Course on Integrated Waste Management for a Smart City
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Module-01 Lecture-05
Introduction

Okay. So let us start with the last module for this particular week which is the introduction week. So we will talk about, so far in the last module if you remember we talked about the source reduction, we talked about the composting, we talked about the waste-to-energy. Again, I am reemphasizing that we will come back and spend lot of time on details in each of these topic.

This particular week is just to give you an overview of municipal solid waste management. And so we will, so in the last video of this particular week, we will be talking about landfilling which is one of the important component. And as you saw from the global map that I showed you in one of the previous module that landfilling is the predominant way of managing the waste as of today. Although we may not like it, but that is the way where the waste is going in. And most, many of these landfillings are actually not landfilling as we will call it as an engineered, it is actually a dump. So at least going from a dump to an engineered landfill will be a significant improvement in terms of the waste management.

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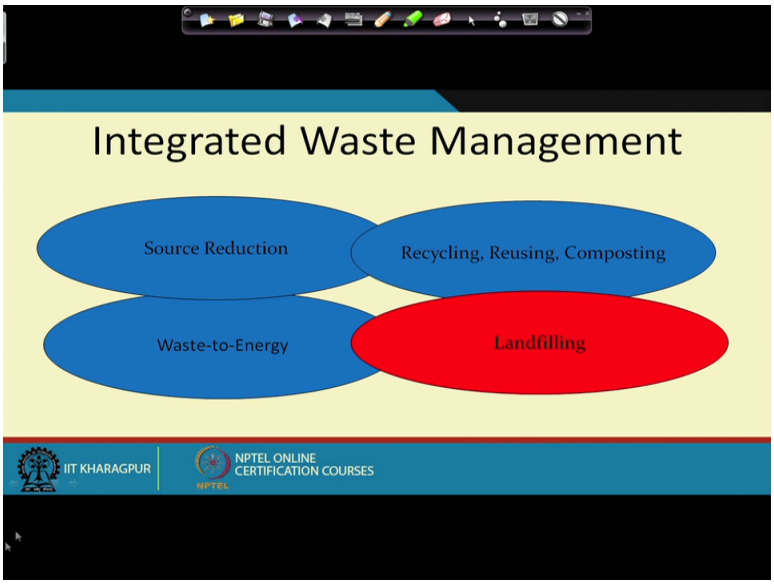

So let us look at like a landfilling part, what is landfilling engine and we will talk about the engineered landfill, we will not talk about the dumps. Here I may show you some picture of the dump but, and I did show you some picture of the dump earlier but here we are talking mostly about the engineered landfill. So that is the fourth component. We already talked about source reduction. We talked about resource recycling, reusing and compost. And so now we will go into the landfilling part and that is what we are going to talk about.

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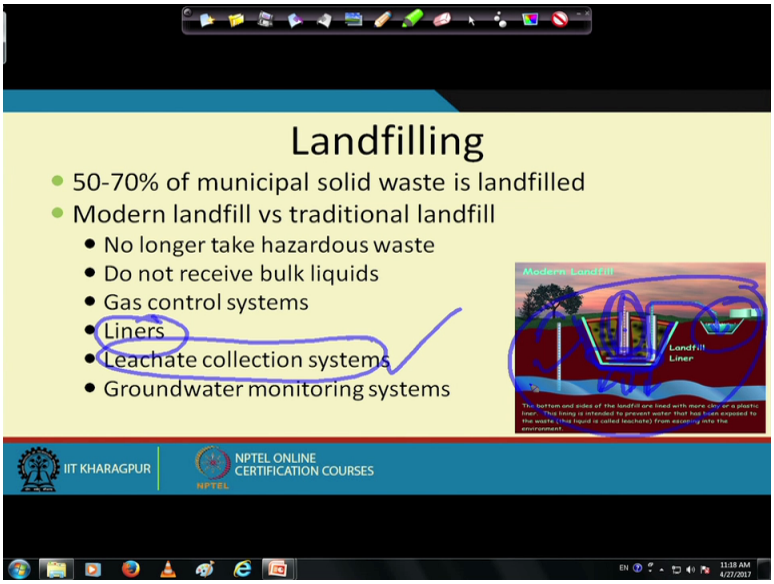

So what is landfilling? So landfilling, 50 percent to 70 percent of the municipal solid waste is landfilled as you saw in that global map in earlier module. There are, there is a modern landfill and there is the dump site, so there is a difference between them. The modern landfills are engineered structure, so they do not take hazardous waste, we only work with municipal solid waste. They do not receive bulk liquids, they, there is a gas control system, there is a liner system, and there is a leachate collection system and there is a ground water monitoring system.

And I will try to explain that using this particular sketch on this particular side. Here, this is your typical landfill that you see over here on this particular side, that is your typical landfill. Here, you can find, this is your liner system and I am just drawing on top of the liner here. So this is your liner system right there and then you have, that is your liner. Why we use liner? We use liner because it to make sure our leachate, if there is any leak, we have this groundwater below

here, so we want to try to protect this groundwater. So we do not want any of this harmful liquid from the garbage going into this groundwater.

So to prevent that, we are using this liner system. The liner system is essentially a big polythene bag that we are using. I will show you some pictures of how the liners are constructed. Then if you put the liner system, that means the water cannot go down, so that water will start pounding up in this particular area. So when the water starts pounding up in this area, the water needs to be pumped out, so that is why you need a leachate collection system and the water is pumped out and taken out and then the water would be treated.

And that is the waste water. That is a very similar to industrial waste water and it would be treated in a leachate collection system. So that is the part of your leachate collection system that we have been talking about. That is your leachate collection system part which is your liner is, liner and your leachate, all these pipes associated with that and the leachate treatment. So that is your leachate collection system part.

We talked about the liner, we talked about liner. Then the gas control, since the gas is produced, when the waste is degrading, gas is produced. And the gas needs to be controlled. You see this particular well over here, that is your gas control system. So you take, whatever is the gas produced, you take it out and then you can flare it, you can use it for waste-to-energy.

And we will talk about, I will show you more, you will see a better like a bigger version of this sketch with different components again but this is your gas collection system. And then there is a groundwater monitoring system which is, talks about, so along the periphery of the landfill, around the 50 feet, so if this is my landfill boundary, if you think about this is my landfill boundary, this circle, this is my landfill boundary, so around the 50 feet, along it I will have what is known as a groundwater monitoring wells.

I will monitor the groundwater and you see here is one of those. So this particular groundwater, this is one of those groundwater monitoring wells right here. This monitoring well as you can see, it is going into the groundwater, so water is coming, water is taken away and it is tested. So that is how it is done. Again, we will come back and spend more like detail in many of these stuff.

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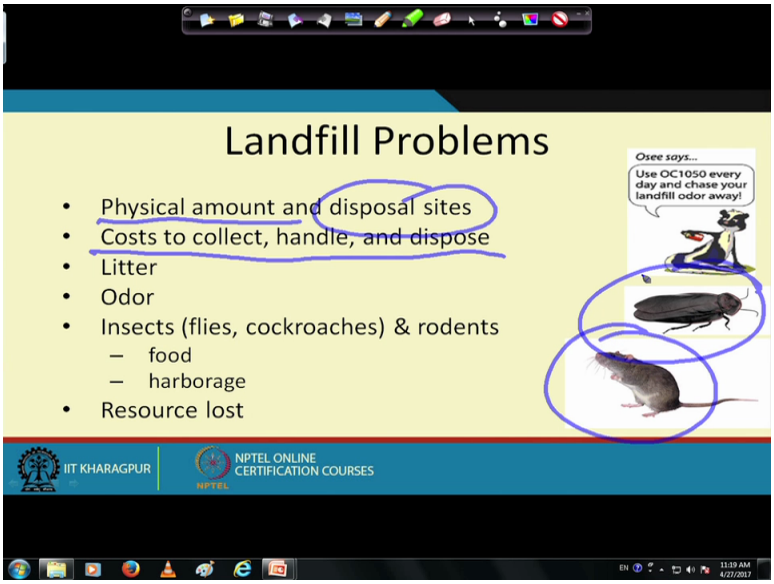

So in terms of, so this is how a typical landfill but there are issues with landfill. There are some problems with the landfill, because that is why many people do not like landfill. Landfill is not, may not be a permanent solution. It is because there is a, think about that you are taking the garbage and putting it in a huge polythene bag and then there is a huge amount of garbage that is going in there, so there is just a physical amount of garbage.

Lots and lots of garbage is being, it is decomposed to, is being disposed using the landfill as you saw in the your, I would say in like previous slides, previous videos where we had a world map with a landfilling in different parts of the world. And so finally the disposal site is also a problem, to identify disposal site where you can dispose it.

There is a huge cost to collect, handle and dispose the waste. Littering is a problem, smell is a problem. Then we have the insects. As you can see over here, rodents, insects, these are their breeding grounds and then they leads to lot of disease associated with that. They breed on those particular areas. And on the big picture if you think about it is a loss of resource, it is a big loss of resource for us that we are dumping all this stuff in a landfill and rather than using it. So it is a, resource is being lost. In terms of rather than using it, we are just dumping it.

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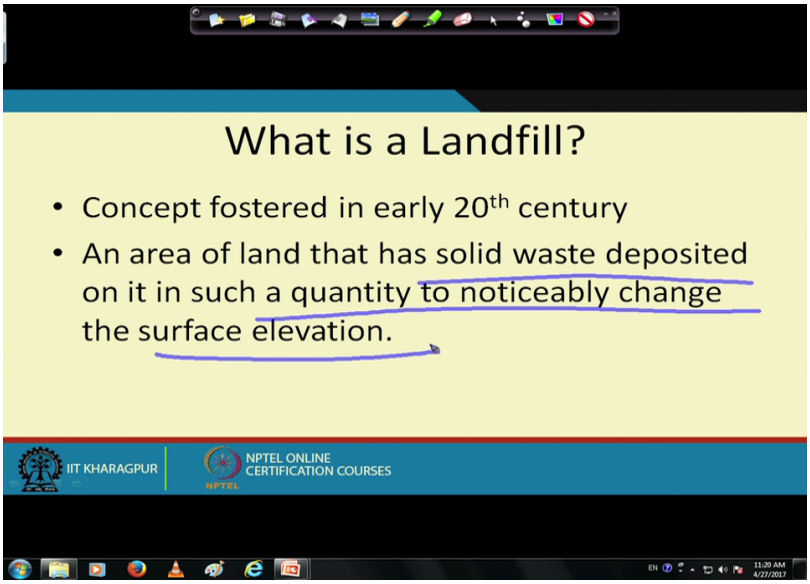

But how this concept started? Concept fostered in early 20th century, where the area of land which is an area of land that has solid waste deposited. So if you have a solid waste deposited in a sufficient quantity, solid where that noticeably change in surface elevation, so you start seeing a height in the surface elevation and that is how the landfill started. And those most of the earlier landfill were dumps.

In 1980s onwards, most of the North American landfills you will see the liner system, similar thing in Europe. In India, the municipal solid waste management rose 2001 and 2016, both requires the liner system. Still we have few landfills now in the country with the liner system and a leachate and a gas control, but most of the cities still are relying on their old dumps for disposal of the garbage which is not desirable actually. But we are moving there with, we are kind of getting there with all they talk about there is smart cities and all that. We need to start using engineered landfill for whatever residual we have after treating the garbage.

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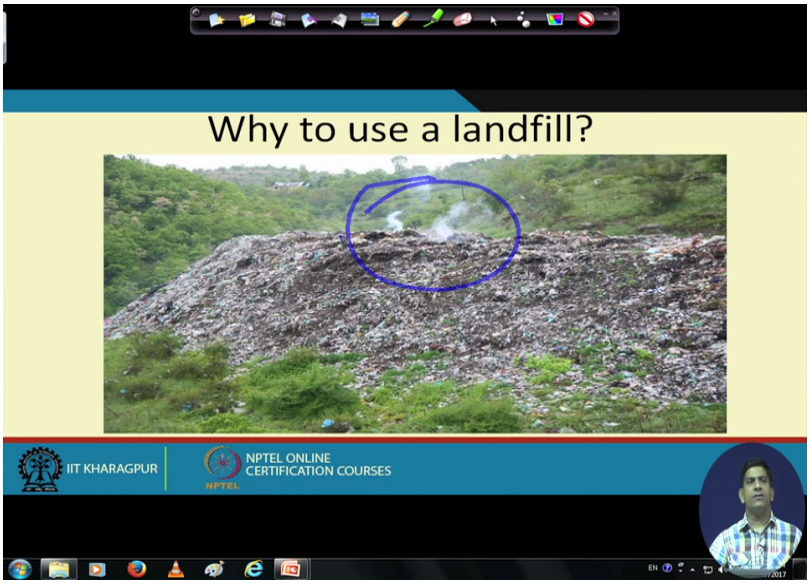

Why to use a landfill? We already kind of talked about that earlier but as you can see here this is, this picture is from the Macedonia where you have garbage being dumped on a very green area, very close to a water body as well which you do not see in this particular picture. And then the garbage has got some fire, you see some smoke coming out there. So that is the problem in terms of waste being not managed properly.

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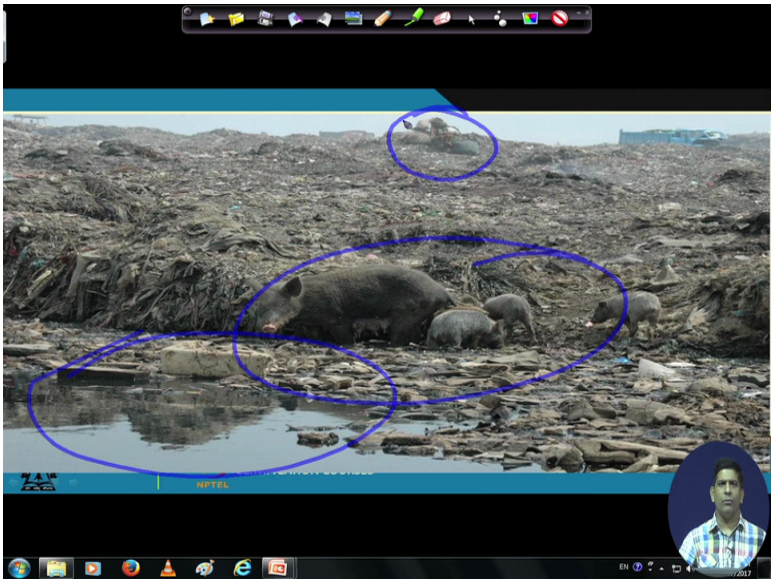

So here rather than putting into this, other picture, here you see, this is from the Delhi landfill. Just again totally lot of garbage all around, you have the leachate also being, you can see some

leachate here where you see some animals here. So it is, and there are actually, there is a people sitting over there and trying to take the recyclables out. So you can think about the human health impact and whatever environmental impact associated with that. All right, this is totally uncontrolled site. There is, I would, there is a little bit of control but most of it is actually uncontrolled site which is over there.

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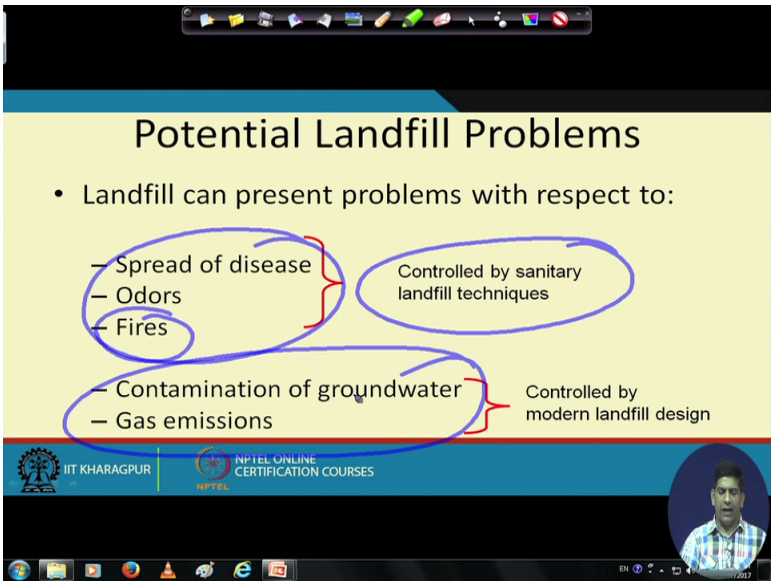

So this is, then there are potential landfill problems that we kind of talked about. Landfill can present problem with respect to, it can have the, it can have problem with respect to the spread of disease, odor or fire. So this is controlled by sanitary landfill technique which we will talk about.

When we say sanitary landfill technique, as you compact the garbage, you put the garbage in a sequential way, you compact it. How the compaction helps? Compaction, first of all, makes it structurally stable and at the same time, it takes all the void spaces, the air is gone. So if the air is gone, even if it catches fire, the fire will not propagate because there is no air.

Remember the fire triangle, you need to have a something which will burn. On then, there has to be an ignition source and then there has to be oxygen supply for fire to sustain. But when you are compacting the garbage, your void spaces are already, void spaces are losing oxygen because the garbage is being compacted. The (pore), the porosity is going down. When the porosity is going down, you have less air pockets. Less air pockets means less oxygen. Less oxygen means the waste will not, the fire will not propagate.

So that is a, then the issue of odor and the spread of disease. What we do is actually end of the every day, we put a daily cover on top of it. So daily cover keeps these flies and other things away and then also tries to control the moisture, controls the smell issue.

Then there are concern in terms of the contamination to groundwater and the gas emissions. And for that, we will have a modern landfill design in terms of leachate collection system, the gas collection systems and those things are used for in terms of modern landfill design that is being done for that. So that is our in terms of the problem.

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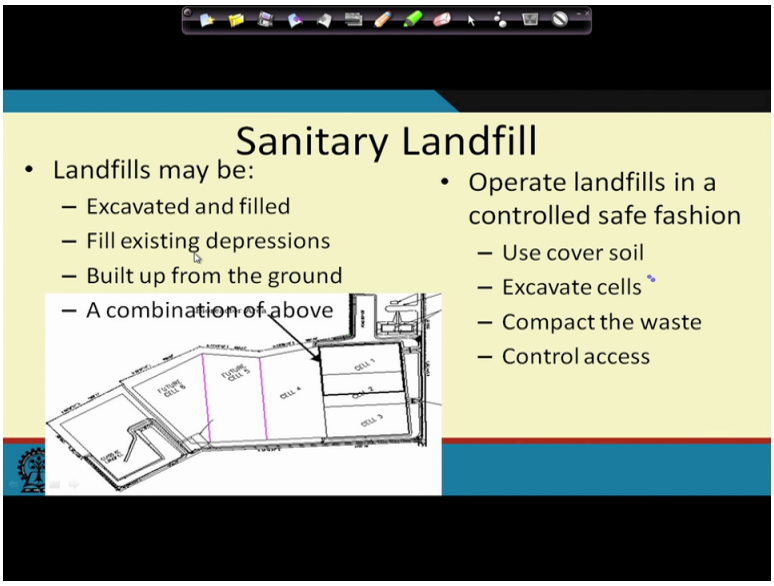

And what we do in terms of solution? So in terms of the sanitary landfills, we have landfills may be excavated and filled, they can fill existing depressions. It is many times it is built up from the ground. It could be combination from above, so that is how the landfills are there. And then they use cover soil, they use, they excavate the cell, they compact the garbage and there is a controlled access as well. So we do not have, there is a controlled access to the landfill.

What do you mean by controlled access? These days most of the landfill has a fence area where you do not have total access to landfill to anyone and everyone because there has been cases of in the past where landfills have been used as a dumping dumping space for certain crime crime I would say evidence. We had the cases where the way the people have found dead bodies from a landfill site. So those things have also, has happened from around the world. So this is how the sanitary landfill.

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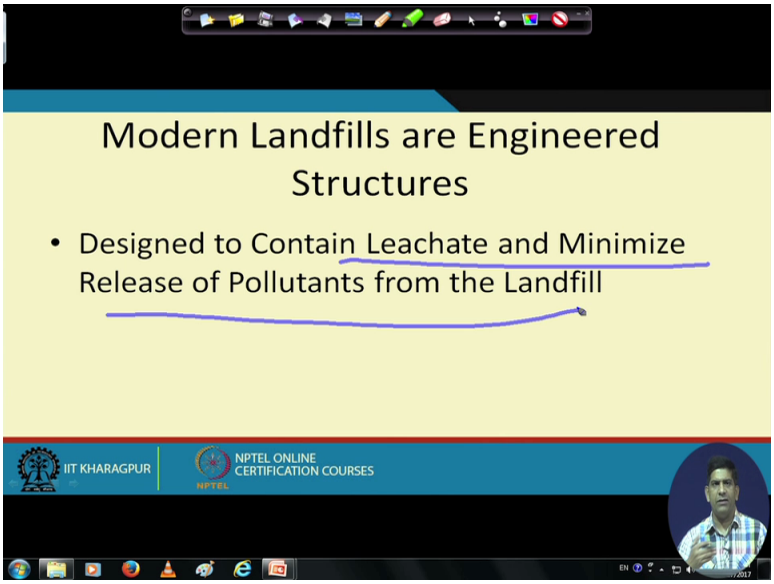

I will now talk about those, they are engineered structures, they are designed to contain leachate. They do contain leachate and they minimize the release of pollutants from the landfill. So that is a goal. Its goal is to contain the leachate and minimize. So the landfill goal was, is not actually, it is not a resource recovery, it is not recycling. It is, and per se, you can also think it is not really, when we started thinking about landfill, we were not really worried about the waste treatment or even waste decomposition per se.

But we have been treating about how to keep this garbage in a way so that it does not contaminate my air, water, soil which is altogether is the environment. It should not pollute my environment and at the same time, it stays in a safe and secure location. But at some point of time, you have to start thinking about, it has to degrade because you cannot stock, keep on making these piles and piles of garbage, these landfills after landfill because land is a problem. As our population is increasing, many places in the world now getting land for landfill is becoming, is a huge task to find a suitable land for siting a landfill.

So right now we are trying to help, work with, I myself is working with several cities in India where we are struggling to find good landfill sites. So that is always an issue. So it is, but at the same time and but they are not. So what we are thinking is now we have to move from these landfills which essentially a containment unit to a treatment unit.

That is why the concept of this bioreactor landfill came which is, was tried at Gorai landfill in Mumbai, and which again can be, this bioreactor landfill accelerates decomposition of garbage and then it makes things go faster so that you can use the same landfill site for much longer period of time. So based on this, there then one of the thing is that when the waste degrades, the leachate is produced.

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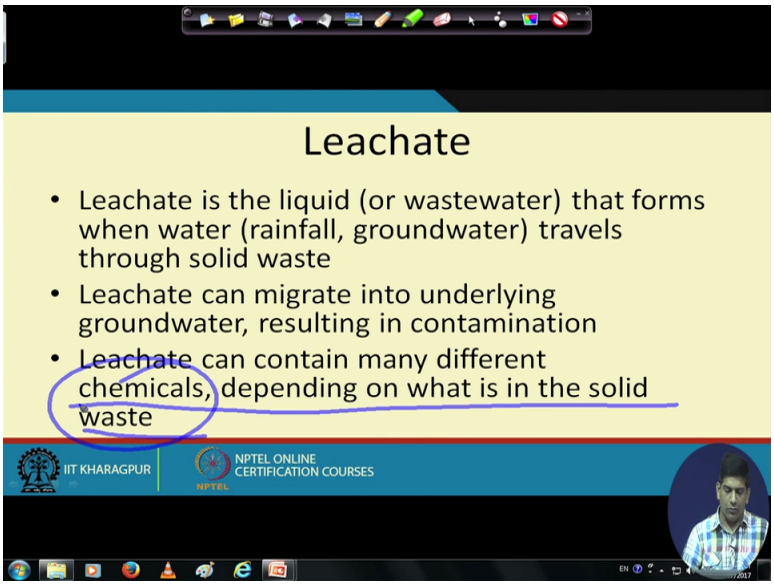

What is leachate? Leachate is the liquid or the waste water that forms when the water gets in contact with the garbage. When the garbage decomposes, the water is also a byproduct. So that is a way how this leachate is produced. So once leachate, it is a water, there is a gravity, our Newton has already talked like taught us about that there is a gravity. So there is a pull, so whatever water is there, it will start, try to palpate down and go to the bottom of the landfill. So we need a leachate collection system at the bottom of the landfill to remove that leachate.

Otherwise what will happen? Your moisture will start building up in the landfill. So when the moisture builds up, what happens? From your feed mechanics class if you remember, your pore water pressure will go up. And if the pore water pressure starts going up, it will, the C and Phi value of this garbage, we have learned it about the soil mechanics in the soil, so we kind of use garbage similar to soil although that is not an ideal way of doing it, I agree.

But in the lack of, because the waste is so heterogeneous, we kind of assume it as a similar behavior as soil. For in general, there are specific, we do research where we look at these in more

detail. But in general, if it, so then C and Phi values get compromised, what will, that will lead to a kind of garbage slide. So where you have the, rather you think about the landslide, most of the landslides happens when? During the rainy time. Because the water gets into those pores, pore water pressure, the waste cannot keep it and then there is a sliding down. So similarly here we may have a garbage slide and that will be a catastrophic kind of. And that has happened in many countries in the world, very recently in Colombo just I think around 10 days back where they had this garbage dump, garbage like a dump sliding down and kill so many people.

This leachate which is a nasty water, it can contain many different chemicals. There could be several chemicals in there. It contains several different chemicals and these chemicals could be depends on what is there in the garbage. So it is based on what is there in the garbage, you will have different kind of chemicals there. So depending if the garbage contains lot of heavy metals, you will see, you may see lot of heavy metals. And based on what is being decomposed, you will see. So that needs to be treated before it can be disposed of into the environment. So that is pretty much the bottom line here.

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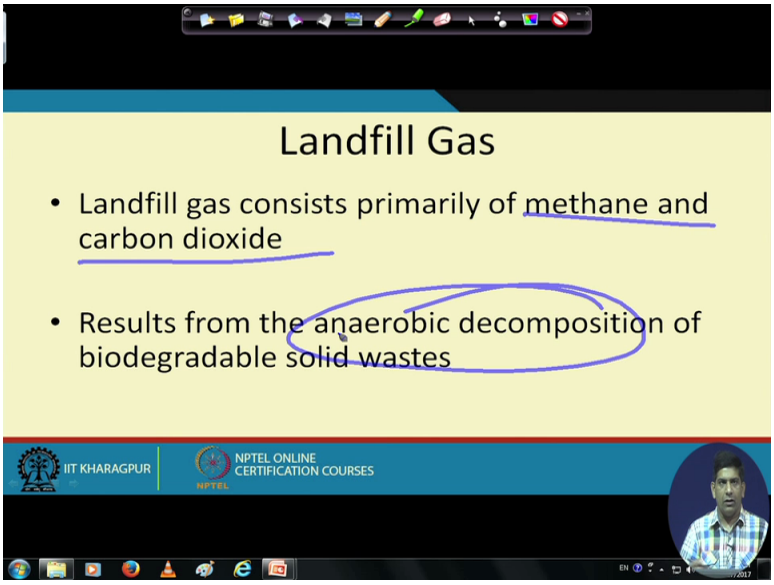

And so other part is the gas where the gas needs to be, our the gas needs to be managed in terms of the landfill gas. Landfill gas consists primarily of methane and carbon dioxide. So these are the two main things which is there. Because it is an anaerobic system, methane and CO_2 both are produced and essentially coming from the anaerobic decomposition of the biodegradable solid

waste. So that is where the landfill gas is being produced. Gas once it produced, needs to be managed to. So we have to like the have a gas collection system and I will show you kind of typical sketch of that.

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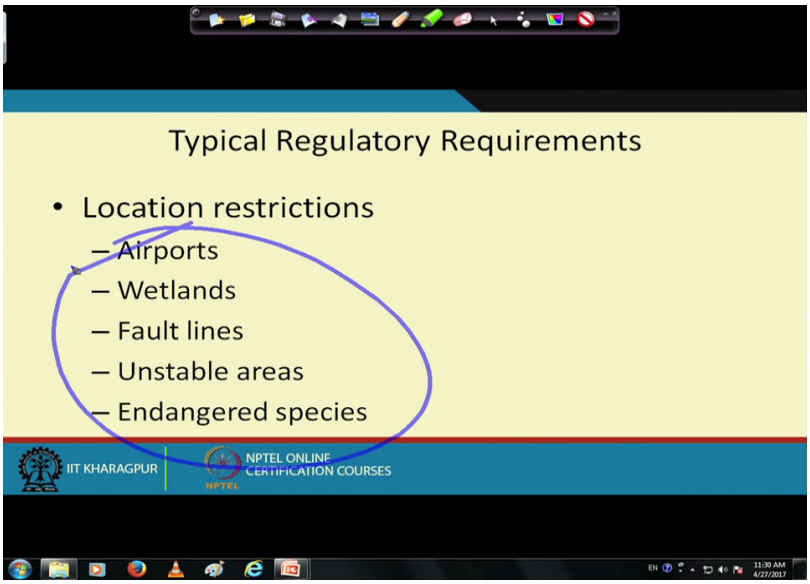

There are typical regulatory requirements as well. It cannot be, there are certain regulatory requirement in terms of the siting of the landfills, in terms of it cannot be near the airport, wetlands, fault lines, unstable areas, endangered species. So all these things needs to be taken into consideration. That is in terms of the siting of the landfill. We have to be careful in terms of how to site it.

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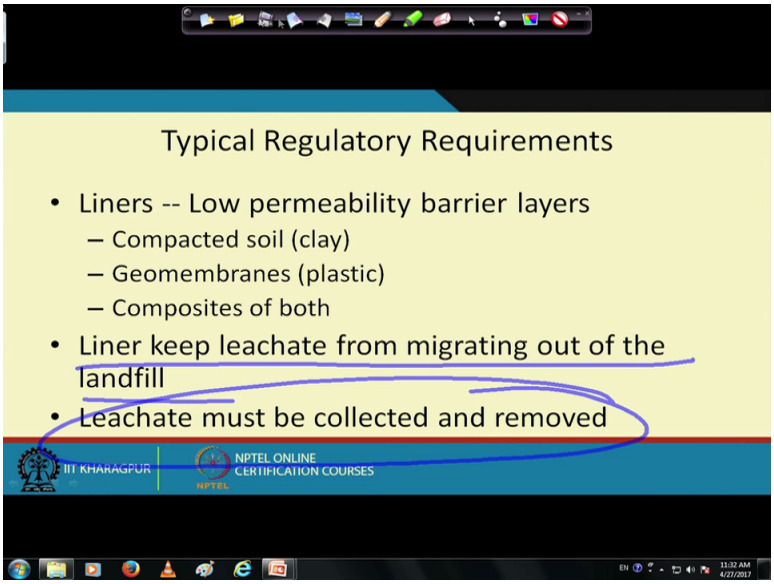

Then in terms of other requirement, we need to have liner, we talked about that. What is liner? It is a low permeability barrier layer. And it is, when we say low permeability, it can be compacted soil, it could be clay, it is a geomembrane which is a plastic or it could be combination of the both. So either clay or plastic or combination of both. The bottom line for the liner system is, if in the event, there is a leakage of, whenever this garbage has this (leach) leachate coming out and this leachate should not percolate down into the groundwater. So that is the bottom, that is a major concern. That is why we need the liner.

Liner what it does, it tries to keep, liner's job is to keep the leachate from migrating out of the landfill. So if it is cannot migrate out of the landfill, that means what? We need to collect it from the landfill and take it for the treatment system. So leachate must be collected or removed, otherwise we will have the stability problem of the landfill. So that is why we have the leachate collection system, is required for that.

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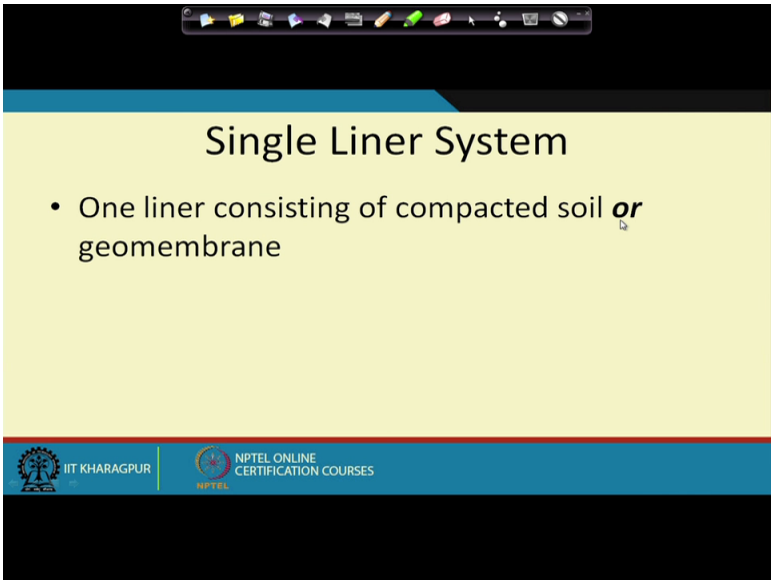

There are different types of liner system. We look at the single liner, double liner, all that. Single liner is liner consisting of either the compacted soil or the geomembrane, either of those two will be single. As the name suggest, that is like one material, either compacted soil or geomembrane.

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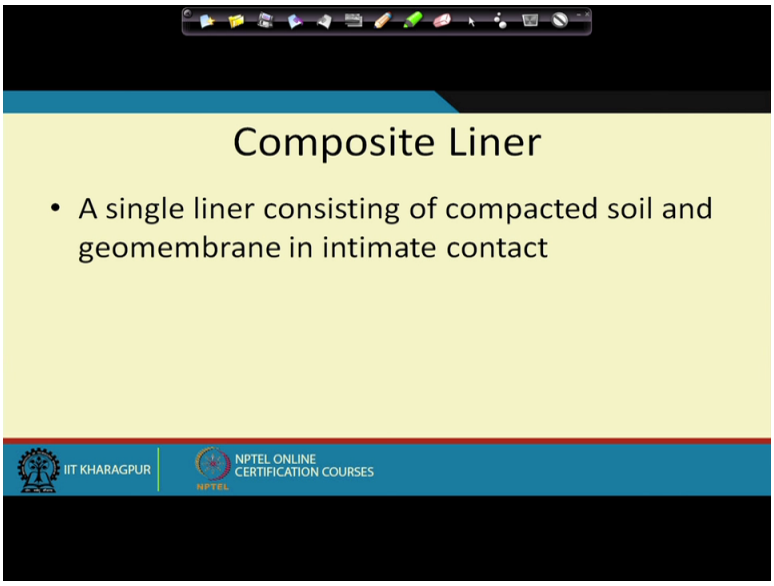

Composite means where you have this compacted soil and geomembrane in intimate contact. That is what you see most of the places. It is actually both of them together and as you will see in typical liner requirement.

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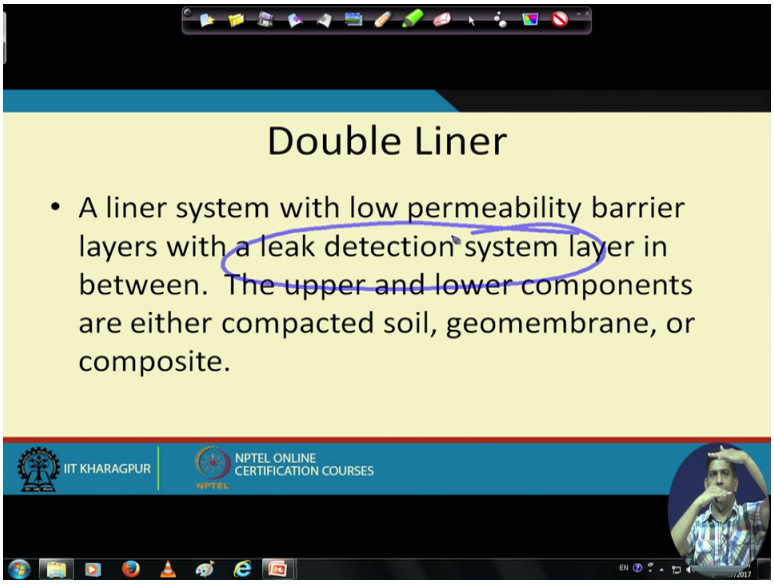

Or, you can also have a double liner system. Usually this double liner, although I will show you the sketch but most of the time this double liner system is used for hazardous waste landfill. In some areas which is a very critical area, the groundwater table is very high, some of the, we have a huge like a surface water nearby which is a very very important surface water like water body, we may go for double liner in MSW landfill as well. But most of the time, double liner system will be for a hazardous waste landfill.

So it is a liner system with low permeability, that is what it is a barrier. And in between, it has what is known as the leak detection system, so that is the important part in terms of double liner. Leak detection is you have a one liner system and then you have another liner in the bottom. In the event, the water is percolating from the top liner to the bottom, to the before it goes to the bottom liner, we have a leak detection system in the middle.

So this leak detection system will help in terms of getting the, whatever is the leachate which has passed through the first liner get caught up before it passes to the second liner and goes and contaminates my groundwater. That is the whole concept of this leak detection system. So that is for the double liner part.

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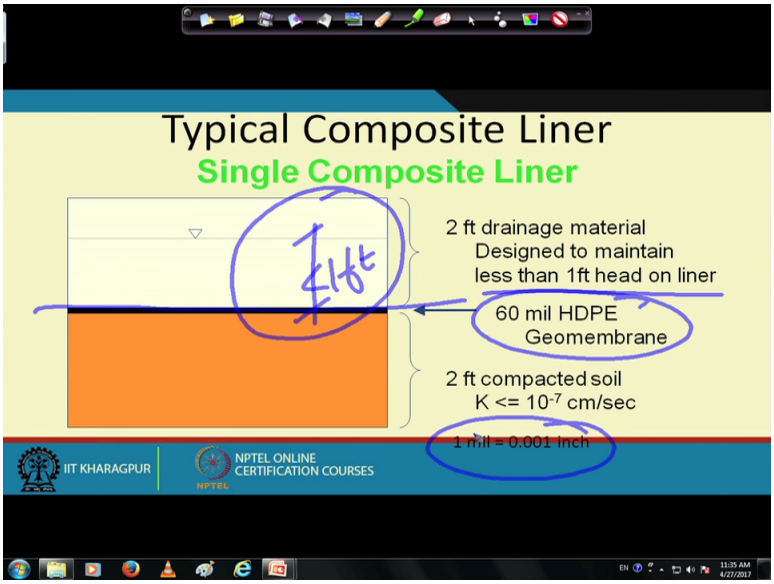

This is a typical composite liner system. This is a single composite liner where we have, it is, we have a two feet of drainage layer that is used for, it is a 2 feet of drainage layer as you can see over here. It is a drainage layer for the leachate collection system designed to maintain less than 1 feet head on the liner. We do not want too much head on the liner because that creates a hydrostatic pressure. So less than 1 feet head on the liner, so that is why this sketch is not to scale as you can see over here. I am showing 2 feet on the big part but at the same time, I have, the 1 feet is not shown accordingly.

So that is a, it is, there is a 2 feet of drainage material. Then after the drainage material, I have a 60 mil HDPE geomembrane there which, so this is our 2 feet of the drainage material that you see on top and less than 1 feet head on the liner, so this has to be less than 1 feet. So this is actually less than 1 feet although it is not to scale on the picture.

So 2 feet of drainage material, less than 1 feet head on the liner, then I have 60 mil HDPE, 60 mil HDPE geomembrane, so I have a layer of plastic here and that 60 mil HDPE, 1 mil is 0.11 inch. So you can find out from there, it is from like how much is 60 mil HDPE. It is not actually very thick. And at the bottom of that, I have 2 feet of compacted soil.

So there is a 2 feet of compacted soil with permeability of less than 10 to the power of minus-7 centimeters per second. So that is, usually that would be a clay material. So that is why we use. This is a typical single composite liner used in a MSW landfill. So if you are becoming a landfill

engineer, you should actually, this liner design, this liner schematic should be in your head all the time. This is the typical liner. In most of the sites, you will use this particular liner system. So that is in terms of the (sing) single composite liner.

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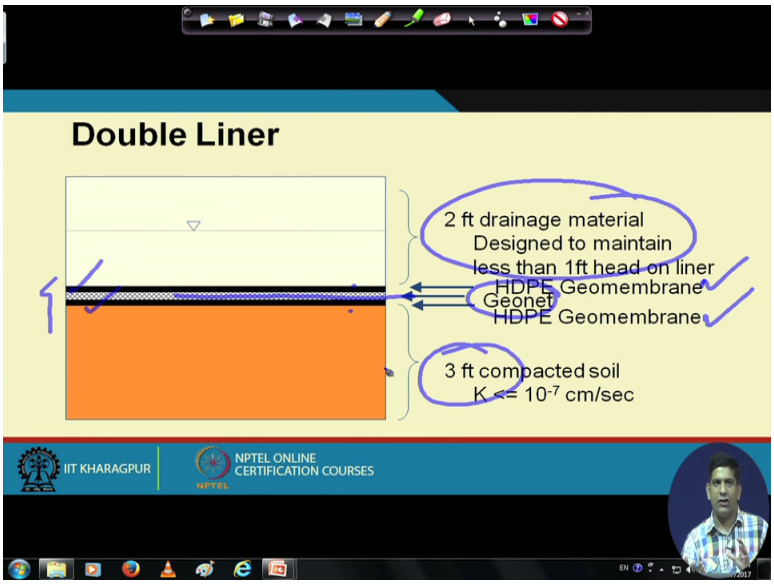

Now if you look at the double liner which I said earlier that we do not use it for MSW landfill most of the cases but in some extreme case you may. But in the double liner system as you can see in this particular slide, things are little bit different than the single liner.

Here we have 2 HDPE geomembrane as you can see on this side, there is a one on top and there is one at the bottom. And in between, what you see is what is known as the leak detection system. So that is the leak detection system in the middle. And that is, we use a Geonet for that. Top and bottom, we have this HDPE Geomembrane, same thickness as for the composite liner. Same amount of 2 feet of drainage material on top. So the difference here is two liners in between Geonet and then rather than having 2 feet of compacted soil, we have a 3 feet of compacted soil.

As you can see, the double liner means you have more protection. So that is why you have more compacted soil. Why we need this compacted soil? The reason for this compacted soil is to have, prevent the water migrating down. That is the whole concept of having this compacted soil. So 3 feet means more protection so that if, it is usually used for hazardous waste, is not it? Hazardous

waste is more dangerous than municipal solid waste. So to keep it more secure, we use at a 3 feet compacted soil for the double liner system.

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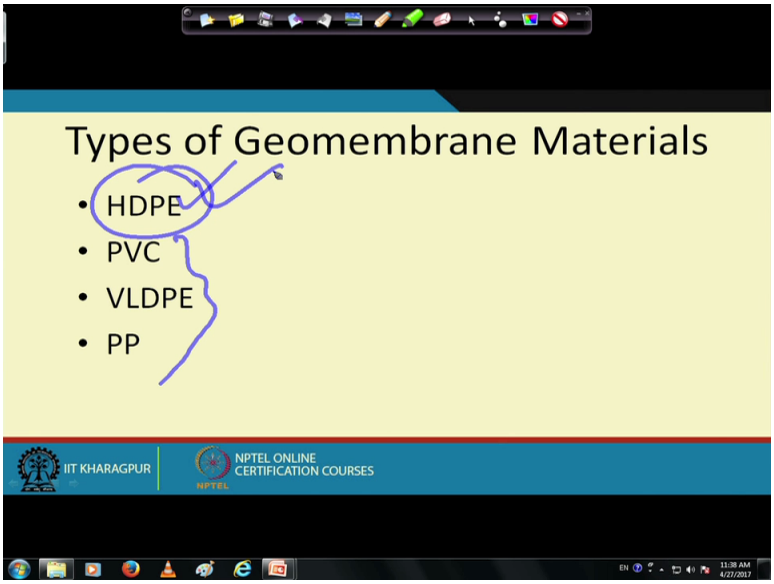

And the next, what are the materials we use for geomembrane? Mostly, most common is HDPE. What is HDPE? It is your high density polyethylene. That is the HDPE which is very similar to if you go and buy a Saffola or Tide and all those detergents in a container not in the pouch, that is that material that is used to make those containers or most of the plastics buckets as well. Buckets are actually more thicker but these what you, if you go and buy the Saffola especially those 5 liter ones. And the material that is used to make that is your HDPE, High Density Polyethylene.

The other materials are also used; PVC, VLDPE and Polypropylene but those you do not see much. But HDPE is the one which you will see being used most of the time in terms of liner material.

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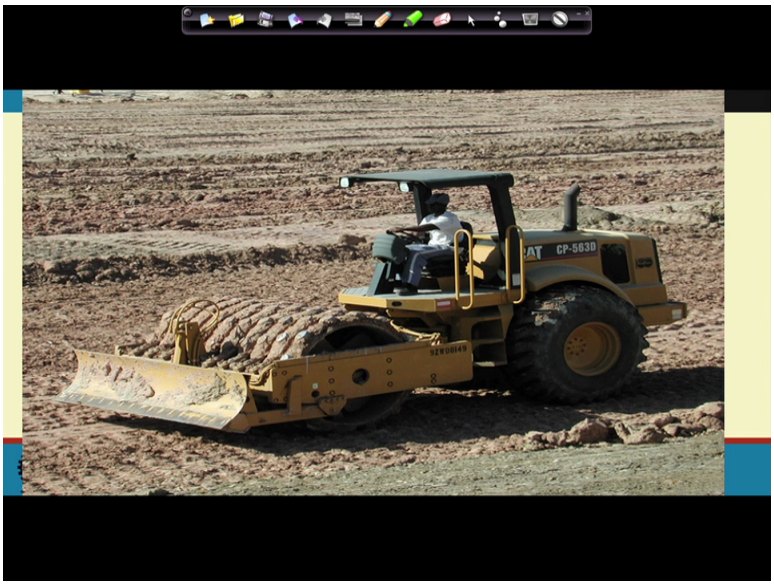

So let us look at some pictures now in terms of how this liner is constructed. So they are, these are the all the pictures. Here this, if you do not have clay at that particular site, you have to bring clay from outside. This, so here the clay is being, bringing from outside, you can unload in the soil. The soil is being unloaded and that is why you see that color of the clay.

And then after unloading the soil, you have to compact. Remember the 2 feet of compacted soil or 3 feet of compacted soil with the clay is less than 10 to the power of minus-7 centimeter per second. That is what being done in this particular picture over here where it is trying to compact

the garbage. When we are trying compact this, sorry, not compact the garbage, compact the clay material, compact the clay to have, to achieve the permeability of less than 10 to the power of minus-7 centimeter per second.

So when you compact soil, we add moisture. And if you, those of you who are civil engineers or if you have taken any soil mechanics lab, you have done Proctor compaction test. So when you do the Proctor compaction test, if you remember from your Proctor compaction test, I can, I will try to draw the graph right here, you come up with your like a dry density.

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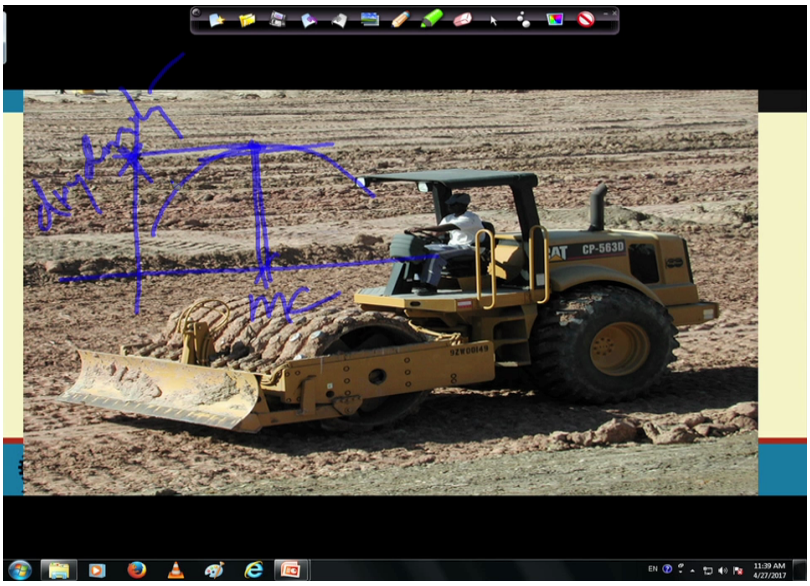

I will just come up with some graph something like this, if you remember that that is your optimum moisture content. If you have, this is your moisture content on x axis and if your dry density on the y axis, then your optimum moisture content kind of gives you the moisture content at which you see the maximum density. So when you compact, you try to use that optimum moisture content number.

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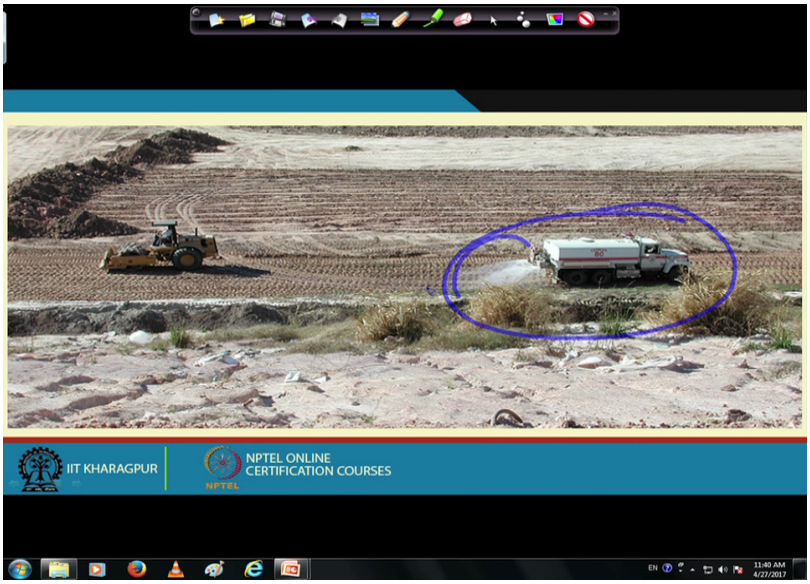

So similarly here for this particular material, in the next slide as you can see in this picture that, let us see, yeah here as you can see in this particular picture, this truck is trying to spray some water. If you look at very carefully, here this water is being sprayed. And this water that is being sprayed is to achieve that optimum moisture content so that the compaction will be better. That is the whole concept of, so again whatever you learn which I tell in my class many times that whatever you learn in different subjects, they are all important. So you may have to use certain language, certain knowledge from one particular class in some other aspect as well. So here your OMC lab is relevant when you are trying to do the liner system of a landfill.

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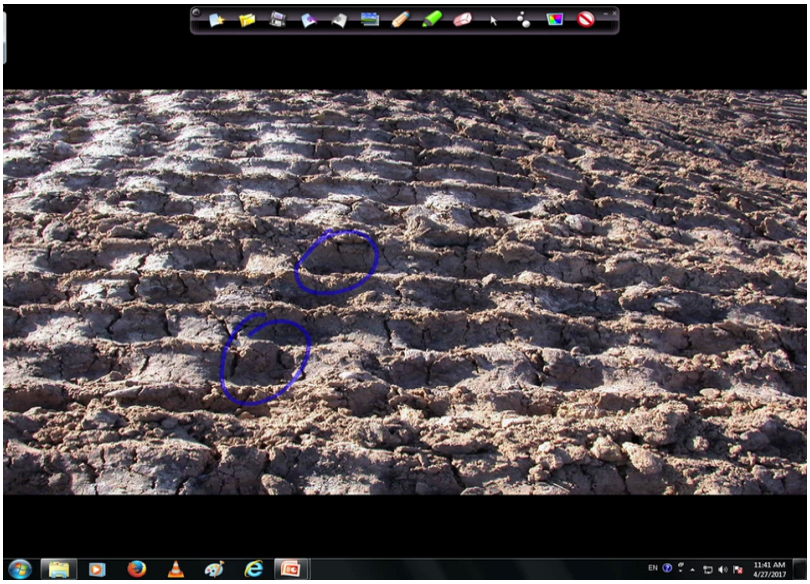

So once it is all compacted, it will kind of, looks like this. But we cannot put the liners, the polythene sheet on this because we have so much undulations as you can see here. Like all these undulations here that will kind of make these things little bit bubbly and then it would be a problematic.

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So to avoid that, what we will do? Very simple, we put a thin layer of clay on top. So just make a nice layer on top as you can see in this particular picture, it is a nice layer of clay and then after that you do a grading top and pass through a roller. Very similar to roller that you see on your

cricket game, most of us are kind of follows cricket, so this is a same kind of roller that used to roll the pitch before a team goes out to play.

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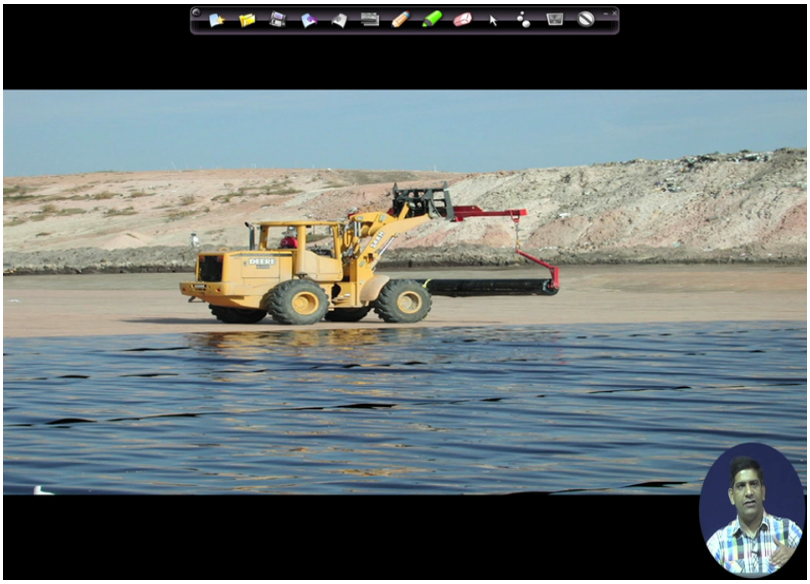

So that is, after the rolling is done, then you put your geomembrane. As you can see in this particular picture, so the geomembranes are being laid. And this geomembrane is used to for, so as you can see the geomembrane has certain width. So in between, there are, it needs to be welded.

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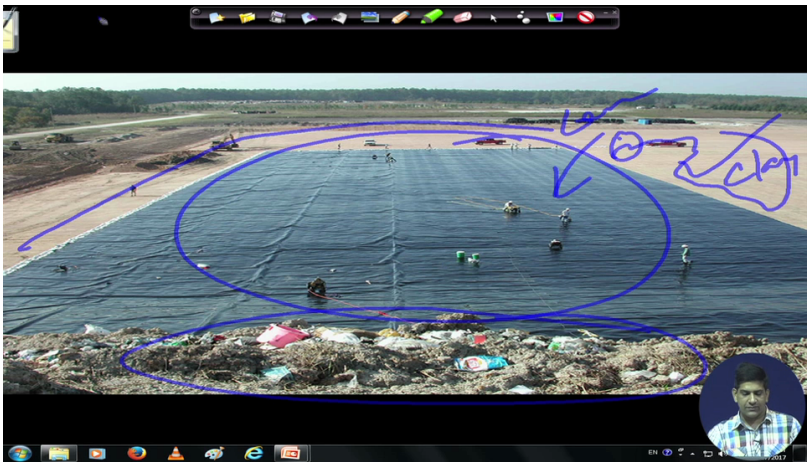

So after laying this geomembrane, this is another, so you see different pictures of that. This particular site, in this particular picture, you see that here the, this is the old area of the landfill.

The picture has been taken from the old side of the landfill. This is the new area of the landfill is being prepared. Here we still have, we have the clay at the bottom. Here our geomembrane has been laid. Now we will have geomembrane coming in all this area as well as you will probably see in the next picture, but this is how it is being laid. And in between, people have to do some welding as well.

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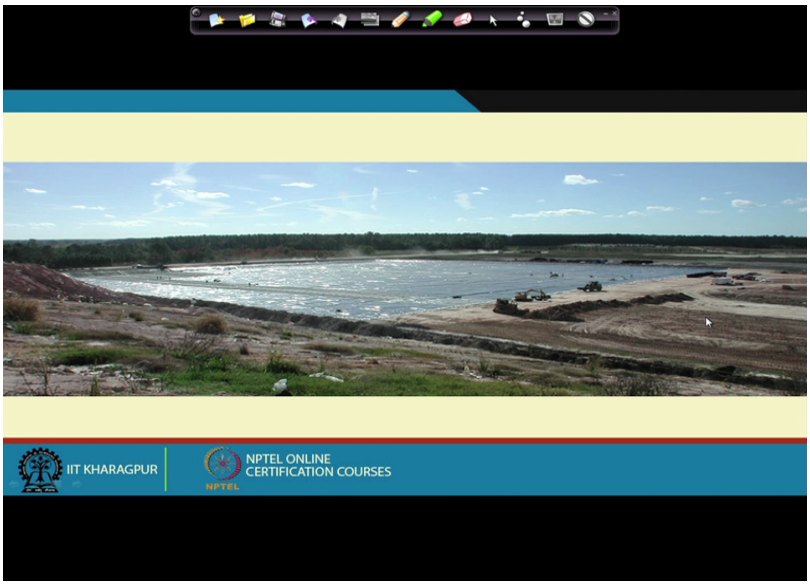

And this is the picture that you, the same picture from a different angle. On particular side, this is the whole landfill area. And then after all, the geomembrane has been laid as you can see over here.

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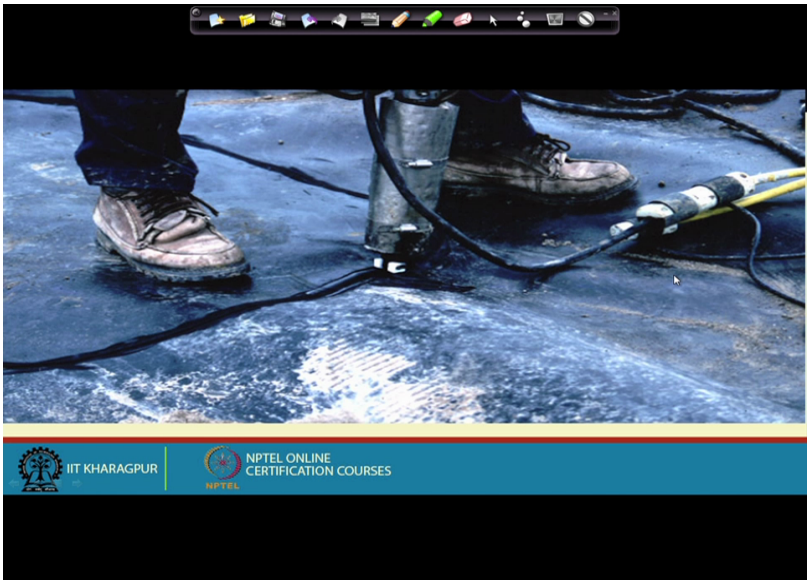

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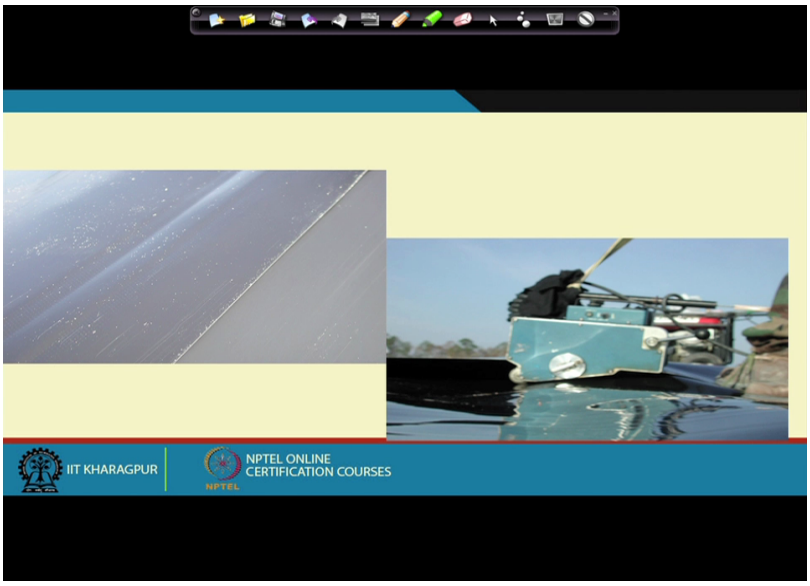

So once the geomembrane has to be welded, as I said, since they had a certain width, so it has to be welded. Otherwise, the water will percolate down through the sheets. There are different ways of welding done. We will not worry too much about the welding part, that is a mechanical engineering job but we will talk little bit about the welding in the landfill chapter. But for you to remember, the welding is needed on those different geomembrane to make it one big unit.

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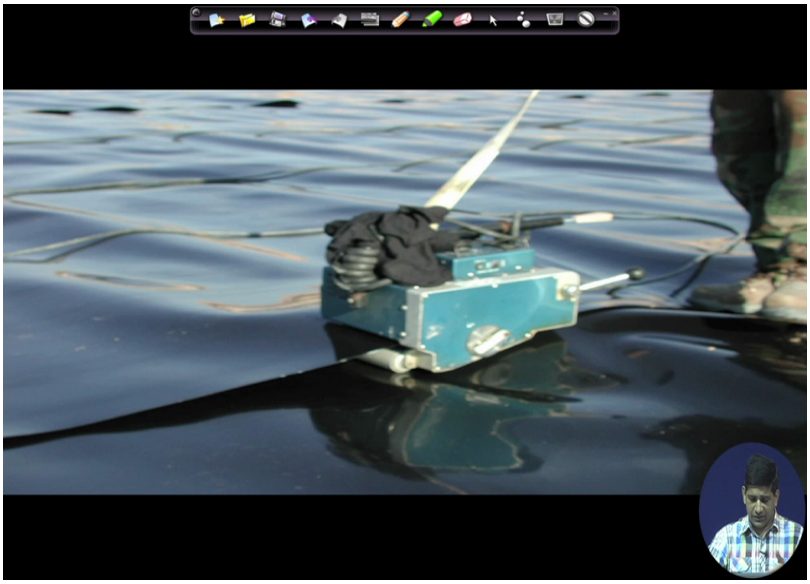

So this is another picture of how the welding is being done.

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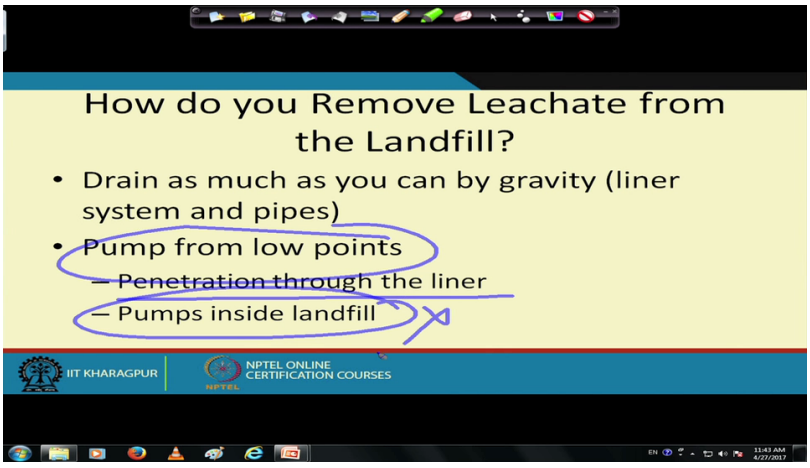

Once you have leachate being ponding on those leachate collection system, on those liners, it needs to be collected. So how will you remove the leachate from the landfill? We try to use gravity like liner systems and pipe. Why we use gravity? Because think, we are inside the landfill, so we do not want to use too many pumps because once the garbage is put in there, we do not have access to the pump. So we try to use the gravity and then we use set of pipes and then you may have to use certain one or two pumps.

We try to use pump outside the landfill. So we try to have pump from the low points. We have a penetration, we have wide penetration through the liner. We do not want pumps inside the landfill, that is not a good idea. We do not like to have a pump inside the landfill because you do not have access to it. In some cases where you cannot avoid, you may want to. If you have to put a pump, you put a redundant pump there as well. Just in case, one goes bad, other will work. And these days with some like robots and other things that is being used, we people have access to things inside the landfill as well. But most of the time, we try to avoid having pumps inside the landfill.

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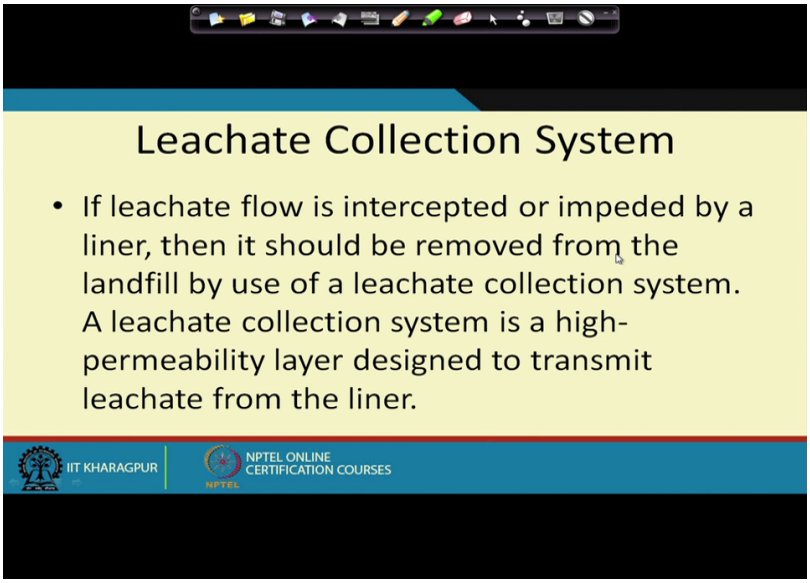

So leachate collection system is the leachate has to be, it should be removed. So collection system, say our liner system is low permeability, leachate collection system is opposite of that. Here we want all the moisture to come to our pipes and then to be taken away outside the landfill. So that, we want that layer to be a very good sand layer like it is a high permeability layer. That is what we use for our leachate collection system.

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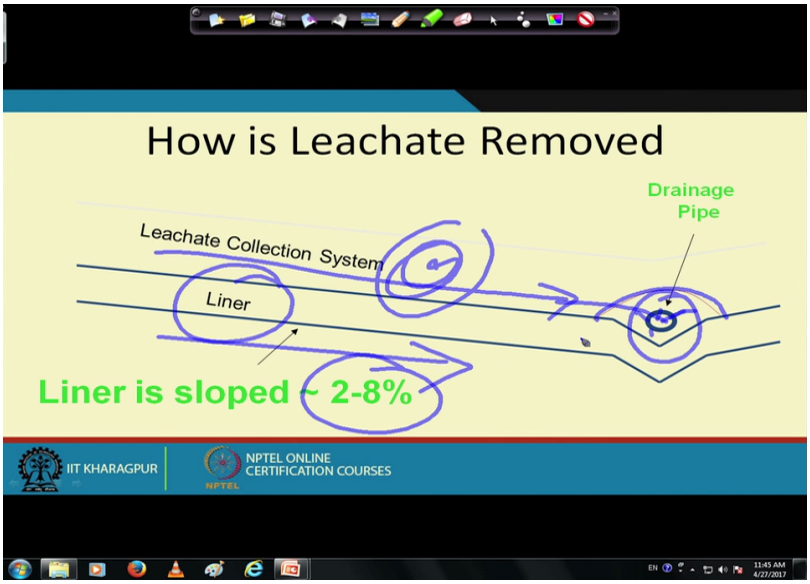

For the leachate collection system as you can see here, this is, this will be our say a typical sketch. So we have a slope, the slope has been shown to you in a very high, just only 2 to 8 percent. The sketch is not to scale, just to show you that there is a slope and there is a liner system in here. And on liner system, on top we have a leachate collection system.

So this area is our high permeability area, so that is our high for sand and then the all the water will percolate through and it will go into this pipe. The pipe actually has a perforation through it, so the water will flow into this pipe. And this pipe has, is, what we are looking at is a cross section of the landfill. So this pipe, you can think about this is the pipe, will actually go like this. Then this whole pipe will come out and then we will have a header pipe which will take the garbage, which will take the leachate out of the landfill. And I will show one sketch of that in a minute.

And on top of this drainage pipe, you see a line here and that is the geotextile which basically, it is a cloth type of material which keeps the garbage out, only let the moisture in so that our pipe does not get clogged and that is the reason for that. And this, they are wrapped around in a style of burrito if you know what is a burrito. And in many, in the western world they call this as a burrito type of leachate collection system.

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This is what that pipe is right there and then you have the some sand around it. This, along with this pipe, you have some sand. The sand keeps the garbage out. This cloth material on top, it is again, keeps the garbage out. Only the water, only the leachate passes through, passes through the sand. There are perforations here on this pipe, so water it kind of goes into those particular pipe and then pipe comes out and then it taken in a header pipe outside the landfill.

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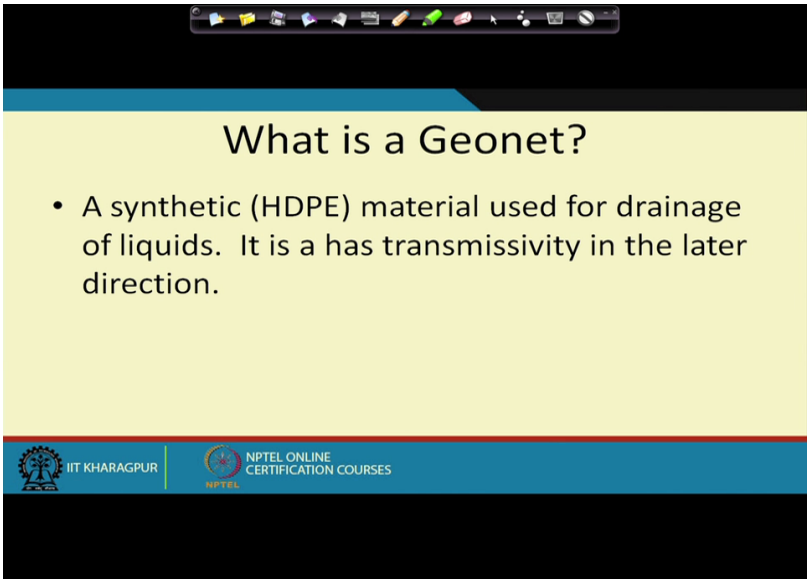

And then the Geonet is used which I talked about the synthetic HDPE material for the drainage of liquid, we will talk about that.

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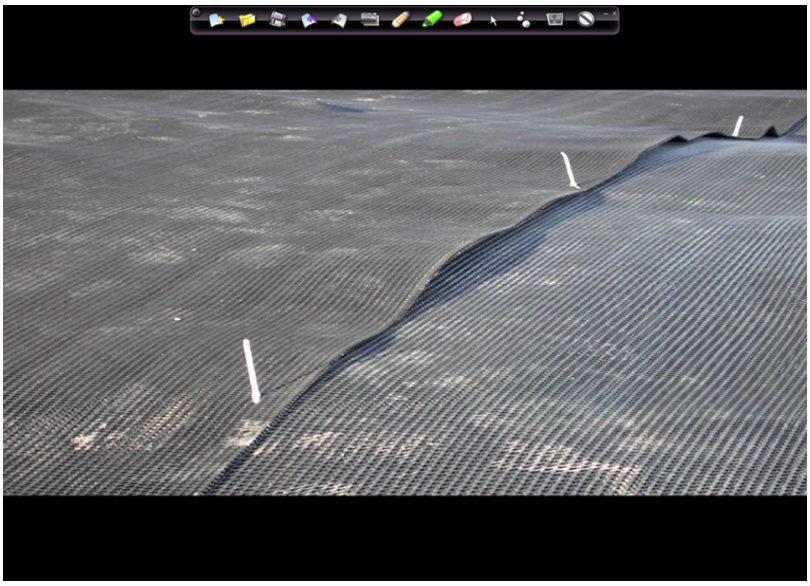

This is the Geonet material, especially it is used for the double liner system. Do not worry too much about this but for the hazardous waste it is used. This particular MSW landfill which was in a very close to certain environmentally sensitive area, so they actually went ahead and did a double liner system here.

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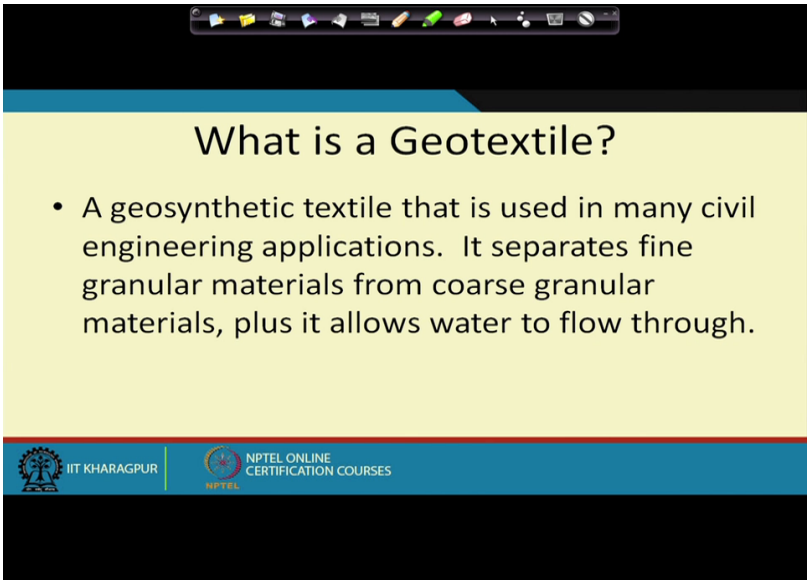

So geotextile is we already talked about, it is a textile material which allows the water to flow through, does not allow anything else.

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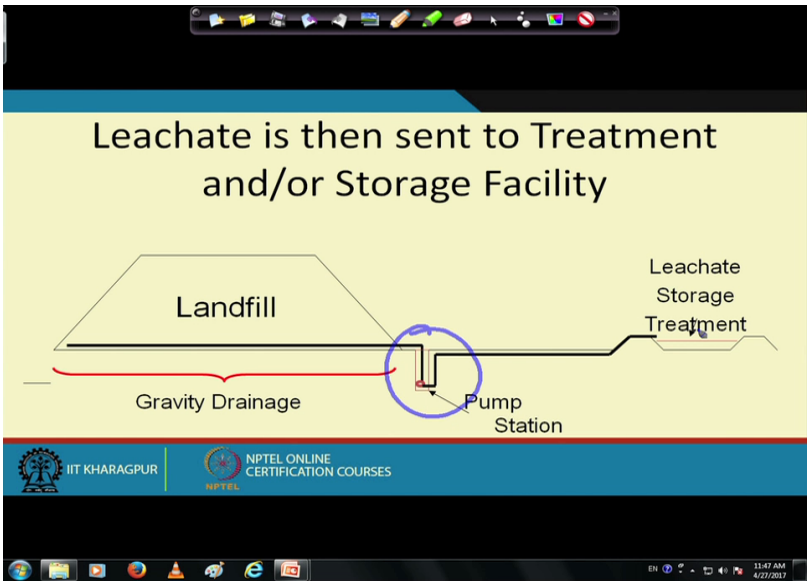

Then leachate is then sent to a treatment and a storage facility, leachate is collected. It is a gravity drainage again as you can see over here. So those pipes that you see, that you saw were actually perpendicular to this particular, what we are seeing again is a cross-section. So those pipes were perpendicular to this. Then, we have gravity drainage through this and then outside we take out this pump which is collected, and then the leachate is stored and treated.

This is how a leachate collection system works. And then, we will be looking at, so the gas collection and other aspect, we will be looking at in the next module and we will wrap it up this particular aspect. So thank you and we will continue this discussion in our next module.