Foundation for Offshore Structure
Professor S. Nallayarasu
Department of Ocean Engineering
Indian Institute of Technology Madras
Module 1
Lecture No 28
Special Topic

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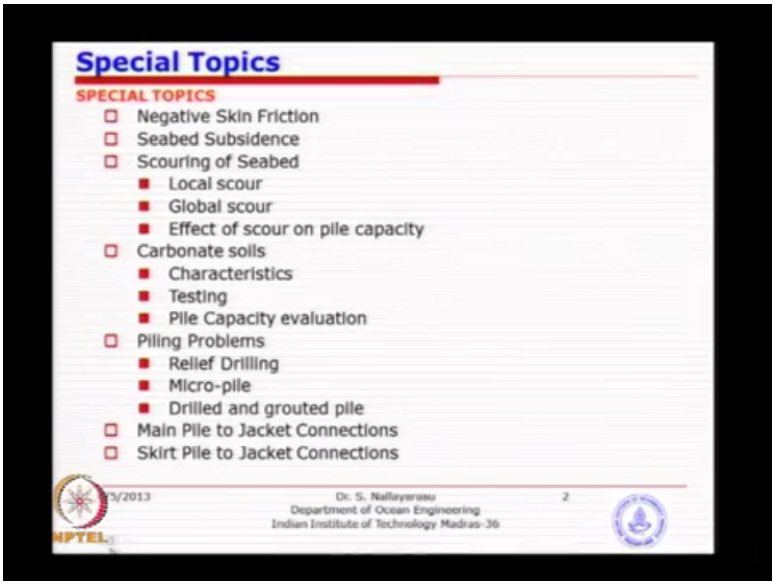

So we will see some of this special topics today, starting with negative skin friction and then covering seabed subsidence and then the soil issues associated with carbonate content which downgrades the capacity and then the piling issues related to refusal and then if the refusal occurs what else we can plan at site, you know unforeseen issues, can we do repair works something similar to you know adding additional piles or do we have planned activities and then finally we will come to the connection between the pile and this jacket. I think one of the connections we have already seen, the skirt pile connection with grout between the annulus of the leg and the pile we have seen in the previous session, so we will just go through some of them which are quite important in in the sense, in case if it occur, it may actually affect the capacity of the pile very seriously.

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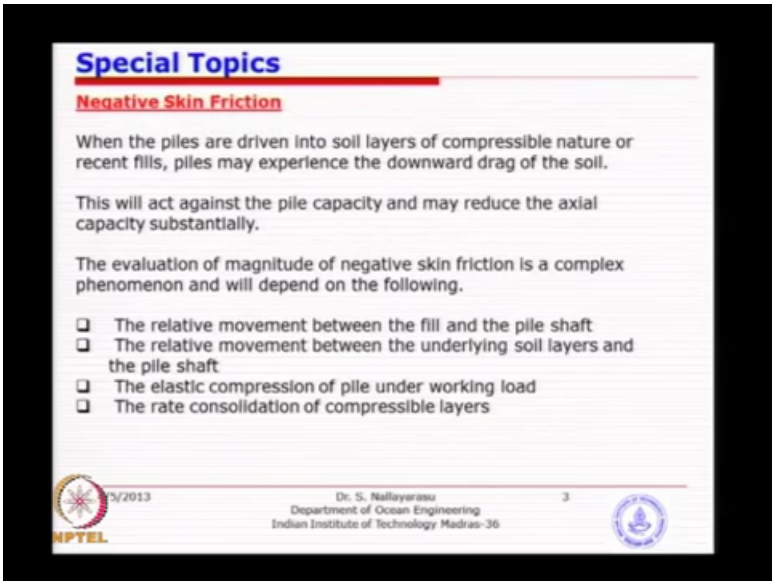

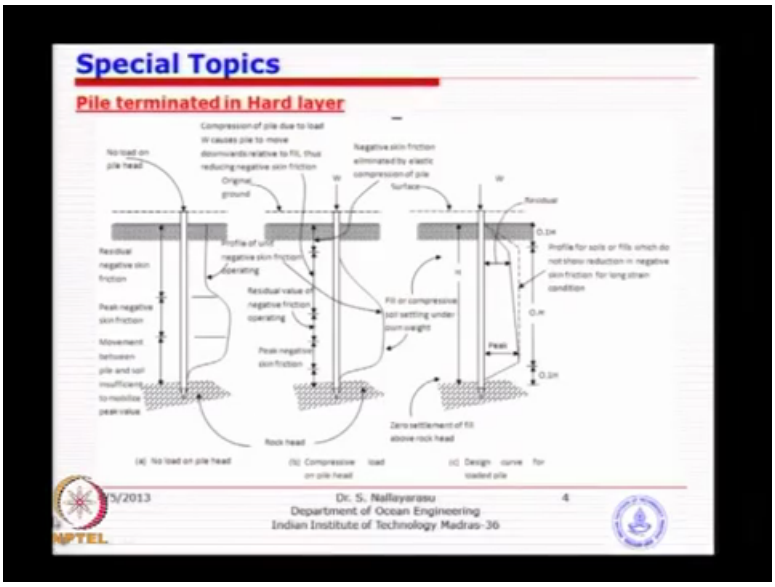

So will start with negative skin friction which is not very much prone to offshore systems because this is a problem where the piles are installed in the filled ground especially the recent fills. For example if you go to this picture you will be able to understand little easier, if you have a fill area probably like in the cities where you have got a recent fill and then try to install a pile foundation when you have slightly better stratum you know few metres away or few hundred meters down, so when you try to install a pile something like this and you see the soil which is recently filled and has you know consolidation characteristics it could be clay or it could be sand.

So when the soil settles down, instead of the pile soil interface providing frictional resistance it is exactly opposite the soil is going down and it gives the down drag, so the weight of the

soil is acting downwards, so instead of enhancing the capacity it is going to add to a problem which is adding to the load, so this we call it down drag negative skin friction you know additional loads in addition to the load applied to the pile, you have a pile load coming from your structure but then then the soil in the vicinity is getting added because of the frictional resistance between the pile and the soil but unfortunately the soil is going down. So this problem is not so much because we, we do not actually install any places where soil is filled in offshore conditions we do not expect but this kind of problem is very much you know there in the onshore as well as coastal areas where you have a fill.

So we will just look at the issues and how it occurs is the relative movement between the fill and the piles shaft which is so that means if the soil…after installation of the pile if the soil the top player settles down that causes this problem and the elastic compression of pile under working load sometimes you may have you know small displacement and that you can take it minus. The rate of consolidation of compressible layer below though the top player maybe not settling down but if there is a clay layer slightly below and that layer gets compressed, the top player comes down. So this is a complex problem which is very difficult to predict, so that is my you know pile type of foundation is not recommended when you have you know the fills oil for the top player.

Also it depends on what is the type of bearing stratum, suppose if you have a very hard bearing stratum the pile is fixed down there, imagine if the pile is not fixed to the basically the hard ground if it is floating pile, the whole soil layer together with the pile will go down, so the relatives moment is not going to be so much a problem, whereas here the pile is not going down it is going to take the load and then try to yield at the bottom, so that is the problem, so whenever you design and end bearing pile, you make sure that the top soil layers are not prone to too much of settlement which is going to cause exactly opposite problem to the pile capacity.

So there are there were several you know proposals how the down track very, so if you look at the picture on the left side you see here the top layer or the initial few metres of these soil is going to cause lesser down track because the cumulative consolidation will happen the total added weight will be increasing the effect of down track at the bottom level, so just simple idea and of course all depends on the type of soil, if it is a uniform soil you may actually come up with something like a triangular distribution which is what you can see here, the increasing effect and then probably the effect is not much after certain depth and then going

to not much effect because the pile…the relative moment is very less because the pile is almost fixed to the hard ground, so this is a kind of assumptions that we will normally need to make during the evaluation of down track.

So you can see here top 10 percent not you know quite a small value to increasing to the maximum value and then this is 0.8, 0.8 is missing here, so the 80 percent of the pile will be having uniform down track then the last 10 percent, so it is kind of simplified assumption in order to do a design activity rather than taking a highly nonlinear profile something which was measured in some of the sites. So install a pile, do instrumentation to measure the fiction and then you look at this profile something like this.

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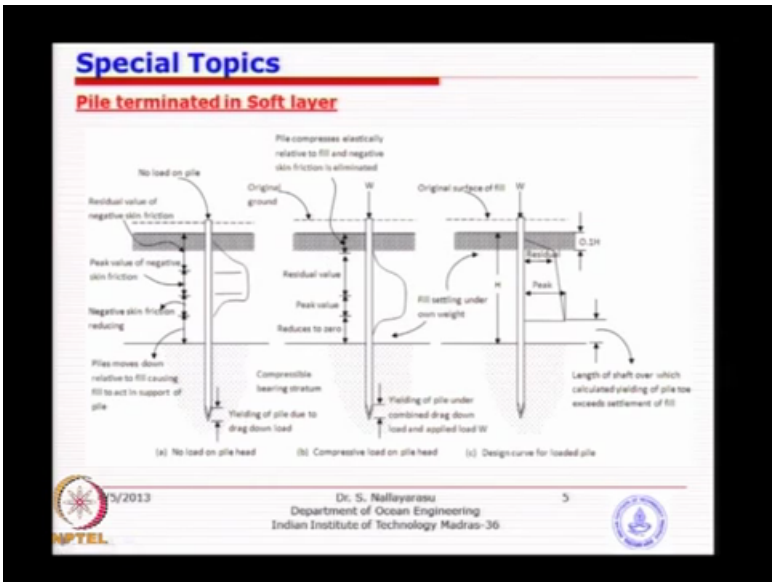

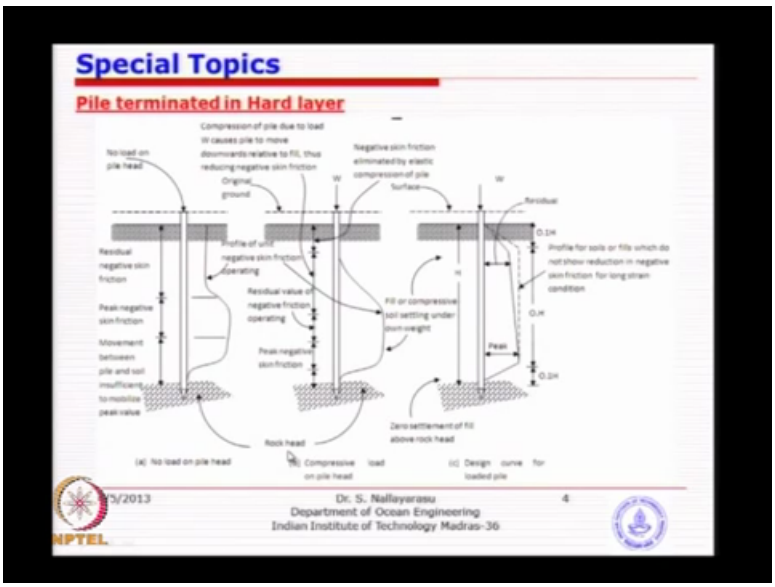

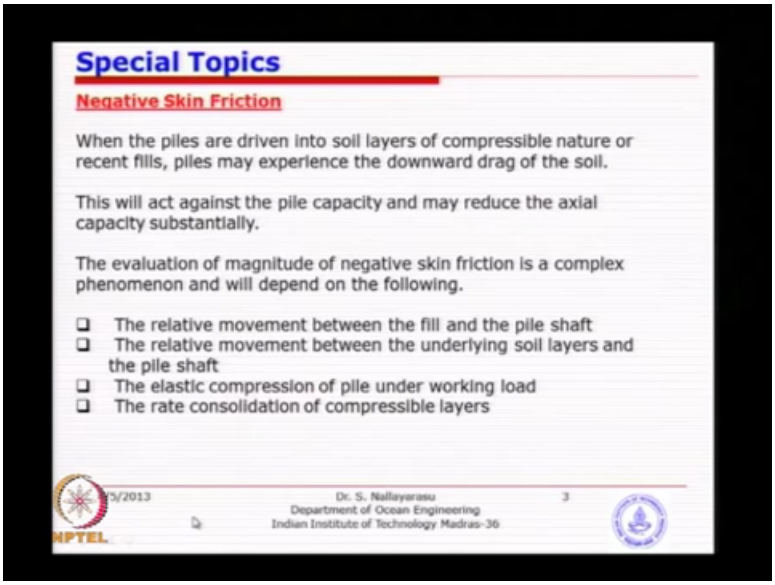

Similarly if you have a pile not installed in hard but installed in soft layer something like this, you see here this variation is also considerably different and here you can see the lower side there is the soil and also going to move together with the pile because this is again not a hard layer, so you can see a slightly different arrangement of the profile of assumption. So whenever you have such situations you have to reasonably assume certain profile and typically you can see the top and bottom is not going to contribute too much, the middle layers where the whole thing is moving down, is going to contribute to the negative skin friction which in some cases can actually cause a big problem you know if you install in a coastal area where you install a pile of 20 meter and make sure that the pile is going to end bearing, your assumption of loading may be hundred tons and you provide 100 tonne capacity but if these soil layer is compressed and displaced the addition of load can be several hundred times you know several times higher than the actual load hundred tonne.

So pile will immediately fail because of this kind of problem because the pile will start yielding at the base because we soil layers also is provided as a the load, some of the piles have failed like that and in fact some of the structures have collapsed because of this kind of phenomena. Constructed unfilled, of courses this problem is not so much for offshore as I mentioned earlier on but still just to understand what is the problem if you have a top player settlement, so you will do just understand this fact.

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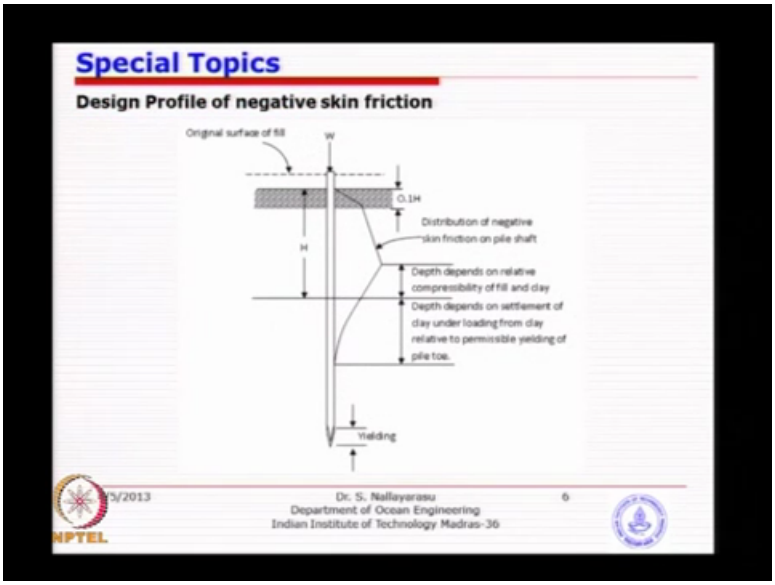

Typical design profile given by one of the code, not Indian code, it is one of the you Euro code, of code taking several sub-segments of the profile increasing and then again increasing in a slightly uhh.

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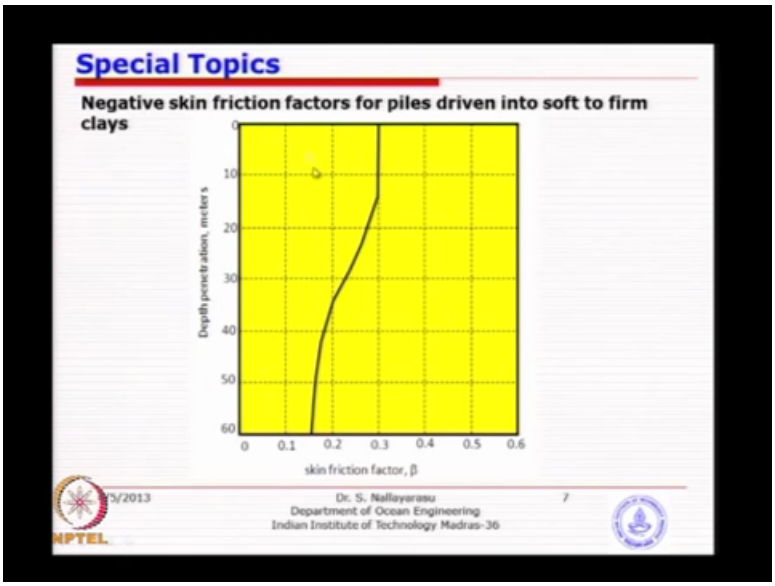

Typical values of skin friction, remember we were talking about calculation of alpha value using alpha method for actual capacity and in here as the depth increases the, the down track also reduces, so that is the kind of profile given by the code which is taken from the Euro code and I just plot it, unfortunately most of the other code does not give any guidance, so that is why I have taken this profile.

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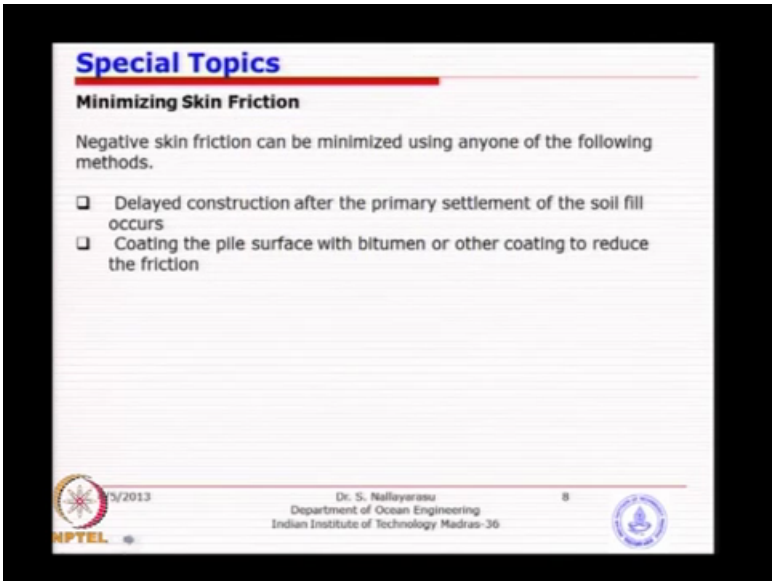

So how do we minimise skin friction in case if you have to install piles in the area where some top layer fill is expected, so you could actually delay the construction that means you allow this consolidation or immediate settlements to happen, so wait for 6 months, one year, 2 years or you actually accelerate the settlement by means of overloading you know, several cases in onshore construction people do this by stacking heavyweights, so if you are having a fill it is fine but then you make the consolidation settlement in 90 percent of them are more happening more before you construct the structures, so by doing this you minimise the amount of settlement that is going to happen post-construction but then all depends on the time and basically several methods of soil improvement techniques which I think we have not talking in a course but it will be very important.

One of the techniques is relieving pour pressure you know imagine if you have a fill soil with pour pressure or the water surface below, so you can actually have several holes drilled into it and somehow you have to drain the water, so you actually do a surcharge loading and make the water to come out, so we have so-called ban drains you know inside the drains vertical drains and with a perforated holes, so the soil is squeezed because you are applying loading and the water might come out through the port and then relieve pressure that means settlement happened very fast, so that is the idea of so-called these soil improvement techniques one of them, there are several other techniques which can be used.

So that the settlements if it is required to happen let it happen before the construction of the structure. The other method is basically active way of doing it basic…coating the pile surface with bitumen or other which reduce friction. See actually when you design a pile (())(10:23)

more friction because of increasing effect and the frictional resistance you will get better capacity, it is exactly you are trying to provide opposites, so that the alpha value will be lesser, so the piles soil interface we want to make it smoother, so that the down track does not cause too much of the effect on the loading, so that is the opposite normally used bitumen coating or other surface coating which reduces the frictional resistance.

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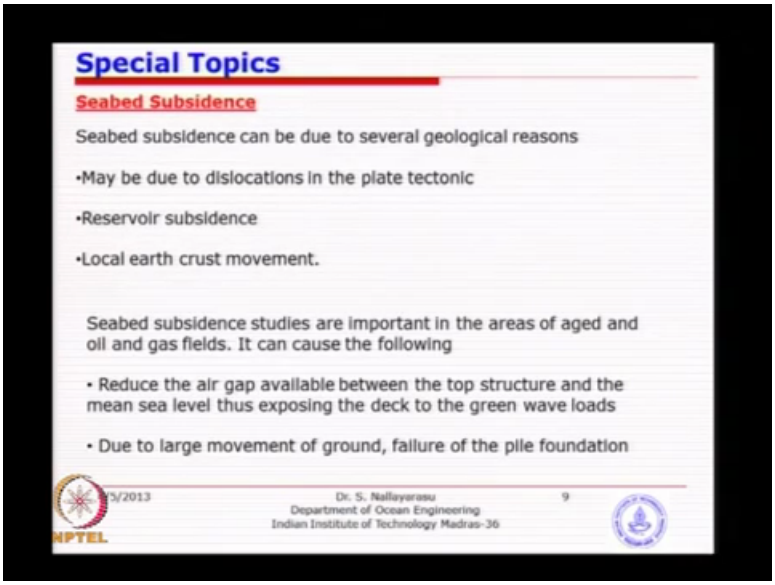

The second topic which we want to see is the seabed subsidence is very much prone to you know offshore platforms. Constructed in the local vicinity several of them as much you want to know this, why it happens? You need to know where we are taking the oil and gas, mostly several thousand metres below the sea bed, mostly I think in the starting of the course we were talking about several kilometres, 6 kilometres 5 kilometres below seabed is this kind of hydro carbon deposits are available. Now if you have only one drill because of one location, nothing is going to be a problem but you can see the shape of the reservoir underground, under the conditions of natural deposition, it is going to extent for several kilometres not going to be just one small packet, so when you are having such kind of reservoir underneath and you want to exploit and drilled, normally we do a several platforms, not one platform and keep drilling in the same location because you will not be able to access the large extent, so you will see that several platforms are drilled and oil and gas are extracted from the location.

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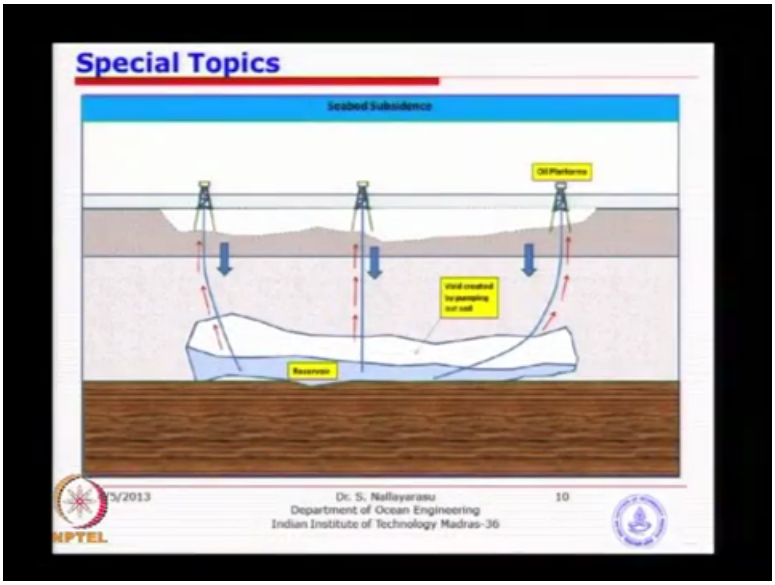

So when you do this what really happens is something like this, you know you are creating a wide below and which is going to cause in stability to the seabed which is lying above which is potential in the recent days because when oil and gas extracutaneous starting to happen 70s and 80s many of these fills were very young but after 20 - 30 years of extraction what you have seen here is the wide space created becoming more and more problem in fact in Narsi many of the old platforms more than 30 years the whole platform together with the subsoil as gone down by 6 to 10 metres over a period of 30 years slowly is going down because the ink stability has happened.

It is not that you are going to see a small pothole happening, it is the whole area of several kilometres going down, so you will not be able to see a major problem with a structure but constantly going down at a particular rate and it will be…the potential problem, initially it may be going down slowly but once major fault line forms with a complete area going down it will actually sink the platform underwater because water levels are not changing much, so you will see that the seabed level is going down together with the structure, it is not only seabed it is a complete layer on top of the reservoir is going to go down, so what has happened is from 90s to now, several platforms in Narsi as well as in some part of Gulf of Mexico has gone down by more than 5 metres.

Now imagine we discussed about this problem in design course where the water level difference the height between undersides of the structure, the superstructure to the water level is basically a minimum required depending upon the sea state conditions, so otherwise what happens is sea waves will actually hit the superstructure. Now one of the problems is the

superstructure may not have been designed for that and the amount of green loading, we call it green wave hitting the superstructure will be substantially larger which will make the platform to fail instantaneously because you have not designed for the condition number one, the loads are going to be very large and also the facilities supported on top is going to be you know subjected to direct water immersion which is not very good.

So you have to change the facilities, that is one side of the story, the 2nd is the major issue is the stability of the jacket itself, when you subject so much of large lower going to be whether sufficient and if you have 2 check such a platform existing in the old say 30 years 40 years old are still producing, what kind of criteria you have to use? You may actually have to reduce the requirements but then what will happen to a platform if you are planning to install now whether you to provide for such…so most of the platforms in the recent times which are getting installed you have to give a provision for seabed subsidence of 5 metres or may be 10 metres, so you construct a platform 10 meter high now, higher than what you normally provide.

See for example if you normally provide appearance of say 10 metres, you provide for another 10 metres, so that the next 30 years 40 years especially when you are installing a platform in the existing area because it is already gone empty and it is going to go down substantially, so you provide for that, so we call it seabed subsidence allowance, so you plan for future subsidence to happened, so that is why this reservoir stimulation is very important but how can you avoid this, so one of the ways in some of the field people have been doing is filling this area with water, seawater.

So for example you try to create an empty condition by taking out the oil and gas but then you can fill or refilled with a seawater but one of the potential problem is when you start filling it mixes with the remainder of the oil and gas. When you are actually taking out too much of water will come, so there is a potential contamination that can happen which is also a problem, so quite a number of studies are going on area wise to find out what is the rate of this settlement, so many of the platforms they have put live instruments to measure the rate of settlement, so that you can actually plan for the future platforms.

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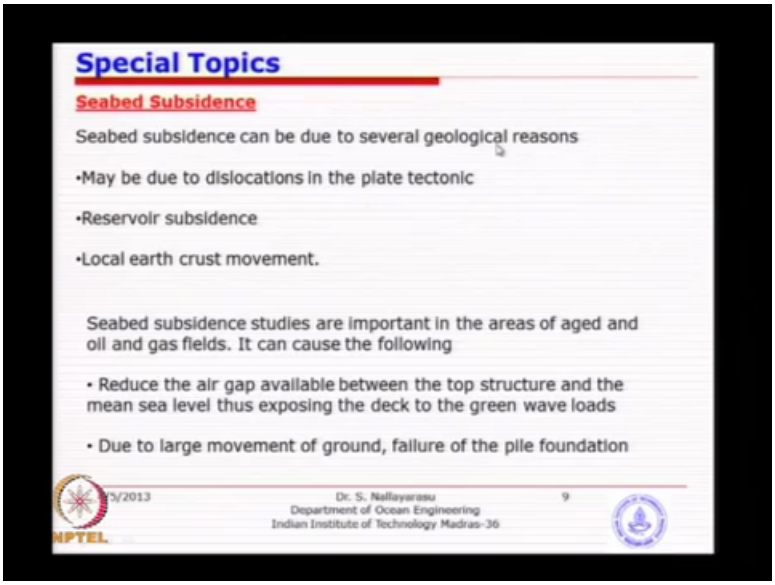

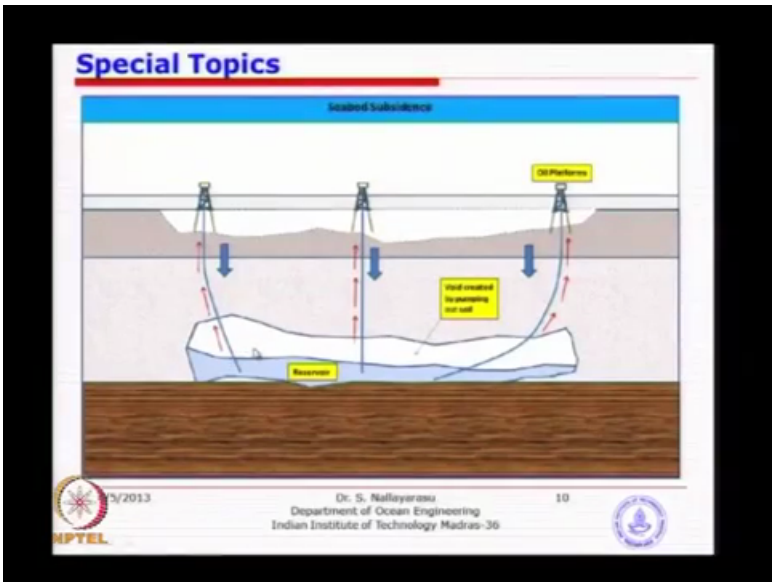

So this seabed subsidence is a potential problem going to happen or waiting to happen for every location only depends on amount of wide space created because of the pumping. Not every place will have such a problem, you know some cases you will have porous structure which may be still stable even after removing the extraction of oil and gas, so not a big issue so far in the West Coast we have not encountered such issues but if it encounters we need to plan and provide for future.

There is one more issue, imagine if the whole platform goes down nicely, in fact to say quite a number of research studies is going on, if one of the leg is going down because of a local issues and the platform start to tilt, so what exactly will happen? In fact some of the universities they have done some research studies on one of the pile going down at the

remaining 3 stable, so what happens to the ultimate strength of jacket, whether it will be stable? So pile settlement by say several centimetres which is one of the issues because when the whole area is going down you do not expect everything is going to be a uniform settlement, you may actually have undulated settlement in local areas.

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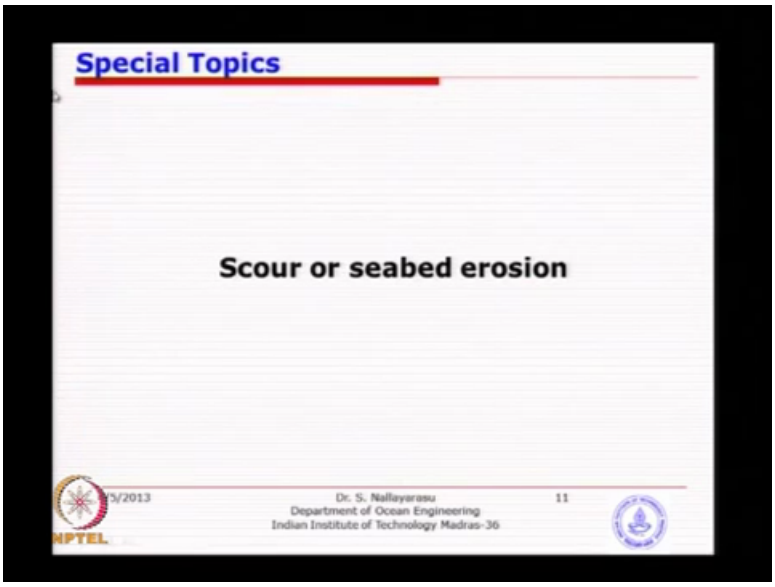

The next issue what we want to address is discover around constructions offshore are coastal discovering is the removal of soil in the vicinity of an obstruction created by you know by construction of offshore structure or coastal structure, so imagine if you have study stream of current going and straight away you make one barrier, so what happens is the current velocity is going to get obstructed by this structure, so it will try to find alternative roots, so imagine if you have only one pile installed in the middle of a current, so the current will try to get diverted, so in the vicinity of the seabed and this pile you will see that increased circulation happening because an obstruction is there, so this soil particles will try to float above seabed when it was in a static condition it is lying under seabed.

Specific gravity may be somewhere near 1 - 1.1 - 1.2 submerged condition and then when this circulation happens because of the turbulence the particles try to get elected up and if you have a sustained stream of current it will get carried away, so this is the simplest phenomena that is going to happen which will take away the soil particles in the vicinity of the structure because of the disturbance and the circulation that is going to happen and that phenomena needs to be investigated and basically because how much amount of soil is getting removed that much of amount of capacity is getting eroded away from our calculation number one and

also it exposes the pile to that much distance becomes a larger cantilever, so which is needs to be taken into account.

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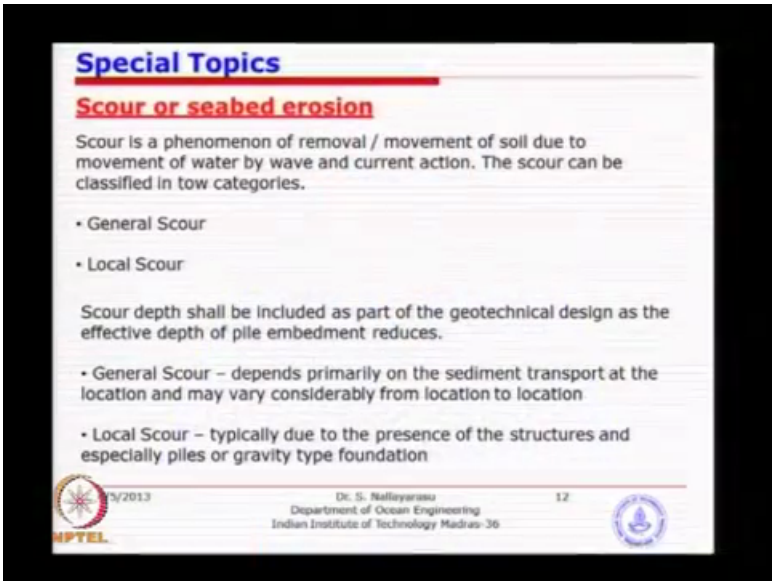

There are 2 types of things that can happen actually it can happen over a larger area like very similar to our seabed subsidence larger current and larger thickness of loose sediments which can get carried away and then get removed which will be not dependent on the type of structure that you have constructed, it could be generally eroding whereas the second one is a specific to an obstruction created by construction activities which is basically called local scour. It will be in and around the structural area where you have a pile or other obstructions so which is called local scour.

Now this depth of scour depends on various parameters, the current velocity, size of the structure and the solid particles basically the surface soil particles. If you have big boulders probably the current velocity or the turbulence may not be able to lift it up and carry away, it will not be able to possible to do that but if the particles are quite small number one and also not very denser then you can see that these particles may get carried away because of this, so you can see, now immediately you have a solution, if you make the big boulders around the structures you can see it may not be able to possible to gets scouring, so one of the scour anti-scour measurer is make larger boulders dump around the structure so that the soil is not able to go away whichever the soil is underneath the problem is if you put a big boulders still the wide space is there, soil may actually get carried away, so you will to have a engineered fill that means the graded fill so that soil cannot escape.

So normally we do this scour protection means trying to avoid you know the particles going away. So this scour phenomena is very important especially in coastal areas because it is the area where you see lot of turbulence, wave breaking and also increased velocity because of the energy is getting destroyed down there only. So you will see that scour is not a very big problem for a jacket type of structure but still it does exist for certain amount which we need to take into account for coastal structure is very serious phenomena where this scouring can be as much as several metres, especially when the current is very large. For example if you if you look at Gulf of Cambay in Gujarat and Maharashtra area the scour depth is as much as 10 metres. The reason is during neap tide and spring tide the current values are almost like 3 to 4 metres per second, 3 metres per second in fact.

The reason is the tidal changes is 10 metres, so during your high tide you will see that the water levels are so high and during low tide the complete river, it is almost like a river taking the water from the inside of the Cambay towards the sea so it carries complete…so every day 2 cycles you can see here within 5 years the scour depth is almost 10 metres, in fact one of the structures was built in 97, after 5 years the pile is almost cantilever by another 10 meter, so you can see that this type of places you either protect all you design for it you know. So this local scour and this global scour also needs to be added together because you may have a general scouring and you may have also a local pit kind of covering wherein uhh…

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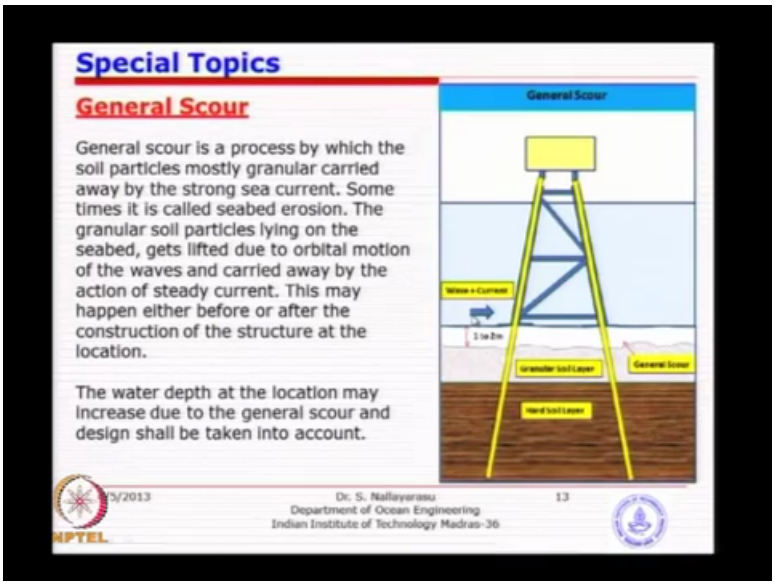

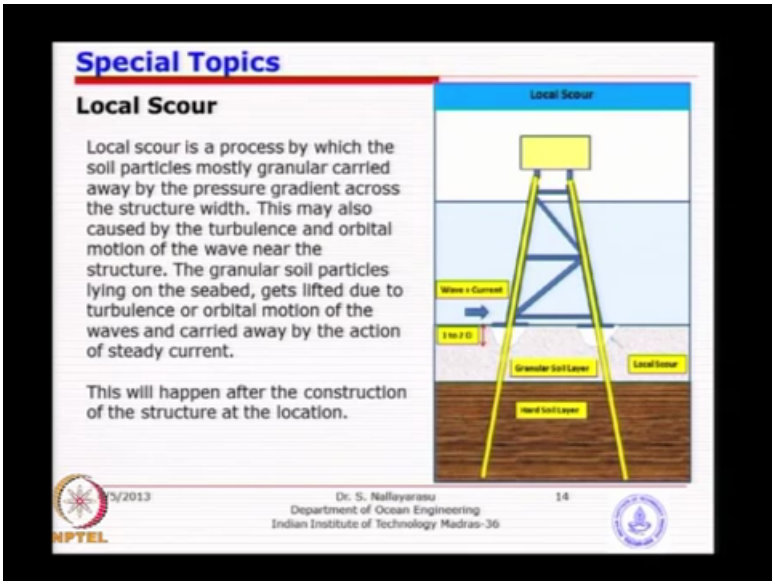

So this general scour typically over a period of long time you may have 1 – 2 metres normally happening when you have a granular type of soil is carried away. Local scour is a kind of phenomena very easy to understand it's going to buy increase the circulation and turbulence near the structure, you have vertical pile or inclined pile does not matter, only the pattern will change, so you can see here, so when we are doing a structural analysis for your jacket structure you are supposed to get a pile resistance, the soil resistance at the seabed level but you do not have this soil, it might be there on the time of installation but after several years it is disappearing, so that is where you have to take into account, so when you are designing the structure and the pile you may have to consider extra 2 metres…soil is not there.

Now imagine what is the difference between the local scour and general scour? When a general scour happens you see the water depth increases by at the site at the particular location of the platform, water depth increases by this much, whereas when you actually look at for hydrodynamic calculation, when you doing hydrodynamic operations, I think most of you are familiar with wave theories and associated calibrations, so you will be using water depth, now here general scour is the overall area, so water depth is going to increase by that much, whereas when you come down to this type of local scour, water depth still the same as original but then there is an increased the depth at the location of pile which causes some amount of reduction in the lateral and axle capacity which is…so this is what you do make sure that differential between you deal with this local scour and global scour?

Normally many places we use the value of 1 – 2 diameter, typically that is what happens many recent studies have shown that, it is not going to be very large, the local scour will be

something like this maximum is 2 diameter beyond which the soil will not be stable, it becomes almost like a global scour it will take away larger distances.

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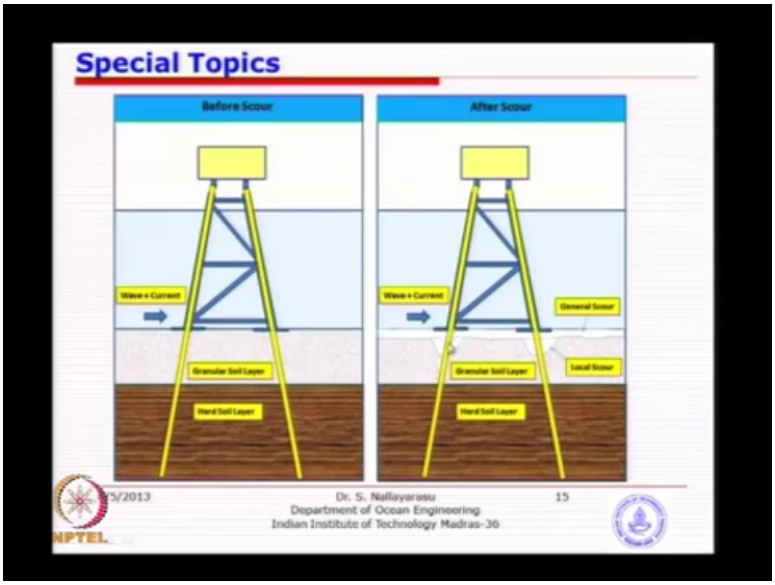

So when you combine them basically it will be like this, so you see here this much of pile has to be exposed and you do the design accordingly, so how do we do or it effects the calculation at we have learned so far for example when you are talking about overburden pressure I think, if you remember alpha method overburden pressure is very much important.

Now you can see here the global scour straightaway it can remove the soil, so overburden pressure is automatically reduced by that much. If the 2 metres soil is missing, the 2 metres soil is not there for overburden pressure but when the local scour happening you could actually assume that another 2 meter or another 1.5 diameter to diameters soil is completely removed you can assume like that but that is too much conservative, so what API says you do not have to completely removed the soil because this is only a triangular portion of the soil has been removed costs sometimes if you assume 2 diameter say diameter is 2 meters, 4 metres of soil is completely removed for local scour your capacity reduction can be substantial because Alpha method are beta method both of them actually lower bottom pressure contribute considerably.

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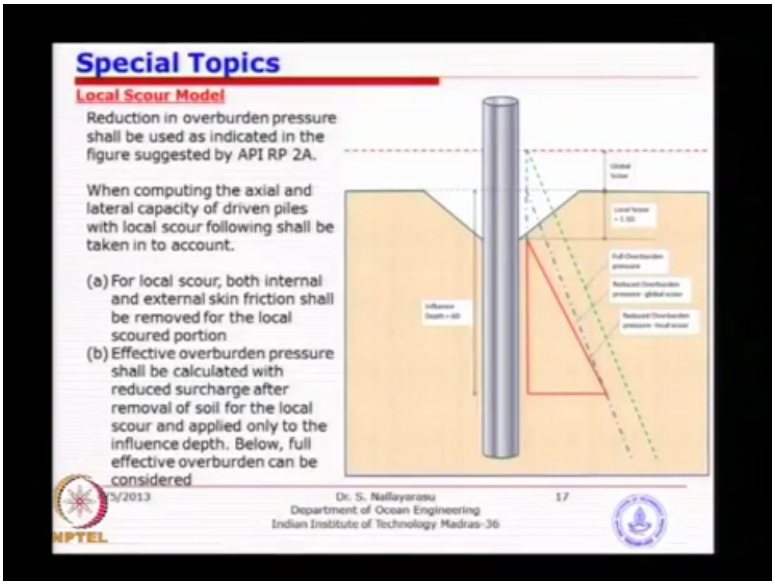

So that is why there is a proposal by API that you do need to completely remove the overburden pressure hundred percent for the local scour, of course for global scour you anyway have to remove but local scour you find out distance at which the 6 diameter after which the influence of the local scour will not be there that means the soil becomes almost… you will have the effect of the soil and the vicinity will provide for you as a as a overburden pressure.

So below 6 diameter that means within the 6 diameter you have a linear increase of the overburden pressure on 0 to maximum value that is supposed to be a reasonable idea because this is anyway to a local because when you look at faraway distance, soil in the other slightly away from the pile will also contribute so that is the local scour model, when you are doing a calculation for your actual capacity including scour effect, you need to take into account this, so which is why we need to learn the effect of local scour into the calculation. Similarly on the lateral capacity, so that is the idea behind. Global scour anyway I do not think it will affect because you will just straightaway assume that the solids removed, so not a big problem.

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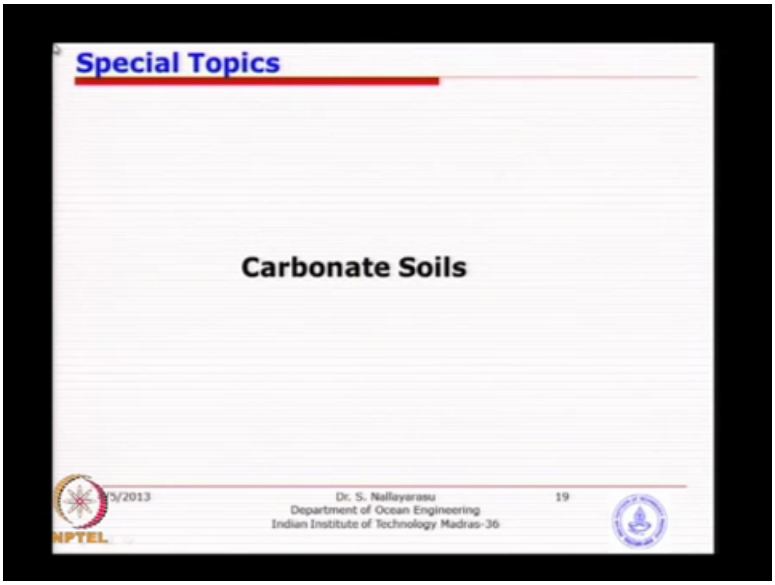

The next topic what we want to find out is the type of soils which is relatively important in cases of areas where carbonate and is very large, in fact every soil sample we do a chemical test to make sure that this carbonate content is as than 2 percent, if it is less than 2 percent contribution of problem associated with downgraded capacity is very small.

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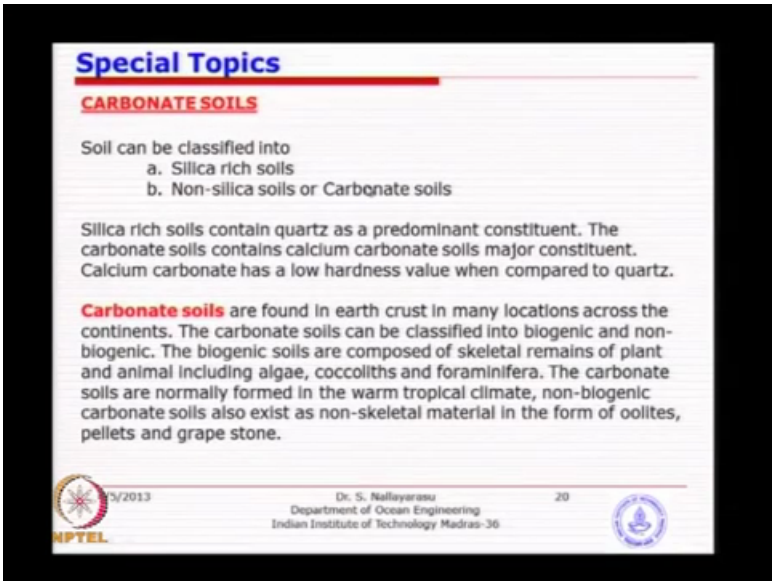

So what is this? We need to understand, soil can be classified into silica rich or non-silica rich at means it is carbonate soil are going to be there, silica riche is basically our grind sized material, parent material coming from you know basically quartz or associated rock minerals. So predominantly most of the soils, whatever we classify whether it is a clay or silt, sand, gravel…every one of them the origin is going to be coming from such type of material, so the

carbonate soil is basically the calcium carbonate arising from biogenic materials, basically the decomposed plants and animals several thousand years back, so you see a skeleton remains under the ground and get decomposed. Forms path of the soil but it may not be separate, it might have got mixed with other silica type of material and becomes like a like a soil, it looks almost like you will not be able to easily differentiate but when you apply loading these carbonate content if it is larger than is like a honeycomb, get crushed will easily but you will not be able to really find out from typical picture of it.

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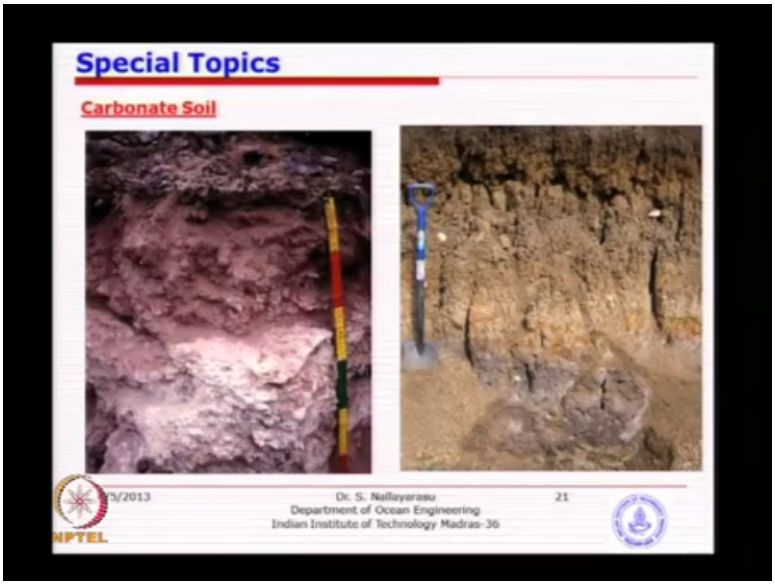

So if you just look at this you can see here this area is having some kind of larger carbonate content, so when you apply loading from the top you will see that this gets compressed very easily, so this is where we have to be little bit cautious in taking samples and take a sample and take to the laboratory, do or chemical analysis find out the content of calcium carbonate, so that is one of the area where API in earlier time has no recommendation because you try… what they say is try to avoid but offshore system, how do you avoid?

If you have placed where you have a larger calcium carbonate then we do not want to shift the offshore platform to another location because that is where the oil is available, so we still have to construct but in many of the cities if you find this type of soil people do not go for pile foundation because potentially they can cause trouble at any time and there is no easy method of treatment available or such type of soils, so the carbonate soils are found in Earth crust in many locations, if you actually look at the survey fortunately in West Coast and East Coast we have very few isolated locations but if you go to Middle East especially the Gulf area many of the oilfields the top crust is having this kind of soil where carbonate contend is

almost more than 40 - 50 percent. In fact that is why many of the API procedure do not apply for that region, they have got the region based its specialised calculation method for pile capacity which I think I will share with you later on.

Slightly downgrading effect, so if you remember alpha method we were learning, alpha method is proportional to your overburden pressure for sand and…so there is again a reduction factor applied on the top of that method to take into account the effect of carbonate contend and that is something practised in that part of the world. So basically the biogenic soils are composed off, skeletal remains of plants and animals embedded into the soil several years back and downgraded, so this is typical example that will be very difficult to differentiate you know the normal place oil from this kind of mixture of soil with this content higher.

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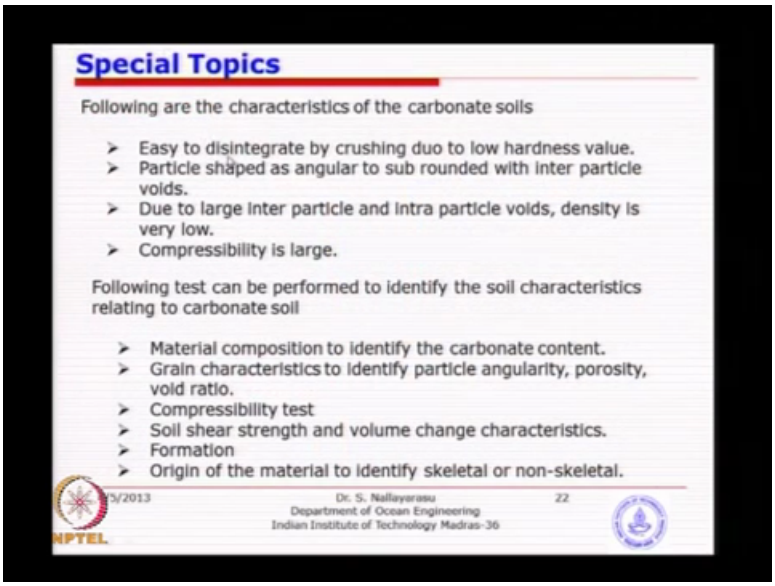

So easy to disintegrate that means if you pick up the soil you just try to squeeze between the fingers you will be able to see at it is having not much strength. Particle shapes quite angular not much sub rounded and then because of larger particle sizes looks and it might actually get too much of a wide space, so that the density will be very low, compressibility when you actually apply loading will be large, so how do you find out these? One of these is method is doing a chemical analysis find out what is the carbonate content which will give you a feel that this soil is having so much of problem.

Grain size characteristics you can do distribution (())(32:58). Compressibility test is normally done in the soil lab, shear strength anyway will be very weak as you know when you do an

even direct shear strength you will get reduced value and then the origin of material which is something which we cannot do by a laboratory testing, what normally have you have the area wise study work for the last several years, so you can look at the origin of the soil from the history of the material.

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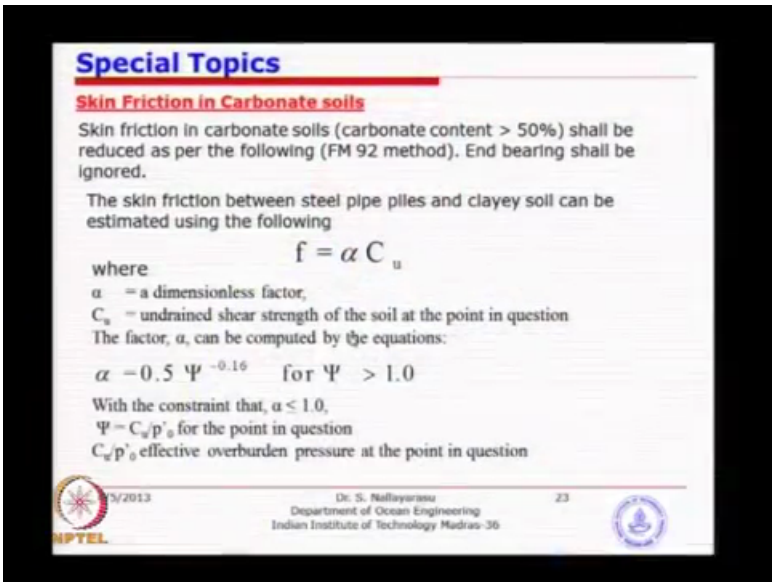

So this is the method which you will remember we were talking about 0.15 I think 0.25, 0.25 was the value that we normally used for 0.5 and 0.25 there were two sub segments were there, so you can see here is 0.16 which will yield slightly reduced value of alpha which was recommended by a company which has done an extensive work in that Middle East region and Fugro there is a company called Fugro who does most of the soil work in that area drilling as well as presentation and working for many oil companies.

So they have proposed after doing so many test and some kind of measurement on-site they have come up with a reduced value of Alpha in which case you can use if you encounter the condition to use is carbonate contend greater than 50 percent, so that is what they have a predominant condition there and end bearing shall be ignored, so you can see here the end bearing at any layer you cannot take because is going to just give up, so that is the recommendation based on Fugro and earlier we used to not even have this. Now API says they have published in one of the OTC paper, so you can refer to this paper or any particular side when you are having such type of soil.

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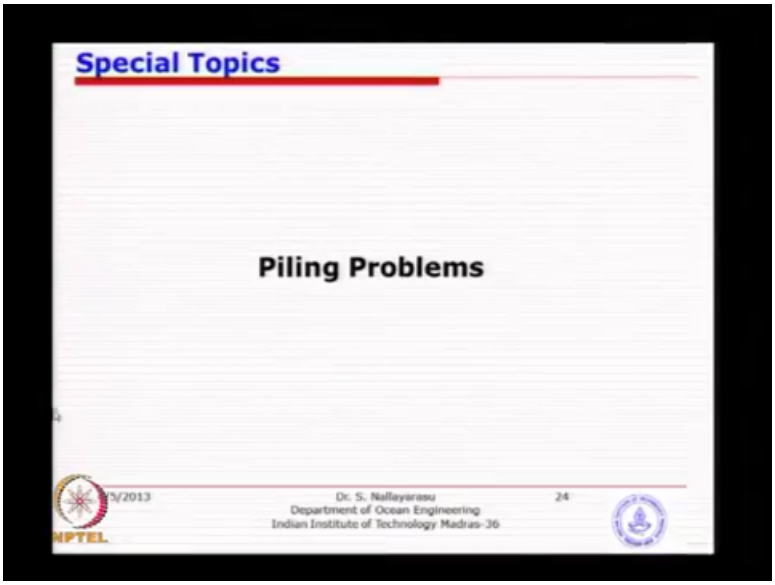

The last one I think he want to see today is basically the piling problems, we have learned about pile drivability. I think during driving if you expect premature refusal because you already have reviewed the soil layers and soil layers seems to be very hard and you provide for you do a theoretical assessment this hammer is required and still you get prepared for some kind of the remedial measures in case if it happens offshore not want to come back and then go again, so you again get prepared because the repercussion is very large if you do not install the platform (())(35:40) unlike onshore or coastal area you can do it tomorrow whereas it cannot be done that way, so the piling problem needs to be understood and then get prepared and provide for while going offshore, so that is the idea behind.

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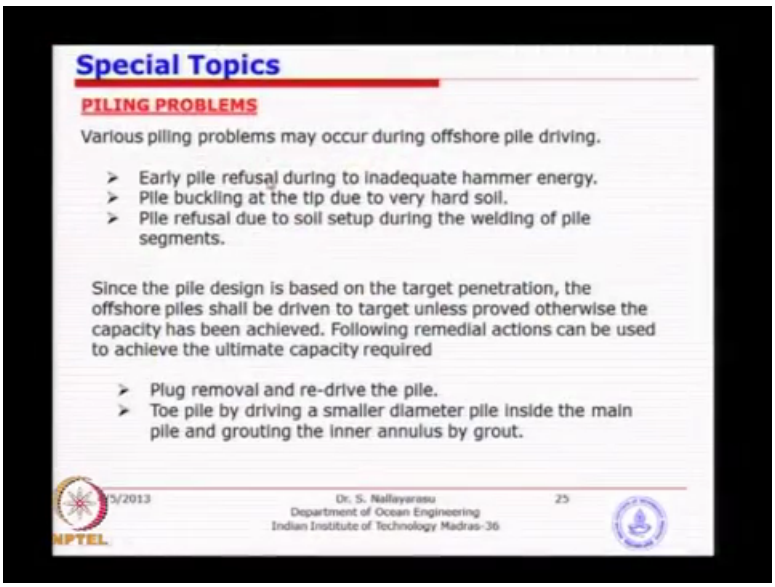

So what can actually happen when you have an earlier refusal because your theoretical calculation of pile drivability is not correct or misunderstood or you have understood the soil is actually stronger than your understanding, your borehole is incorrectly understood. So there could be mild refusal even after so much of engineering work still you could expect earlier refusal. Pile buckling because your pile calculation sub-stresses was incorrect, so pile starts to buckle locally because there is a big boulder something normally happens. Pile refusal due to soil setup because your hammer breakdown or weather conditions are not permitting you to drive continuously, you stop and go back again to start driving after see 2 days, you see that the resistance is larger, so these are some of the areas where unexpected things can happen, so you can get prepared for it.

So if you have such issues on-site some idea you can just think about, how do you restart? For example one of the idea is removal of the plug, so you just remove the soil within the pile somehow, so what happens if the internal resistance is removed, pile end area resistance is removed. So when you re-strike the resistance is reduced so pile can actually go down, so that means she knew to have a machine which can actually remove the soil which is called relieve drilling, so that means you have a drilling machine on board, so while going offshore you only have are driving machine, now you actually have additional drilling machine.

So if you have a drilling machine I think you should not have a bigger worry on thing is you need to…if you have it, if you do not have this cannot be done or you can imagine you have a larger diameter pile and drill and provide a smaller diameter pile within the pile we call it micro-pile, we call it several different names add on pile, the reason is the pile is unable to go because it got stuck, so if you make a smaller diameter inside it may go. So these are some of the ideas that you can think about.

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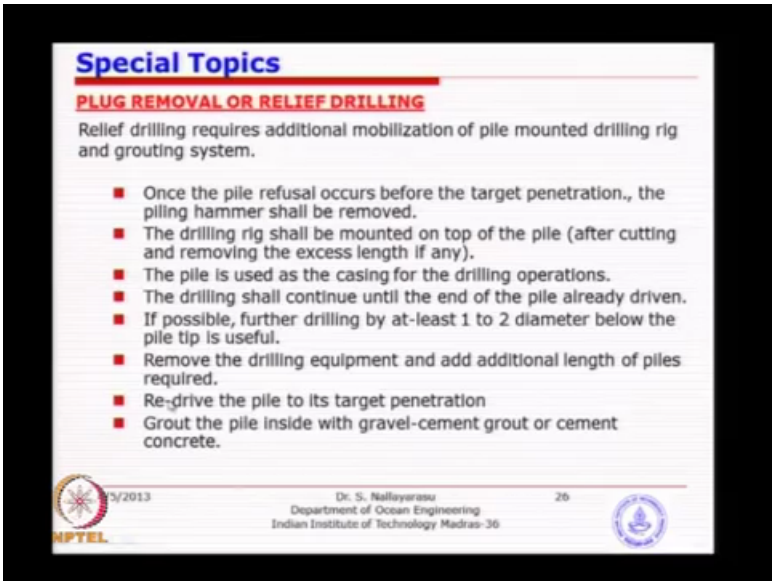

So plug removal how it is done? Because you do not have any superstructure there, so on top of the pile itself you will install a small drilling machine we call it pile top drilling machine. It is unlike drilling machine used for oil and gas drilling that will be bigger machine, this one will be a very small you can just put it through and start removing the soil. Once you remove the soil then you can again plays the hammer and start driving and you can repeat this procedure…but one of the issue is, what has happened to our original calculation? See we assumed that soil is inside the pile, soil is outside the pile.

You have done a calculation for skin friction outside, skin friction inside, end bearing now the soil is not there inside, so your design calculation for your engineering capacity is not correct, so we need to either make sure that you fill the soil back to achieve similar density which is very difficult or you fill a material which is better than the soil. So normally what we do is? We do a feeling of grout which will be far better than the loose material which you are going to fill, so that is why so you can imagine now when you expect such thing to happen you need to have a drilling machine, you need to have sufficient amount of material to make grout. Material and also to methodology to fill up the grout, so these are the things that you… so how do you evaluate whether this is going to happen not? All depends upon your understanding at site and the boreholes and the vicinity what has happened in the last few projects. If you have expected similar things happen, so you get better go with that kind of idea.

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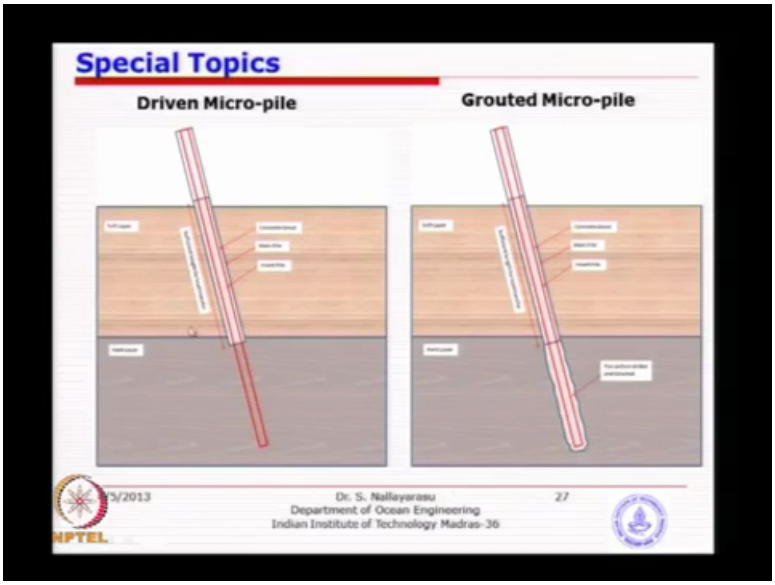

The other thing is basically installing a driven micro-pile that means…the reason why we can understand the reason why the pile is not going because larger diameter means larger capacity or larger resistance, so you make the pile smaller, you may actually have lesser resistance because it is going to go inside and that is there idea behind installing a reduced diameter pile which we call it micro-pile. The effort required to drive that smaller pile may be slightly smaller than the bigger pile but you are have the hammer which was driving the bigger pile, so that means it may be able to easily drive the smaller one, so that is the idea behind driving a micro-pile straightaway within this as long as you already have thought about it you have taken the material.

If you do not have the material you may not be able to do it, so that is one idea the grouted micro-pile is just an alternative that is because if you are not able to drive then you actually drill the soil within which and then you insert this pile and then do the grouting, so what happens is? Whatever the capacity you could not achieve because the pile supposed to have gone to this place supposed to be original design will be derived from the ion that you have inserted, so that is the idea behind, so we need to just make sure that, that capacity is sufficient enough, so grouted micro-pile versus driven micro-pile is depending on the type of situation. If you have a very hard layer like sandstone or rock and probably driven micro-pile is also not going to work, so you may have to do a drilled Micro pile. In some cases I think I have shown some video one of the I think sometime, you have a complete the pile itself is drilled and grouted, you know. So you can have a situation wherein you cannot think of driving because of the soil is in shallow depth itself you have a hard material.

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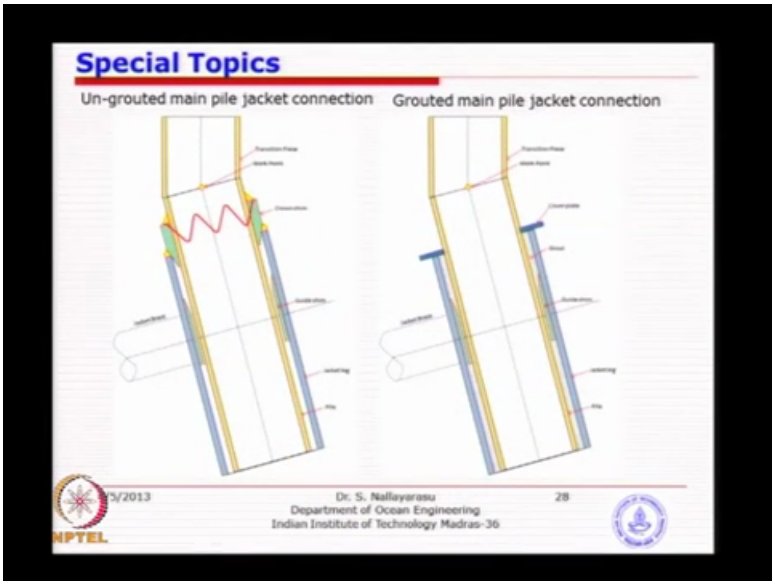

The last one I thing we were discussing about this connection between the leg and the pile, the grouted connection anyway we have already gone through the design methods adapted. The other one is basically the (())(42:15) connection wherein you do not have any grouting, the load transfer is only through contact at every horizontal support framing of the jacket through a sim connection. Basically you see the green color, hope you are able to see within the leg you actually install a plate which is tapered in nature, so wherever you have a load on the outside sleeve or jacket, the load is trying to push the jacket towards the pile because the pile is already anchored into the ground, so this is when the contact happens the load will be taken by the pile, so the gap supposed to be smaller.

If you give larger gap you not be able to get the load transfer properly, so that is why we give about 6 mm gap but one of the problems is the smaller the gap installation of pile becomes a problem goes if you have a smaller annulus gap, when you try to install a pile because of the fabrication tolerances pile may not go through, so what we do is we give a larger gap but we give a chamfered surface by which the pile will be able to somehow insert into it, so this will be installed in every horizontal framing of jacket, so that the load transfer happening at the strong points and the top connection is a simple plated connection between the jacket as rest of the pile so that jacket and the pile is not moving away separately.

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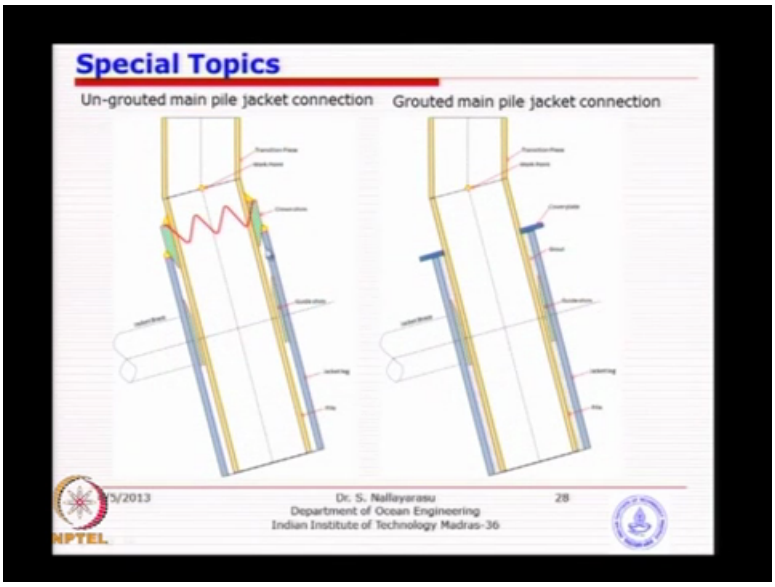

Something like this, so the reason why you made a…we have got this kind of zig-zag connection to increase the length of the weld otherwise you will have one circumferential weld which will not be sufficient enough to take the larger movement connection there, so you just have looking at something like the counter, so that is why it is called the Crown plate or Crown sim connection which is very much essential to make sure that we pile load transfer as the top happening through this movement.

The remaining is only a contact surface, there is no other place there is any welding is going to be done because all are underwater, so you do not expect. So that is why sometimes type of method is not preferred but then when the jacket water depth is more than hundred metres you cannot imagine thinking of doing grouting because grouting will take several days, if the

grout length is about 10 metres you may take one day if it is hundred metres only grouting will take 10 days for each pile which will not be possible to stay there in an offshore environmental, so that is why we go for a ungrouted piles system mostly water depth beyond 50 metres.

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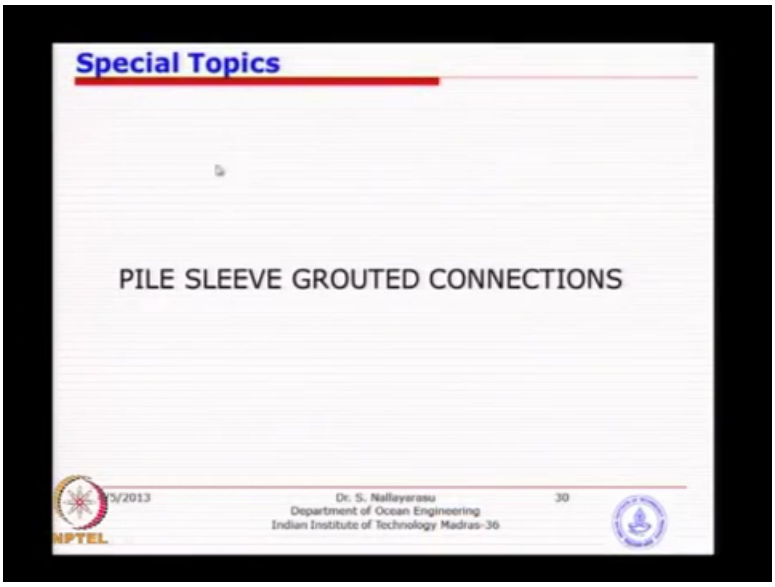

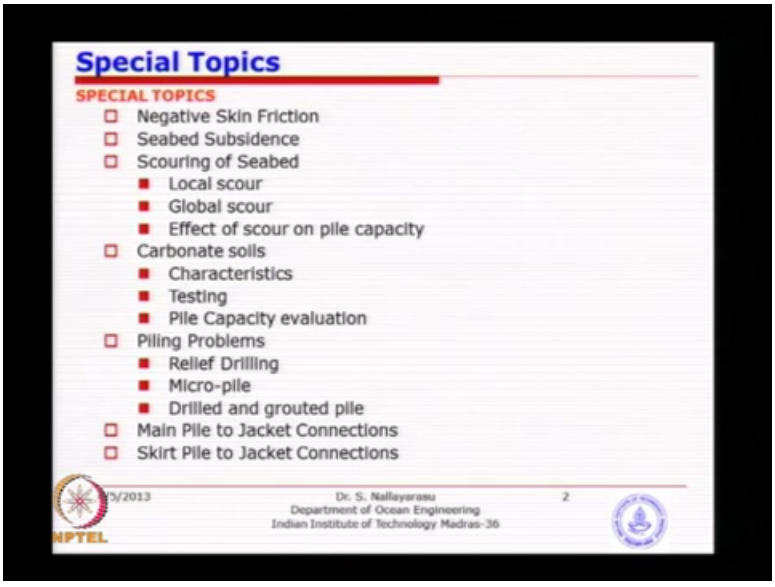

Pile sleeve grouted connections I think we have already covered it the other classes, so these are some of the areas I think if you look at it these are some of these special problems which you need to remember when you are doing the pile foundation design.