Coastal Engineering
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Module - 4
Geosynthetics
Lecture - 1
Geosynthetics – I

Today, we will just look at recent technology. I would not say new technology, because this application of geosynthetics has been invoked for several years particularly in the field of highway engineering and geotechnical engineering. Recently it has also found its application in the field of coastal engineering. So, let us try to see the basics of geosynthetics and then later I will try to tell you about its application.

The different versions of geosynthetic products, and then we start looking at its application mostly pertaining to the field of coastal engineering. Herein there has been a number of case studies that have been presented and I would like to place on record my sincere thanks to several organizations, industries, manufacturers of geosynthetic products and institutes like CWPRS, Pune who has, who have allowed me to take some of their slides informations in order to go ahead with this presentation on geosynthetics and its applications in the field of coastal engineering.

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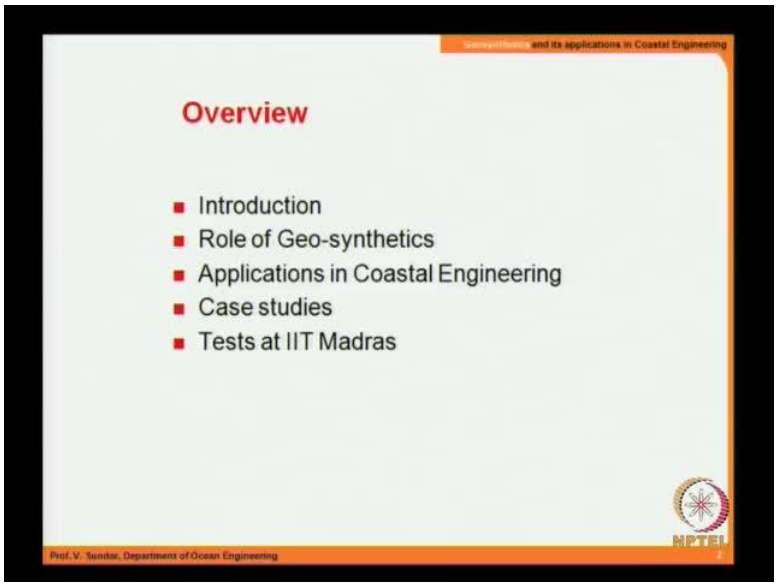

Overview, I will try to start with introduction. The role of geosynthetics, I mean the geosynthetic products, then its application, the field to the field of coastal engineering followed by a few case studies and I I will also cover some of the tests carried out in IIT, Madras.

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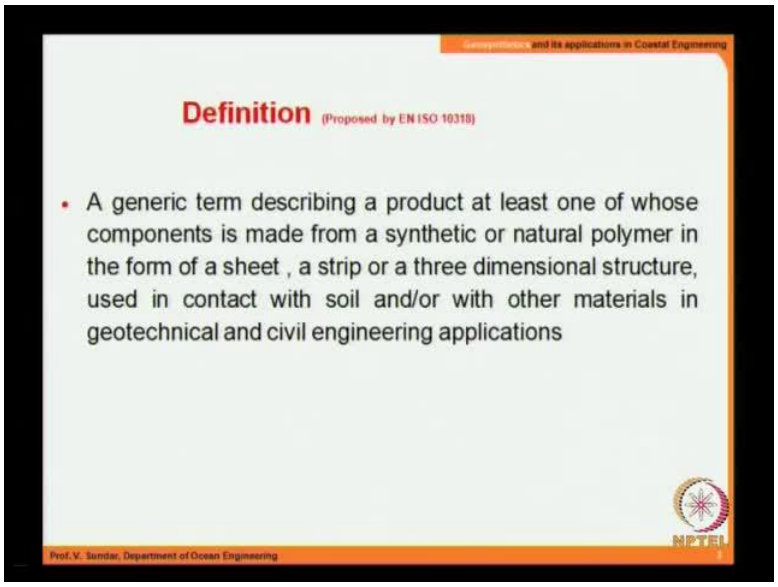

Let me start with the definition. This definition clarifies in brief what exactly is geosynthetics. The, a generic term describing a product at least one of whose components is made of made from synthetic or natural polymer in the form of a sheet, a strip or three-dimensional structure used in contact with soil and or with other materials in the field of geotechnical engineering or for that matter any other field of civil engineering.

In fact it is got started in the field of civil engineering particularly in the division of geotechnical and transportation engineering. Later it it found its application in the field of hydraulic engineering, and finally we have our field of specialization that is in the field of coastal engineering, the application of the geosynthetic products. So, that is the definition in general that it is made of made from synthetic and natural polymer. So, it can be strips or sheets etcetera. The different types of products that are available at our disposal will also be discussed.

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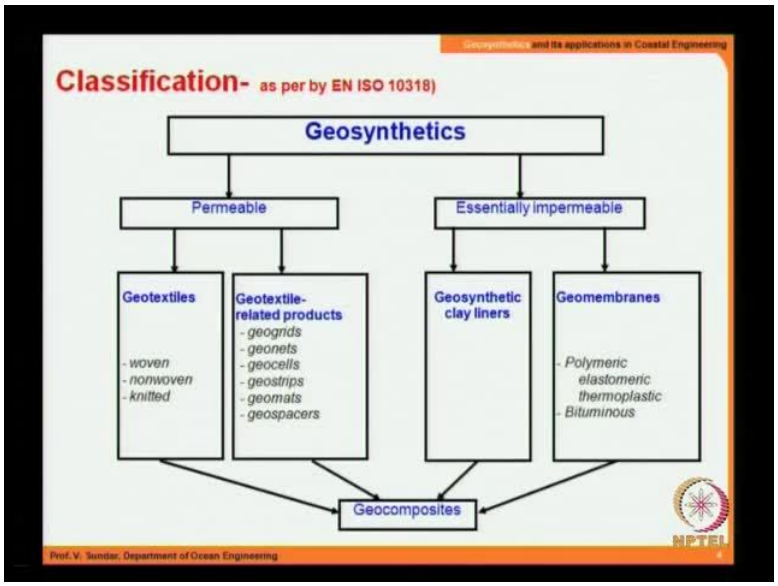

A broader classification of geosynthetics are as you can see here you can have either permeable or essentially impermeable. Under permeable you have further two classified products one is geotextiles, geotextiles mostly it is just a sheet or geotextile related products as you can see here, you have under permeable you have geotextiles and geotextile related products. Whereas, under essentially impermeable you, we have geosynthetic clay liners and geo membranes.

When you come at, come with look at the geotextiles you have three type of goesynthetic I mean geotextiles. One is woven, non woven and knitted. Under geotextile related products we have six types of products one is the geogrids, then you have the geonets, geocells, geostrips, geomats and geospacers. Some of them they are not very that popular in the field of coastal engineering. So, these are general classifications of geosynthetics. So, again going to the geomembranes you have either polymeric or bituminous and then all these things combined they are called as geocomposites, maybe geotextiles and geotextile related products can be combined together or geosynthetic clay liners or can be combined with geotextile products. So, any of these classification or the sub classifications combined together the product is termed as geocomposites.

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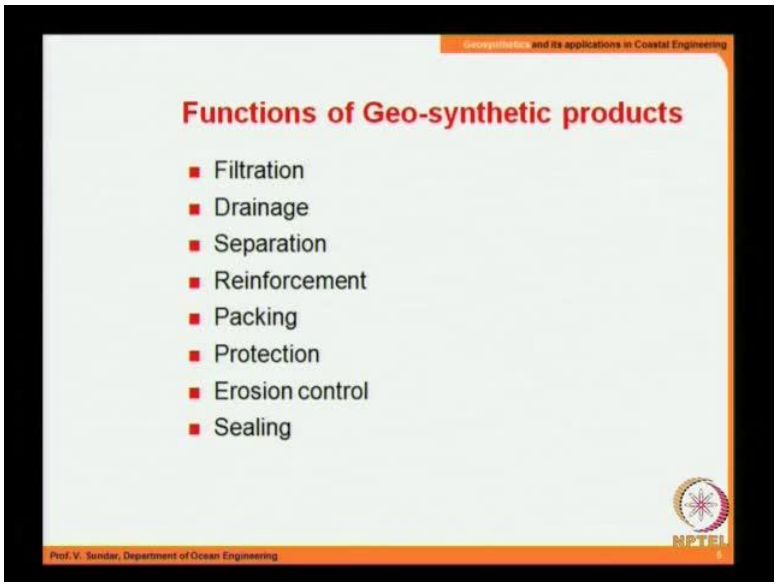

Functions of geosynthetic products. We have several role or functions of these geosynthetic products. One is filtration, then drainage, separation, reinforcement, packing, protection, erosion control which is the most important aspect or the function in the field of coastal engineering and then finally, sealing. So, you see a variety of functions of geosynthetic products.

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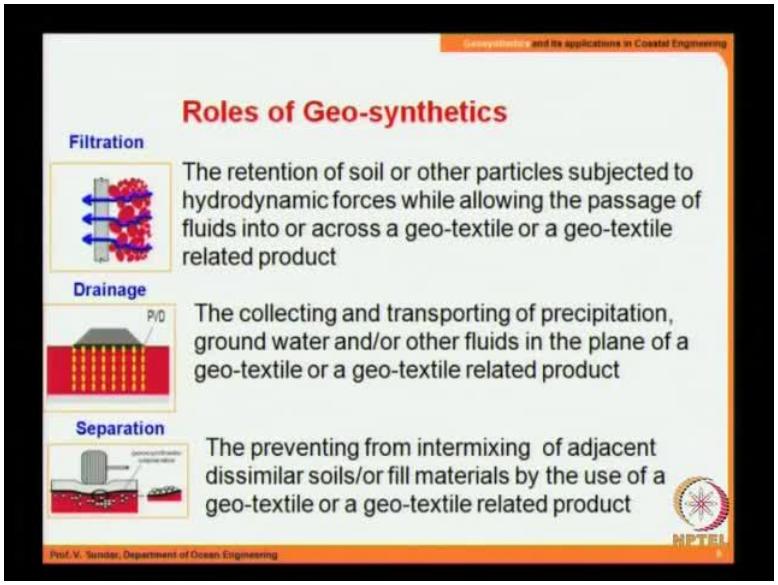

Now, this is further explained here concerning the, I mean the role of geosynthetics. The filtration as you can see here, the retention of soil or other particles subjected to

hydrodynamic forces while allowing the passage of fluids into or across a geotextile or a geotextile product, related product. That is it acts like a filter, what it does is it filters the sand and allows the water to go.

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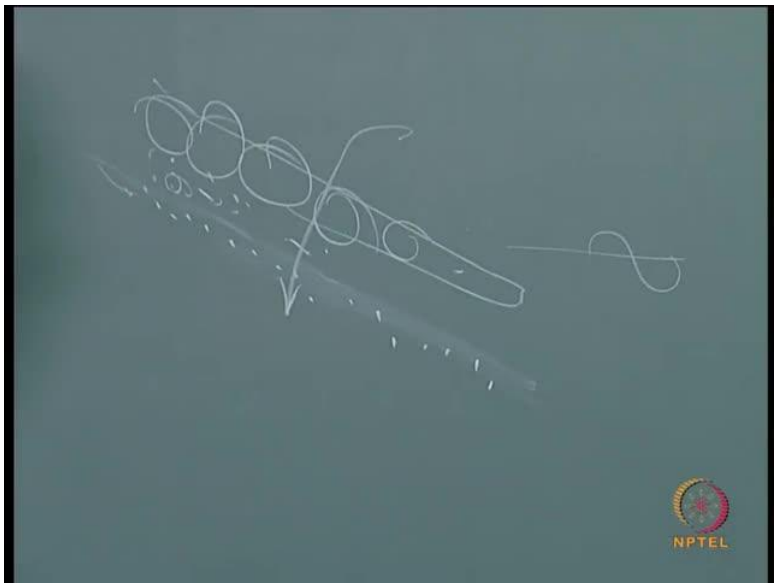

So, for that matter if you have something like a sloping wall and you have the waves coming, in case you do not have this geotextile product and then you are trying to protect this with small filter and then armour layer which is consisting of bigger stones, this filter layer there assume that there is no no geotextile, it is only, it is supported on sand. What will happen? Due to the percolation the water will remove the sand. So, that is going to create pockets of cover and if the percolation is more, mostly in the case of during storm or extreme events what will happen is you might have also have the over topping and removal of sand from this end and so what will happen, this will be removed.

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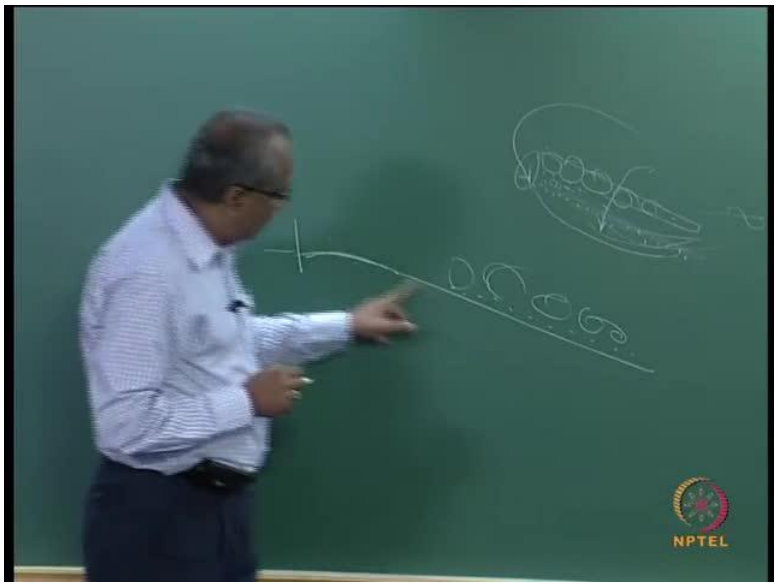

So, in order to avoid that you have a geotextile over, which you can have the filter layer and then may be your stones. Now, make sure that the geotextile runs over the bed of sand or loose soil so that it is and it has to be properly anchored. So, that this whole thing is protected and it allows only the water to penetrate and the sand will be retained. So, in that way geotextile is very very important when you are dealing with protections with, protections of coast. Then drainage, collecting and transportation, transporting of precipitation that is ground water or other fluids in a plane of a geotextile or geotextile related products.

So, this is just collecting and then transporting of either precipitation or ground water. So, that have, definition itself is more or less clear. Then you have the separation. Separation is the preventing from, this is nothing to prevent from intermixing of adjacent dissimilar soils or fill material by the use of a geotextile or so what you can do have is you have a, you can have a a geotextile between two different material and avoid mixing up of these two materials. So, particularly when you want to say for example, you want to have some kind of pebbles and then small pebbles and then sand, very small pebbles and sand and you do not want them to get mixed up. So, you can have this kind of material like your geotextile material that will help or function as the role of separator.

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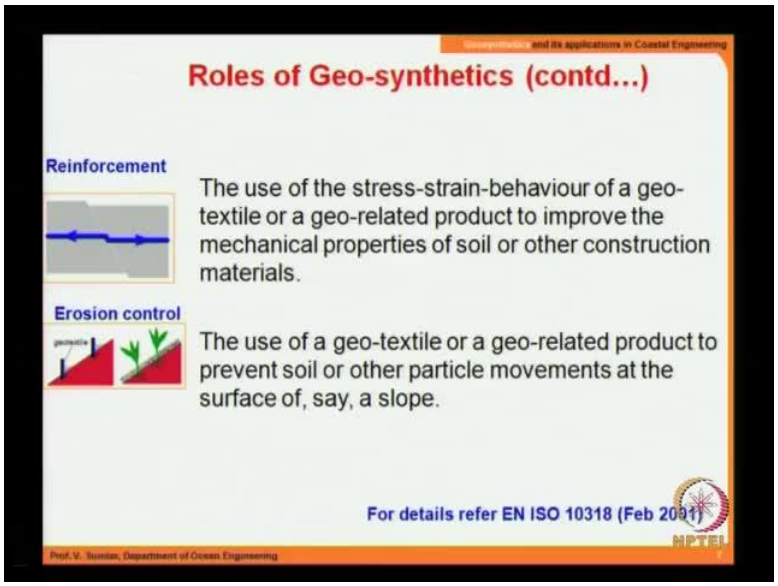

Then use of, then reinforcement use of stress strain behavior of geotextile or georelated product to improve the mechanical properties of soil or other construction material. So, later we will see some of this application during the course of the lecture. Finally, we have the erosion control, the use of geotextile for preventing soil or other particles at the surface say over a slope and this is what I have been explaining just now. So, that is where you have find, you have a wide application. I mean it is very commonly adopted the geotextile is very commonly adopted. Some of the details available available in this code, which gives a complete description of the type of material that has to be used, the classification of geosynthetic products, etcetera.

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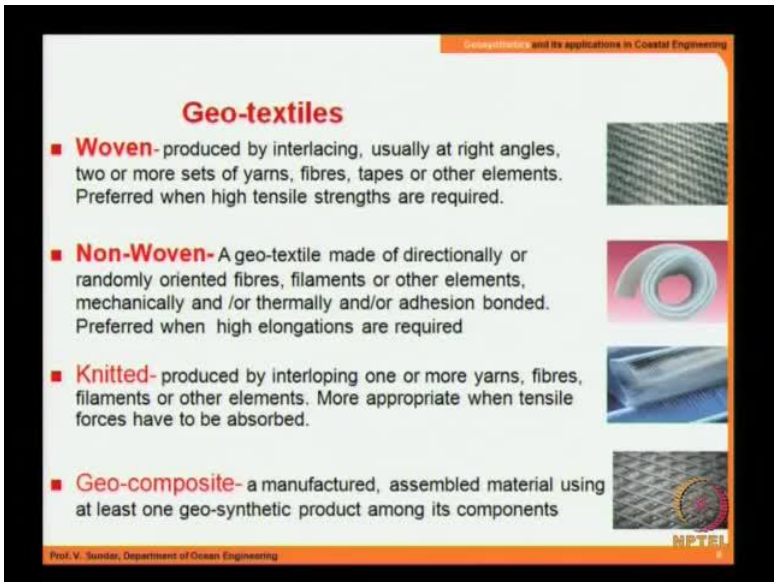

So, then as I said earlier the geotextiles are classified as woven, non woven and knitted. So, in the case of woven geotextiles these are produced by interlacing usually at right angles two or more sets of yarns, fibers, tapes or any other kind of elements that are basically geosynthetic, of geosynthetic type and these are preferred, I mean the woven type of geotextiles are preferred where when high tensile strengths are required. So, typical figure, typical picture of woven geotextile is shown on the right side. Non woven type a geotextile made of directionally or randomly oriented fibers, filaments or other elements mechanically or thermally or by through hydration bonded, it is all bonded together.

What are all bonded together? Oriented fibres that is the fibers are randomly oriented and so whereas, other one is not randomly oriented. Here, it is randomly that is basic, one of the basic difference between woven and the non woven and preferred at locations where when you need higher elongations elong elongations. So, in such cases you prefer non woven type of geotextiles. Knitted these are produced by interloping one or mone more yarns fibers filaments or other materials. More appropriate when tensile forces have to be absorbed.

So, it gives us a kind of a broader picture like when you need to go for woven, non woven and knitted type of geotextiles, but then there are several other criteria's which decide on the type what which which is which which of the three would be would have to be considered. So, I suggest a detailed look into references and one I think I I will give the

reference later. So, at the end of the lecture there is one book by geosynthetics by Pilarczyk who has done considerable amount of work on this geosynthetic products and its application.

And I suggest if some of you are interested you read that book. It is quite thick, voluminous and it gives a lot of information and I mean further classifications of woven for example, what is what is exact difference between woven, non woven all this products, when exactly, because this only gives you a broader idea. Now, geocomposite; geocomposite is again another material as I have already told these are manufactured, assembled material using at least one geosynthetic products among its components. You can have two or more than one add together to get a geosynthetic composite.

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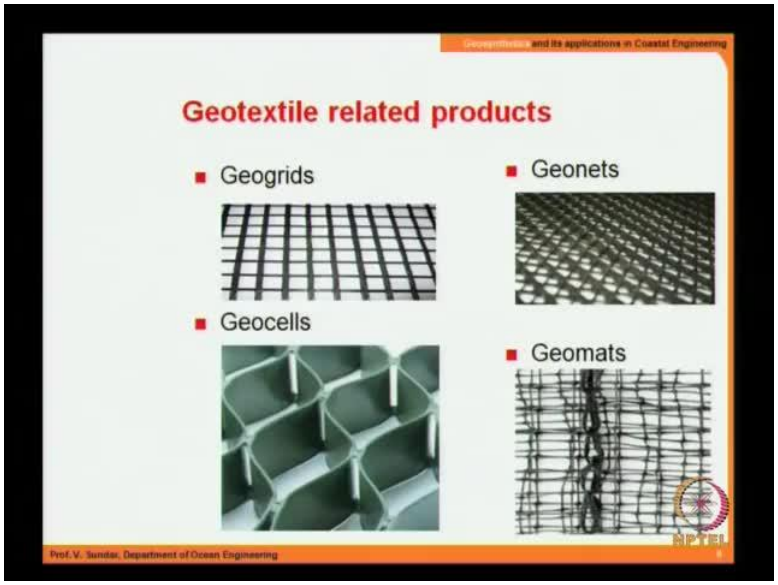

So, geotextile related products you have geogrids, geonets, geocells as well as geomats. Geogrids are mostly used for reinforcement, reinforcing the slopes and the role of geocells and geonets are also similar to geonets geogrids, but geogrids are more stronger if you want to have real control of the slope sliding over then I think geogrids can be better. Geomats are adopted mostly when you want to have the protection done and over it you want to have plantation then geomat is good for example, this is we always talk about plantation particularly after the tsunami, we talk always about the plan plantation being a good buffer against reduction of the run up etcetera.

So, one of the concept may be something like you have a, you have the slope you have already protected using geotextile and then may be here you can have a kind of a mat geomat over which the growth of plants can take place. So, this itself can have the plants so you can have the geomat. So, that is one application, but there are several other applications so you need to refer into some of the references.

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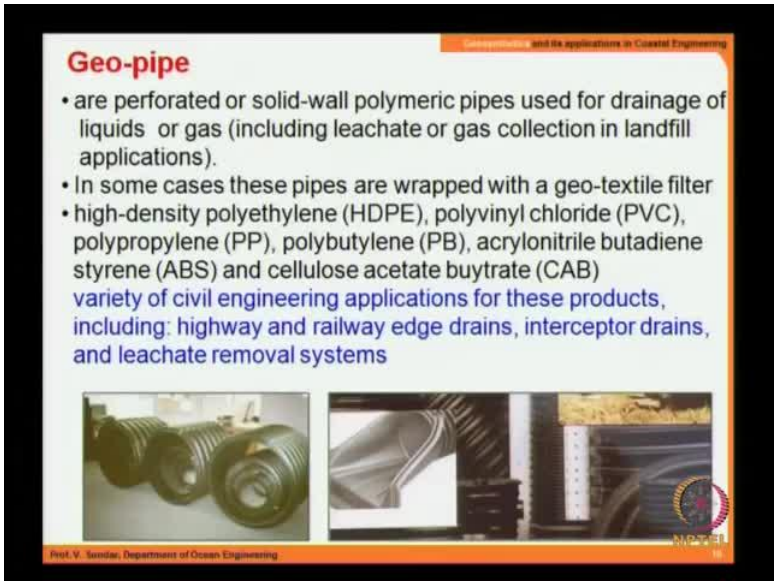

Next, geopipes, geopipes are perforated, it can be perforated or solid pipes of poly polymeric pipes used for draining liquids or gases including the leachate or gas collection in land fill applications. In some cases these pipes are also wrapped. So, you have a pipe, it is also wrapped over a geotextile. High density HDPE or PVC or PP or PB are some of the products material that is being used for manufacturing these geopipes.

It has been widely adopted in the field of civil engineering including highways, railway edged drains, interceptor drains and leached removal systems, but its application among this is significant in the field of highways and railways. Some of these products are shown below and so how it looks like so this geopipes.

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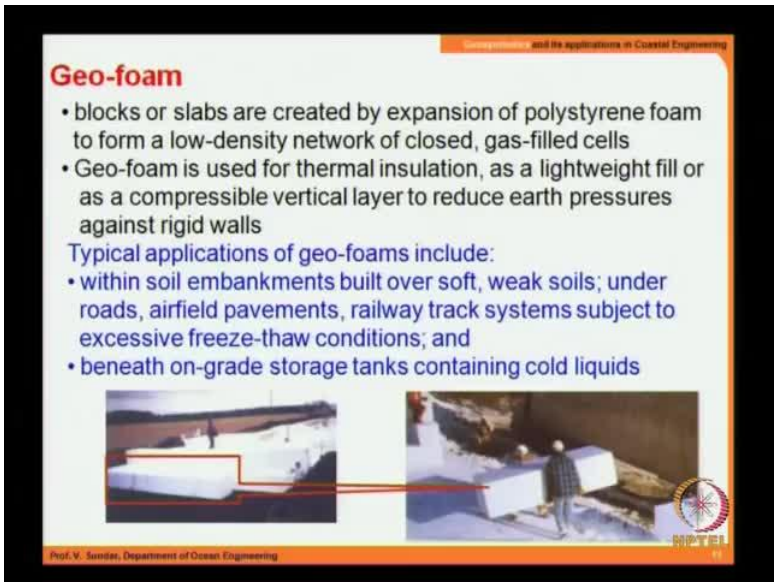

Geofoams, geofoams are directly it is not having much of application in the field of coastal engineering. So, far there has not been much of work which has been where they have adopted geofoams in coastal engineering, but I do not think, I do not see that its applications may not be there, there should be some application, but not much available in the literature. So, geofoams are blocks or slabs that are created by expansion of polystyrene foam to form low density network of closed gas filled cells. So, it is quite light. You look at the size of a geofoam so it is just looks massive, but it is being carried here by two persons and two persons not for the weight, it is probably because of the volume because volume has to be taken care of....

So, the geofoam is used for thermal insulation as a lightweight fill or as a compressible vertical layer to reduce earth pressures against rigid walls. Now, you when you say reduced earth pressures against rigid wall. Now, you see there is a kind of application for the coastal engineering for example, if you have bulk heads. Bulk heads, what are the purpose of bulk heads? Look at the lecture which I have already given. So, bulk heads one side its main purpose is to retain the earth earth and on the other side with a secondary purpose to protecting against waves. So, in the case of a bulk head this can be easily adopted.

So, typical applications of geofoam include within soil embankment built over soft weak soils under roads, airfield pavements, railway track systems subjected to excessive fees

freeze thaw conditions and finally, beneath on grade storage tanks that contain cold liquids. So, these are all some of the applications where you can think of I mean these are the applicable some applications for the geofoam.

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So, again geotextile forms. When you look at geotextile forms you have basically for the application in the marine environment we have geotextile bags, geotextile tubes, then we have geotextile containers. All these are widely used and it is also quite not so difficult to handle, but many times you need skilled labor to adopt this material. Selection of material is extremely important. There are several manufacturers with a wide range of specifications for the geosynthetic material. So, before we order or before we plan for it the selection of proper material is of paramount importance.

You need to look at the specifications. What are the standard specifications for the material and once you obtain the standard specifications then go in for the standard test to fulfill all those specifications, and then finally select the manufacturer. So, as I said we have geosynthetic geotextile bags as you can see on the right side. These are looking like cement bags. So, these look like cement bags, bags that are filled with sand. Then geotextile tubes these are long tubes may be about 10 to 20 meters or even longer you have a pump to pump in the mixture of sand as well as water into the tube.

The water will come out, that is the principle of your geotextile, but the sand will be retained. Depending on the size of the pipe or size of the tube make sure that you have that

kind of quantity of sand because availability of sand is another very important issue in the application of geotextile tube for coastal protection or any field of any any problem related to coastal engineering. Later you will see that you you will see a lot of green pictures on geotubes, but one important point as I said earlier is the availability of sand.

So, in a location for example, if you have an estuary and you have some kind of a sand bar formation here and you want to construct a training wall, assess what is the kind of sand you have, nature of sand, quality of sand plus even inside the estuary you can go into the estuary because deepening of the estuary is always good. Assess the quantity of sand or if you cannot remove the sand you need to go into the offshore, but make sure the environmental impact when you by dredging sand you should not create some problems for the environment and then one of the solution may be having a a pair of training wall and now reat replace this training wall with two geotubes.

Geotube is nothing but a tube, but it needs sand. So, that sand anyway you have to dredge this, dredge and normally you throw it in the offshore. So, you dredge this, fill the tube and these are the areas where this can be adopted or if you consider a port for example, when you have a port and if you have the sediment transport taking place like this. You know that the sand will form here and if you allow the sand to go then it will bypass and maybe it settles in their approach channel, this is the usual problem. So, in that case on the down drift side you may have erosion taking place and this area needs to be protected. This is a straight forward location where you can think of using geotube.

Again you need to consider the distance, but still it may be worth because getting the sand from somewhere else is going to be very difficult. Now, in this case I am talking about a a port. Then what will happen you can transfer this sand to this side and have your geotubes installed. So, so this source of sand is one big question to be clarified 100 percent before you get started with such kind of projects. Then you have geocontainers which will again be sausages, all these things look like sausages. So, this can be dumped offshore geocontainers and I will come back to geocontainers with the help of one of the project that has been executed later.

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So, this is a typical picture of a geobag being lifted after it has been filled with sand. The geobags can be of different sizes. See after all the geobags are made of geotextile. So, it is a sheet. So, you can build your own bags according to you own sizes. So, the concept of using these geobags came from the simple, a simple something like thumb rule you know. So, in the case of a flood what is the immediate solution they think of, you would have heard so in the case of flood what will they do?

They will dump sand bags. Sand bags are dumped as a first a protection. So, that will give some amount of relief, because it will retain the earth from further collapse and it will reduce the, it will act as a barrier for the flow of the water and that is where from sand bags only all these things have come up.

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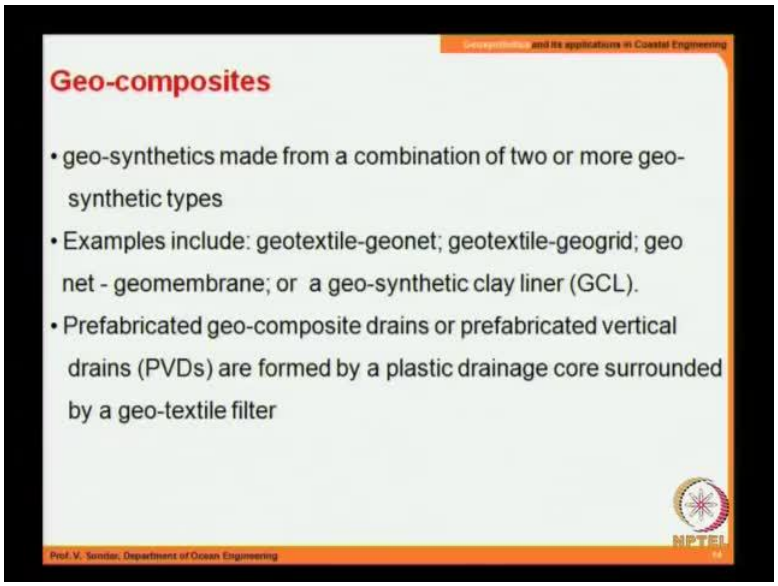

So, geocomposites I have already explained is a combination of number of geo synthetic products as I mean the geosynthetic textile, geotextile or geonet etcetera I have I have explained here the different kinds of materials, products that can be combined together to form as geo composites. So, you can also have a kind of plastic drainage core and surrounded by geotextile filter. So, you have a pipe. So, the application of geotextile is rapid over the pipe. So, that it offers an additional protection for the pipe.

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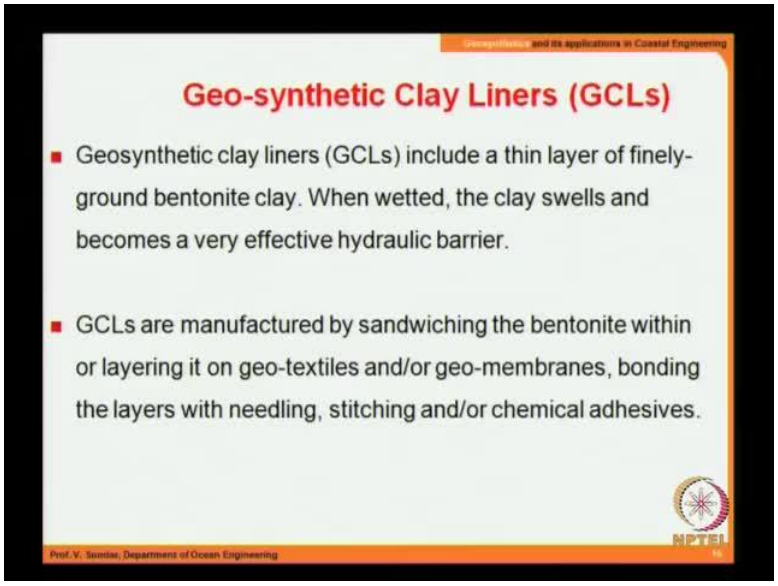

I will further continue with the geosynthetic clay, clay liner. This include a thin layer of finely grounded bentonite clay, when when you wet, when it is exposed to wetness, the clay swells and becomes very effective hydraulic barrier. So, the clay liner will just stand like this. They are manufactured by sandwiching the bentonite within or layering it on geotextiles either with geotextiles when combination with geomembranes or separately with geomembranes or bonding the layers by needling, stitching or chemical adhesives.

So, only thing is make sure that you have the bonding taking place within the different kinds of material that products which we are, which are available like products means geotextiles or geomembranes etcetera. So, geosynthetic layers as we see here are very effective hydraulic barrier and it has been widely adopted in dam engineering or river engineering etcetera.

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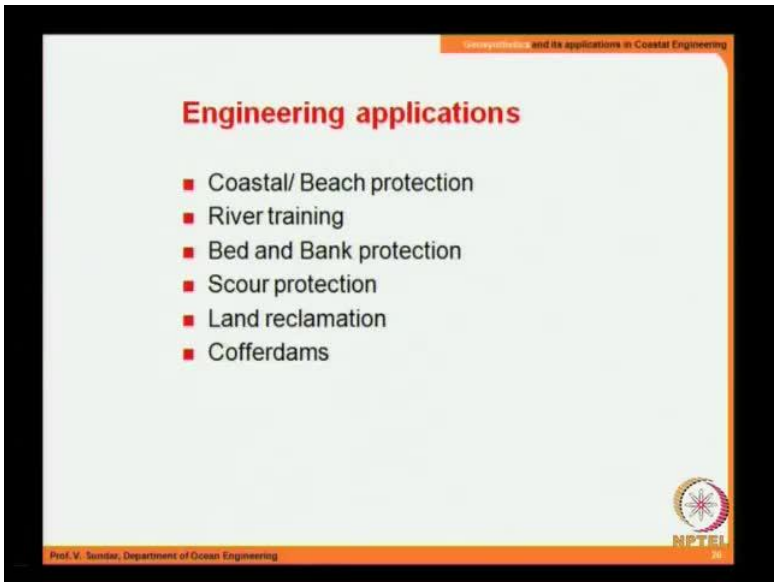

So, now coming to engineering applications as I have been telling now and then about its applications while going through the introduction itself, you see that broadly it can be adopted in the fields listed here, coastal and beach protection, river training I already gave you a small example, bed or and and or bank protection, scour protection that is very important, land reclamation that is a major major field of engineering particularly in islands, then finally, cofferdams. So, these are all the engineering applications wherein you have the application of the geosynthetic products.

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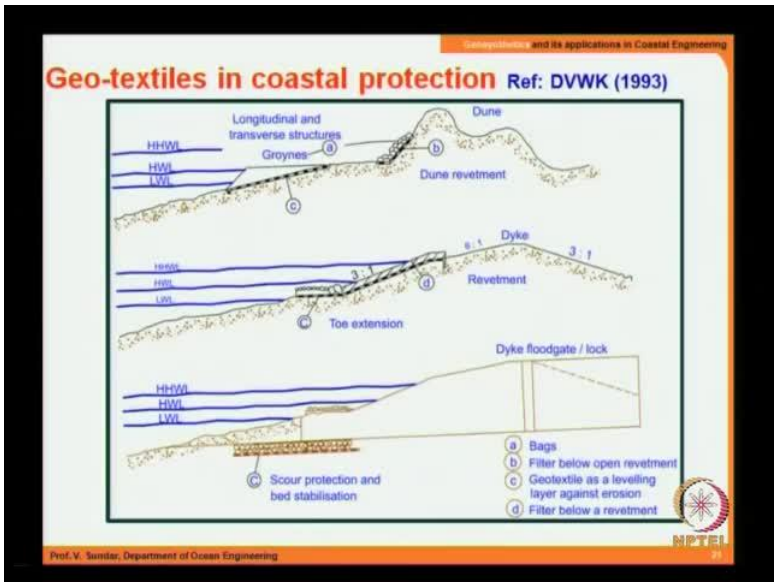

Geosynthetic, geotextiles in coastal protection. Look at suppose we have a a dune, this is the dune. What are the products used where that is what is illustrated in this picture. So, these are all the different levels which are of course, important when you are talking in terms of coastal protection. So, you see that if in case you are thinking of groynes or sea wall so you can adopt bags or geotextile against as geotextile as a leveling layer against erosion here. So, you can have geobags either for groynes or for this for the protection of the coast when you talk about the revetment, underneath the revetment in between the sand and the stones you use the filter.

So, this is the filter below the open revetment can be a geosynthetic products like the geotextile. Then here sea is for use of geotextile to level the surface, not only to level the surface to also prevent escape of sand. If you do not have that geosynthetic material geotextile then you can also experience some unevenness also. So, this compensate for the unevenness once it is laid and another thing I would like to point out here is when the geosynthetic products is completely submerged in the water you do not have much of any problems. Later you will see the problem if it is exposed to sunlight for on a continuous basis.

So, again you see here in the case of normal revetment, this is in the case of a dune revetment; this is normal revetment again in the case of a dyke. This is sand dune and this is normal dyke. So, in a dyke you see that you have filter below the revetment and you

also have the toe protection wherein the geotextiles can be used and in fact you do, if you experience or if you anticipate sub some amount of overtopping they also think of having a a geotextile running all over because in the event of flooding if this is having a geotextile beneath this that will protect to some extent.

Otherwise the sand over it will get washed off as I have said earlier. So, herein you see that scour protection is taking place, you can either use the geotextile and you are in fact there is one more addition to this which is not taken into account. One thing is here you see the scour taking place, here either you can have a geotextile over which we can have gabions. Gabions is also coming under geosynthetic products because gabion I have already explained to you. These are all something like nets, you have something like cubes. So, you put smaller size stones and make it as a flexible stone.

So, the, this is in areas where you do not have big size rocks. So, this is preferred. So, herein for this also you can think of having gabions for the sea wall, for all, for all this may be for the groynes also you can think of having gabions. So, you see that this picture explains to you to certain extent the application of geosynthetic textiles, a geosynthetic geotextiles in a broader sense when I say geosynthe geotextile that means that includes the geotube and geobags because the material used is nothing but the geotextile.

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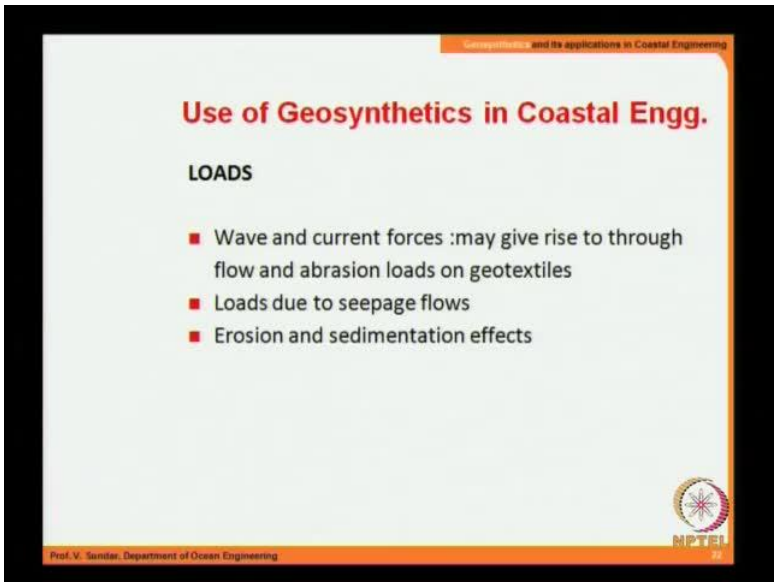

Use of geosynthetics. What it should reduce or withstand waves, loads that are coming are waves and current forces may give rise to through flow and abrasion loads on geotextiles

for which it has to be designed for. Loads due to seepage flow, seepage and erosion are interrelated. So, erosion and sedimentation effects all this things have to be considered when you are planning for geosynthetics in the field of coast.

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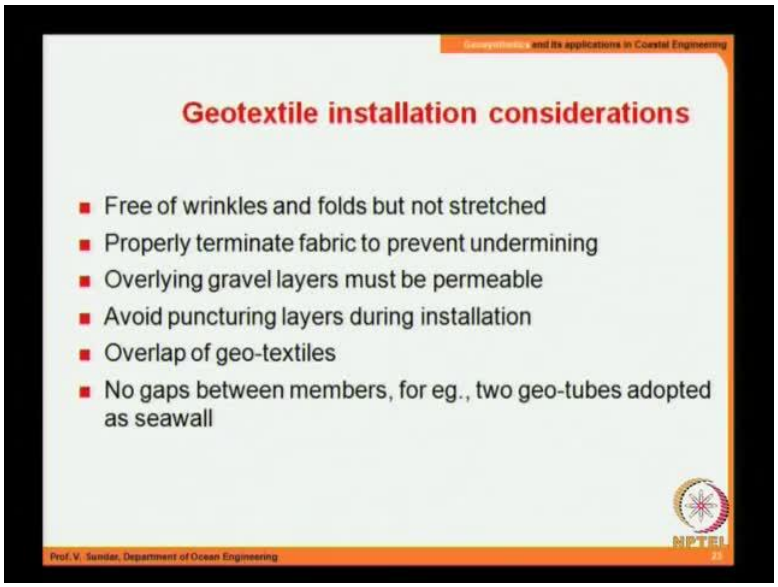

This is very important assume that you have finalized your geosyn geosynthetic geo textile. You have fulfilled all the requirements as far as specification is concerned and you have been provided the best possible geotextile by the manufacturer, but still there are after having completed that part of the work it does not stop. It needs periodical inspection during the construction. It should be the geotextile should be free from wrinkles and folds, but free from, but not stretched. So, it is nothing but you keep a material under some folding condition after sometime what happens?

After sometimes it gets brittle and then it can even tear off. So, it should be clear without any wrinkle and there should not be any folds. Properly terminated so when you have the geotextile it should be only like this, it should be placed on the sand so it is not, it is no joke. So, you have a beach where you can have a lot of unevenness, but still you have to make sure that the sheet is straight like this and along the, along this direction also it has to be wrinkle free. Properly terminate fabric prevent undermining.

So, this is a big very important thing when you are taking the because only for a certain stretch of the course you may be planning, at the ends it has to be properly anchored. Not only at the ends over the slope also, over the top slow top and this is the for example, so it

has to be properly anchored here. So, usually you will have you will have a toe, it should not be left like this. It is preferably to take the geotextile further down and anchor it properly. The other way of doing it is sometimes it is also taken like this and again on the land side it has to be properly anchored, overlying gravel layers must be permeable, this is clear. Avoid puncturing this is very common during installation of geotextiles.

So, which means before you lay the geotextile a kind of a ground preparation is needed. You should make sure that not, there are not many short corners etcetera so otherwise it will puncture. Once it punctures it is almost like not having the geotextile there. Overlapping of geotextiles, so the width of the geotextile may be like this, this much may be 30 meters or 20 meters and you are going to protect a coast of length about 1 kilometer. So, you cannot get a roll with 1 kilometer length right. So, the width may be of of 20 meters.

So, the next piece will come this is one piece and you have another piece. This is your overlapping. This is a vulnerable location where in enough care should be taken care. So, the over lapping should be carefully decided. So, a minimum of 1 meter, at least half a meter is very essential. No gaps between members for example, geo tubes. Later you will see that geo tubes can be used as sea wall also. I will not go into this sea wall aspect. Now, again let us get back to the training wall, I want to have a a training wall with geo tube and when I calculate the length, the length comes to say 100 meters and you have only about 30 meters length geo tube.

So, you install one geo tube here and then the geo tube is something like this so this is the joint geo these two are budding against each other, but there is a weak point here. If this is not taken care of you can have excessive flow here because this area is very small, the velocities can be higher and then this can give way for the entire structure. So, this is more vulnerable in the case of just you look at the slope. I have two geo tubes so geo tube I will tell you what is meant by geo tube again. So, you assume that there are two geo tubes and this is joint and here they are budding against each other and this of course, I am talking over a slope and then the wave is coming.

During a extreme event what happens the wave will go over the slope and during the down rush the velocity will be very high. So, this will create a cavity here, settlement then collapse of the geo tube. So, this is very, very important when you are planning using these

geo textiles and so that has to be done when you are, that has to be taken care when the installation is in progress.

So, this essentially needs a continuous and dedicated supervision and of course, skilled labor and the required machinery is very, very important because see in spite of all this what we are going to get is eco friendly protection measures because we are not getting, we are now getting rid of the stones which are li which are something like eyesore, but when you want to achieve this kind of a eco friendly the preparation takes more time which needs more dedication. So, if that is done then the application of geo synthetics as you have seen is quiet good. This video clip shows the installation of geo bags.

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See, now we will move on to coastal engineering. So, the different kinds of measures or structures wherein you apply the geo synthetic products are one is in terms of groins, then for coastal protection or sand dune protection, revetments, offshore breakwaters, artificial reefs, shoreline structures, sea walls, dykes, bank protection in the case of rivers, also cliff protection. So, you see there are a number of loc number of fields wherein the geo synthetic products can be adopted. The mostly wide widely adopted is geo textile tubes or it is called as geo tubes.

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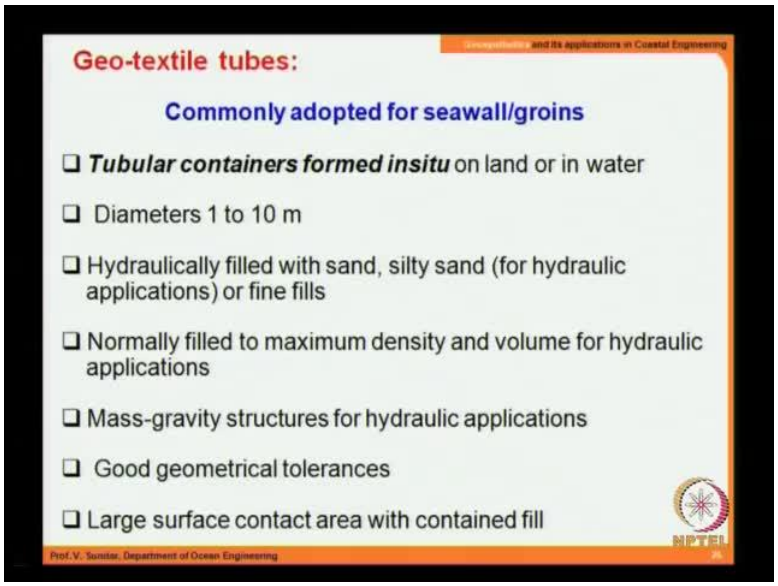

As I said earlier I have already introduced you to a geo tube. These are tubular containers formed insitu on land or in water, both are possible. The diameters can vary from 1 to 10 meters. 10 meters is not that common, maybe diameters 1 to 3 meters are more common hydraulically filled with sand, silty sand for hydraulic pur, applications or fine fills. So, as I said earlier you have a tube, you fill with both sand and water, the water comes out and the sand occupies the tube and then it takes the shape of a sausage, normally filled to maximum density and volume of volume for hydraulic applications.

Mass gravity structures for hydraulic applications, good geo metrical tolerances although you say that it is a circular tube after filling the whole thing and then place it on the insitu then you will see that it becomes a kind of a sausage it will look like a kind of a ellipse. Large surface contact area with contained fill, some of these aspects we will have a look at.

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The basic features of in adopting a geo tube. This is the geo tube the length maybe as I said up to about may be 10 meters, 20 meters or 30 meters. So, you keep filling. You may have 2 or 3 holes also, pumping points wherein you pump the sand and then slowly the tube gets elongated and after sometime once you have done it full extent, it will form as as I said a solid unit and hence it can be retained. So, here you see a geo tube being filled in presence of water.

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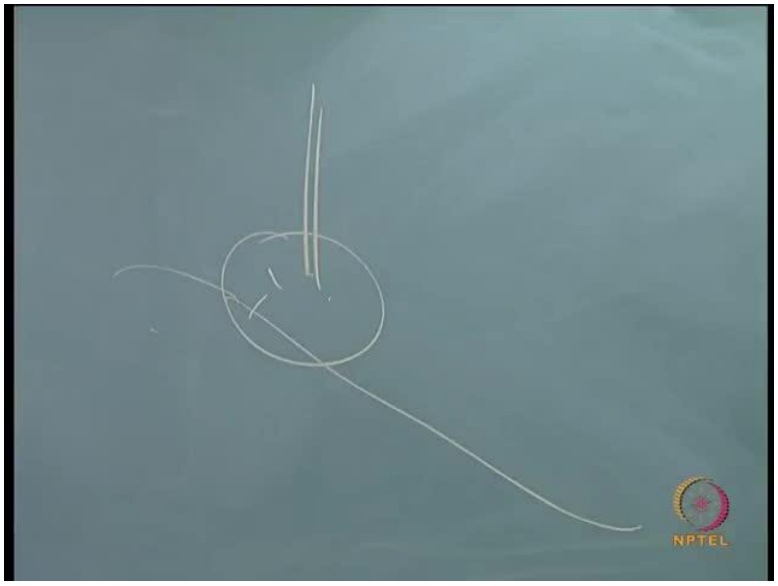

The same geo tube can be placed over land and filled for example, along a beach which is getting eroded somewhere here you can have the geo tube and then supply the sand and mixed water into this so this elongates. So, here you see that this is being this process is being done inside the ocean or in the lake. So, at least you have the water. You normally have a geo tube when you have in marine environment that is near the sea bed.

All of us know that when you have a geo material, geo tube or any any kind of obstruction the contact between the obstruction and the sea floor is vulnerable for scour. See in order to avoid the scour you need to spread the geo textile on either side and also properly anchor it, so that it acts as a a toe. So, this is inside where the sand is been prepared and then it is send to for send for filling up of the…

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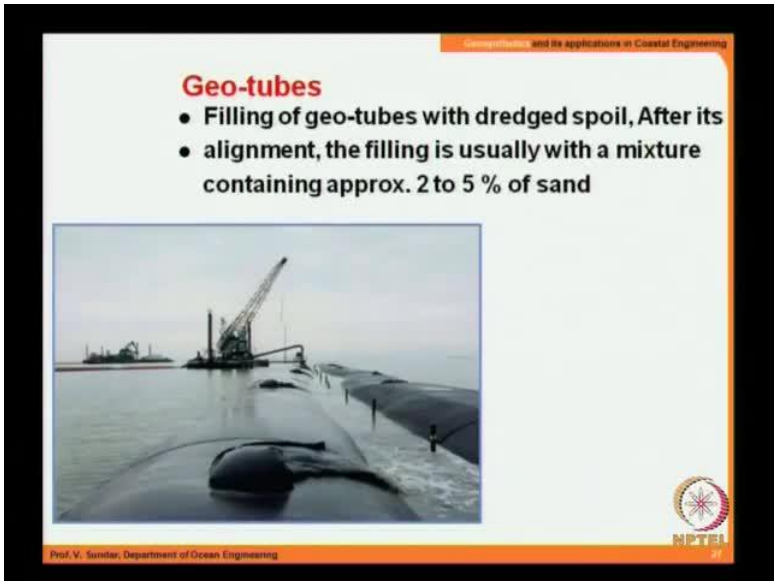

So, filling of geo tubes with dredge spoil. After its alignment the filling is usually with a mixture containing approximately 2 to 5 percent of sand. So, the water will come out as I said earlier. I also mentioned that we call it as a tube it is circular, but after filling you look at the shape it takes. So, it takes something like the shape of an ellipse and you can now this looks like a solid obstruction for any and it can resist forces due to waves or currents.

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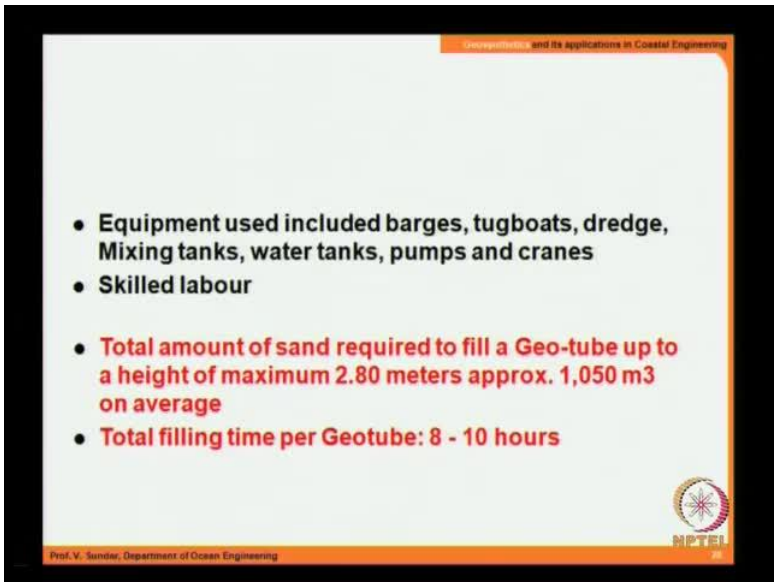

Equipment used include barges, tugboats, dredges, mixing tanks in fact settling tanks also sometimes they we need, water tanks, pumps and cranes, more important is skilled labour. Many projects fail because of non available of availability of skilled labours. Total amount of sand required to fill a geo tube up to a height of 2.8 meters is estimated to be approximately 1000 meter cube on an average. Total filling time of a geo tube is 8 to 10 hours, these are only qualitative so it depends on say, it depends on so many other factors etcetera.

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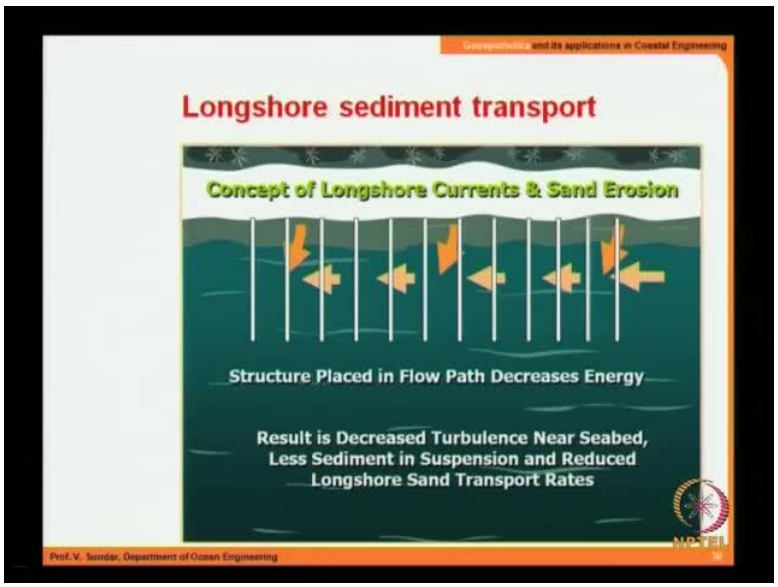

Application of geo tubes, as we have seen in the basic course on the phenomena of long shore sediment transport and long shore currents structure placed in the flow path decreases the energy as we have already seen. Result is decreased turbulence near the sea bed, less sediment in suspension and reduced long shore sand transport. Due to all these features you can have the groins at regular intervals not regular intervals at intervals and number of groins getting into the ocean is referred to as a groyne field.

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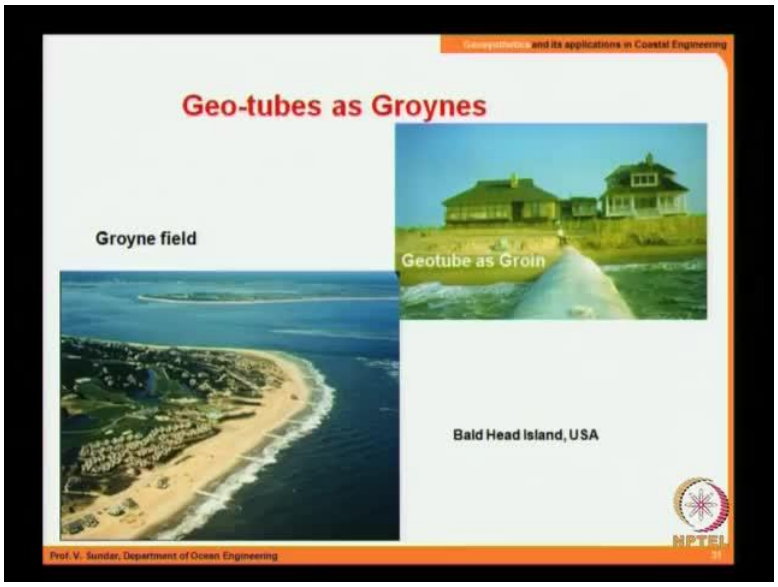

Now, when we have something like this instead of you usually you have seen the groins made of is usually a core layer.

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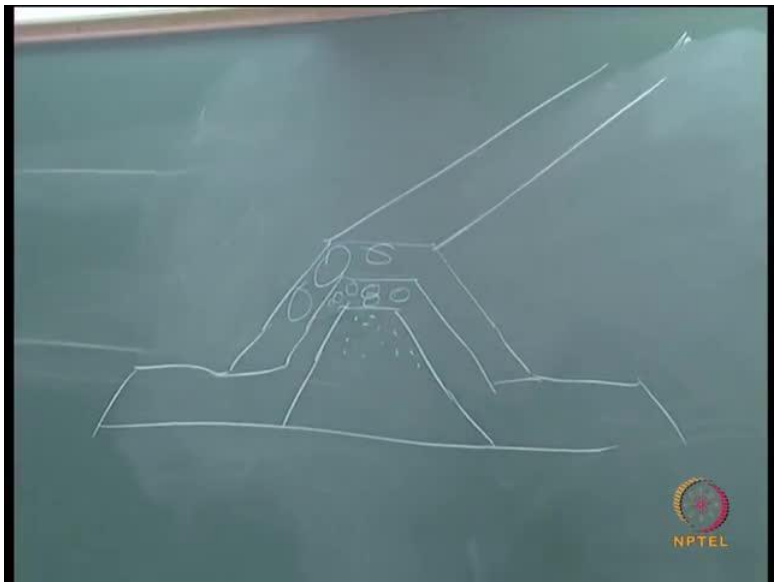

Sometimes you have a, this is the primary layer, this is the secondary later and then you have the core layer. Something like this you will have and this is going to run normal to the shore. So, this is of course, you need to keep on maintaining on a regular basis because the stones can get dislodged so you need to replenish this at regular intervals. Now, this looks like an eyesore. It is not so good aesthetically it is not good. So, aesthetically what you see on the board, on the screen looks more appealing, structurally it is performing the function of that of a groin.

After all for groin what you need you need only a obstruction and that obstruction which is achieved by having a a geo tube. So, this is somewhere in a US where they have protected the groin, protected the coast using a geo tube. Is that clear?

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So, you can also use geo bags instead of geo tube for construction of groins. So, only thing is enough care should be taken to make sure that the stability of the geo bags is ensured. In picture it looks very nice, in reality if you have a extreme storm you know that a single bag can look like a pebble for the mighty waves. So, there should be some kind of interlocking connections etcetera to be established or sometimes it this will be used as core of the, that is inside the, I just now said.

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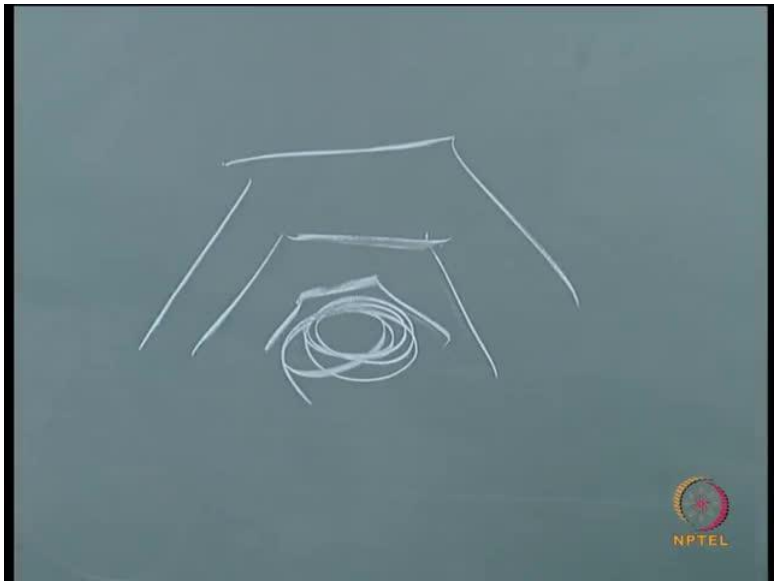

You have the core. So, for this you can use the geo bags that is you save so much of material by using this geo bags. Here in issuing for application for revetments.

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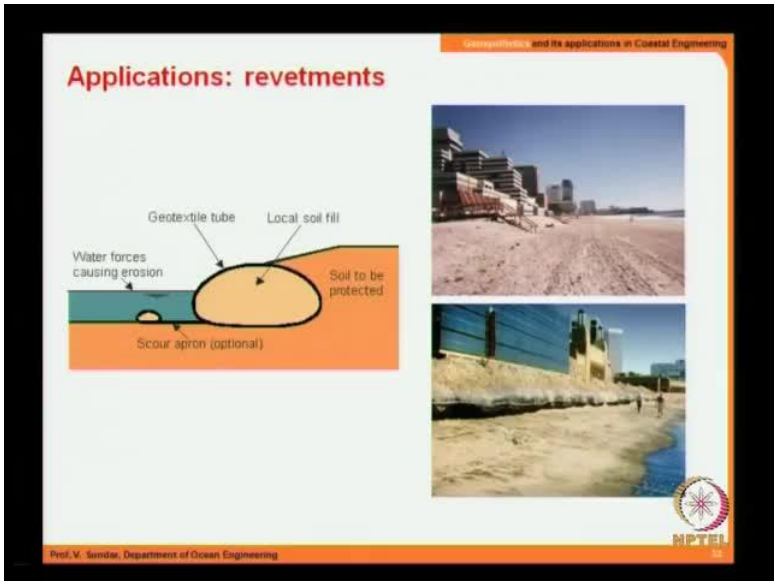

So, look at the revetments now. So, this is the geo tube you see here and this is what in picture it shows, this is local soil fill, it is standing there it has been installed and now you also have an aprin apron which is very important and the apron is anchored by scour protection. So, this will make sure that you do not have the loss of sand taking place because this is going to act as a filter medium. So, hence because of this process you see the kind of protection measure you have here.

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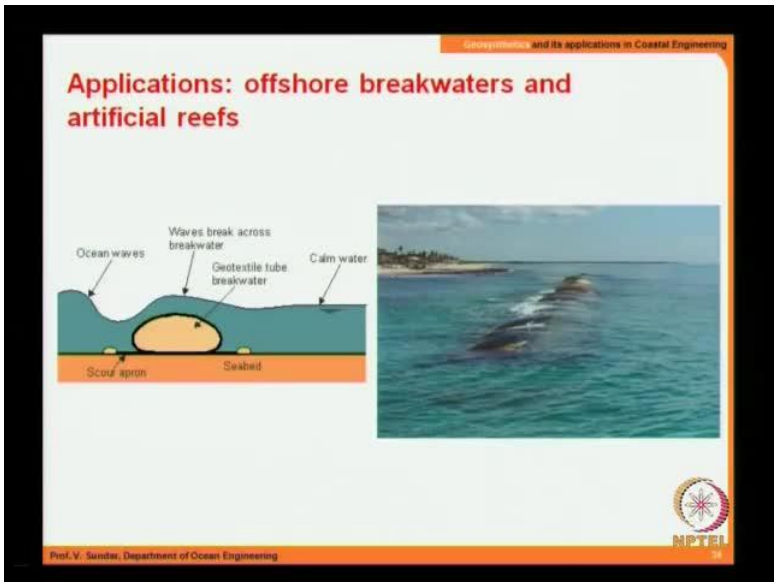

So, artificial reefs or offshore break waters. Offshore break waters we have already seen, offshore detached break waters can serve as coastal protection measure. That is one application, then artificial reefs. What is meant by artificial reefs? This artificial reefs can be submerged at a distance certain distance from the shore line. So, these artificial reefs will enhance pre mature breaking thereby you can have a a beach in front of in between the shore line and the artificial reef.

Sometimes this orientation of the artificial reefs can be adjusted in such a way you have focusing breaking waves in between them and the shore line. So, thus enhancing the surfing and other I mean other kinds of activities, recreation activities near the beach. So, it finds an application in the case of tourism also the geo synthetic tube.

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For protecting an existing development or a structure there may be an existing structure, may be a monument which needs to be protected at any cost. So, remember when I took the coastal protection measure earlier under one of the case study I showed you the protecting of Mahabalipuram temple.

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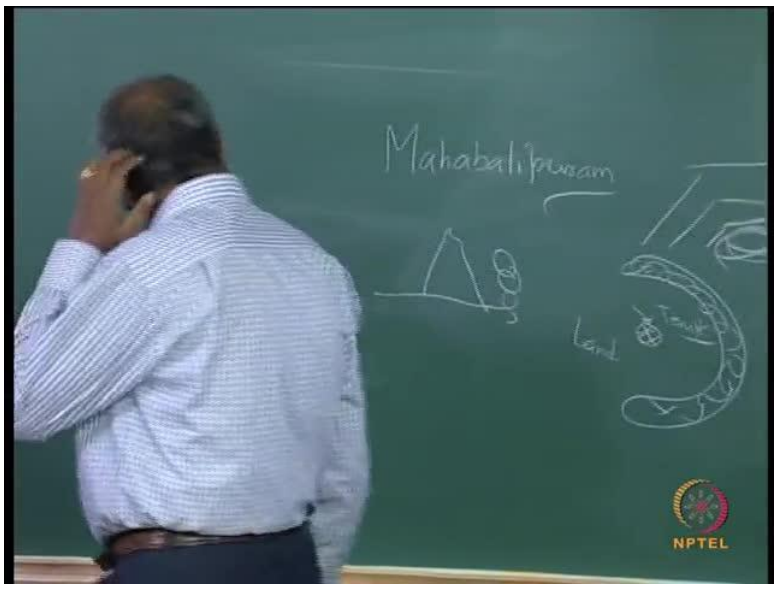

So, where in the temple was here around the shore and it need to be protected. So, it was protected by stones that is this is in section and in plant if this is the temple and all around the stones were dumped and this is the ocean. So, this is the temple. So, what happened in

this case, this has become kind of an, it is not so aesthetic and its looks like a very massive structure when it is being used for protecting a single temple. Whereas if you think of a geo textile probably if all other conditions being satisfied, this could serve as a better proposition. I said if all other conditions been satisfied so we need to explore the possibilities for such kind of protecting such kind of structures.

Now, you see that again in this case as we have seen the two protection measures. These are all small geo tubes can be standing there over the apron as anchor as well as protecting the coast, protecting the main geo tube. So, here again the same thing, here it is completely submerged and now this will be protected. So, here in this case this looks this is emerging type, but you can also have a submerged type. If you have a submerged type then what will happen?

So, the structure is here. So, I am having a submerged reef may be 2, 2 or 3 geo tubes may be 2 geo tubes then what will happen? The wave will break here and the sand will deposit here. So, this may be a much better proposition compared to that kind of a situation because here in the geo synthetic geo tube is completely submerged in water. Later you will see that UV ultra violet rays is one biggest problem in dealing with geo synthetic materials. For a tropical, for topical countries when you have something like submerged totally submerged then it may not have a much of a problem compared to if this is exposed then you will have problems.

But in this case what has been done is after having the geo tube the whole thing is filled with sand, but when you have the sand this again sometimes becomes a problem because there can be erosion of the sand itself. So, when you see there are situations where by trying to protect one structure you built another structure and ultimately both the structures will be lost. So, you need to be very careful in finalizing the design. So, herein you see a geo tube, a geo tube is here.

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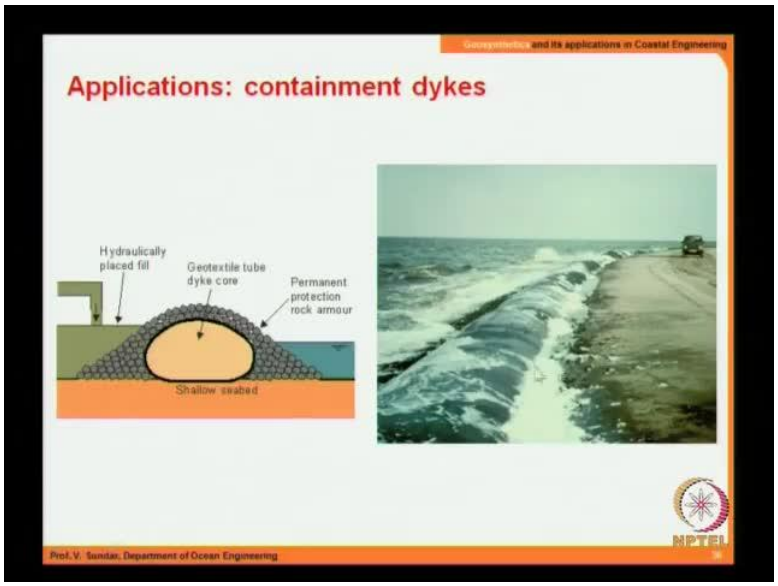

This is the coast and this is serving as a kind of a sea wall and you have here, it can be containment dy dykes wherein you can have the geo textile tube as the core and then over it you have to, you can have the stones. This is only for saving the material, but then from aesthetic point of view you are not really solving that problem because still it is going to be stones when you go in for this kind of a a design.

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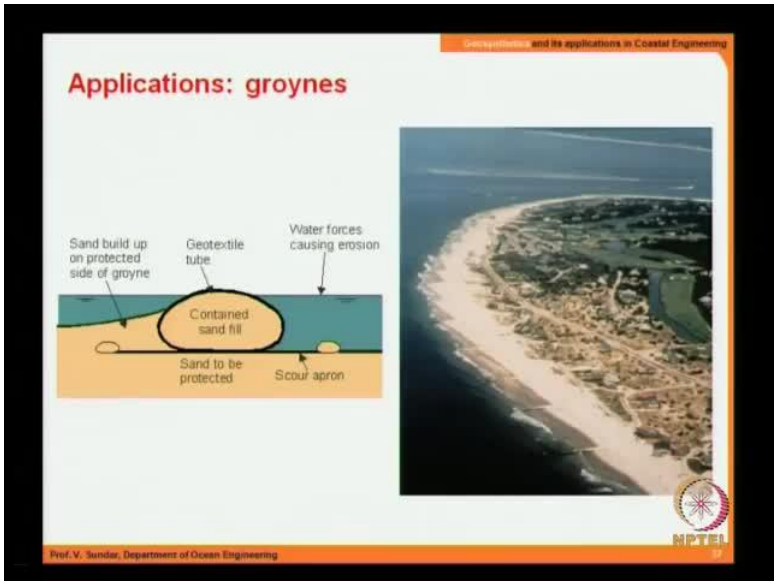

So, again this is for the groins. The details how the groins should be there, it should have the most important thing is this is most important thing. Apart from this, this has to be taken care.

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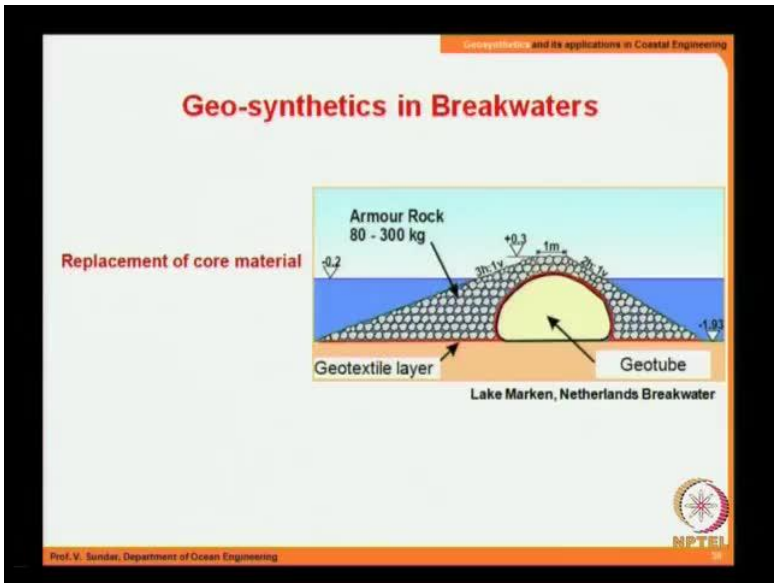

The same thing what I have shown you earlier, when you are dealing with this kind of a geo tube with stone on top make sure that you have run make sure that you run a geotextile over this. So, you see that red color that is the geo textile layer.

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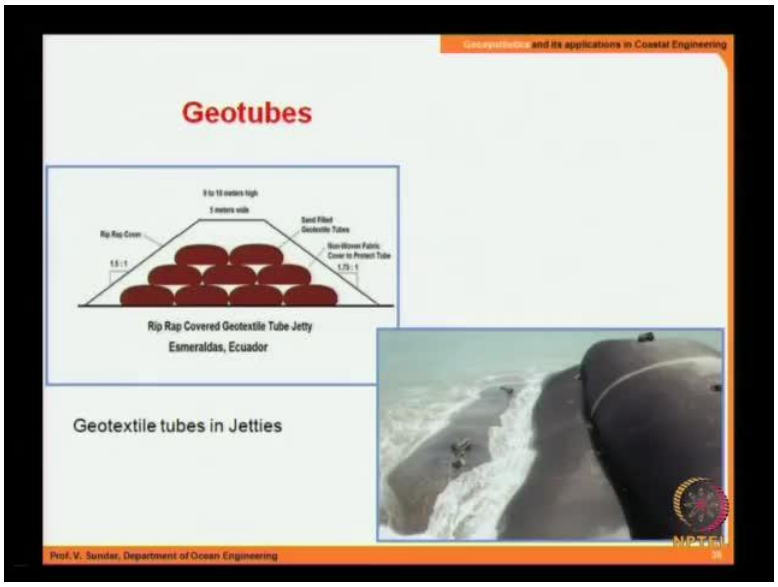

A number of geo tubes or number of geo tubes can be formed as a huge case as you can see here. This has, this was the concept that was adopted in Ecuador. So, geotubes being used as jetties.

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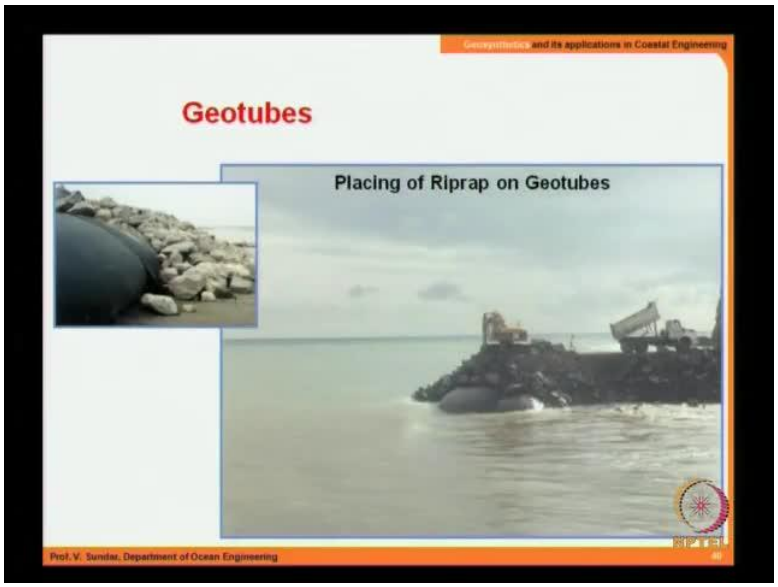

So, this is, this figure shows how the geo tube is placed and then in order to protect the geo tubes then you have a, you have the stones, dumping of stones is in progress in both the, in the, in this picture.

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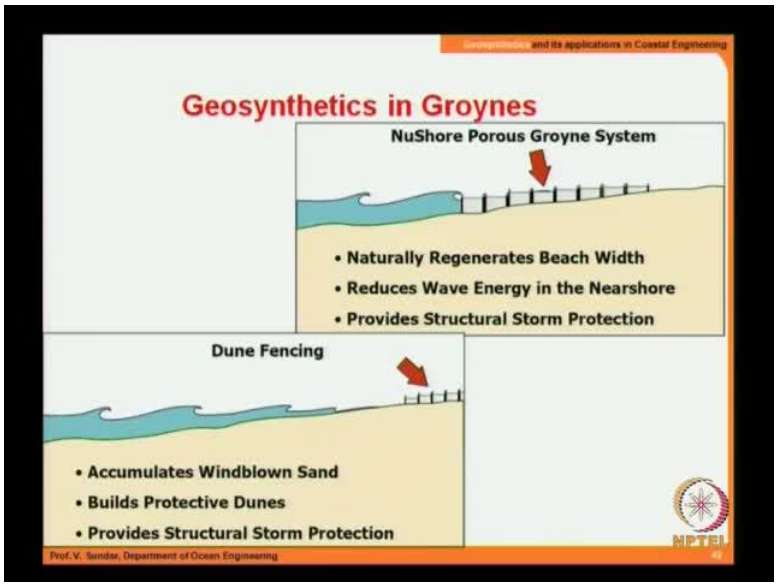

Syn geo synthetics in groynes. So, naturally regenerates, this is the top one is porous groyne system and the down one is the dune fencing. When you have large dunes it can be windblown, the dunes disappear in process. So, for that if you have something like groynes as shown above, look at the way the waves are coming and these are some kind of jetting into like this. So, naturally regenerates beach width, reduces the wave energy in the near shore, produces structural storm protection. Accumulates in the case of din dune fencing accumulates windblown sand, builds protective dunes, provides structural storm protection.

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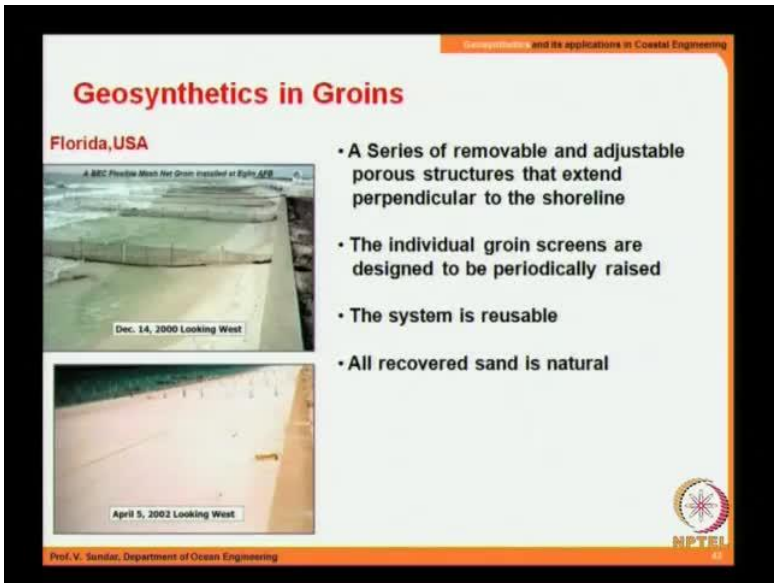

So, this is how it looks. See, a series of groins, geo synthetic groins, series of removable and adjustable porous structures that extend perpendicular to the shoreline. The pictures are clear, the individual groin screens are designed to be periodically raised, system is quiet reusable, all recovered sand is natural. So, these are all the concepts available, this is not been tried in India, nowhere it has been tried, but concepts do exist and it is left to us to consider them and these are all net groins that has been used in Florida.

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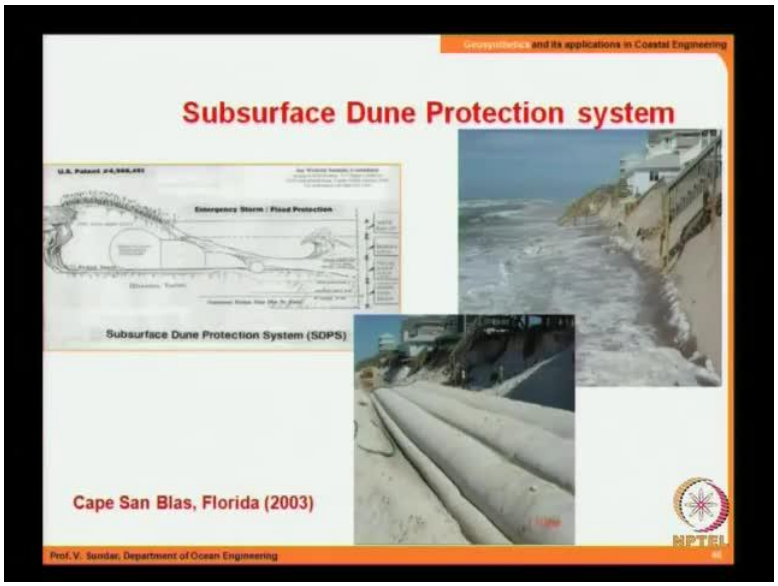

Then these are all subsurface dune protection. So, you look at the geo tubes here. You can just go into the Google and then try to look into look into the details, all the complete details are available. So, here you see that a number of geo tubes are formed in order to have a a protection like this. So, what could be planned also is have geo tubes as you have seen.

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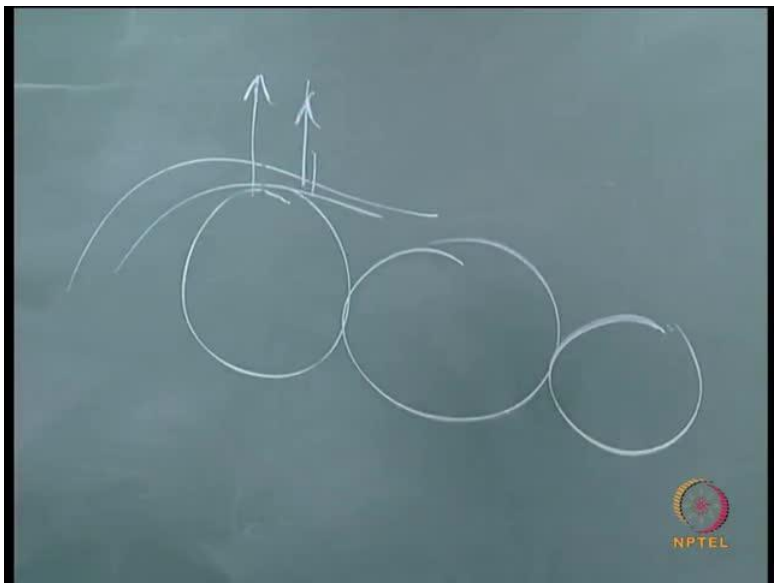

And also run a geo mat and geo mat will help in flourishing the plants as I have said earlier. So, this yet another picture, sand dune protection.

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Yet another picture on the application of geo tubes, look at this how the whole thing has been protected. After having the geo tube then you can have greenery over it, it is possible to have that.

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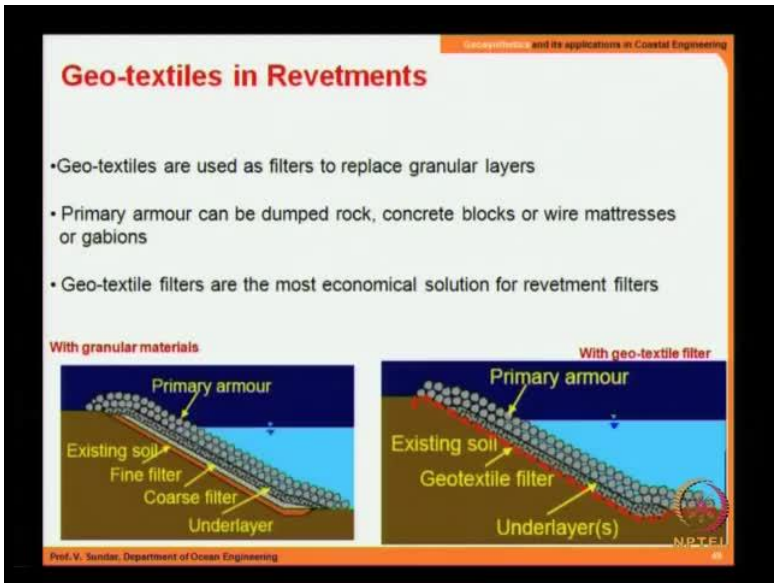

So, let us move into geo textiles, application of geo textiles in revetment. These are used as filters to replace granular layers, primary armour can be dumped, can be dumped rock or concrete blocks or wire, wire mattress or gabions. So, this is how it looks like. You have the geo textile running through the red color, over it we have the under layer or the filter

layers etcetera and then the primary layer. Make sure that the textile is anchored properly at both ends, at the crust elevation and near the toe.

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As I said earlier preparation of geo textile is extremely important, wrinkle free and over lapping. So, once this is done so you see here woven geo textile is used in this case. So, once it is laid and checked properly then they start putting in the filter layer.

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So, geosynthetics in dykes. Dykes can be of for flood protection, containment, spur dikes, under water dikes, dike breach repair etcetera. In all these cases you can use geo synthetics.

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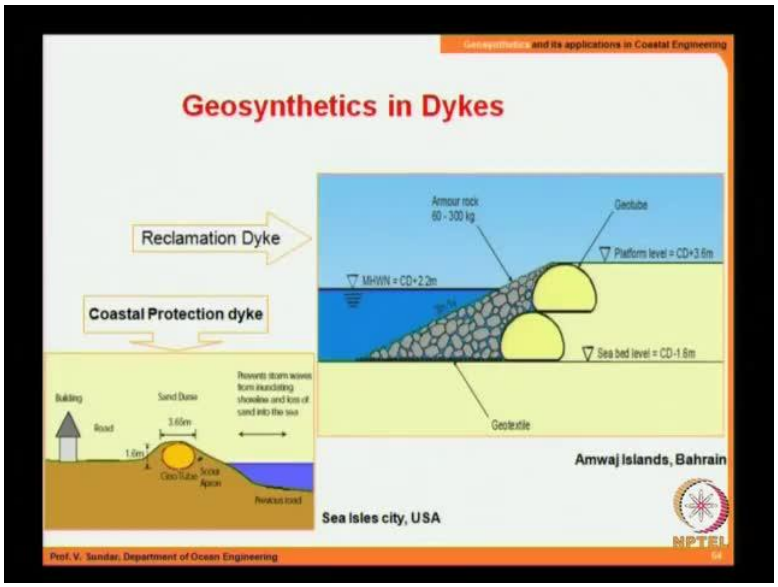

For example, here are some of the examples. This is somewhere in Bahrain where they have used the geo tube here to retain this earth, at the same time resist the action from the water side, yet another condition of coastal protection here. So, this a dyke wherein you have a geo tube, the elevation of the dyke has gone up because of this and you see that this is going to protect the land site. This is going to protect the land site and the elevation can be appropriately fixed. So, inundation is avoided by this kind of a concept. Now, we move on to geo bags as well as I am trying to combine all these things together.

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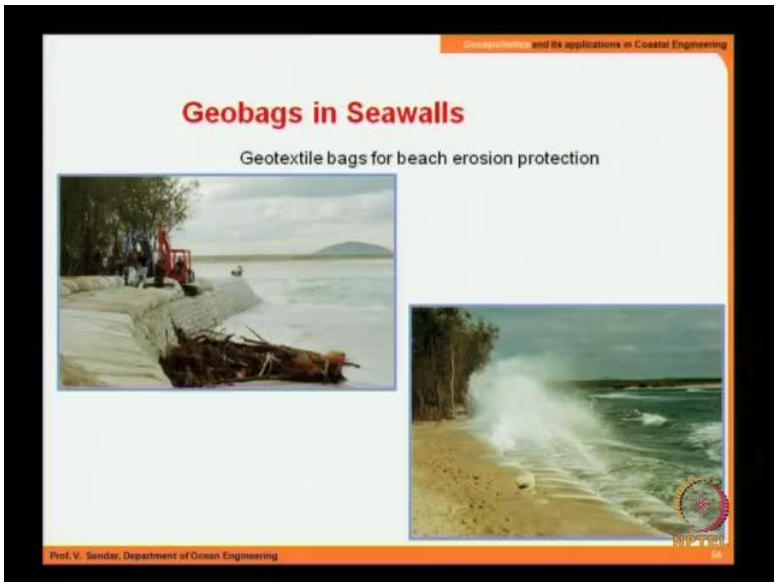

So, here you see that geo textile bags can also perform the function of a geo tube. On the left side you see a number of geo bags, all set and done although it acts as a protection measure experience has shown that it can serve only as a short term solution. Maybe if you are interested in as a, an emergency measure for a short term duration you can go in for the geo bags as coastal protection measure.

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So, this is adopted for the bank protection. So, bank protection is going on. So, you see the geo textiles already laid on the sides. The side has to be prepared, there should not be

much of undulations, if you have too much of undulations then you see that unevenness can lead to, lead to tearing of geo textile over sometime, later and now look at after it has been installed.

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This is island of Sylt where a cliff protection, cliff is protected with geo synthetic materials as you can see. So, the, this is the kind of set back line for these properties that has been thought of. We now move on to some of the projects that has been executed using geo synthetics in India. One is the geo bags that was adopted in Ullal.

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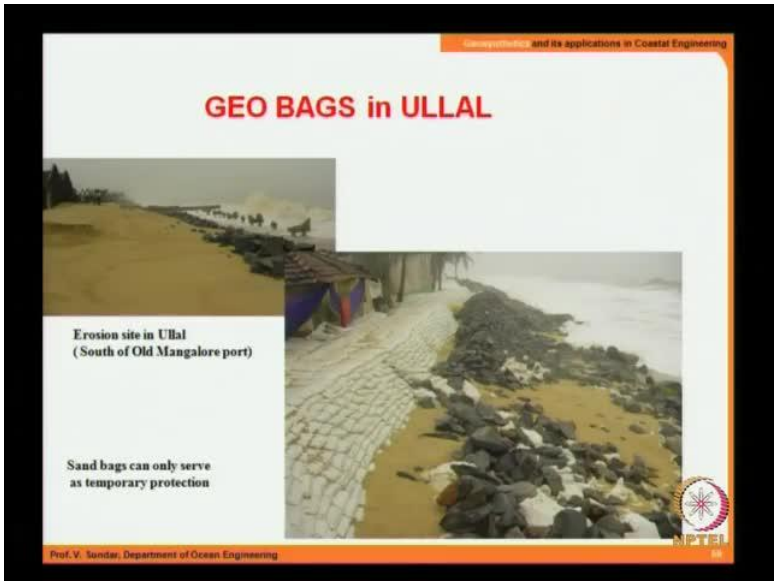

This is in Mangalore, south of old Mangalore port where on the left hand side you see the vanishing of a rubble mound see wall. The rubble mound see wall is completely gone in this case and it is a coastal community and you need to protect the lives as well as the property.

On a war footing they have adopted geo bags, but these geo bags can serve only for a short duration and it has served its purpose and now there are some other measures which are being planned and again it is being discussed about geo synthetic application for protecting this coast. Next, we will look at one of the most interesting projects carried out by C W P R S wherein this concerns beach protection at Tithal.

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The location is indicated in this map and the protection is to be done for Swami Narayana temple.

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The beach protection that is to be done is for this kind of a scenario. So, you can see the kind of erosion that has taken place, the erosion is almost like vertical cuts and this needs to be protected.

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The site conditions are severely affected over a beach length of about 350 meters, the beach slope was measured to be ranging between 1 is to 15 to 1 is to 30, beach material consists of fine silt and fine sane sand, high water line is plus 4.5 meters, low water line is 00, maximum beach width available between high tide and the low tide, high water line

and low water line is 500 meters. The fine availability of the 500 meters is very advantageous, this is one one important aspect which need to be considered when you are planning for a coastal protection measure.

At several locations the distance between the high tide and the low tide line will be only of the order of very few meters, so in which case kind of a sea wall becomes very difficult to be implemented. So, maximum breaking wave height expected us around 2 meters. With these design particulars the design adopted was going in for flexible gabions.

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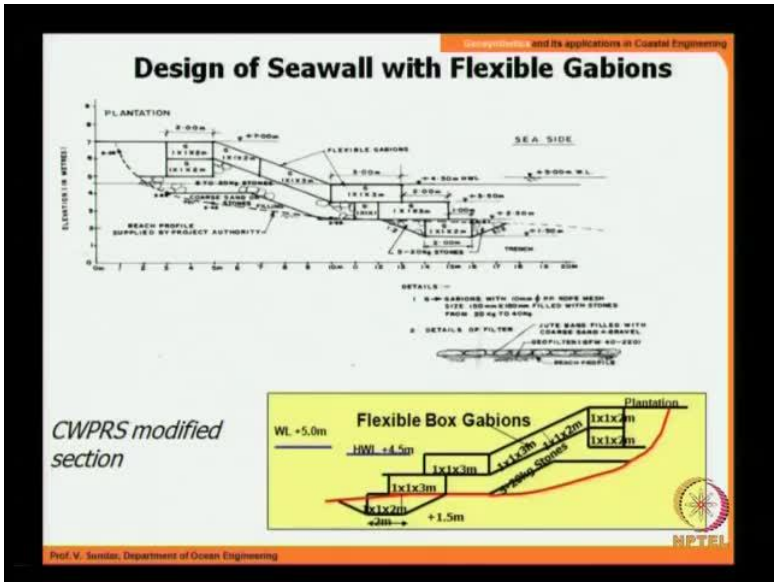

As I said gabions are filled with nets and handled. So, the filling and handling will be only in on site. So, there is the need for handling huge rocks and for its transportation from quarry to the site is avoided thereby so much of loss is avoided. I mean damage to the highway etcetera are avoided and it is also quiet easy handling the flexible gabion boxes. So, this was modified, this was the original design and then it was modified as indicated, this shows the red line shows the profile eroding profile and they modified the cross section and this was the kind of solution.

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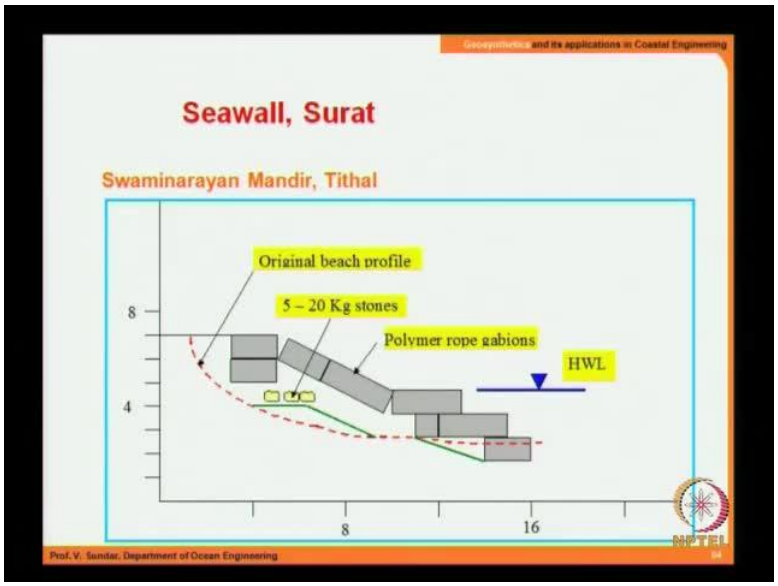

So, they used the polymer rope gabions. The construction is in progress wherein you see those gabions being installed.

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And this is the sea site. So, this is the sea site, the construction has started.

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And now it is still in progress.

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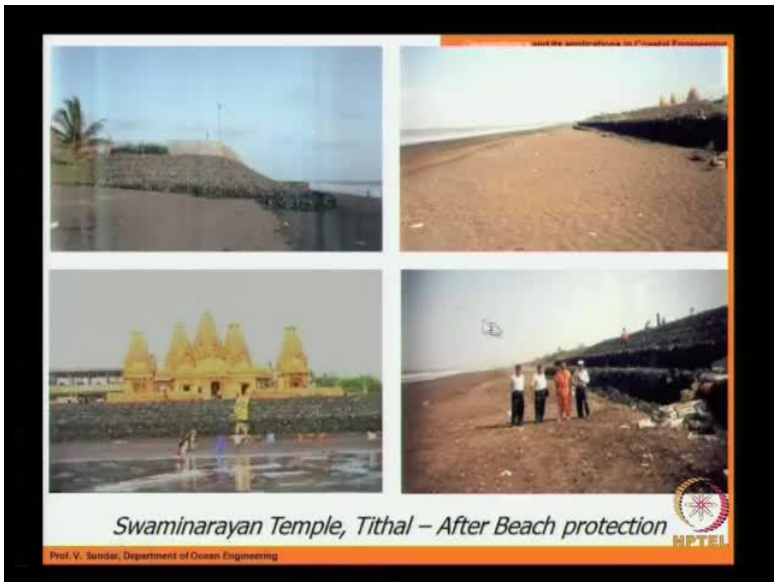

Now, it is part completed now completed after the beach protection.

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Completed sea wall running for about 300 meters.

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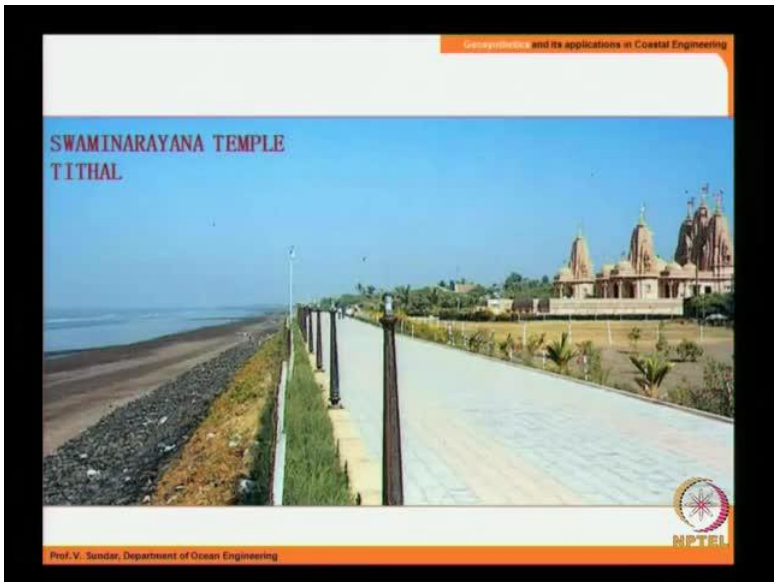

This is, as of now, this is how it looks like.

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This shows a movie of this location the Swami Narayana temple at Tithal being protected by the gabions, it also shows the construction sequences going on and the kind of problems that were faced when the construction was going on even during this kind of a scenario, the construction was in progress. So, is that clear? So, that was only a short clip video clip of the Tithal, then we move on to Gujarat.

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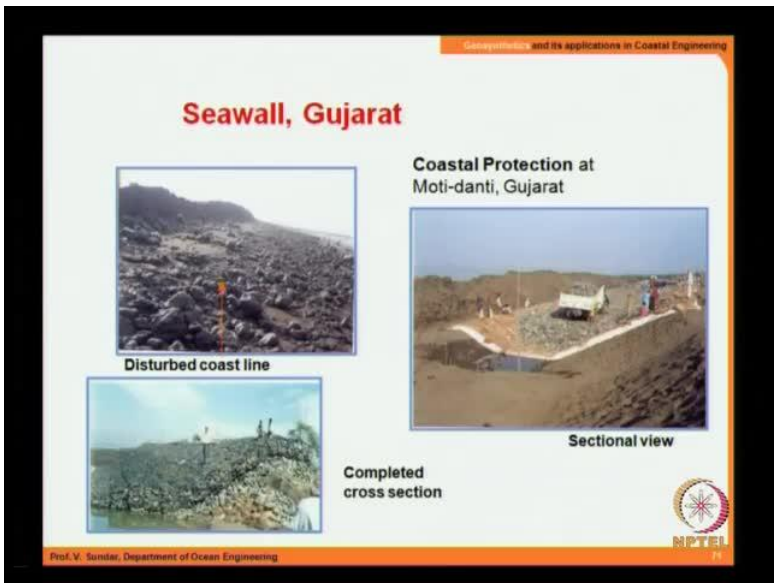

So, this was the disturbed shore line. Now, you see the geo textile. So, this is the sectional view and you have the complete cross section shown here in this part. So, this is perfect and it is understood that it is intact. So, I will stop here.