kind of tides are happening here, and water level is rising at this point; which is very close to the moon, or which is located towards the moon at this moment. What about this point? Here you can also see that the, if I divide in half earth, this part is also making these horizontal forces, and this is also creating a tide. Or again the rise in the water level of the sea. Or any river also, because if river is quite big that will happen that it is area is quite big like sea, that will also be affected by the moon.

Now, you can see very wonderful effect here or you can see very wonderful phenomena here; that is, on the 2 points on the surface of earth tides are occurring and high tides are occurring. So, one point is where which is very close to the moon or towards the moon on surface of so, one point on the surface of earth which is very close to the moon or towards the moon, and one point which is exactly opposite of my first point.

So, one is sublunar point and another is antipodal point. Similar thing happen with the sun also, but there is some issue here. There is small critical analysis has to be done that who is more stronger or who is stronger the force of sun or the force of the moon? Fine, here you can see that what is accumulating over this place. And water is accumulated over this place and because of that both these places are experiencing the tides, because of the presence of moon or maybe some other planet like sun.

But as I told we have to see now that which force of stronger; that means, the force of the moon of force of the sun. So, let us look into this thing. Moreover, we can see here the tractive forces although 0 at the antipodal and sublunar points, but they are responsible for creating the tides. Because water is accumulated although force is 0, fine.

And now what should be the height of the water rise? Ok that water is rise or the water rises to a level where the force of the moon on the water and the force of the gravity of

earth are same; that means, the water surface becomes in equilibrium after creating the tide, fine.

I hope you agree with that idea now. So, let us go ahead and here we can see the tractive forces are maximum at alpha equal to 45 degrees; where alpha is shown with respect to center of earth here. And so, this is somewhere moon is here, ok. If the high tractive forces are there although they are in equilibrium, but it will create higher tides, ok.

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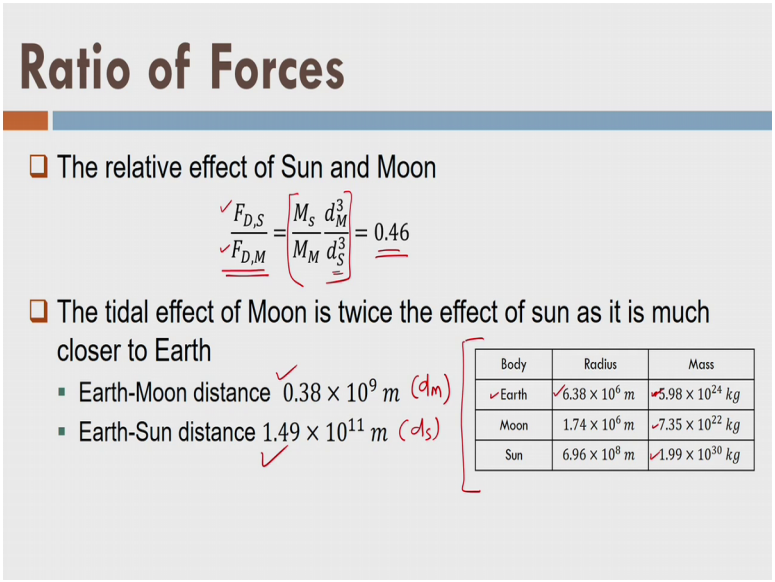

So now, as we told that which force is stronger on the earth. So, let us look into the ratio of the force. So, if you take the ratio of the forces, let us say this is the force created by the sun and this is the force or acceleration created by the moon, if you take the ratio you will get this expression right.

We I can see that the force created by sun is proportional to the mass of the sun, but inversely proportional to the cube of the distance and similarly for the moon. And if I take this data which is listed here right about the radius of the earth and about the mass of the moon and sun here. So, not this data so, this data if I use this data and then I use this data the distance that is my d S and that is my d M, fine.

So, if I put this here what will happen? I will get a ratio 0.46. You can try it yourself ok. So, what does it convey? It is conveying very important aspect that the force exerted by the moon it is more than 2 times of the force exerted by the sun. And that is why we say

that tides are basically cause by the moon, right. Yes, that is reality that is and also contributes that, but tides are always caused by majored all that major forces of the tide is because of the move, fine.

One more aspect I would like to tell you here, that is a go back here. So, water is accumulating here under the influence of tide and accumulating here but what about this point? Water has been withdrawn from here towards this side and this side. So, these are the points of the low tide. Similarly, this point is point of low tide, here point of high tide, and here also we have high tide, right.

So, it is my sub lunar point and it is antipodal point, well, what about the forces here? It is 0 tractive forces, but still we have experiencing the high tide at both places, fine. So now, you understand that there is a variation of the water surface of sea because of the moons attraction.

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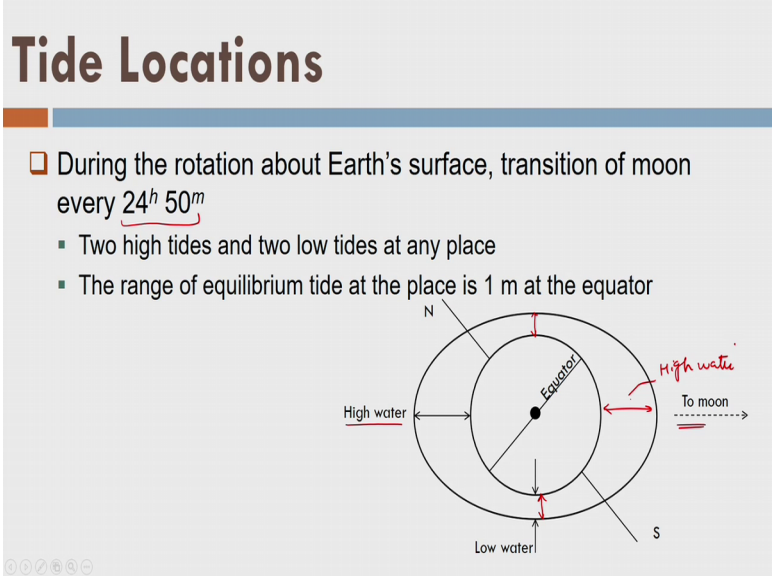

Now we can see here that the moon rotates at it is own axis in 24 hours and 50 minutes. And this is the solar hours and let us we can say almost 25 hours. So, what happens? Let us assume that moon is at fixed and earth is rotating like this.

So, I can see here that because of the rotation of the earth like this at one place, the one place on the surface of earth will face the moon 2 times in a day, fine. Or I can say 2 times in this 24 hours and 50 minutes, why? Because let us say there are 2 point, 1 point

here, 2 point here. So now, earth if earth rotates let us say points are like this one point here, so if earth rotates like this. So, after 12 hours and 25 minutes, this position will be here which is away from the moon and this position will be here, 12 hours and 50 minutes this point will be coming here and it will be like this, fine.

So, during these 2 times I can see at when the moon was here and this point was here, there was high tide here and high tide here. After 12 hours 25 minutes again situation is same, high tide is again here and high tide is also here. So, in one day we experiences 2 high tides at a place; similarly, when this point is at 90 degree to the moon, there is low tide and low tide. When this becomes like that low tide and low tide.

So, the experience 2 high tides as well as 2 low tides in one day or one tidal day. And tidal day is nothing but 24 hours 50 minutes. So, that is explained here, but you can see here that there is a high water here and there is a low water here fine ok. And this is the moons position so, it is high tide here, I can say high water ok.

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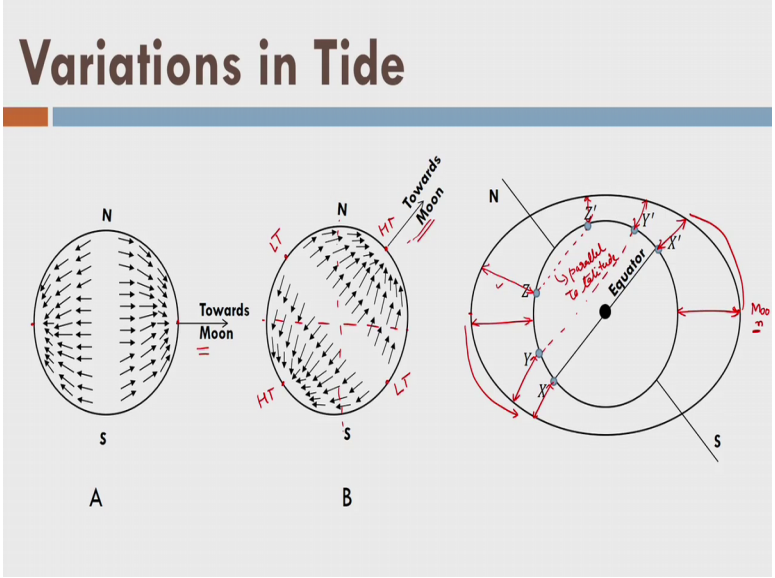

So now, we also observe the variations in the tide, why do we observe? Fine, let us see there is a moon and we have already resolved this problem that, this high tide here and high tide here, ok. What is moon is like this? Fine what will happen? Although this is my north south axis here and equator is like this, this point will experience high tide and this point will experience high tide and these points are low tide points here, you can see and this is let say high tide and high tide here, fine.

Now you can observe the same situation here, I am marking the equator by x x dash, and moon is let us say here somewhere and this meridian moon is there. What will happen this is my high tide here? Fine and this is the high tide here. What about the point z? If you see that point z is having high tide, but the point z dash is having which is at the same latitude, you see this is my parallel of latitude here. And z and z dash both are located at the same parallel of latitude. What will happen here? This is the tide level which is quite low compared to this level, ok, fine.

Now, you can understand that, why do we have different different tides within a day also, ok. Because as points are away from the equator and moon is not located at the equator it will create different tide levels at the same parallel of latitude. Similarly, if you look at the y position here which is again on the same parallels latitude, this is the tide level and this is the tide level right. So, you know that y and y dash when they will be having high tide in a day, but at the same time between high tide and low tide they will have they will be having different different tide levels.

So, what about the x position which is at equator? You can see here with respect to moon with respect to this point this has same tide and with respect to this point it has same tide. So, at equator the tide levels are same, but as we go away from equator for any given position of the moon we have we can experience the different level of the tides at the same parallel of latitude.

Because one point which is near to the antipodal or sublunar point will have higher tide, but the point which is quite away from the antipodal or sublunar point will have low tide. So, that is a key here that we also very the, we also see the variation in the tide levels, ok.

Now, what about the frequency of the tides? We have understand the variation of the tie, variations in the tide level we have also understand there is a high tide and there is a low tide and across the day we will feel 2 high tides and 2 low tides, ok. But we also know that moon revolves or orbits around the earth.

So, what is the effect of that? We will have the tides remember that there is a electricity in the orbit of the moon, as a result moon will be sometimes closer to the earth sometimes little further to earth. And what we have said? D S and d M they are the average distances, fine there is other real distances. And because of that this variation of

the average distance and the real distance we will have variation in the tides across the year also, fine ok.

So, we will see this thing now.

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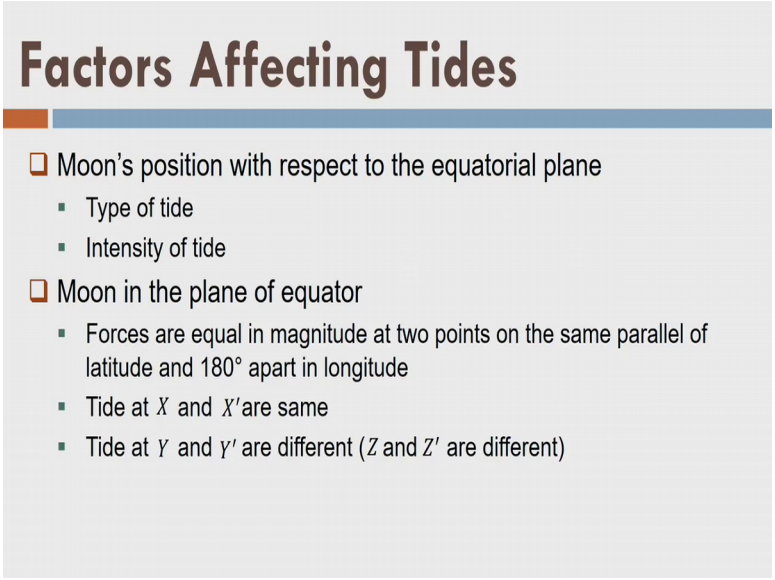

So, what are the factors that affect the tides, I have written on this slide. So, you can read it yourself and you can confirm this thing from the previous slide.

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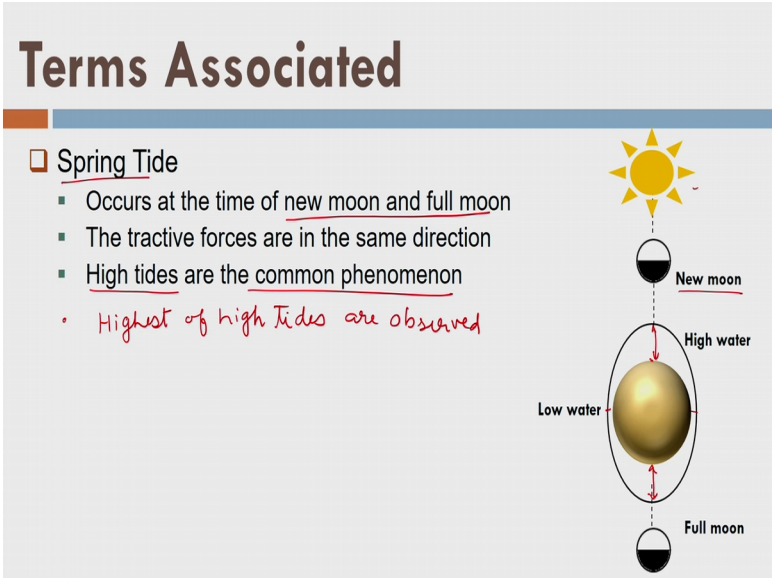

Fine, now let us there are 2 terms associated here that is the spring tide ok. We have seen that moon and the sun were both are exerting force on the surface of the earth, and moon is more effective because the distance and the mass combination. Distance is much closer to the earth and as a result moon is more effective.

However, what if both of the moons and the suns force are exerting in the exerting in the same direction on the surface of earth, and we will experience the highest tides. And that is shown here in this picture on the slide. This position is called new moon, when it is sun and moon are aligned in one line and they are basically above on this meridian of this point, and here we can see the high tides here.

Similarly, as we know there will be low high tide here also and there will be lowest tide here also fine, ok. And this phenomena is called the spring tide ok. So, it occurs at the new moon and full moon, and tractive forces are high tides are the common phenomena. One more thing I would like to write here that I can see that the highest of the high tides can are observed, fine.

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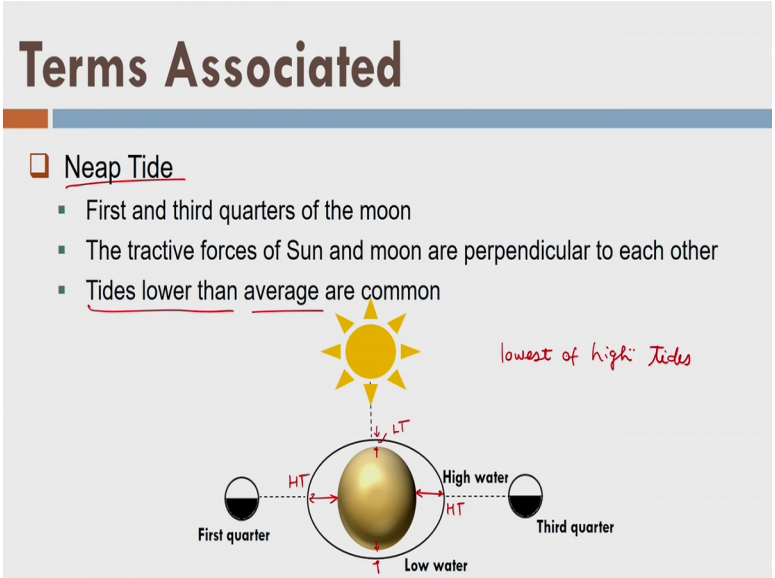

This is another phenomenon called neap tide; where sun and moon are at 90 degree to each other with respect to the earth. What will happen? As we know that moon is more effective. So, there will be high tide here and there will be high tide here, right. But you can see here that sun is less effective.

So, we have low tide here, and low tide here. But you can see one more thing since both sun and moon are trying to attract the water surface in completely opposite direction or at 90 degree, fine. So, one is this vertical direction one is horizontal direction on the screen.

Now, what will happen? We will expeditiously high tides no doubt in the direction of moon, we will experience the high tides towards the moon, and you will experience the low tides towards the sun. However, the amount of the high tide or the height of the tide in the ration of moon will be much less than the highest tides or the spring tide. And I can see here one thing that this tide is although high tide, but it is the lowest of the high tides, right.

So, I can see the tides are lower than the average here, fine now you can understand what is meaning. Meaning here is we see that it is the lowest of the high tides. And that is called neap tide here, fine. So now, we have understood why tides are coming, why the water level is raising, what why there is a variation in the tide level, when we have maximum tide, when we have minimum tide ok or the lowest tide or highest tide, fine.

Now, at this stage we should also know, what is the frequency of the tide at a place on surface of earth. So, here you can read it the position of the moon at third and first quarter are creating the neap tide.

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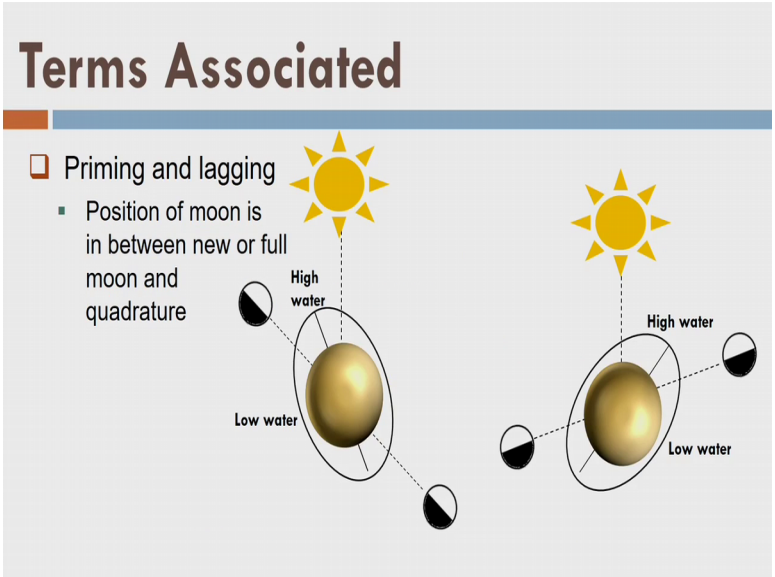

This another phenomena called priming and legging. When the position of the moon is from the lowest tide to towards the high tide, that it is called the priming and the vice versa that is the position of the moon from the high tide to low tide is called lagging. So, like these are the fixed terms here ok you can now, what is the frequency of the tides.

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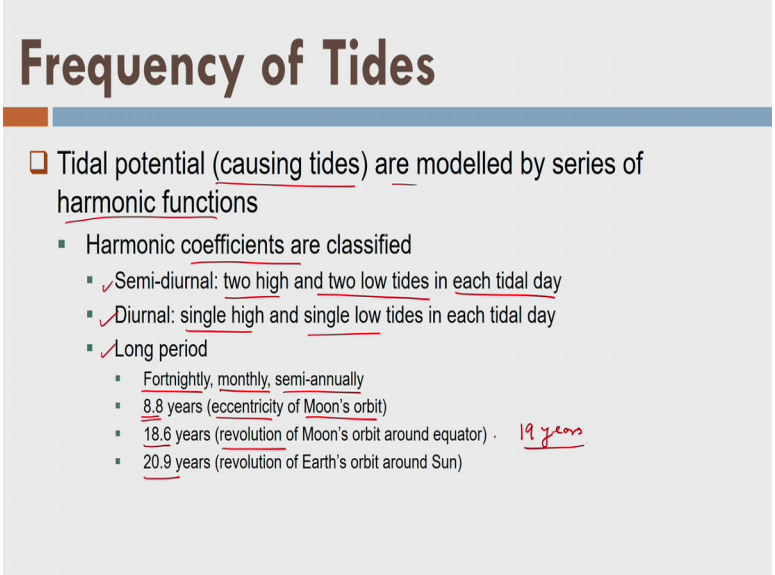

Ok, so now we can see the tidal potential which are causing the tides are modeled by series of harmonic function, because they are basically varying like sinusoidal form or we can say some kind of periodic functions the tidal forces. And they are creating the tides like that.

Now we divide the harmonic coefficients into the 3 categories one is semi diurnal; that means, too high and too low tides in each tidal day, then diurnal that is daily the single height and single low tides in each tidal day, then we have long period. Long period means fortnightly monthly semiannually that is 6 month, then 8.8 years because eccentricity of the moons orbit, sometimes moon is closer sometime moon is away from the earth in it is orbit. So, then we have 18 point 6 years or 19 years if you remember that year. That is because of the orbiting of the moon around the earth.

Similarly, earth also revolves around the sun over a period of 20.9 years; that means, the point will be exactly at the same position with respect to sun after 21, 20.9 years or 21 years, fine. So, but as we know that effect of the sun is much less than the moon, that is why we always prefer a period of 19 years for the observation of the tides; that means,

the create the MSL by observing the variation of the tides over a 19 periods, 19 years' period at a place or at a seacoast right. So, I hope that you got the idea what we having lot of variations or why do we you know go for some kind of technical analysis for the tides.

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So now let us understand, what is the necessity of the hydrographic survey, well we have said the tide is there and tide is going to increase the water level, tide is going to decrease the water level, then the average value. But I want to measure the depth at each and every location at each and every moment instant.

So, what is the reason? Reason is that we want to expand the offshore engineering and shipping industry, and if I construct some structure or some sea coast I need to have this data of hydrographic survey, that what is the material available or what is the material has to be cut from the available sea surface, right.

Then we have to locate resources like, oil and gas wells in the sea offshore sites, for that also I need to bring my boat or the staff members to act place for the drilling. And for that purpose we also need this data of hydrographic survey ok, then we also see the supporting material has to be provided, sea and river navigation we already talked about and then recreational purposes.

What are the recreations? If you go to some kind of place like Goa, you will have near the sea, what will happen? Some there are some scooters are moving in the water surface and they are available on rent for such kind of recreational facility also we have to have the information about the tide as well as information about the 3D data of the surface bed of the water body.

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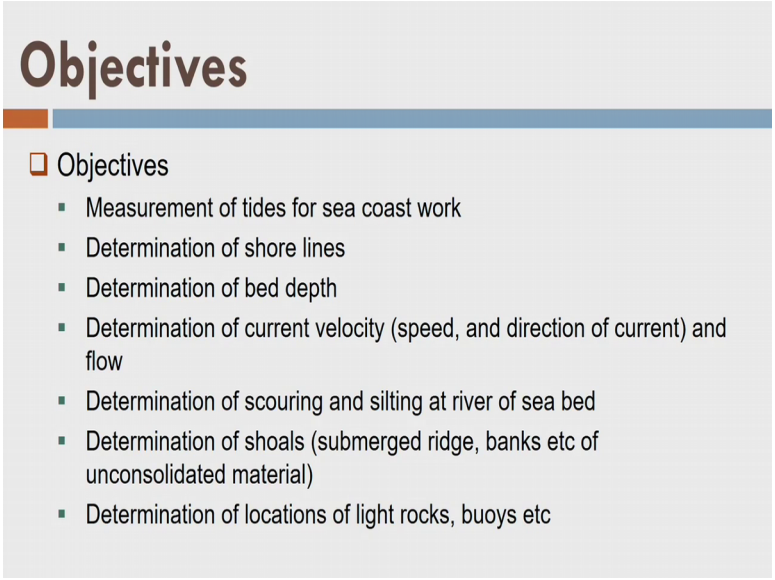

So, what are the objectives here? First of all, I want to measure the tides, then I want to determine what are the shore line's, then what is a bed depth? What is the current velocity and speed and direction of current in case of reverse, and what is the amount of flow?

Fine, because for the river navigation, these factors are very important. And ok, what are this scouring and silting, then for the rivers. Then shoals, shoals are the submerged ridges and banks of unconsolidated material; that means, they keep on moving with the flow of water; that means, when there is high tide in the sea what will happen? Because of the attraction forces or tractive forces are bringing the water at one place and again they are withdrawing water, because of that movement, because of that there will be a moment of the shoals so I want to determine those.

Ok, then what are the places where light rocks and buoys are there, right?

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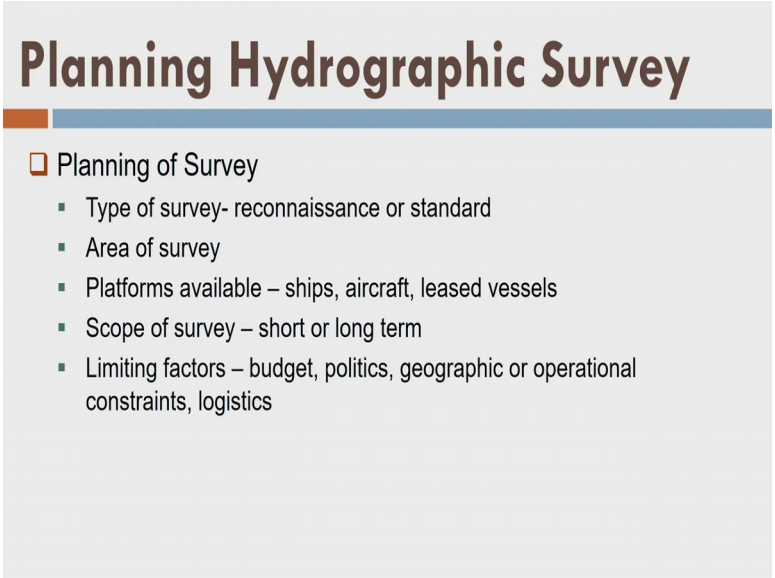

So now how to plan the hydrographic surveys? First of all, we go for the reconnaissance survey, then we also should know what is the area of the survey, which is like 6 some kilometer square, some kind of few kilometer to kilometer what is that and then platforms available like they have ships aircraft or vessels. Then whether say short term or long term survey; that means, long term means I will collect the data after certain period which is quite long and short term means and frequently taking the data.

Then other limiting factors like budgets, political regions geographic or operational constraints and logistics are these all factors we should consider in planning part of the hydrographic survey.

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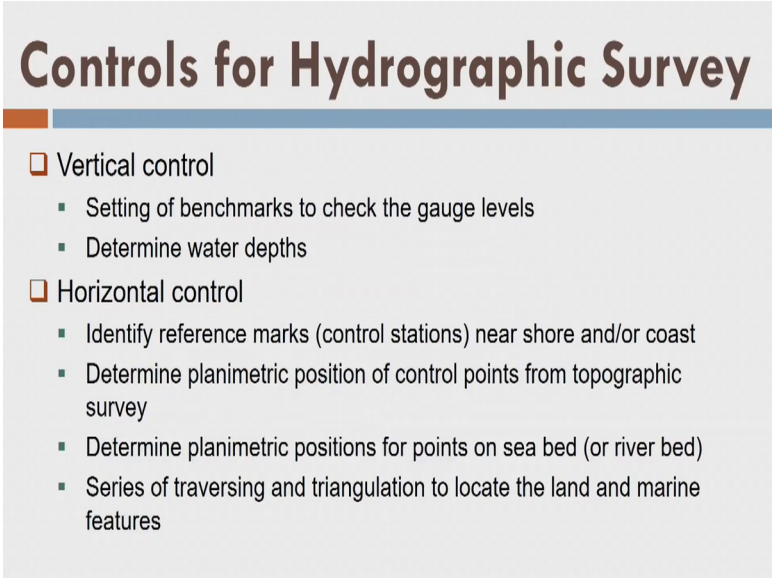

Now, in case of hydrographic survey as we told I want to observe the 3D information, or I want to measure the 3D information, fine. The thing is that how to obtain that. So, we have to establish the control service. So, first is vertical control. So, what is vertical control? We have from the topographic data, some data available about the benchmarks.

So, using those benchmarks we bring the control stations very close to the sea surface or what you call shoreline. We will see all these terminologies in the next lecture, but right now try to understand what is the concept here ok.

Then using those benchmark sense, we establish the levels of the seabed fine. So, that is my vertical control. What about the horizontal control? Similar to the vertical control, I have bring the points of the horizontal control, that is the x and y positions from the topographic survey to the near to the sea coast.

And there also establish some control stations, and those this process is called the horizontal control. And using this horizontal control we determine, what is the horizontal position of the point, which is lying under the water, but we measure it from the surface of the water, ok.

Now, you can understand that because the planimetric position x y is measured on the surface of the earth. At the same time we measure the depth of the water surface, right by some mechanism. So, we need to ideally separate into 2 surveys, but still it is not a

pseudo survey, no, it is not a pseudo survey because we are maintaining xy and z at the same time.

Moreover, we are considering the curvature of the earth also, and we are we have no more projecting the earth on the you know plane projection fine. So, it is not a pseudo pseudo 3D survey, it is a perfect 3D surrey. But the thing is that the measure the xy on the water surface, also we measure the depth of the sea bed on the water surface, but we need to have the different different instruments.

For that purpose, because I cannot measure the depth of the water using the convention instrument like pseudo light total (Refer Time: 42:58) and so on. I need to have some different instrument. And for that purpose we separate the planimetric survey and the vertical survey in case of hydrography, fine. I hope that you got the idea here.

So, let us see that some more terms.

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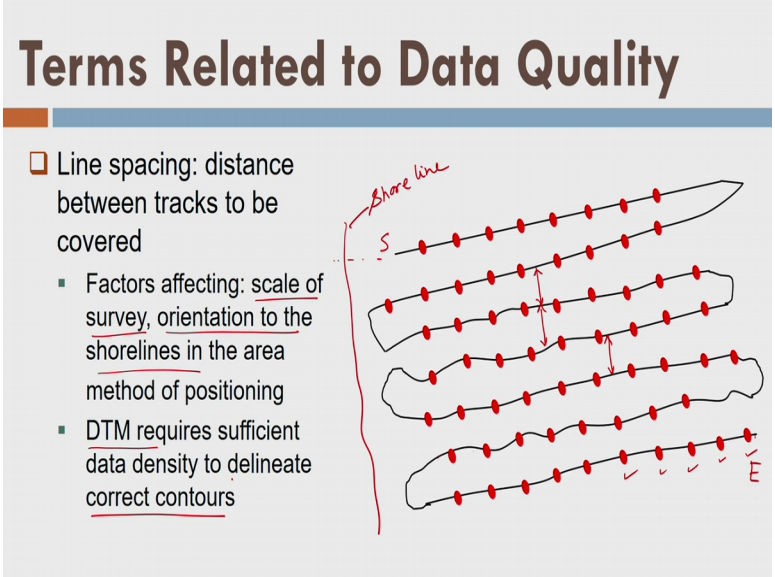

So, once we conduct the survey what do we do? Basically we take a vessel, now (Refer Time: 43:19) the vessel along a straight line ok. During that straight line we observe the points at regular interval, a regular time interval or regular distance interval whatever, fine. So, this is shown here, now you can see here because of the variation in the current velocity, or variation in the boat we are having lines which are not straight, but still we are trying to maintain them.

So now these are the data points I have collected at irregular intervals, on the each line, and these are the lines or the track of the vessel or boat, fine. You can see here that the distance between the 2 lines here, I can say that average distance. So, that is a good way to mark here, this is my line spacing. This is the line spacing, this is the line spacing and so on, right.

So, line spacing besides the density of the data points. At the same time we will see in coming lectures that line spacing besides the time interval to cover the whole area; that means, the duration of my survey a rather indirectly it is giving me the cost of a survey. The higher the data density, higher the cost, higher the data acquisition time, higher the cost, fine.

So, what are the factors that affect this line spacing? One is the scale of this survey as I told if I have higher density of data points or higher accuracy of data points, what will happen? Definitely, my line spacing should be smaller. What about the orientation of the shorelines in the area? Right now, we assume that the shoreline is like this, and that is why we are starting either from this point, this is my starting point and this is my end point here, right. So, the starting from shoreline with the boat here, and we are finishing of survey here at end point.

So, this orientation of the shore line, that also decides the data space or the line spacing, ok. Now the DTM ok, the efficiency of the DTM is or for the correct contouring now. So, DTM require the sufficient data density to draw the correct contours; that means, I need to have more amount of data at the same time I need to have more accurate data; that means, each and every points should be more accurate for higher contour interval.

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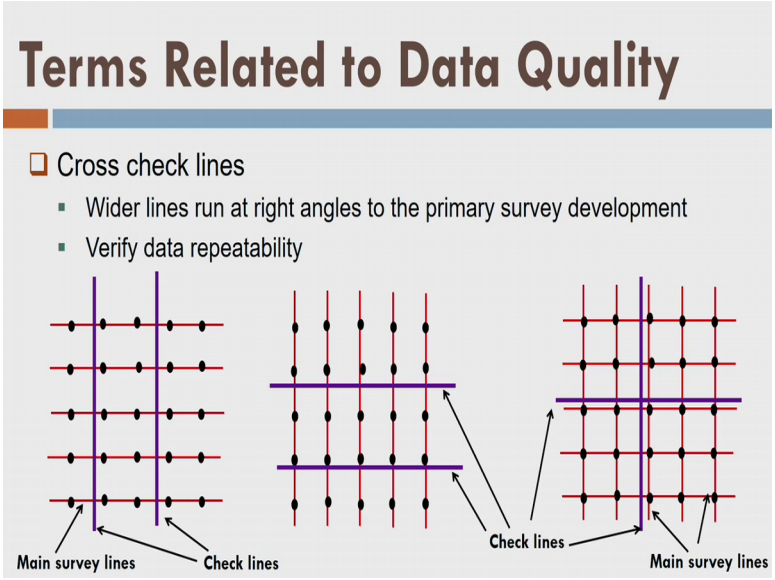

Fine, here these are cross check lines or they are sometimes called tie lines ok.

We can see here, these lines are the cross check lines. Here we can see that these are my main survey lines that we have already discussed in last slide. Then after doing this survey and after collecting the points on these black dots, what do we do? We try to validate our work by collecting some points on these lines which are perpendicular to the survey lines, fine, and these validate my work here.

Similarly, if my survey lines are vertical on the screen, these are my cross lines. So, I am collecting data over there in order to validate my work, ok. Similarly, if I have 2 type of survey lines horizontal vertical. So, I will have 2 type of my cross lines also like this right. You got the idea that how do we validate our work.

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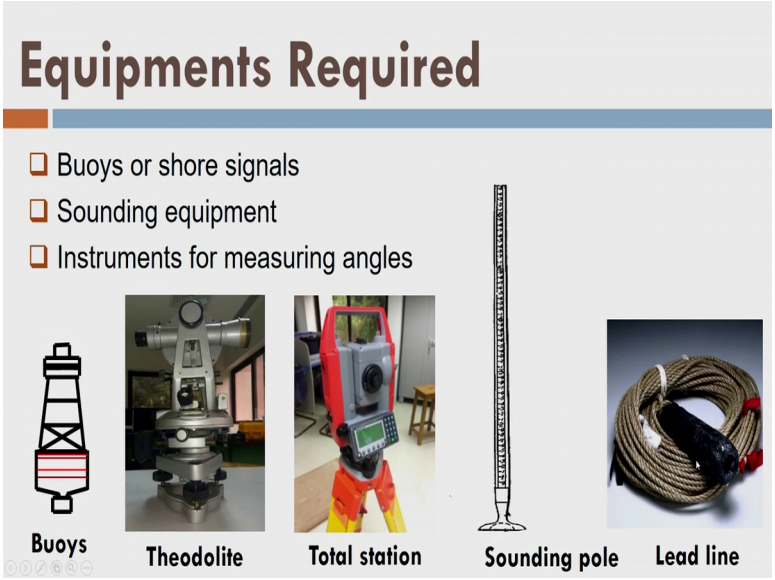

So, what are the equipments required bios and shore or shore signals; that means, there are some signals which are floating in the water and where we measure our xy position as well as depth. So, these are called bios and here it is indicated ok. For the angle measurement we have theodolite, what the total station? Also now they did it is used, because we can measure the distance as well as angle with the total station.

Now, sounding poles and the lead lines. Well, we will look into these things what are the lead lines and sounding pole, basically these 2 instruments are used in order to measure the depth of the water surface or the water bed. And then we have sounding equipments, in sounding equipment, these are my sounding equipment, lead line and the sounding pole, and also we have sounding equipment like echo sounders. We will see all these thing as we proceed in this lecture.

So, first the lead line method which is the data collection method we can say the planimetric data as well as the; So now, we are considering some of the methods to introduce you how to do the measurement of the depth.

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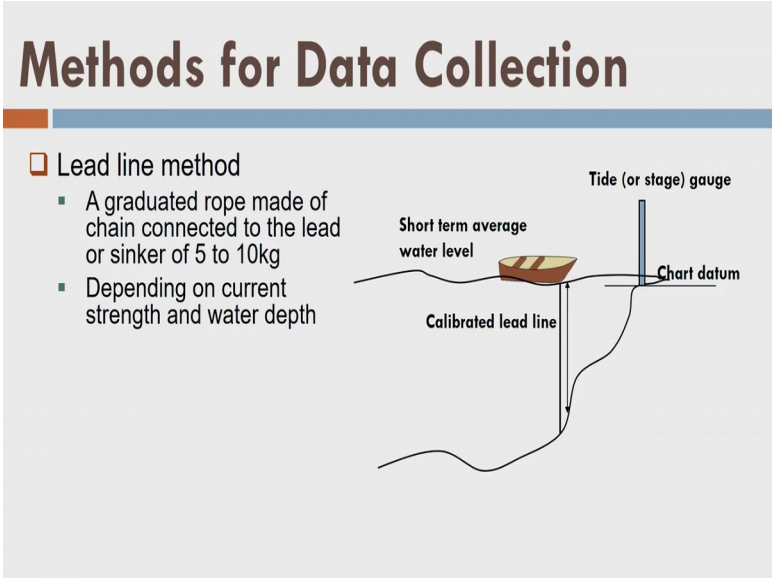

So, first this lead line method here there is a graduated rope, now with the help of some heavy weight 5 to 10 kgs I am suspending that at a position where my bio are located. So, bios are there on the water surface which is floating. So, I bring my boat there stop there and try to suspend the lead line. So, lead line having a heavy weight at the end what will happen? It will keep on going lowering down itself under the itself weight, and when it touches the seabed or riverbed, I will stop and I will measure the height.

Since it is a graduated one and having a 0 mark on the bottom what will happen? The point which is closer in my hand of the rope, it will indicate the depth of the water surface fine. That is a simple idea here. So, it is also shown here in the figure.

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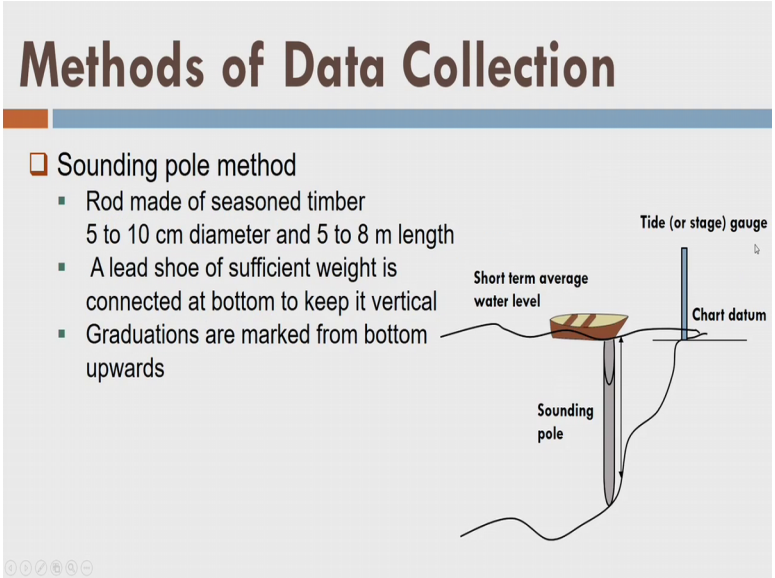

Now, second is sounding pole method. So, instead of rope now I am using a sounding pole, which is 5 to 8-meter length and it is having 5 to 10 centimeter diameter, ok. What I am doing? I am again approaching the bios, that moment I reaches to bio at the x y location or at the position of bios, I will just drop down pole which is called sounding pole vertically down ok. I assume here that there is no water current.

So, water is still a very it is very, very calm and as a result whatever depth of the water is there, that will be indicated by the sounding pole. And sounding pole at the time of measurement it touches the riverbed or sea bed, fine. As I know that it is only 5 to 8 meter in height or length. We can conduct from hydrographic surveys with this sounding pole if the depths are in this order, fine.

So, these are the idea. And the key point here is that the 0 point is always marked at the bottom where the sounding pole or the lead line touches the river bed.

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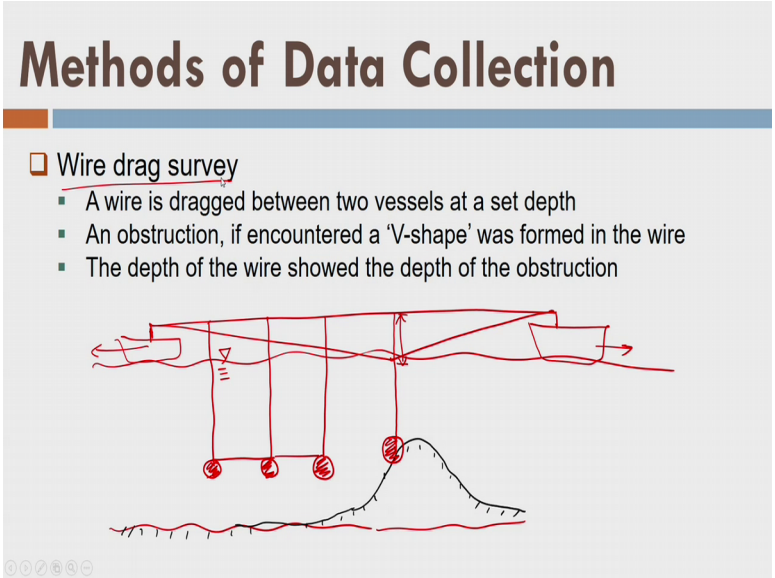

There is something called wire drag survey. In case of sea or in case of big water bodies, what happens? We have 2 vessels. Let us see there is one vessel here, and there is a water surface here. And let us say there is some water bed here, fine. So, let me just draw this is water surface here like, ok.

Now, we have 2 vessels here, and there is a wire we dragged a trash between the 2 here, ok. On this wire what do you do? We have some bios ok, and then we try to suspend some heavy weights like this. These are my heavy weights here ok. And again we suspend the another one here, like this, and they are also connected here in now.

Similarly, we do keep on doing this thing, fine? Now let us say there is some obstruction like this here. On the water surface; that means, my the river bed or the sea bed is like this fine ok. That is here this is sea bed and sea bed is here like this. What will happen? The moment we suspend the wire here, it will happen it will interact here at this less height, fine.

Now, as 2 ships moves what will happen? The catenary or the straight length of the wire drag will be made like this, and they will v shape here, at this point. Now we can understand that there is some obstruction in the on the water on the sea bed or river bed, right. So, that is idea here. So, I can find out by putting this correction, what is the sea bed depth here. And so, that is the idea called wire that is the idea of the wire drag survey, ok.

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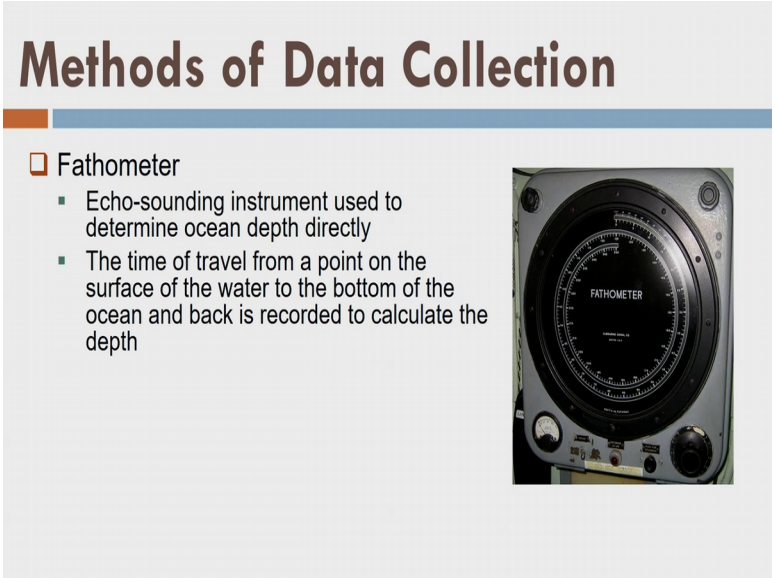

So now we have the fathometers or what we call echo sounders, originally there named fathometers, and now the days we are using the term echo sounder. What it does? It basically sends some sound waves into water surface, and that sounds waves interact with the surface of the seabed or the riverbed and it reflect back the energy of the sound, and again it is collected by the instrument.

So, by measuring the travel time so, by measuring the travel time of 2 in flow distance, we measure the time of travel and using that time of travel, we determine the depth of the sea bed or river bed fine. So, that is the idea of the fathometer.

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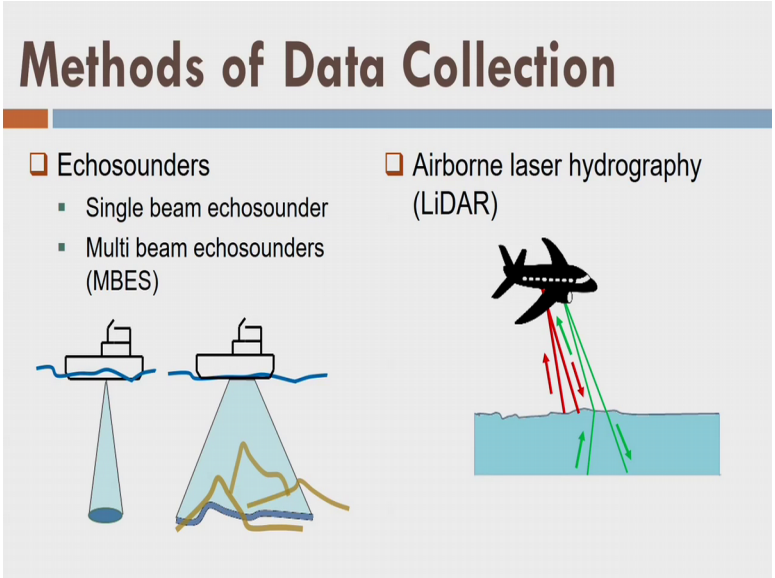

Then we have the eco sounders as we told, then we have the single beam echo sounder. Means, it throws the sound pulses vertically down towards the surface. Then we have multi beam echo sounders, which throws the pulses in the across the track manner, remember? Like LiDAR or in case of radar we have the same mechanism what we call of this broom mechanism.

So, according to this broom mechanism if sea bed is moving like that so the multi beam echo sounder is throwing the pulses in this direction like this 1, 2, 3, 4, 5, 6, 7, and again as we move 1, 2, 3, 4, 5, 6, 7 and so on. So, the multi beam echo sounder is throwing the pulses towards the sea bed, and it is acquiring the data in the zigzag fashion, fine.

Now, let us look another method airborne laser hydrography. You can see here that all the methods what we have discussed like sounding pole, sounding line the lead line or the echo sounder, all of them are little time consuming, because there are coverage is very less.

But at the same time we realize that there are some pulses like sound pulse or the laser pulse they can penetrate through water and as a result we are now want to use them; what if I use the airborne facility; that means, there is a LiDAR sensor that is throwing the pulses towards the water surface and as a result there are 2 type of pulses one is a red pulse here; that is interacting with the surface of the water and it is reflected back ok.

On the other hand, this is another type of pulse which is green pulse here and that is being that is penetrating the water interacting with the river bed here and going back right.

It is reflecting also, but again it is reflected back and it is going back to the sensor, and by measuring the time interval of the green and the red pulses, I can find out what is the depth of my sea bed. And the coverage because of the airborne facility will be much higher compared to the echo sounder which is used with the vessels, fine. That is the idea here about the measurement of the depth.

So, we will be discussing all this instrument in detail in coming lectures, but here we are giving just an introduction that how do we perform hydrographic survey, and what is hydrographic survey? So, as we realize now that we need to collect the data by hydrographic survey. So, first we should understand that it is a different kind of survey compared to the topographic survey.

And so, we have the different standards and that is why we should first understand those standards, and then we should try to think that what is the quantity of work, and what is the kind of work we need to conduct when we talk about hydrographic survey.

So, let us go ahead one by one.

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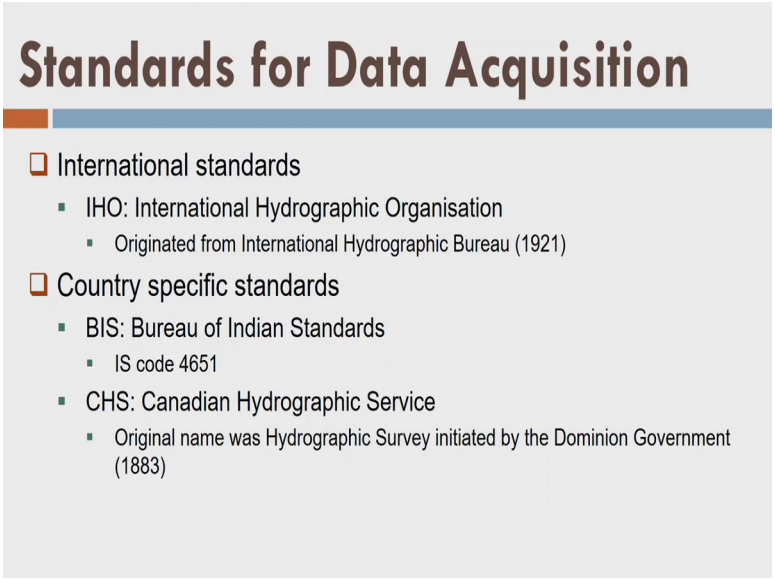

So, we have 2 kind of standards; that means, one is international standards, that has decided by the International Hydrographic Organization IHO, and that is basically governed by the International Hydrographic Bureau IHB, fine. And then we have the country specific standards.

For example, India there is a bureau of Indian standards. They are they have developed a code is code 4651, which discusses about the standards for India. At the same time, we have the Canadian hydrographic services they are developed for the Canada.

So now we are going to discuss about the IHS standards and the BIS standards in this lecture. We are discussing the context specific code at the same time we are discussing the provisions in the international standards

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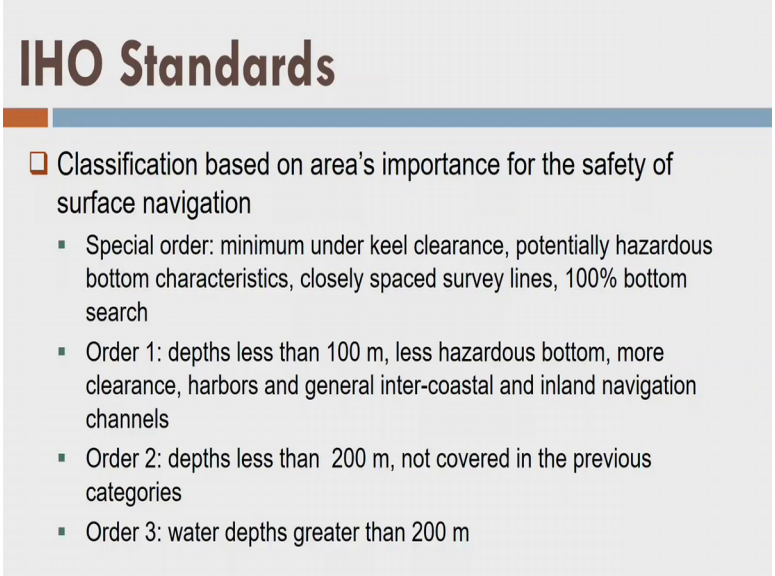

So, let us talk about the IHS standard first. It divides the basically the area, area to be surveyed, right according to the importance. And so, it has 4 orders one is special order then we have order 1, order 2 and order 3 surveys.

So, order 3 surveys are for the water depth more than 200 meter, order 2 for less than 200 meter. Order 1 is less than 100-meter water depth. Again it has some other specifications according to 100 meter 200 meter and 300 meter, fine; that means, for 100 meter or order 1 survey we have less hazardous bottom, more clearances harbor and general intercostal and inland navigation channels.

Now, what about the special order? Ok, we define a term minimum under keel clearance; that means, because of the weight of the vessel what happens vessel or ship, some emergence partly into the water surface. So, after some emergence from the bottom of my vessel to the riverbed there should be some minimum distance, and that is called mean under keel clearance. So, in case of a special order survey, we try to determine what is the mean under keel clearance is it available or not, for a given water vessel or for a given ship under the some loading conditions, right.

And hence here we see that we are looking for potentially hazardous bottom characteristics; whether their shovels whether there is some underwater permanent body at a given point or any other obstructions there, we should look for those things. And that is why we say that we should have the closely spaced survey lines. Or we say that whatever we do we should cover the 100 percent bottom search and that is called a special order survey.

I hope you got the idea now, that why do we need a special order survey order 1 survey order 2 survey and order 3 survey for hydrographic survey practices. And this is the specifications of the international hydrographic organization.

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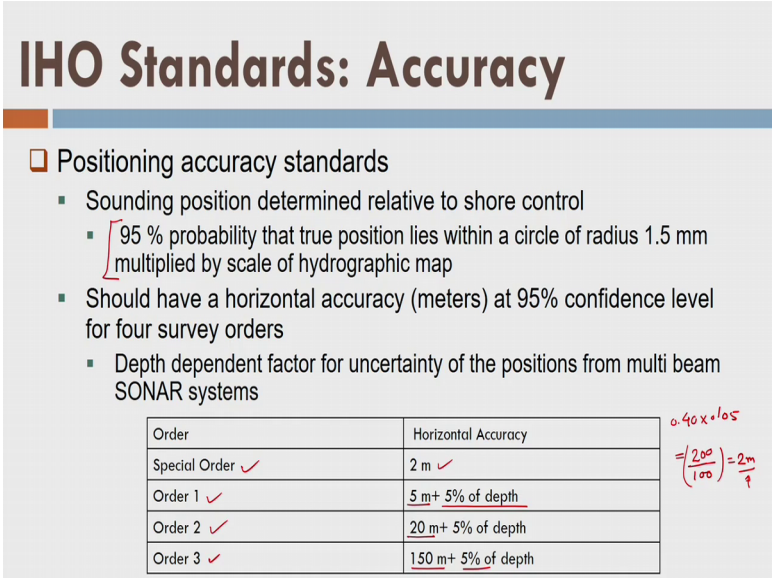

Let us go ahead, now what about the positioning? So, we want to discuss about the positioning also, we determine the sounding which is nothing but depth ok, at the same time we determine the xy position; where we are determining the sounding position.

Now, imagine that I am using a sounding instrument which is quite accurate, but if there is no accuracy of my sounding position x y, then there is no point of having the higher accuracy of the sounding instrument. And that is why we need to specify the accuracy of the horizontal positions also fine. So, that is why we see define that the 95 percent probability that the 2 positions should lie within the given accuracy level of horizontal position, fine.

Now, the days and the latest version of IHO we have a specified that we should also consider the depth of the water right in order to define the horizontal accuracy; that means, if higher the depth, I can have some little tolerance on the horizontal accuracy of my position. And that is why they say that for a special order, there is no compromise; that means, each and every point xy should be located within 2-meter accuracy; that means, and that is coming from 95 percent confidence interval fine. I hope that you want the idea, because we have already discussed these 95 percent criteria in my adjustment competitions or in the basic surveying there in dealt in detail ok.

Next is order 1 survey what is this? It is 5 meter plus 5 percent of the depth; that means, if my depth is let say 40 meters now we say that the order 1 survey has to conduct for the depth below 100 meters. So, yes 40 meter is appropriate for order 1 survey, now if we take the 5 percent of the 40 meter that will be how much? 40 into 0.05, it is equal to let us see here ok, then we can see like this, ok.

So now you can have 2 meter additional one. So, we have a 2-meter additional tolerance in case of order 1 survey. Similarly, we have 20 meter for order to survey we have 20 meter plus 5 percent of the depth, and for order 3 we have 150 meter plus 5 percent of the depth. So, this is the way we calculate the possible accuracy level for a given depth of my (Refer Time: 60:44).

Now, you can see here if I measure the depth with high accuracy, I can comment that what is the tolerance of my planimetric position. Or what is the tolerance of my accuracy of the planimetric position, fine. Now one more thing is there that the depth accuracy. So, we just talked about the position accuracy, now we are talking about the depth accuracy.

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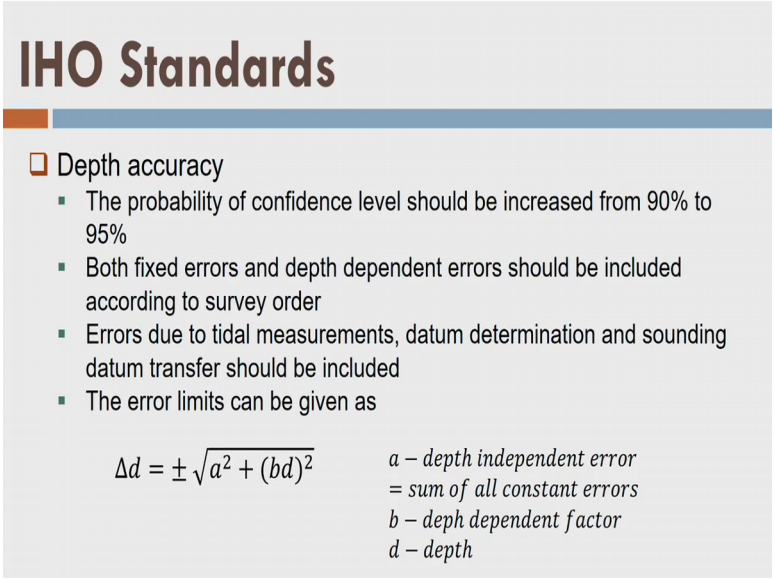

Again we have defined the 95 percent confidence interval level, and both fixed errors that is constant errors and depth dependent errors should be included here, ok.

So, all these errors has to be included and other finally, how to determine the errors or the accuracy. So, it is a square plus b into d times whole square; where a is by depth dependent or the constant error. So, if I make the sum of all the constant errors which is equal to a here, and b is depth dependent error so, these, my depth.

So, I say that remember we said in case of position error, 5 percent of the depth. So, it is somehow b is like that factor. So, b into d then will make this square, and we make they summation of the squares, and then we take the square root, and then we say that this is my depth accuracy. So, we should be very, very careful now in order to evaluate the my depth accuracy of the surrounding operations, right.

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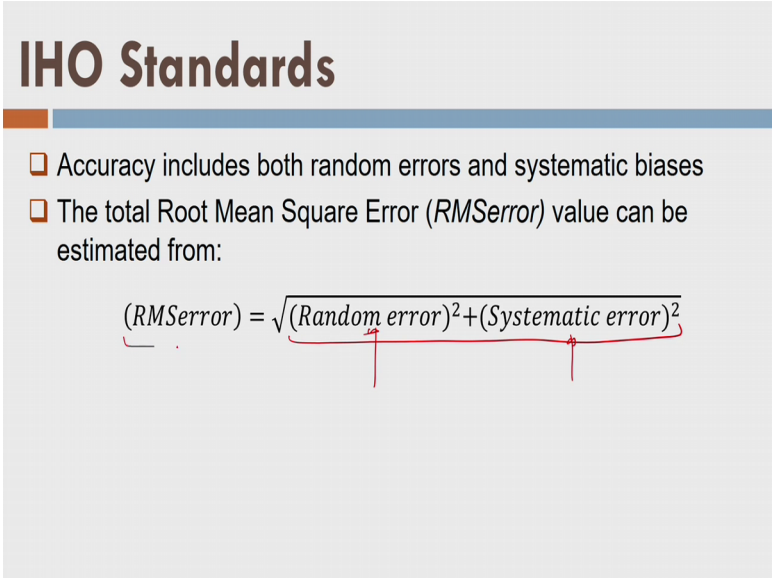

Then if we have systematic errors and is random errors, we should make the use of this formula; that means, this is my systematic errors square, random error square and then we use this RMSe logic

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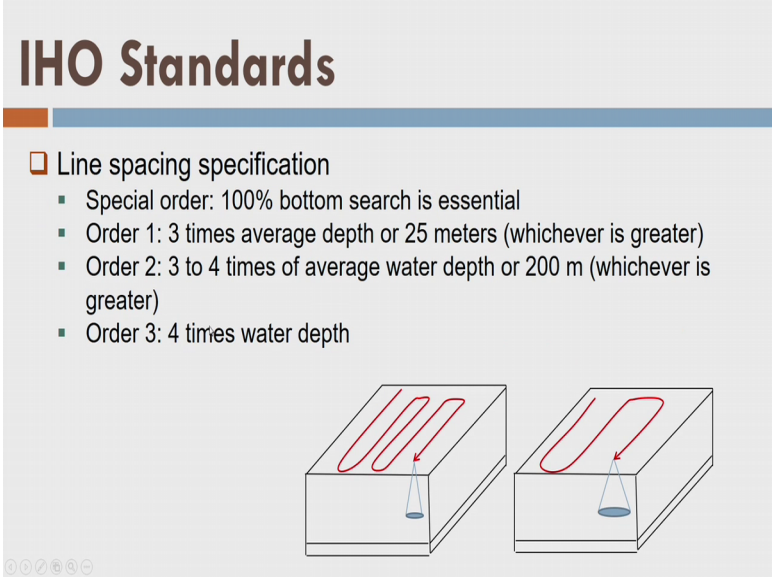

Ok, what about the line spacing? Fine, in case of special order we have 100 percent bottom search which is essential that whatever accuracy we maintain or whatever line is spacing the maintain in case of special order survey, I have to have exploration of 100 percent bottom; that means, complete sea bed or river bed has to be checked. In case of

order 1, we have 3 times average depth or 25 meters in case of order 2 we have 3 to 4 times of the average water depth or 200 meter. So, whichever is greater and then we have order 3, which says 4 times of the water depth.

So, here the line spacing has shown here and it is fighter line spacing here, you can see. So, these line spacing are decided according to this survey order criterias.

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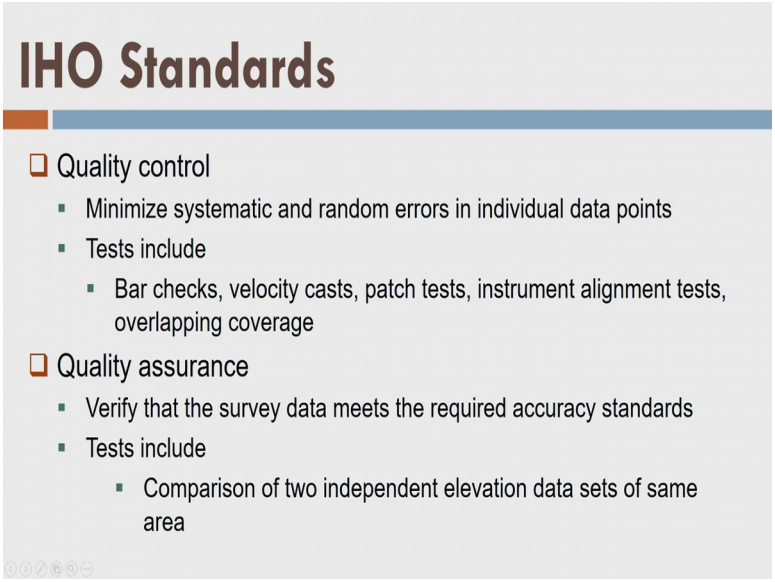

Now quality control so, we should minimize systematic and random errors that is my quality control, and then what is the quality assurance. I should validate my accuracy is also, right, that is called the quality assurance here, ok.

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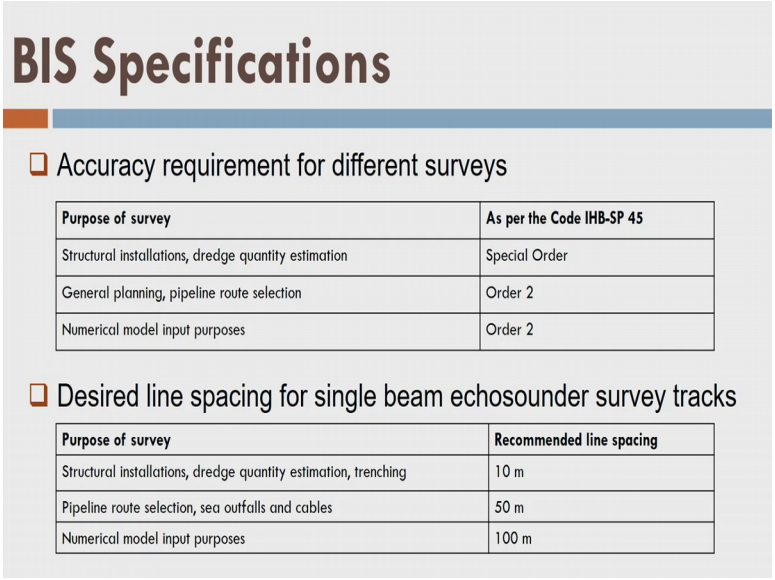

Coming to the Indian standards, which are governed by the Bureau of Indian Standards. So, the accuracy requirement here is according to the purpose of this survey. So, for the structural installations dredge quantity estimation we should have a special order survey, and a special order survey are according to the, is standard not the IH standard, please careful ok. So, then general planning pipe line a route selection, we have order 2 survey, and then we have order 2 survey for the numerical model input purpose.

So, how to design the line spacing for the single beam eco sounder purpose for this structural installation here, we have 10-meter line spacing, then we have for the pipeline route selection we have 50 meter, and again for numerical model input processes we have 100-meter line spacing.

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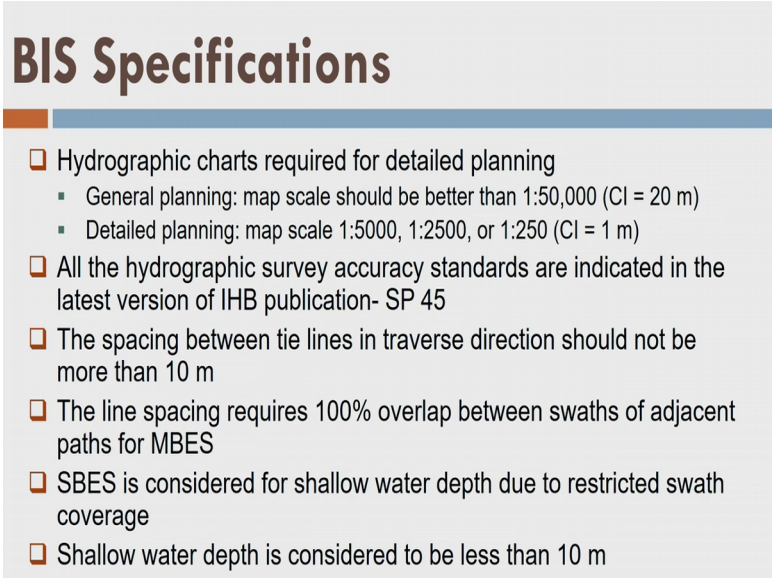

Now, we should also prepare the hydrographic charts, for the detailed planning, and in order to do the general planning we should have a map of once to 50,000 with a contour interval of 20 meter. For the detail planning you should have a map scale of 1 is to 5,000 a 1 is to 2 5 double 0 or one is to 2 50 also very high level map, but very high contour level also 1 meter, fine.

So, the accuracy standards are to be followed as per the IHB publication sp 45 which is nothing but international hydrographic bureau. Then the spacing between the tie lines or the cross lines in traverse direction should not be more than 10 meter. Here is spec very special thing about the cross check lines be careful on this.

And line spacing requires 100 percent overlap between the swath of adjacent path for multi beam echo sounders; that means, if I am using the multi beam echo sounder for very special purpose services surveys, then I should have the complete coverage of my seabed.

So, single beam echo sounder are to be considered for shallow water depth; that means, if water depth is less than 10 meter I can use the single beam echo sounders.

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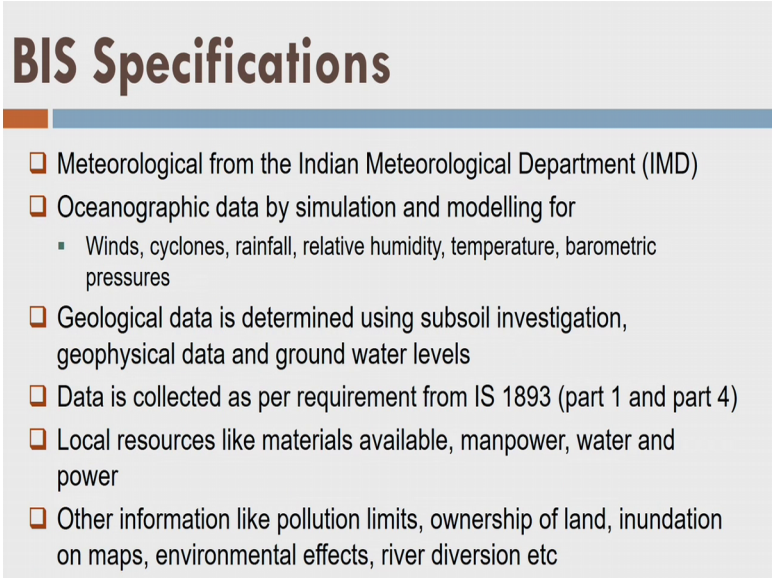

Now, in addition to that the Indian standards also specify meteorological data, oceanographic data, zoological data, data to be collected as per this standard, when local resources and other informations ok.

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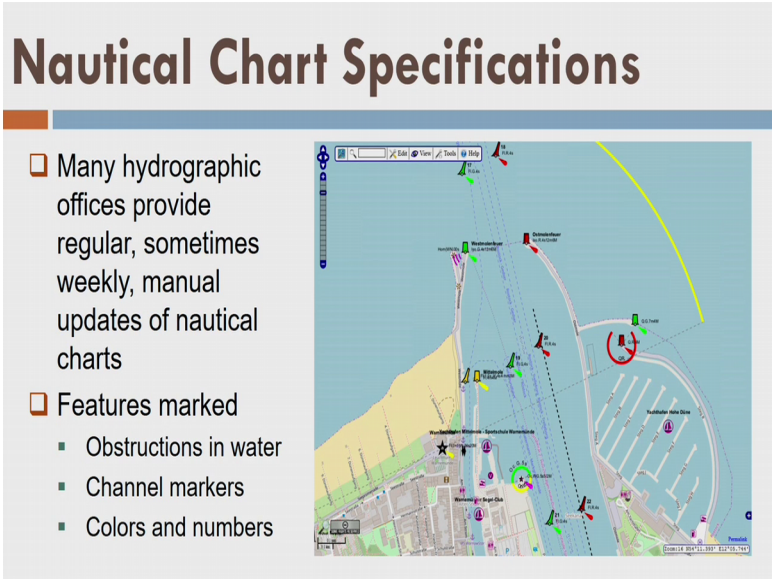

So, once we collect the hydrographic data or by hydrographic survey, what do we do with data? We develop the nautical chart. So, what is nautical chart? Ok so, nautical chart a specifies obstructions in the water and channel markers and it uses different colors and numbers. So, we will see this a specification now.

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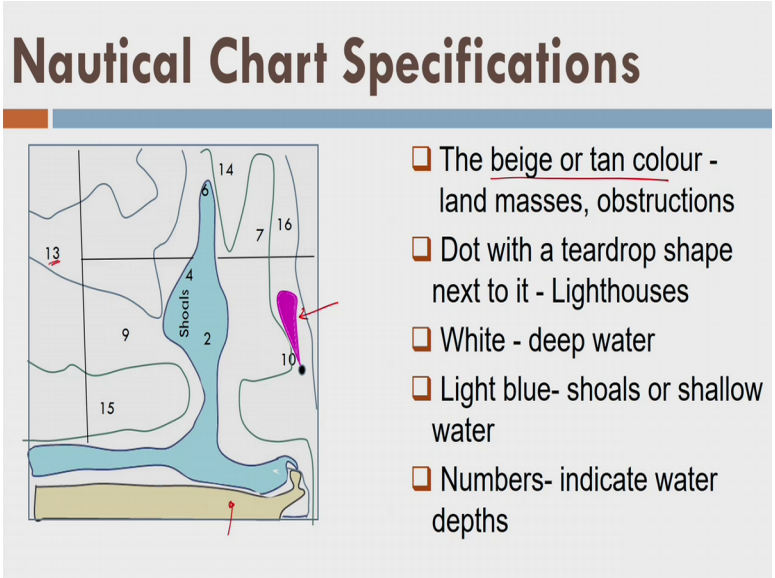

Let us see this is my nautical chart. So, the beige or tan colour here indicates the land masses or obstructions, fine? So, this is my land mass or it could be the shoreline or some kind of land surface.

So, if we have dot with a teardrop it indicates lighthouses like this. So, this is the location of the lighthouse ok. Then we have white for deep water and we have light blue for shoals or shallow water. So, like this, this is my shoal and this is the remaining by part is my deep water fine. So now, you can see here shoals ok, then we indicate numbers to indicate the water depths. So, these are my numbers indicating the water depth here, fine.

So now you can see that here some depth of unit 13, fine.

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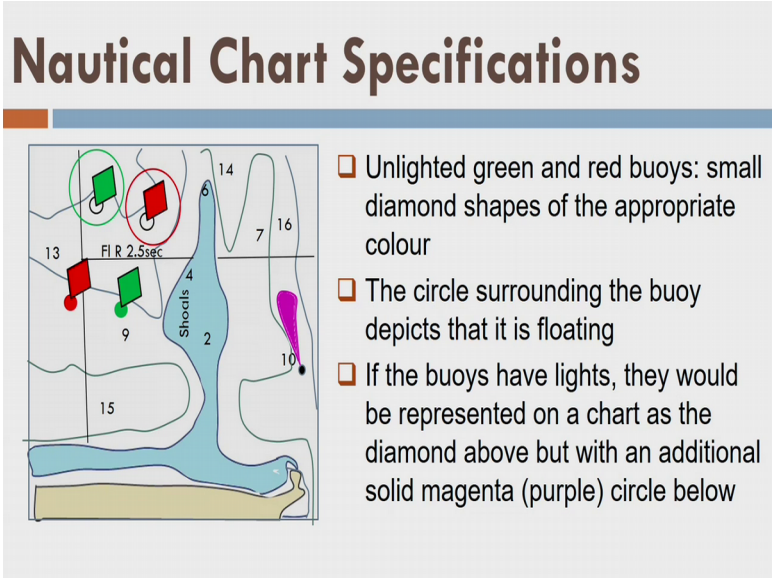

Ok, what next? We have the unlighted green and red buoys to that is small diamond shapes of the appropriate colour. So, these are my small diamonds; that means, the red is indicating the red colour bios and the green is indicating the green colour bios, fine.

Now, we have the circle surrounding the bio depicts that it is floating; that means, if I draw the circles like that, it means that both green and the red bios are floating on the surface of water. Then we have bios like that which we are showing with a colour here, the fill colour, filled circle you see, they are indicating that they are flashing, they have some electricity light and they are flashing.

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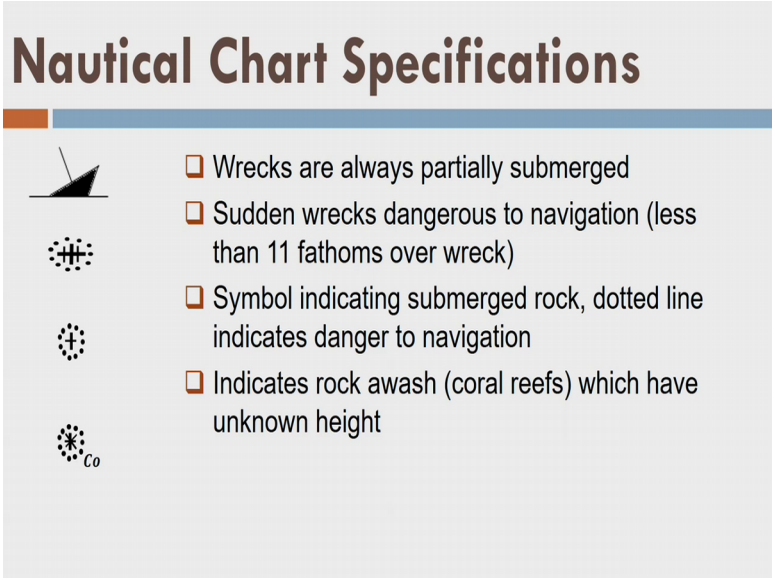

Now, we have some other features also like wrecks, and sudden wrecks and they symbols other symbols like indicating danger to the navigation so, like this. So, then we indicate rock awash coral reefs which have unknown heights, like this.

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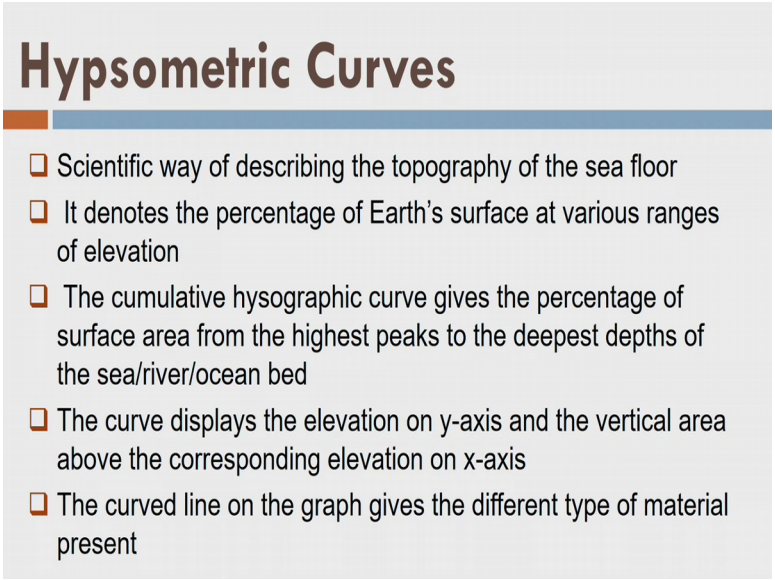

And then there is another expression of the hydrographic survey data which is hypsometric curve; especially for the sea ok.

What is the hypsometric curve? It is the scientific way of describing the topography of the seafloor, fine. It denotes the percentage of the earth's surface at various ranges of

elevation; that means, if I draw a elevation level, that how much area is above that level on the land as well as above the land in the sea. The cumulative hypsographic curve gives the percentage of the surface area from the highest peaks, to the deepest depth of the sea river ocean bed.

So, this idea this kind of elevation curve it is giving me, and that is giving that where the sea depth and what is the depth. But it is very, very low scale curve. So, the curve displays the elevation on y axis, and the vertical area above the corresponding elevation of x axis. The curve line on the graph gives the different type of material present, fine.

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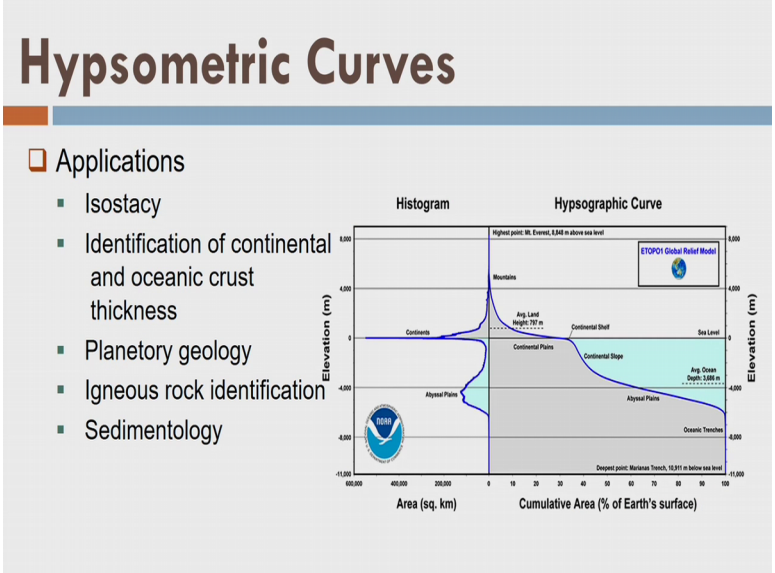

Now this is an example that we have taken from the website of nova. And here we can see that this is the water here. So, this curve is showing the surface level of the sea floor or on the land as well as under the sea. So, this is my continental plane and this is my sea here; so, here is my sea depth, fine ok. That is my 0 level so, as we go along here by unit of 10 20 30 and so on.

I will, I am having at this elevation levels for example, at 4000, minus 4000. So, this is the water level and this is my sea level. So, I am saying 0 level, and again I am indicating what is the average ocean depth here. So, this is my elevation level here now you can understand and this is the cumulative area of all surface on the; so, as we are going in the x direction the cumulative area is 10 20 30 40 and so on, right.

So, what is the data available here? And here I am we are showing the histogram that is what is the area, here like this under this one water and so on. So, that is what we call hypsometric curve and, what are these applications? Like, isostacy continental ocean crust basically they are later to the geological studies, but they also come from the hydrographic data. And that is why we say that we have 2 products one is nautical chart and other is hypsometric curve.

So, with this we say that we are now close to the end of our lecture 1, and that is the introduction and the fundamental concepts of a hydrographic survey. I hope that you could understand why do we do the hydrographic survey, what are the tides, what is low tide high tide, what is the frequency of the tide, how tide varies.

So, how the tractive forces are accumulating the water on a 1 surface or the one point on the surface of earth and creating the high tides and low tides of other places, fine. With this we realize that how hydrographic surveys are very important for river as well as for the sea in case of river, we have the river navigation; in case of sea we have navigation as well as tide problem or tide phenomena.

So, with this idea we also at the end we understand that, what are the standards, which are quite different from the topographic survey and we should follow those standards. And they are completively quite different.

So, after those standards we realize if we collect the data, we have 2 products that can be prepared one is hypsometric curve and other is vertical charts, fine. I hope you got the idea of the hydrographic survey, here we would like to highlight that we have used these documents to prepare our lecture, to the same time we have uses some of the sources for our images, and with this I would like to say you, thank you, thank you very much. In the next lecture we will be talking about the field procedures; that means, how to correct the data in hydrographic survey.

Thank you.