Coastal Engineering
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Module - 4
Geosynthetics
Lecture - 2
Geosynthetics – II

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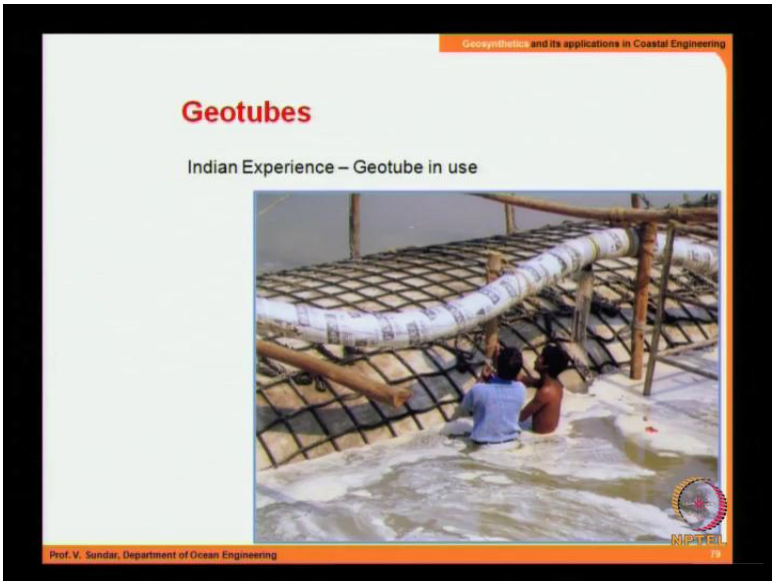

So, now we will continue with the geosynthetics, application of geo-synthetics in the field of coastal engineering. So, here this is one of the major projects carried out in India.

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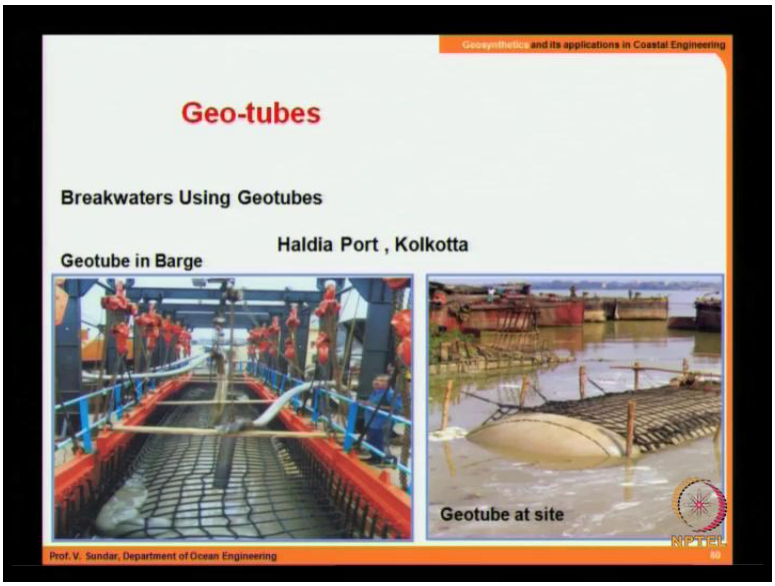

So, it is for, so that is application of a geotube. You see, the geotube is taken in a barge and then geotube is laid at site. This is mainly to protect the caving in of the site, slopes of a approach channel. This is somewhere in Haldia port and this was very successful project so far.

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About close to the same location you have the installation of geo-mattresses. This is particularly helpful or useful in the case of leveling and also making sure, that the soil is being retained from erosion.

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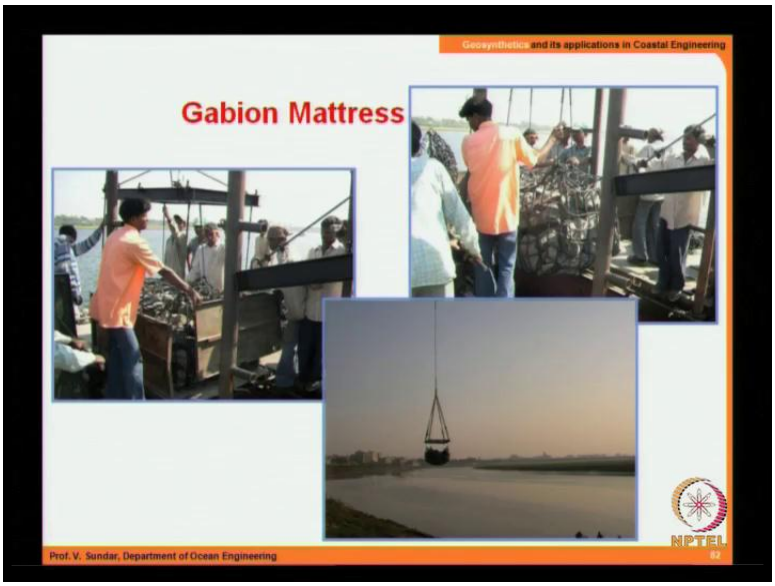

So, again this is the, how the geo-mattress is being laid there in the bottom on and there on the top you have lifting of gabion.

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So, with this we will move on to yet another major project. This is in Dhiga beach, so this is in West Bengal and there was an urgent need for protecting the site.

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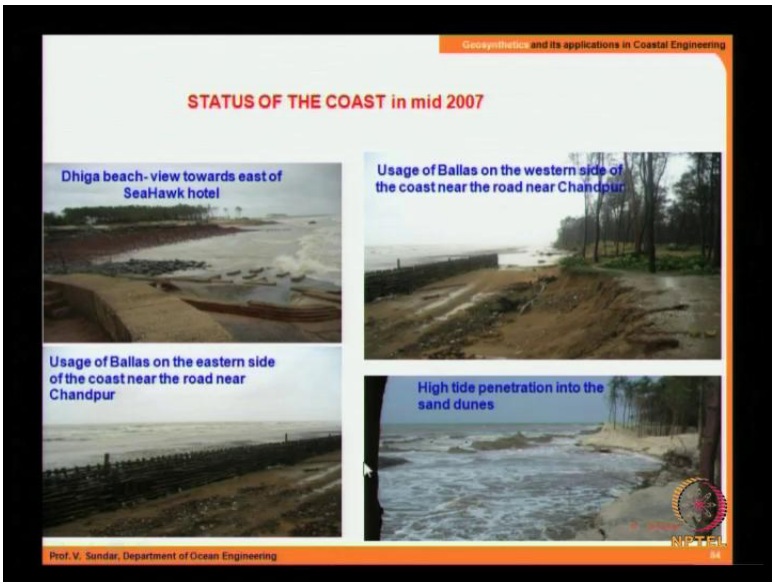

So, this site, so this is in West Bengal and this area is called as Shankarpur, only this location, wherein you have good amount of beach formation. Unfortunately, due to the unprecedented coastal floods during few years back, the entire stretch of the coast was washed away and in fact, the land was also inundated and the people had to run away from the coast leaving all there dwelling unit.

So, this was taken up on a war footing and initially, there are proposals for protecting it with rubble. There are two points, rubble stones were not available in the near vicinity and it has to have it, has to be brought from a long distance. Then second point is, that the local people did not want to have any stones because they did not want to spoil the beach.

So, hence there was some kind of, alternate kind of solution, which need to be thought of and then when we visited the site, this is the kind of scenario. So, you look at the erosion, this is called as locally, Ballas. So, this is just rows of timber logs, timber polls driven and you have horizontal brazing also and inside that they keep sand bags. So, unfortunately this is all the way continuous.

So, this was not providing them much kind of relief, but maybe it was offering them a kind of temporary relief for a short duration. But then the net effect was that erosion was still continuing, as you can see, inspite of the Ballas. So, you have the erosion taking place.

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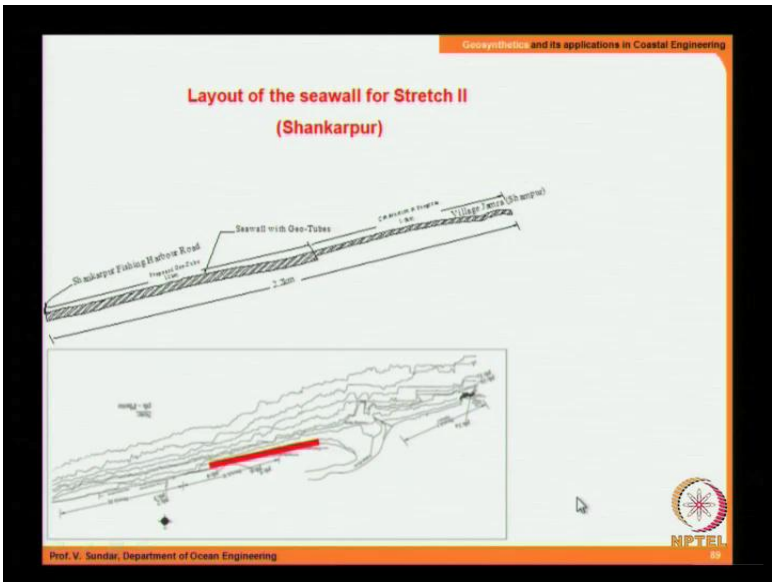

So, this is the stretch of, so as a pilot project we considered about 800 meters wherein this need to be implemented. So, how did we go about?

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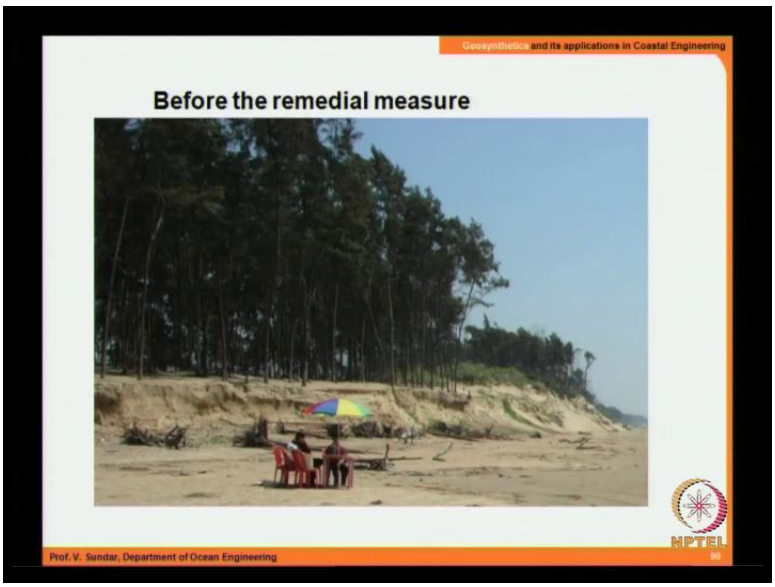

So, we naturally went in for the geosynthetic material and this is a site before, before the remedial measure. And this picture, obviously, has been taken during the low tide wherein you can see the status of the coast clearly.

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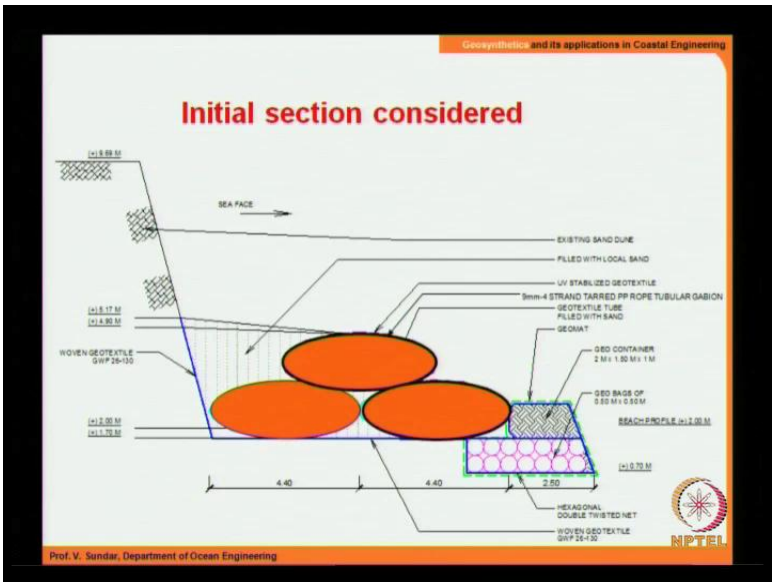

So, the initial section, how do we go about it? So, we need to look at the different elevations and the problem is you have to give a solution, one is for protecting the coast, second is, you should not have much of inundation into the land, so in which case, we need to consider all the levels.

So, the top level, so we considered three geotubes. As you can see here, geotube is, it looks circular, but when you fill it and then lay it, it takes the form of an ellipse. So, then we had, this blue color is the geo-textile all the way here and as I said in earlier lectures, the toe protection is extremely important, so we had a toe protection here. This is nothing but a kind of exposed toe.

So, you have the geobags here, a number of geobags and then we also had, here we provided geocontainers filled with sand. And then over this we had the geo-mat for certain locations and then but the geo-textile was running. You see, look at this point, this is where the anchoring, was taking, was done. On the other side, this was anchored on to the land somewhere here and at much higher location.

So, you see, that this area was filled after laying the three, deo, geo-tubes, in order to, I did not touch upon the UV resistance. See, one important, one of the, one of the major problem with geosynthetic products are, is the UV resistance. If it is exposed to the sunlight, over a period of time, it, the geosynthetic material becomes brittle and there is a possibility, that for it breaks in the event, that it is completely submerged below the

water. You do not have this problem, but when it is exposed to the sunlight and there is no kind of a guarantee for how many years the geosynthetic products can sustain in kind of weather like what we have here, for example, around forties during summers. So, this kind of weather, the sustainability during this time of period, this period is extremely important.

So, in account to in order to address this problem you see, that an extra strand tarred polyrope tubular gabion, that was adopted and we had a extra coating over the geotube, that is, the top geotube wherein, that was nothing but the UV stabilizer. It is a kind of a coating, which is given to the geotex, geotextile, which is wrapped over the top, at least the ones, which are directly exposed to the sunlight. Even today there is not much of problem with the quality of geosynthetic material. Although it is around, I would say it is around 5 years.

So, what happened is, this is the kind of scenario and once these tubes are leaked, then you have the filling that was suggested here, that is, natural rock, so that you do not really, that acidic point is preserved. And then probably we can expect some quantity of beach being formed in front of the geotube, as well as this obstruction can serve as a protection measure in prevention of the flooding in, during extra, I mean, extreme event.

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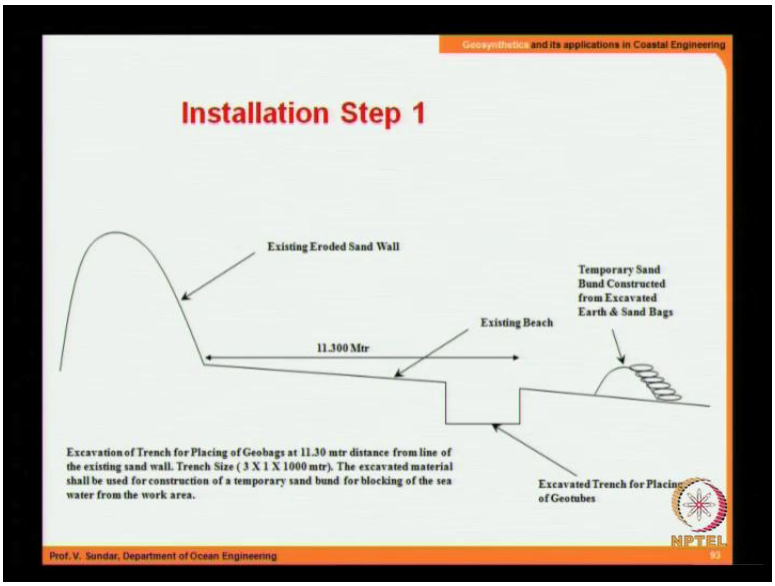

So, what was the site condition? This was the kind of a site condition. So, what was done is, initially the construction sequence, I was just suggesting a temporary bund was

constructed from excavated earth and sand bags. Then the excavation took place, here excavated. This is in fact, for, mostly for placing the geo-textiles.

So, and then the placing geobags at 11.3 meters distance from line of existing sand wall. So, this is distance, a trench of this size, 3 by 1 into 1000 meters for the entire length was dug. The excavated material shall be used for the construction of, so this material was used for the construction of the bund and that bund was also provided with sand bags.

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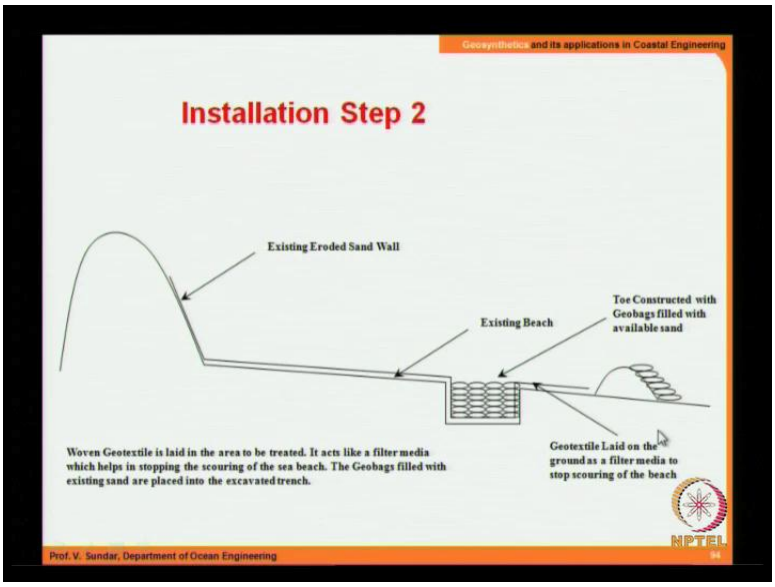

And then once this was done you have the excavated thing. So, you have the, you run the geotextile making sure, that you follow all the basic requirements and the geotextile is also taken below the below the sand and then the geobags were put it in position here.

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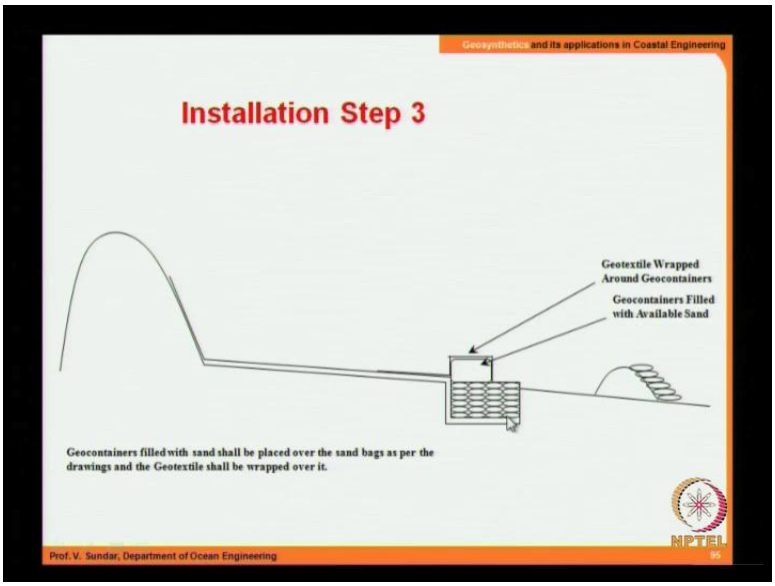

Then, you have the geotex, geocontainers filled with available sand. These are slightly bigger than the geobags and now this is how the toe was constructed.

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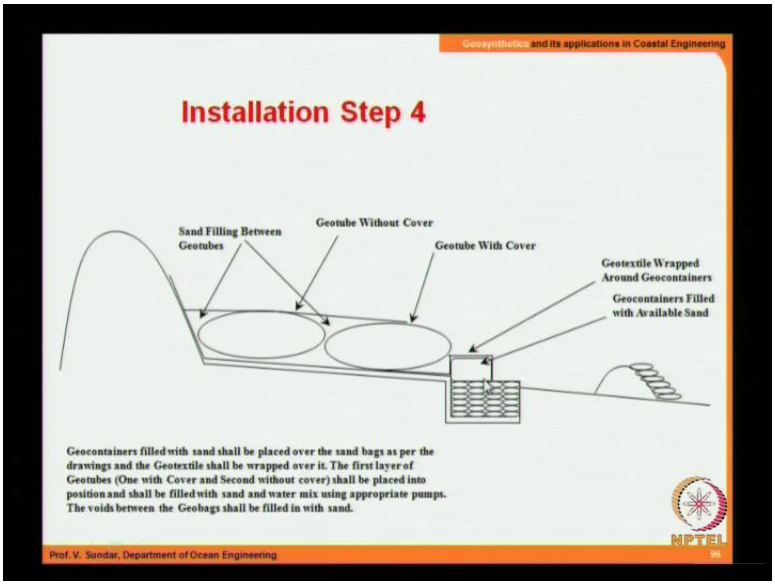

Once this was constructed, then the two geotubes are placed over this geotextile and then after this the third one is also placed.

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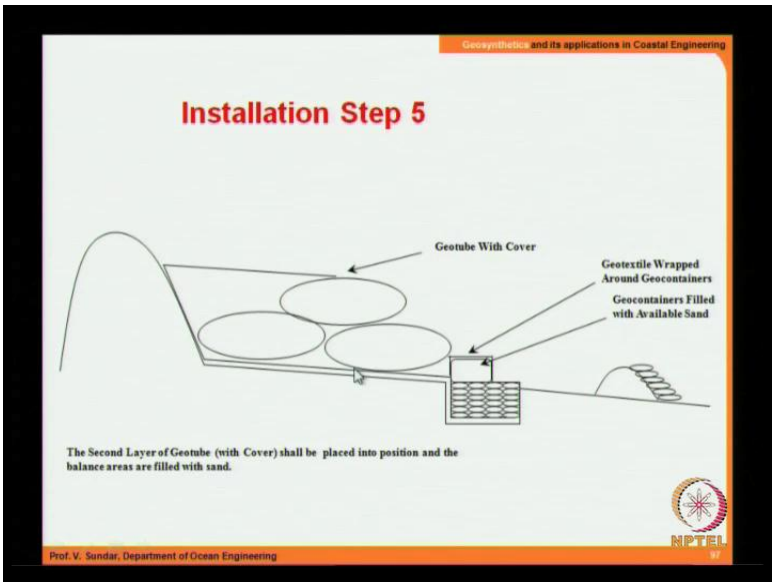

But make sure, that the geotextile, geotextile is running through.

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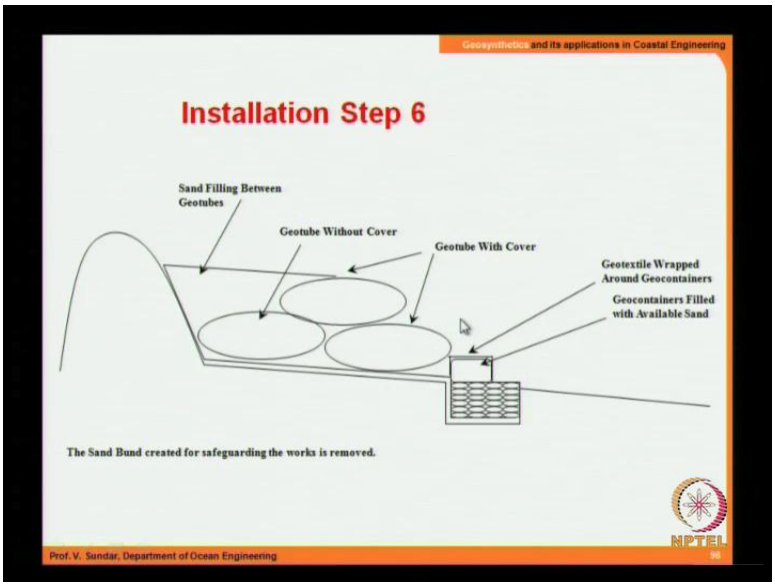

And you have the geotube fill, filled up and geotube with the UV resistance cover. Once this is done, the sand filling between the geotubes was done.

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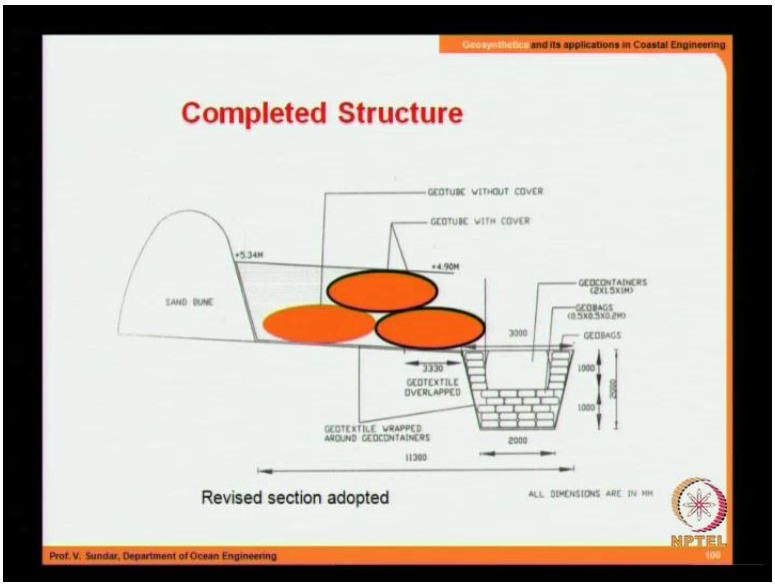

And this is, finally you have this kind of a cross-section that was implemented in Shankarpur. Once this was done what happened was, this was done initially for about distance of 100 meters and surprisingly we saw, that the geotubes were intact, but kind of a tilt took place because of yielding of the toe. This is a kind of an exposed toe, kind of a toe. Although I used the word excavation, but the depth of excavation is not much, so that means, it can be still called as.

So, you see this, this the order was about only 1 meter, I think, or less than 1 meter or of the order of 1 meter. Then we found, that the damage took place for the initial 100 meters or 200 meters and then we had to go for another 800 meters. Then we looked at the problem and then we found out, that this is the main culprit, that is, the toe. So, we needed to strengthen the toe. So, what we did? Used the same procedure of having the temporary bund, continue with the temporary, the bund was already there. So, you, we increased the depth of the toe and then also the width and then we had put the, we had placed in position a number of geobags as well as the geocontainers.

So, the excavated toe added to the strength and there was no disturbance and the entire thing was intact. So, this was the revised section adopted.

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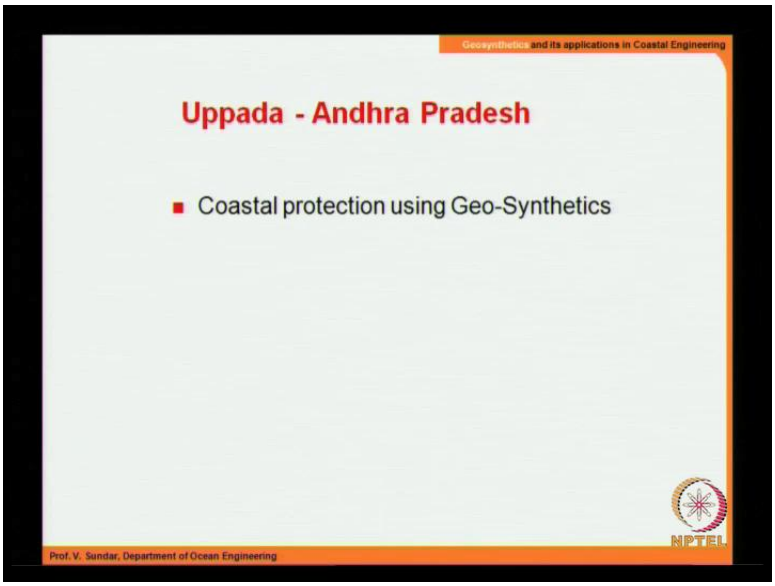

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Then, let us see some of the photographs and this was around mid of 2007 and early 2008. This was done sometime around mid 2007. So, you look at the initial geobag, the bottom one and then over which you see this bag, this geobag is provided with that UV stabilizer and then once this was laid, you see the filling up of the position, that is, this position, this location was filled up with the beach material, so that the people are not starved.

They do not starve for beaches because they have been exposed to this kind of an environment and I mean, with the, to the beach. And now, suddenly they are devoid of the beach and in order to win back the beach this was the idea that was suggested and implemented.

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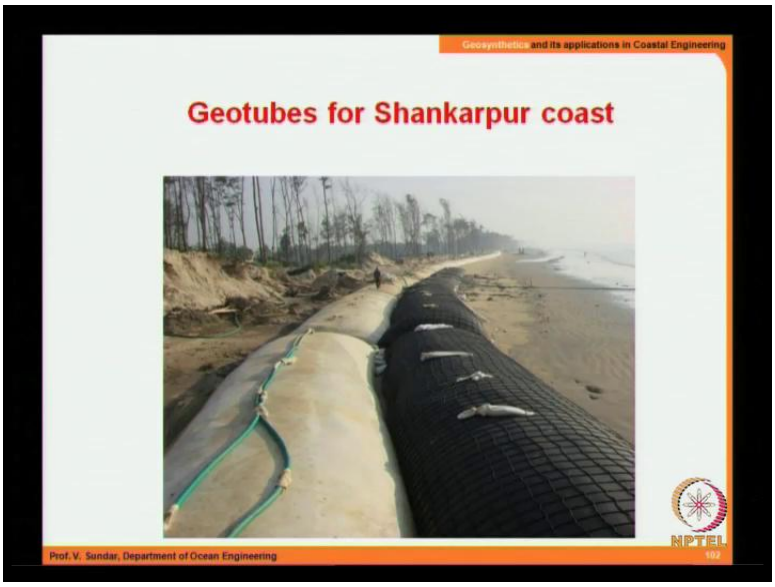

And you see the view of the geotubes along the Shankarpur coast for length of about 1 kilometer. The project was quiet successful, but there were a bit of shortcomings, the geotubes are in position, but some locations have been damaged. So, let us look at the problems.

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So, I would like to say, that the title is now performance, as well as, damages. So, you see, that these pictures show the stability of the geotubes against the waves and I would not say, that these are 100 percent extreme waves because it has withstood, withstood waves much higher than what you see on the picture and stability was not a problem. But there were other shortcomings and what was the, what were the short comings?

Tearing of the geotube, geomaterial, geosynthetic, it is possible, that is, vandalism. There is a possibility that people just put a knife and then dig it out of curiosity to show, to see what is inside that is one possibility. But you just (( )) it, I do not think that it comes, but then if you use force, naturally there is a possibility, that it gets torn.

The other possibility is, the other problem was when they fill in the tube. If they do not fill in to the complete level, then there are depressions, there are unevenness over the surface of the geotube. So, then in that case what happens? You have tension created and there in due course, over a period of time, that is, it gets torn and once it gets torn or punctured, then it is a problem, other serious problem. So, some of these damages, once it is damaged somewhere, you need to have immediate rectification. If you fail to do that, then leads to catastrophe that is biggest disadvantage with geosynthetic products.

See, as I told you in one of the lecture earlier, see this gap that is placing of geotube. So, it needs lot of the skills, skilled labor and also lot of dedication is needed. So, when you are placing geotubes like this look at the gap. So, this is what happened. For example,

there is a gap here and when there is monsoon, the water flows through this and there is a small gap and the velocity increases. Then and once it increasers you see, that one geotube goes below the other and then you have unequal settlement and geotube itself might yield.

So, this is one of the major problems, which needs to be done. So, in the case of geotextile I already said about overlapping, but in the case of geotube you have to make sure, that it is intact and that is not so easy to achieve. Now, we move on to another case of in coastal protection in Uppada.

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So, herein what has to be done is, you have a toe protection based on experience we gained in Dhiga. So, this is a kind of protection measure. You have a, geo, geotextile here running all the way, which is, which is shown here and over which you have the geo-tube and over that we have placed geobags, over that we have gabions. This has to prove to be very good and it is quite successful. And we are likely to continue with this project for this has already been done about for a half a kilometer and additional stretch of the course is likely to be protected in this fashion.

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Gabions are, as I told you, is also very, very nice way of protecting the coast and you see, that here you have geotextiles, geobags, that geobags act as something like a cushion and geotextile prevent the soil erosion, and this gives the resistance of waves and over which your gabions can be placed.

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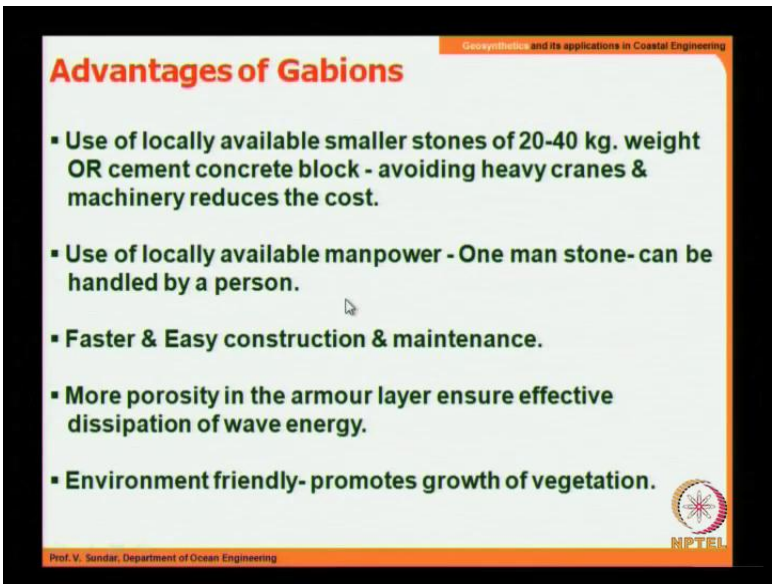

Advantages of gabions, use of locally available smaller stones of, maybe, up to about 40 or even 50 kgs or cement concrete block sometimes they will use. So, you avoid heavy cranes and then machinery. And then use of locally available manpower, one man can

lift one gabion, if possible, if he is really quite strong; faster and easy construction and maintenance. More porosity in the armour layer ensure effectiveness of dissipation of energy, (( )) wave energy, and also it is quite environment friendly, provides growth of vegetation, that is another important thing.

In fact, when you have the geo, I mean, the gabions also coupled with geomat, that helps in the growth of vegetation; that is very good.

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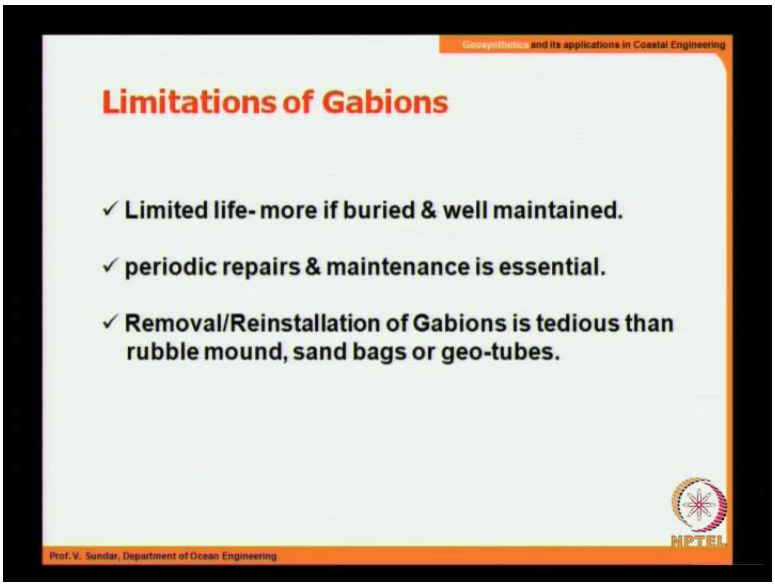

Limitations, limited life, more if buried and well maintained. Periodic repairs and maintenance is absolute essential that applies not only for gabions, all other geosynthetic products. Removal and reinstallation of gabions is quite tedious than just rubble mound because the rubble mound we are going to have a bigger stone, but here it is going to be big problem and then sand bags are geotubes.

Then the other problem, this applies even to geobags, geo-tubes, sand bags. The other problem is when you have gabions. This boat people try to tie their boats to the rope and this sometimes poses some problem and sometimes local people cut also the rope. So, that is also dangerous. Once the rope (( )), then it is a problem. Earlier there use to be some, what it is, steel ropes, but galvanized steel rope, but this is not so successful. So, they have now polyproplene ropes, which are quite effective.

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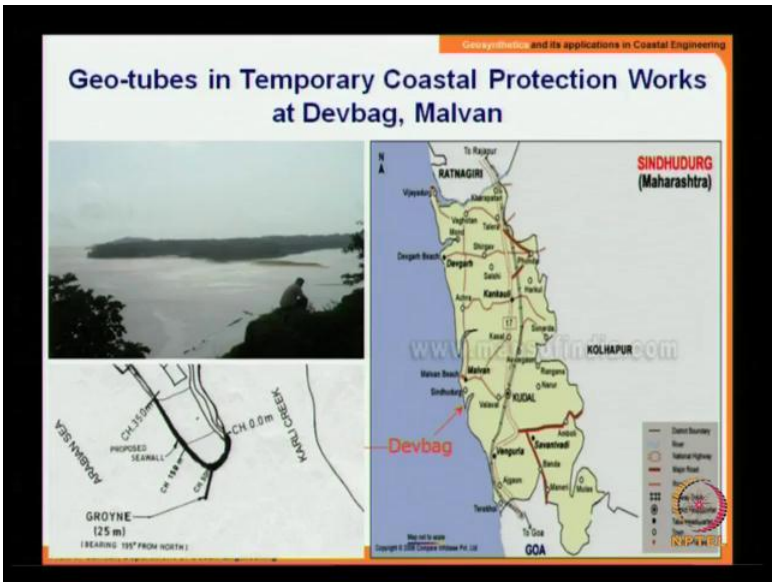

So, this is at another location, that is, the location is shown here.

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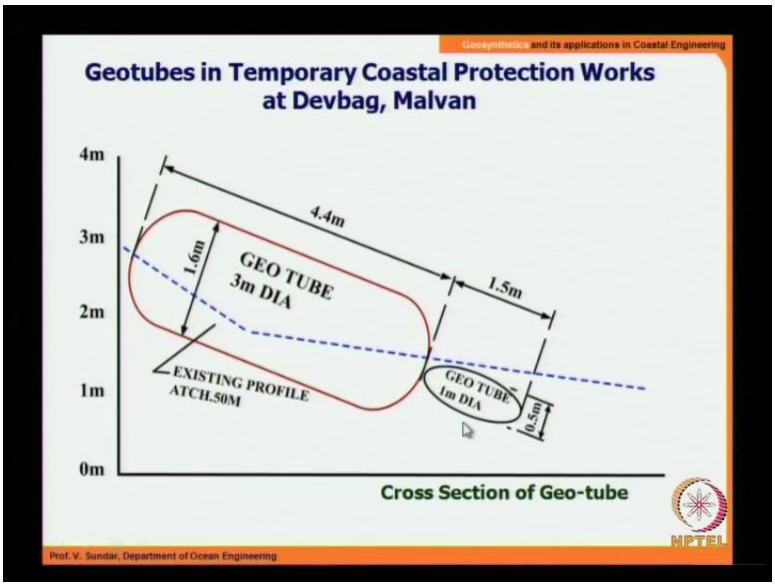

So, the idea was to have geo-tubes as shown here, one 3 meters diameter Geotube and 1 meter tube and this one, 1 meter dia geo-tube is to just act as a toe.

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This was a site and this you see kind of implementation they had for this area.

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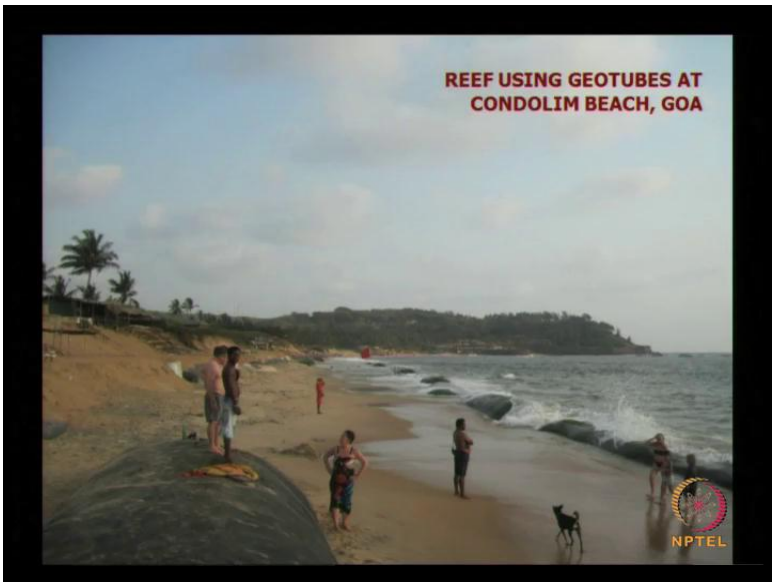

And then this is in Goa where you see the series of geo-tubes provided there. And if the same kind of the geotube is oriented just below the water level, it can facilitate a breaking also. So, this is a kind of another kind of concept that is being thought of or adopted.

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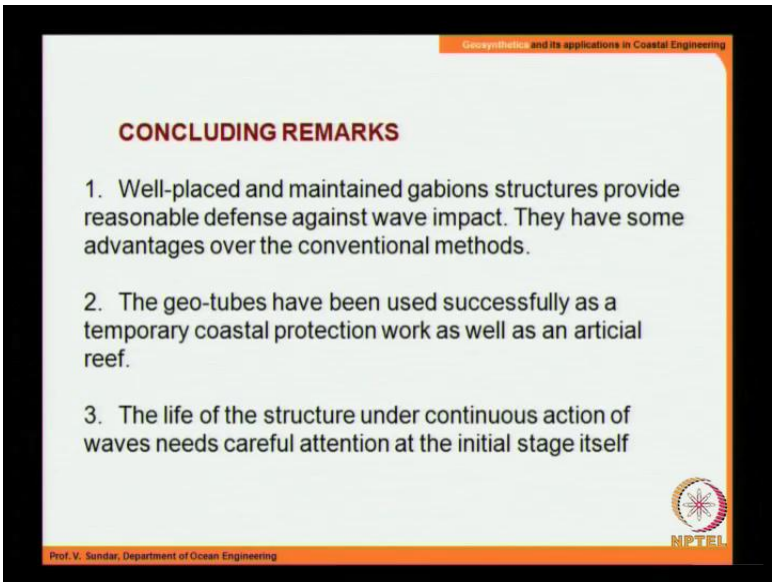

So, concluding remarks, well-placed and maintained gabions structures provide reasonable defense against wave impact. They have sometimes some advantages over the conventional methods. The geo-tubes have been used successfully as a temporary coastal protection work as well as artificial reef. The life of the structure under continuous action needs careful attention at the initial from the right from the initial stage itself.

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So, that concludes with a variety of the problem because the reason why I have covered number of case studies in geosynthetics is that there has been a discussion or at least,

people are of the opinion, that much of work has not been done in our country with geotube, I mean, geo-synthetic product, particularly in reference to the coastal engineering. And this the reason why I had shown you more number of case studies and in fact, I have limited and there are much more case studies, there have been wherein geosynthetic products have been adopted. Any questions, shall I proceed?

So, when you deal with geosynthetics, one is the strength, the properties, the material, properties of the material need to be tested, which I have already covered. The other one is the performance of the structure as a unit, mostly it is on the hydrodynamics stability, on its hydrodynamic stability, which is, I will just present few studies. What we have done in IIT Madras, this is the department in ocean engineering and we have a few wherein such we carry out such studies.

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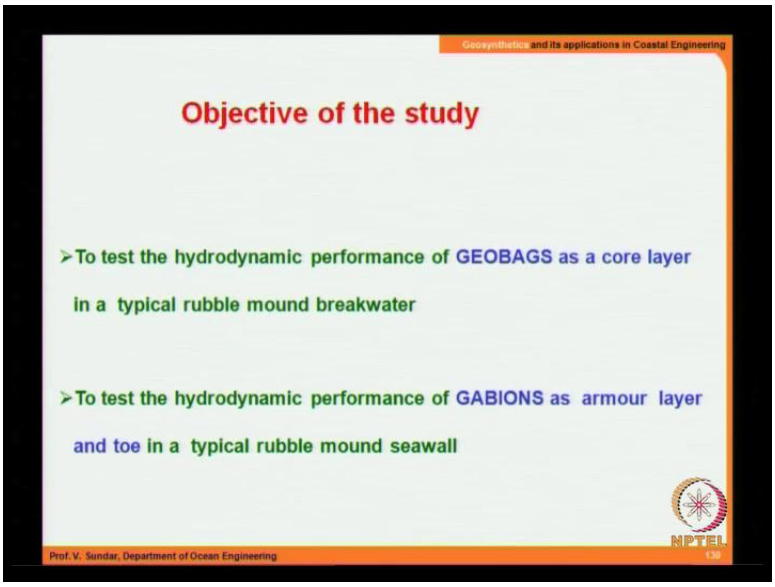

So, here, so here the objective of the study is to test the hydrodynamic performance of geobags as a core layer in a typical rubble mound breakwater. Then also to test the hydrodynamic performance of gabions as armour layer and toe for a typical rubble mound seawall.

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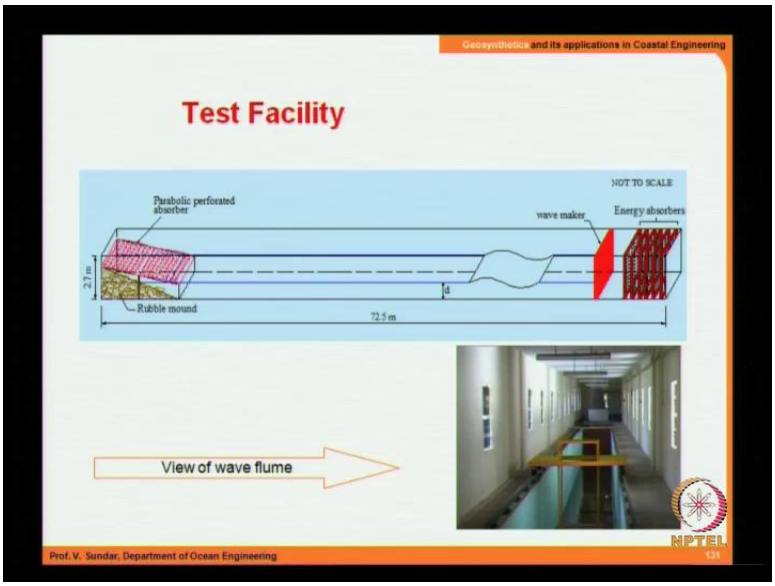

This is a wave flum, which we have and this is 72 meters long and we have a wave maker here and the water depth can be varied from 0.3 to 2 meters and we have, it is a wet bag. So, we have water in rear side of the wave maker. In order to take care of the reflection within this area we have progressive energy absorbers, which die down the, absorb or dissipate the energy behind the wave absorber and we have a parabolic absorber here in order to absorb instant wave energy, so that dealing only with the progressive waves in the wave flow.

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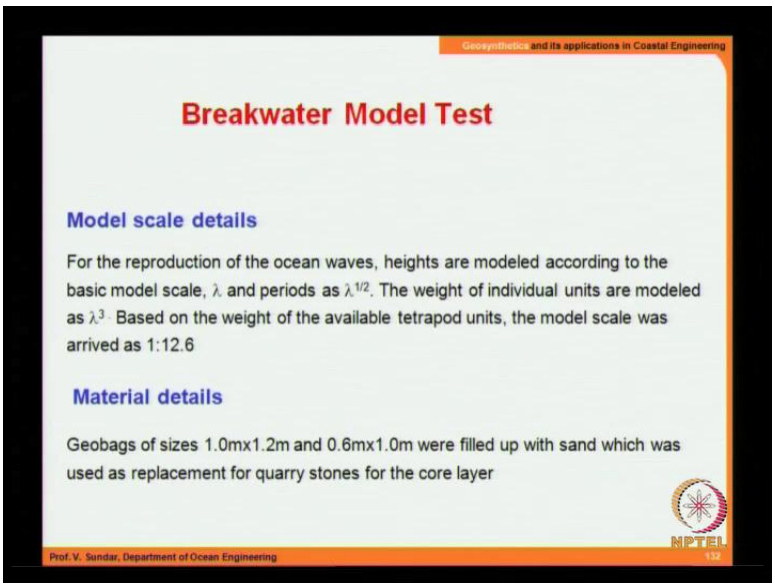

For the production, reproduction of the ocean waves, heights are modeled with a model scale of lambda and the period will be alpha, I mean, lambda into square root of lambda and the weights will be modeled as lambda cube. This I have already mentioned during in the lecture on stability of breakwaters and based on whatever units we have, that tetrapods. So, we had used it as 1 is to 12.6.

The material geobags was provided, the sizes are given there and this filled with sand, which was used as replacement for quarry stones.

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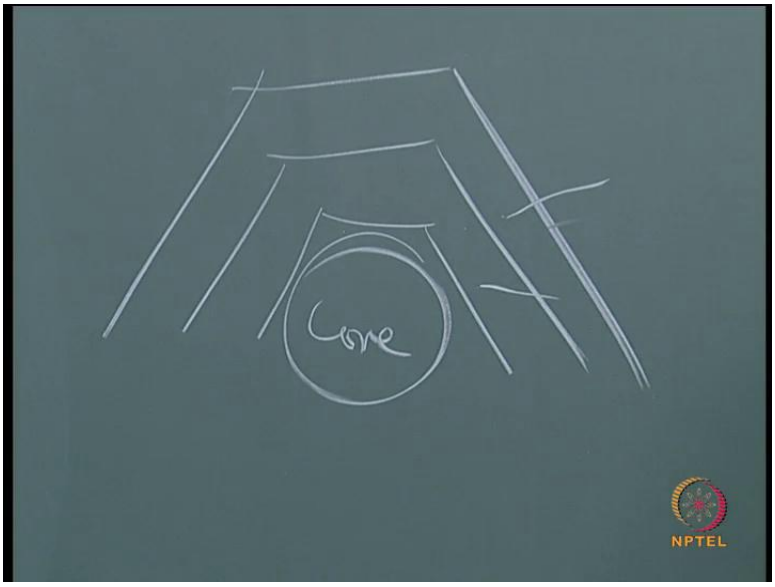

So, instead of core layer, so core layer, as you would recollect, you have the armour, secondary, core. So, this is replaced with the geobags.

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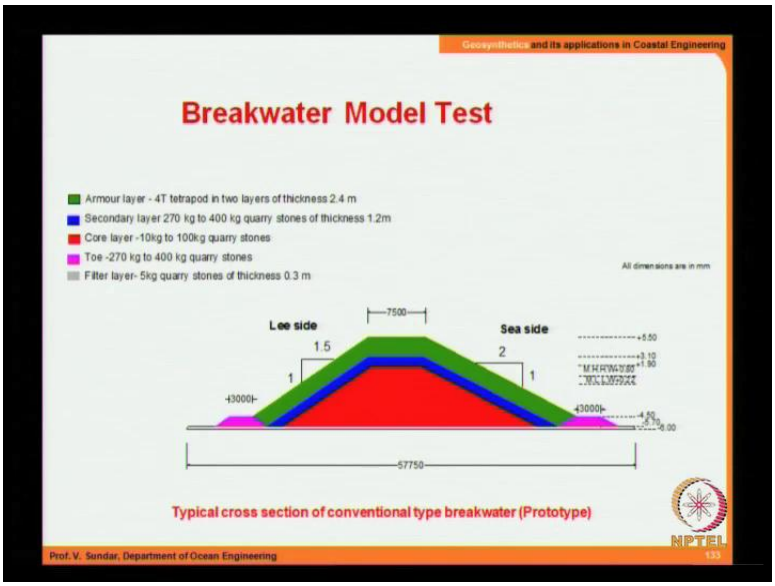

And this is a last section in the prototype, which we had selected, which we had adopted. So, in the field it would be having (( )) tonnes tetrapod, a secondary layer 270 to 400 kg stone and the core layer would be 100 kg, up to about 100 kg stones and the toe is 270, 270 to 400 kg. And we also adopted a filter layer, that is, a quarry stone, 5 k g. So, this is the model. After adopting a model scale (( )) this much, the cross-section, that needs to be trusted in the model is shown here. So, the tetrapod weight is around 2 kg and other things are indicated in this picture.

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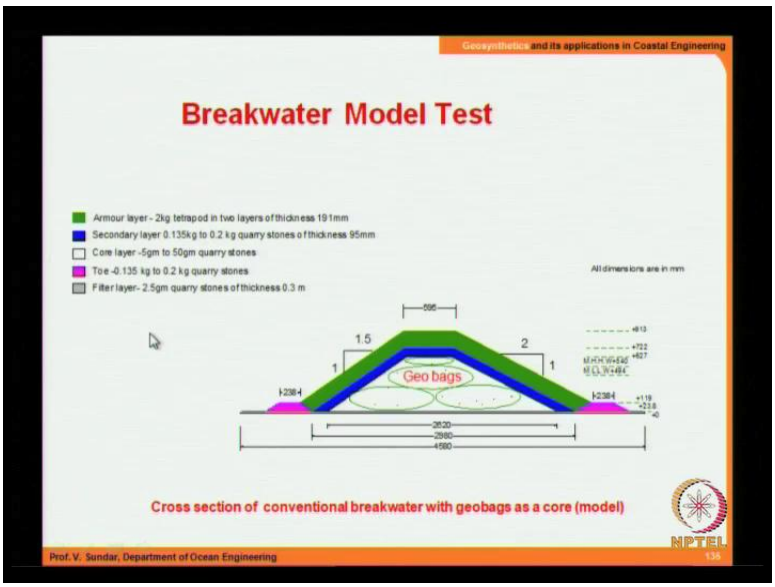

And in the case of geo-tube, the same tetropad was adopted here and you had geobags filled in the, occupying the core layer.

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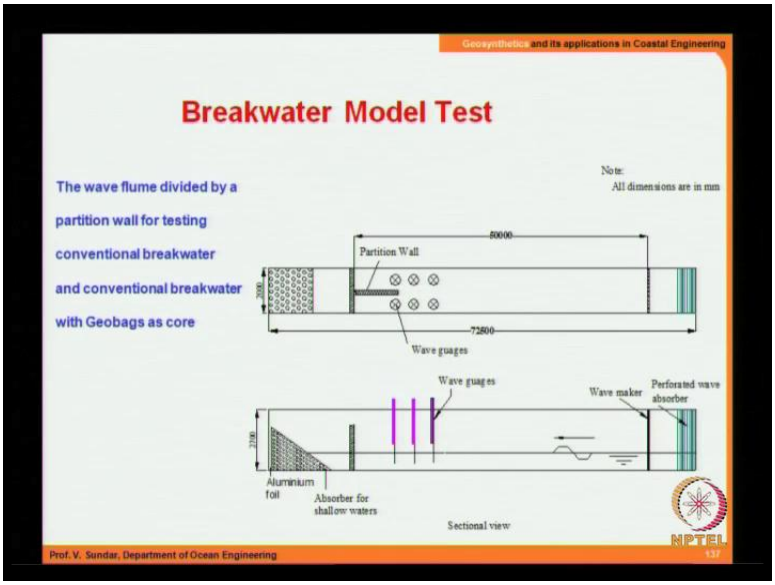

So, these are the testing conditions. So, we partitioned the flow into two half. So, the width, so the flow is 2 meters, when we partitioned, you have 1 meter and 1 meter. So, you have the wave gauges here in order to find the reflection from the structure and also the structure one with tetrapods, with a rubble stone in the core.

As the core has been placed in the other compartment, the geobags occupying the core has been placed, as you can see here, filling geobags in the flume and placing. And now you have both the cross-sections.

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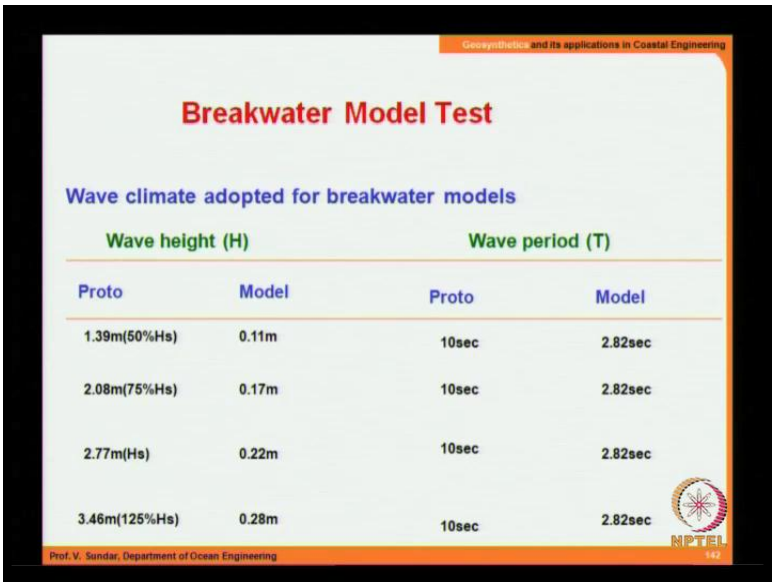

And we had subjected to this, subjected this to particular wave and wave height, that is, this was designed for particular significant wave height and the testing would be the significant wave height, that has been tested in the (( )) 2.8 meters. So, then you see, that it has been subjected to 25 percent in access of the significant wave height and the corresponding prototype wave height, wave period is given here. The model, etcetera, the model values are also provided here.

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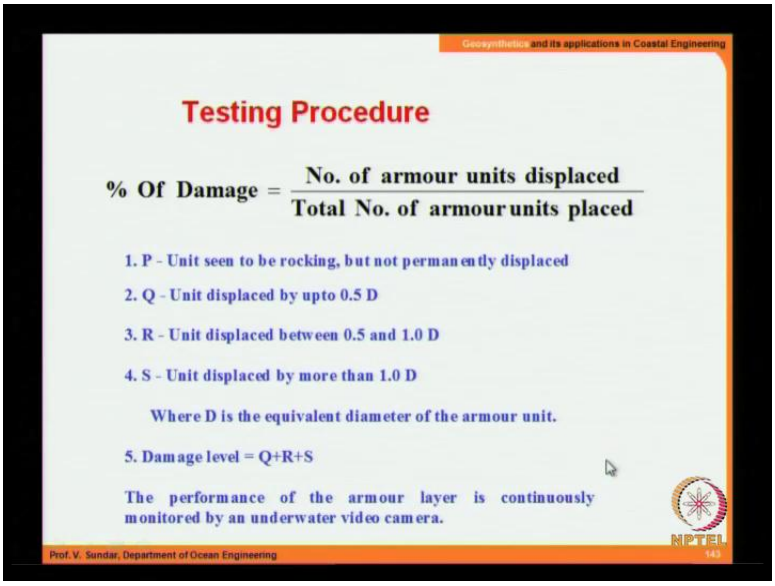

So, then we use a usual procedure, that is, unit rocking P category. This I have already explained, so I do not want to repeat, just touch and go. So, the percentage of damages, number of units displaced divided by the total number of units. So, this was visually done, as well as, done through online recording, and all these category unit permanently, but only rocking unit displaced by 0.5 times the diameter. Diameter means equivalent diameter and R is unit displaced by 0.5 to 1 meter and 1 diameter and s is more than 1 diameter.

So, which, when you add all these quantities, all these classes and you will get the damage level. The damage level should not exceed 5 percent.

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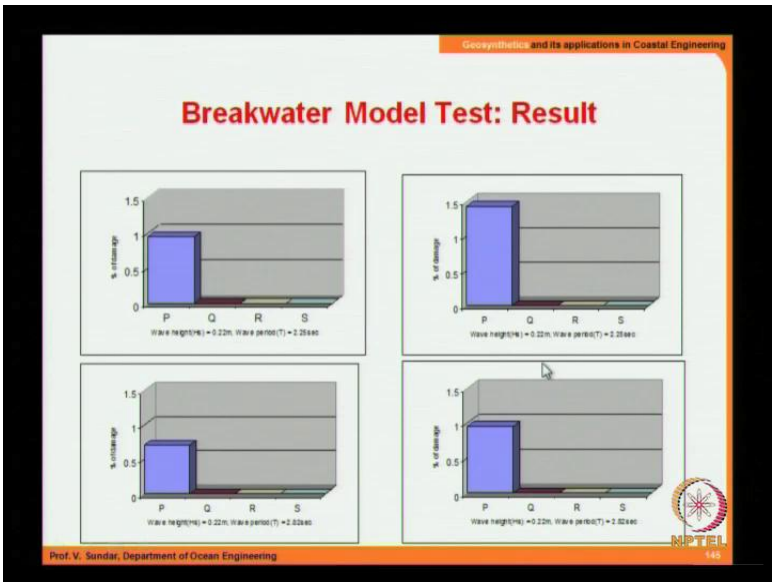

So, now you see, that the cross-section are tested for number of scenarios, and then you see, that in all the cases, the, the damage level was well below 5 percent. And then both the cases, with, with, with a core replaced by geobags is also equally good and so you, you, that results in a lot of saving material also.

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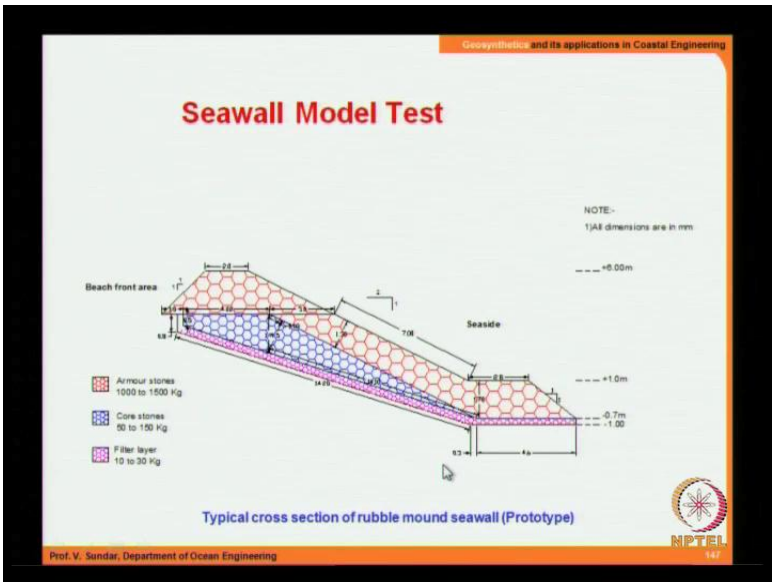

So, this is in, so the case of gabions. So, what we have done is, seawall, as you see here, are all this things, are core stones. This is core stone and this is a filter layer and this is a armour stone, as you can see here. And the armour stone is 1 tonne to 1.5 tonnes and instead of having this portion and this portion, has been replaced with gabions.

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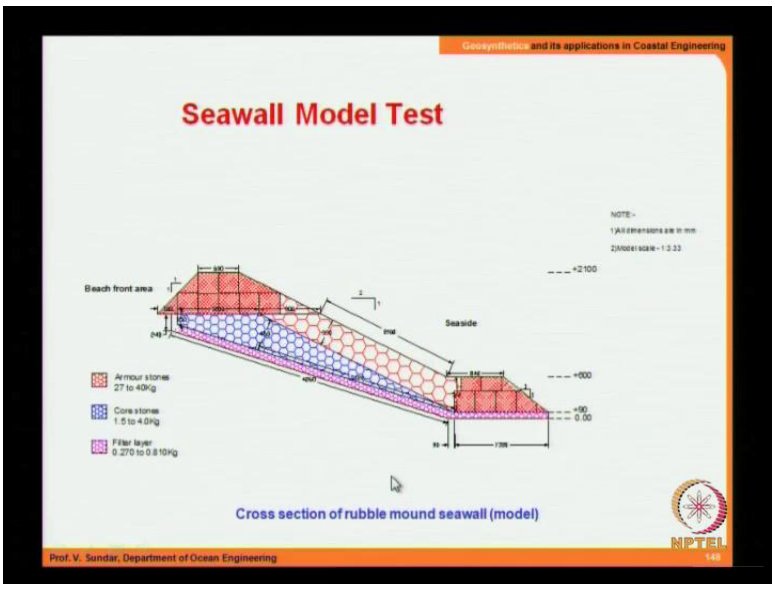

So, this is a gabion, which is shown here and this is another set of gabions, which are grouped, I mean, joined together and this has been, this in fact, working, working quite well in the field.

So, these are gabions, that was fabricated in the flume and before this we had geo-mats over sand. So, this just consists, consisted of having a geomat. So, instead of geotextile and then laying of the filter layer and then laying of the armour units, I mean the gabions at the two locations indicated in the earlier figure.

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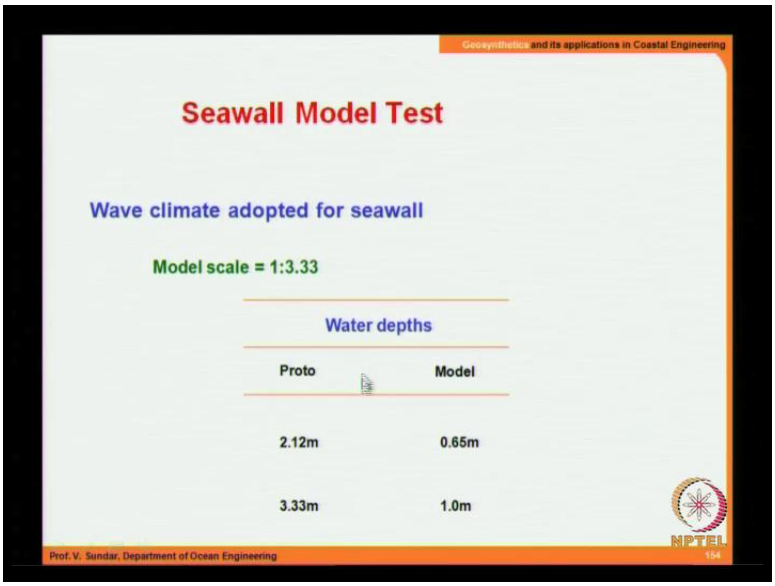

And then it was subjected to the water depths indicated here and the wave heights are provided here and the singular wave height was 1.2 meters. So, you see that I think the different wave heights are tested here and then some of the results shown here and then finally, you look at the result. The stability was well below, the damage was well below 5 percent indicating, that the assumed cross-section are the design cross section is quite safe. This, this kind of assessment is extremely important.

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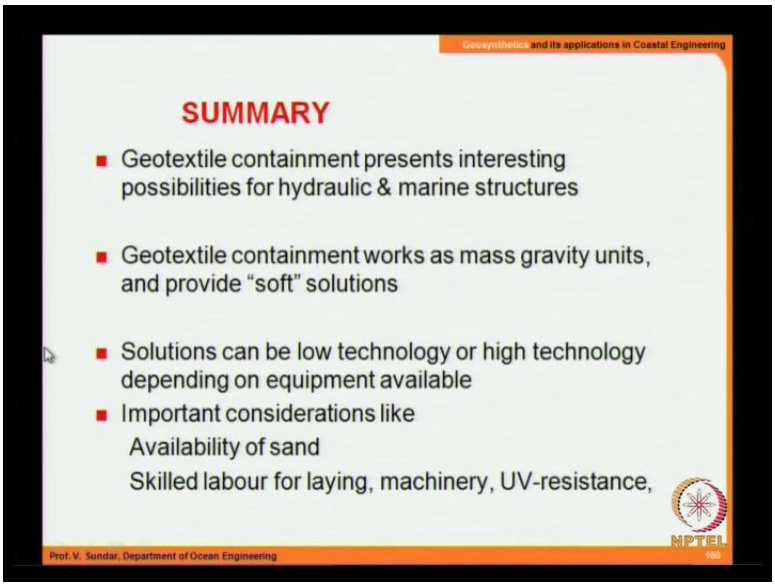

And so to conclude this, my lecture on geosynthetics, geotextile containment present interesting possibilities for hydraulic and marine structures. Geosynthetic containments works as mass, mass of the gravity unit and provide real soft solutions.

Solutions can be low technology or high technology depending on equipment available. So, the product can be same, but still it can be converted as low technology, but whether, even if you converted into low technology, still skilled, you need to have skilled labour. For this important consideration, for this important consideration are like availability of sand skilled labor for laying machinery and UV resistance, which I have already highlighted during a course of my lecture.

So, we have seen, we have seen the application of geosynthetics in the marine environment taking an upper hand or gaining a lot of momentum in its application.

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And so this is treated as ecofriendly, as, as I have already said, as it is quite easy to handle also and it is not an (( )), unlike when you use rubble mound structure. So, now, this demonstration is by with the help of the geotube, which has been considered as a geo, geotube as a coastal protection measure somewhere in Marida that is in Mexico. And I could get this two videos put in along with coast of Mexico in one of the important residential areas in order to take care of the residential area with this position of geotube because they do not want the, did not want to have stones, etcetera because they wanted to have same kind of scene, I mean, they do not want to lose the view of the ocean also. So, what you see, all these beach houses here. So, now, how does this, I should place on record my sincere thanks to (( )) engineer who are main consultants for these two projects.

So, this clear, will give us clear indication as here they are using a, they have adopted as a geotube, submerged geotube. The idea is, once you have a submerged geotube, it will allow the premature breaking and there will be a, I mean, the dissipation of wave energy and then it will, because of the dissipation of energy you can have enhancement of beach formation. And also, not only just protecting the coast, but also enhancing the beach formation. So, now, we will see this, but there is a way of designing this now.

So, let us examine with this phenomena of the submerged barrier or the geotube. How it, what kind of information you need in order to and how does it perform? See, now herein

you see, that both are submerged near the beach and you see the difference here, you have the dissipation of the energy and that is going to enhance the beach formation, but the same geotube is fixed here, submerged and you see, that this is acting as a reflecting boundary.

So, if you have a reflecting boundary what will happen is, instead of protecting the coast wave, the reflection is going to be high, and then that the amplitude is also going to increase near the structure, that will facilitate your erosion to take place. And once the erosion is taking place, the stability of the geo-tube also becomes questionable. So, hence, before identifying you have to put in a lot of effort in making sure, that you identify a proper location for the submerged, submergence of this geotubes.

So, this depends on prevailing wave climate, the kind of beach profile and there are so many other factors, which govern the response of the geotube in protecting a beach.

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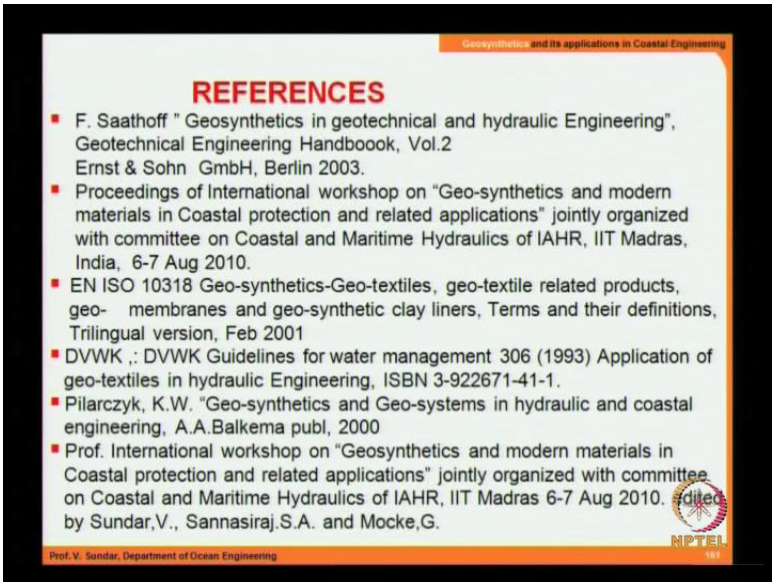

So, these are some of the references available, all are excellent references given and I would strongly recommend the Pilarczyk, Geosynthetic and Geosystems is quite a good book. And also, there are other guidelines, which are available, which can be used for this kind of investigations.

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So, I would like to place on record particularly for this lecture, a number of, I have taken material as I said from number of sources. And starting from CWPRS, Garware Ropes, then (( )), that is in Germany, where I had the opportunity of visiting them. Then Garware Wall Ropes, we have lot of work with them jointly and CWPRS is one of the pioneering institute in this field. And then TENCATE Geosynthetic, then TechFab and all other established companies, they are all working on this. They are mostly manufacturers of Geosynthetic products. So, with this I conclude my lecture.