Coastal Engineering
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Module - 2
Sediment Characteristics and Longshore Sediment Transport
Lecture - 2
Sediment Characteristics – II

Yesterday we have seen about the effect of temperature and the effect of sediment concentration. So, effect of a temperature certainly it, I mean the property of the fluid that is the coefficient of viscosity as a direct is a direct function of temperature. And you know the properties of a flow a, I mean your fall velocity etcetera is going to be some way or other related to the Reynolds number, through your coefficient of drag. And hence the temperature has come into picture, which was explained yesterday, and similarly the effect of concentration also has been explained, and you the concentration is higher is going to settle down and the concentration can become higher, when few particles cling on together and this in terms of flux. Then you can see that the fall velocity increases and the practical relevance of this the field of costal engineering, also I have explained yesterday.

Now, today we will talk about the effect of turbulence, again effect of turbulence see where does this turbulence and all comes into picture. See when you talk in terms of coastal engineering, the effect of turbulence is, later I will also explain when I am talking about the mechanics of wave induced sediment transport. There you will see that when the simplest thing is, when you look into the ocean, you see that the waves break right. When the waves break what happens, there is lot of turbulence created and if you have a lot turbulence, you have lot of mixing of the sediments.

So, this is one direct relevance and when you have more mixing due to more turbulence, what will happen is, the sorting of sediments will be more or less uniform, you understand. So, this has a direct bearing on the quantity of sediments, that are brought to the surface form the sea bed.

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Now, here in you have already seen, how does the coefficient of drag vary, when you have Reynolds number and a C D. You see the, you see the curves something like this right. So, at low Reynolds number, you see that there is a significant decrease in the coefficient of drag, and after certain value of your Reynolds number, you see that the C D is more or less constant or more or the variation is not much significant. So, now you have this in mind and try to understand the effect of turbulence.

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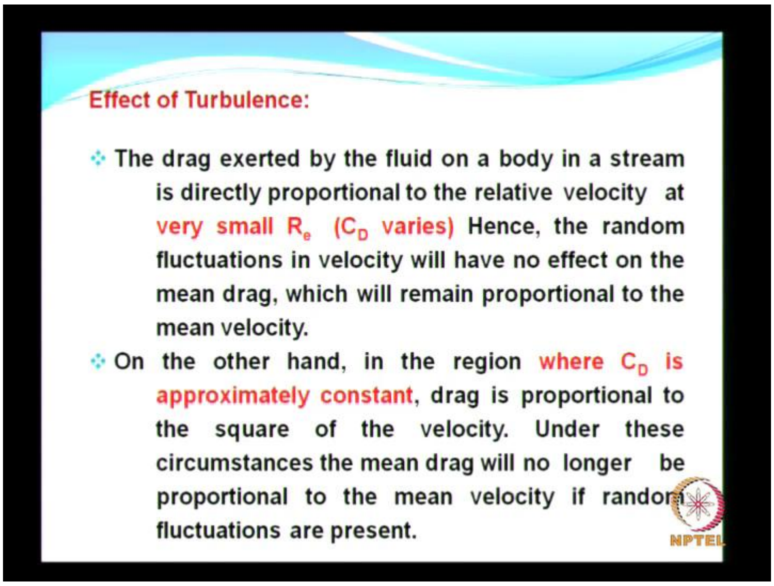

So, the drag exerted by fluid on a body in a stream, is directly proportional to the relative velocity at very small Reynolds number that is, this is where, you have the variation of the coefficient of drag. So, one classification is, where there is a variation of C D and the other classification is where there is not much of variation of C D. So, in the first classification because of a, the variation in the C D as shown here, the random fluctuations in the velocity will not have much of effect on the mean drag.

Hence, we can say that, the there is there will be no effect on the mean drag, which will remain proportional to the mean velocity. After all, it is the velocity which controls, on the other hand, in the region where, you have approximately the C D is more or less uniform that is, particularly, in the case of larger Reynolds number. Drag is of course, proportional to square of the velocity of the flow so under such circumstances what happens, the mean drag will no longer be the be proportional to the mean velocity, in case the random fluctuations are present.

So, this is what it conveys that is, this is more important when you consider the practical application, I told you already and this effect of turbulence is quite difficult to work with, the turbulence, it is not so easy to work with turbulence. Although there are some research work, which is in progress in some of the leading laboratories, trying in order to understand the effect of turbulence.

Now, we move on to another important aspect, which is nothing but the permeability permeability, so you ask know, how permeable is this medium, is this medium permeable? Is this medium permeable? No. So, if you pour some water, it its stand there, it does not penetrate.

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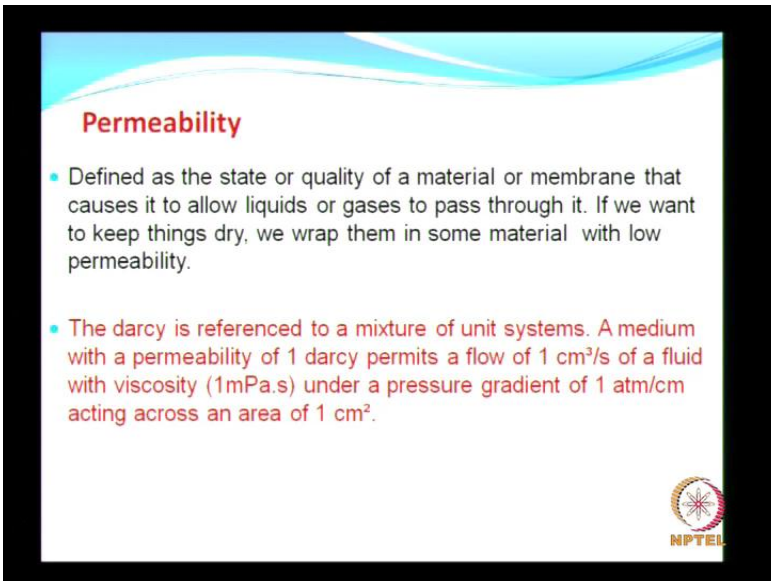

So, this is defined as the state or quality of a material or it may be a membrane, both has direct application in the field of coastal engineering, both the material as well as membrane. In fact, membrane has a wider application recently so this is a recent kind of innovation we could say, that at least for the last a decade, they are using these membranes for coastal protection. That causes what does it do, it causes it to that the membrane causes it to allow liquids, we are not interested right now in gases, at least liquids to pass though it.

If you want to keep things dry then normally what do you do, you wrap it wrap it with a material with no permeability or very less permeability. So, all of us know, because for non in a civil engineers, I think even they must have been exposed to, what is mean by permeability but where does it find its application.

For example, when you look at a several structures in the coastal zone, why in the coastal zone, even on even in for that matter even the your highways bridges, etcetera are revetments for that matter.

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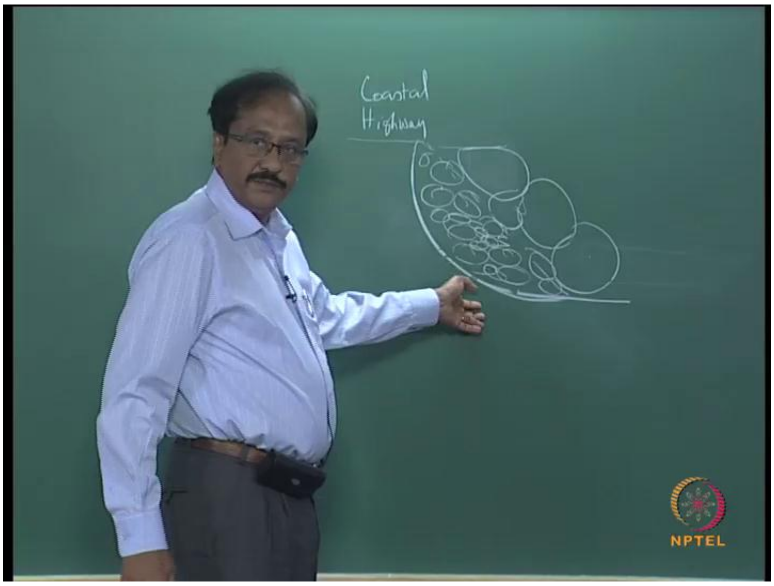

What will happen is suppose, for example, I want to protect an area, which is getting eroded, this is may be, this is a coastal highway coastal highway and the whole thing is probably initially, the which slope been, would have been something like this. And slowly, as time propagated then you see that the erosion has taken place, so the usual thing is, how do you protect this, you will the simplest way is to dump stones. What will happen, if you dump the stones, if you dump too big stones then there will still be some amount of water escaping through and that might create some problems.

So, you have to be careful while using the stones, normally under this case, what they do is, they use a smaller stones and then they have a bigger stones. So that, the bigger stones will resist the action, the forces due to the waves and after resisting, the flow will take place the flow through this medium will take place through smaller stones. So, what will happen, the flow gets slowly dissipated, is that clear so that is the reason, we have few larger size stones then smaller size stones and then you have something like a filter layer.

So, the concept the, again I am telling you, this is only to reduce the flow through the medium so that, the this part is protected. Now, that is a how, you consider, how you consider the porosity or the permeability etcetera, which will which we will be again seeing about the porosity and permeability.

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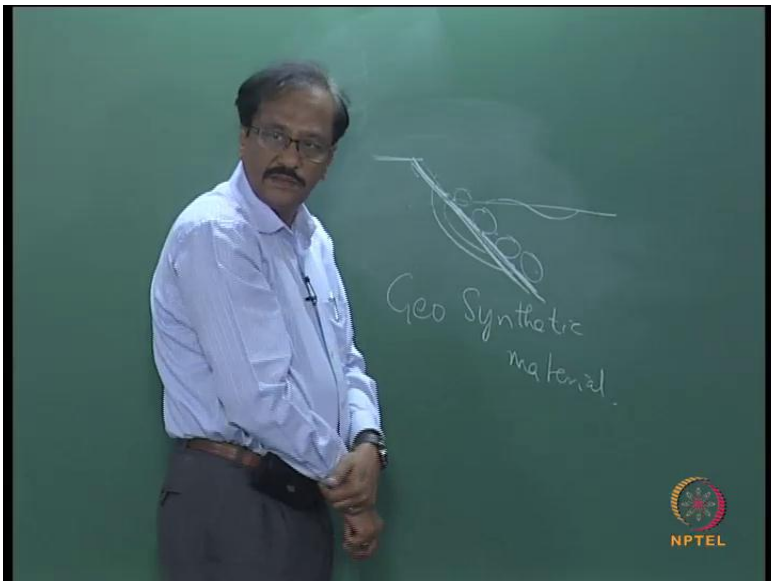

Now, next comes your membrane, what exactly is this membrane, one typical example is when you have an area, which needs to protected, a beach for example. The beach is undergoing erosion, progressive erosion, how can we protect this, we use what is mean by geo synthetic material. This geo synthetic material, the purpose of the geo synthetic material is, to allow the water to penetrate but retain the sand or the other materials.

So, what you can do is, you will have the geo synthetic material here, wrap it wrap it and then when over it, you can have the stones or protection layer of course, you need to have a smaller size stones, which is called as a filter layer. And then over that you can have smaller stones, what it will do is, when it brings some amount of sand to this area, the sand will be retained on the sea side and it will allow only the water. So, there are varieties of geo synthetic materials available, now only problem is, it is more favorable in location in non tropical countries.

Because, the material itself is a big, again it is under discussion, whether it can be widely adopted for tropical countries because what happen this, when you talk about synthetic material, when it is exposed to alternate sunlight and it becomes wet and dry, what will happen, it become brittle after a few years. So, once it becomes brittle, you know what happens, it breaks so its effect is lost so that is the reason, we people are still discussing about, whether the geo synthetic material can be adopted.

We will be discussing, we will be having few lectures on the geosynthetics later so you see that, permeability or of a material as well as the membrane has a some effect significant effect in the design of coastal structures, and also when you talk about break waters, etcetera which we will be looking at the design classification, etcetera later. Now, coming to the permeability, there are different ways of expressing permeability, I have chosen this, that is the it is the darcy is refer reference to a mixture of unit systems.

A medium with a permeability of one darcy one darcy permits a flow of 1 centimeter plus where as centimeter per second centimeter cube per second of a fluid with viscosity 1 mega Pascal second, under a pressure gradient of 1 atmosphere per centimeter. So, what are all the things you have what are all the parameters you have, you have the rate of flow, you have the property of the fluid that is, the viscosity and how does this fluid flow takes place.

This fluid flow takes place because of, existence of certain pressure gradient and in how far it has to flow, it has to flow through certain area. So, you have the area, you have the rate of flow, caused the rate of flow is induced by existence of a pressure gradient and this is going to be done by a fluid with a certain viscocity.

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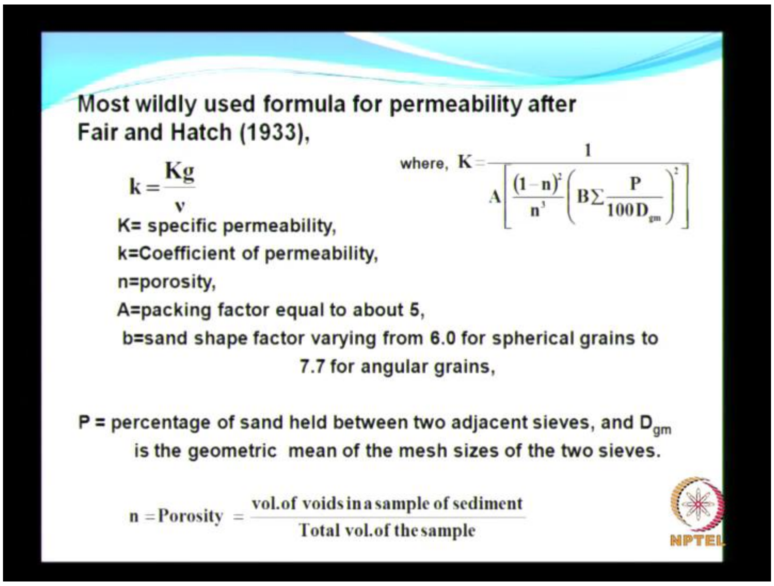

So, this is how the permeability is defined but for if you want to have more information, you can read a number of books available. So, now, the most widely used formula for permeability there are the so this is after a Fair and Hatch, which is widely used even today. And that gives as here, capital K into g so capital K is the coefficient of permeability, the coefficient of permeability is governed by this expression.

Wherein, a is the package factor equal to 5 about 5, capital B this is small b, but this is capital B this is sand shapes factor varying from about 6 for spherical grains to 7.7 for angular grains. We normally take an average also and what is the other parameter, g is the gravitational constant. Now, capital P is the percentage of sand held between 2 adjacent sieves and D g m is your geometric mean of the mesh sizes of two sieves, I have already mentioned about the sieve analysis.

So, this is the diameter of the geometric mean of the geometric mean of the mesh size of two size sieves and n is nothing but the porosity that is, the volume of voids in the sample of a sediments. You take a volume of sediments then volume of voids in the sample of the sediment divided by total volume of the sand. I will not go into the details of how all these things are measured etcetera, I suggest you refer to some basic books now, herein you know, how this permeability is calculated, what are all the parameters that are necessary.

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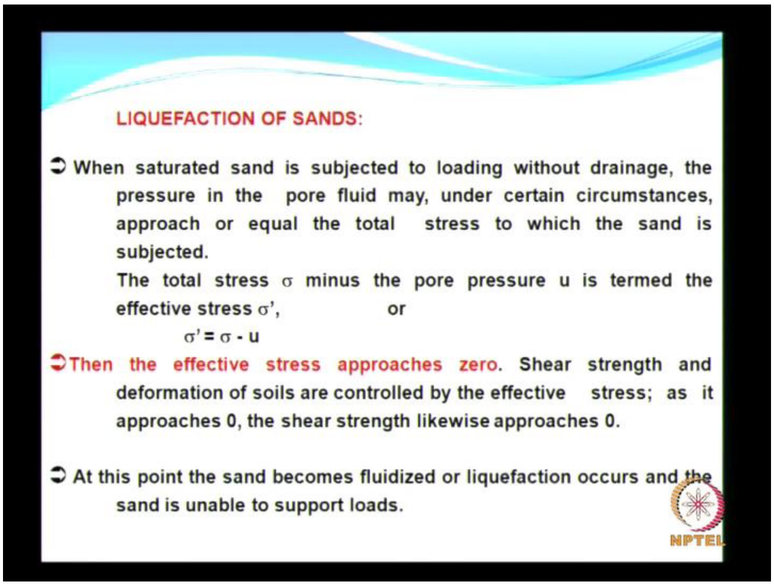

Now, we have more or less done with the basic properties of soil, that are of direct relevance to coastal engineering. One important aspect is the liquefaction of sands, liquefaction of sand is what, how important is liquefaction of sand. It is extremely important because if the if you are going to construct a building in the location, where you can anticipate the liquefaction, the entire thing is going to collapse. So, when saturated sand is subjected to loading without drainage.

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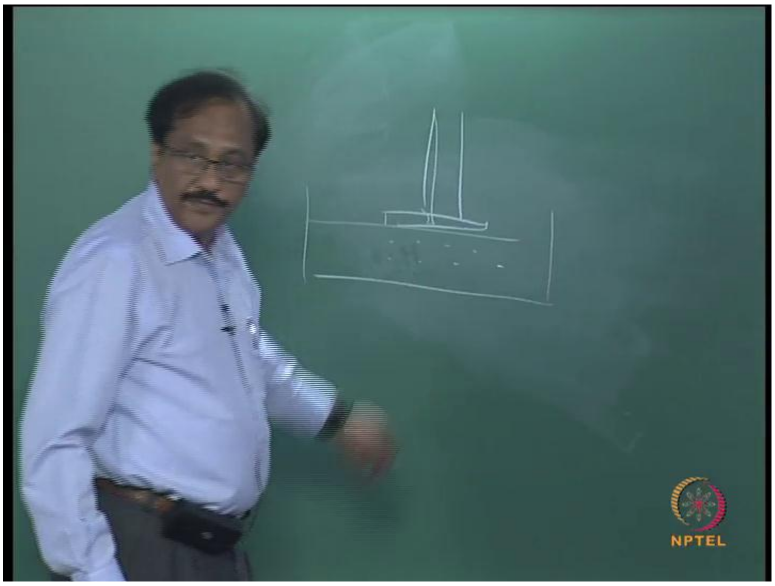

So, I have a container with sand, saturated sand and this is subjected to loading, I have the load, now, there will be pressure exerted in the pores. What will happen, when the saturated sand is subjected to loading without any drainage because it is now a confined container. What will happen, the pressure in the pore fluid, may under certain circumstances approach equal to the total stress, what is total stress, load by area. So, the pressure may equal to the stress, the total stress that is, sigma minus the pore pressure is expressed or defined as effective stress.

Under such a circumstance, when the pore pressure is equal to the total stress then the effective stress must approach 0 right effective stress must approach 0. The shear strength and the deformation of soil are controlled by the effective stress, the shear strength of the strength of the soil, as this approaches 0, the shear strength also become 0. What will happen, can we it withstand any structure. So, we should make sure that, liquefaction should not occur, at this point what happens, the sand becomes fluidized, the sand will now become something like a fluid.

When it becomes a fluid or when liquefaction occurs, the sand is unable to support any loads and that will lead to total catastrophe. So, but I suggest some of you to read some extra books, some of the books are list of references are given at the end of my lecture material. Where you can find, apart from those references there are some standard other standard references, where you can get details of a liquefaction of sand, the physical, I mean the phenomena etcetera in much more detail also, you may be in a position to get, I suggest that those books for additional reading.

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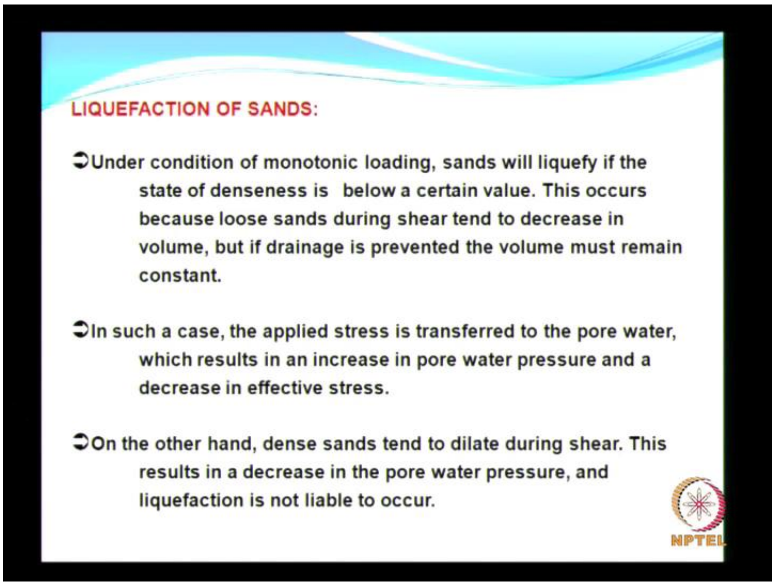

So, I will continue with the liquefaction of sand so under continuous monotonic loading, sands will liquefy, if the state of denseness is below a certain value. This occurs because loose sands during the shear, tend to decrease in volume but if drainage is prevented, the volume must remain constant. So, in such case what will happen, the applied stress is now transfer to pore water, when the applied stress is now transferred to the pore water, what will happen, this will result in an increase in pore water pressures, under decrease in the effective stress.

So, you do not want to have increase in the pore water pressure, am I right. So, on the other hand, now, a dense sands will dilate during the shear during shear and this would result in a decrease in the pore water pressure and liquefaction is not liable to occur. So, the quality of sand, the characteristics of a sand is extremely important, there has been a number of a studies to understand the behavior of, I mean understand the variation of pore water pressures, in case of rubble mound structures.What do you mean by rubble mound structure, we will be seeing about rubble mound structure in detail later now, the kind of a studies would be something like this.

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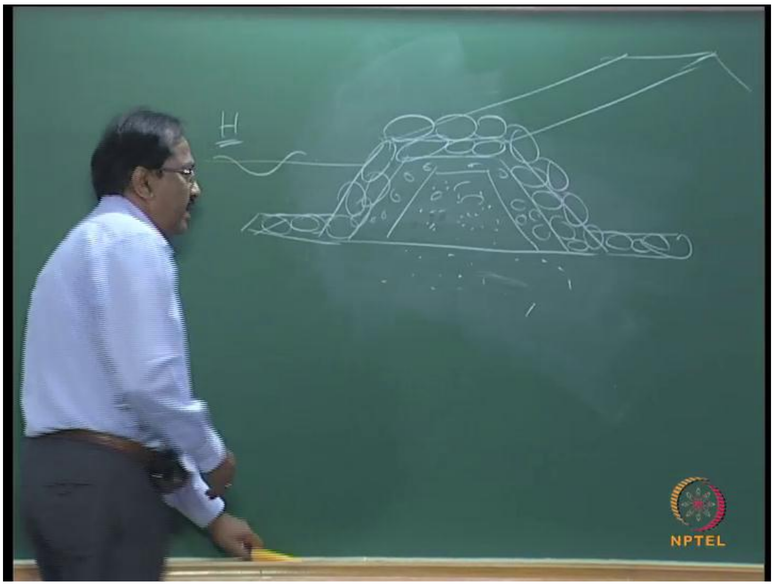

So, you have some characteristics of sand and then you usually have a structure, which is called as a break water. Again I have already emphasize, the need for having the variation in the permeability of the structure. So, you see that, you have bigger stones on the top, I will emphasize about all this design, etcetera later. Now, for this, what is the usual kind of studies in relation to pore water pressures, most of the studies are so this will be extending like this, this is.

So, you see that, this is the structure, which is called as a break water, constructed for creation of artificial harbours. And before you really construct all these things, you should understand about the pore water pressures, whether there is excess pore water pressures being built up, etcetera. So, you people have measured the pressures inside this medium as well as in the and in the sea bed and this pore water pressures naturally, have to be related to the characteristics of the waves, the characteristics of the structure as well as the soil.

And this is one area, which people are still working on, trying to establish a relationships on the variation of a pore water pressures, as a function of the incident wave characteristics as well as the characteristics of the structure.

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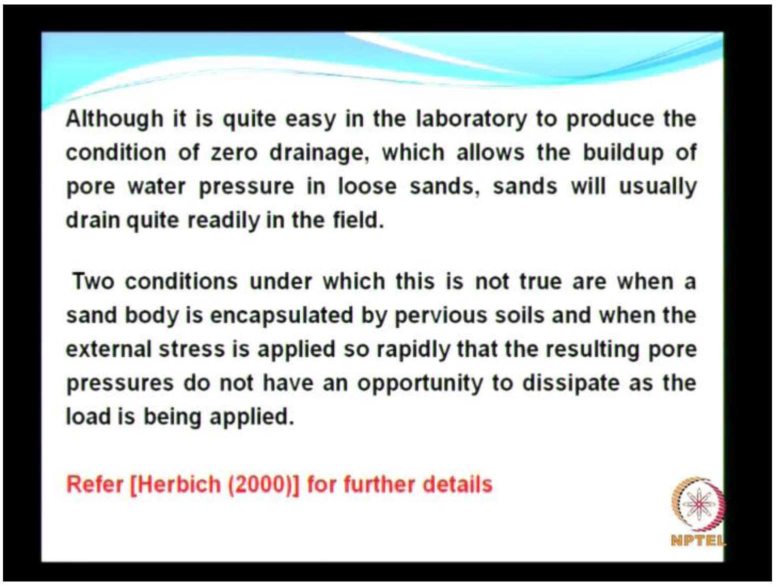

So, as we have seen that, if you want do not want to have your liquefaction, make sure that the pore water pressure is minimum. Although it is quite easy in the laboratory to produce condition of zero drainage, yes of course, it is very easy to create a condition of zero drainage, because if you have a tank. So, there is no water, which is released right so which allows the built up of pore water pressures in loose sands.

Sands will usually drain quite readily in the field, understood so you have to be careful, while you are doing some such studies in the laboratory also. If you are trying to do some test similar to something to do with the liquefaction, you have to make sure about the boundary conditions. Two conditions under which, this is not true, the above are, when a sand body is encapsulated by pervious soil and when the external stress is applied so rapidly, that would result in, I mean pore water pressures pore pressures that, that the resulting pressures will not have an opportunity to dissipate the load, that is being applied.

So, this is what, I have been explaining with the help of some of the figures and now, if you want to have much more information on this, I suggest read the reference. That is, the book written by Herbich, it is an excellent book giving all the details about whatever I have discussed.

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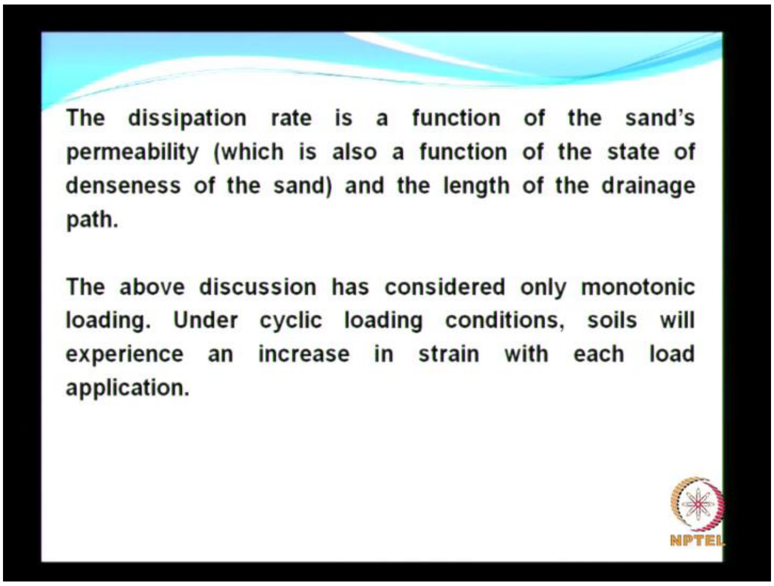

Now, when I said about the dissipation rate, so I also when I talked about dissipation when I talked about the structure having a larger stones then followed by smaller stones, and then again by the smallest stones that is, progressive decrease in the permeability. The reason, why I said is gradual dissipation and gradual dissipation is always good so the dissipation rate is a function of sands permeability, which is also a function of the state of denseness of sand and the length of the drainage path.

So, the above discussion has clearly considered as considered only monotonic loading then but in the case of coastal engineering, we talk about cyclic loading. So, under cyclic loading, the soils will experience an increase in strain with each load application because it is cyclic. So, all this things will, the strain will keep on increasing under every wave so in fact, when you want to test, you should test with a number of waves in order to, understand the physics behind all this phenomena. I would like to continue that earthquakes are an important cyclic loading mechanism.

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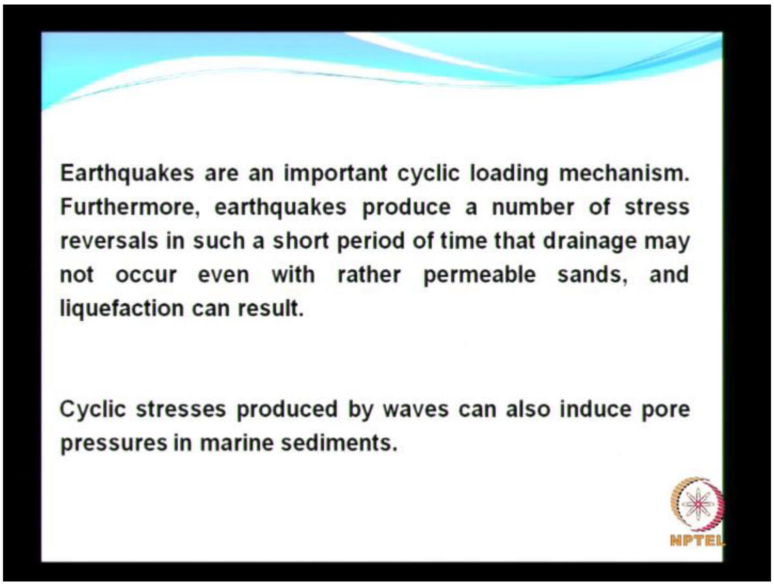

For the earthquakes, produce a number of shear stress reversals in such a short period of time where, it is a very short period of time that the drainage may not occur, even with rather permeable sands and liquefaction can result. So, one is we are talking about the permeability of the sand so even if it is occur, even if it is a permeable, you can have the liquefaction to occur.

Now, cyclic stresses produced by waves can also induce a pore pressures in marine sediments, which is a well established fact. So, that is due to the action of ocean waves. So, the loading will be cyclic and the this will this will induce pore water pressures pore pressures in the marine sediments.

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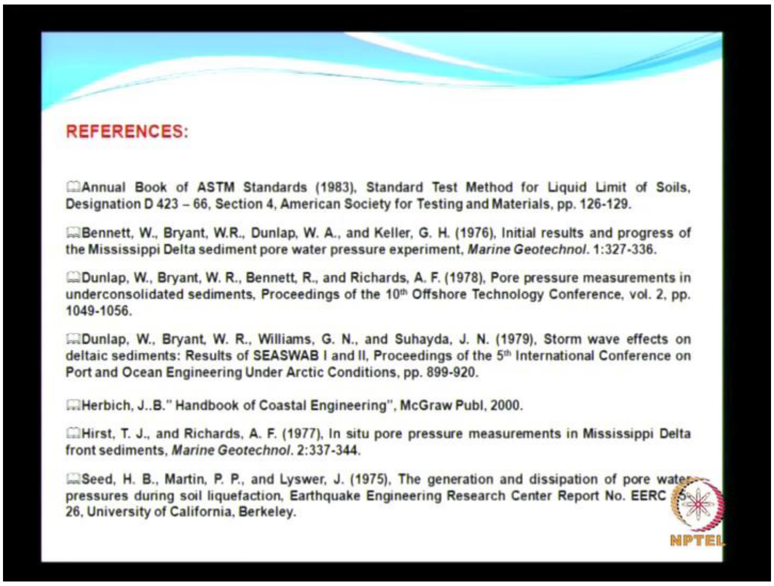

So, you look at all the references given and Herbich was the one, which I have been referring to, this gives a lot of information, not just on the characteristics of the sediments. But, also on other aspects of a coastal engineering and there are other kind other books also now, some of the other books, which are given here, are some books on the verifying the liquid limit or the plastic limit, the methods to conduct all these things and the classifications, etcetera.

And I have also given one or two publications on the results from pore water measurements etcetera, may be it is of a may be although it is bit old, you can still have some idea. This is only to give you an idea about the nature of studies, that could be carried out, under the pore water pressures, etcetera. So, any questions under, so with this, we finished the sediment characteristics and then we will go into the initiation of sedimental motion or the wave deformation, etcetera from next class.