Foundation for Offshore Structure
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Module 1
Lecture No 30
Special Foundation 2

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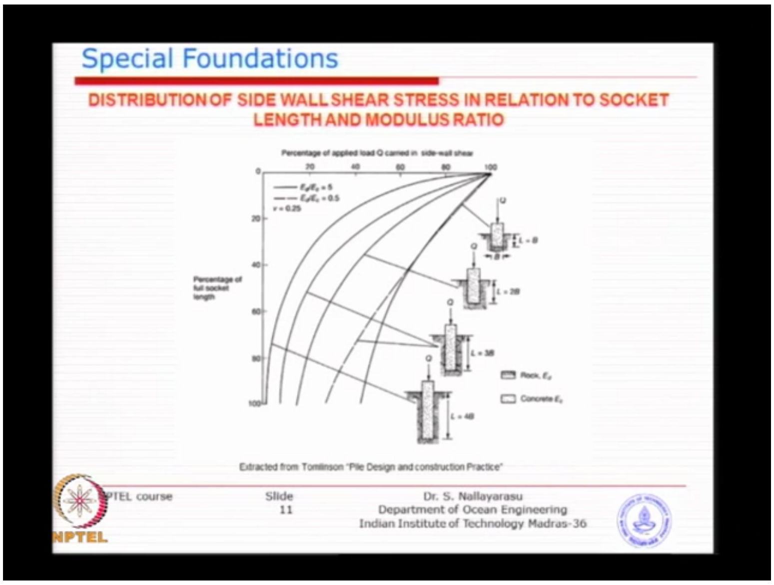

So let us look at one of the concepts for bored concrete pile, if you look at this chart in fact that is the major concern even when we were discussing about the TZ versus QZ I think I did mentioned about it earlier on you know when you talk about 10 percent of displacement for end bearing and 1 percent of displacement for side wall friction, I think that is what we were looking at earlier, the larger displacement is require at the base in order to mobilise the good end bearing, so basically that is the idea behind even when you are designing concrete piles normally when you actually do a boring would tend to have more debris collected at the bottom.

If you do not do a proper clean up what will happen? When you insert your reinforcement cage you will have lot of debris underneath, maybe after half a metre or so you will get good bearing stratum but then what happens when you actually apply a loading when you do a concreting then you apply a loading, you already have decided a lower displacement for skin friction and bigger displacement for end bearing. Now when you want to achieve is full end bearing, what will happen is? You will have lost almost all the skin friction because the 10 person of the pile displacement at the bottom would have sheer of the skin friction at the sides.

So that is why whenever we design a pile either you design as a floating pile basically there is no end bearing this means you will only rely on skin friction or you design as end bearing pile and simply ignore whatever the little bit of skin friction you may achieve but if you design a pile with some amount of end bearing, some amount of skin friction there is always a risk which one actually governs the design or which one is going to take higher…so when we are designing a steel concrete steel pile driven into ground we always terminate, try to terminate at a good layer thinking that you may get some amount of end bearing but when you designing a concrete pile there are 2 cases, normally we design as an end bearing pile because this concrete to soil interface if you allow for larger displacement or shear failure to take the end bearing full amount that means you have to terminate the pile at a good layer which may not be possible and in case if you have a combination of skin friction and end bearing several tests have been conducted by number of people the book by Tomlinson has collected all the information and they have come up with a chart.

In case if you have to actually use combination of end bearing and skin friction for different modular ratio on different types of rocks that means the socket at pile, you will construct a pile then the layer by 3 to 4 diameters and the remainder will be taking skin friction, so basically some amount of end bearing some amount of skin friction. This is a chart gives you an idea the relative modules of the Rock with the concrete pile and basically the ratio, 2 ratios they have given charts one for 5 and another for lower bond of 0.5 with varying socket length and varying side wall friction, this is just an example to show that whenever you have a pile designed with combination of skin friction and end bearing in embedded into rock you have to be careful and most of the time when we design socket at pile into concrete socket at pile into rock, we simply ignore because the stiffness of the Rock is so big compared to the stiffness of the side wall friction that you are going to get from the upper layers of soil.

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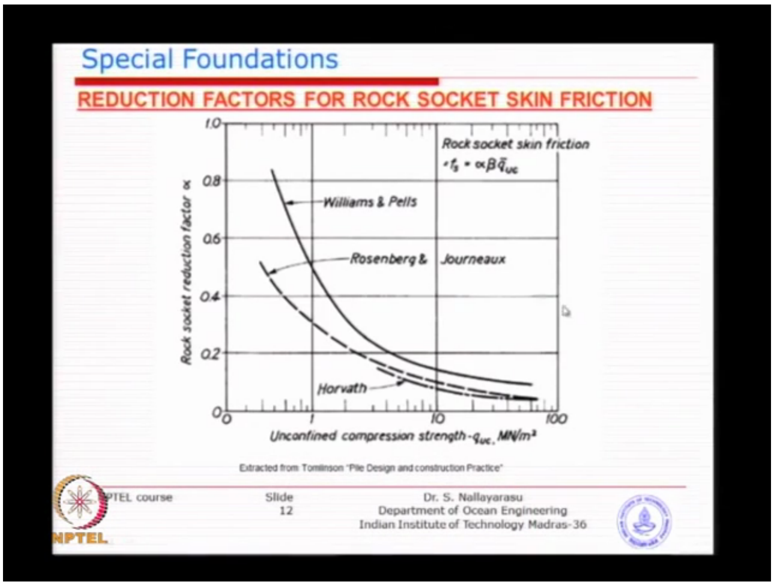

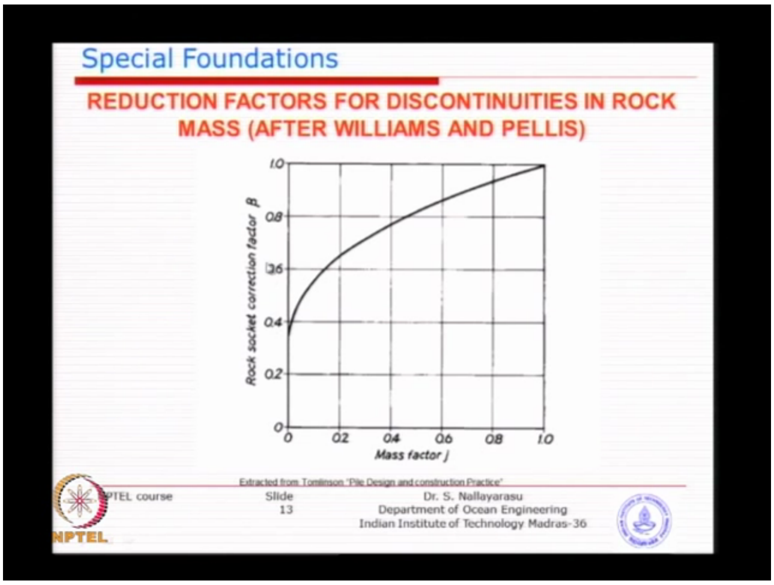

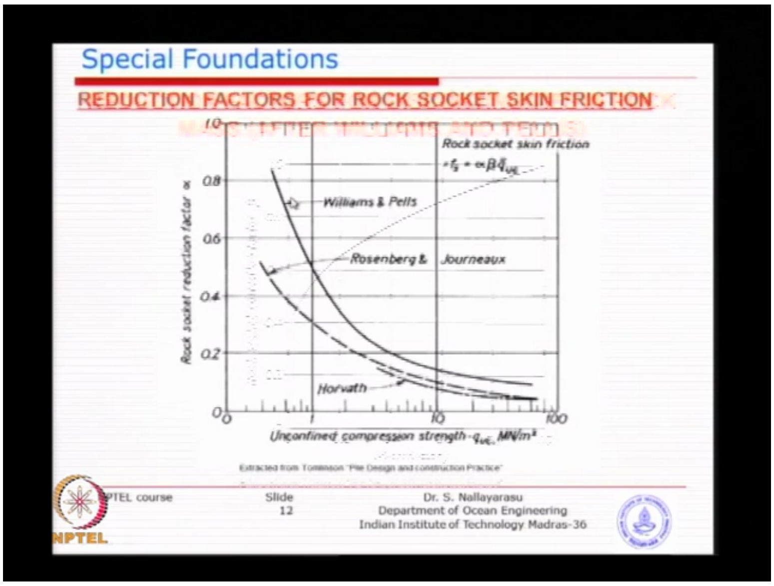

When you trying to find out what will be the skin friction in the socketed portion of the pile in the Rock, so similar to our alpha method but only thing is there is a modification factor called beta, so the skin friction is alpha times the un-confined compression strength multiplied by a modification factor which is given by rock socket correction factor with respect to the mass factor of the rock itself. Now this is what we were talking about RQD, yesterday we were talking about the Rock quality designation which you can get a tableted values of mass factor is that means how dense is the rock, how porous or how much fractures exist in the rock or how many numbers of fractures exist in the rock will indicate the mass factor higher or lower.

Again you can link this one with respect to the RQD values and basically will be able to get this factor and you apply this reduction factor will be less than 1 multiplied by alpha, alpha will be taken from this, so various research studies depending on what type of rock like confined compressive, un-confined compressive strength values starting from almost as low as 1 to hundred and can see here the alpha values varies up to 0.8 - 0.85, so you can calculate f s is multiplication factor of very similar to the alpha which we were trying to calculate unfortunately we cannot calculate based on the overburden pressure, it does not depend on that but it really depends on the strength of the rock itself.

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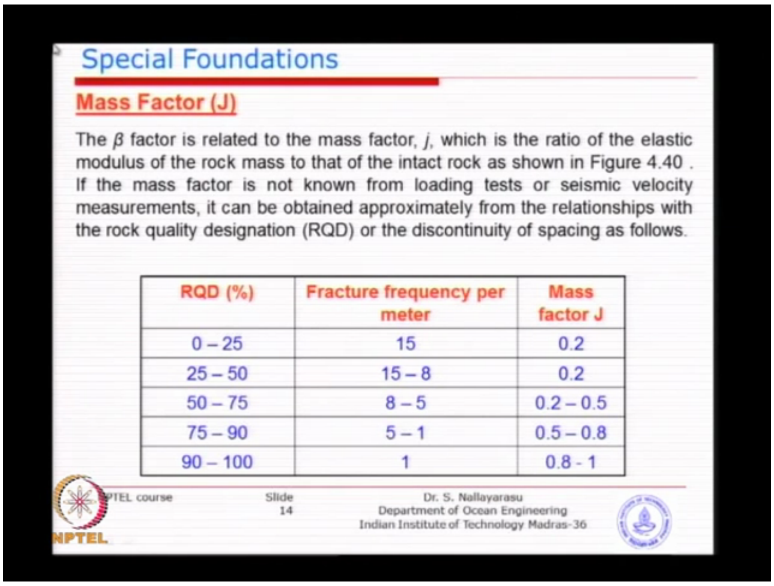
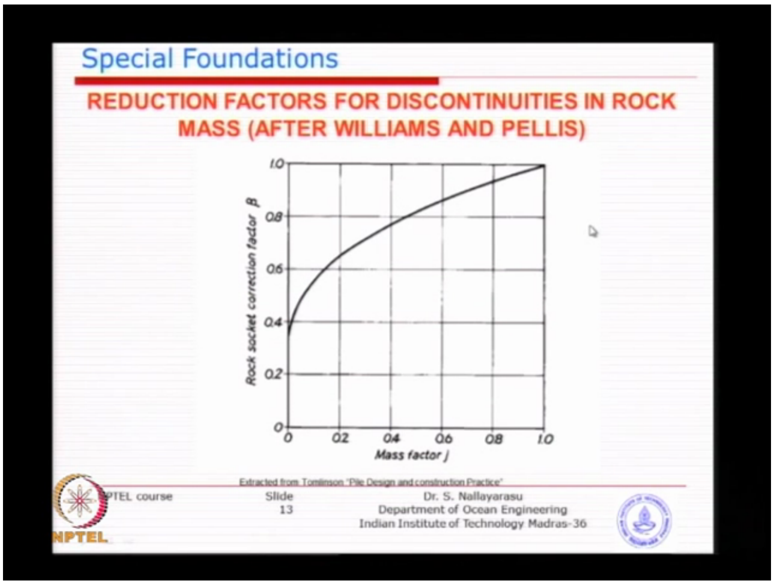


RQD (%)	Fracture frequency per meter	Mass factor J
0 – 25	15	0.2
25 – 50	15 – 8	0.2
50 – 75	8 – 5	0.2 – 0.5
75 – 90	5 – 1	0.5 – 0.8
90 – 100	1	0.8 - 1



The relationship between mass factor also given by the collection data from Tomlinson, so you can see here RQD value is lower mass factor is smaller and mass factor is higher when the RQD values are almost like a solid rock when you get full intact core of the drill length. so mass factors will indirectly integrate that the higher the quality of the rock that you receive from the boring you are going to get a better side wall skin friction that means almost like a solid concrete.

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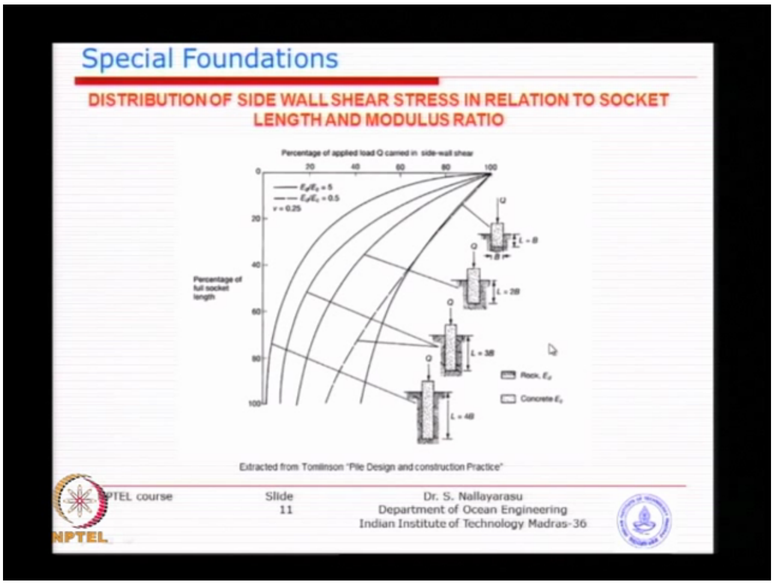

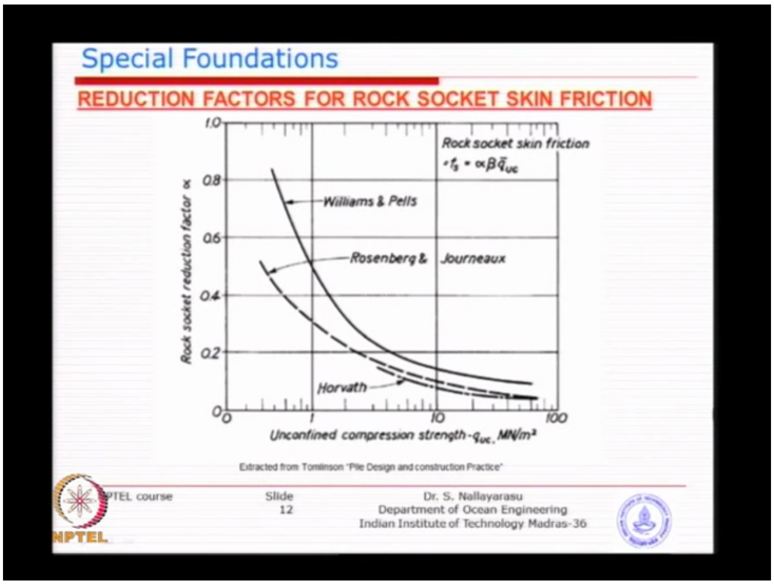

This method is basically applicable to only for concrete piles such ideas have not been developed for steel pile drilled and grouted into rock, we could apply but basically the methodology developed is purely for this type of concrete to rock interface, it is definitely different from the stiffness of the steel pile and with a small amount of grout analysts and the rock, this may not be a 100 percent applicable but what it goes to say is the methodology adopted here you could still apply to, so it is going to be a fraction of unconfined compressive strength whether you apply alpha time beta or you take a 10 percent like if you look at BS 8081 yesterday we were talking about is just taking 10 to 30 percent of the strength itself as the interface skin friction and you can use that.

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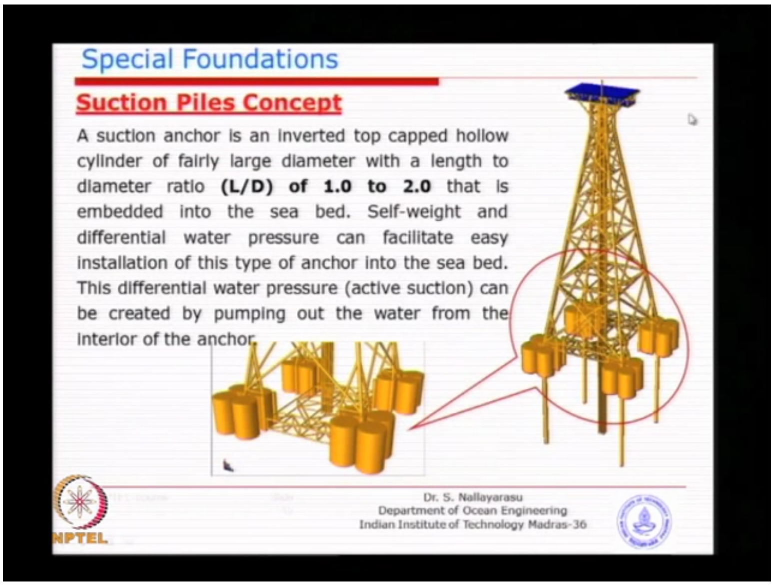

The next concept we want to look at I think in summary what we have looked at is the drilled and grouted piles is a rare opportunity and are still used whenever you encounter a situation like this. The next one what you want to look at is the alternative concept of suction piles, the piles embedded into soft clay but still we want to achieve larger amount of tension capacity, see we started with unable to drive the pile and we actually drilled and grouted. Now you encounter a situation we still have clay but then we do not want to go for a piles because after say 20 - 30 metres you got a hard rock, so but we want to make our foundation within the top player itself by alternate means, so this alternate means is something like instead of increasing the length increase the diameter.

Remember when we were starting about this course during the initial few classes we were talking about pile design or jackets. Unlike onshore structures onshore structures you got lot of flexibility of adding many number of piles in any configuration you want, whereas jacket we have got 4 legs or 8 legs, each leg might actually get few piles because the loads are concentrated on the corners. Now when you look at that we were having 2 options, one increase the diameter increase the diameter and number of piles or increase the penetration, so in this case what has been proposed is basically do not increase the diameter the length and basically increase the diameter, so the behaviour is going to be shifting from basically from longer skin friction with trying to search for a bearing stratum that is what we were looking for, now you forgot about searching for bearing stratum, increase the diameter large enough you get some amount of skin friction but is that adequate?

May not be adequate because a soil is very soft, so we need to apply some additional principle that actually can enhance the capacity, so one of the ideas was you see here the top, the pile is closed. Now remember when we were driving an open-ended pile both ends are open, so when you drive the pile, this soil will squeeze up and then go inside the pile and then will not have any restriction effect whereas if you imagine you drive a pile with a top end closed, so when the soil is trying to squeeze inside it is getting condensed or maybe compressed and then your pour water pressure will not be able to escape it will be just…so what will happens is the soil inside will become part of the pile and basically your soil at the bearing at the bottom will get a better bearing in fact several cases you will find that when you close the top end you will so almost like you will definitely get a plugged pile even if the pile is shallower.

So that idea was mooted long time ago 1980s, why not we look for such type of solution? But when we can call this as shallow type of pile when the length to diameter somewhere around 1 to 2. Remember when we designed the pile for offshore structures, we are talking about 1 metre, 2 meters, 3 metres maximum pile diameter at the penetration was (())(10:36) 100 metres, so if you look at the pile diameter or length to diameter ratio could be in the order of 30, 40 and 50, is not it? So if you take 100 metres 2 meters diameter is about 50, even if you go for 3 metres diameter you get about 30 is when you make length to diameter 1 to 2 means this is almost somewhere equal. 20 meter diameter may be 20 meters or 30 metres length, so that is the kind of thing we are talking about, so large diameter cylinders top end closed, you can take a (())(11:14) actually and try to place it on a soft soil try to just compressed by means of its own weight or can give an artificial weight by means of placing something heavy on top.

So what happens is a soil try to go inside a there is no escape because the top end is completely closed, but is that going to give adequate capacity? Maybe not, so that is the idea behind. This suction pile is nothing but we are trying to create artificially suction effect which enhances its bearing capacity. So when you can call this suction pile is basically L by D ratio between 1 and 2 something around there, so you can see a jacket here with provided with 4 numbers of such suction piles at each corner. So advantage of this you do not need a piling hammer, you simply place it you can place a little bit of heavyweight and then try to see whether the the whole cylinder can get embedded into the soil or not.

The second thing what they were trying to do is you can see at the at the last stage line, if the whole the bucket or so-called the inverted cup doesn’t go into the soil on its own weight, what you can do is? You can induce differential pressure by pumping out the water from within and there is an external pressure from hydrostatic which will be higher always, so you try to pump out the water from inside, so create a differential pressure which causes the whole thing to sink, so that was the idea that is why we call it suction basically we are trying to create a pressure differential between internal to external. Though this concept looks very good but achieving, capacity and installation also several difficulties, so that is why it is not used very often, occasionally this also has been used but this is very useful for deep water project as I mentioned yesterday piling hammer in 1000 meter water depth is going to be tough, so this kind of ideas is very useful for such type of projects.

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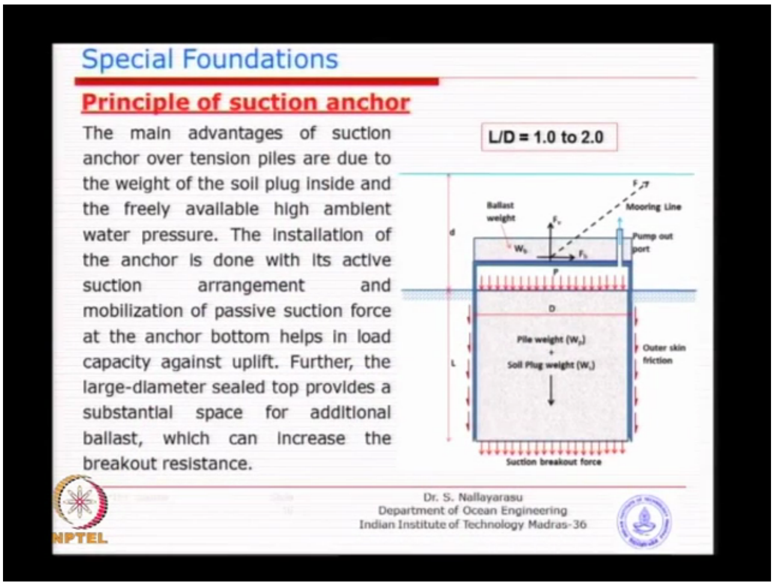

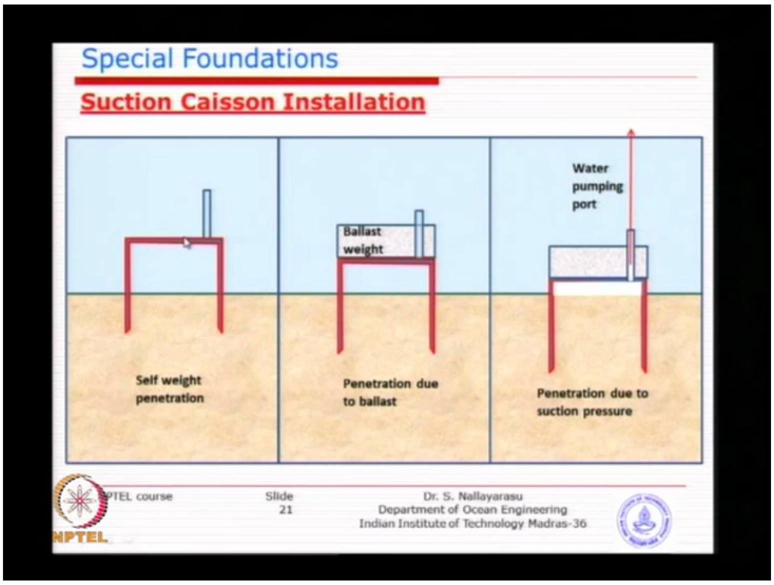

So the idea behind you will have an inverted or large diameter cylinder with top end closed with provision for…means you will have a pipe connected with the the top cover with sufficient capacity to pump out the water, see the larger the water depth for example if you have 1000 meter water depth you have to pump out the water from within this cavity you need such a high capacity pump, so what we need is power, so you need to just take your pump out, so what we normally do is, if you look at installation sequence something like this you bring this and place it on the seabed, so it might go down by several metres of penetration depending on its weight, so it is self-penetration which we talked about during our pile installation sequence, then if does not go through enough the reason why we cannot pump at this stage is because you have not formed a shield here, see if there is not sufficient penetration what will happen? The water will keep on coming out, so not a very good idea, is not it?

So what we need to do is? We need to have a sufficient penetration in such a way that when you do a flow net calculations I think if you have studied soil mechanics and flow net, the distribution of pour water pressure, if you do not have sufficient nutrition here, the water will start entering this way, not very good. So that is why you want to achieve further penetration, you place a heavyweight you can bring iron ore ballast or other steel weight ballast, simply place it on top and basically we will try to…the reason this is possible because soft clay at the top few metres is allowing us to go.

If you encounter a very hard layer like a sandy material or a rock, you may not actually propose this type of anchors for sure it will not work because getting penetration itself will become a bigger issue, so basically you place the blast weight just to achieve additional penetration just to make sure that you got enough amendment to avoid water ingress through the leakage coming from the soil to inside because then the pumping will become too difficult. Once you achieve this and then you start pumping out water, so you create pressure difference which will make the caisson to sink which is what is the idea behind, but how to do it? Shallow water may be 20 meter, 30 metre no problem but when you go to deep water you may have to have a higher pumping capacity. Once you finished the pumping up the water you just close the valve, so you permanently lock it so that the water does not go in again.

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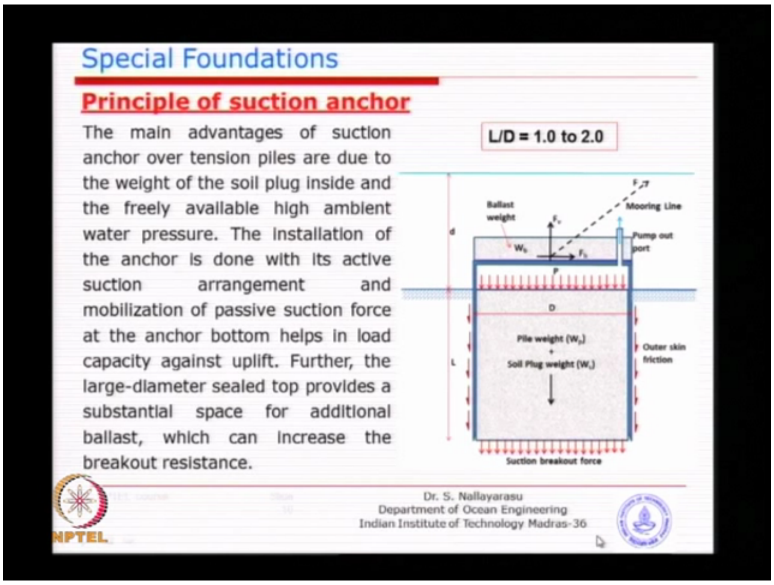

So the idea behind this so-called the suction anchor is to create artificially the amount of hydrostatic pressure available you utilise it, so if you have 20 meter water depth that is the present difference you will get if you have 1000 meter water depth then you will get a 1000 meter equal (())(16:29) pressure which will be substantially higher. So you see here in this particular picture you can see here once you have taken out the water, the same amount of pressure is acting on the top of the soil which is compressing the soil downwards and basically you apply the mooring line load inclined if it is a mooring line going in particular angle or you can have a horizontal line and going and…so you can have a horizontal load or you can have a horizontal and vertical component, so what we are looking at is?

Horizontal component, design is very simple all of you have studied the lateral capacity of pile but there is a smaller diameter longer length whereas your large diameter and smaller length, the behaviour could be slightly different very similar to one of the cases which we have introduced I think there were several cases of short pile versus long pile versus bending versus rotation, so one of the case will be applicable here the clay type of soil, pile head not restrained, so it is going to be almost like a translation because it is such a massive size and soft material when you apply horizontal load you will just simply get a uniform pressure distribution from the soil, so you can apply one of the case and calculate the horizontal capacity.

So what we are looking at is the vertical capacity especially intention. Now if you imagine if we have not done this pumping of water out, the capacity against pull out is the weight of the pile plus the weight of the plug plus the weight of the ballast that much is the capacity because plus we will get the skin friction from the exterior surface, so that is what we I think have learned in our calculation of capacity for tension piles. If it is a plugged pile external skin friction plus weight of pile, weight of soil, weight of the ballast. Now in addition you are going to introduce this negative pressure which is going to actually prevent the soil to rapture at the bottom of the pile because if you have compressed the soil so much that when you trying to pull out the soil will not break, we call it breakout force that is why I have just put suction breakout force is nothing but the soil is trying to hold because we are compressing the soil by means of the differential pressure applied from the water depth, so the larger the water depth you are going to gain larger the breakout force.

So this is a great advantage because when you go for deep water project, when you are having mooring line coming for anchoring at the seabed, if you have 300 metres, 400 metres water depth that much of extra capacity you can achieve with simply by means of pumping one time water making sure that you have a proper shield here and close the valve, so the principle of suction anchor, the whole thing depends upon how you achieve the suction pressure and just nothing else because otherwise it is going to be a very shallow penetration driving becomes easy you not going to actually take a piling hammer, such size piling hammer anyway you cannot get it, you know 20 meter diameter no one will have the piling hammer, so you have to achieve the penetration by means of its own weight and the ballast weight.

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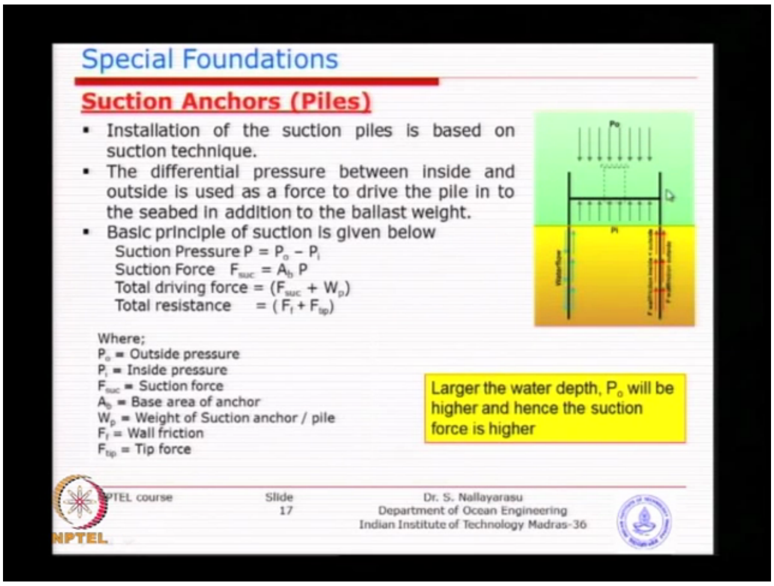

So the differential pressure which we were talking about is just the internal to external and suction force which is basically the area times, the bottom area times, the differential pressure and then the total driving force at that time will be the weight of the pile. If you have not used ballast plus the suction pressure that is what is going to cause the whole thing to go down and the resistance will be the skin friction and the end bearing on that smaller thickness wall which we can calculate, so larger water depth larger will be our P naught and larger will be our suction force which will get better advantage, so sometimes we call it as suction anchor, sometimes we call it suction pile, sometimes we call it suction caisson or if you look at some of the literature you will call it bucket foundation but every one of them work on the similar principle of large diameter of cylinder cover the top with and without suction pressure, sometimes no suction pressure is used if the capacity smaller.

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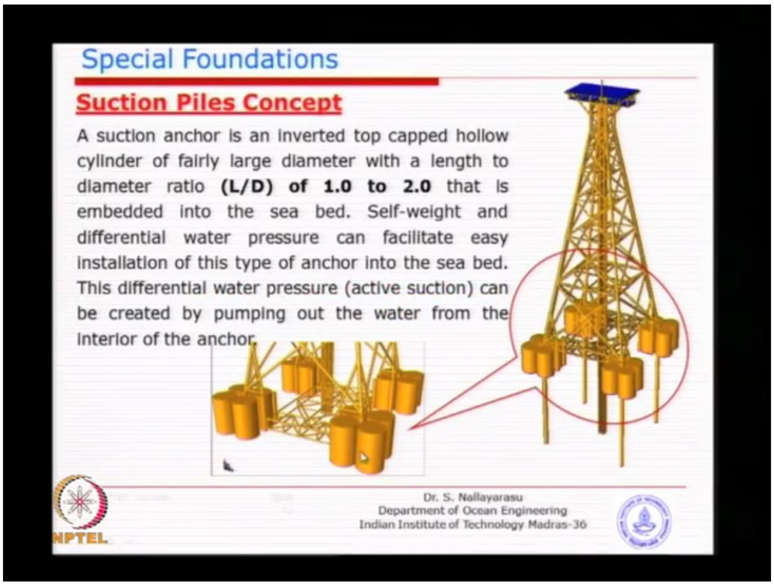

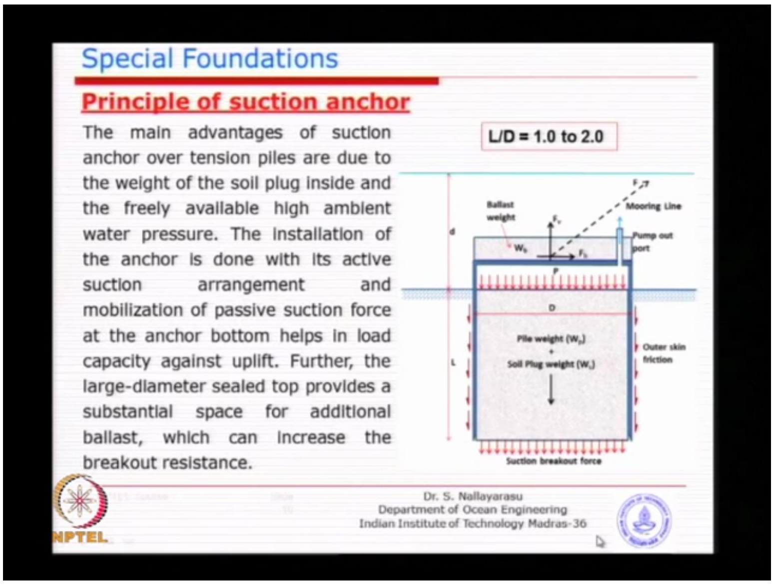

In some of the cases you can also use it for this picture shows you can also use it for compression loading, imagine if there is a jacket when (())(21:01) loading is applied you can actually get compression here tension here, is not it? And the vice versa so you can also use it for compression because you can see here is a larger area number one and the soil becomes part of it and basically the bearing capacity at this point may be better than these bearing capacity higher, so that is the case so that is why you have got in this particular case each corner 4 of these caisson has been put so it actually takes tension as well as compression.

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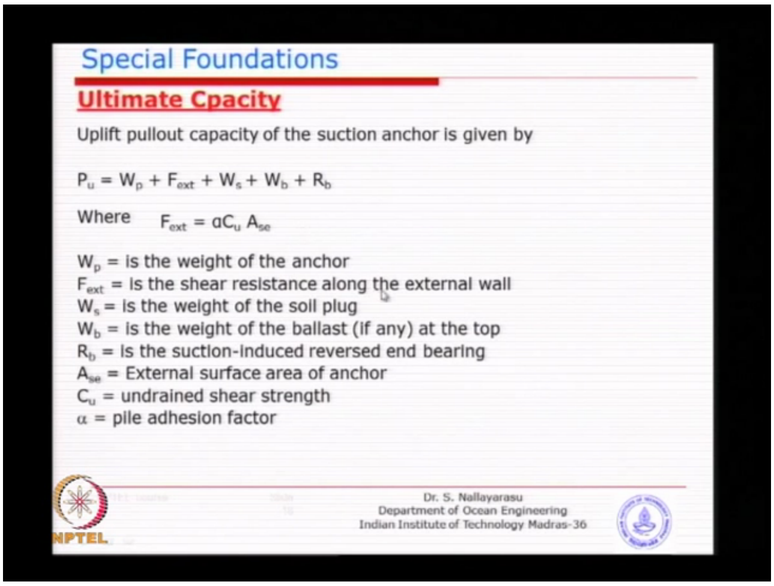

So the uplift capacity that we are worried and which we are looking for is basically summation of all the gravitational effects basically the weight of the pile, weight of soil pluck, weight of ballast and external skin friction and finally the breakout force which is obtained because of our differential pressure of the water and you can use the external I think should be (())(22:05) this one, alpha times cu which is our alpha method you can use it for our external skin friction multiplied by the external surface area of the caisson or anchor, so there is a simple conventional cancellations. So what we are looking at is what is this value? That is depending on your the pressure difference.

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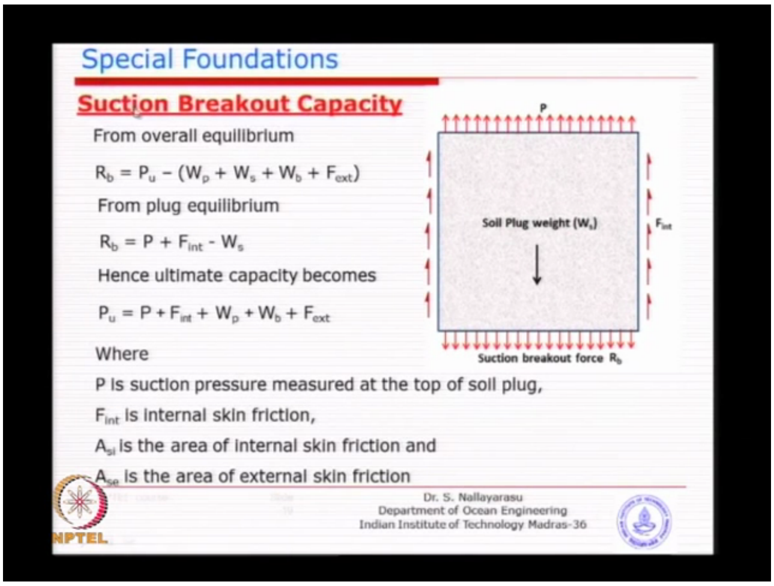

So from overall equilibrium you can find out R b will be P u minus all of them you know just simply reverse that, from equilibrium of the plug you can point out you just take out the soil pluck, you got an internal friction which is very similar to your external friction, only thing is the diameter will be slightly smaller and basically the pressure plus the internal difference, internal friction minus the soil pluck will be the your the R b and, so you substitute this one back you will get P u in terms of P which is the pressure difference instead of R b what we are putting is the pressure difference and basically you supposed to have multiplied by area which is what I forgot, so basically P times a will give you the suction force itself and then you will have all other components of internal external friction and the weight of ballast and weight of pile, weight of soil plug is removed because it get cancelled.

So basically the breakout capacity then if you look at some of the research papers instead of expressing purely on terms of internal friction and external friction you combine all of them together, they come up with area times the breakout force with an empirical parameter. Some of the research papers not the recent one earlier papers they do not ask you to calculate the ultimate capacity is based on this weight, you will have a bearing capacity factor which is very similar to our n gamma, n q which we were using for pile and the shallow footing. We can take the empirical number pending upon L by D ratio, L by D ratio and water depth, so you got empirical charts which can use it which I purposely avoided here because the number of data available is very limited and that is why even now quite a number of study work many places not only in our institute many places still the research on the capacities of anchors especially the suction type anchors is going on because not much data is still available.

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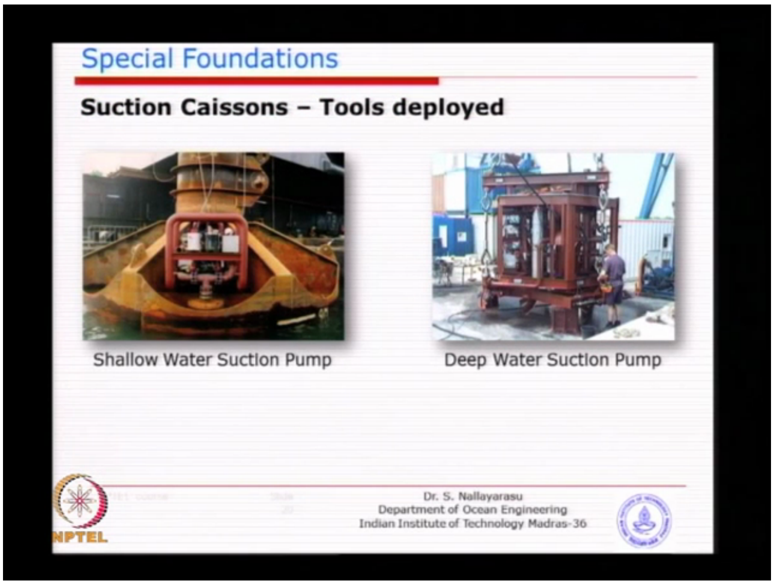

Typical picture of the know the pumps and the assembly which will be placed on top connected to the port to pump out water will be like a small assembly of skid which houses everything including some electronic will be placed on top, after you achieve the required penetration once you pump out you close the valve and then this whole assembly can be taken out and they will not be permanently you know placed on top because you have say for example 4 number of this suction pile to be installed, you have only one system like this, you go there and just remove the water and go to another one instead of having another permanent pumps because after you evacuate the water you do not need them permanently you know so you need only one time after…

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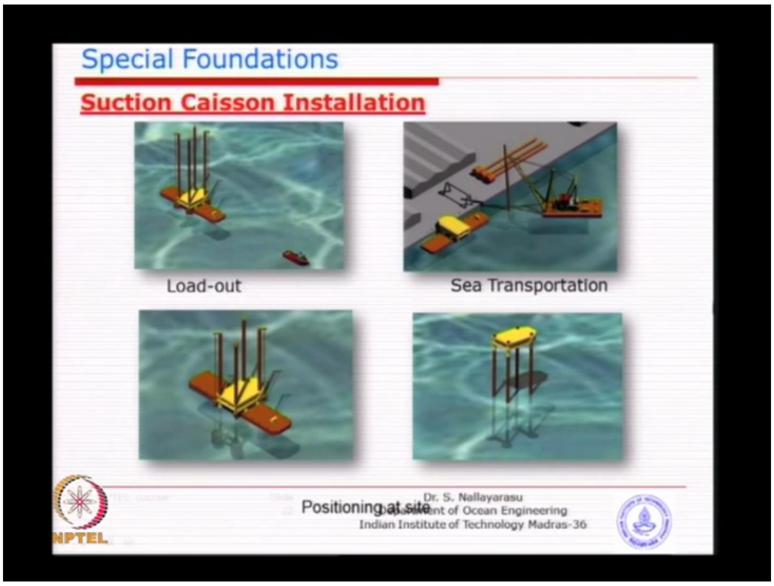

Some of the typical example of suction case and used in industries basically something like this temporary foundation, see in this particular case it is 4 legged jack up at type structure, temporary structure wherein we require to embed this into seabed and basically used this suction type of caisson, so you see here this transportation like a conventional cargo barge with 4 legs mounted with the suction caisson already and you go to the site, you lower than and then basically allow them to penetrate then you just do the evacuation of water which will achieve the required capacity, so you will get both tension and the compression capacity as required, later on when you want to remove you relieve the pressure of water and then try to jet water around to loosen the soil and then…so very similar to the operation of our jack ups which we were talking about accept that instead of a (())(26:31) you have a large diameter you know the suction caisson.

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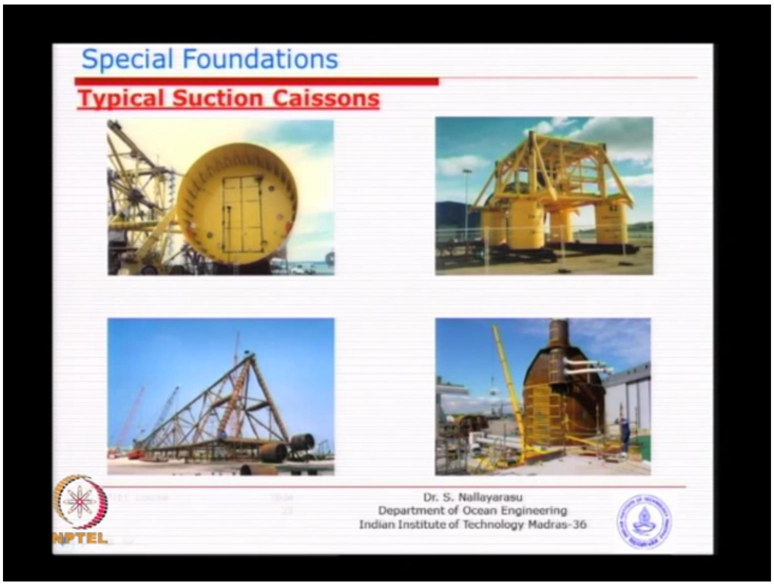

Typical picture of the size you can see here the same jacket with stiffened cylinder you can see at the junction here quite a number of stiffening has been done otherwise there will be bending and the (())(26:52) and the tension between the top plate and the side wall and you can see the relative size of a typical jacket leg this is already installed this is waiting to installed at this corner and this one, so you can see several times the diameter of the legs. This picture gives you an idea of subsea template for…not for jacket type of structure is actually going to be placed around seabed for connecting valves and pipes.

So you can see 4 corners large diameter cylinders, so simply placed on seabed and leave it there and probably you can evacuate water for suction. In some cases we use gravity foundation instead of this 4 times this cylinder we actually make a big concrete base which we will talk about the gravity type of foundation, instead of this you just make a complete enclosure with the bottom open and simply place it under seabed which will just go down because of its own weight, if not enough weight is there you can is a weight on the top. That is the ports which are actually used for taking out water from the site.

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So that completes the idea for suction caisson which is very useful for deep water structure, we will now move on to a gravity base foundation which I think is very familiar. As early as 1976 you know there was a development based on gravity-based structures for Island gas exploration especially when they came because of storage requirement not only because of foundation requirement because of storage. You know some of these remotely located platforms requiring storage because they could not actually connect by pipeline, so what you have a storage and then you off load by tankers shuttling between land and platforms, so when you want to do storage what kind of storage space, what type of material?

Especially hazardous storage whether steel is better or where it is better, whether it is above water is better or below what is better? So those days concrete caisson you know basically large diameter concrete caisson were thought of very useful and that is how you look at this design of concrete gravity base foundations came up because one is the foundation requirement the other one is purely large volume of storage required for storing oil, not gas. So one of the earlier developments is the (())(29:31) of platform, you will have 4 legs large diameter 9 meters or 11 meters diameter with shaft going all the way from the bottom to top and these shaft will be supported by the concrete base which is a very thick concrete of 5 to 6 meter deep with the dimensional of 30 to 40 metres implant and basically the topside is a conventional topside supported on top, so you have a facility to store and each of the shaft is designated for specific purpose one of them for drilling or 2 or 3 of them for storage and other functional utilities.

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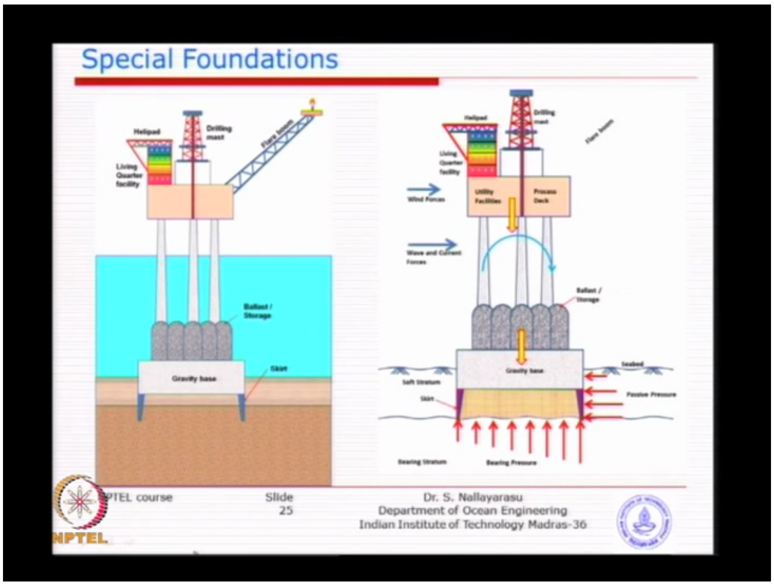

So that is the idea of concrete gravity type foundation basically looking something like this which I think you might have seen the picture, basically what you see here several components, you have conventional topside which is very similar to any of the offshore platforms only thing is supported on columns and not braced. We do have jackets also have columns but because of steel structures and the way that we design we have a braced columns whereas here they are purposely made large diameter is to avoid any bracing requirement for sure, so if you have one 9 to10 meters diameter the cylinderness will not be a problem but if you make it 1 meter diameter column for sure it will not be able to design, possibility is not there.

So that is why you make large diameter, so you do not need additional bracing that is what the idea behind and also large diameter helps us in 2 things, create sufficient buoyancy and sufficient storage during operation, so that is the idea of, so this this columns you can have 3 you can have one…mono ports also exist for concrete gravity based structures 3 or 4 depending upon the requirement, depending on the topside requirement, if it is a very small topside probably you can survive with one but if it is a large topside and you may have 3, you may have 4 and you also have base which is sufficiently thicker, sufficiently larger to produce bearing capacity and you may also have additional Chambers added because remember later on when we are going through the descent procedure you will find the requirements are conflicting.

You may actually need initially large buoyancy during your (())(32:03) or during towing stage but when you actually come and place this structure on the site you should not have buoyancy you should have larger weight that means you need to have provision for buoyancy and you should also have provision for a ballasting or adding weight and the side because you want to create a heavy structure so that the stability is achieved without much problem. So basically that is why you may actually have an inverse dome type of compartments on top of the gravity base and to achieve sufficient bearing capacity you have a base dimensions large enough but how much is larger, you cannot go for kilometres, so you can only go for few metres, a few hundred metres 30 metres, 50 metres, 100 metres, so you also need sufficient methodology to create horizontal and vertical capacity.

For example if you do not have the skirt the soil just beneath the gravity base will be the effective strength but if you imagine if you create a skirt say 10 metres down, the soil inside becomes part of the base itself, so the effective soil strength you can take it at the bottom of the skirt your calculations because the soil inside is almost not allowed to deform because by the time it is already getting squeezed inside, so that is advantage of creating skirt is not only horizontal capacity but also utilise a better soil strength available at the deeper depth.

For example the if you have a clear soil 5 KPA at the top, 100 KPA at this point, so if you come down to the tip of the skirt you may get actually maybe 20 KPA 30 KPA, so that is where you get an advantage of providing skirt, also means you can enhance the bearing capacity because a summary at that level only will be behaving because the soil inside here is already squeezed inside and will not be able to reform. So the provision of skirt is a very important activity in when you are designing your of course you have to be careful if you have very large skirt, the problem is installation know there is a smaller tilt then you have a serious problem of bringing back to verticality which will become potentially…so that is why the skirt height cannot be too large also.

So typically if you look at the gravity platform what are the loads that is arising is basically you have gravity load coming from your top size as well as your structure itself, the column and the base and together and you might have the environmental force from wind wave, current and so on and redistribution of the pressure you can see here could be depending on the type and the size and shape of the structure, so you will have a non-uniform pressure at the bottom due to the effects of horizontal and the vertical loads and also you may get some amount of horizontal lateral pressure, so you can see here on this side, so these are the things that we need to keep in mind when we are trying to make a design for a gravity platform. Only one important thing is, how we make the design of concrete cylinder.

So far I think in the design course we were talking about circular shapes are good for hydrostatic pressure we have we get additional strength and similarly how do we design a circular cylinder especially underwater. You might have already studied concrete beams, columns designed in your concrete design in basic courses, so similarly we can make a design of a design of concrete cell.

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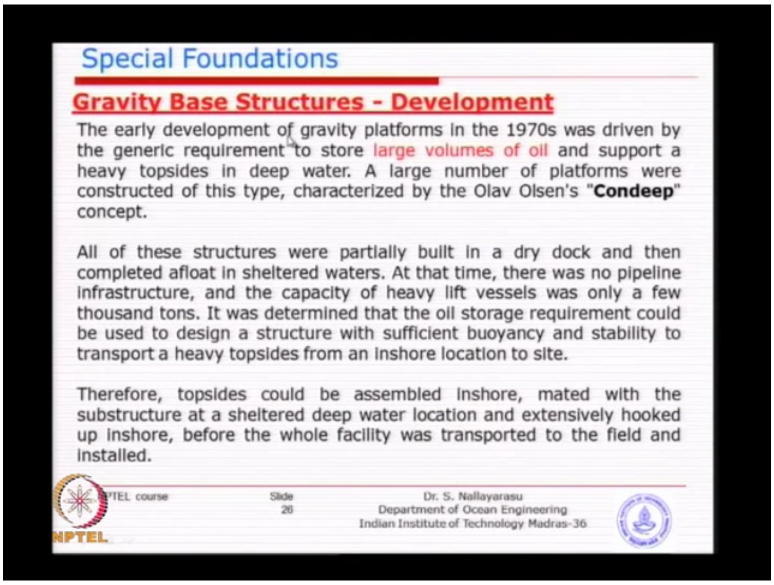

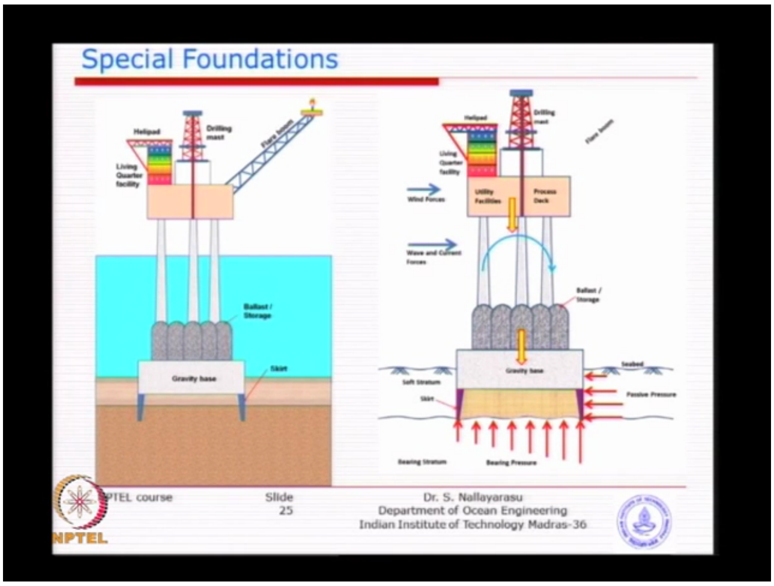

So gravity based structures, it is not very recent it is as old as 30 to 40 years. Many platforms are in existence both in Narsi but not in this part of the area. Mostly Narsi or in (())(36:10) of Australia we have got quite a number of platforms but very rare, not very often if you count the number of steel platform versus concrete platforms you can say 1 in 100, 2 in 100 something similar, so one of the idea is if you look at the installation methodology which I was talking about is very important because so far the steel based structures can be fabricated in a dry yard and can be transported by means of barges or ships which is what we were talking about, so in this particular case because of its weight trying to find crane which can lift and install such type of weight may be impossible we are talking about several hundred thousand tonnes.

If you look at this particular case for 100 meter water depth if you think about the weight it could be somewhere around hundred thousand tonnes, so you will not be able to imagine to even think of lifting, so we need to find alternate ways of fabrication of this and then transportation of this, installation of this which is what is a primary concern because not everybody can do it and not everywhere can be done you require substantially different facilities then what we normally require and that is why it is not getting familiar with most of the places and most of the contractors, unless it is absolutely essential we do not go for this because there are alternative ways of doing the fixed jackets quite easily especially in shallow waters like 100 metres, 200 metres, 300 metres.

Of course this cannot be used for very deep water also because designing a cylinder (()) (37:54) for 1000 meter is definitely impossible, so this gravity platforms are also have a very limited application wise water depth can be done, the maximum gravity platforms you can see 200 to 250 metres not even beyond that, so that is where when you have a 250 metres water depth and there are so many difficulties wherein steel jackets can be installed easier you prefer to go for that.

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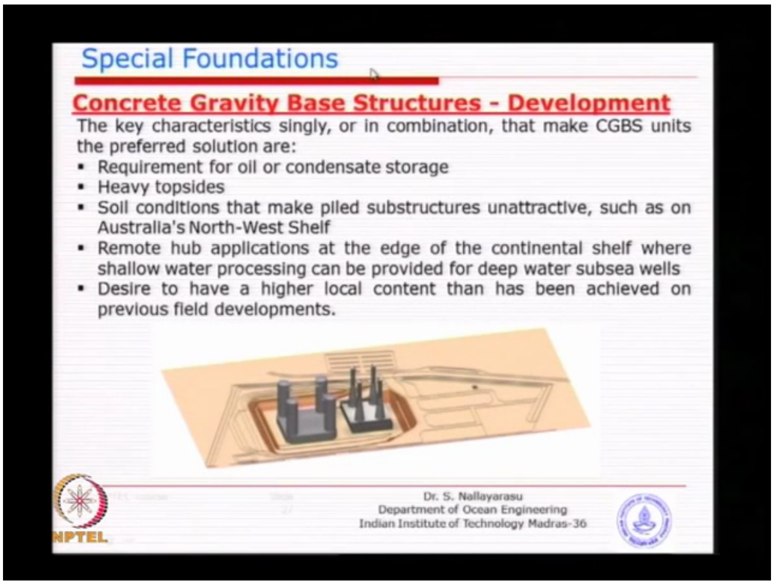

So concrete structures construction underwater I think most of you will be understanding easily, very difficult because the concrete requires proper placement and curing and after curing you will be able to achieve certain strength and it takes longer time, it is not going to be half an hour or 1 hours, it requires substantial time to cure, so that is why you cannot think of constructing this on site, so what means is you need to construct somewhere on land which will facilitate float out and towing that means it will be done on a dry dock which is basically a barrier all 4 sides enclosed and after construction you can open one of the sides to the open sea, so that it will get floated out and you can actually tow to the site.

So that is the idea behind this concrete based structures with and without top sites, some cases we have seen some of the projects you actually put the topside also together, is not it? which will make no installation at site because you can place the topsides as long as you have sufficient buoyancy to hold its weight and to hold the topside also that means that you need to create sufficient chambers which will create buoyancy at that stage, when you go to the final stage will do a ballasting so that it will set down but then during transportation it will carry the weight of its own and the topsides as well as the towing forces and must be stable enough.