Lecture - 17
Sampling and Geotechnical Investigations in Offshore Environment

Welcome all, to Lecture 17, of subsurface exploration techniques and important techniques involved. So, in today's Lecture, we are going to discuss more precisely, about what are the methods, may be go for sampling particularly in offshore environment and Geotechnical investigation. If we remember correctly, when we are discussing about, onshore geo technical investigation, like the methods, we used for Geo technical investigation on landmasses. We generally go for standard panatisation test, as cone panatisation test, galiometric test, prizeometric test and many more. Then, when we, highlighted also about, what are the requirement of offshore investigations.

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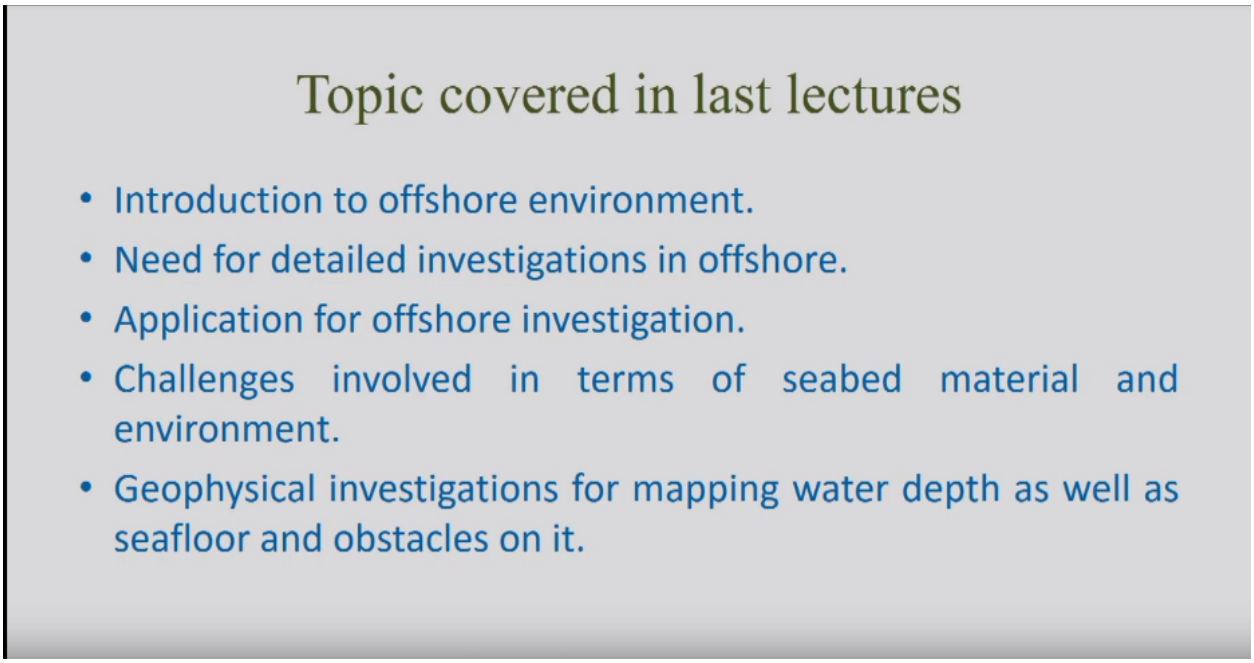

So, the first slide mainly targets for, what are topics we had covered, more specifically with respect to offshore investigation. So, the first presentation I try to give you an introduction about the offshore environment, starting with the continental drift theory, then different layers of the earth. Then going to the origin, going to the process which were responsible for creation of different mediums or a how the present configuration of earth in terms of major continental plates or a oceanic plates as come in to the which are the driving fruits is there. Then, as I mentioned because of where in rate of whether as well as in position the process of sediment, deposition and neurogen keeps on happening. That's why you can see change in the topography, change in the elevation differences as well. Then I told you more precisely when we came to offshore investigation, the way there is change in the topography, there is change in medium characteristics between the continental plate as well as the adjacent oceanic plates. So, at times, it is a gradual change, at time it is very stipend depending upon the what are the governing processes, dominating at that particular interface between continental plate as well as oceanic plate. Secondly, depending upon the thickness of each of those plates, at that interface and the characteristics of the medium which are available at the interface. That is going to govern where the it will be a gradual change or whether it will be a very stipe change between the oceanic plate as well as the adjacent continental plate.

When we also discuss, when we gradually move from continental plate, oceanic plate, there will be continental margin, there will be selves, then possible location, where you can actually get high chances of oil and when will depositions, so called generally continental margins. Based on which people over the period over time started exploring those, because throughout the earth. There are significant proposition

of continental margins available which are possible location for oil and gas as well as mineral deposition, and which of course when we go for detailed investigation, or exploration of those kind of minerals and oils. We have to go for specific structures which are particularly oil, ricks and so on. And so far, so in order to design those we have to go for detailed investigation. So, we have discussed that like what are offshore environment, why, why what is the need for go offshore environment? Particularly related to oil and gas exploration. Then I also mentioned in addition to these two primary objectives, now and I, we also see like, laying of pipeline around the seafloor, then telecommunication cables also lay at the seafloor.

In addition, now a day's peoples are using, seafloor as a, I mean, sea environment as particularly for erecting wind turbines as well as for creation of artificial highlands, support ports so and so port. So, those highlights what are the necessity when you go for offshore environment. Because accordingly is depending what kind of project you are targeting you have to go for detailed investigation. Whether it is related to suitability of the material particularly for creation of highland or airports, knowledge peoples are going for offshore environment invest, actually you can create airport also and bridges also now we are saying across the globe like lot of bridges which are constructed on onshore, offshore in the sea. So, what are the investigation do we done? Where in similar to onshore but a because there is change in environment particularly there is water in available, we need the globe wearing stratum and the surface which from were able to do, that is, so there are some challenges then in comparison to learn mass. Of course, the seafloor are not that detailed investigated for small, small projects. So, only in case of were in detailed projects. Peoples go for seafloor investigation. So, what are the need for investigation? We have discussed. Why it is required to go for offshore investigation? Whether it is for laying of pipelines or a construction of support ports or may be erection of wind turbines or may be setting up jack up platforms or oil leaks, you have to go for detailed investigation onshore.

Then we also discussed what are the application of offshore investigation, what are the challenges involved? We discuss like depending upon the characteristics of seabed materials, depending upon the air bubbles which are an tract in between the sediments or between the different layouts of sediments below the seafloor. Some time it can lead to blasted, some time it can lead to relive a poisoners gas subsequently lead to death so and so. Then possible send news, movements of send news, then a cavitied deposition with in the I mean where at the seafloor, which is happening at a variable rates and depending upon the binding characteristics of the calcite. It is going to govern what is the strength characteristics of the subsequent or adjacent seabed materials which as been deposit it or which as been densified. So, depending upon the characteristics of the particular calcite. which is responsible particularly for binding that particular seabed material, it is also govern in the strength property of that materials.

Then going to particularly what are the waves, what are current set shall were adapted as earlier as default as subsequently. And the off in suspended load, in the water, sea water there will govern your sand dunes, deposition, weathering, erosion and so on and depending upon the height of the sand dunes, some time it can be, it can be load or provide immense pressure on the foundation of any existing offshore structure. Which can lead to even, failure of this foundation or it can lead to, I mean it can lead to during opposite failure or it can lead to settlement failure as well. So, what are the challenges involved we have discussed? In terms of stability, because finally it's, it's not only about the resistance the seabed materials offering against the external loading but it is also the characteristics of the environment, which is created at the seabed. Whether it is related to bridge, whether it is related to shell, whether it is related to continental margin and again depending upon what kind of I mean what is the extended water, what is the characteristics of seabed topography seabed obstacles. It can induced more and more challenges which have to be highlighted, which have to be understood, which have to be clearly assets, before we go for actual erection or laying of the foundation tentative of the proposed structure. So, that is the challenges as to be highlighted here we have discussed.

Then we went for geophysical investigation which are particularly used for two characteristics understanding. One is like determination of water duct along the study area. Of course, if we have talking about laying of pipelines, Then your study area will be along particular root. Second think if you are going for oil and wind exploration you have to go for surveying larger area, but it will be I mean the dimension will be comparable in both the dimension like learn that study area. Which makes it completely different for your investigation which is done for pipeline laying or design of support system for pipeline transmission cable so and so for. Other whenever based on your preliminary investigation if you find there are possible false, so your encode system should be designed such a way like any possible movement along the fault should not fail in case you cannot avoid the placement of anchor on that fault alignment. So, so, accordingly the location of those water duct sediments courtesies and obstacles or may be possible. Unconfirmed materials faults which can be available on the seafloor that can also be measured or that can be determined based on geophysical investigation. Both precisely we have discussed about echo sounding method, in which your acutely transmitting sound in to the sea, sea environment and then depending upon the time for reflection you got an idea about the water duct. And same way if you know your time series at particular duct as respect to the base of the vessels. You can actually did at it and get an idea about how much will be the through the water duct. Deduct or increase depending upon, what is the relative position of that receiver with respect to the sea surface.

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And then obstacles it is not only about the change in topography, but it also dependent upon what kind of obstacles which may be temporary or which may be permanent that is site of the investigation. So, all these thinks water depth as well as obstacles present on seafloor, what is the prime objective? When, when we started about the geophysical investigation, so they are the topic particularly related to offshore environment which have been covered so far.

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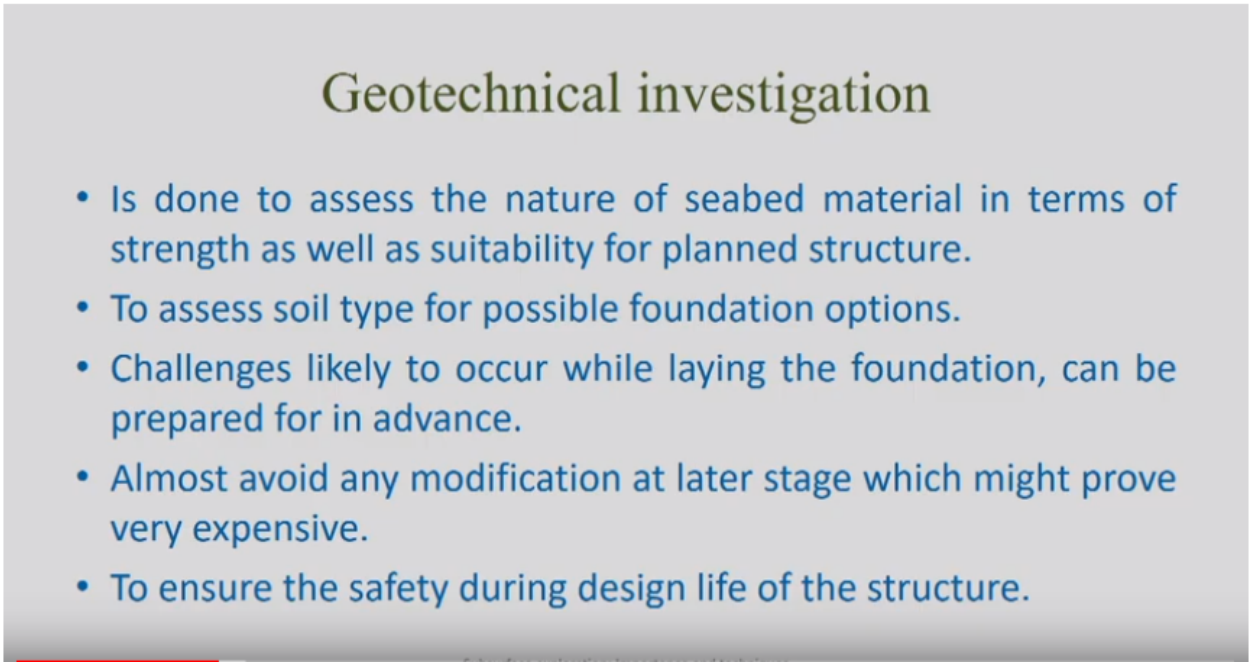

Today class we will be discussing more precisely about sampling and a were be brief, how the geo investigation can be done in offshore environment. So, in order to assess the nature of seabed materials in

terms of strength, as well as suitable for the planned structure. We all know like, when we were doing a onshore investigation. I told like it is also desirable, because it's always desirable to, to go for more than one test. It can be combination of geo technical, geo physical test, it can be onigeo physical test or geo technical test. Because some methods may give you, were you go to result in case of , of drive size some way were you go to result in terms of rock medium, some were it will give you. So, depending upon the medium characteristics when methods may give you very good result, but they may be limitation more precisely because you are not getting sampling most of the geo physical methods, so in addition do geo physical method you also go for geo technical method.

But when it is come to offshore investigation, as I mentioned earlier also like offshore investigations are very much costlier, so before going for detailed investigation that is collection of samples, so collection of samples means your vessels is there and considering the water ducts, which can where it from few meter it's may be hundred meters or more than that. So, whenever you go for any kind of sampling you have to consider minimum that particular depth of the water after which only the seabed starts. So, any sampling means minimum that particular depth you have to pass or you have to cover, before you actually start the any kind of drilling or sampling operation. So, that makes geo technical investigation offshore environment quit compassion, challenging as well as in compassion to geo physical investigation those are manifold costlier.

So, on like onshore when we go for geo technical, geo physical investigation parallelly, in order to get more confidence, in order to get choice sample similarly some other reason, in offshore investigation we go for geo technical investigation once we, once based on geo physical investigation we find like that site requirement are very positive or supporting the site selecting for the particular project. Then now we can go for detailed investigation. So, we can put whatever the investigation cost, I mean to report there. So, that is one thing. So, this way once you go for geo technical investigation, the family objective is to understand the nature of seabed materials. What kind of seabed materials is available, so nature means in terms of what kind of soil is there in terms of fluid strength characteristics. Of course based on tour strength characteristics we can also get an idea how safe the proposed foundation will be safety during design life of the structure.

Where it can be pipeline foundation, where it can be mobile foundation for floating structure, or it can be fixed foundation. So, all those things will tell like for particular kind of foundation for planned super structure or offshore structure. Then second when we go for geo technical structure investigation, we also planned to assets soil type for possible foundation option. What are the possible foundation option which are suitable considering a soil type which is available at the sea wide or it can be depth adaptation what is the depth of the exploration.

Then third one, geo technical investigation are also likely to give clear indication what kind of challenges Which can be witness while laying foundation that's we all can be prepared in advanced , so those kind of challenges redact, because as I mentioned earlier also like in shore unlike onshore investigation where you can depending upon the nature of the challenge. You can attains alter it try's of foundation on may be the investigation methods. But in offshore investigation method highly undesirable because the construction cost or investigation cost are will be significantly higher or the penalty will be significantly higher. So, it will be very favourable, if we can identify what are the challenges, which were involved which were possibly to be encountered during laying of the foundation. One example is like you find some local material which is available, we need or may be particular offs ruction, which is though off ruction but it is available at certain duct below the seabed. So, if you do not consider that in to the account may be while laying the foundation of while designing, I mean you design the foundation based on geo physical investigation data, but you once you start laying the foundation and if you find of some kind of obstacles which is kind of foreign materials in nature which is like may be ship racks or some other thing, which cannot be used as direct load bearing medium and as to be removed. So, that consideration as not been accounted in your design part. That will of course lead to some kind of challenge or difficulty while laying the foundation. So, those kinds of challenging its like very much similar to some varied object. In case of onshore at the same think at the offshore that will again impose more and more challenge to your medium. Because finally these particular mediums which having some varied object is going to contribute are is going to contribute or is going to provide resistance to your external load or over coming load.

In case if it is not properly addressed it can lead to challenges or it can lead to difficulty or subsequently it can lead to penalty or significant change in your execution cost. And then next almost avoid any kind of modification with us whatever challenges are likely to be according you are taking all those in to accounts, you, you are after those challenges you must have as per all the possible type of foundation, and what are the challenges if you go for those kind of foundation. Whether in terms of mine involved, whether in terms of depth of exploration, whether in terms of detailed foundation to be provided, whether in terms of infrastructure or a machines which is require any kind of foundation suitability or availability of those kind of machines, so almost you can avoid all possible modification chances which have to be done as literal stage because again those will be proven very expensive. And the last one of course whenever we going for identification of problematic soil, whether we are targeting for identification of any kind of varied structure, when a whether we are confining to any particular foundation types among many possible option The overall objective is ensure the safety, because again die visibility investigation cost of super structure the overall cost of the super structure, whether it is a exploration rays it will be

significantly higher. So, cannot compromise the safety of the structure unless its designs get over minimum.

So, that all indicates, that's we are going for geo technical investigation, whether it is related to the choice of foundation, whether it is related to the identification of problematic medium which is available beneath surface. In order to for cast any possibility change which is possible during laying of foundation or a lateral scale which can compromise the rise times of hard, in this condition we can reference to the design criteria or in order to ensure that safety of the structure during it design life, you have to go for detailed investigation. But repeatedly I'm telling when we go for geo technical investigation, it has to be done after based on your preliminary investigation as well as geo physical investigation, which is suggesting your site selected for detailed investigation it is very much, meeting your requirement for your project. Unless there is no point in going for, detailed you taking the investigation.

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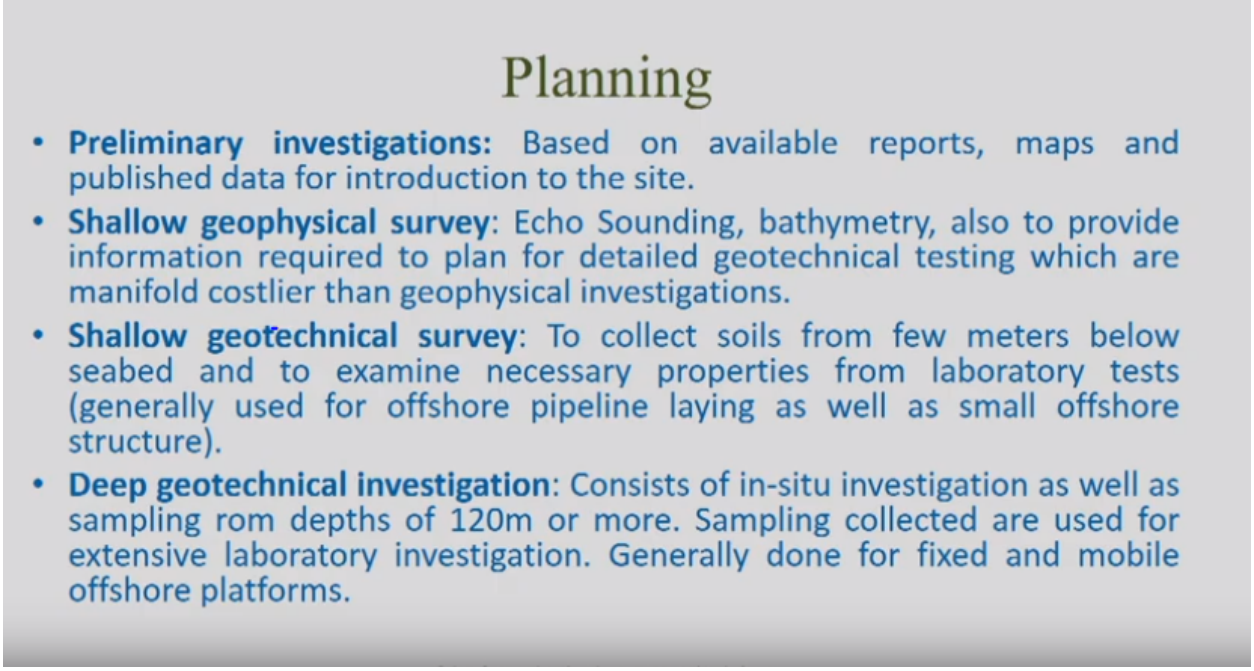

So, when we go for planning of any geo technical investigation, first of all we have to start, like other discussed surveys, we have to first of all go with preliminary investigation. Which, which start with the exploring, what are the available reports which talks about, may be the soil type may be the topographical information, geo information, geomorphological information or may be some kind of challenges, some kind forensic of investigation done, at the proposed site or in its environment or observing side in the past. So, that is going to give you confidence about your site selected even if you going for any kind of investigation. So, that means you know your site based on your existing literature without spending much

on detailed investigation. And based on that you possibly select most suitable method for detailed investigation. If you find your site is suitable for going for detailed investigation whether it is geophysical or geotechnical.

Then, based on report you can have maps, you can check based on published your data lot of time because of may be environmental issue, may be because of ecological issue, may be because of seismic issues, geological issues, may be meteorological issues, people do lot of service offshore even for construction of important structure particularly for nuclear power plant those not offshore but because in order to ensure the safety of that structure, if available near to sea environment people go for detailed investigation offshore. So, such kind of literature whether in terms of report whether in terms of published data, if it is available it is advisable to go through the report before we go for detailed geo physical investigation. With already lot of money where particular agencies had been put in the past for investigation related to your Sacket side.

Then we go for software preliminary investigation you go for shallow geophysical method, which precisely consist of echo sounding as we discussed about bathymetry for water depth determination as well as mapping of seafloor and possible obstacles available on it these will also provide how suitable it is, we go for detailed geotechnical investigation. So, this is possibly and indication like preliminary investigation gives you an idea you go for which method of geophysical investigation whether it is required or not two or four geophysical investigation and collectively based on your preliminary and based on your finding from geophysical survey you can planned for detailed geotechnical investigation survey. Remember in compression to geophysical investigation, geotechnical investigations are manifold costlier. So, there is very important decision making quit before you go for detailed investigation because one you do detailed geophysical, geotechnical investigation you have to arrange assembly which are required for default dealings may be sampling and interpretations and everything most of the time we done now a days at the site itself . So, it's not like the correcting the sample bringing to your onshore laboratory testing it. Now everything is done onshore because that time we were doing testing may be 50 kilometre, 80 kilometre within the sea. So, it will be highly uneconomical to correct the sample bring it into the onshore laboratory to do the test and then go for next exploration. So, everything is done there itself based on the kind of, again based on the kind of infrastructure which is available, or the vessels which is involved in detailed investigation.

Then, we start with shallow geotechnical survey which, which depending upon the water depth. Which depending upon the what kind of structure we are planning. So, particularly for laying of pipeline you need not go for very detailed investigation, because of course the load distribution of such kind of pipeline will be limited to may be few meter depth. So, you will go for shallow geotechnical

investigation. So, this consist of collecting soil sample, form few meter below seabed. Because that will be the medium which will be acting as a globe wearing medium. So, that in a shallow geotechnical survey, you can actually collect soil sample for those particular depth which are acting as the load wearing stratum. Example them in terms of property, in terms of strength characteristics based on laboratory investigation. Generally it is used for offshore pipeline as I mentioned laying as well as small offshore structures, you can go for like any offshore structure which is may be in shallows water depth, we are planning to go for, so you can for shallow geotechnical investigation for those kind of data. This collect the soil sample determines its strength characteristics and soil properties, from laboratory investigation then based on the potential you can go head with your execution part.

When, comes deep geotechnical investigation which are used when we are going for may be high load wearing structures or may be for exploration rate or you can go for or may be bridges also be there which may require deep geotechnical investigation at that site. So, It consist of in-situ investigation call everything should be done in-situ. So, now a days again when we go for geotechnical investigation there are two ways either you can doing the testing vessels itself, or you can low down your testing assembly at the sea floor. And there on word you can start your drilling sampling and testing everything in seafloor itself. So, the entire operation can be control from the surface vessels or a control unit by means of cable or other medium or you can do the testing from the vessels itself. So, both options are available simultaneously, which peoples are pretacing now a days. Then sampling did you like consisting of in-situ investigation you can do from the vessels which is available at the sea surface or may be at the seabed itself. So, this may like when you are doing any kind of sampling from depth of 120m or more. So, this 120mtr or more is the depth, below seabed. So, it's not a depth of water, it's rather, depth from the seabed downward which you are interested to explore. So, this is generally classified as detailed geotechnical investigation as I mentioned, these kind of investigations are generally required when we are laying foundation, when we are going for exploration of oils depositary or for laying jacket platform or oil ricks in to the sea.

Again, for design of encorp of these kind of things or particularly when these are not floating characteristics ricks rather it is a fixed or direct supporting to the seabed. So, you can go for this kind of depth. So, samples collected from deep geo technical investigations are used for extensive laboratory investigation which are again done offshore itself and are generally done for fixed and mobile platforms. So, platforms mean which are directly transferring the load to the seabed. So, that case considering the, the load of overcoming structure is too high. So, you have to go for deeper investigation. If you are going for anchored system like in case of floating rays you can go for comparably shell ware investigation. But more, more common in offshore platforms.

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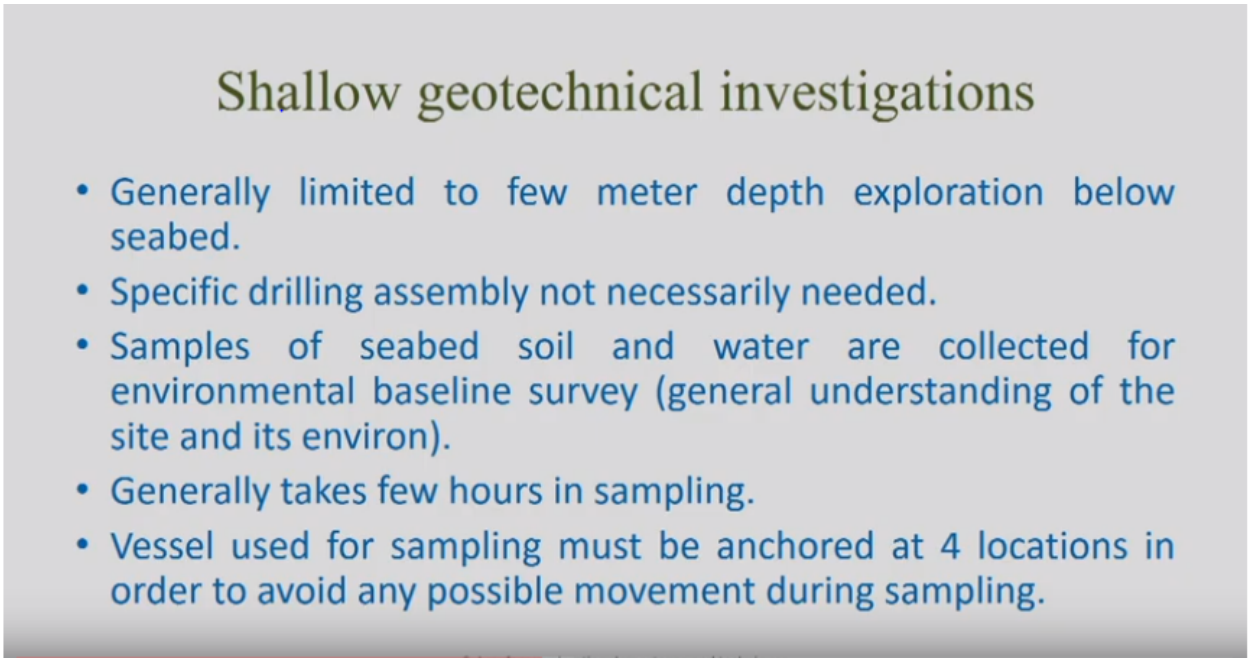

So, these are generally limited in depth, so whenever we got trying for shallow geotechnical investigation as I mentioned, the depth is generally limited to few meters depending again upon what are the method we are using for sampling and characteristics of the medium at the seafloor. So, this is generally limited to few meter depth. So, you cannot go for 50m 80m like that based on your shallow geotechnical investigation. Because the objective here is just to know about what kind of soil, what kind of strength characteristics or may be in terms of chemical composition also, what kind of medium characteristics is available in shallow depths below the seabed? So, every time in case of exploration if I giving the dimension with respect to the seafloor and major downward. Then specific drilling assembly are not require here because you are only interested in few meters so you can use probably the kind of sampler which are specifically designed for sample collection and offshore environment. But specific drilling is nor require in this shallow investigation.

The sampling of seabed oil as well as water which is available different, different depths are also collected, so that you can get an idea of which is the characteristics of your seabed materials as well as water which available in your environment. Now you start going, if, if require you can start go detailed investigation or in case you have to provide a anchor or may be geo foundation correction or modification. So, these gives you idea about environmental baseline survey. What is on in every soil characteristic in water characteristics which are available. So, general understanding it will be useful for about the site and environ. Then any difficult in geotechnical investigation is correct the sample from seabed so at a particular site of observation generally where is from few hours, I mean 2 hours, may be 4

hours like that. So, that you can just correct the sample, soil sample or seabed material sample from your tentative site. Then probably you can move to next site. As I mentioned like this kind of investigations are more commonly practising of pipeline along the proposed root of the pipeline. So, you can do this kind of investigation sampling bringing the sample in to the laboratory do the strength characteristics then go to the next site which may be few hundred meters away from the previous location and so on you have to do throughout the pipeline alignment. So, it is generally used those kinds of investigation.

When vessels used for must be anchored this is more important because, if ,if you are collecting the soil sample and by the time, if the vessel itself moves there can be two thing, one like your, your, connecting cable between your sampler as well as the vessels may break or some time. If, if you're your vessel is not properly anchored you may end up in miss inter-predicting the finding with respect your location. It may be you collected sample for somewhere but by the time you have collected sample and brought it to the surface vessel, when if it is moved you will end up in assessment of soil properties some other depth or to other location. That's why anchoring during sampling is very much require, anchoring and what it will do, it will actually prevent any kind of lateral movement of the vessel particularly during sampling.

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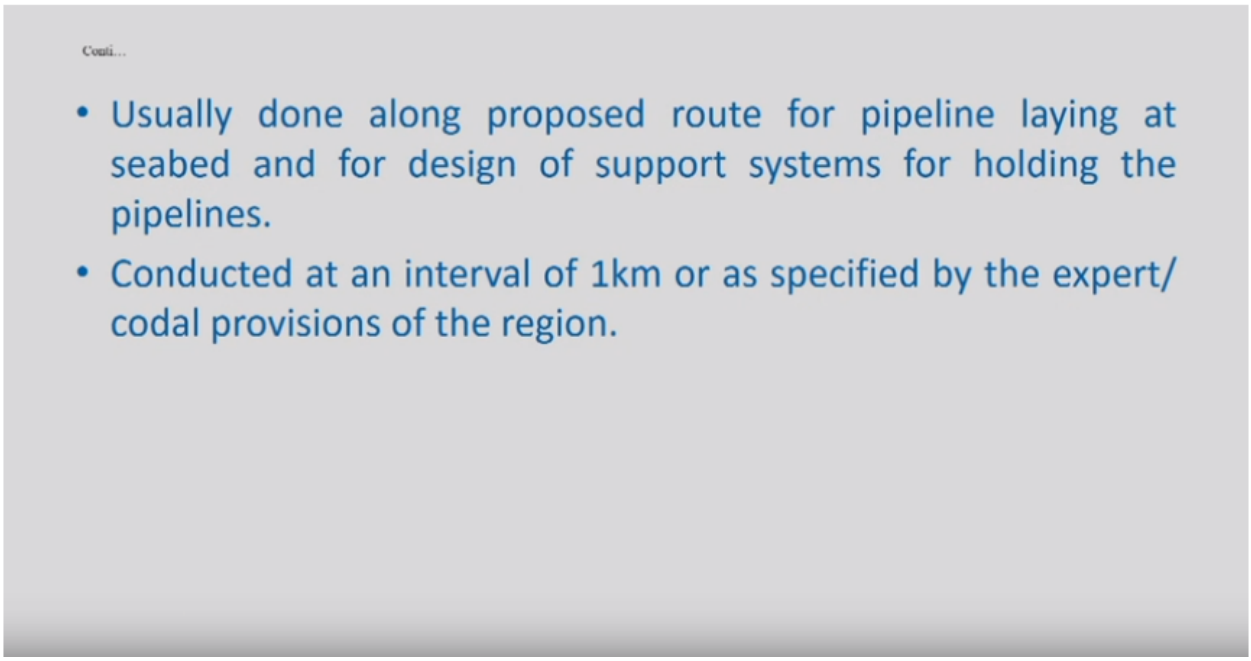

So, it is usually done along the proposed root of the pipeline, as I mentioned because it is a continuous structure which may be late for over a 100's of kilometre or may be more then that so you have to ensure the safety of every anchored or every support system you are planning to provide against the lateral stability of the pipeline you have to go for these kind of shallow investigation. As well as I mentioned if, if based on your shallow geophysical investigation or based on your geo technical data if it is going to be

give a idea like your there are possible fault along that. So, in order to ensure that the design of the support system should be shows that possible movement it can do. It can based on without any significant settlement or any kind of safety compromise with respect to the pipeline system. That also be get a useful input from shallow geo technical method. Again it is conducted at an interval of may be 1km or if its is used a too much of variation in topography or a to much of obstacles are there you can actually reduced the spacing of shallow geotechnical investigation interval or as specified by the expert generally expert might be having again understanding about a radiantoms of the obstacle antoms of topographical changes in terms of geomorphological changes also which are adding more and more complexity to your foundation medium are which are adding more hydrogenate to your form continuous foundation medium. Sometimes codal provisions are also available but those are again region specific so you can one can consult those kinds of codal provisions before going for deciding how many numbers of test for one kilometer or how frequently these kinds of real geophysical, geotechnical testing has to be done can be determined.

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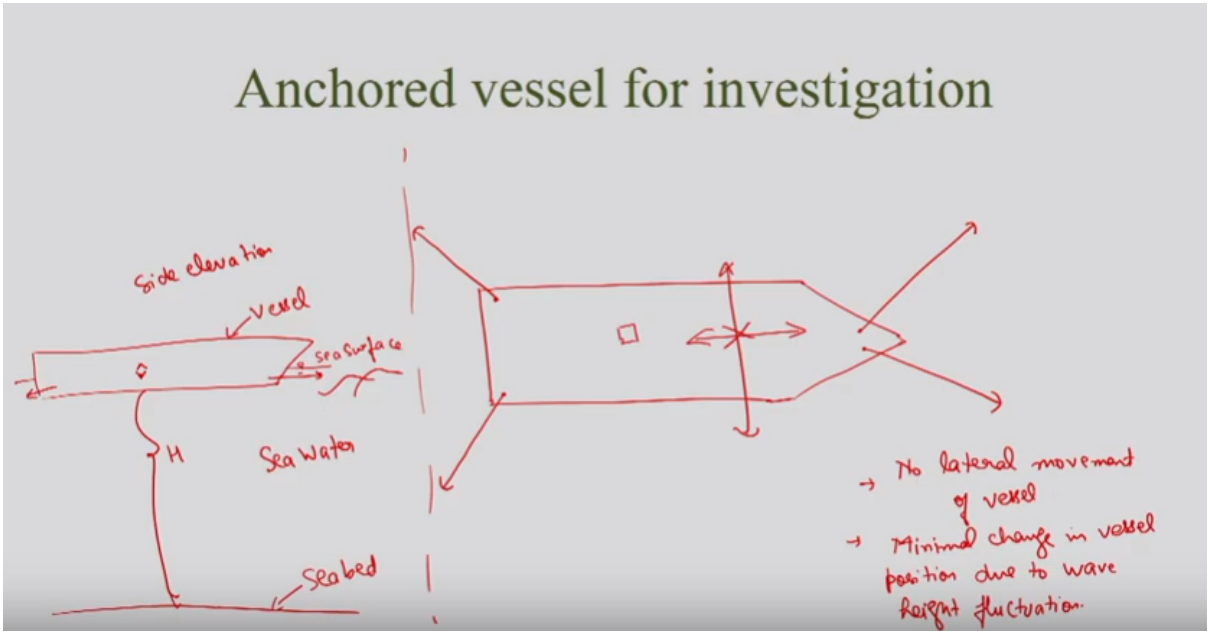

So anchored system mentioned here as like suppose this is your vessel which is generally used for investigation which is actually it's like if I see here it's like something like this which is available in the seabed I mean floating on the sea floor or sea surface or this is mean sea level this is vessel and this is your depth seabed. Now you are interested by means of vessel which is everything filled with water sea water. So, every time you collect a sample minimum this depth

has to be by-pass before you actually come in contact with any kind of possible medium from the sea water. So, this is the vessel again so I am seeing this inside elevation may be what I meant to say here like whenever so it's like whenever you are lowering some kind of assembly for sampling may from here. In order to ensure like this vessel should not move in any lateral direction like perpendicular to this. So, there will not be any movement in this direction or in this direction. So, in order to ensure this generally you actually go with anchoring this same way you can have anchors here so this anchor will almost will be there in any moment in any direction and, it will also ensure no lateral moment of vessel, as well as, no or as well as minimal change in vessel position, due to wave currents due to waves. Because of wave fluctuation, wave height fluctuation. So, again, because it see so, again there will be some kind of waves here, is a times I mean there will be rise in Wave disturbance created by the waves. So, it can again called some kind of moment in the vessel, along the in vertical direction. So, this will also ensure, this anchors in alpha direction ensure, this minimal disturbance in the vertical direction. Because it will have, direct consequence on sampling method, or the characteristics of the sample or it will induce, more and more disturbance of the sample. So, there are two primarily the objectives here, and no lateral moment of the vessel, during sampling, otherwise error with testing location, and minimum change. So, this will minimize error or disturbance in collected sample.

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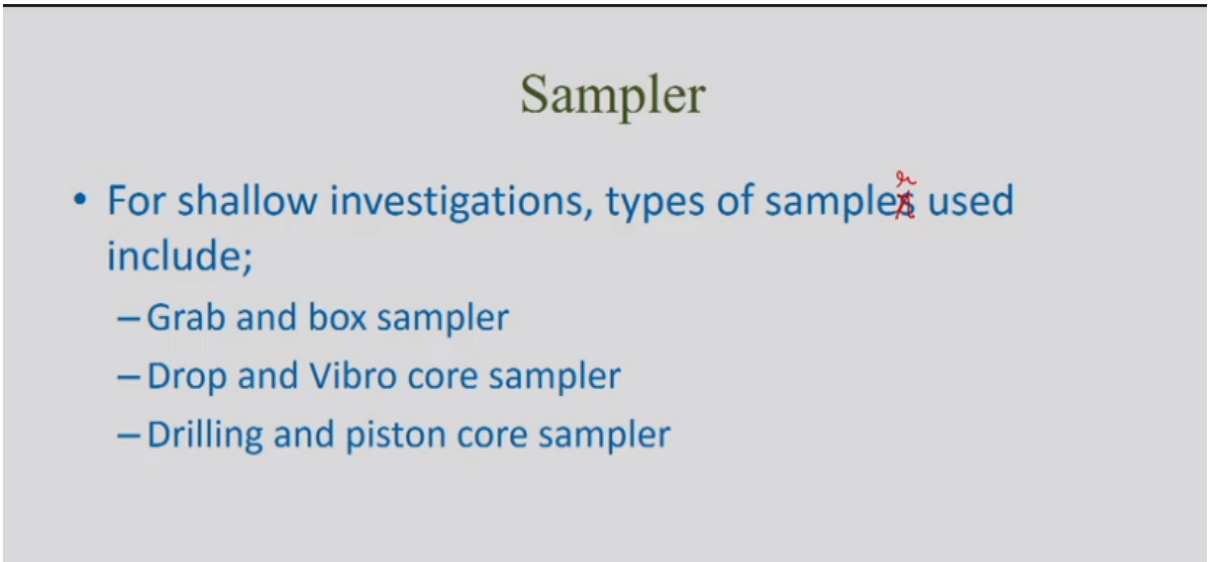

Now, we discussed like okay, also environment is there, some variation in obstacle, or topography is there for, which you go for detail investigation like. Then we have to collect

samples. Because, finally you bring some sample on to the, the we elaborate it to go for may be determination of moisture content, in-situ density, or stan characteristics, soil classification itself. So, you have to have some kind of sample in order to correct rise, the medium in detail, which is not laboratory investigation. So, sampler was shallow investigation, the type of samples the type of samplers used include so, you have grab and box sampler, and drop and Vibro core sampler, and then you have drilling and piston core sampler. They primarily kind of sampler, which are used for sampling here from the shallow order.

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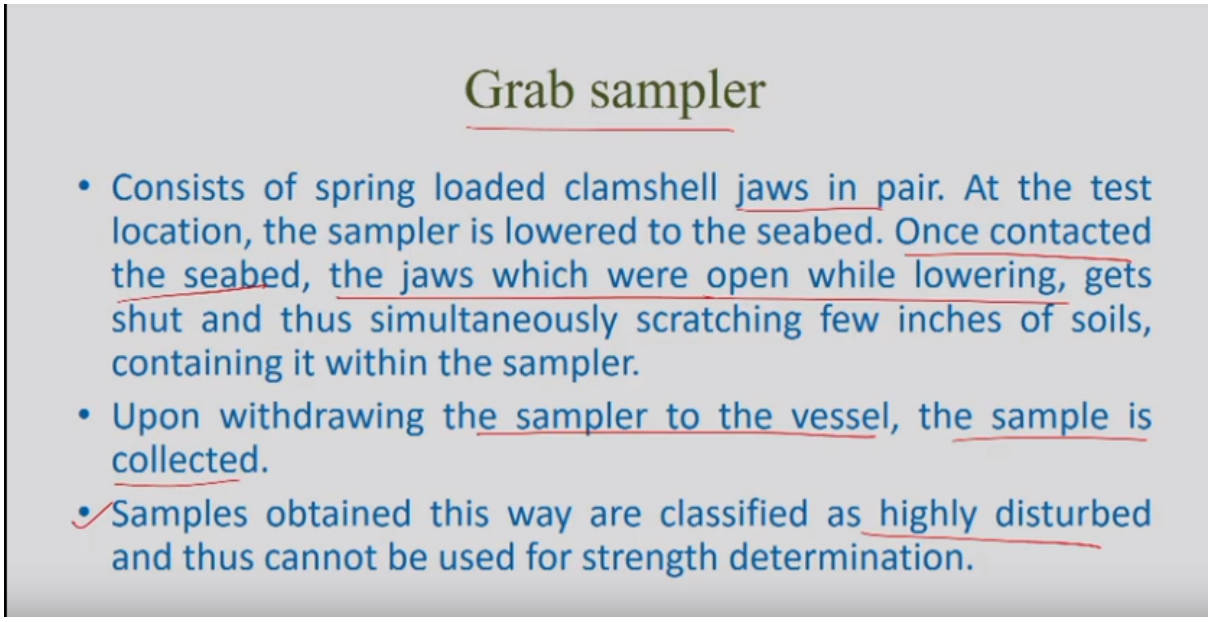

Now let see, what grab, and box sampler is about? So, the grab sampler again, grab and box the basic phenomena is same. But the way it is collecting the sample it varies between, grab and box sampler. So, grab sampler it consists of spring loader, clamshells, clamshells jaws in pair. So, there will be like two clamshell, which we are a test to the sampler at the test location, where actually you interested to collect the sample the sampler is lower from the vessel to a seabed, upon contacted the seabed. So, once the samplers comes in contact with the seabed, what happened the clamshell which, were logged in position, by, by means of spring arrangement, will actually will released and as a result of, which this clamshell will actually move and get logged at the bottom surface. So, this the jaws, which we are open like this the, the this is the condition of the bottom, of the sampler, when you are lowering the, the sampler from the vessel, as soon as, it comes in contact with the seabed, the spring will release the, the clamshell and because,

and then once the, the clamshell of the jaws comes in contact with each other, it will get logged. Now, while lowering, it gets logged or shut, and then simultaneously. Because, again these are again toots, these are again, tests at the lower end, which will actually scratch the material, and thus simultaneously scratching few inches, or depending upon the seabed characteristics. Even sometime in half or meter are more than that. It can scratch, the seabed material, and after because, it is after shutting known no it is logged from the bottom.

So, there is no place actually, thus are sample grabbing further go, you can bring the sample around to the surface, that's how it is also, containing the sampling into it. So, this is called as grab sampler. So, just like anything you are grabbing. This sampler also, going to a seabed, and then this thing and bring it to the surface, that's why it is called as, grab sampler. So, upon withdrawing, the sampler to the vessel, the sampler is the sample is collected. So, that's how you can collect the sample from the about the seabed material. How one important thing here is, sample obtained in this way or classified is highly disturbed. Because, you yourself can understand, while collecting the sample, it is actually scratching. It is it is inducing some kind of external disturbances. As, a result of which, the sample are which are collected from a grab sampler are highly disturb in nature, and thus, you can used it for determination of the strength characteristics.

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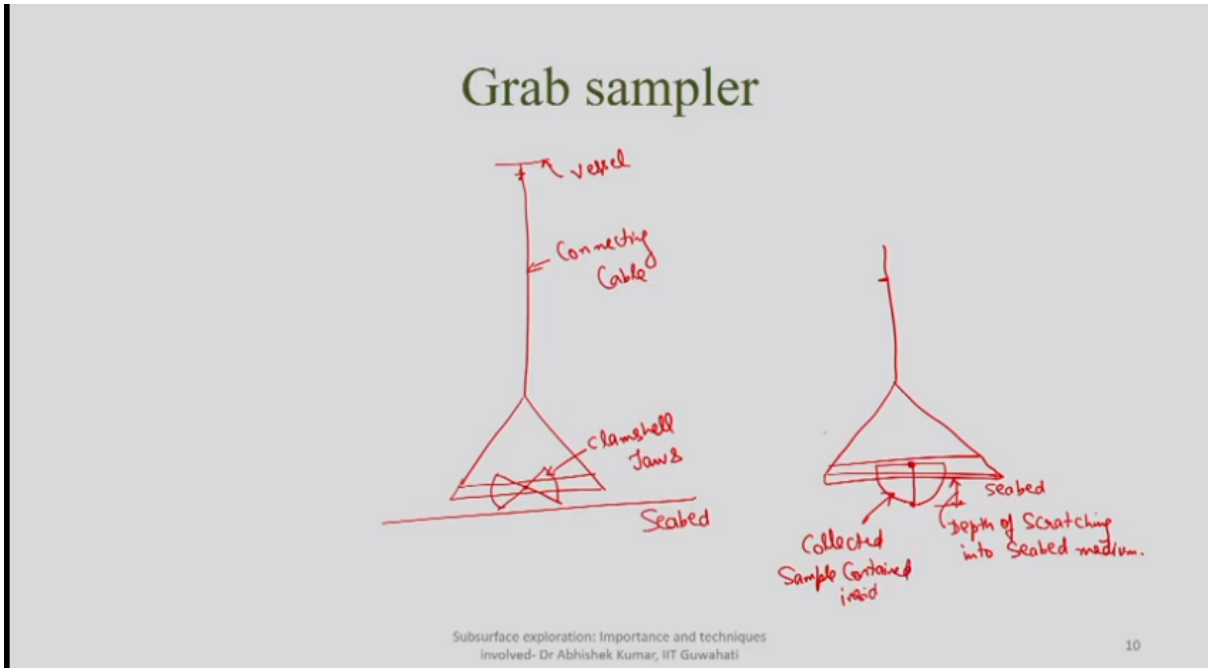

Now, this one I am telling like, this your sampler, this your connecting cable, cable. So, this your seabed and this is somehow it is coming from vessel. Now, it is having this kind of assembly, which are called as clamshell jaws, which are right now, note in logged position. But as soon as it reaches the surface, what will happened these jaws will be released. So, the sampler will remain like this. But you're a clamshells will come in contact with each other, and it will actually close from the bottom. So, this moment will be hap happening from this particular direction. So, initially it was in logged position up. So, once you release it. So, this is like I can call it as seabed material. So, whatever it have it is actually scratch, it will be depth of scratching or collection of depth of scratching into seabed medium. Depth of scratching into the seabed medium that will define collection on the sample. So, this like the sample which is collected here. Collected sample will be contained inside, contained inside.

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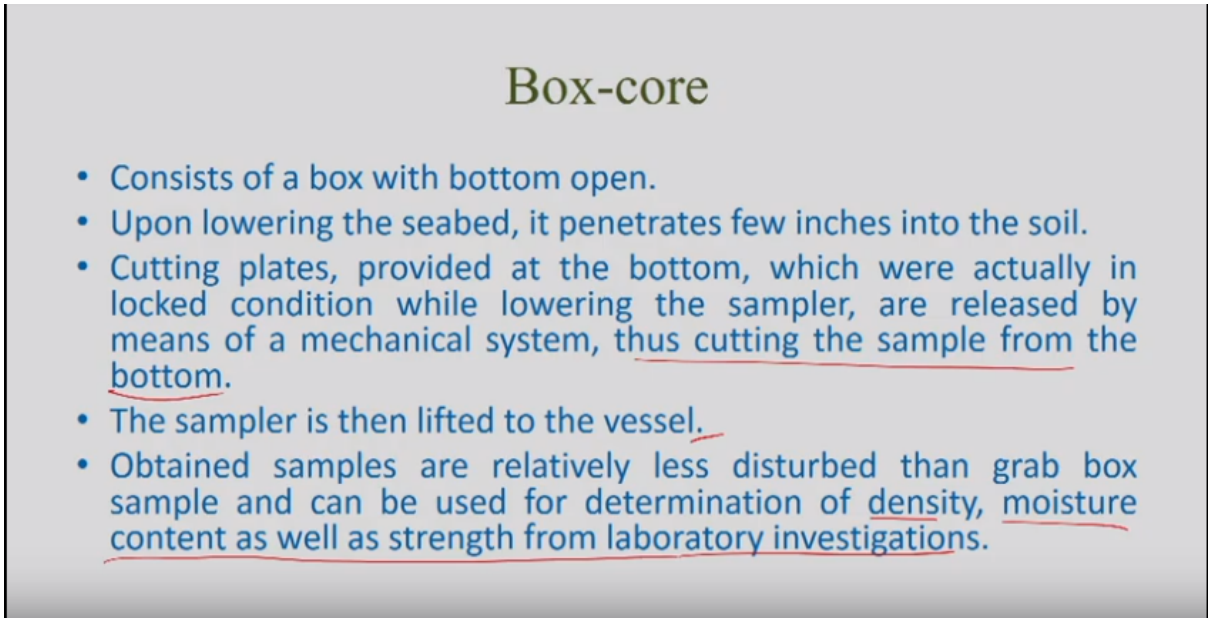

Now, let see, the box core again. As, I mentioned the def the fundamental concept remains same like each of these are actually collecting the sample from the seabed. By means of one or the other arrangements. The box core it consists of, a box is name suggest with open base. So, the bottom is opened, upon the lowering the box, which is open at the bottom, When It touch is the seabed. It actually penetrates into the seabed into the seabed material. So, the cutting plate provided at the bottom, which are in locked position. So, cutting plates, which are in locked

position, while lowering or released by means of mechanical system. As, a less as, a result of which it will actually cut the material, which is collected the bottom and also contained the sample, which is collected by their particular depth. This cutting the sample from the bottom. So, its like you lowered the sampler, which was opened. As, you lowered it, it might penetrate, it must penetrate certain depth. Once it penetrated by means of mechanical arrangement. A cutting assembly, or cutting plate will come, which will disconnect the quant ate of sample, which is within the sampler, and the actual seabed material and contain it inside, and then you can the sample you can shift it, or slightly you can bring it on to the surface, on to the labor vessel from where you can actually go for detailed elaborate investigation. Now, obtained samples, in this particular case are relatively less disturbance, in comparison to grab sampler or grab box sampler and thus it can be used for determination of in-situ density moisture content, as well as strength characteristics. So, whatever sample you have collected. You can actually use it for necessary elaborate investigation. Because, thus how you are you are you will be able to get an idea about what kind of medium is available we need the surface, what is the strength characteristics.

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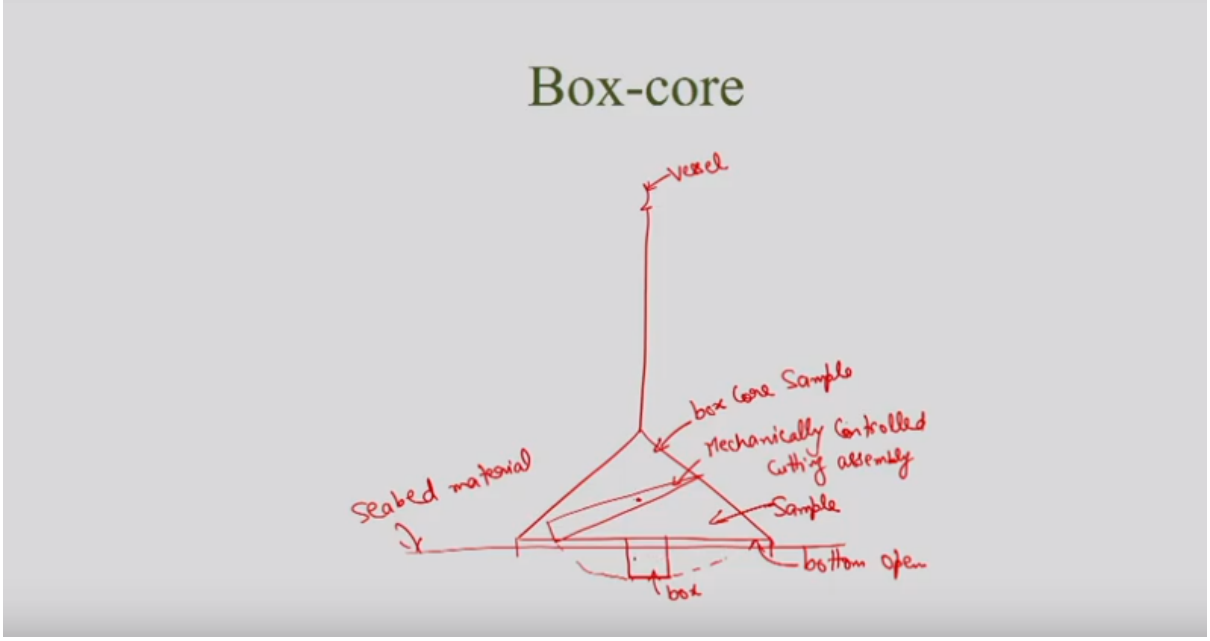

Again, here is she here. So, it's like the sampler again here, which was actually, bottom was opened. But as soon as it comes, in contact with the seabed. So, there will be some kind of

cutting assembly, something like this. This assembly. So, when the material upon, upon getting inserted to particular depth into the seabed. This cutting assembly you can call it as mechanically controlled cutting assembly. It will actually, cut the material. So, the sample will contain the sample, the sampler will contain the sample. This is box core sampler, and it is connected to your vessel. So, once it has cut, and this is actual seabed material. Upon correcting you can bring that sample, which is no more in contact with the plate. So, there will be some kind of box also here, which will be actually inserted into the material. So, this mechanical assembly will actually towards some kind of cutting here, at this particular location like this, and it will lock it here. So, that there will not be any chance, that the material, which is correcting the box sample will be again, coming back to the will remain there at the seabed.

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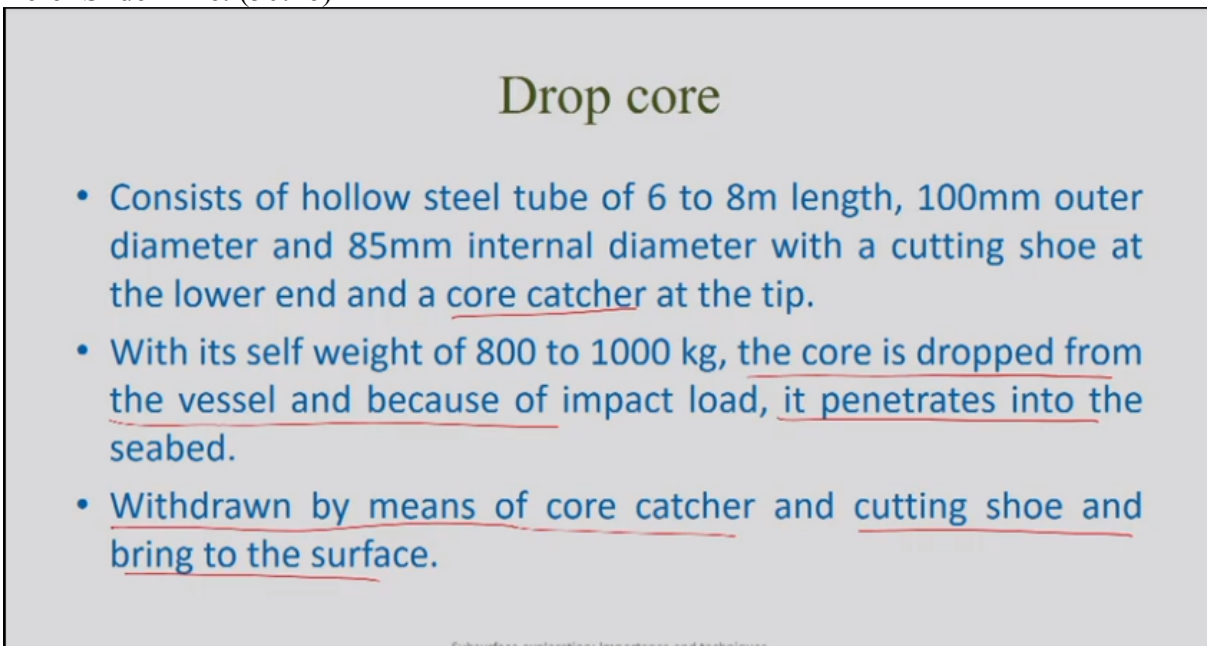

So, this award box core, As I mentioned like in compression to grab box, the box core samples are relatively less disturbance. Then come the drop core, which is also one of the widely used in method. It consists of hollow steel tube, which six to eight meter in length, hundred mm outer diameter and eighty-five mm internal diameter with a cutting shoe, cutting shoe is there at the bottom, and a core catcher. So, core catcher, the purpose of core catcher, where in similar to your auger. It's like to retain the, the collected sample within the sampler itself. So, that you can bring it in to the surface for necessary field investigation. So, this steel tube, which is six to eight meter in length, is having weight of eight hundred to one thousand kg. So, itself weight itself, is too

high. So, you need not provide any kind of external loading mechanism, rather you can simply lower this tube, from the vessel into the sea floor. So, its like freefall, once the core the drop core is drop from the vessel to the seafloor. Because, of this impact load, it will insert into the seafloor via certain margin or certain depth or it will penetrate into the seabed, and then core catcher, by means of core catcher u will ensure, the collecting sample will not be remain there. But it will retain within the sampler. So, withdrawing by means of core catcher, core catcher means I mean only it will ensure, that the sample should not be should not be left at the seabed itself. But it come along with sampler. So, it is again, bring back on to the surface, from where actually, do lot of detail investigation.

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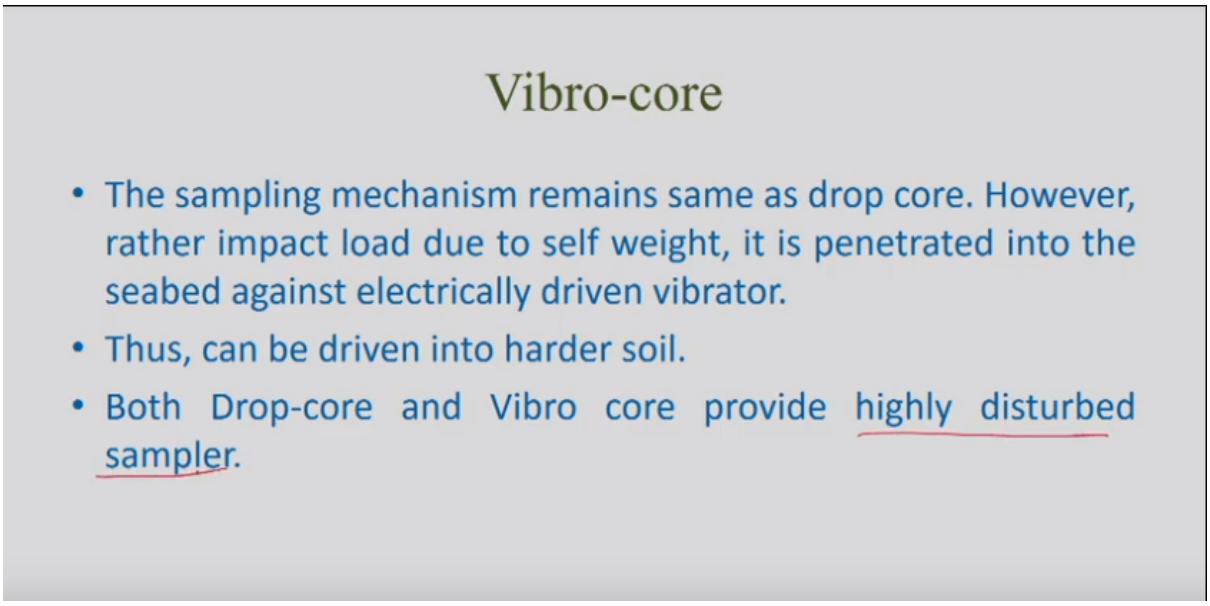

The other one is, Vibro core, which is very must similar to the previous one, that is drop core. The only thing in drop core, we you are actually pushing the sampler into the soil, under the impact load. Because of self-weight of the soil. In this particular case you are actually, pushing it into the soil, by means of vibration, the soil electrically driven. So, you are lowering the sampler, or the tube into the into the sea by means of electrically operated vibrations. As, a result of it, it will actually, penetrate into the seabed, and then you can bring it on to the surface for necessary investigation. Remember like some of the sampling method, may give u highly disturbed sample, which can which can only use for child classification. Some may give you, relatively less disturb sample. So, you can use it for strength determination also moisture content, in-situ density

determination. But I mean so, for box core is only giving you chance of highly disturbed highly undisturbed samples.

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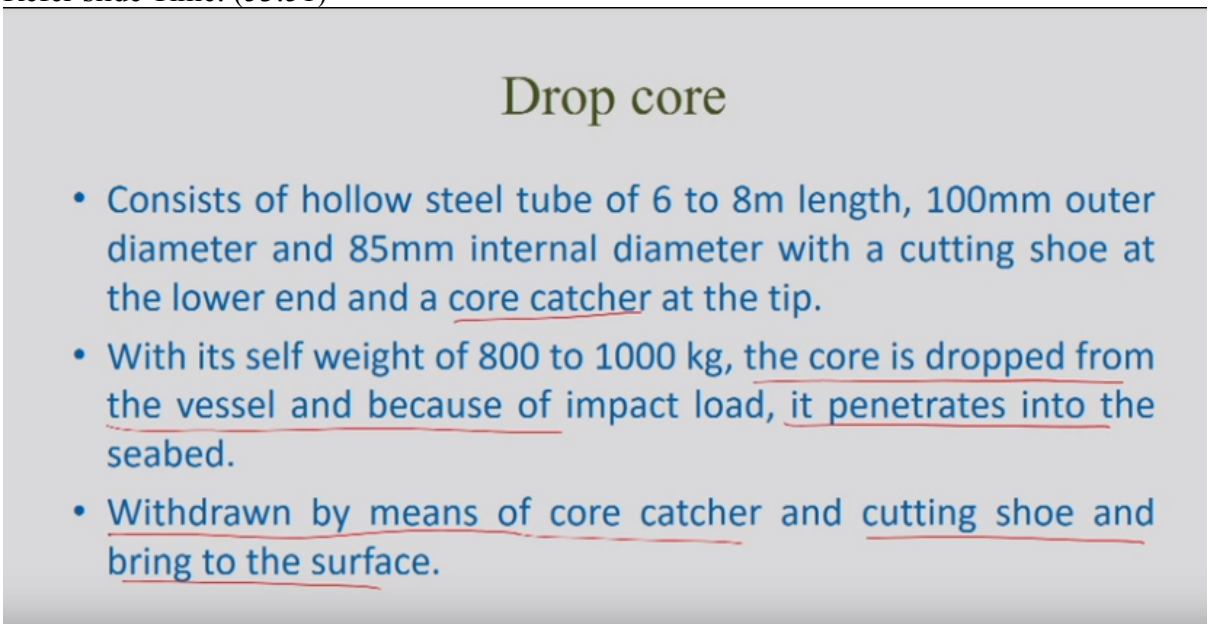

Grab, Vibro and the drop core all the three gives you highly disturbed samples. So, these cannot be used for strength determination. That is, we keep in mind.

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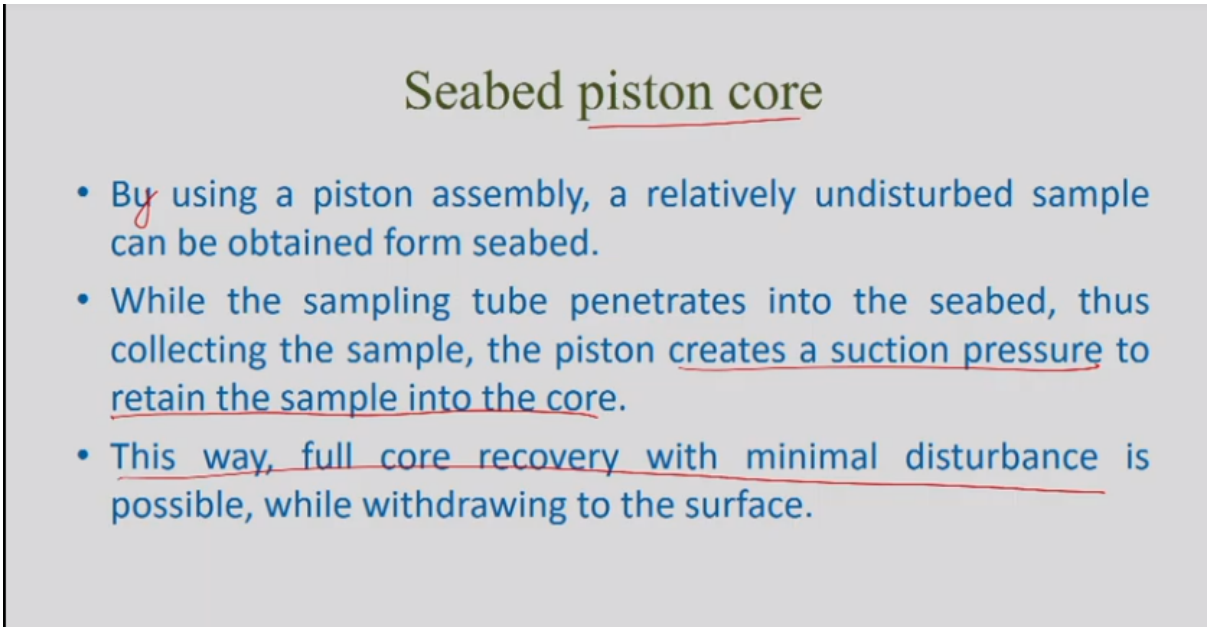

Then see at piston core, by using a piston assembly. Now, in this particular case also, you you put the sampler in to the seabed by means of cutting shoe at the bottom. But the beauty in the particular case is, while withdrawing the sampler, see most of the time whenever it is with respect to grab box, whether it is respect to Vibro core, or something you are actually, impacting some kind of disturbance into the size. So, that first of all, it will penetrate, and second thing, while, while bring it on to surface, you are providing some kind of cutting shoe or or, or may be Steel plate, which also inducing some kind of disturbance into the collected sample. However, in this case you are actually, keeping the sample intake, and in order to ensure the sample should not fall down from then sampler on to the seabed. You actually, use some kind of suction pressure. So, this piston assembly will ensure, the creation of this suction pressure, to retain the sampler into the core, and thus, how the sampler the sample collected by means of seabed piston core or relatively, almost no disturbance is there, minimal disturbance is there. So, you can use the same sample, for collecting the for determination of strength characteristics for understanding the soil structure, as well as for other properties also. So, this is considered to be more appropriate, than the earlier discussion method.

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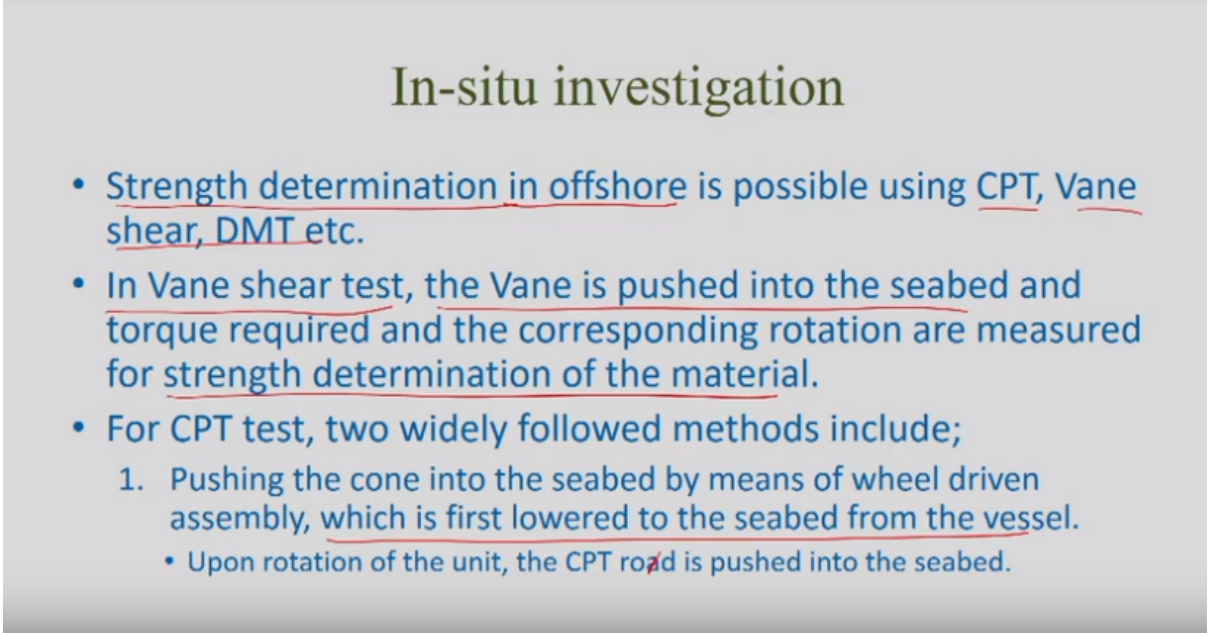

Now, we discussed so, for about shallow investigation, which are primarily used from few inches to few meters into the seabed. Now, when we go for detail deep geo technic investigations, of

course we are interested toward from may be fifty-meter hundred meter more than that or may be one twenty meter. So, the method, which we are used for geo technical investigations, are more or less same like, we have used scone paintation test, then, dialeto meter test the you go for vane shear test, So, method remain the same. Only thing, the minimum depth of exploration starts, after I mean by passing the water depth. So, from vessel whatever method you are using, either you are doing from the surface assembly or vessel live in or you are actually, lowering the entire assembly from the seabed, and from the seabed on ward in the downward direction you are actually doing the test. So, Primarily objective from the deep geo technical investigation is strength determination, in offshore environment particularly the seabed material, or the material which is below the seabed by means of CPT test, vane shear test or dial or to meter test, in a last couple of decades DMT also been proven very accurate, in terms of strength determination for offshore environment. So, vane shear test, the vane is pushed, again, this more generally, practices like lowering the assembly, on to the seabed and from there onward you can do the test. So, the vane push on to the seabed and the torque which is required and to the corresponding rotation are recorded. As, we discussed incase of onshore also, like what is the rate in which, rotation has to be done, and the torque, which is required to, to ensure, that particular rate of rotation, is recorded, and these two things will help you in understanding the shear strength characteristic of the material. Because, the sample in which you are actually, inducing the torque, it is undergoing shear failure. So, that's how you can determine the in-situ shears and characteristics using vane shear test, even for offshore environment. Now, when we go for CPT test, so, there are two widely used method. Again, in CPT test, more count practice is to do the test is from c word itself. So, the, the entire assembly will be installed the c word or will be there at the c word and from there onward you actually, start position you are rod, and if you recall in case of cone tip resistance test, we precisely go for two measurement. One is like cone tip resistance and the second one is your skin friction no sleek friction, and at times if you are have transducer, behind the account tip, which can also, be used for determination of pore water pressure, that arrangement is also possible and the practice in many of the setups. So, the first one so, this one the CPT test, which consist of two to three kind of typical leadings, and as, assumption like CPT unlike other methods, gives you a continuous profile link in terms of cone tip resistance sleek friction or pore water pressure.

So, this is the advantage only thing, in case of CPT you can get any any sample. So, the test more specifically, we are doing from sea floor downward, can we done in two ways. So, in first method, you can actually, push the cone, into the seabed, by means of wheel driven assembly. So, there is a wheel driven assembly, which are actually so, two sides of the drilling rod. There will be some kind of assembly, which may be wheel assembly, which will actually, ensure continuously pushing of the sampler into the drill rod into the seabed. Which is first lowered into the seabed, from the vessel. So, you lowered your assembly to the seabed your wheel assembly also, your drill assembly also, and from there onward actually, you can push in to the seabed, and that's how you can get a idea about how much is the, cone tip resistance, sleek friction, and poor water pressure. Which is one method. So, upon rotation of the unit that is wheel assembly, the CPT rod pushed into the seabed.

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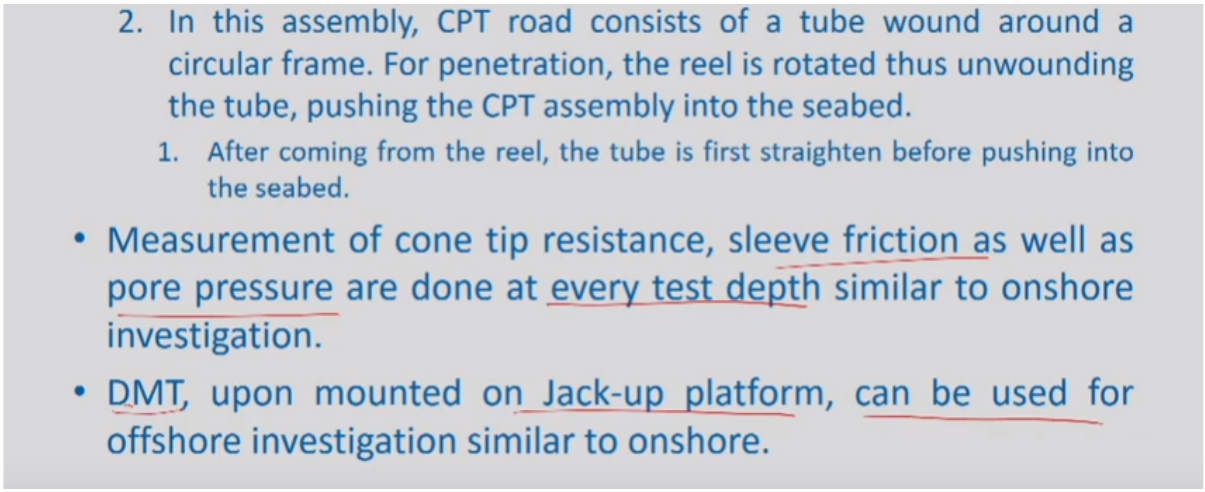

And the second method CPT consists of I mean in this particular case the tube the road is push by means of tube. The tube is wound around the reel so in order to push the CPT to the deeper depth you can actually unwound the tube and, then the tube will straighten by means of other assembly and then it is pushed into the seabed that's how also you can major an the typical information about the seabed. Now the measurement of cone tip resistance sleeve friction as well as pore pressure can be done at continuous at every depth or continuous recording both both. The DMT di electro meter as I mention it can be done from the surface assembly by means of mounting on jack-up platforms which is almost like fixed platforms, from which you can do so

any possible fluctuation in water level will not affect your DMT measurement, similar to your on shore investigation.

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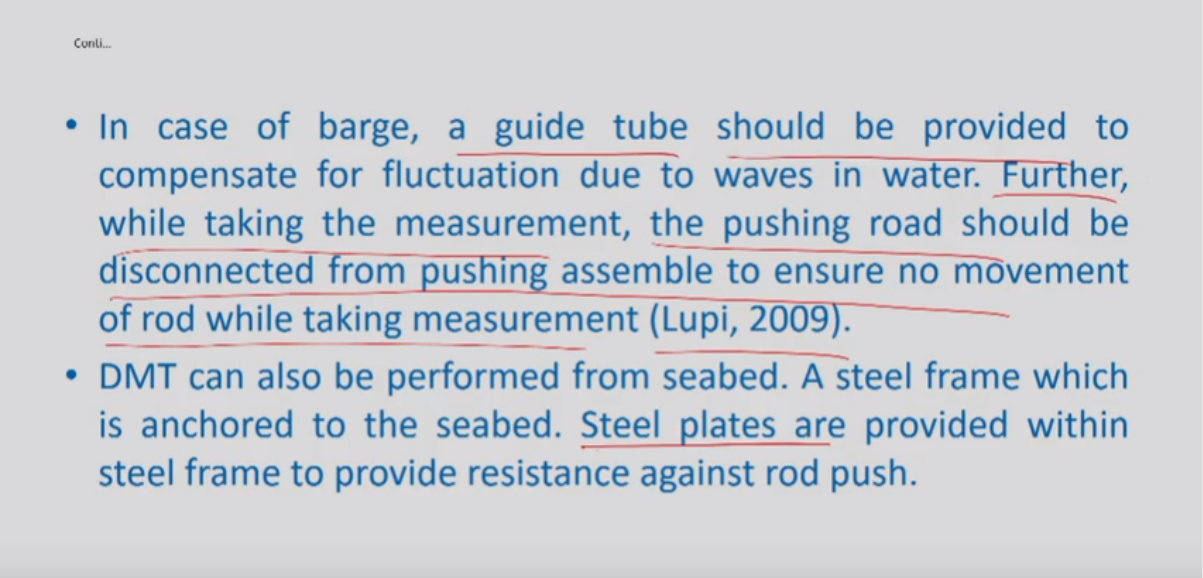

In second like you are doing the DMT by means of barge, you have to provide the kind of guide tube that will compensate or that will minimize the possible fluctuation in the wave heights on your the rational provided to your testing. Further while taking the measurements every time when you make measurement like applying pressure for 1.1mm disturbance or pushing into the soil. Every time when you are taking measurement you connect your push road with your pushing assembly that will ensure your field measurements are minimal affected by fluctuation in water height that is most important when you are going for fluctuating platform particularly the barge. So, for more detail one can go for (Lupi, 2009). So, DMT can also be performed from seabed itself as I mentioned most of the geo technical investigation either you can do from vessel control or you can go with seabed control, I mean you can do the test from seabed. So, when you doing it from seabed you have some steel frame which will ensure some kind of anchoring of the assembly with respect to the seabed and then you will have steel plate which will they are to provide ration towards pushing the rod in to the medium.

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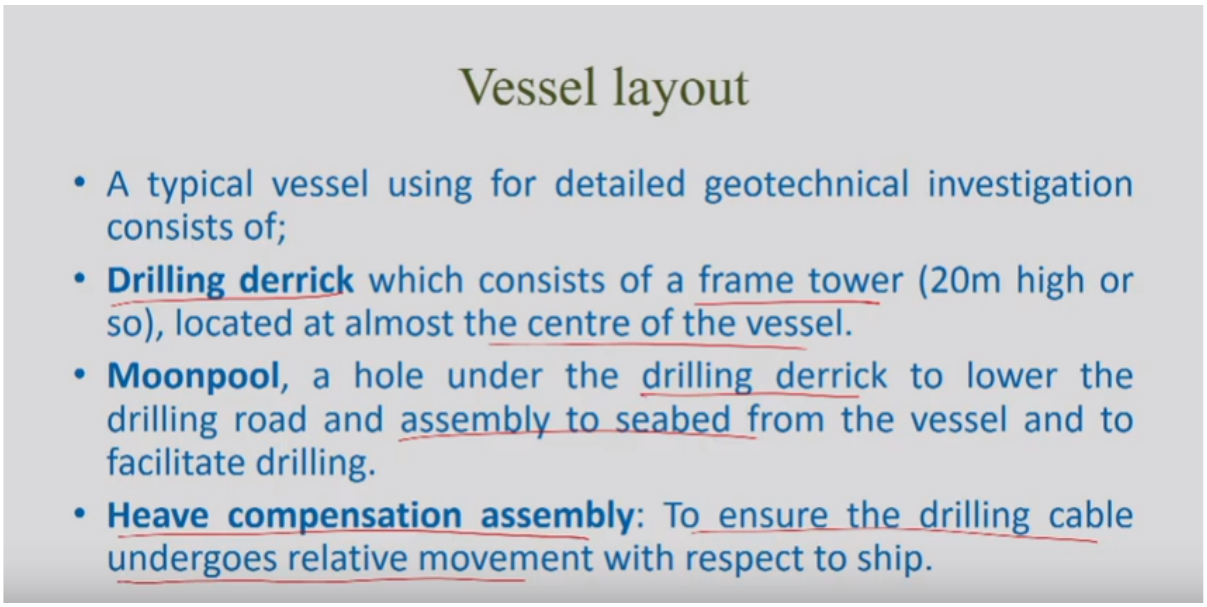

Now the last thing is like vessel lay-out everything like whether we go for DMT, whether we go for CPT, whether we go for reinsure test every test or even for assembler also we using vessel. So, what is the typical vessel, vessel is like kind of relatively bigger boat or kind of ship kind of assembly, but it is precisely designed for this kind of investigation. So not every kind of boat or ship can be used for this kind of assembly, the typical lay-out consists of a drilling derrick, so drilling derrick is basically a steel tower which is more precisely used, so that you can actually lower because your depth of explosion will be very high so you can actually start your drilling assembly, drilling operation by means of a drill rod which will be significantly as you can actually erate your drill rod through your drilling derrick and then as a drilling progress it will keep on lowering. So, it consists of frame tower which is 20m height located almost at the centre of the vessel. Then you have moonpool which is basically a hole through which you can lower your drilling assembly suspended from your, I mean for which you are provided drill derrick and to that seabed. So, this connection or opening within the vessel which is precisely for lowering any kind of drilling or exploration assembly to the seabed. Heavy compensation assembly is provided so that whatever drilling you are using it you will have minimum affect because of possible fluctuation in your water device. In order to ensure that the drill cable undergoes relative movement with respect to ship rather a fix movement because the, the ship itself will have some kind relative movement of fluctuation. So, in order to have minimum disturbance the drilling assembly you have to provide heavy compensation assembly.

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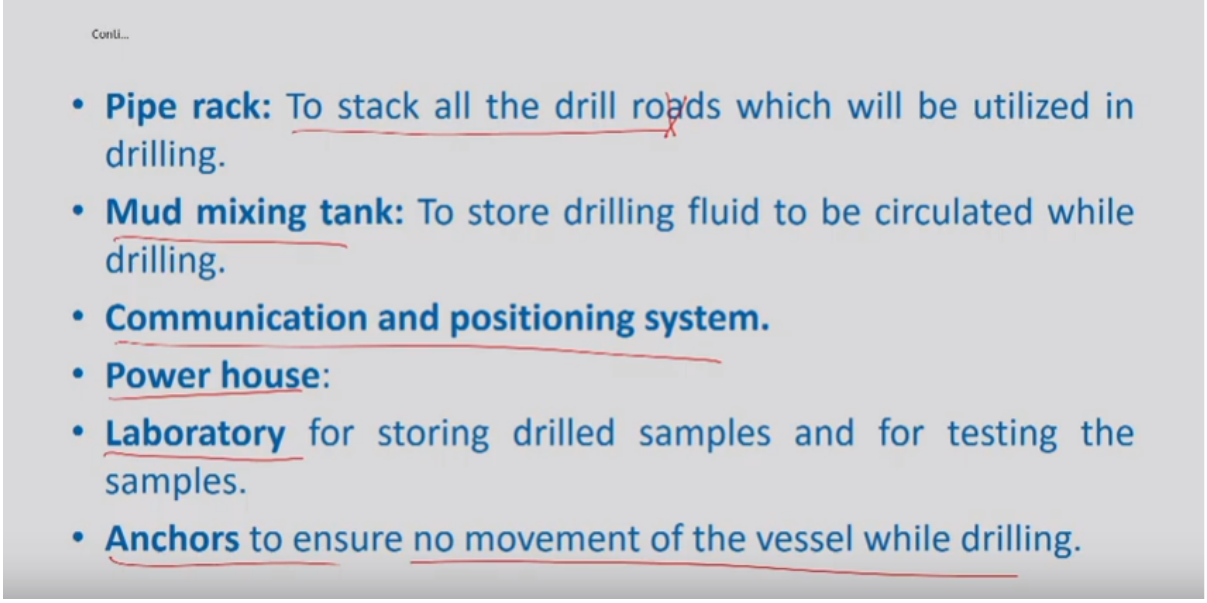

Then you have pipe rack, which is actually an assembly where you can stack all pipes, which are particularly used for drill which can be utilized in drilling. Then mud mixing tank assembly were you can actually put your drilling fluid which has to be circulated continuously when you are going for any kind of drilling. Communication and positioning system which are very much required in case of any assistance in case of emergency as were as positioning system because it is very much important you should know at which particular depth or which particular position you have done the test. Because everywhere water is there so this positioning is very much important. Then powerhouse, because you have to have continuous supply of power in order to do the test. Laboratory detail laboratory where you can actually test what kind of sample you have collected even for storing the sample collected from different depth. So, laboratory which is again NC_2 or at the vessel itself then anchors to ensure no relative movement of the vessel particularly while driving. Otherwise there will be breakage in your failure of driving and drilling assembly as well.

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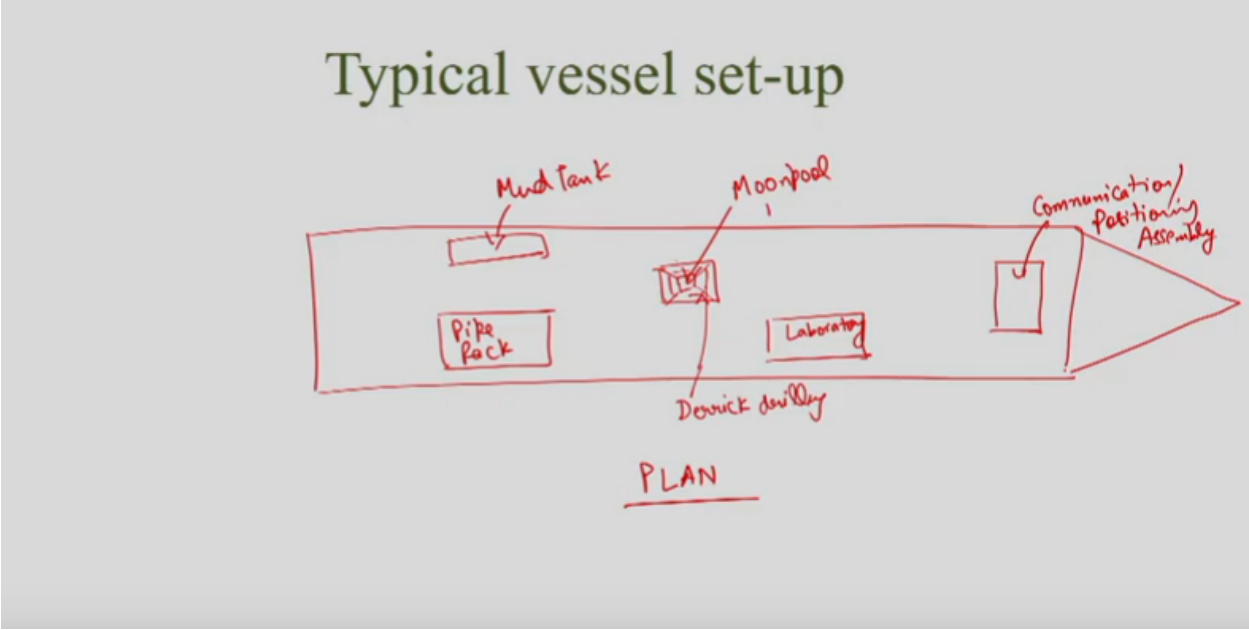

So this is a typical setup if you go, it consists of this is last slide here you have some mud tank you have pipe rack then you have some kind of moonpool here which is assembly, and on this moonpool only you can actually see this moonpool this opening and then this is like steel frame or derrick assembly, derrick drilling assembly and you can have your laboratory then you can have your communication, positioning assembly. So, these all things I have shown here in plan, so these all are the must requirements, whenever you go for any kind of offshore geotechnical investigation. So, with this I will stop here I hope today's lecture is given you very elaborate information about how you plan how you go for sampling as well as geotechnical investigation in offshore environment. Thank you so much.