Coastal Engineering
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Module - 3
Coastal Erosion Protection Measures
Lecture - 11
Cheaper CEP Methods – XI

So, now… We just now we move on to the geotechnical considerations, when we are addressing the problem related to scour under marine structures.

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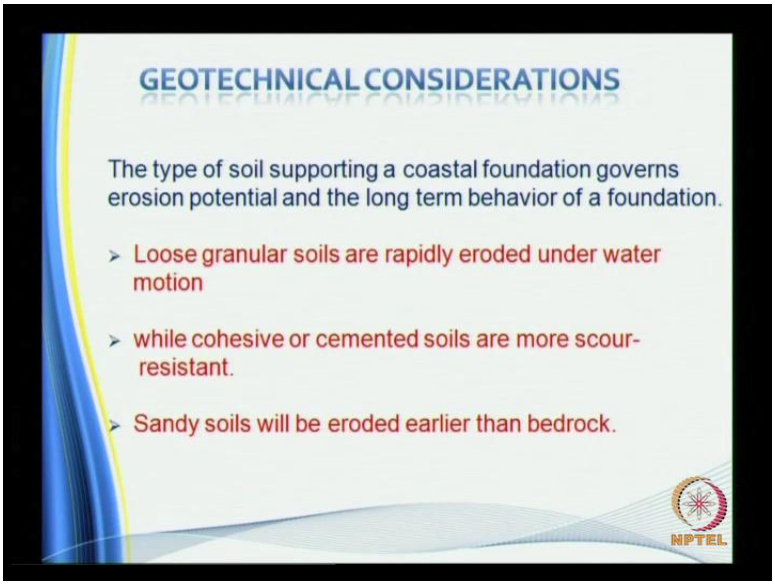

The type of soil supporting a coastal foundation governs this scour protection, scour or erosion potential and the long term behavior of a of the foundation of that particular structure. Loose granular soils are rapidly eroded under the movement of water flow of water, while cohesive or cemented soils are more scour resistant as we all know. So, that is the one of the reason why we use natural rocks as scour protection. Sandy soils will be eroded earlier, not only earlier it will be eroded in more rapidly also compare to the other types of a soil like bed rock, etcetera.

So, sandy soil, sandy beaches when you want to develop in case you want to develop some promote some kind of infrastructural facilities on a sandy beach then you better be watch out, on the watch out for the scour; again there is a difference of scour and

erosion. Scour is a kind of a local phenomena more intensive with respect to the local near the obstruction, but erosion can be felt over long distances.

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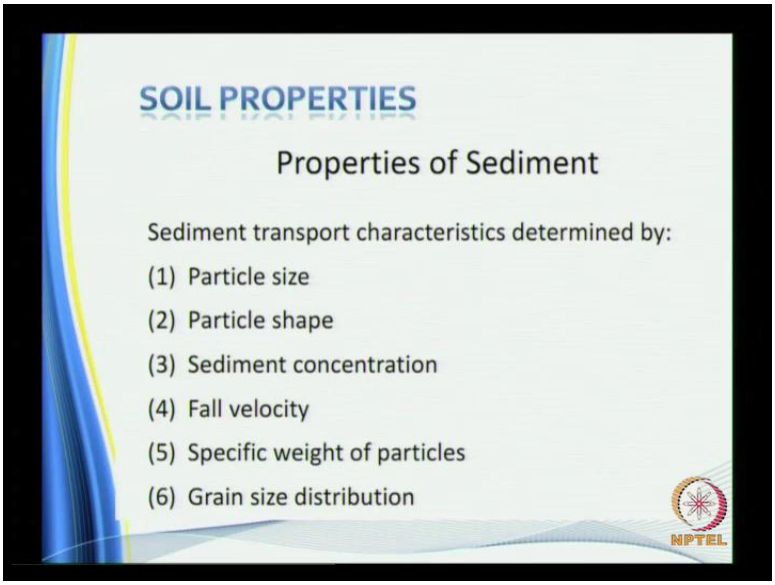

Next soil properties. So, properties of soil, I mean sediments which are very important in the in the phenomena of a scour. A scour is governed, these are the characteristics of the sediments which control or govern the extent of scour, the namely the particle size, particle shape, sediment concentration, fall velocity, specific weight of a particles as well as grain size distribution. Apart from a few other characteristics if you want to have a detailed information on this, you can go to my lecture on sediment characteristics.

Where in we have discussed most of the aspects and some additional factors also or you can refer to a number of references books given at the end of the lecture.

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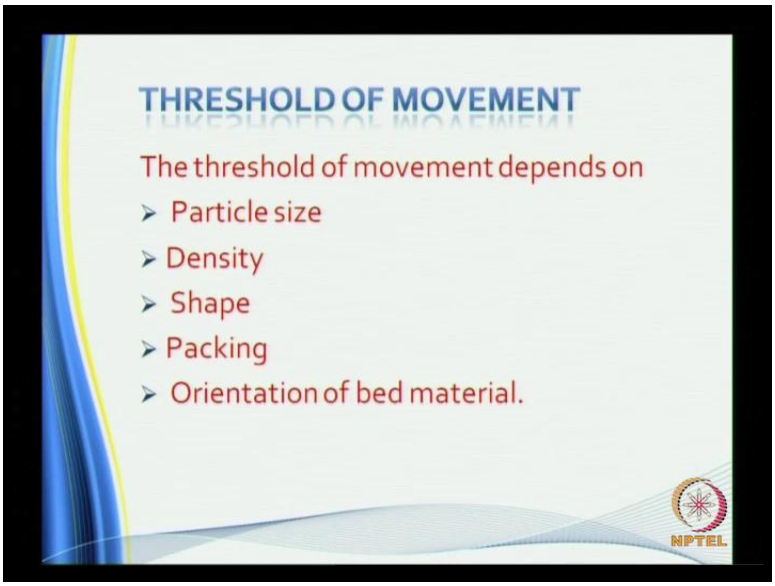

The threshold of movement that is where your hydrodynamics shear stresses exceed the sea bed shear that is going to depend naturally on the particle size, the density, shape packing orientation all those sea bed material all this factors. They control the threshold movement that is the initiation of sediment motion, under ways we have worked out a few problems also on initiation of sediment motion. So, look at the informations that have been discussed under the chapter on initiation of sediment motion.

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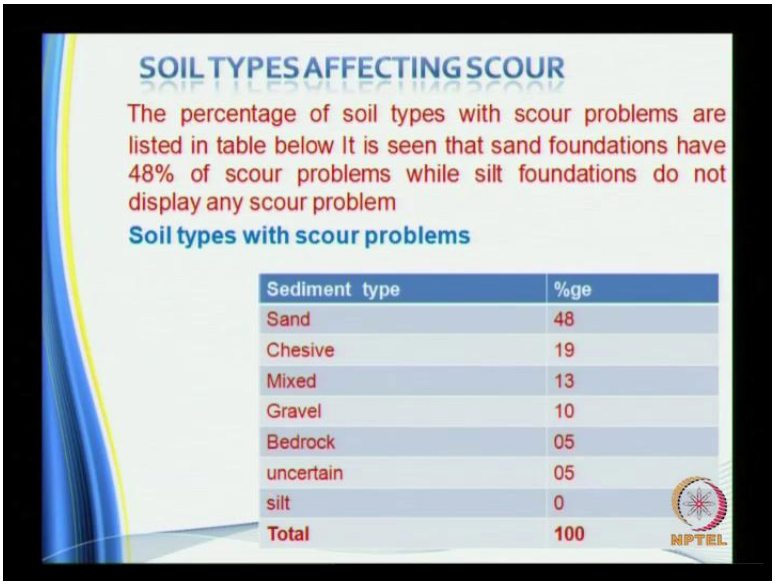

Soil types occurring affecting scour the percentage of soil types with scour problems are listed below. It is seen that the sand foundations have 48 percent of a scour problems, while silt foundations do not display any scour problem. So, percentage is given on the right hand side and the sediment size is given on the left hand side. So, sand has the maximum percentage, all these informations are available in the list of a references that are given at the end of the lecture material.

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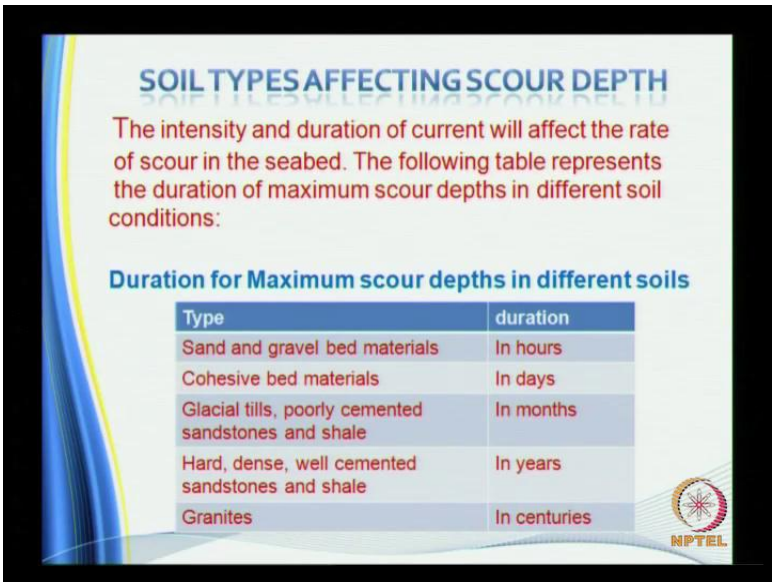

Soil types affecting scour depth the intensity and duration of current will affect the rate of scour in the sea bed. The following table represents the duration of maximum scour depths, in different soil conditions; some of the scour depth which are used are local scour depth, ultimate scour depth, the ultimate scour depth is the depth beyond which almost like steady state once you. So, some of these informations can be hacked from a number of references I am not going to discuss about all those details. Duration for maximum scour depth in different soils or given here sand and gravel bed materials in hours cohesive bed in days glacial tills poor cemented sand stone in months, hard dense well cemented sand stones in years and granites in centuries.

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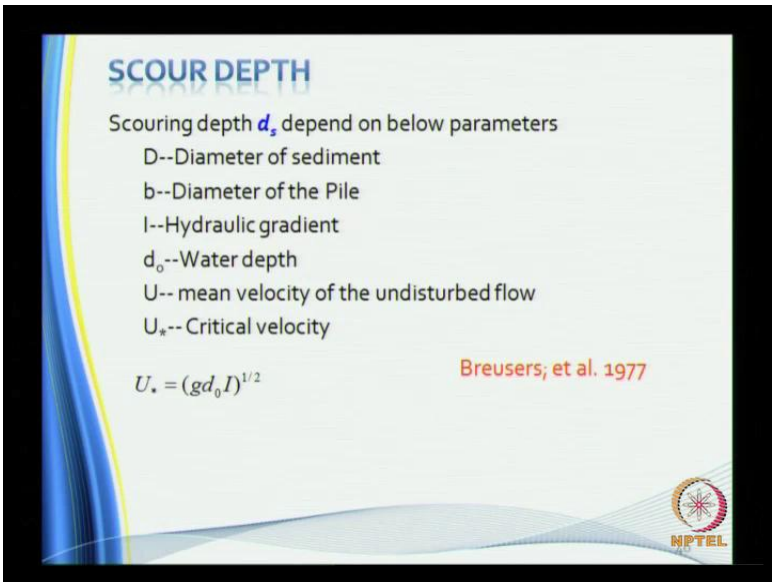

Now, scour depth depends on the following parameters, diameter of the sediment size I mean the grain size or the diameter segment diameter of the obstruction that is in this case we are considering a pile. Hydraulic gradient I D is the water depth, U is the mean velocity of the undisturbed flow and U star is critical velocity given as this expression g into d naught into I square root of this product as mentioned by Breusers et al 1977. So, the critical velocity is a represented as a form of the water depth as a function of water depth and the hydraulic gradient; the hydraulic gradient is going to the driving force.

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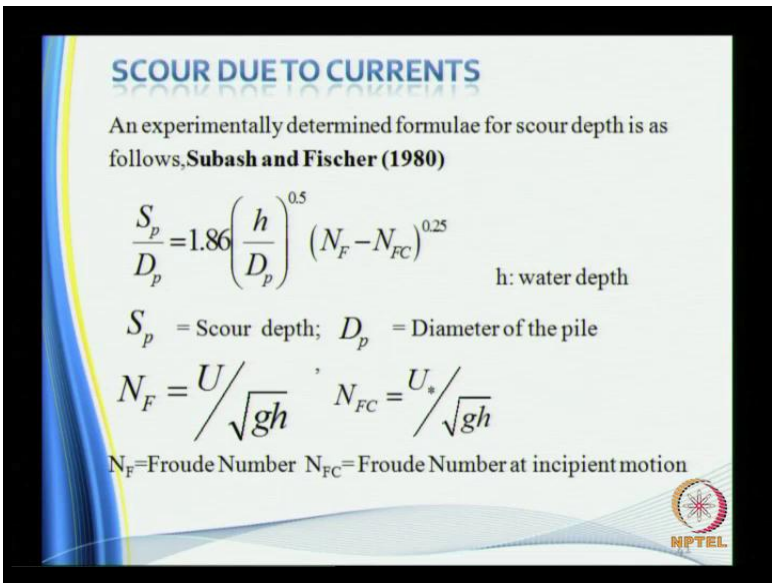

Now, let us look in to the scour due to currents most of the most of the empirical relationships that are available in literature are based on experimental work. The experimental work I mean in the laboratory is not, so easy, because modeling the sediment is not, so easy. You can easily model the flow, but modeling this sediment is a bit tricky and is not, so easy this is on equation or a relationship available for the prediction of scour depth as given here S p is the scour depth, D p is the diameter of the pile.

Now, this is given as a function of relative water depth h by D p and the Froude number and Froude number at the incipiention at the incipient motion, which is governed by this is the un disturbed velocity with for which you calculate your Froude number and the other one is based on the flow field at the incipient motion.

So, once you are able to calculate the all this variables if it is available to you, you can estimate I would use rather estimate, because all these things are derived from experiments and it is the an empirical formula, then sediment scour depth in quasi soils under currents.

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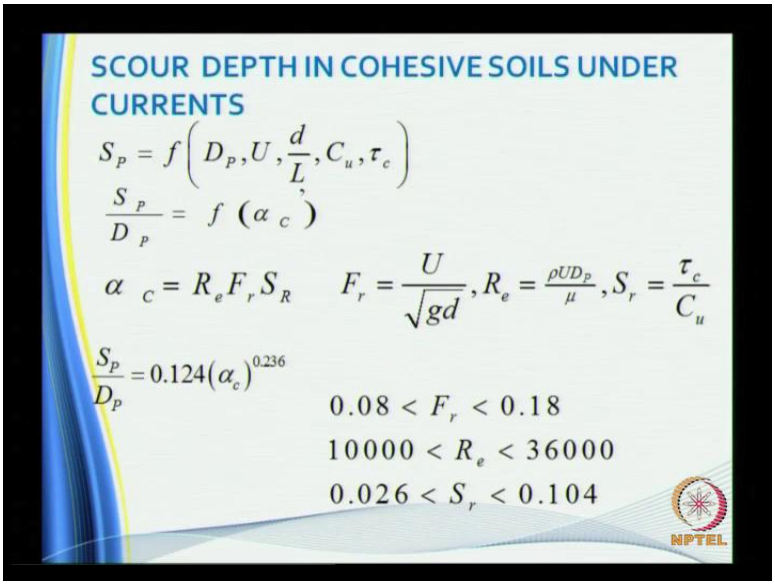

So, this is the a relationship as given here these alpha c is the product of these numbers and all these things U is the velocity, D is the water depth and D is the capital D p is the pile diameter, then tau C is the critical shear stress and all these variables are given to us. So, based on this you can estimate the scour depth under cohesive soils.

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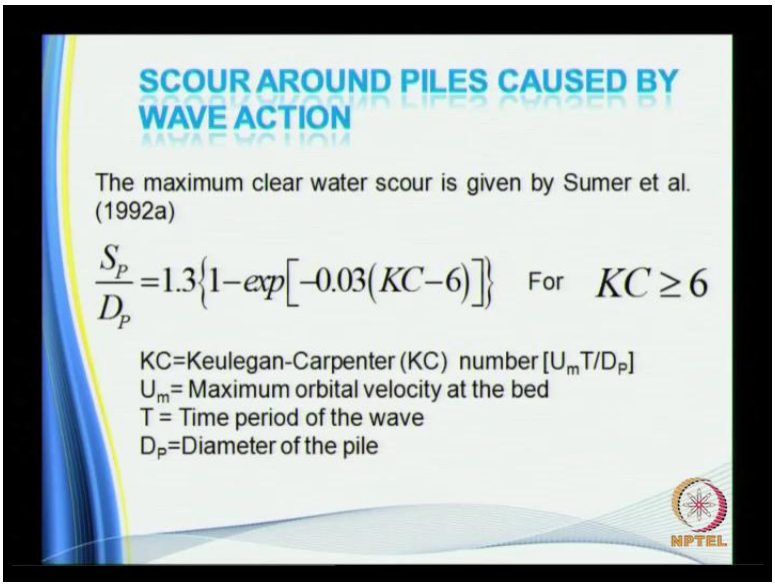

Scour under piles caused by wave action this basically a function of Keulegan-carpenter number, Keulegan-carpenter number is U max T by D. So, this equation is a quite straight forward, but it is valid only for K C number greater than 6.

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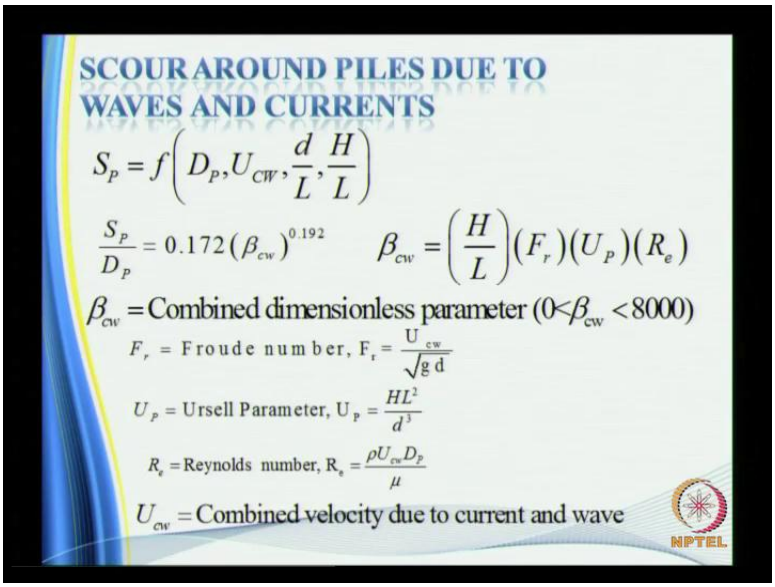

Scour under piles due to combined action of currents and waves. So, you have a beta of parameter coming here which is controlled by this factor, where U p is Ursell's parameter, this is Froude number, this is Reynolds number this is wave steepness once

you are able to calculate this then use this relationship to get the scour depth (No audio from 10:58 to 11:12).

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Now, we having seen some of the basic starting with the basic phenomena of scour, we saw what are all the problems associated with scour, the importance of scour. The consequence of scour, if you do not consider this scour protection what will happen to the structure, then we looked at the combination of environment as far as flow is connected. So, you can have a steady current or waves combined waves and currents etcetera; and finally, we came up with we looked at the formulas for current all these conditions different conditions.

We also looked at the different soil characteristics that are very important I am sure that this lecture should be a starting as a base for you to, if you are interested in proceeding further in this area this can form as a base material. And of course, additional reading is very much essential in order to understand the, in order to really do some kind of research or in the case of a filed application.

So, now we will move on to scour protection measures as I said earlier is a very important aspect to be considered for the construction of any marine structure. Protection is chosen based on the type of structure and it is importance, location of the structure availability of material, what kinds of material are available. And finally, the most

important is the cost criteria, we have a wide range of products that could be thought of, but a careful planning is needed.

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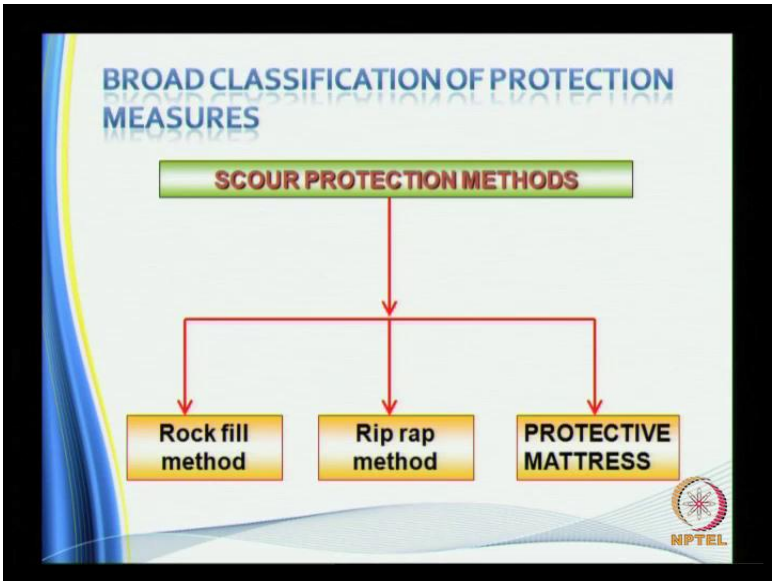

Broad classification of protection measures the scour protections methods can broadly be classified as rock fill method, riprap method and protective mattress.

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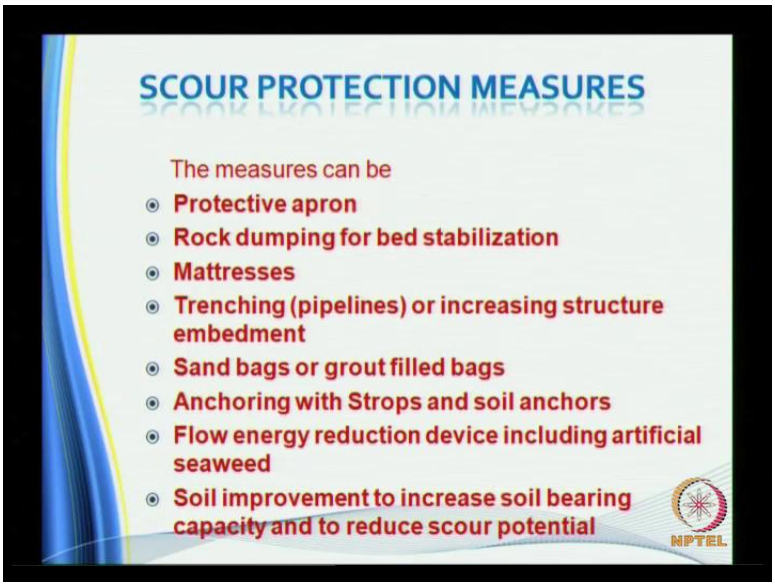

Scour protection measures, the measures can be actually the details we has have a I have presented the details here it can be either protective apron, like the apron near the toe of the dam, rock dumping for bed stabilization. Mattress, this mattress can be geo synthetic

mattress look at some of the look at the lecture on geo-synthetic materials application of geo synthetic in coastal engineering. That will give some information about the protection scour protection then trenching this particularly is very important in the case of a pipelines or even in the case of a, I would say even in the case of a break waters.

If you have excavated toe you need to have a kind of a trench where in you can place your toe, although difficult it is extremely effective then sand bags are to are ground field bags this is the most commonly adopted, it depends on the environment. For example, if you have a location where you have lot of shop corners sand bags is not a recommended procedure, anchoring of stops and soil anchors, flow energy reduction device including artificial seaweed. So, now, there are some geo synthetic products where you can have a seaweed growing.

So, this is this can result in rich a flora and fauna also there are options, but naturally when you want to have more benefits, the product is going to be costly. So, you have to decide what exactly you want, soil improvement to increase soil bearing capacity and to reduce scour potential; these are all soil improvement studies, ground improvement techniques.

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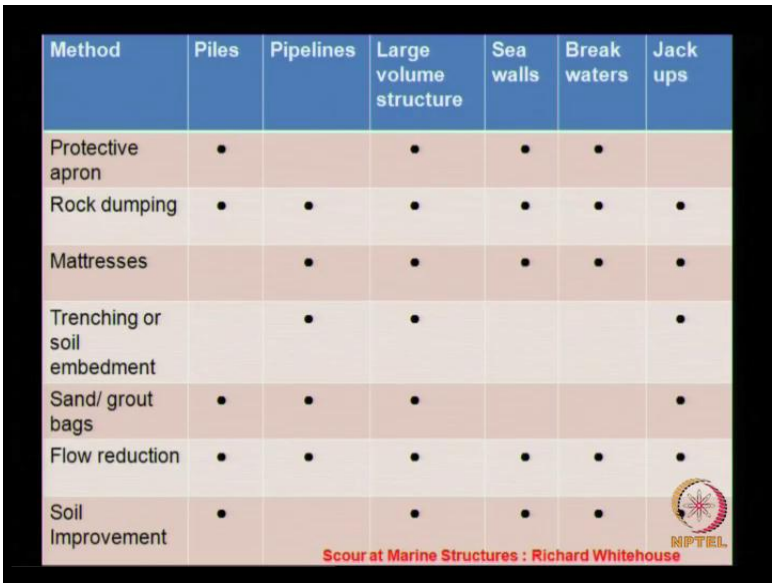

So, there are a verity of problems and methods also. So, you have on the top the types of structures this I have taken from a Richard white house, from his book scour on marine structures around marine structures. Piles pipelines large volume structures, sea walls,

break waters, jack up rigs these are the variety of structures that are in existence in the marine environment in the ocean or in the coastal zone.

So, on this column you have a the type of a the method for protection, protective apron for piles, large volume structures, sea walls and break waters, rock dumping can be used for all. But of course, the size of a rock will be varying, then mattress can be for pipe lines; in fact, mattress is widely used for pipe line pipe lines widely used.

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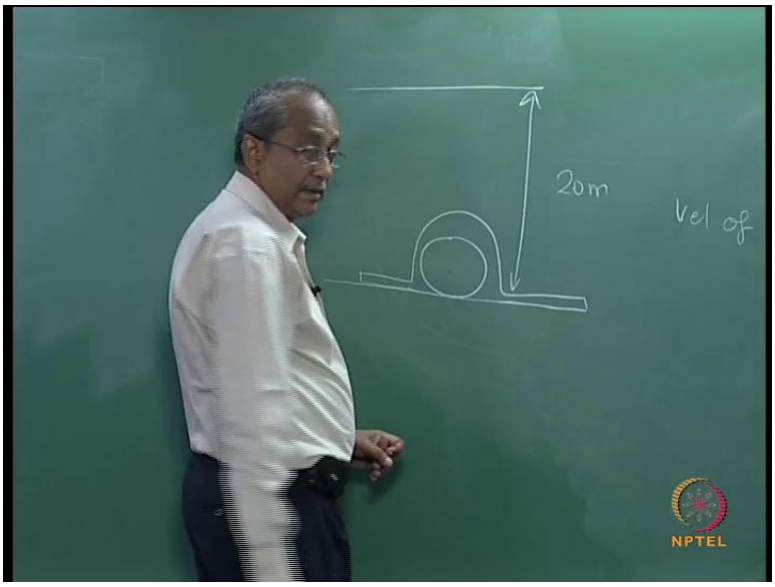

And in fact, we had a very nice experience of a pipe line in a water depth of 20 meters, where the velocity of water was approximately 9 meters per second 8 8 to 10 meters per second, this is somewhere in Gujarat along Gujarat. So, you can imagine with this kind of a speed the pipe line is resting on the bed and we need to have a protection for the pipe. So, we looked at a several, I mean options and finally, we went for this matters unfortunately I do not have any pictures on this. So, what was the main problem is not even the anchoring, the main problem was dropping it and making it keeping it in position because of the huge velocity involved.

So, this has been completed and the pipe line is in its position without any problem for at least now may be about between 5 to 10 years. So, then sand bags there are several cases, in fact, it is also used in the case of sea walls and break waters also, although it is not marked here. Flow reduction in all the cases we have, then soil improvement scheme mostly piles large volume sea walls, etcetera.

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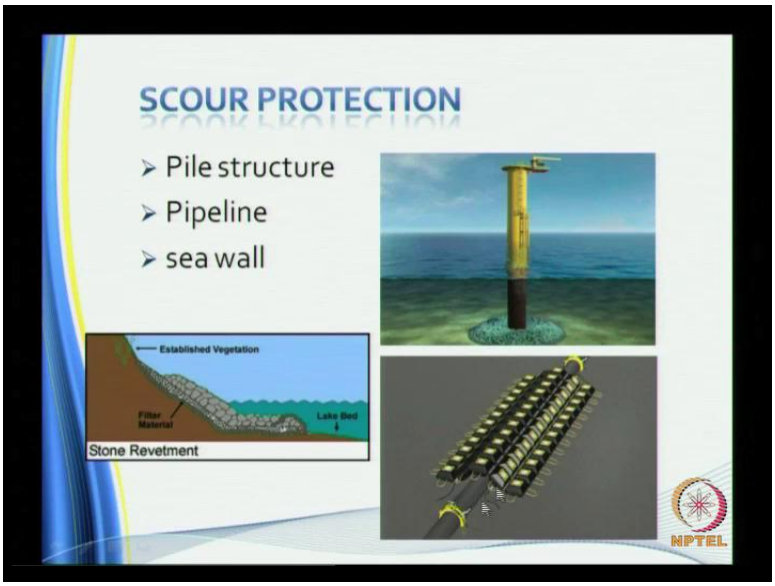

So, you see that there is a pile structure here how a how it has been protected you see that this is the kind of protection. So, the width a height all these things need to be calculated or you can have a stone revetment in order to provide, prevent this slope erosion the scour around this. And you can also have a vegetation here, which is strongly recommended, this is for the case of a pipeline you have a kind of a mattress.

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This is a application of geo bags of shore wind plants wind energy plants which is gaining a tremendous importance these days. So, when you operate when you go in for

wind form, this is one important area where we need lot of information, scour protection forms a basic necessity.

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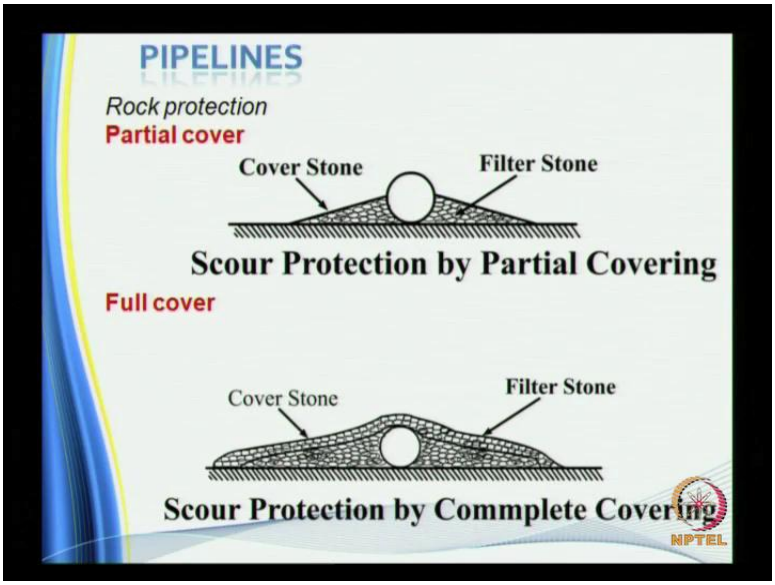

Then this is in case of a pipeline, this is only a partial protection you have you protect only for this portion. Probably in deeper waters, because if this kind of a situation exists in shallower waters, the ship anchors etcetera might hit by chance.

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So, in case of a mostly this kind of situation this kind of a protection is considered the whole pipe is scoured, protective mattress as I have said earlier this is a free

prefabricated mattress used where less control over a rock dumping they are flexible and follow local bed contour, so the those are the advantages.

So, a synthetic it is fascine this is another product which was which has been mentioned in Herbich et al. So, filter fabric strengthened with geo synthetic natural this is nothing but your natural your geo synthetic material and you have a strengthening. So, that it is very flexible you cover it and use it for.

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So, this is another block mattress a continuous array of concrete blocks held together by cable and then it is a laid over the concrete block; see for example, you look at this is to take care of end scour.

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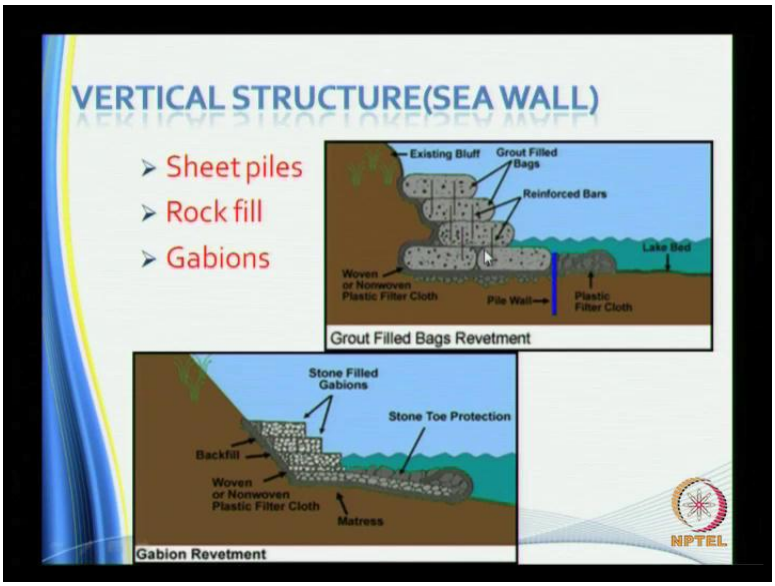

So, this is vertical walled structures sea walls as I have told you these are used by using gabion's. See scour and erosion they are together infant there is a slight difference, but the effect is almost same effect is loss of material.

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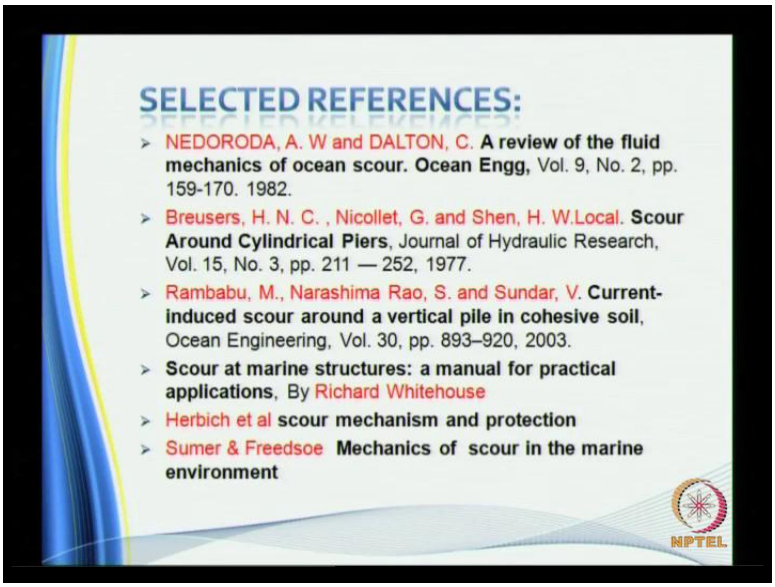

So, with this I will conclude and I would suggest like to list the books all these all these references have provided some useful information on scour under marine structures.

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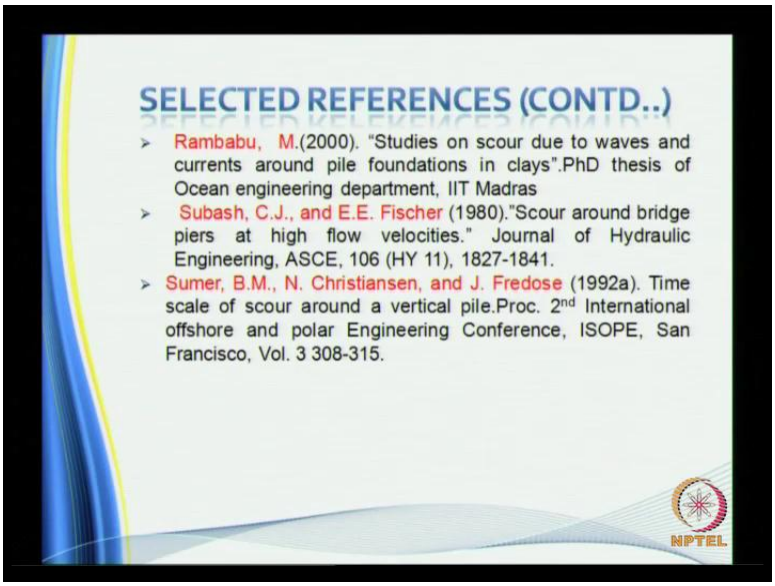

And these are all some of the references that I have used in preparation of this lecture and there might be some others also, which I might have missed.