Geosynthetics Engineering: In Theory and Practices
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Lecture - 9
An Overview of Geosynthetics

Welcome to lecture 9. My name is professor JN Mandal, Indian Institute of Technology, Bombay, Mumbai, India. The name of the course, geosynthetics engineering in theory and practice. Now, we will at this module 2, lecture 9, an overview of geosynthetics. Now, recap of previous lecture which we have covered. Now, it is design example, sustainability using geosynthetics, application of sustainable geosynthetics, in various infrastructure.

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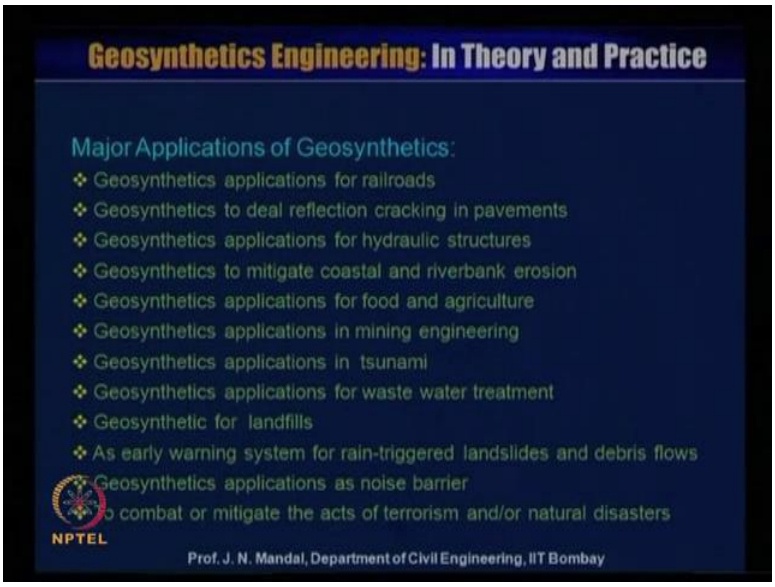

Today's lecture is mainly on, major application of geosynthetics: geosynthetics application for rail road, geosynthetics to deal reflection cracking in pavement, geosynthetics application for hydraulic structure, geosynthetics to mitigate coastal and riverbank erosion, geosynthetics application for food. And agriculture, geosynthetics application in mining engineering, geosynthetics application in tsunami, geosynthetics application for waste water treatment, geosynthetics for landfill, as early warning system for rain triggered landslide and debris flow, geosynthetics application as noise barrier, to combat or mitigate the act of terrorism and or natural disaster. So, there are many application and I just addressed first, the geosynthetics application for railroad.

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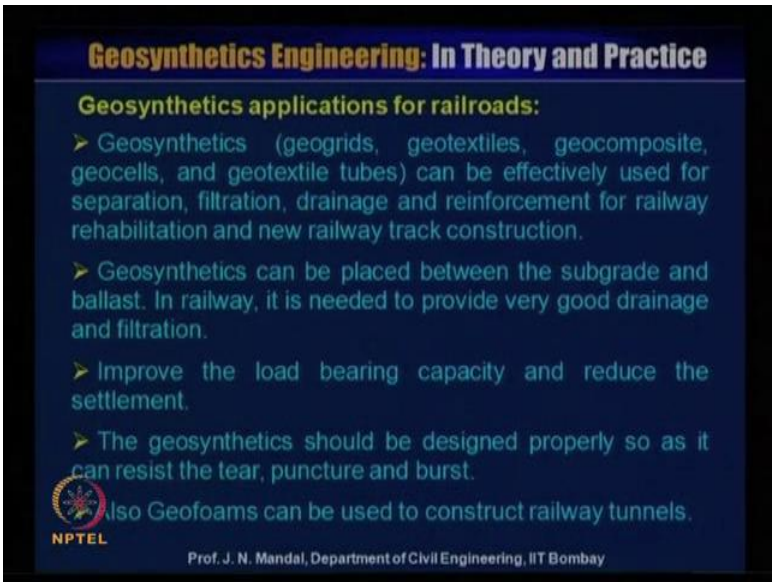

So, geosynthetics it is may be in the form of geo grid, geo textile, geo composite, geo cell and geo textile tube, can be effectively used for separation, filtration, drainage. And reinforcement for railway rehabilitation and new railway track construction geosynthetic can be placed between the subgrade and the ballast in railway. It is needed to provide very good drainage and filtration, improve the load bearing capacity and reduce the settlement. The geosynthetics should be designed properly, so as it can resist the tear puncture and burst also.

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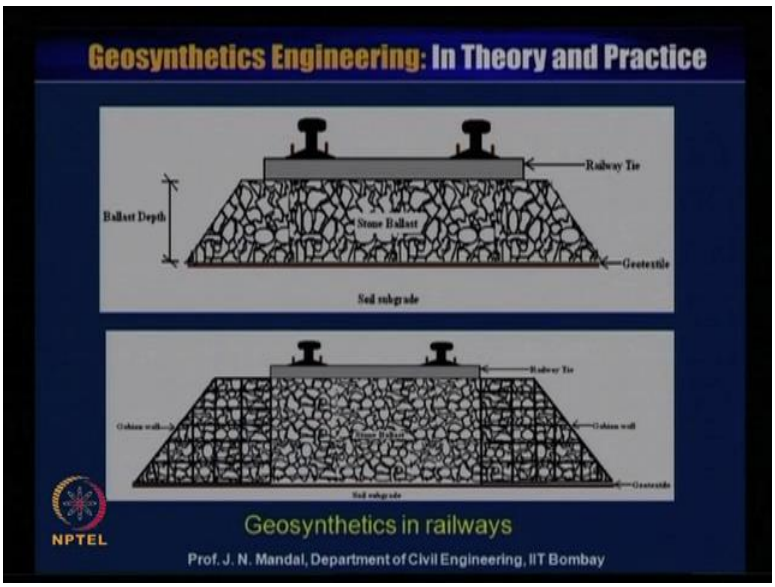

Also, geofoam can be used to construct the railway tunnel, because this picture that what is the geosynthetics material is placed between the subgrade and the stone ballast. Beneath the stone ballast, upon which that wooden, what is called wooden or the concrete tie is placed and the design also should be beneath ((Refer Time: 04:43)). Sometimes, what will happen that there is a possibility for the level sliding of the adequate, so there will be demonstration. So, we can also provide thea kind of the gabion.

You can see here, this is the gabion and this gabion is,it islooks like, looks like this, this is a, you can see that hexagonal mess and this is galvanized mild steel and this also covered with the p v c. So, there will be noformation of rust, it can be protected and this kind of the gabion, you can have different size and the shape in general that 1 metre by 1 meter by 1 metre cube. The top side is open and you can fill up with the good quality of the aggregate compact it and then, top portion of the lid it can tighten and you can form a kind of this gabion. So, this as kind of design should besize specific and we can use this material as a separate in the rehabilitation for any railroad between the rail containment and the ballast view.

Sometimes also, you require that, you can remove all the contamination of the aggregate and you can place the geosynthetics material and then you can provide with the new ballast material or new aggregate.So, this geosynthetics material act as is a separation function it also act as a filtration function also act as a drainage functionand also geo ((Refer Time: 07:06)) like or the gabion type wall, also can act as a confinement function. So, sometimes what are penetrated through the geotextile to the subgrade soil or sometime there will be the excess pore water pressure development below the subgrade, and it will move to upward to the stone ballast and there is a possibility for the collapsing of this railroad.

So, if you can provide with the proper kind of the geosynthetics material, so it will act as a good filtration and good drainage material. Also, there will be no mixture between the two disability kind of the material, which is lying between the soil subgrade and the stone ballast. Apart from this, you can look that here, in this example that how the geosynthetics material is acting so many function at a time. It act as a separation function, it act as a filtration function, it act as a drainage function as well as it also act as a confinement function. So, that is why it is called multifunctional application.

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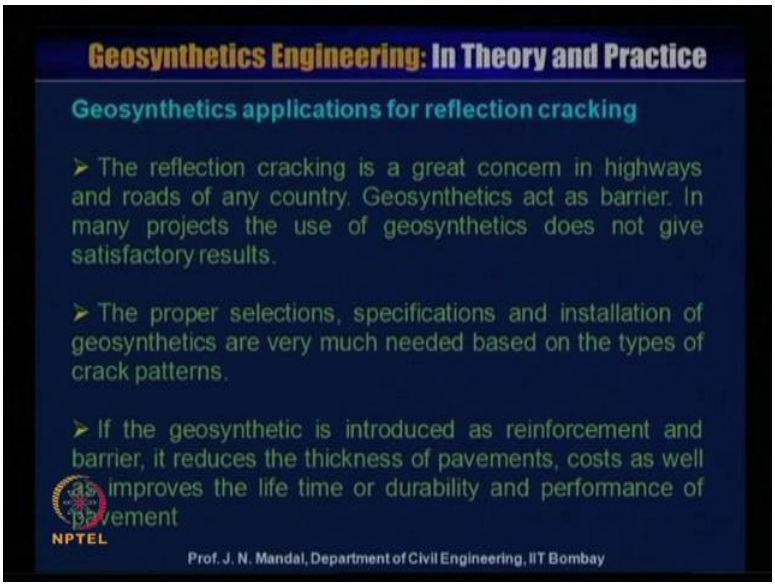

This geosynthetics application for reflection cracking. So, reflection cracking is a great concern in highway and road of any country. Geosynthetics, act as barrier in many project, the use of geosynthetics does not give satisfactory result, because the proper selection specification and installation of geosynthetics are very much needed, based on the type of crack pattern.

If, the geosynthetics is introduced as reinforcement and barrier, it reduces the thickness of the pavement. I showed you also in my earlier lecture how the thickness also drastically reduce due to the presence of the geosynthetics material. Also, cost as well as to improve the lifetime or durability and performance of the pavement.

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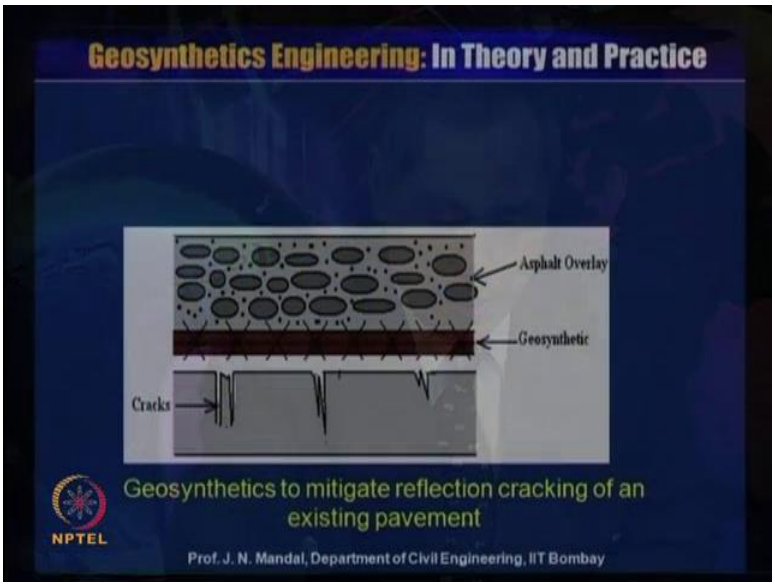

Now, reflection crack prevents an in pavement overlay look at here that if this is the pavement and there is a possibility of different cracking pattern of the road surface.

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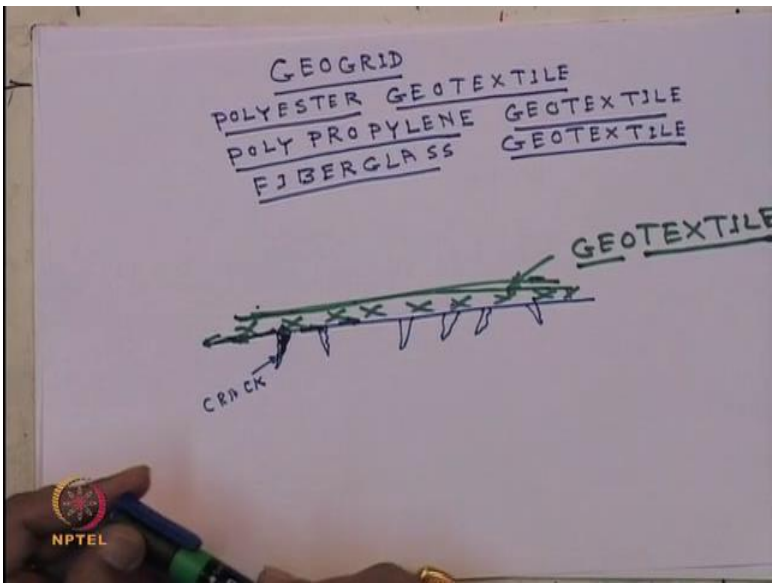

So, it is required to resurfacing the existing pavement due to excessive crack, so this is the crack. So, you provide the bituminous overlay in general ranging in the thickness of 25 to 100 millimetre in the traditional method and crack in the original pavement then reflect up through the new overlay. So, again there is a possibility for the formation of crack on the surface of the road.

Therefore, it is required to provide this strip of the geotextile have been placed over this crack. You have to place a layer of geotextile material at the top of this crack. So, there are different types of the geotextile material, can be used it may be the geogrid, it may be polyester, geotextileor it may be poly propylene geotextile, poly propylene geotextile and also fiber glass geotextile, fiber glass geotextile.

So, this is a geotextilesheet have been impregnated with the asphalt cement or asphalt emulsion. So, this will decrease in the thickness of the overlay and increase the lifetime of the overlay and main function of this geotextile material as a reinforcement, that means tensile strength of the geotextile or geogrid or glass grid. Also, it function is as a moisture or the water proofing. So, what is is to be done that, initially you have to clean this, all the crack of course, the selection of the geotextile material depend upon the type of the pattern of the crack, whether it is in the longitudinal direction or transverse direction and there is a alligator cracking.

So, based on the pattern of the crack and the width and the depth of the crack, you have to select the geotextile material. Now, when there is various formation of the crack in the existing pavement, then you have to thoroughly clean this crack. And then you have to fill up, fill up with the bitumen bituminous on the pavement, then you can spray the asphalt base on the existing pavement, then you can place a layer of the geotextile material. This is geotextile material, this is to be placed, then the hot mix bitumen and the overlay on the top. So, what will happen if there is no geotextile material.

Then crack will propagate and will appear on the surface of the pavement. When you are introducing a layer of geotextile material, then the crack will propagate up and arrested by the geotextile material and propagate on the other direction. So, then you can solve this a problem the reflection cracking problem and how geosynthetics can help you to mitigate the reflection cracking on the pavement.

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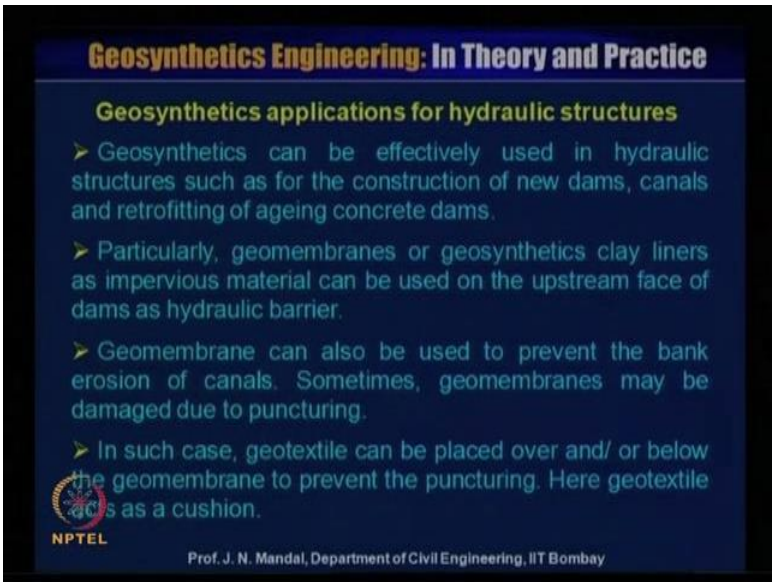

Now, geosynthetics application for hydraulic structure. Geosynthetic can be reflectively used in hydraulic structure, such as for the construction of the new dam, canal, retrofitting of ageing concrete dam. So, you can use the geosynthetic material for the new dam. You can think about dam which is a huge quantity of Earth required huge quantity of concrete, is required if it is a concrete dam. So, where the geosynthetics can drastically reduce the volume of the soil, volume of the concrete and also if there is any problem with the existing concrete dam and then, how you can retrofitting, how we can repair the existing concrete dam?

So, we have the geosynthetics material in terms of permeable material, as well as impermeable material in such cases we can use the impermeable material, what you call geomembrane material to protect the water or to control the slippage. Also, sometimes, we can also use the permeable material like geotextile, as either it is woven and non woven for the proper filtration and the drainage. Particularly, geomembrane or geosynthetics clay liner as impervious material can be used on the upstream face of the dam, as hydraulic barrier.

Geomembrane can also be used to prevent the bank erosion of canal sometimes geomembrane may be damaged due to the puncturing. In such case geotextile can place over and or below the geomembrane to prevent the puncturing. Here, geotextile act as a

cushion as I showed you earlier lecture, in case of the tunnelling. So, here you can see that how the geosynthetics has been used in a hydraulic structure.

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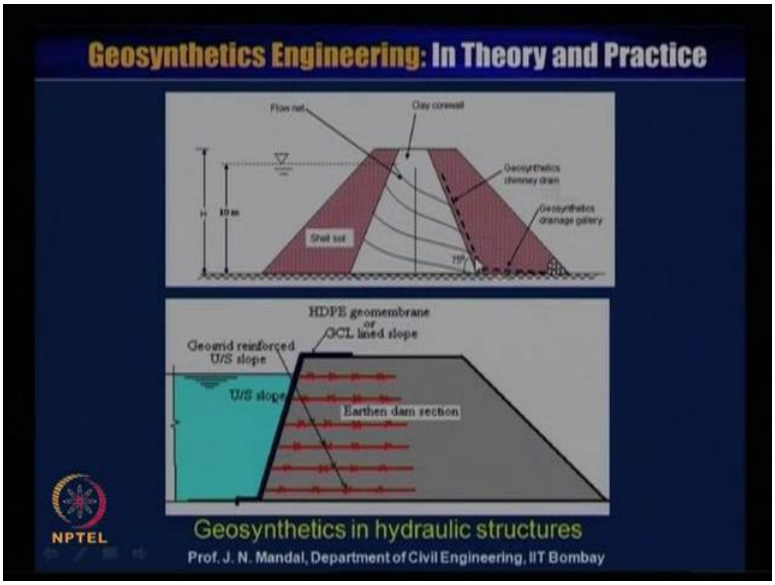

This is the clay overlay and this is the core and here is the geosynthetics material, this is as a chimney drain and geosynthetics material or as a gallery, it has reduced you can see this material is core, so you have to check that what quantity of water passes through this. So, you can calculate that what will be the water flow. So, we can draw here in the core zone that flow line.

You can draw that flow line and the equipotential line and the combination of flow line as the equipotential called the flow net. So, if you know that what is that quantity of flow of water passes through this area, because you know that what should be the permeability of this and you know what will be the hydraulic gradient and you know the area. So, you will be able to find out that what quantity of water passes through that. Then how the geotextile can help to drain it out from the dam and there will be no development of pressure here.

So, you can see that how the geotextile material can help for the filtration and drainage in a dam. Also, we can see here this is the number of the layer of the geogrid reinforcement in the upstream slope. This is the water level, this is the upstream slope and this is the earthen dam section again and then you canconstruct this damusing this number of layer of the geogrid material. We will design later about how to slope design is to be designed

and then in the front slope you are providing with a geomembrane or geosynthetic clay liner, which is an impermeable material. So, you can see that geomembrane will act as a barrier so you can make any slope or angle. What I am trying to focus sometimes here that when you construct a dam you need the huge quantity of the Earth.

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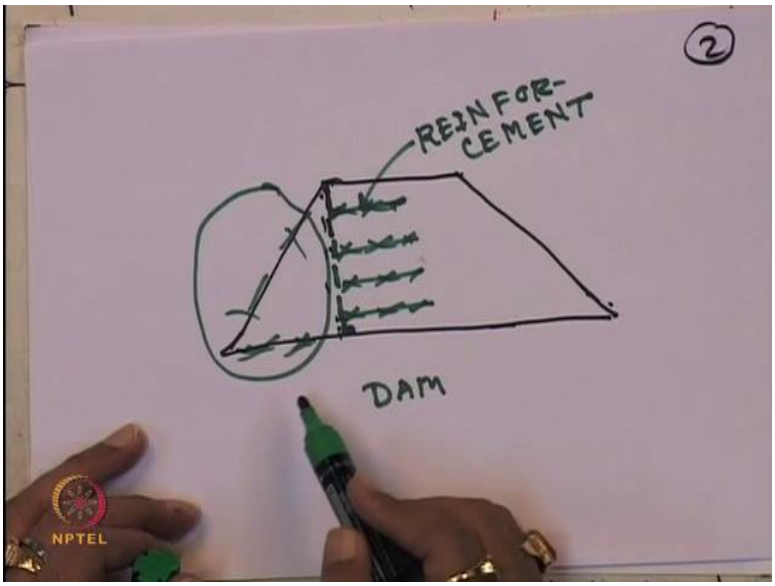

So, instead of this kind of dam, you can make the dam, like this so you do not need, you do not need this quantity of the soil huge quantity of soil you can remove it. You can place a different layer of reinforcement material, you can make,these are different layer of the reinforcement material.So, you can make a stable dam like this so you are saving huge quantity of the soil which you have to transport some place when you have to compact. Alternative, you can see now, how you can use geogrid. You can make a almost like a 90 degree reinforced soil retaining wall and you can provide with the geomembrane. In the front you can say, so it will be the more economical design. So, next is geosynthetics application for coastal river bank erosion.

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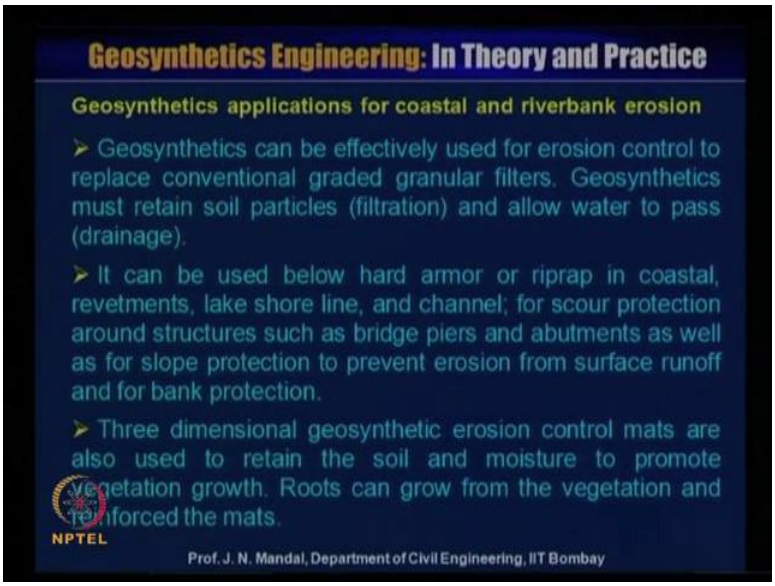

Geosynthetics can be effectively used for erosion control to replace the conventional graded granular filter. Geosynthetics must retain soil particle, that is filtration and will allow water to pass, that is what you call drainage. It can be used below the hard armor or riprap in a coastal, revetment, lake shore line and channel, for scour protection around the structure such as for bridge piers and abutment. As well as for slope protection to prevent erosion from surface run off and for bank protection. Three dimensional geosynthetics erosion control mat are also used to retain the soil and moisture, to promote vegetation growth roots, can grow from vegetation and reinforce the mat.

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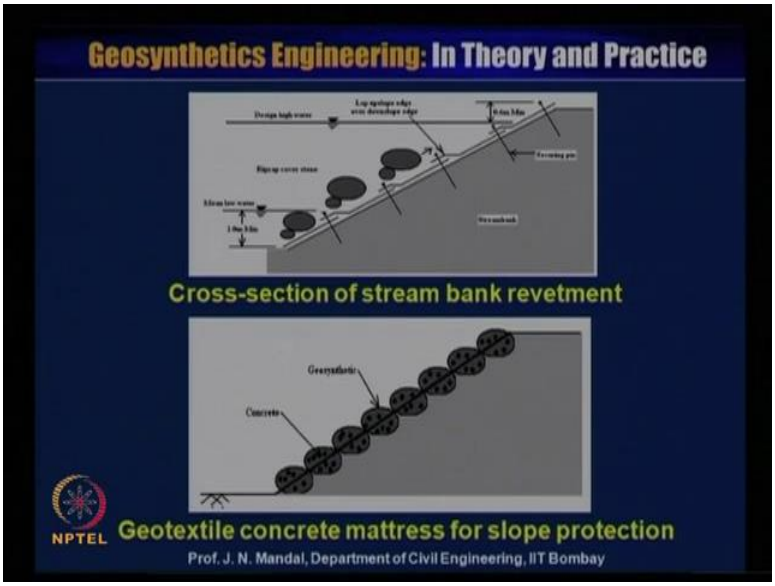

You can see, that some of the slide, this is called section of the stream bank revetment and this is also geotextile concrete mattresses for slope protection.

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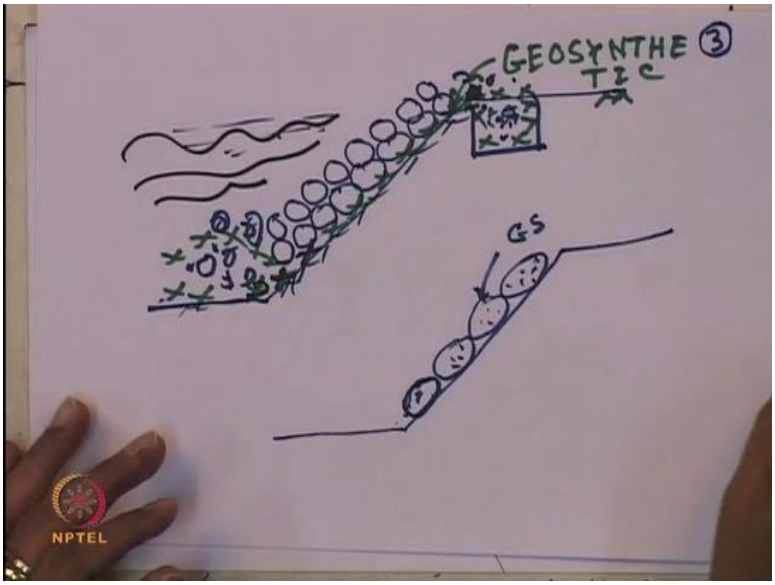

For example, that in a in a slope, suppose, it is a riverbank one protection, this is a river bank protection the water level. Some where here and this is a subgrade, so what we do conventionally we provide some kind of this armor or the stone, like this you can provide two layer of armor like this. So, what will happen from here the subgrade, that there is a development of excess pore water pressure and then the whole system will damage.

So, many cases in the road or in the this kind of the slope in ariver or in a sea shore, you can provide this one layer of the geosynthetics material. I can show you some other colour. You can provide with the here in between the subgrade or armor stone, so this is geosynthetics material you are providing this as a geosynthetics material.

So, what will happen that whatever the excess pore water pressure developed from bottom to the top and this excess pore water pressure, you will divert it through the geosynthetics material. While, this geosynthetics material act as a separation at the same time, it act as a filtration and drainage. Sometimes, you can see there is a flow wave. What will be the height of the wave, whether it is a laminar flow condition or it is a turbulent flow condition? So, when you design this, so you have to be very careful that whether you have designed based on the laminar flow whether or you have designed based on the turbulent flow.

So, accordingly you have design and also this side, backside of this you can rap like this, you can rap like this, you can rap like this and then you can fill up with the armor stone like this. You can put on the top, so it can be act as the anchor. Similarly, on the similarly, on the top side also you can place the geotextile material, then you can place this armor stone like this or you can make a trench. Also, like that for this geotextile material also can be placed like this and can be covered like this and it can be filled up with the aggregate, to make it a stable.

So, you can see that how this geosynthetics material can be used for the erosion control. Also, that geotextile concrete mat slope protection somehow or also we can use if there is a slope. It is nothing but a kind of the gunny bag, this kind of the gunny bag and this the is the geosynthetics material and this is filled up with the concrete and this also can be placed along this slope. So, here geosynthetics concrete mattress can be used or also slope protection. You can also use some kind of the slab, the fabricated concrete slab and below the concrete slab, also you can place this geotextile material. So, there are different types of the system different types of the material. It can be used for the erosion control.

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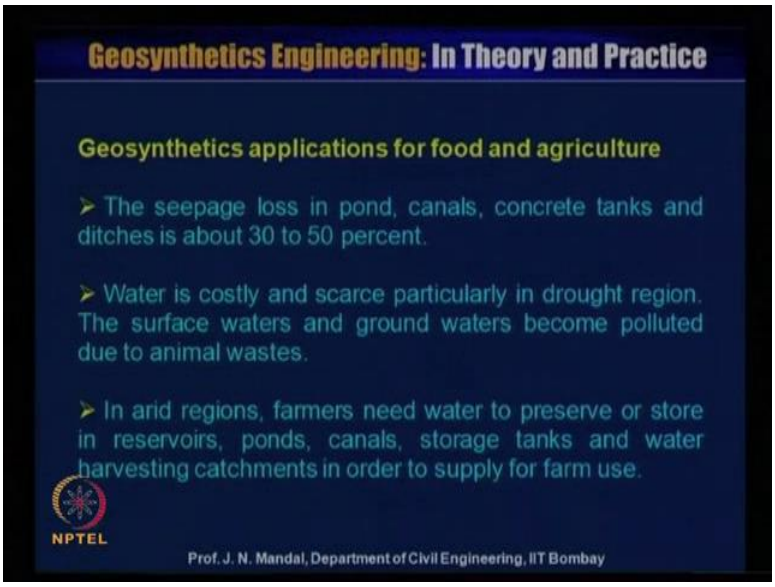

Now, geosynthetics application for food and agriculture, you know that, see page loss in pond tunnel concrete tank, the ditches is about 30 to 50 percentage. Water is costly and scarce particularly in the drought region. The surface water and ground water become

polluted due to the animal waste. In arid region farmer need to water to preserve or store in reservoir, pond, canal storage tank and water harvesting catchment, in order to supply for farm use.

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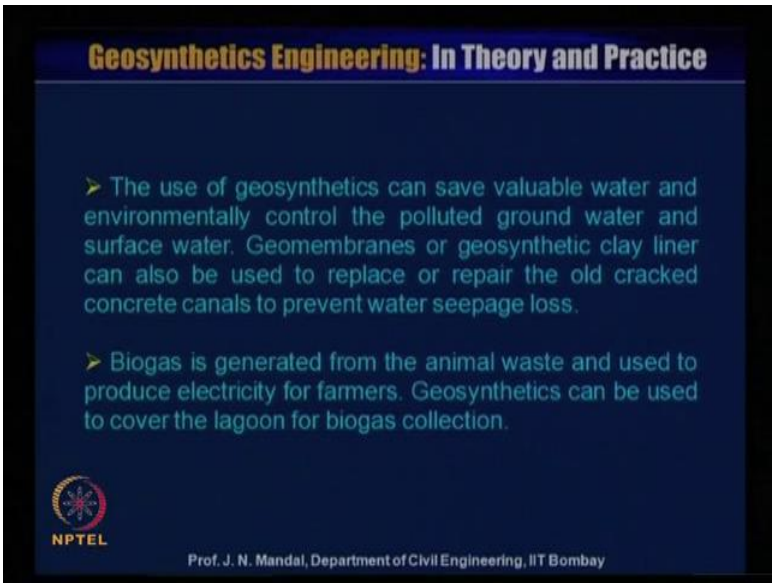

So, how the geosynthetics material used for the agriculture? The use of geosynthetics can save valuable water and environmentally control the polluted ground water and surface water. Geomembrane or geosynthetics clayliner can also be used to replace or repair the old cracked concrete canal to prevent the water seepage loss. I have already mentioned earlier that if there is a crack formation, how we can use this geomembrane material or the geosynthetic clay liner. Biogas is generated from the animal waste and used to produce electricity for farmer. Geosynthetics can be used to cover the lagoon for biogas collection.

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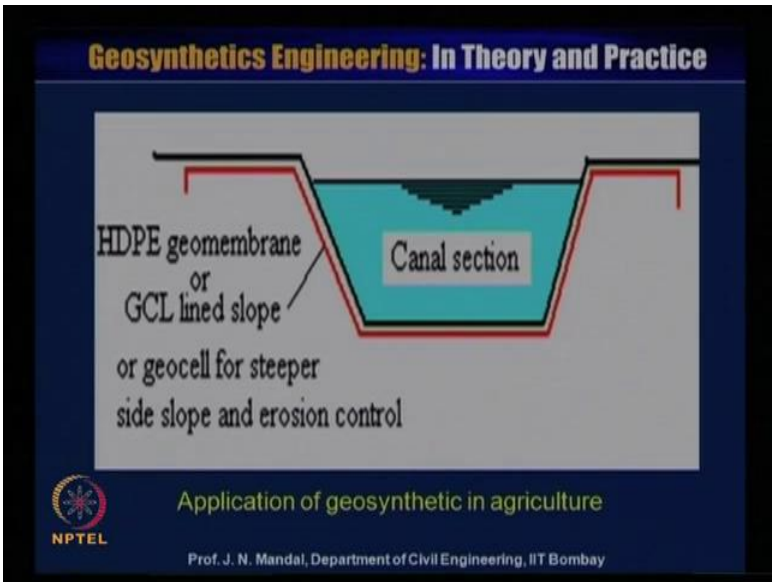

There are many, many use for the geomembrane or geosynthetics clay liner. Here we can see, that one canal section where we can place that red colour either high density polyethylene in geomembrane or you can use the geosynthetic clay liners cell or you can use the geocell for steeper sideslope and erosion control and there will be no seepage, okay?

So, how we can apply this geosynthetics in agriculture, then we can make use of the water for the agriculture purpose. Also, you can you can use this geosynthetic material for the cultivation purpose or there is a small kind of the tube, which it can be passes through the agricultural land and from some sources of water. Water can be just to pass through that tube and it is a kind of woven geotextile material. It is in the, it is in the form of tube and water can be passed through that tube. It is a kind of woven and material, so it has an apparent opening size or equivalent opening size and waters can spread across the agricultural land in different location.

So, you need sometimes that proper quantity of water for a particular plant, so you can also distribute the water accordingly. So, this is also one way you can use the geosynthetics material for agricultural purpose. Also about the cow dung, also you can put it the huge quantity of cow dung in USA ((Refer Time 33:48)). Then you do not know how to control it and then also they are with the use of the geomembrane, it has

been controlled and from that cow dung also they can use the biogasor electricity geosynthetic application for mining engineering.

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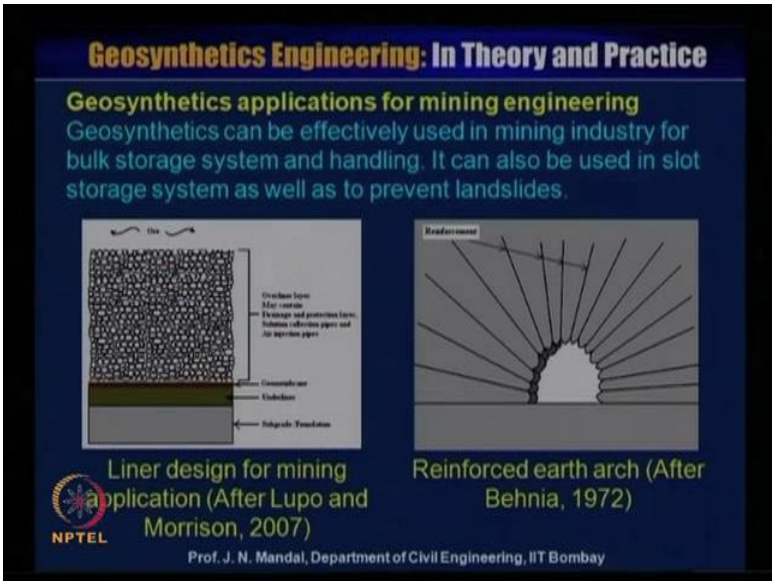

Geosynthetics, can be effectively used in mining industry for bulk storage system and handling. It can also be used in slot storage system, as well as to prevent the landslide. You can see that on the left hand side, slide the linear, liner design for mining application this is after Lupo and the Morrison, 2007, where you can see that here, there is a subgrade and how this geosynthetics material or the geomembrane material is used? You can see that this is the our all kind of the mining ore is here. So, it should be contaminated the ground, so that is why you are providing a layer of the geomembrane material to control the seepage.

Also, right hand side, you can see the reinforced Earth arch this is after Behnia,1972. Even then below the mining, so you can construct a tunnel like this. This is the reinforcement, this is the reinforcement and you can make a stable structure, because in the mining sometimes most of the time this kind of the tunnel it collapse, because for instability of this tunnel. So, you can provide with this kind of the reinforcement material that the metallic, reinforcement material and also you can form a tunnel and people can easily go and come. You can make a much more stable reinforced Earth arch.

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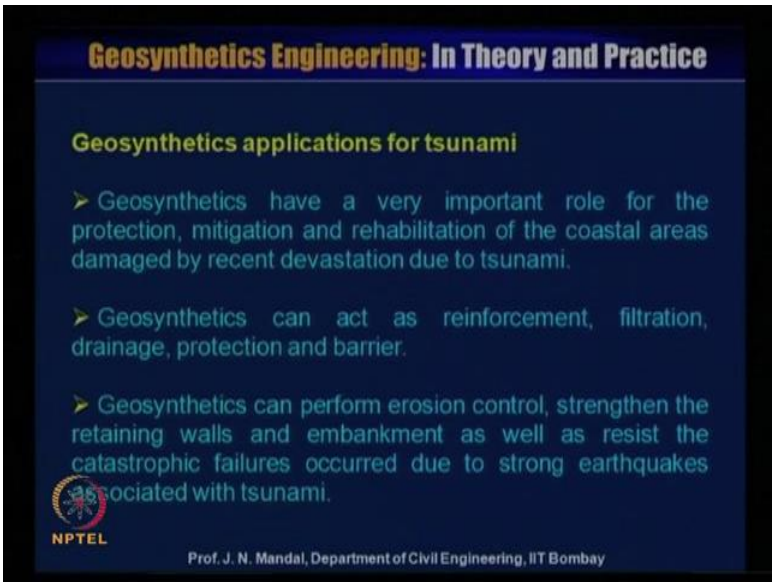

Now, this is geosynthetics application for tsunami. geosynthetics have a very important role for the protection, mitigation and rehabilitation of the coastal area damaged by the recent devastation, due to the tsunami. Geosynthetics can act as reinforcement, filtration, drainage, protection and barrier. Geosynthetics can perform erosion controls, strengthen the retaining wall and embankment, as well as resist the catastrophic failure, occur due to the strong earth quake associated with the tsunami.

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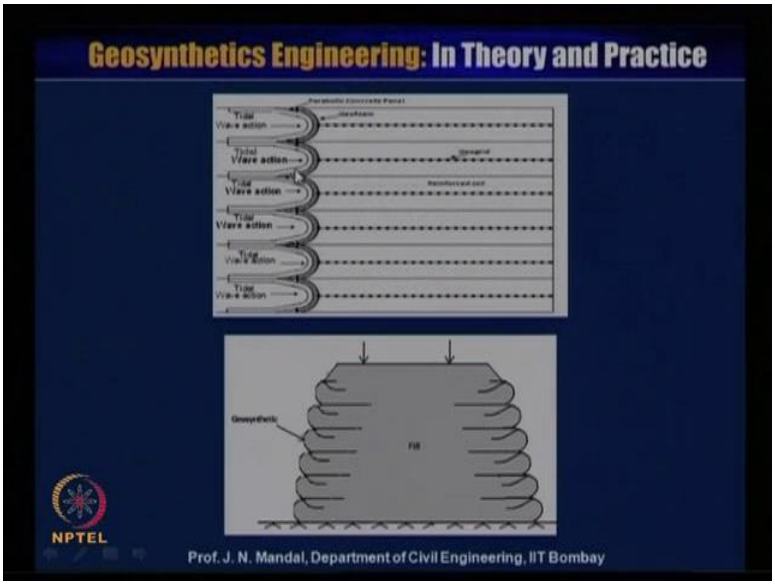

So, how we can control this? You can see that this is near to them, since forth, where you can construct a reinforced soil wall, this is the reinforcement and there is a development of the pressure and which can be controlled by this facing element. Here, most typical, this is the facing element, this is the wave is acts towards the spacing element.

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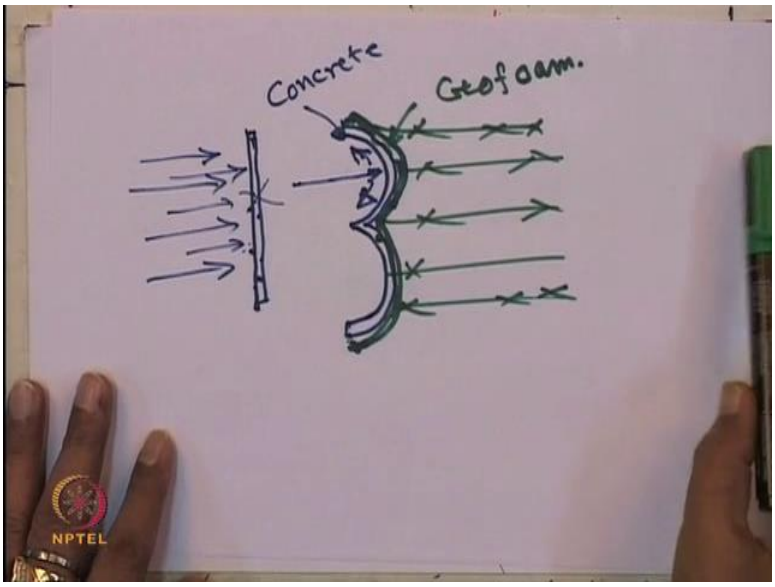

Now, if you simply can place this, if you can simply place a concrete like this and this all the wave, then it will attract this facing of element, which is made of the concrete, because this is a rigid. And there is a possibility for breaking this kind of the concrete because however the force applied on this concrete, it is direct applying on the concrete and this is a rigid, so most of the time it fail.

Alternatively, if we can provide with a kind of the semicircle concrete block like this, so whatever the force then it should be diverted like this. So, you can minimize the wave which is exactly here and also same time you are providing with a layer of geofoam material, here this is a geofoam material, here. It is a geofoam material. This is the geofoam, this is geofoamand this is the concrete, this is the concrete block.

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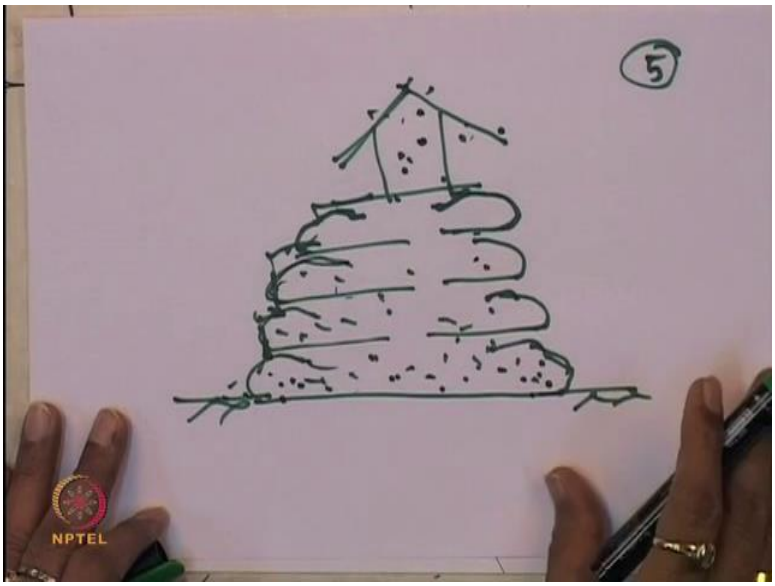

So, and when we are placing this number of layer of the geogrid material here, so you can see that when any pressure attract this and this geofoam material has a very good compressibility characteristic. So, it can be resisted by the geofoam material and also at the same time the lateral Earth pressure can drastically reduce. So, you can adopt this kind of the system to protect the Tsunami and most of the time you can see that when the Tsunami comes and the people run away they do not know what to, where to go, where to run, where to stay.

So, you can construct a kind of this, kind of the structure near to the sea shore and it is very simple, very simple. So, you can place this non woven geotextile material and can wrap it like this, then you can make like this then you can make like this so any height you can construct like this and these all slide filled up with the sea material you can fill up with the sand you can make it like this, like a wrapping system of wall, so this also we will, we will study, so near to the sea shore you can construct a wall like this and people can go up, very fast can go up, on the top of this and you can make a shelter.

There also house for temporary to protect themselves most important, that how you can protect the people. So, you can easily construct this kind of, this is the geosynthetics material. This is a flexible material, this may be the woven and non woven geotextile material and you can have locally near to the sea shores and you fill up and construct this

wall and on the top. You can make a house or something shelter, so as height as you can do.

All this people can run and can stay here and this is much more stable structure, because even then the water comes, because this is for filtration and drainage this is nothing will happen. So, most important that, how to protect the people? This is very important, to save the people, to save the life of the people. So, this kind of the system can be useful, so geosynthetic application.

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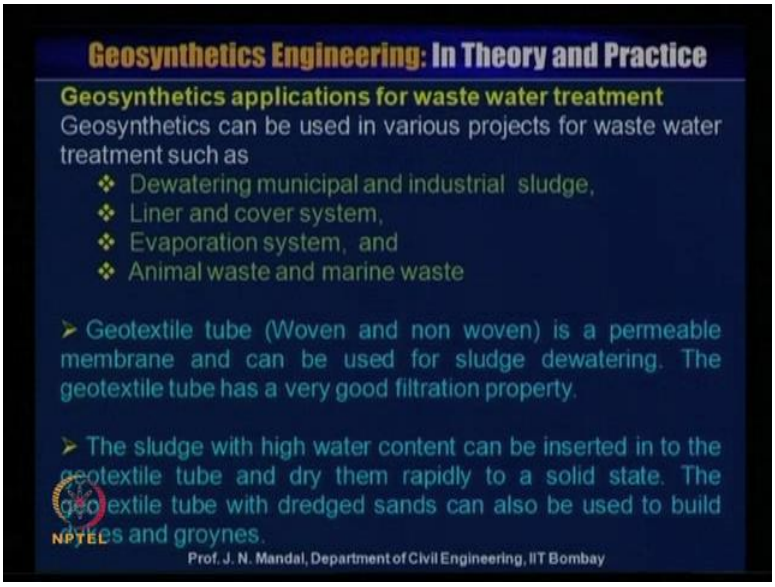

For waste water treatment geosynthetic can be used in various project for waste water treatment such as: dewatering municipal and industrial sludge, liner and cover system, evaporation system and animal waste and marine waste. Geotextile tube is made of woven and non woven geotextile material is a permeable membrane and can be used for sludge dewatering. The geotextile tube has a very good filtration property. The sludge with high water content can be inserted into the geotextile tube and dry them rapidly to a solid state. The geotextile tube with dredged sand can also be used to build the dykes and groyres.

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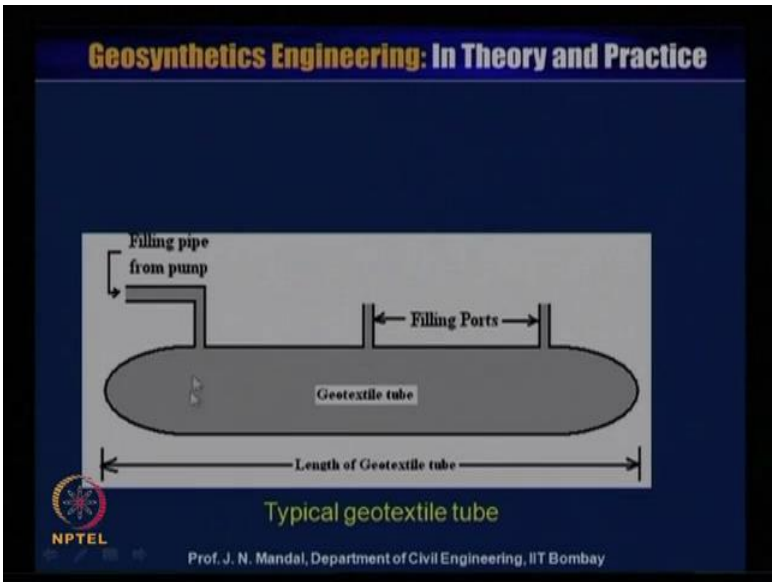

You can see, this is a geotextile tube and that you have to fill all kind of the draining material and fill it to the pipe from pumping and filled up. This is nothing, but a tube and then it can be filled up this is a filling part. So, this is the length of the geotextile tube and fill up and then you can apply the load and then water can be coming out from the geotextile tube. I will later also explain more about this.

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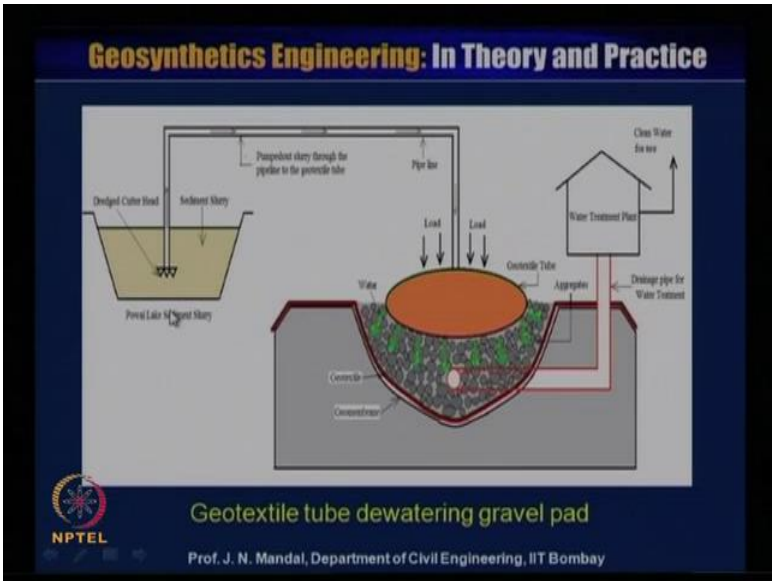

You can see here, for example, this is the Powai Lake sedimentary soil, so this is the dredged cutter head and this is all sedimentary slurry and they you can pump it out and

pumping through the pipe line and this is the geotextile material, this is geotextile material and you are applying some load here and at the base you are providing with the geomembrane material and the geotextile material. So, due to the geomembrane there will be no loss, no water can circulate through this all the contamination or the drainage dirty water contamination water, which it can comes out from the geotextile tube due to the application of the load.

Then it can be drained it out to the water treatment plant and this drainage pipe for the water treatment, for the water treatment plan can be made and you can have a very clean water for use. So, also this geotextile tube also you can put to the near to the for example, that PowaiLake.

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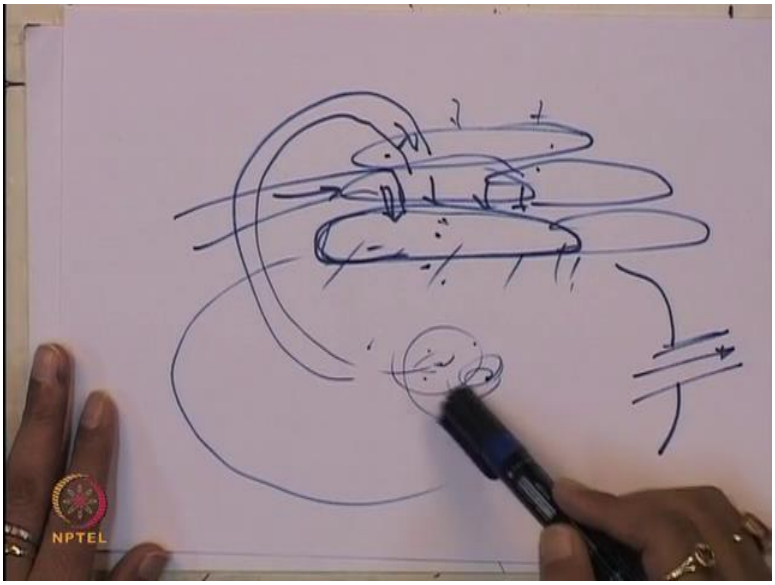

You can make a, it is a length of geotextile tube, you can insert the all kind of the contaminated here and then you applying the load and then water can be drained it out and the soiling area of the Powai Lake you can provide with a kind of line, which can be drained it out after the process of time. You can see this, Powai Lake is absolutely clean and this geotextile tube you can keep it as, it is then one after another one after another. You can also construct this embankment, so we are using this all kind of sediment here, pumping it to the geotextile tube. Then you are applying the load, so you can use both as a geotextile tube for the construction of embankment and also you can protect the lake.

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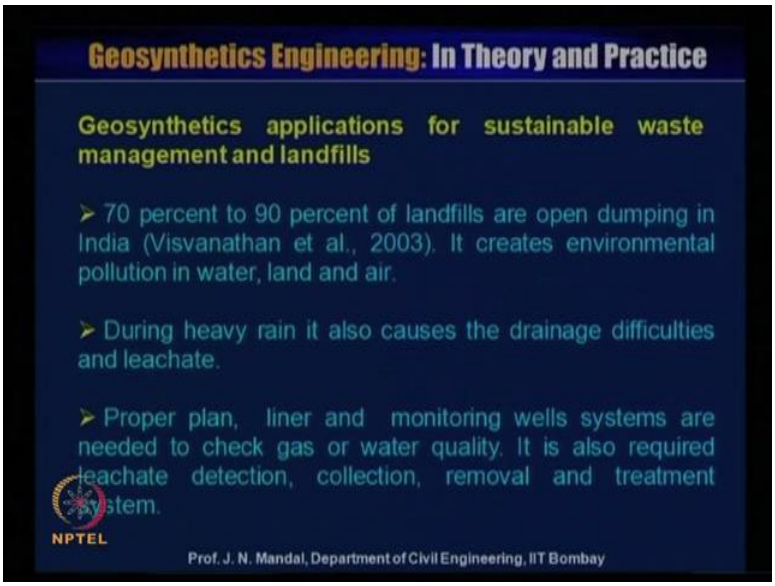

So, geosynthetic application for sustainable waste management and the landfill 77. Now, I will begin geosynthetics application for sustainable waste management and landfill 70 percent to 90 percent of the landfill are open dumping in India, Visvanathan et al 2003. It creates environmental pollution in water, land and air. During heavy rain it also cause the drainage difficulty and leachate. Proper plan, liner and monitoring oil system are needed to check gas or water quality. It is also required leachate detection, collection, removal and treatment system.

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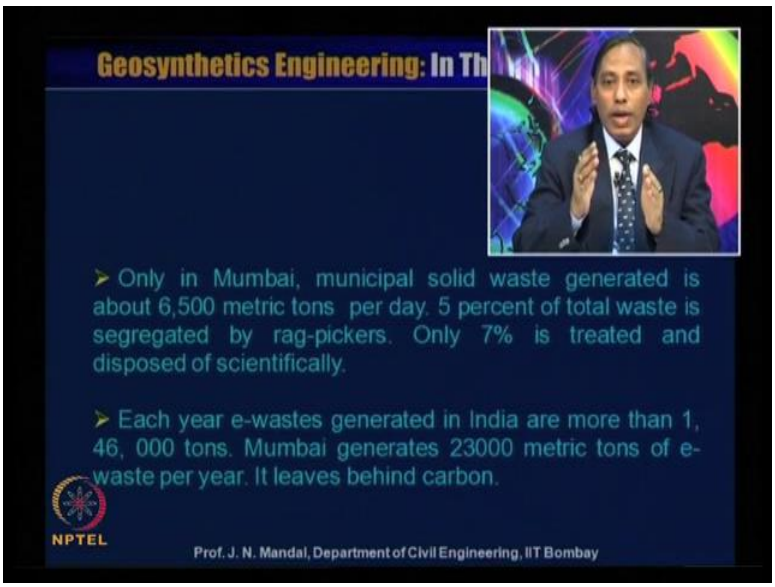

Only in Mumbai, municipal solid waste generated is about 6,500 metric tons per day. 5 percentage of total waste is segregated by rag picker. Only 7 percent is treated and disposed of scientifically. Each year e-waste generated in India are more than 1,46,000 ton mumbai generated 23,000 metric ton of e-waste per year, it leaves behind carbon.

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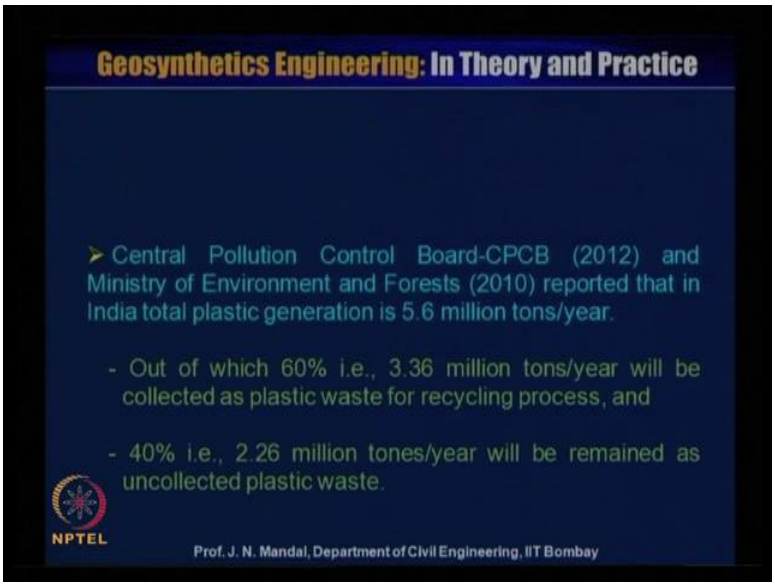

Central pollution control board-CPCB 2012 and Ministry of Environmental and Forest 2010, reported that in India total plastic generation is 5.6 million ton per year. Out of which 60 percent that is 3.36 million ton per year will be collected as plastic waste for recycling process and 40 percent that is 2.26 million tons per year will be remained as uncollected plastic waste. So, we also show later on that how we can use that plastic in different project.

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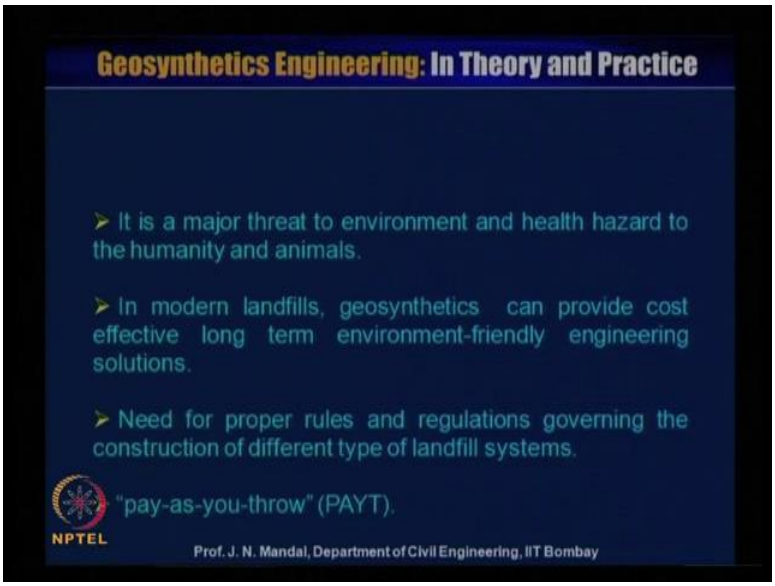

So, it is a major threat to environment and health hazard to the humanity and animal. In modern landfill, geosynthetics can provide cost effective long term environmental-friendly engineering solution. Need for proper rules and regulation governing the construction of different type of the landfill system. Pay as you throw.

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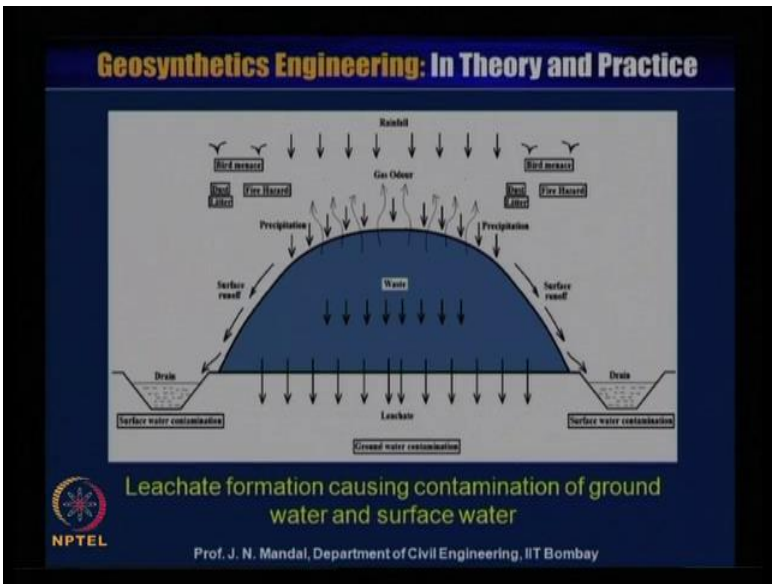

So, this figure you can see that leachate formation caused, during the contamination of ground water and surface water. You can see this is all kind of the waste material and this top if you do not provide any kind of the geosynthetics material, that will be surface

run up which can be drained it out with the surface water will be contaminated. Also, from the waste material, it will pass through the ground water willbe also contaminated and leachate also will form and deep in the waste material there is any formation of the gas, then gas will move to the air.

Sometimes, also you can see some birds also appear in the landfill slide there is a dust there is a sometime fire also happens in the landfill that also the fire hazard and also there will be the precipitation. So, you need to control if there is a formation of the leachate and that due to happen due to contamination of the ground water and the surface water.

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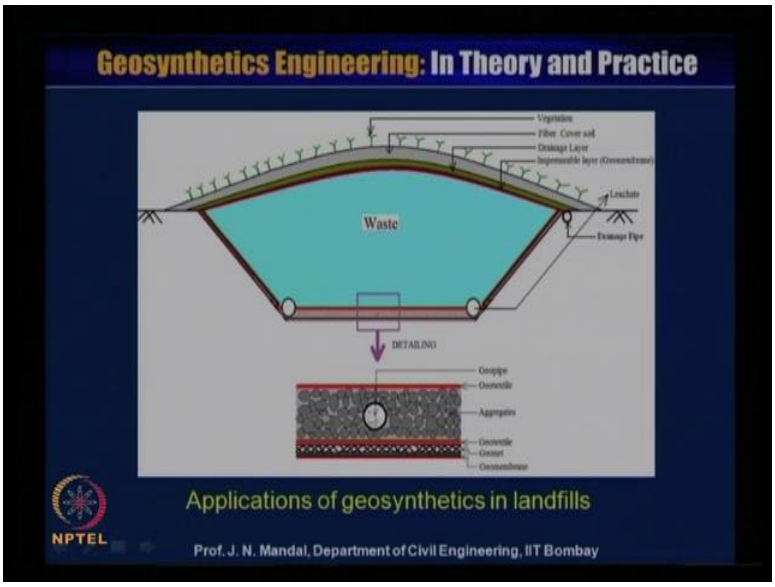

So, you can provide with at the base you can provide with the with the geomembrane material, geonet material, geotextile material.You can provide with the kind of the geo pine material, at the base which you can protect the contamination towards the ground. So, geosynthetics material system can protect in the landfill and at the same time you have to provide the top with the cover or you can use the impermeable material, drainage material. And then you can cover with the soil or there are many system and you can put on the top of the cover with the clay and then the grass can grow. So, you can see that one system will also study more about the design and analysis of the landfill. I will focus one of my chapter, so I am not going detail about this landfill system here.

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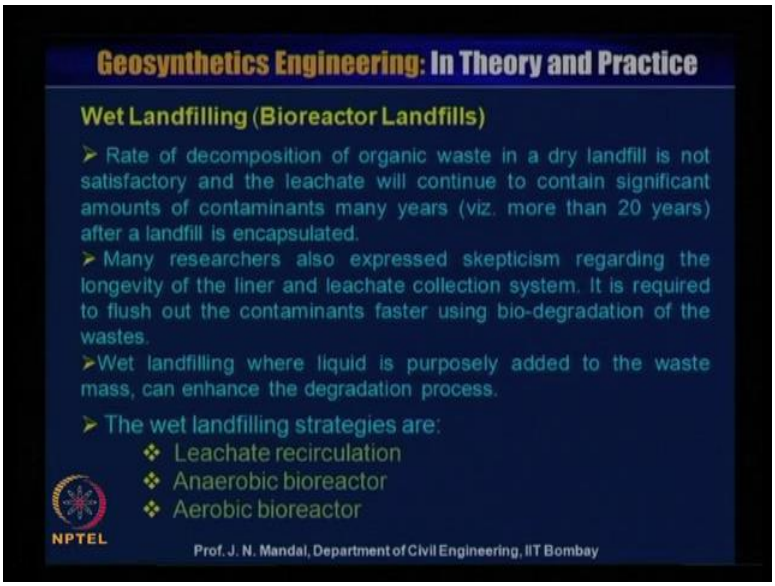

So, wet land filling, that is bioreactor landfill. Rate of decomposition of organic waste in a dry land fill is not satisfactory. The leachate will continue to contain the significant amount of contaminant may many years that is more than 20 years after the landfill is encapsulated. Many researcher also express skepticism regarding the longevity of the liner and leachate collection system. It is required to flush out the contaminant faster using biodegradation of the waste. Wet land filling where liquid is purposely added to the waste mass can enhance the degradation process. The wet landfill strategy are: leachate recirculation, anaerobic bioreactor and aerobic bioreactor.

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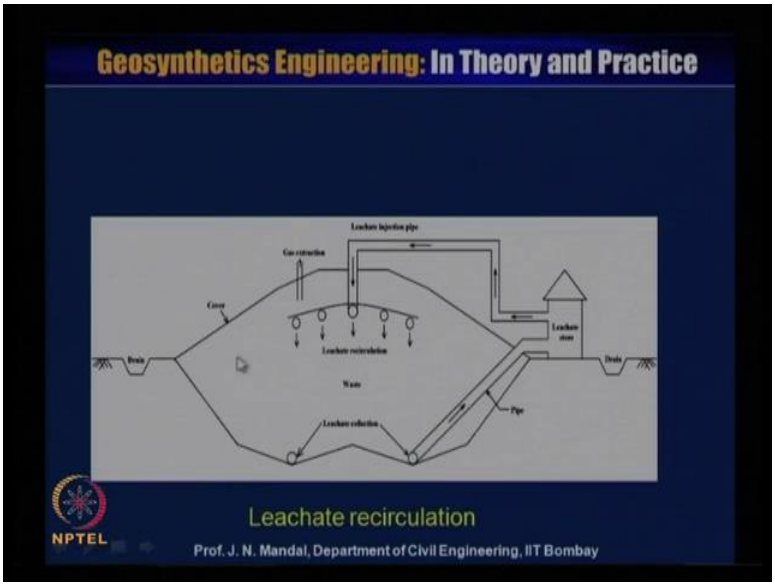

You can see here, that one of the landfill system this is the leachate here, is the leachate collection. There is a drain and this drained it out through the pipe and here you can leachate storage and again this leachate is re-circulated through this pipe here. So, this leachate, is leachate is re-circulating here and from this you are also providing some cover and also the drainage and you can see from this. You can generate the gas can be exhort from here. So, you can use for the electricity, also you can use for the cooking gas by the leachate recirculation system.

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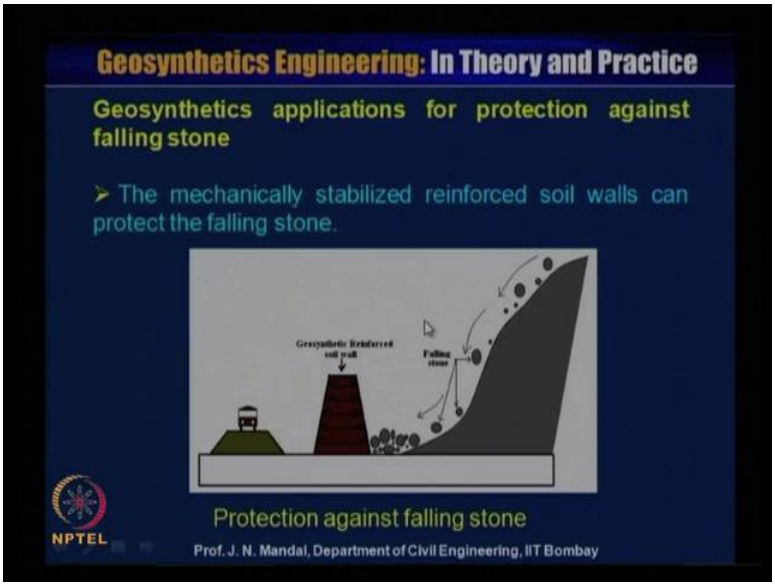

Now, geosynthetic application for protection against falling stone. You can see that any hillside area where there is a possibility for the stone falling, and then there if there is a road car is passing that means lot of problem, you can see also in Pune road, also that for Konkan railway, also we can see this kind of the problem. So, we can provide with the mechanical stabilized reinforced wall, which can protect the falling the stone. So, you can also protect against the falling the stone. You can see the car can move the safety, so how this geosynthetic system can be used to protect the falling stone?

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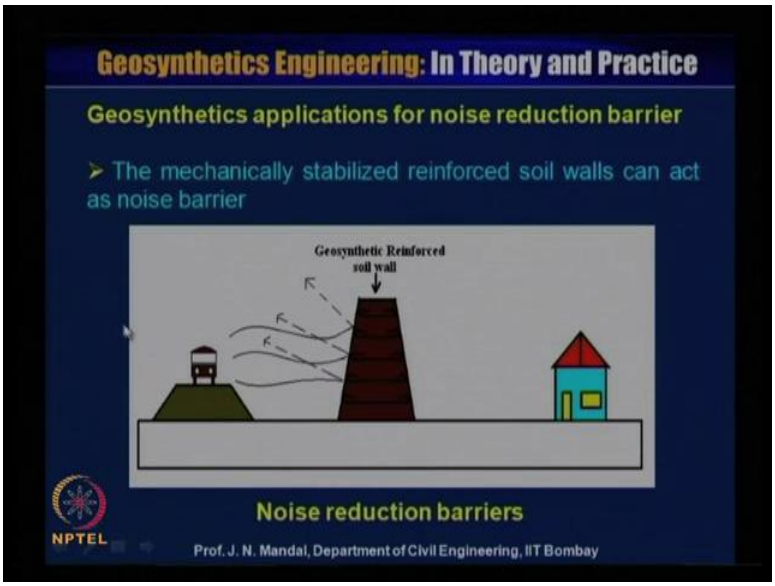

Now, the geosynthetics application for noise reduction barrier. Most of the time, you can see that both side of the road something car of vehicle is passing there is a lot of the noise, but you can provide with the mechanically stabilized reinforced soil wall which can act as a noise barrier. So, any sound or system is good and reflect it back. You can also use the geofoam material and you can see if there is any house, so they will not be disturbed due to the noise, so they are on the safe, no noise and this also very cheaper with respect to the conventional system. So, here we are saying that how the geosynthetics material used as a noise reduction barrier.

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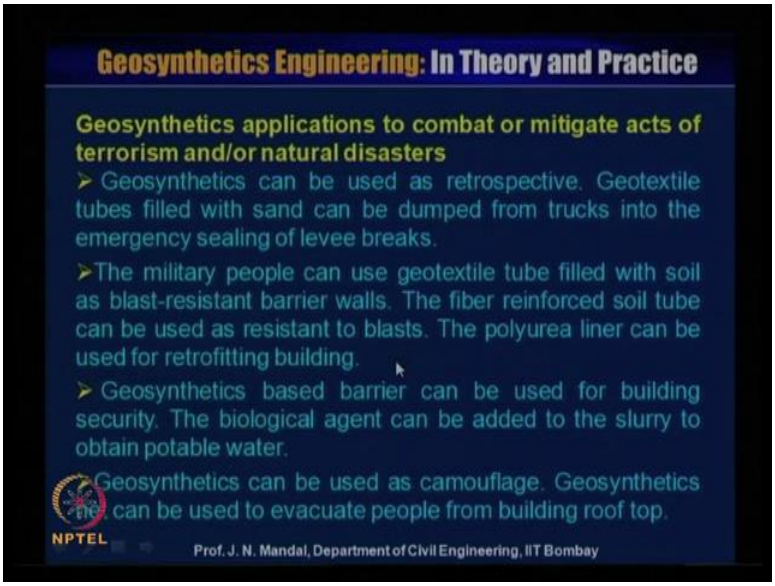

Now, geosynthetics application to combat mitigation act of the terrorism and or natural disaster. Geosynthetics can be used as a retrospective. Geotextile tube filled with the sand can be dumped from the truck into the emergency sealing of levee break. The military people can use the geotextile tube filled with the soil as blast resistance barrier wall. The fiber reinforced soil tube can be used as resistant to blast the poly urea liner can be used for retrofitting building. Sometimes you know there is a possibility for attack for terrorism in the building or any place.

So, you can provide the wall proper kind of poly urea lining which can protect the building from the retrofitting and also building from the terrorist. Geosynthetics based barrier can be used for building security, the biological agent can be added to the slurry to obtain the potable water. Geosynthetics can be used as camouflage geosynthetics net can be used to evacuated the people from the building roof top. So, we can see that how this geosynthetics can be used in the various activity.

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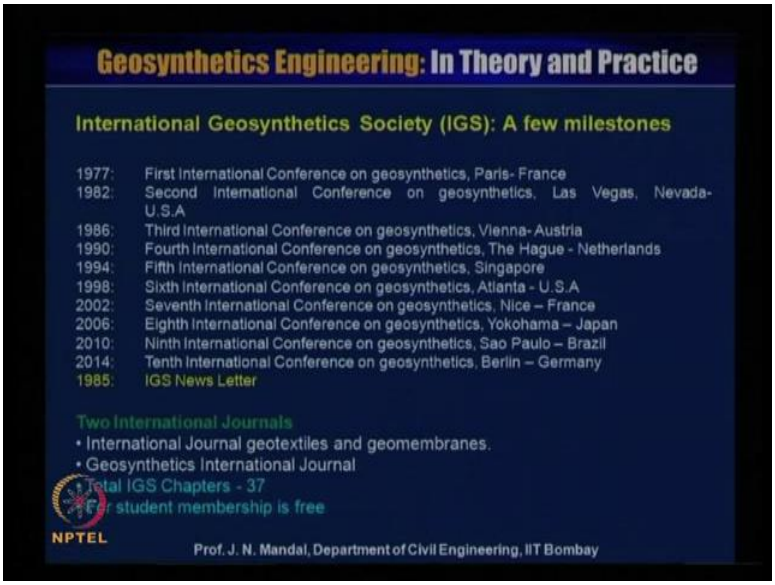

Sometimes, in the terrorism we have to provide proper kind of the geosynthetics system in the building. You can al, make the grill building. There are different types of the system, you can make grilled building, will be the grilled and also you can make the greenery of surrounding area using this geosynthetics system, then you are not to put the water for many days, so the plant can survive. Now, there is lot of green building are

coming up. While, in international geosynthetics society, I am showing these slides some few milestone.

1977 first international conference on geosynthetics held in Paris and France, initial its name of the first international conference on the fabric. But we considered this as a first international conference on geosynthetics, 1992. Second internationalconference on geosynthetic in Las Vegas, Nevada, USA, 1986; third international conference on geosynthetics in Vienna, Australia, 1994; fourth international conference on geosynthetics the Hague, Netherland, 1994; Fifth international conference on geosynthetics in Singapore, 1998; sixth international conference on geosynthetics Atlanta, USA 2002.

Seventh international conference on geosynthetics in Nice, France 2006. eighth international conference on geosynthetics Yokohama, Japan 2010, ninth international conference on geosynthetics in Sao Paulo in Brazil and 2014, tenth international conference on geosynthetics in Berlin, Germany in 1985. They have come up with the International Geosynthetics Society news letter, now edited by professor from Germany and you that we have the two international journal. That is, International Journal on Geotextile and Geomembrane and the second journal is Geosynthetics International Journal. You shall it as name also geotextile and geomembrane, then there is a lot of debate discussion about geotextile geomembrane natural material jute coir.

So, ultimately we cover that entire that geo systems comes under the umbrella of geosynthetics, that is why the second international conference journal has come with geosynthetics international journal. We have the total international geosynthetics chapter about thirty seven and particularly for the student membership is free, so you can you can make use of this of these societies benefit what is the role of Indian Institute of Technology, Bombay, 1985.

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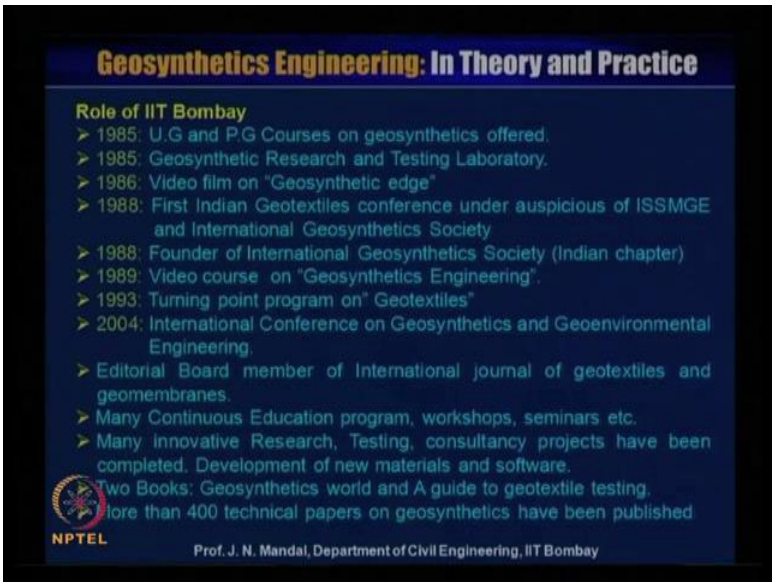

We have an undergraduate and post graduate course on Geosynthetics 1985, Geosynthetics Research and Testing Laboratory 1986. We make a video film the title of the film is Geosynthetic Edge, 1988. That is the first Indian geotextile conference under the auspicious of international society for soil mechanics and geochemical engineering and international geosynthetic society, 1988. Founder of International Geosynthetic Society, Indian chapter in IIT, Bombay.

These are all in first times in India and 1989 video course on geosynthetics engineering 1993 turning point program on geotextile in TV in 2004, International conference on geosynthetics andgeo environmental engineering from IIT. There is a editorial board member of International journal of geotextile and geomembrane from India in IIT. That is the first time editorial board member in International Journal of Geotextile and Geomembrane.

You have a many continuous educational program, workshop seminar, have been conducted, many innovative research testing consultancy project have been completed, development of new material. And software two books geosynthetics world and a guide to the geotextile testing more than 400 technical paper on geosynthetics have been published.

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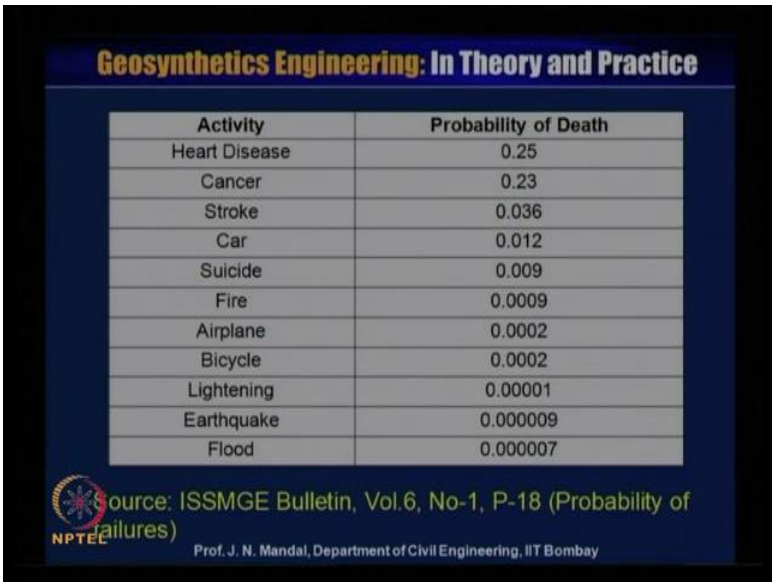

This site source from International Society Soil Mechanics, and Geochemical Engineering, bulletin volume 6, number 1. One probability of failure, if you look this activity and the probability of death, you can see from the heart disease it is 0.25, cancer 0.23, stroke 0.036, car 0.012, suicide 0.09, fire 0.009, airplane 0.0002, bicycle 0.0002, lightening 0.0001, earthquake 0.00009, flood 0.000007.

You look at this chart, this is the probability which has been given that we are spending much more money may be on the earthquake, or so related problem. Where probability of death is less, but you can see that in some or the civil engineering infrastructure the probability is less than the medical and others, so with this I just finish my today's lecture. Please let us hear from you. Any question?

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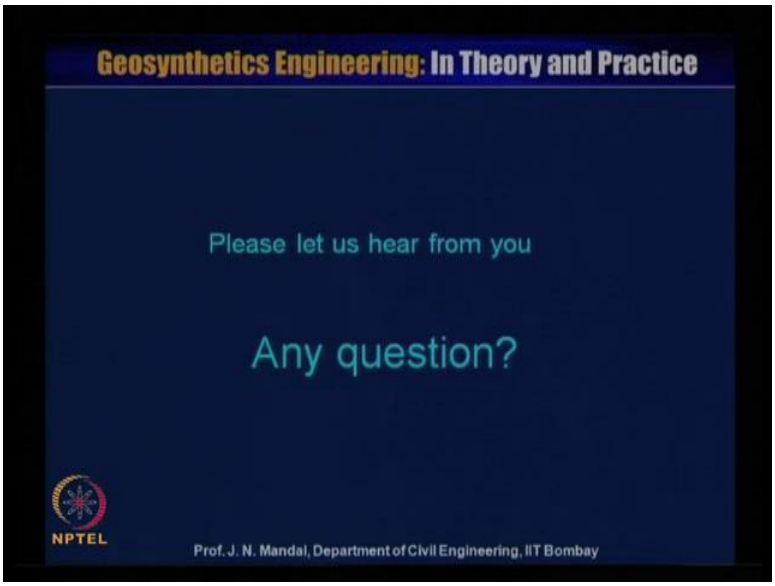

Thanks for listening.