Geosynthetics Engineering: In Theory and Practices
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Lecture - 53
Design of Geosynthetics for Landfills

Dear student warm welcome to NPTEL phase two program video course on geosynthetics engineering in theory and practice. My name is Professor J. N Mandal, Department of Civil Engineering, Indian Institute of Technology, Bombay, Mumbai, India. This module twelve lecture number fifty has three designs of geosynthetics for landfill.

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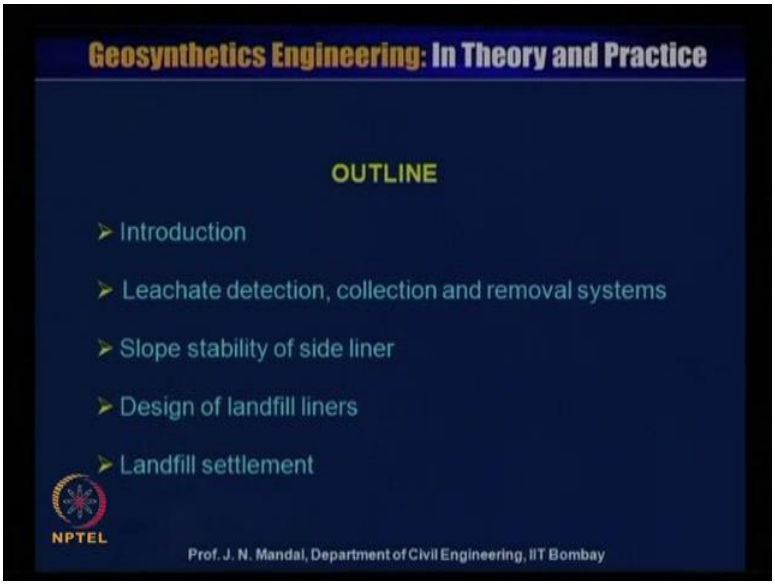

The outline of this present course introduction, leachate detection, collection and removal system, slope stability of side liner, design of landfill liner and landfill settlement.

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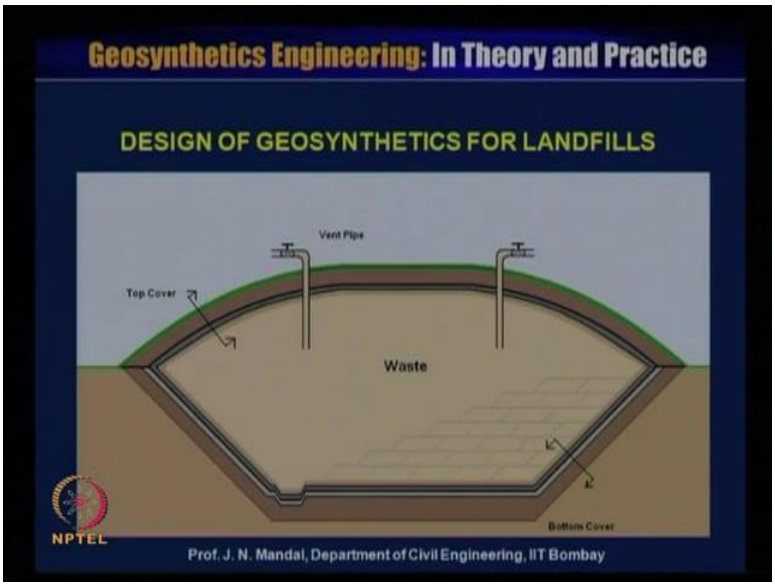

So, for any design of the geosynthetics for the landfill, you can see here this is the landfill and this is the waste material and this is the top cover. So, protection of the top cover soil layer is required and it depends upon whether it is a municipal and the ash landfill cover, it generally takes about 300 to 600 millimeter. If it is an industrial landfill cover, it takes about 450 to 900 millimeter and if it is a hazardous material landfill then cover will be 750 to 1200 millimeter. In case of rollover radioactive material cover will be about 1200 to 2000 millimeter.

So, what will happen in case of the waste, how the ground water will be polluted, so what should be the mechanism you have to provide with the liner on the bottom of these slides and also the side slope it is required. This is also implemented since the 1970s and most of the cases that production of this geomembrane or geosynthetics clay liner is for not properly available the loom in India and some other developing countries. So, if you do not provide the proper kind of the liner, so there is a problem for the pollution, so it should require proper kind of the liner otherwise it will pose the threat of the pollution.

What we use in general that compacted clay liner is called CCL value so far in the conventional method. And in case of the compacted clay liner whose coefficient of permeability also varies from 1 into 10 to the power minus 6 to 5 into 10 to the power minus 8 centimeter per second, and this is quite very satisfactory result are given. But then what is the problem? There are two problems, so this one problem is that you have

to provide about 900 millimeter to 1500 millimeter of thickness of the compacted clay liner. That means you require that good quality of the soil, then also it is very difficult to compact and second problem is that there is a possibility that chemical reaction with the waste also there is shrinkage or the xylene or the methyl or the any acidic acid formation.

So, these are the main two kinds of the problem with the conventional landfill system. So, this also give that environmental and the health concern, so we have observed that different type of the hazardous it may be the low level hazardous, it may be the in toxic waste hazardous. It may be any construction or the demolition material, it may be the flyers how you can put it in to the landfill side.

It also the intoxicated any kind of the waste or it may be any river or the harbor sediment also the biological or what is called hospital what is called case waste. So, how you can protect this kind of the wasted material and particularly even then radioactive waste material. So, also household hazardous waste like a newspaper, corrugated paper, even then office paper. So, this is why that we require understanding that how this geosynthetics can help for the landfill system.

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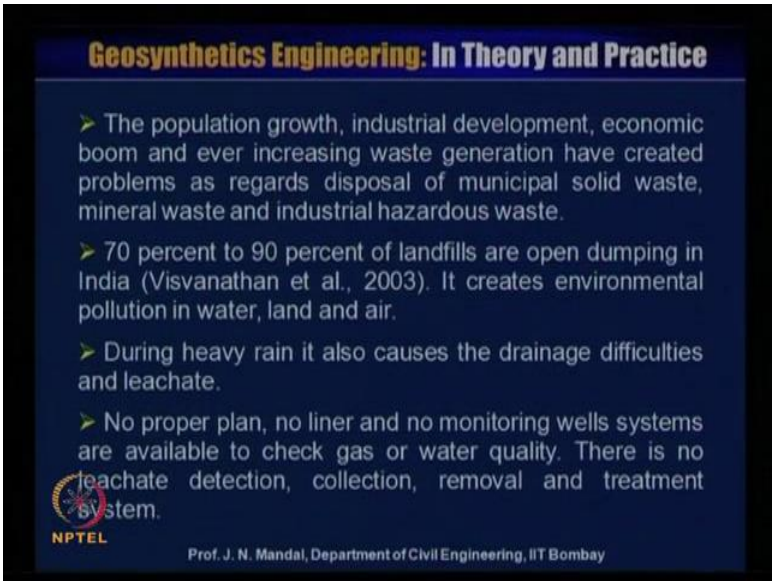

So, population growth industrial development, economic boom and ever increasing waste generation have created problems as regard disposal of municipal solid waste, mineral waste and industrial hazardous waste. 70 percentage to 90 percentage of the landfill are open dumping in India Visvanathan et al 2003, it creates environmental

pollution in water land and air. During the heavy rain it also causes the drainage difficulties and leachate. No proper plan, no liner and no monitoring wells system are available to check gas or water quality. There is no leachate detection collection removal and treatment system.

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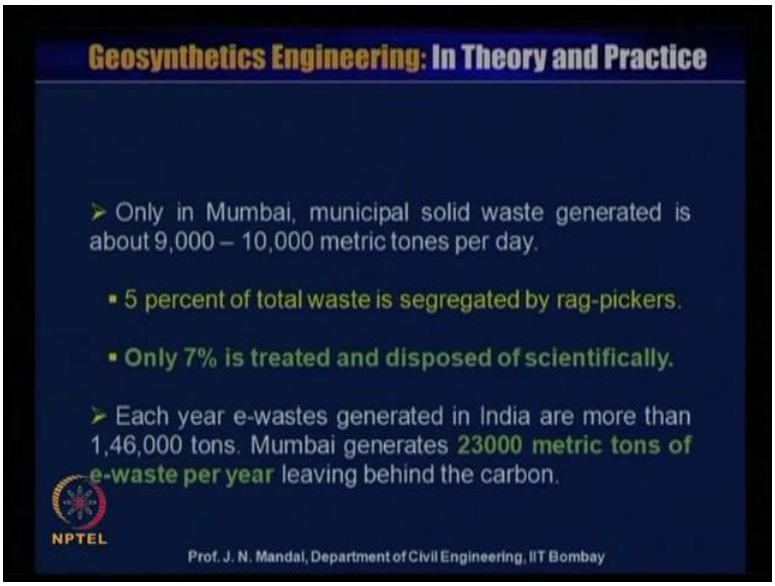

Only in Mumbai municipal, solid waste generated is about 9000 to 10,000 metric tons per day, five percent of the total waste is segregated by rag picker. Only seven percent is treated and disposed off scientifically, each year e-wastes generated in India are more than 1,46,000 tons. Mumbai generated 23,000 metric tons of the e-waste per year leaving behind the carbon.

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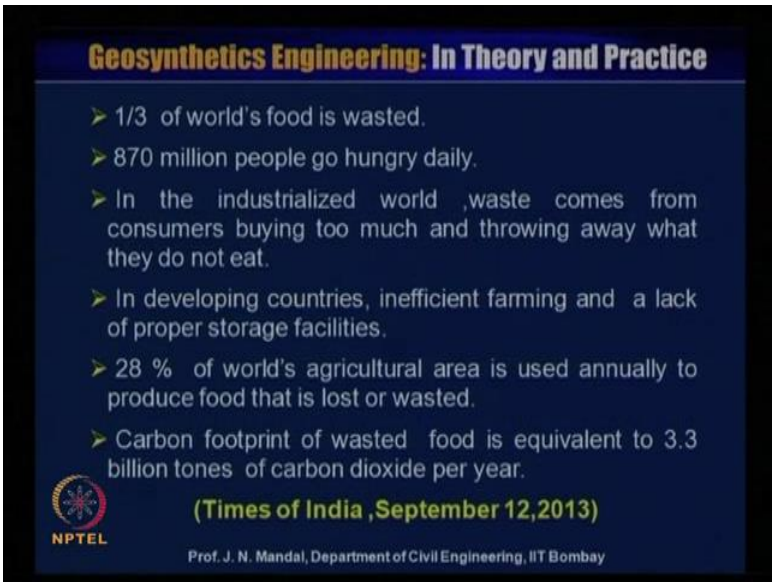

So, one third of the world food is wasted, 87 million people go hungry daily. In the industrialized world, waste come from consumer buying too much and throwing away what they do not eat. In developing countries it is inefficient farming and a lack of proper storage facilities. 28 percentage of the world's agriculture area is used annually to produce the food that is lost or wasted. Carbon footprint of wasted food is equivalent to 3.3 billion tons of carbon dioxide per year as per times of India September 12 2013.

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Central pollution control board C P C B in 2012 and the ministry of environmental. And

forests 2011 reported that in India total plastic generation is 5.6 million tons per year that means 60 percentage, that is 3.36 million tons per year will be collected as plastic waste for recycling process. 40 percentage, that is 2.26 million tons per year will remain as uncollected plastic waste. It is a major threat to environment and health hazardous to the humanity and animals need proper rules and regulation governing the construction of different type of the landfill system.

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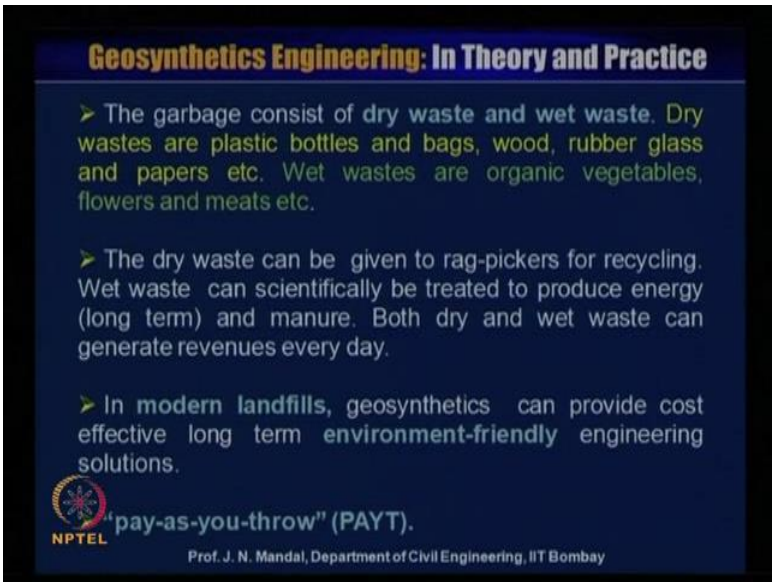

The garbage consist of the dry waste and the wet waste dry waste are plastic bottle and bag wood rubber glass and paper etcetera wet waste are organic vegetable flower and meats etcetera. The dry waste can be given to rag picker for recycling; wet waste can scientifically be treated to produce the energy that is the long term and manure. Both dry and wet waste can generate revenue every day in modern landfill geosynthetics, can provide cost effective long term environmental friendly engineering solution. You can adopt pay as you throw any developing country they are the landfill and with the landfill strip same they are generating, the revenue through the electricity and the gas and also entertainment program. So, for the landfill design system you required different types of the geosynthetics.

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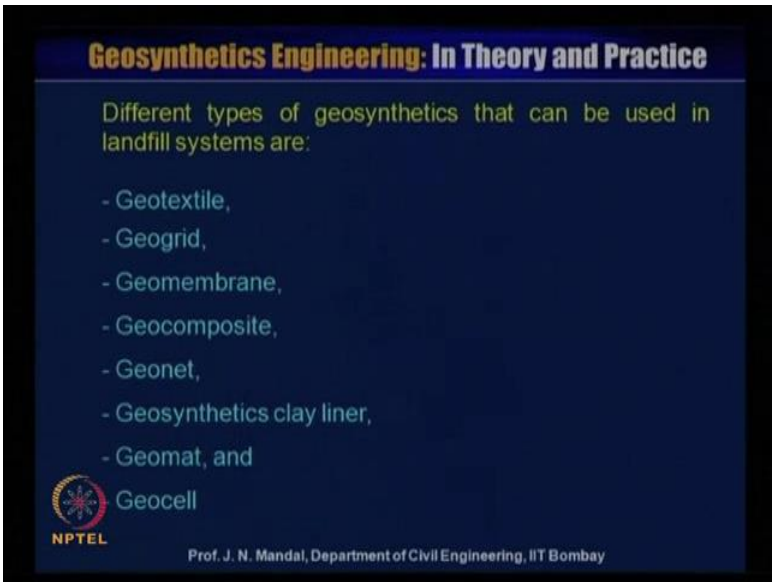

That can be used in the landfill system and they are geotextile, geogrid, geomembrane, geocomposite, geonet, geosynthetics, clay liner, geomat and geocell. Almost all type of the geosynthetics material is required for the design of the landfill system.

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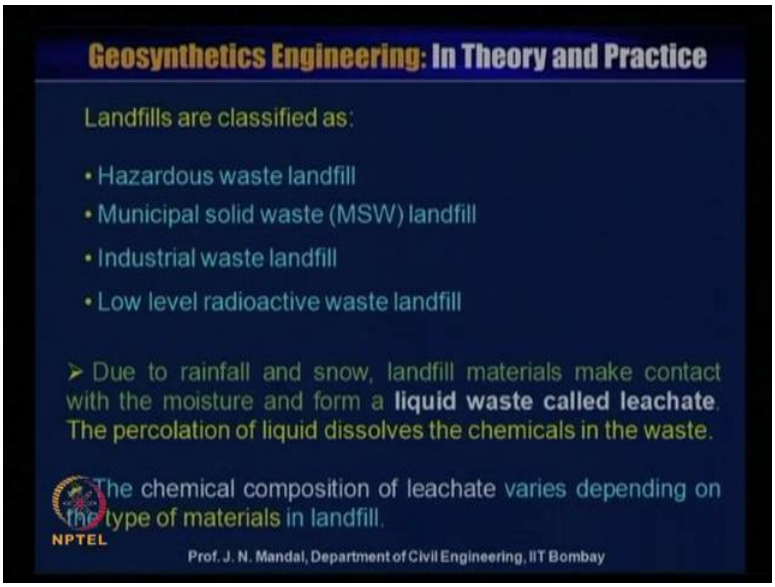

Now, landfills are classified as hazardous waste landfill, municipal solid waste landfill, industrial waste landfill and low level radioactive waste landfill. Due to the rainfall and snow, landfill material makes contact with the moisture and form a liquid waste called leachate. The percolation of liquid dissolve the chemical in the waste the chemical

composition of leachate varies depending upon the type of the material in the landfill.

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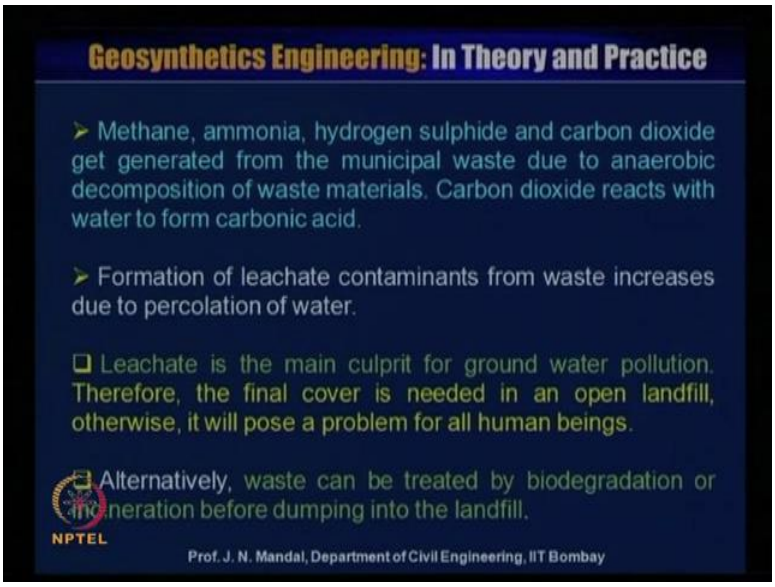

Methane, ammonia, hydrogen sulphide and carbon dioxide get generated from the municipal waste due to the anaerobic decomposition of waste materials. Carbon dioxide reacts with the water to form carbonic acid. Formation of leachate contaminant from the waste increases due to the percolation of water. Leachate is the main culprit for ground water pollution. Therefore, the final cover is needed in an open landfill, otherwise it will pose a problem for all human being. Alternatively waste can be treated by biodegradation or the incineration before dumping into the landfill.

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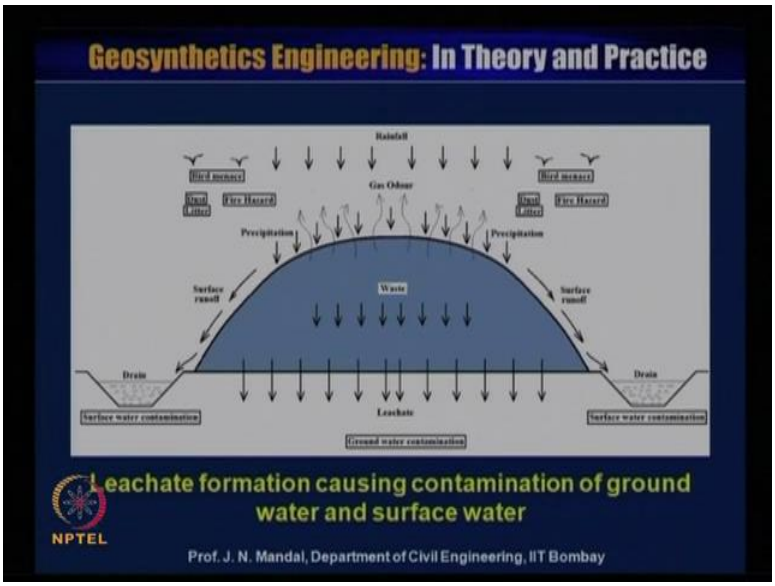

So, here you can see that leachate formation causing the contamination of the ground water and the surface water.

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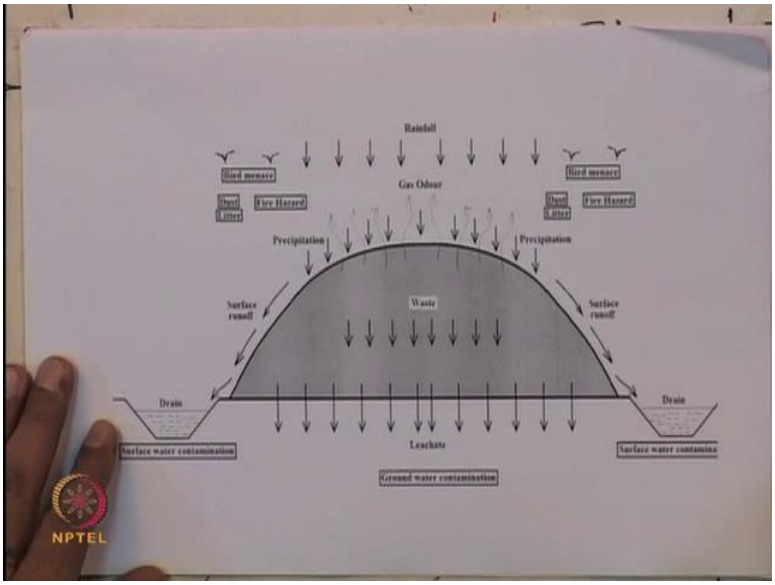

So, here you can see that this is the waste material and there is a possibility that any rainfall may occurs at if you keep it the open. This is the open landfill and rain water can pass through this landfill, also there is a surface runoff and which can be passed through the drain. So, the surface water also will be contaminated and also due to the rainfall and the rain can passes through the waste and then it will percolate to the ground, so there is

a formation of the leachate. So, leachate can pass through the ground and then ground water also should be contaminated, also there is a precipitation here and there is sometime also fire hazard.

I can show you some slide that fire hazard; how this has been fire in the landfill there is a dust litter. Also birds sometimes means also comes here, so you should address here that whether the waste is hazardous, or whether the waste can be can be put it to the landfill if there is a formation the leachate and how the treatment can be done in for this ground surface.

Also you have to check that water how to has to monitor, also you should know what will be their physical properties of the waste material or how we can design the landfill. How will be operational of the landfill, also most important that safety precaution of the landfill operation and inspection and how the waste can also be reduced.

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So, here some of the slide you can see that this is the open sanitary landfill Okhla in Delhi. So, if you can open it and rain water, what may happen? All ground water will be contaminated. This is the Mumbai Devanar, that landfill you can see this is absolutely open landfill, here also Mumbai Mulund landfill. You can see here is a fire, it is fire a smoke here and also here is a Mumbai Devanar landfill. You can see that water is stagnant, all kind of the waste material how it has polluted the ground water, also the environmental.

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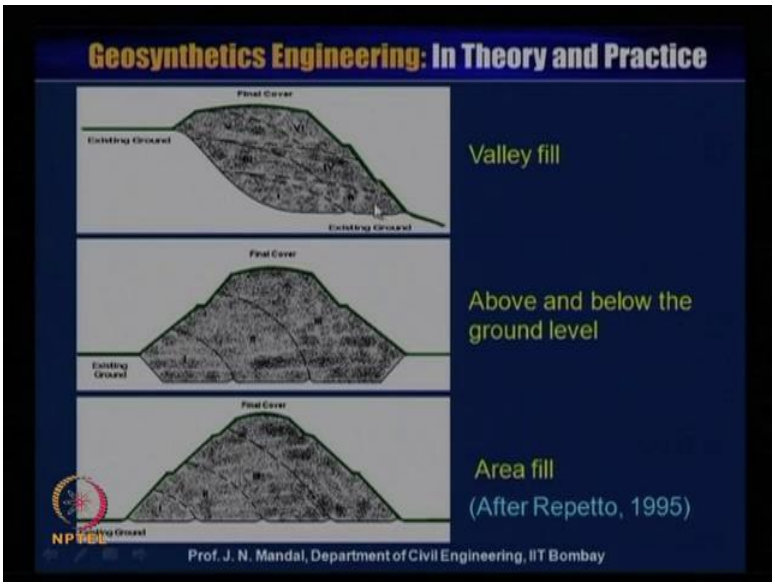

So, there are different types of the landfill one is, maybe you can place to the valley fill, this is the existing and this you are dumping the all kind of the waste material and this is the final cover. This is called the valley fill, this is the existing ground level and this is above and below the ground level. So, this is the existing ground level this is below and the above you are dumping this all waste material and ultimately this is the final cover. So, all are open and also this after this is fill here, so this is the existing ground water level and you are just filling like this and this is the final cover this is given after repetto 1995.

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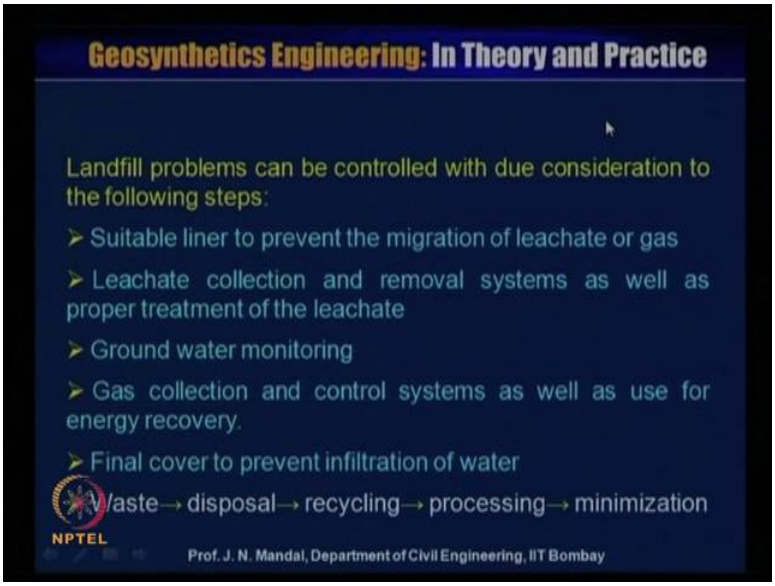

So, landfill problem can be controlled with due consideration to the following steps, suitable liner to prevent the migration of the leachate or gas leachate collection. And the removal system as well as proper treatment of the leachate ground water monitoring is essential. Gas collection and control system as well as use for energy recovery and final cover to prevent infiltration of water, so if there is a waste then disposal then you can go for recycling and then you can processing and that way you can also minimize the waste.

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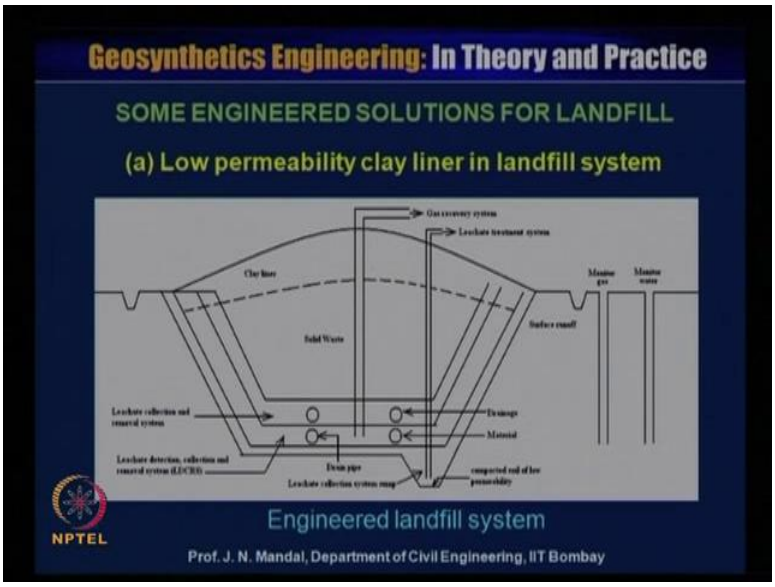

So, one of the aim you can minimize this, also this waste this is some engineering solution for the landfill, so low permeability clay liner in the landfill system.

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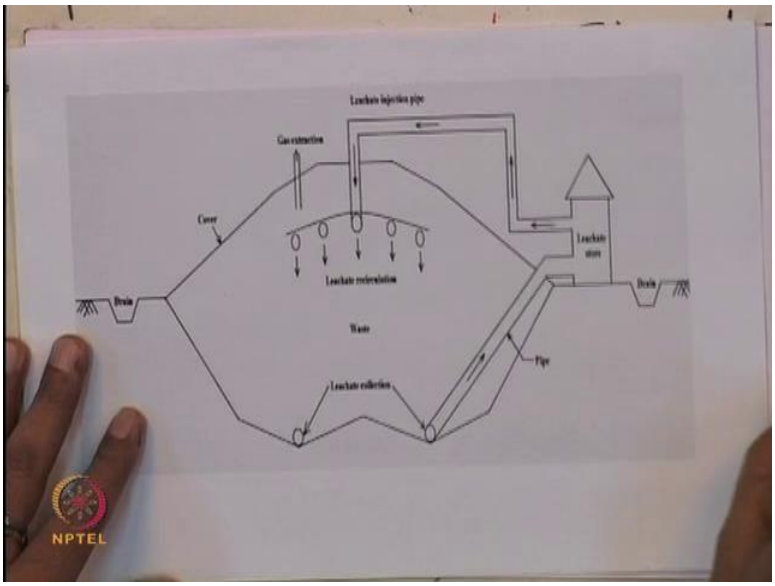

So, here you can see that here is the landfill, all waste material and here is the drainage, the leachate collection system, so here can be leachate can be collected and then you can pump it through the pipe and then to the leachate store and then pump it to the leachate injection pipe. Then again you can see leachate how it is recirculation and that way you can have the gas extraction from here and you should provide proper kind of the cover and then water can be drained it out from this side. So, this is a kind of the recirculation of the leachate recirculation system how you can make it.

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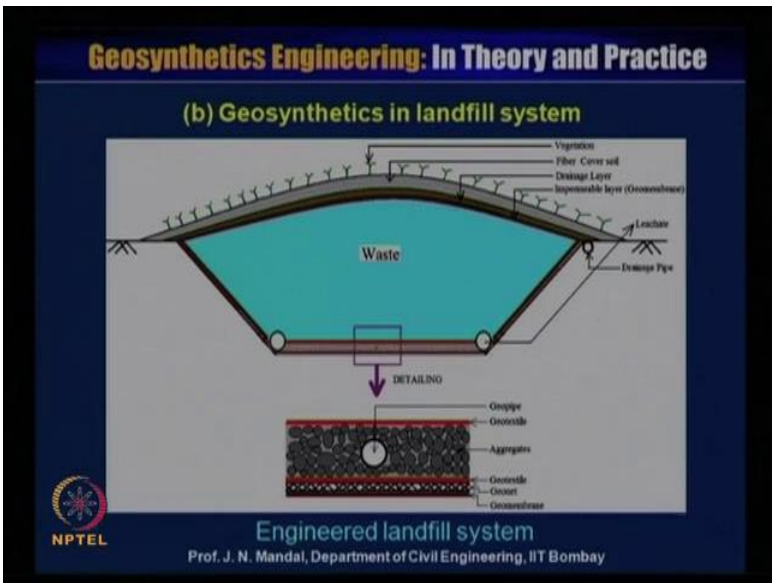

So, here geosynthetics in the landfill, so three most important part of this geosynthetics landfill system.

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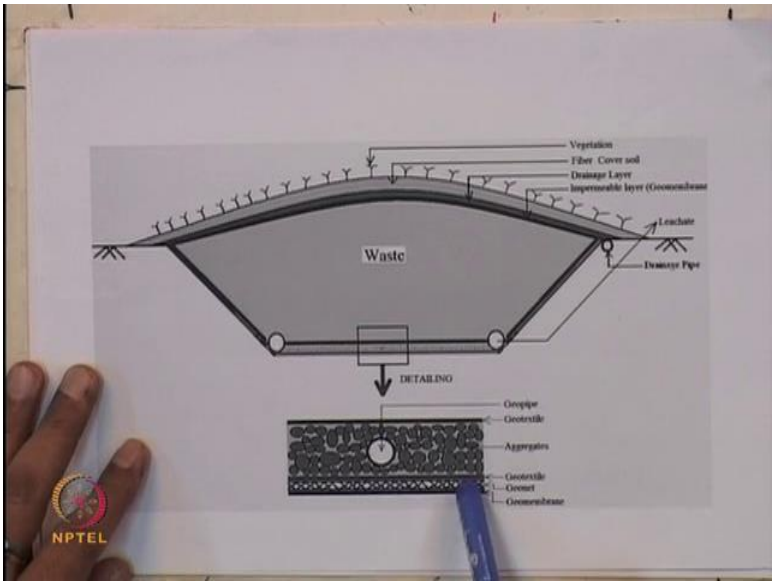

You have to design at this base you has to provide proper kind of the geosynthetics material in order that waste cannot percolate through the landfill to the ground. Also you required for the design for the slope, also you require design for the cover here at the base. You are providing this geomembrane, then the geotext net and then the geotextile and every material have their individual function.

So, geomembrane will act as a barrier, geonet will act as a filtration geotextile also act as a filtration and drainage and also you have to provide aggregate. You provide this geo pipe here and then on the top also you have to provide with the geotextile material for this here, I am showing the detailing of this section.

At the same time you have to provide with the geomembrane along the side slope and it is sometimes required the geogrid if you make a most stable slope. On the top of this you have to always the landfill is to be covered and for the covered you have to provide with the impermeable layer that is geomembrane. Then the drainage layer and then the fiber cover soil and then the vegetation can grow and also that any rain water it can pass and passes through the drainage.

Here is the drainage pipe which can be the leachate which can be collected and can be

detected and you can measure how much it is contaminated. It may be the one layer, two layer double layer system, I will also talk about this different kind of the system for the geosynthetics landfill. Now, this is engineering landfill system.

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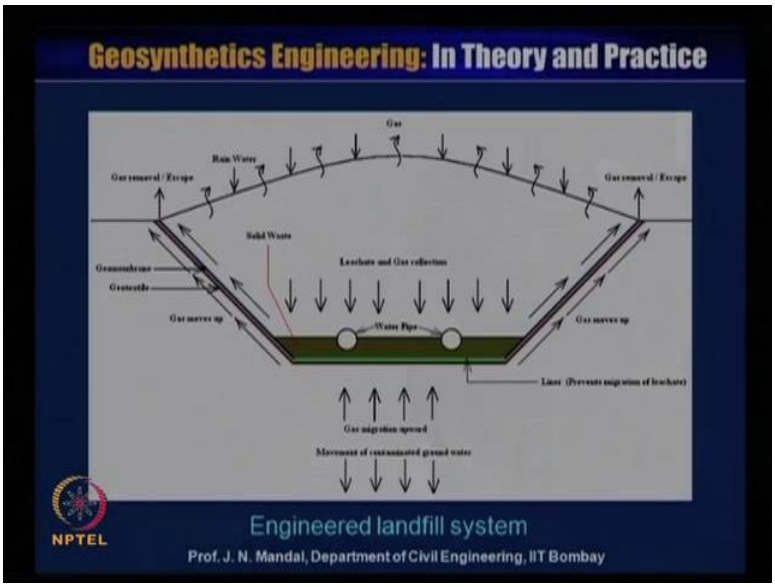

Now, similarly also you can see that here also this is the pipe this is the leachate or the gas collection, this is all the solid waste which there because leachate may pass gravitation it is downward that is movement of the contaminated ground water or if there is a gas that also migrate to a upward direction. So, this is the lineup that prevent the migration of the leachate and then this gas can be moving up, so gas can be removal or exist from this side escaped from this side and also from gas from the remove and escape from this side. So, you have to provide the geomembrane material, geotextile material and also you require proper kind of the covering.

Always there is a gas formation gas can move also up rain water can penetrated into the solid waste and which will form the leachate. So, proper engineering landfill system is required that how also the gas also migrated on the top and how through the drainage how you can pump it out. Now, here just we want to focus that what is conventional method and what we do and what is the engineering solution for this.

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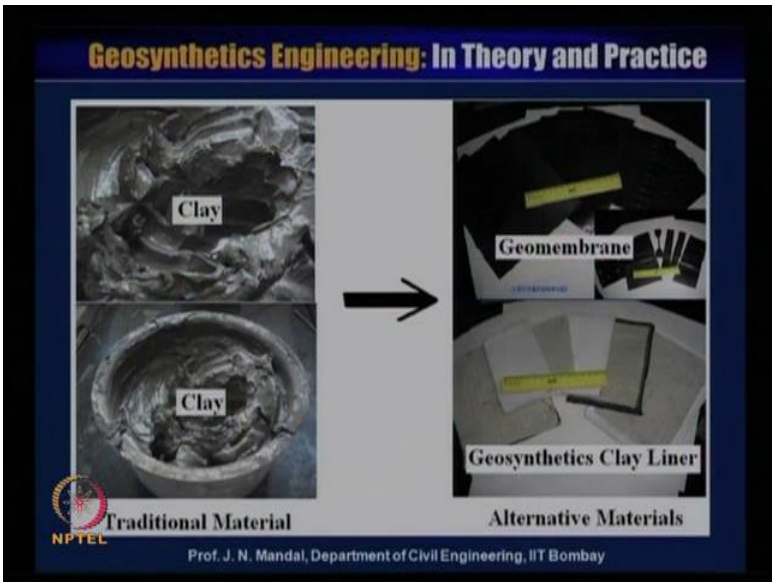

You can see left hand side is the clay, so alternative to the clay material traditional material we wanted to adopt the geomembrane which is impermeable material and geosynthetic clay liner which is also impermeable material alternative to the geomembrane. Now, in case of the clay you require about 600 to 900 millimeter, even then 1500 millimeter and 2000 millimeter thickness of the compacted clay liner alternative to this clay liner system we can adopt the geomembrane or geosynthetic clay liner system.

In case of the geomembrane, this thickness of the geomembrane is 0.75 millimeter or 1 millimeter, 1.5 millimeter or 2 millimeter. Only in case of geosynthetic clay liner, it may be the 2.5 millimeter or 3.5 millimeter or 5.5 millimeter thickness. So, you do not require so much thickness of the clay liner and all this geomembrane or the geosynthetic clay liners are prefabricated.

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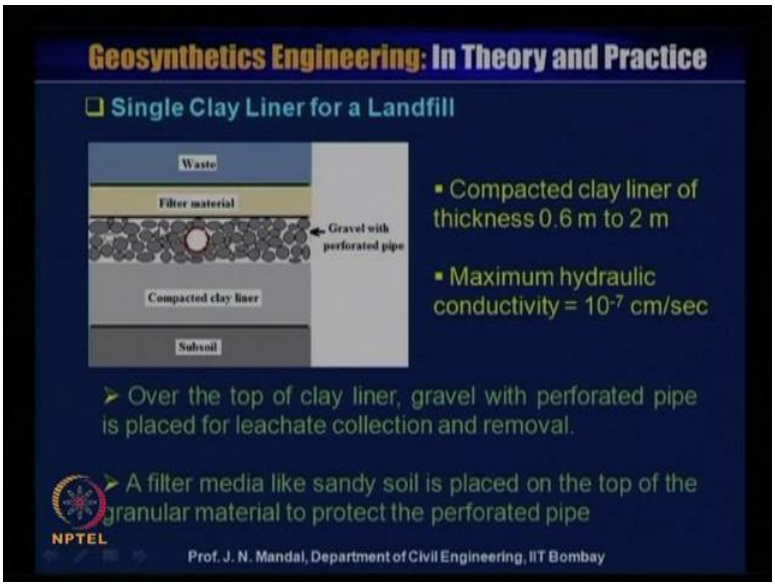

Now, single clay liner for a landfill, so here you can see this is the soft soil this is the compacted clay liner and this is the gravel with perforated, this pipe and this is the filter material and this is the waste. I say this is the single clay liner of a landfill, so this here you require compacted for the clay liner thickness as I said 0.6 meter to 2 meter and maximum hydraulic conductivity is about 10 to the power minus 7 centimeter per second over the top of the clay layer.

The gravel with the perforated pipe is placed for the leachate collection and the removal from here; you can collect the leachate collect and can be removed. So, a filter media like sandy soil is placed on the top of the granular material to protect the perforated pipe so this is single geomembrane liner for a landfill.

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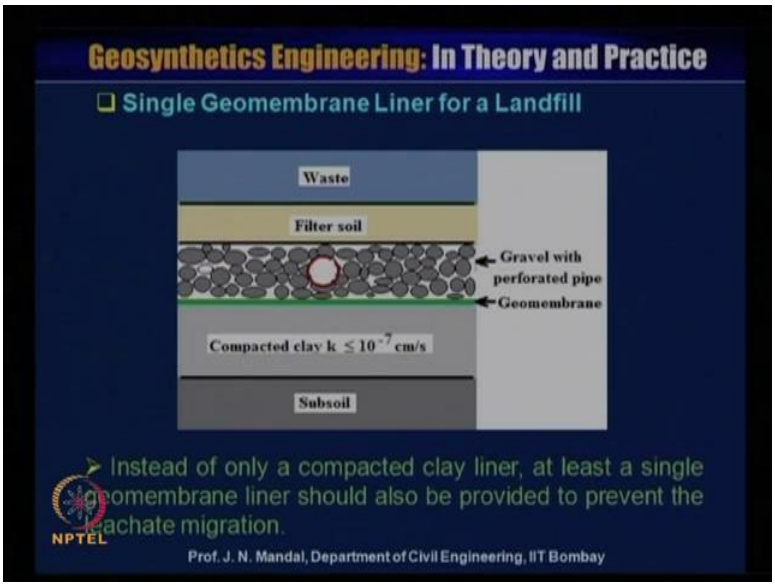

Now, you can see this is subsoil this is compacted clay liner which coefficient of hydraulic conductivity less than equal to 10 to the power minus 7 per centimeter and then you are introducing a layer of geomembrane this is single geomembrane liner. Then the gravel and perforated pipe, then the filter soil and the waste, so instead of only a compacted clay liner at least a single geomembrane liner should also be provided to prevent the leachate migration. So, this kind of the one layer or maximum double layer geomembrane system is much more suitable for indian condition in terms of the cost.

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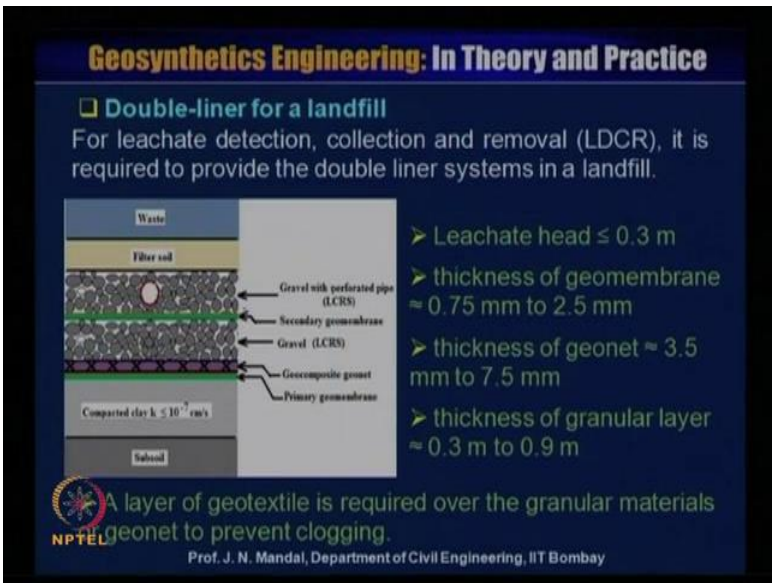

This is double liner for landfill, so when the high toxic or the hazardous waste kind of the waste material. In that case you can adopt the double liner for the land fill for the leachate detection and collection and the removal it is required to provide the double liner system in a landfill. So, here it is a subsoil, this is compacted clay liner whose hydraulic conductivity less than equal to 10 to the power minus 7 centimeter per second and this is primary geomembrane.

Then geocomposite or geonet, then the gravel and from where you will be leachate collection and the removal system and then the secondary geomembrane here and then again the gravel with perforated pipe and here also leachate collection and the removal system. This is the filter soil and this is the water, so when this when the any that leachate is passes through this and you can also through the drain. You can also measure the how much there are contamination and even then after that secondary geomembrane if any contamination can pass through this.

Also, you can measure here through the leachate collection and removal system that how you can minimize the contamination. So, that is all you will be knowing there after passing one layer of the geomembrane what will be the contamination if it can satisfy, the as per the standard then it is. If it is not, you can provide the second layer of the geomembrane, then you can check whether it satisfies the criteria or not.

In all cases it is very important that leachate head, so leachate head will be equal to less than equal to 0.3 meter. Sometimes, you can drainage pipe, you can provide with the v shape, like this v shape and then like this and then like this v shape you can provide and thickness of the geomembrane generally use 0.75 millimeter to 2.5 millimeter. Sometimes, you use also 1 millimeter, sometimes you also use 2 millimeter, so depending upon the type of the hazardous waste, so you can adopt whether it is a 1 millimeter or the 2 millimeter or 2.5 millimeter and also you can design it and you will be able to tell that what will be the thickness of the geomembrane.

So I will show you also what we have developed model and from that model, also you can determine what will be the thickness of the geomembrane and thickness of the geonet is 3.5 millimeter to 7.5 millimeter, whereas you can see that thickness of the granular layer, you require 0.3 meter to 0.9 meter. So, instead of the thickness of granular layer, 0.3 to 0.9 millimeter, you can simply adopt the geonet material whose thickness is

about 3.5 millimeter to 7.5 millimeter.

So, drastically you can reduce the thickness and at the same time you require good quality of granular layer and you have to transport. Then you have to compact you have to place and there is a possibility for the clogging, but alternative to that you can adopt the geonet material or geocomposite material whose thickness is only 3.5 millimeter to 7.5 millimeter. So, two way it can be adopted one is that alternative to the compacted clay liner geomembrane, thickness is very, very less.

So, for the compacted clay liner is about 900 millimeter to 2000 millimeter, you can simply adopt 0.75 millimeter to 2.5 millimeter of geomembrane. Whereas in case of the good thickness of the granular layer which thickness about 0.3 meter to 0.9 meter. Alternatively you can adopt the geonet material or geocomposite material whose thickness is only 3.5 millimeter to 7.5 millimeter.

So, a layer of geotextile is required over the granular material or geonet to prevent the clogging because that sometimes that there is a clay and then clay can directly can penetrated into the geonet and material because it is a plastic net, there is a possibility for the clogging. So you can provide with the a layer of the geotextile material or you can make the geocomposite material or geonet can be laminated with the geotextile material. So, it can be prevented for the clogging, so here I talk about that double liner for the landfill system and how you can collect the leachate detection collection and the removal system.

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Now, wet landfill and that is bioreactor landfill, now this wet landfilling where the liquid is purposely added to the waste mass can enhance the degradation process. Rate of decomposition of organic waste in a dry landfill is not satisfactory. The leachate will continue to contain significant amount of contaminant for many years that is for more than 20 years after a landfill is encapsulated. Many researchers also express skepticism regarding the longevity of the liner and leachate collection system. It is required to flush out the contaminant faster using bio-degradation of the wastes. So, wet landfill has a leachate recirculation anaerobic bioreactor and aerobic bioreactor the leachate recirculation.

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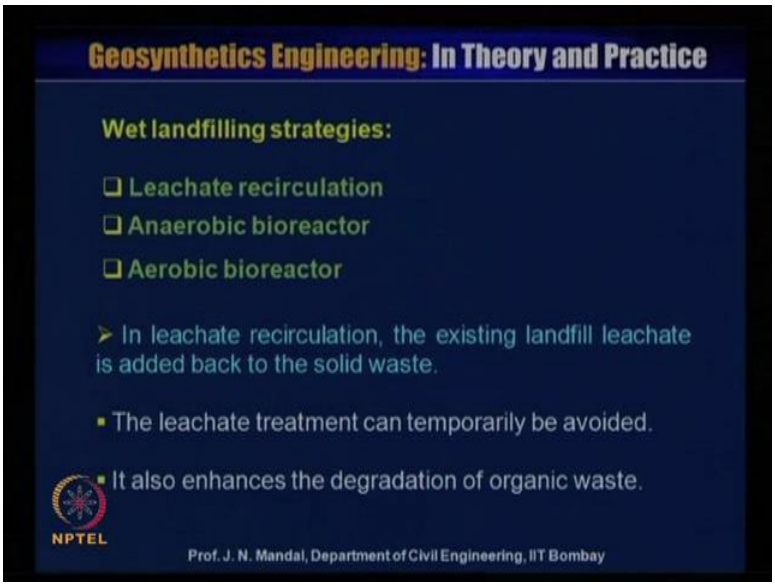

The existing landfill leachate is added back to the solid waste, a leachate treatment can temporarily be avoided. It also enhances the degradation of the organic waste, so here is a schematic of the leachate recirculation.

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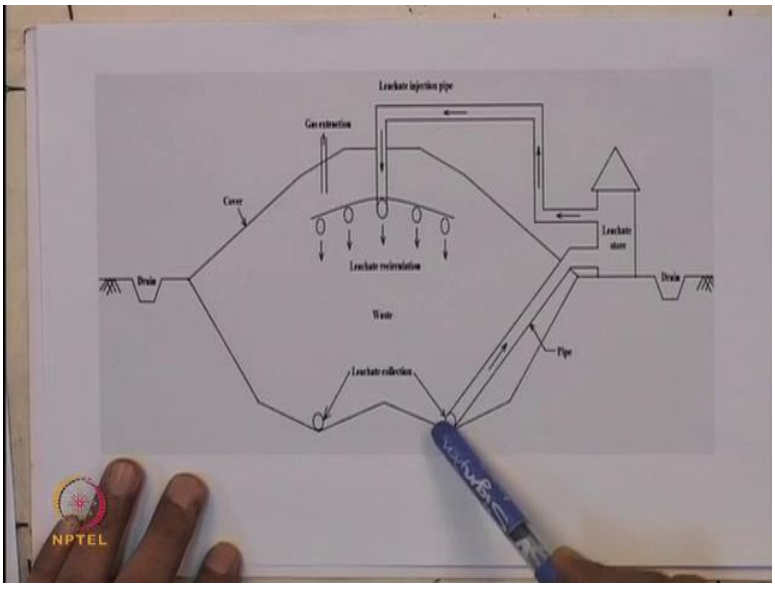

Here is the how the bioreactor for the landfill, so leachate will continue than more than 20 years after the land fill is encapsulated. So, moisture availability is the key factor in the sustaining the bio reactor operation moisture contains of municipal solid waste in conventional landfill is approximately 20 percent. So, minimum moisture content of 40

percent is necessary for bioreactor landfill. So, addition of the water increased the microbial activity and that way increase the gas which will be generated from this landfill.

So, here you can see how the leachate recirculation occurs this is the waste and this is the leachate collection and through the pipe it drained it out to the leachate store. From the leachate store, again the leachate it injected through the pipe, so here is a recirculation is occurring and there are three type of the bioreactor and that is that aerobic bioreactor landfill or anaerobic bioreactor landfill and as well as the hybrid bioreactor landfill.

In case of the aerobic bioreactor landfill both the moisture and the air is injected to promote the aerobic bacterial activities and in case of anaerobic bioreactor landfill. The only moisture is added to promote the microbial activity and on the other hand in case of the hybrid landfill, aerobic conditioning are maintained to create the anaerobic condition and it is to be noted that aerobic bioreactor do not produce significant quantities of the gasses.

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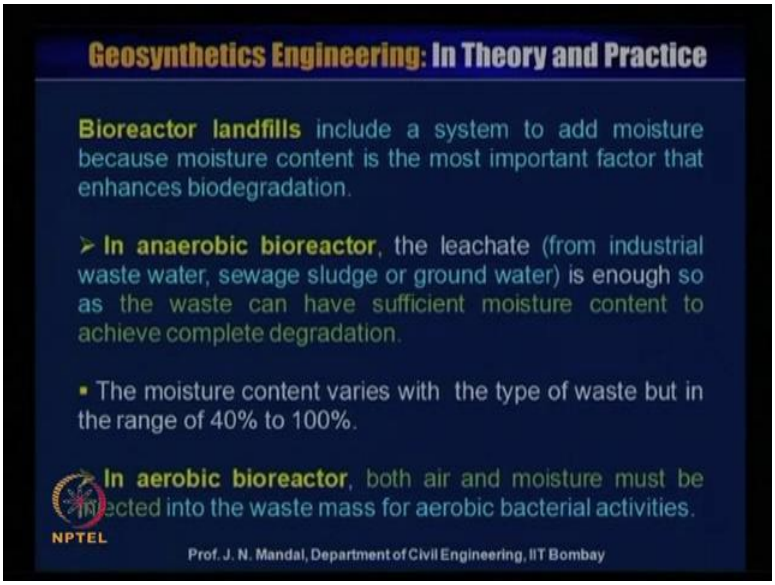

So, bioreactor landfill that is include a system to add moisture because moisture content is the most important factor that enhance the biodegradation in anaerobic bioreactor. The leachate from the industrial waste water sewage sludge or ground water is enough. So, as the waste can have sufficient moisture content to achieve the complete degradation, the moisture content varies with the type of the waste. But in the range of 40 to 100

percentage in aerobic bioreactor both air and moisture must be injected into the waste mass for aerobic bacterial activity.

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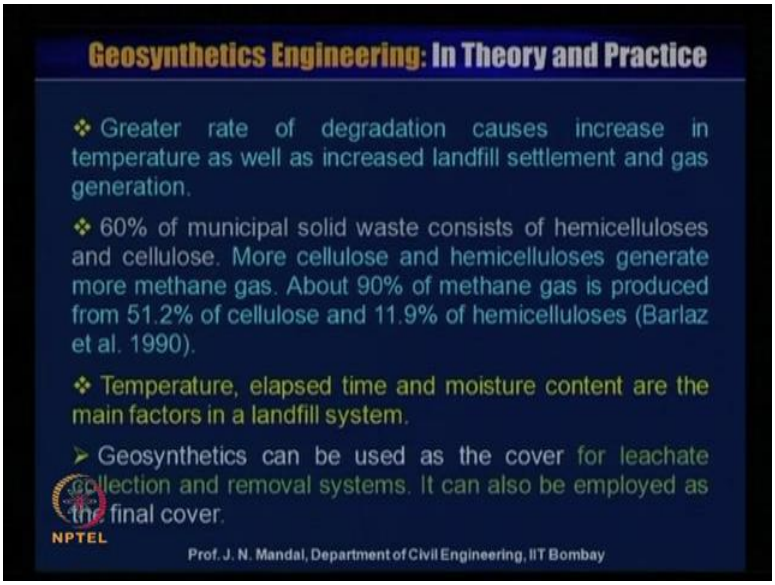

Greater rate of the degradation causes increase in the temperature as well as increase the landfill settlement and gas generation. 60 percentage of municipal solid waste consists of hemicelluloses and cellulose more cellulose and hemicelluloses generated more methane gas about 90 percent. Methane gas is produced from 51.2 percentage of cellulose and 11.9 percentage of hemicelluloses that is barlaz et al 1990. Temperature elapsed time and moisture content are the main factor in a landfill system, geosynthetics can be used as the cover for leachate collection and removal system, it can also be employed as the final cover, so most of the time that what you can happen.

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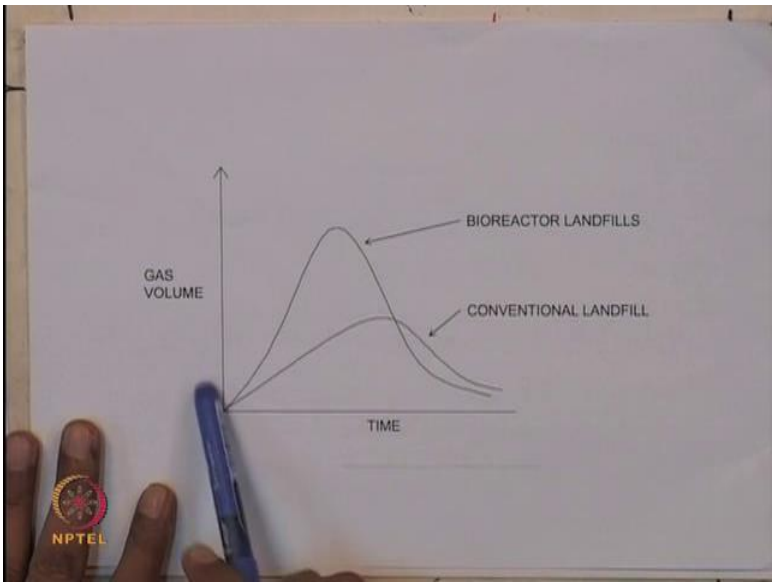

You can see that if you use that conventional landfill and the bioreactor landfill and this is the gas for the volume and this is versus the time this is the comparison of the idealistic gas generation react rates between the conventional and the bioreactor landfill. In case of conventional landfill it takes time for to produce the their quantity of the gas volume, whereas in case of the bioreactor landfill that within a shortest of time. It can produce the more gas volume than the conventional landfill, so that way the bioreactor landfill has certain benefit and advantage because gas formation is more with compared with the conventional or traditional landfill system.

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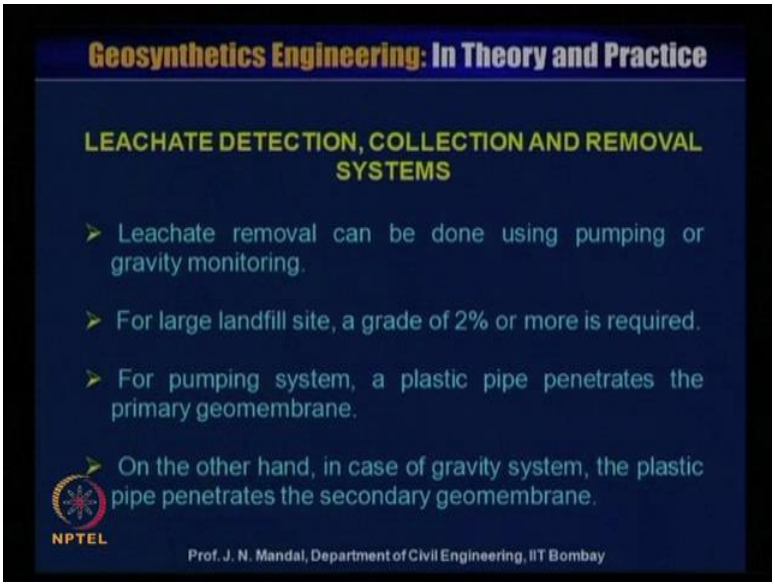

Now, it is called leachate detection collection and the removal system leachate removal can be done using the pumping or gravity monitoring. For a large landfill, site a grade of 2 percentage or more is required, so you have to remember that you have to maintain certain gradation for pumping system, a plastic pipe penetrated the primary geomembrane. On the other, hand in case of gravity system the plastic pipe penetrated the secondary geomembrane.

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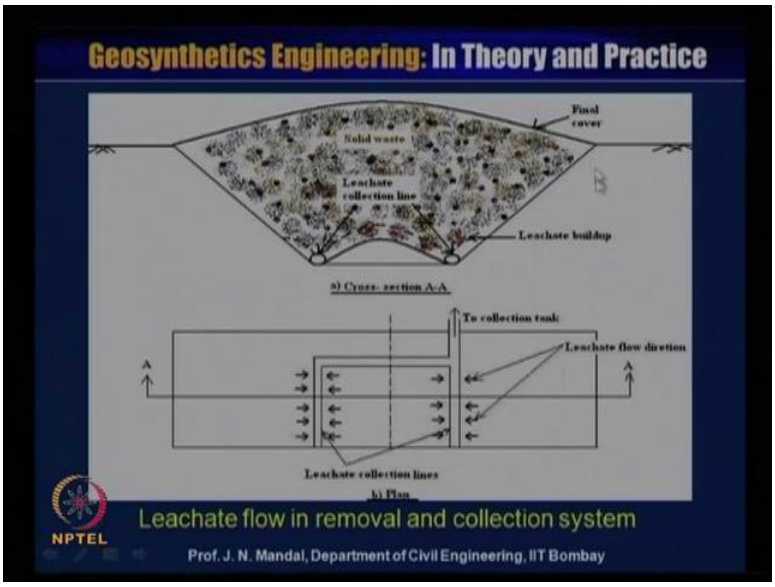

I can show you here that this is the leachate flow and the removal system, this is collection system, you can see this is the plant and this is the cross section of the a a. So, this is the solid waste and this is the final cover and this is the leachate collection line and this is the how the leachate is build up here. So, you have to maintain certain height as well as the certain the slope or the gate and these are the pipe to collection to the tank and these are the leachate flow direction. You can see you can provide with the leachate collection liner in the plant and this is the leachate flow in the direction.

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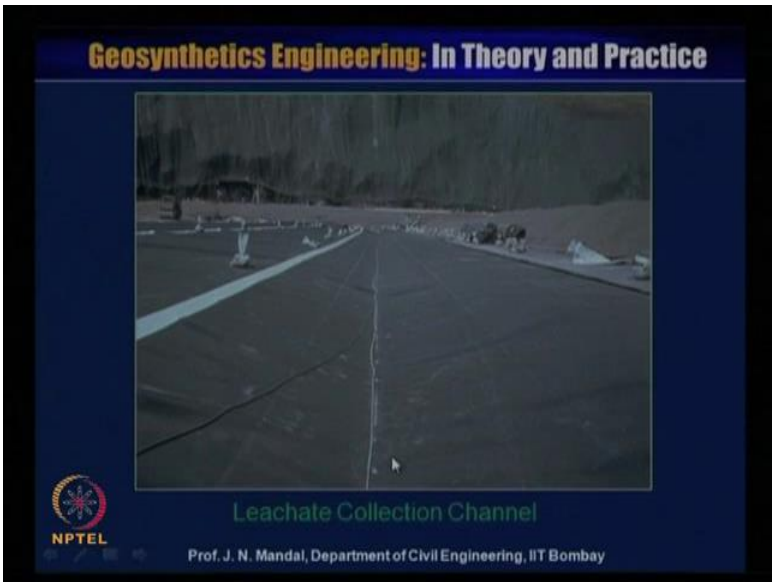

You can see here how the leachate collection channel.

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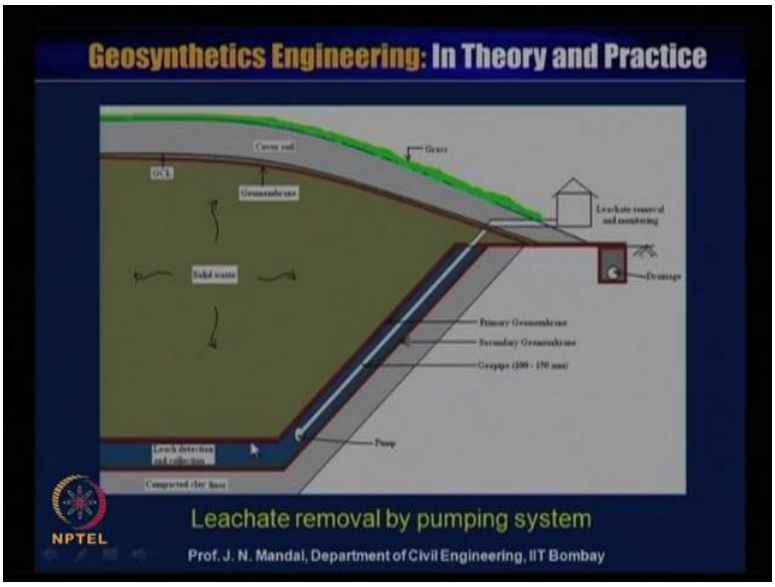

Here is the leachate removal pumping system, I said two types of the leachate removal pumping system, this is the solid waste and here is top is the geosynthetics geomembrane then geosynthetics clay liner and then the cover soil and then the grass will grow. Sometimes, also there is a possibility for the cracking on the top of the cover soil and you can provide also me adding some fiber and you can make it much more stable. There is a possibility for the erosion of the soil there is a possibility for the crack formation due

to the cover soil which is made of only the clay soil.

So, there are lot of research work also have been going on in I I T Bombay and also we have also adopted some different types of the system using the cellular reinforcement system and also addition of the fiber which can reduce the cracking and also the grass can grow. So, here we are talking about that that leachate removal pumping system.

So, this is the this is the all solid waste and this is the leachate detection and the collection system, this is the compacted clay liner and through this pump, this is the geo pipe whose diameter about 100 to 150 millimeter. This is the secondary geomembrane and this is the primary geomembrane, so you can observe that when you are pumping the all the leachate from this here leachate detection and collection system.

You are pumping and when this pipe the geo pipe which is passing through the primary geomembrane this is primary geomembrane. So, it is passing through the primary geomembrane through the leachate removal and the monitoring system here. So it is just passed through it can be connected, geo pipe can be connected with the geomembrane. So, there will be no problem, but in case of the leachate removal by pumping system, it passed through the primary geomembrane not the secondary geomembrane and also you can provide with a some kind of the drainage system here, but in case of leachate removal for gravity gravity system.

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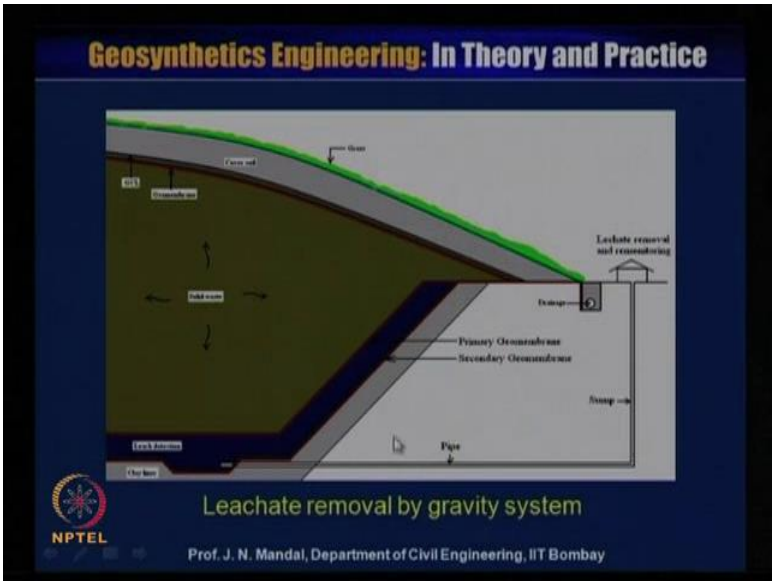

Let us say this is the clay layer this is the leachate collection this is the solid waste and this is geomembrane this is geosynthetics clay liner, this is cover soil and then grass can grow on the top, but here we are adopting the leachate removal by gravity system. So, this is the pipe and this is the sump and it will go to the leachate removal and remonitoring here and this is the drainage.

So, when it pass through this you can see this is the secondary geomembrane, but this is the primary geomembrane, but when leachate removal by gravity system, so it is passing through the secondary geomembrane not the primary geomembrane. As you have observe earlier that leachate removal and collection is pass through this here the primary geomembrane, but in case of the gravity system this pipe is passing through the geomembrane secondary geomembrane. So, this way you can leachate collection and removal system can be adopted.

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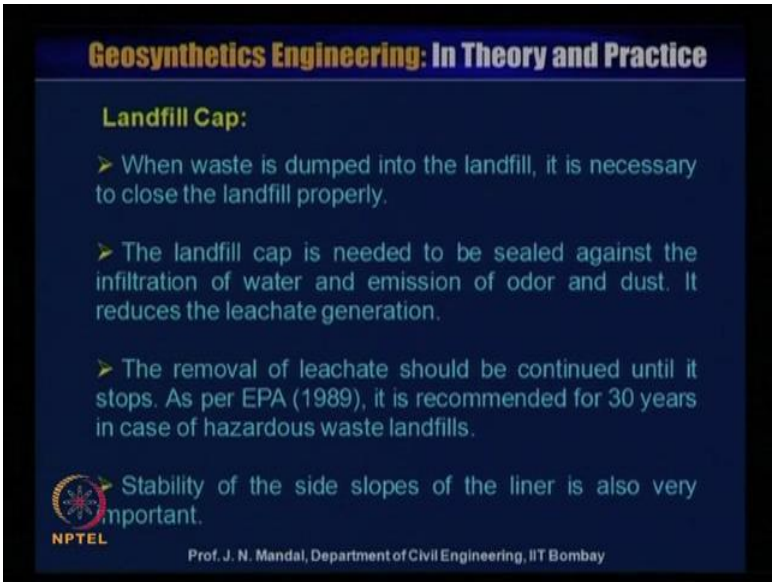

So, apart from this for all these cases of the landfill is at the end when you are dumping this all the waste material it is required to proper capping. So, landfill capping is very important otherwise the rainwater can pass through the waste material and then solid waste will be contaminated and the leachate will form and then ground will be polluted. So, it is essential to provide the proper kind of the landfill cap, so when the waste is dumped into the landfill it is necessary to close the landfill properly, the landfill cap is needed to be sealed against the infiltration of water and emission of odor and dust it

reduces the leachate generation.

The removal of the leachate should continue until it stops as per environmental protection agency E P A 1989. It is recommended for 30 years in case of hazardous waste, landfill stability of the side slopes of the liner is also very important. So, here you can see that closure of the landfill cap, so this is the solid waste and you should cover the landfill.

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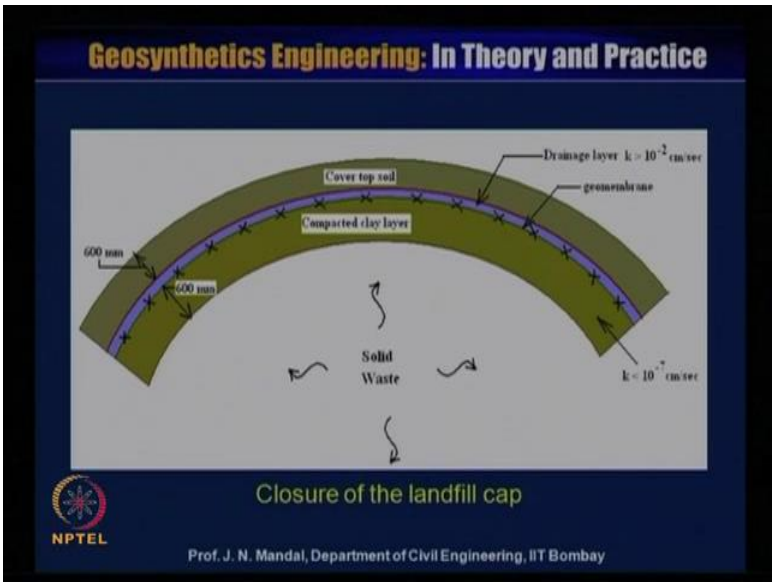

So, here you can provide about the thickness about the 60 millimeter, this is the compacted clay liner which coefficient of permeability is 10 to the power minus 7 centimeter per second. Then you have providing with the geomembrane material in over that water cannot percolate and in affect the solid waste. So, geomembrane here acts as a impermeable material, then you can provide the cover top soil is it about the 600 millimeter and you also providing some drainage layer.

So, here the drainage layer which could be sent of permeability 10 to the power minus 2 centimeter per second. So, water can be this drain it out there is a drainage both the side so water can be drain it out through that, so water cannot percolate through this solid waste because you have providing with geomembrane as a barrier and also top of this the grass can grow. So, in this system you it is allow that essential to provide the proper kind of the closing system of the landfill.

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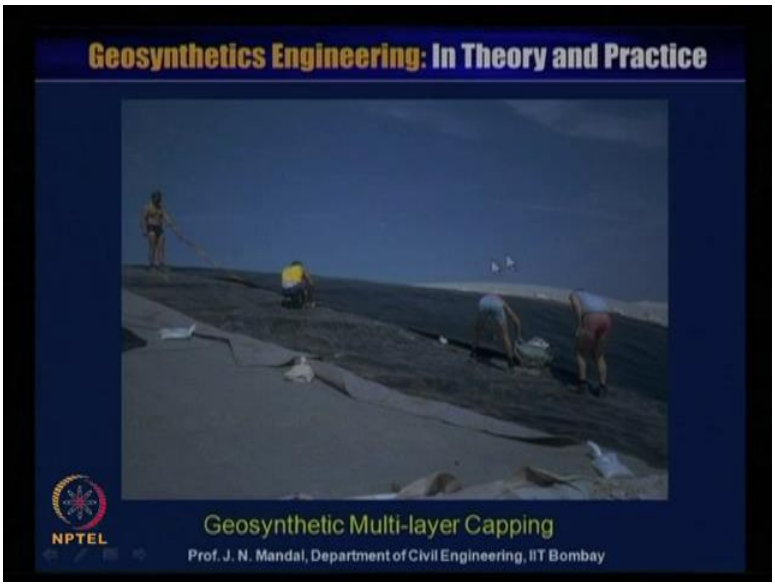

You can see some geosynthetics that multilayer that capping here.

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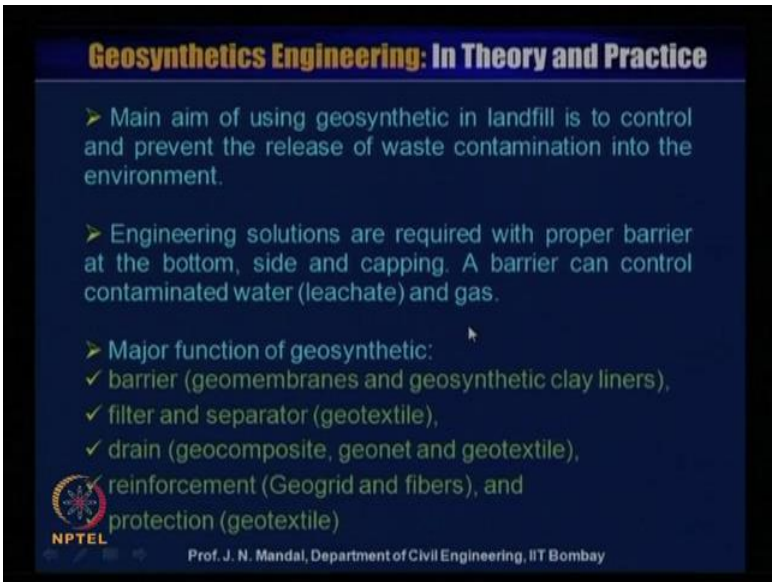

So, main aim of using geosynthetics in landfill is to control and prevent the release of waste contamination into the environment. So, you need engineering solutions are required with the proper barrier at the bottom side and capping a barrier can control contaminated water leachate and gas. So, major function of geosynthetics that act as a barrier as a geomembrane and geosynthetics clay liner filter and the separation that is geotextile material drain that is geocomposite, geonet and geotextile material

reinforcement.

If the slope you need, the more stable you wanted to make a steeper slope, then you can use the geogrid material which will act as a stable slope. Otherwise, you used the geogrid or the fiber material or protection, sometimes there is a possibility for any clogging or blocking, so you can provide with geotextile material which will act as a act as a protection as well as also act as a filtration drainage and separation. So, while the geotextile or geosynthetics material act as a multifunction, so these are the main or the function of the geosynthetics materials.

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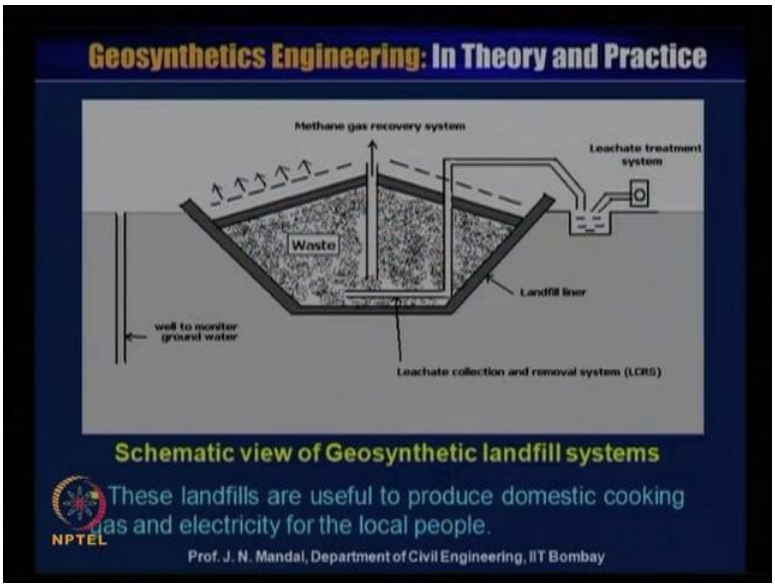

This is a schematic view of geosynthetics landfill system, so this landfill are useful to produce the domestic cooking gas and electricity for the local people. So, this is the waste material and this is the leachate collection and the removal the system and this is a leachate the treatment system and this gas can go methane gas which can be recovered from this system. You can also setup that at any location near to the landfill where there it is contaminated or not, so you can provide with the well to monitor the ground water, so if you find that if there is a any water is contaminated.

So, you have to be taken care for this landfill system here, so here that how the leachate collection and removal system has been used for the preparation for the cooking gas and the electricity. So, apart from this, this, that landfill we are using, that main geomembrane material as an impermeable material or it will act as a as a barrier. So,

when you are insulating that geomembrane also for any for any landfill system or any cannel or any reservoir and you also you call him have to check that whether that there is a leakage of the geomembrane or not.

It is very difficult to understand that whether there is any defect of any geomembrane or not because it is a black in color and it is very difficult to detect, but you can use some current and which where wherever there is a hole in the geomembrane it can spark, but it is not giving that accurate result most of the cases. So, what you can that adopt that you do not know that where is the geomembrane leaking or where there is a formation of the hole. So, alternatively it can adopt some other system which we can say like that principle of the electrical.

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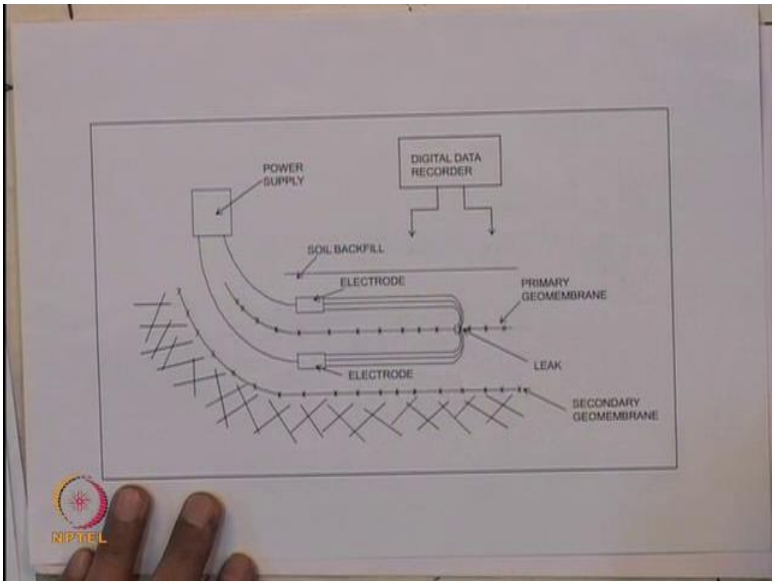

Electrical leak location method for soil cover geomembrane or the double liner facility, so this is the geomembrane, this is you call primary geomembrane and this is the secondary geomembrane. This is the power supply from here and there is a electrode here there is also a electrode this is the soil backfill. So, when the power supply passes through the electrode and whenever you can see there is a leak in the geomembrane. For example, in the primary geomembrane there is a leak, so this will pass again to the electrode and power supply, but here is a digital data recorder. So, digital data recorder there will give you the idea that at what location this geomembrane is leaking or there is a hole in the geomembrane.

So, you can you can have a curve like this means your digital data recorder and you can observe that there is a there is a leakage also sometimes, that some instrumentation which you can put it into the layer and can check that there is a sound wherever there is a leakage in the geomembrane. So, this is very important to detect the geomembrane whether there is a leaking or whether there is a hole, so this also will create a problem for the for because it is a waste material. And it is essential to protect all kind of the hazardous waste material, so proper quality control and quality assurance is required.

So, you have some idea about what the geosynthetics landfill system while there is a collection and removal system, and how we have to design at the base, and the side slope, and also the cover soil also that we have some idea about the bioreactor anaerobic aerobic and hybrid landfill biological system. So, with this I finish my lecture, today let us hear from you any question.

Thanks for listening.