Integrated Waste Management for a Smart city
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Lecture 41
Landfill Disposal (Contd...)

Ok! So welcome back so we are in the ninth week now. So if I think about this is a twelve course so out of twelve weeks we have finished 8 weeks and we are in the ninth week. So that means we are in the last one third of the course. So we have already finished two third of the course we are in last one third part of the course and I hope that you are enjoying the course so far.

So we will continue our discussion from the last video if you remember video of the last week for the week 8. I was showing you the details of a landfill how the liner is constructed I also showed you some pictures towards the end where the waste the landfill the liner requirement because of the clay, the clay was not available locally so the clay was brought from outside compacted we talked about the proctor compaction the optimum moisture content we also talked about liners HDP liner especially and then the liner has to be welded. So we kind of ended at that particular point.

So now once you put the liner in place what you are doing is you are putting an impervious layer. So if you put a impervious layer what will happen the leachate will get produced. So once the leachate is produced why the leachate will get produced because once the during the operational period of the landfill the cap of the landfill is opened because you can put the garbage in.

So when you put the garbage in, if it says rainy season even the water can come in. If you have any rain event you will have the water coming into the garbage. So that will pass through the garbage and become part of the leachate and it will flow down because of gravity. And at the same time waste itself has some moisture so that will also percolate down over time.

And as the part of anaerobic degradation of the waste you also have moisture being one of the by-products. So let if there are different sources of this moisture and ultimately all this moistures together is called leachate. So leachate will start coming down and since we have this impervious layer leachate will start building up because it cannot move down.

So if it start building up problem is if it becomes too high and if the hydro static pressure becomes too big we have the land slide problem as you see during the rainy season every time during the monsoon and rainy season you hear about the landslide happening in Uttarakhand or certain hilly areas. It is because the moisture getting into those pour spaces and comprising the C and 5 value that you learned in soil mechanics class.

So that leads to the failure the interaction between the soil particles are not good strong enough and then they slip and then they have a failure . So similarly in a waste if you let this water pound up we will have the slope stability problem. So we need to remove this water. And this water needs to be removed and treated. So that is where the leachate collection system comes in picture.

So for landfill design as of today there are few aspects of landfill which is very very important if you want to become a landfill engineer you have to be very very good knowledge about leachate collection system of course the liner system the leachate collection system, gas collection system, storm water protection system and the ground water protection system and we will talk about those.

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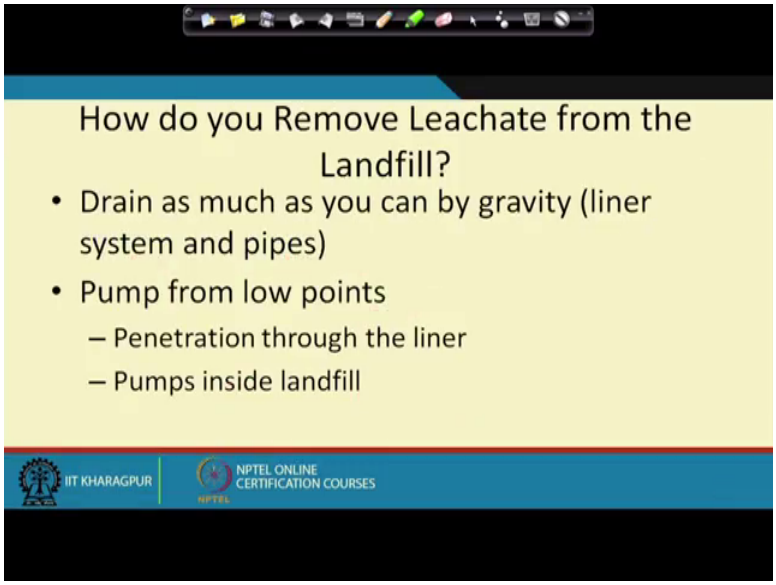

So let us talk about the leachate collection system first. So how we remove the leachate from the landfill? We try to drain as much as possible by gravity. Now we do not want to use pump inside the landfill. So for the obvious reason so we want to drain as much as possible by gravity which is the liner system and pipes. So we will have a slope we will like a slope and I will show you some pictures of that.

So there would be a slope and then we try to drain as much as by using a gravity and then we will have a pump from the lower point. Minimizing the penetration through the liner we do not want too much penetration through the liner as well because more the penetration more chances of moisture getting into the landfill.

And we want to minimize the use of pump inside the landfill. Because for all these reasons so once the waste is put up and you have the pumps inside the landfill those pumps are inaccessible. So if something happens to the pump you cannot do anything about it. So incase you may have to use some of these pumps what we do is we add some redundant pumps.

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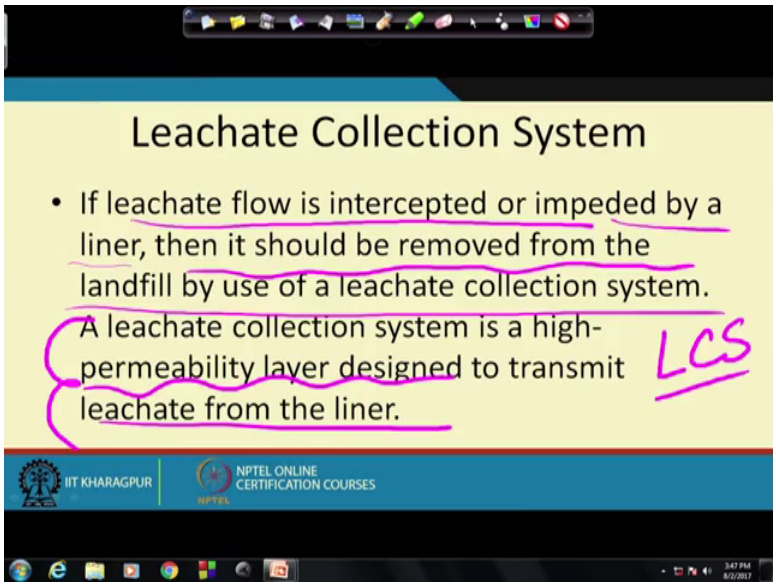

So if requirement is 2 pumps we provide 3, so even if one goes bad we will have others to take care of the work. So the leachate collection system is one since the liner in the liner system the leachate flow is intercepted. So in the liner system we have intercepting the leachate flow or impeded by the liner.

So one then it should be removed that is what I am talking about it should be removed from the landfill by the use of the leachate collection system. Many times you here as LCS this is the short form you see for leachate collection system. So that is the abbreviation used for that. So the Leachate collection sytem is kind of opposite to the liner system.

So if you remember from the liner system we had a impervious layer isn't it? We put a impervious layer of high density polyethylene with the clay at the bottom that you saw in the

previous video of the last week. But now what since we have on top of this impervious layer we does not want this leachate to be pounded up to much.

So we put a drainage layer here. We put a high permeable layer and then we put several pipes also you the sketch of that. So we have several pipes and those pipes will collect all the leachate and the leachate will be taken out. So here it is a high permeability layer designed to transmit leachate from the liner. So that is what the leachate collection system is all about.

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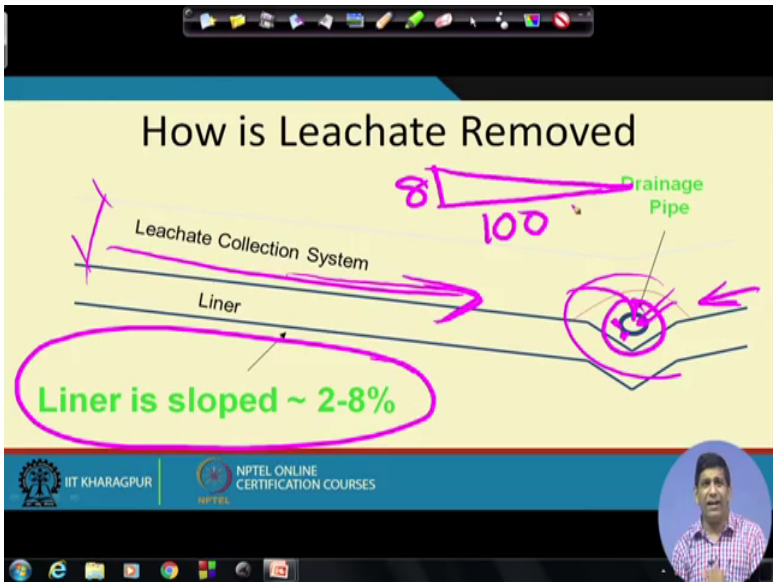

So let us look at some, so this is how it will look like so you have we had this liner system at the bottom this is the liner system at the bottom where you have this high density polyethylene and the clay and all that thing at the bottom that is your liner system we already saw that and then we have the leachate collection system on top of here.

So what is this leachate collection system we have a series of pipes and these pipes have actually perforations, there are perforations here, perforations means the holes, we have the holes in there. So the leachate from this side and similarly length from the other side it flows in here. It would be flowing in from this side and as well as from this side.

So that is how the leachate will flow in and then it will get into these pipes and what you are looking at is across section. So you are looking at the cross section of the landfill. So there will be the pipe is actually going you can think about the there is a long pipe, so it is a what you are looking at here is actually the cross section of the pipe.

So this pipe is you can think about the pipe is going into this screen for a long distance and then you have a header pipe where all these pipes say so this is my thumb if it signifies a pipe there are several pipes like this and this is my header this is the header pipe the main pipe. So there will be one pipe here, one pipe here, one pipe here and then paste on the width of the landfill we will have some.

And the spacing of the pipes will we have to design, that depends on how much leachate is being produced. So we can we have to do some leachate like leachate volume calculation to find out how much space and for all that if you remember for the liner requirement we had should not be head should not be more than one feet, it should not be more than one feet head on the liner.

So here the liner again we have put a slope, the liner is slope so leachate collection system is also in a slope so it will essentially flow through gravity and the slope is 2 to 8 percent. When I say 2 to 8 percent that means if it is an 8 percent you have 8 vertical and 100 horizontal in terms of the unit. So it highly and it is not to scale.

This is actually this slope is much more than 8 to 10 8 percent , but this is just to show you this is what it means. So it is a very tiny slope not too much it is a tiny slope the sketch here is not to scale it is just an illustrated sketch do not think that this is to 8 percent slope what I am showing you over here actually it is much more than 8 percent.

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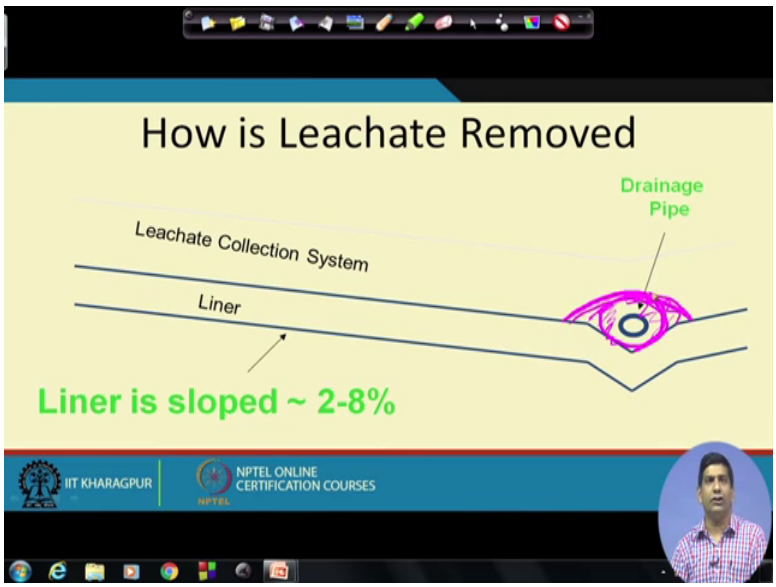

So it is just to show you how it looks like and then it will get connected to these pipes and these pipes over here will have this area will be filled up with some sand kind of material and the reason for that and this is geotech style the line that you see on top is actually Geotech style.

Geotech style acts as a filter so its does not let so just this is thin line see is a Geotech style that acts as a filter which only lets a moisture come in only lets a water come in not any gluey kind of material with the leachate otherwise it will clot the pipe and then you have this sand here which prevents from getting any clog in from from the like a waste coming into these pipes and all that.

So this is and that is this kind of this is wrapped in and I will show you the picture some picture of that as well. So this is how this thing look like and as you can see this mostly what is known as a saw tooth design. So this is in area of saw tooth. Remember the saw that we use for cutting the wood. So this is like a saw tooth design where you have .

So there are other designs out there too so when you will walk in a landfill industry when you talk to some other landfill Engineers you talk about the leachate collection system. Many times you may react like a they talk when they are talking in a voiced conference or other places whether you have saw tooth design or whether you have a fish bone design.

The other one more popular other one not as popular as saw tooth but other popular method of leachate collection system is a fish bone design, the fish bone design is where as you remember especially if you are from fish eating place you know that the fish has a central bone, most of the fish will have a central bone and there will be lot of side bones.

So that is why the side bones are there and this is a header pipe, that is the header pipe for the leachate collection system and then you have the side pipes which is very similar to how a fish bone look like. So if you have a smaller fish you have a done a full fish fry and then you take all the flesh out just look at the bone structure that is what the fish bone design for leachate collection sytem.

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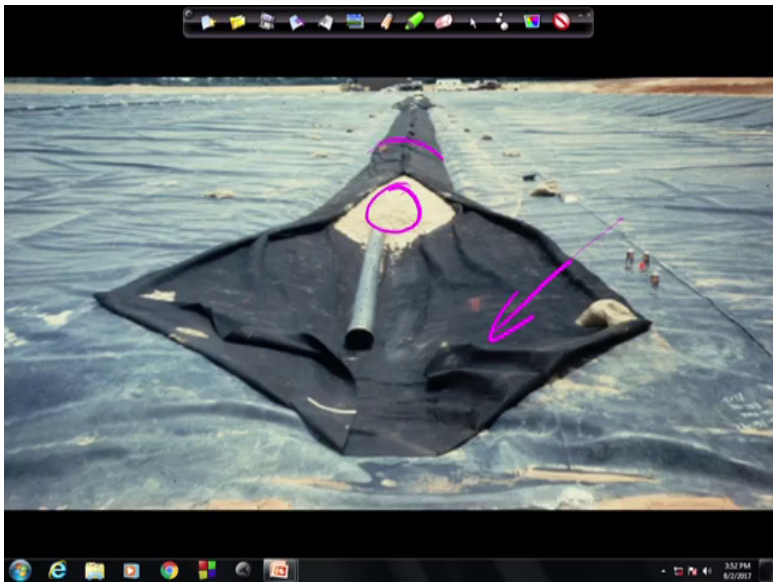

So this is also called like a fish bone design for leachate collection. So that is the head and the middle pipe that you saw and this is your geotech style that I was talking about. So this is your geotech style part that is the black part that you see is the geotech style and then this is the pipe the pipe has perforations where the waste is getting collected sorry the leachate is getting collected.

That is the sand in there and it is wrapped into this geotech style and so to prevent it from getting clogged and to save this pipe for any breakage and all that. So since it is a wrapping kind of design it is also called burrito design. Burrito is very famous Mexican food which is actually wrapped food so that is why it is also called Burrito kind of design. So this is how it looks like.

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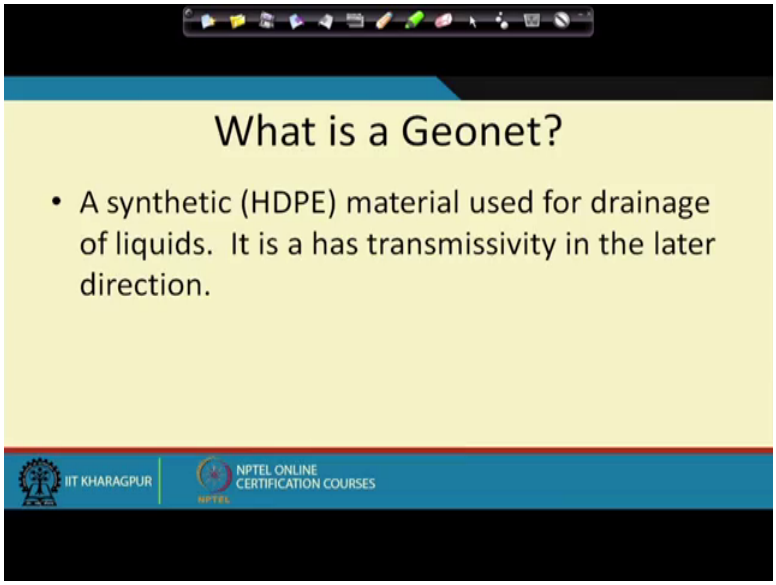

So then there is another thing used is a geo net. Geonet is a synthetic HDPE material its used for drainage of liquid and geonet.

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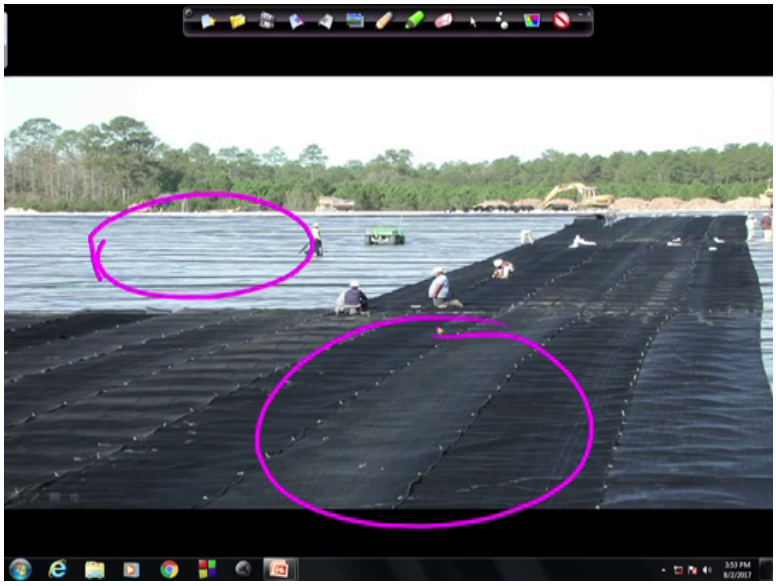

If you remember from the previous video we were talking about the double liner system with a leak detection system in the middle. For the lead detection system we use this geonet. So we use geonet for the lead detection where it actually it has more transmissivity in the horizontal direction.

So it allows the water to flow more in the horizontal direction then in the vertical direction. So it helps in terms of finding any leaks another stub and then the water flow through and getting collected in the leak detection system. So the geonet is used for that. So this is another I will show you the picture of geonet right there.

So we had the liner at the bottom but you saw from the previous video as well that was the liner at the bottom and then you have this leak detection system in the middle. That is the geonet it has been put in place. So there would be pipes in between here which will remove that so that is the closer view of the geonet.

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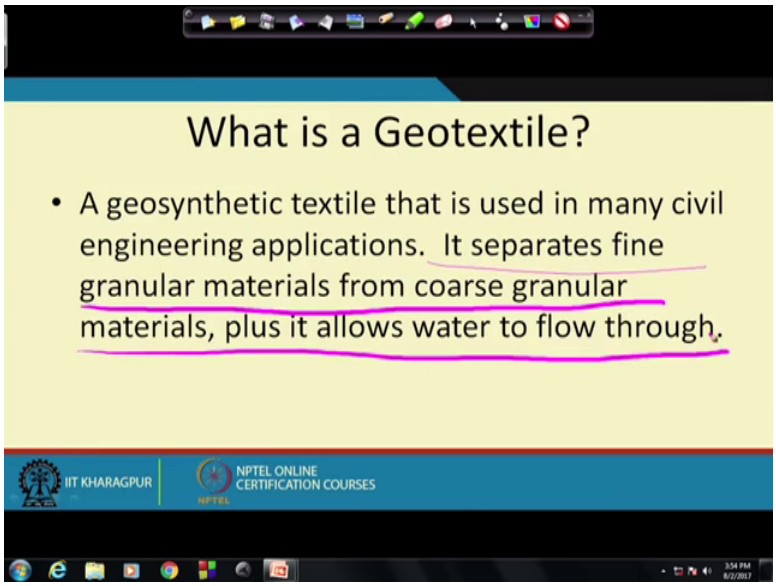

And then we have this geotextile which is a geosynthetic textile it is used in many Civil engineering application I showed you the wrapping of those pipes with this sand in between so that is the geotextile essentially as a filter. What it does it separates fine regular material from coarse granular material plus it allows the water to flow through. So basically it acts as a true filter. So that is what the geotech style does.

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So that you can have a this is your like in toe drain and then we have the another area where you can use for the storm water system. For the storm water system you can use these kind of pipes where water coming into the storm water after say rain event whatever the water coming in there you can get this will get into this drain and then you can use these pipes to drain those water. So that is this is called a toe drain which is its at the toe its at the bottom of the landfill that is why it is called toe drain.

And if one thing you can see on the picture towards the back you see those white white stuff those actually the birds and as I told you earlier if you have if you really want to watch birds in many coutries you go to the landfill and you will find lots of the birds there. So that is the those are the birds you see on the back over there.

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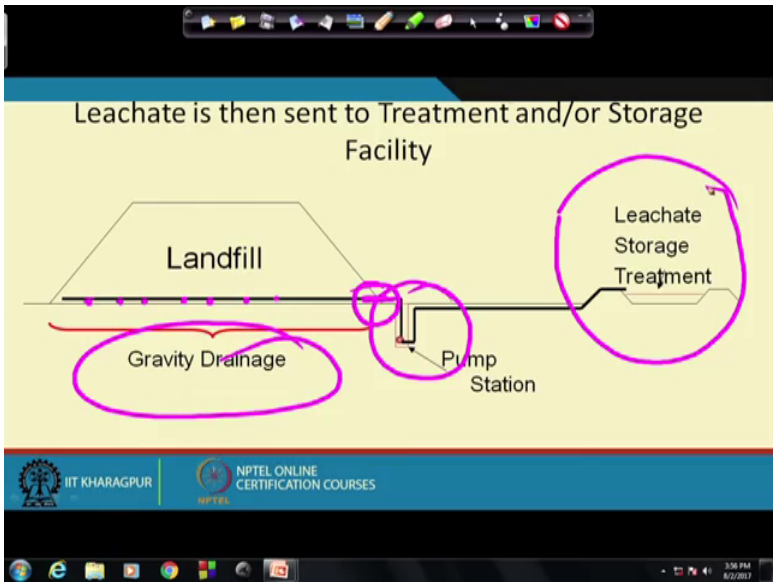

So then the leachate is then, so all those pipes that we saw those pipes are actually if it is basically those pipes are coming and joining these pipe. Let us see so these are the so the pipes are coming in and joining to these pipes over here. So those basically you will not be able to see it because it is on the other side of this pipe.

So if you look at the cross section of the landfill and if you are at the edge of the landfill so landfill is over here so all these pipes are coming and basically this is my header pipe so if I take this as header pipe so pipe is coming and joining here joining here joining here joining here and that is how it gets into this header pipe.

And there is only one place where it is coming off from the liner. So there is only one breakage point one point where the pipe has to come out of the liner in this area we are using gravity drainage. So once it comes out it goes to a pump station where the leachate will be collected and then it can be sent for leachate storage and treatment.

And this leachate is stored and leachate treatment or it is same as the waste water treatment. So if you have taken waste water course so this leachate treatment is essentially same as the industrial waste water treatment. So it is a nothing the same concept are used here as well.

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So this is some pictures of those leachate wells which you saw in this case earlier. So as you can see there is a landfill on the other side of this burmp we have a this liner system leachate collection system and then the leachate collection system where pipe will come into these and the leak detection system pipe will come into these particular well.

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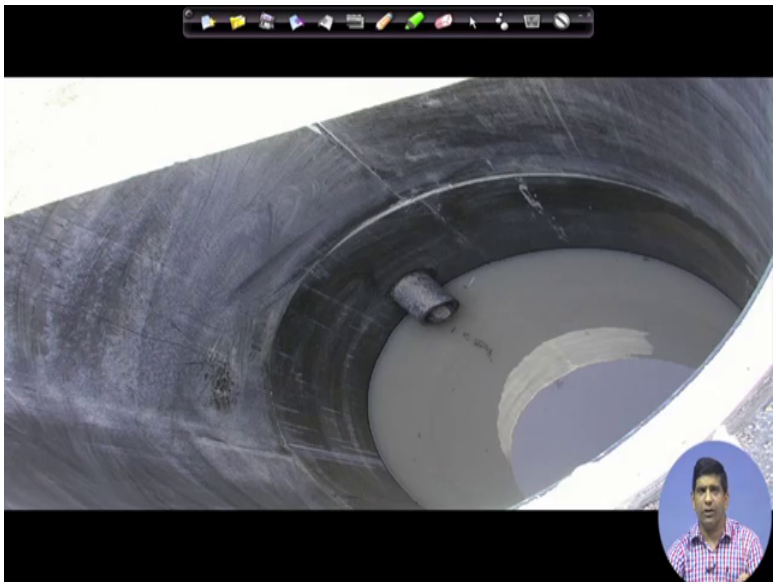

So that is how the leachate will be and then we will put pump in these wells because these wells will be accessible during the landfill operation. So this is another picture of those like a wells and then you can see the picture from inside you see the pipes coming in right now it is

not an operational landfill it is just a storm water some storm water some concrete water you see over there.

And that is once the leachate will start coming in there as well. So then how do you predict the leachate generation. I told you that the it depends on the spacing like when we come up with those pipe say let us back up so in terms of the leachate collection system what we need to design. It is very similar to what you have done in hydraulics class so you have to have set of pipes because there is a leachate being percolated through either through the rainfall or through the garbage decomposition or whatever reason you there is some inherent moisture there.

So all these moisture will come down and ultimately this is my liner system this started stub little pounding up. So my job as a leachate collection system engineer is to design a series of pipes so have a 1 pipe here, then have another pipe then I have another pipe so I will have several like 1 pipe 2 pipe 3 pipe 4 pipe and then I have to have a series of pipes if you are looking at a cross section of the landfill we will have series of pipes.

So when I say series of pipes that means I need to find out the pipe spacing, what should be the pipe spacing that is one parameter we need to find out. Another important parameter we need to find out is what should be the pipe diameter. So what should be the pipe diameter and not only the individual these pipes and also for the header pipe.

So everything comes and joins this header pipe. So once all these pipes individually over the cross section of the landfill comes and joins to this header pipe at the end. So what should be the diameter of the header pipe. So all these things we need to predict sorry we need to calculate this as part of the leachate collection system.

And then we need to design accordingly in terms of and then we decide whether we go for a saw tooth design whether we go for the fish bone design and that also depends on the geometry of the landfill. And some is one is more popular in one area other in other area so it does not matter bottom line is you have to remove this leachate from the landfill and take it to the treatment plant. And does not let it go into the ground.

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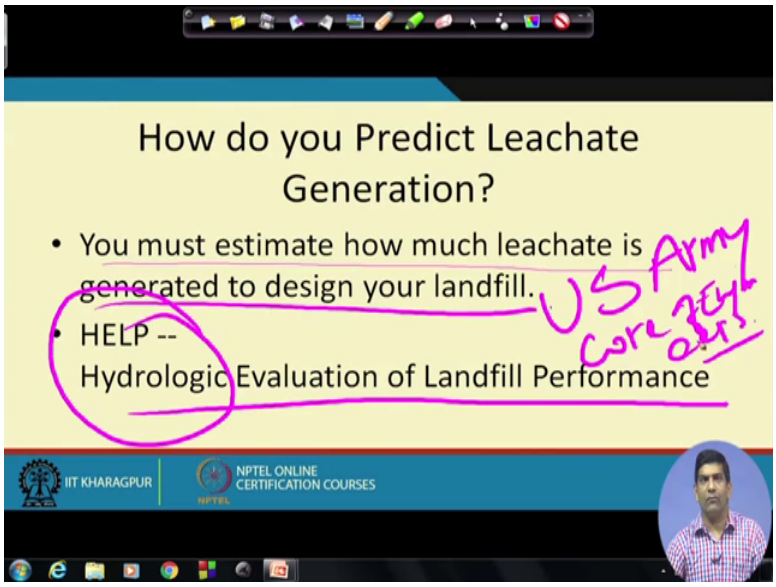

So for to get the prediction like how much the pipe is spacing as well as the pipe diameter. One of the input parameter will be what is the volume of leachate we are looking at? How much leachate is we need to manage? So in terms of how much leachate we need to manage the one thing we have to do is we have to predict because we do not know the waste how much waste will produced over 35 years period or 30 years period over the life of the landfill.

Or How much leachate will be produced every year ultimately we need to look at the flow in the pipe and everything so that is the in terms of the leachate production we have to do some sort of prediction because we do not we have to predict that because this pipe and everything is done first then the garbage is put on. So we do not know as sure how much leachate will be produced.

So there has to be some design for that and to find out this how much leachate will be there, there is a method out there is a model which is used which is called help model. So as I said earlier we must estimate we have to estimate how much leachate is generated to design your landfill and for that we use what is known as how much it is a HELP model which Hydraulogic evaluation Landfill Performance.

This was developed by US Army core of Engineers many of the things that we like know as of today it actually started from US Army core of Engineers. So this is again army core of engineers they had come up with this help model. The software which is used for help model is available for free the older version the newer version you may have to pay some money.

But the older version is out there you can download and you can do that but how that software works we will try to understand that a little bit.

In terms of the very basic how this help model does. Help model is nothing but a water balance model. So it is essentially a water balance so you have to look at a conservation of water basically like conservation of mass. So you need to have this water balance. So in terms of the water balance what we are looking at.

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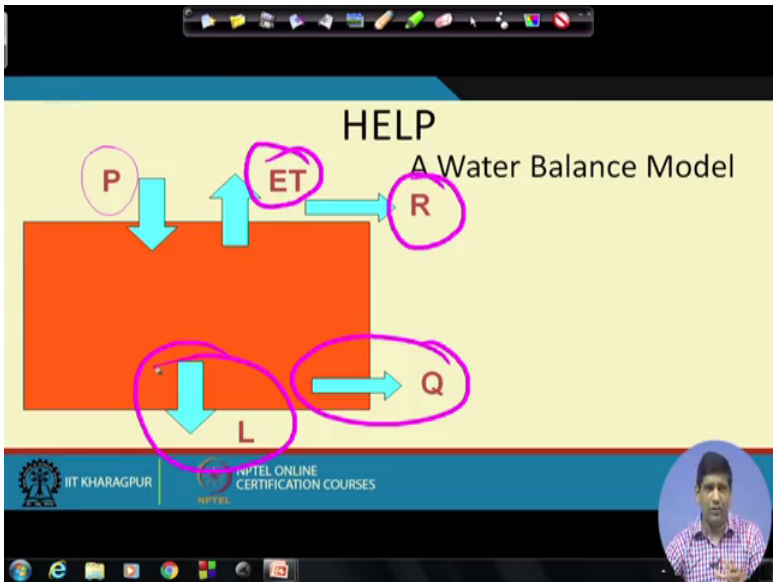

So there will be certain input and certain output. So this orange rectangular box if that is the landfill. If this orange rectangular box is our landfill we have certain input, there is a precipitation input.

And then we have some like a moisture inherent in the garbage so that is also we included in there. And then we have some what are the like a output going out of the system. We have evapo transpiration we have some storm water run off which is now it is going there. Then this is the flow of the leachate. And there could be some leakage happening into the below ground usually there should not be any.

So but I should not say usually like ideally there should not be any but this is how you will look at. So for each of these parameters we need to find out what are the values and then put these values into this model and then we try to predict what will be the value of Q. So we can write down the equation where we try to do the balance and then we can come up with the value for Q.

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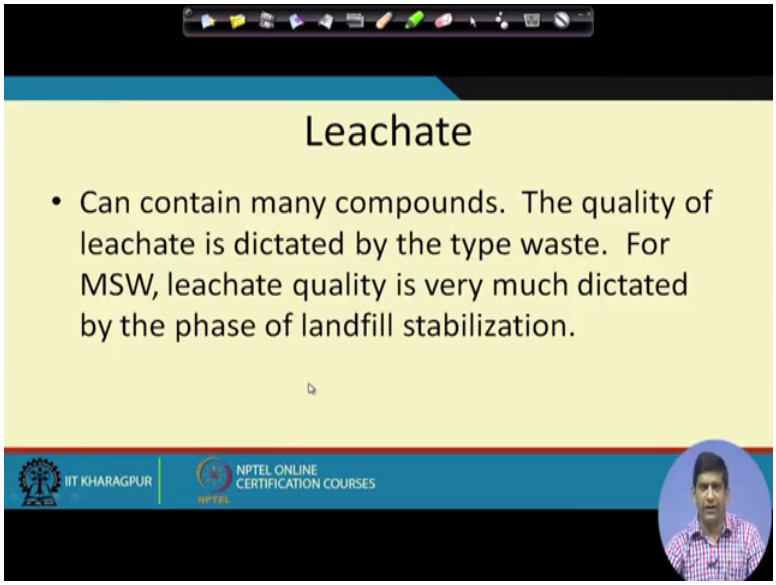

So to do that what we do is actually we look at we will come back and spend more time for each of those components we break it down to like a calculation of how this is those parameters are calculated. So which will come back after few slides. So in terms of the leachate first one of the thing is the leachate quantity and another thing is the leachate quality.

Leachate quality is important for its treatment isn't it? When you try to go for leachate treatment you need to know what kind of leachate it is like whether you should be able to treat it. So leachate can contain many compounds and the quality of leachate will depend on what kind of garbage that particular landfill is accepting.

So based on the quality of leachate is dictated by the type of waste. For MSW the leachate quality is very much dictated by the phase of landfill stabilization. So there is also based on what is the phase of landfill stabilization. Where the how in which stage the landfill is in terms of aerobic phase or anaerobic phase methanogenic phase the quality of leachate will change based on those different phases.

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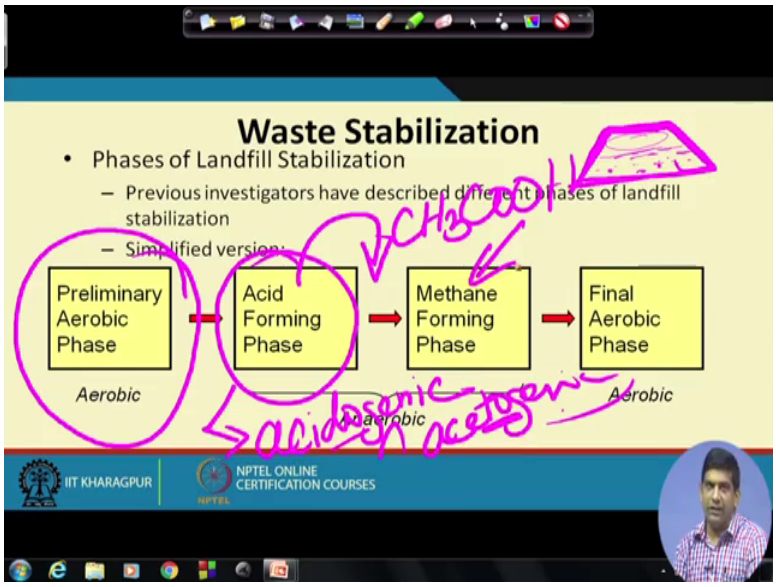

So these are some of the waste stabilization phase which I think we talked about in the very beginning as well. So its a there are research have been done in different places in the world where we have come up with this they described the different phases of landfill stabilization.

So different stages of landfill stabilization was like it is defined and will go over that. And this is a simplified version of that. So if you look at the simplified version of the different phases which initially we were talking about its a preliminary aerobic phase. So now what we mean by this preliminary aerobic phase.

So you have this landfill which is excepting garbage is still open to atmosphere so in between garbage you may have some air pockets and since it is open to atmosphere it is accepting more garbage. So you have the interaction with the oxygen happening all the time oxygen present in the air so there is an interaction of air with the garbage happening all the time.

So the things are a bit aerobic in the system, so you have this aerobic like situation at the first and then as you put the cap so if you think about this is a landfill place and as you put the cap up as you stop putting this as you put the top cap and then what happens because you stopped the supply of oxygen from there. So once you stop the supply for oxygen and then as the landfill depth also starts like layer after layer these bottom layers are already under anaerobic condition only the top layer will be exchanging air with the atmosphere .

So once you put the cap up the whole landfill starts getting anaerobic over time, so once it gets anaerobic and during the decomposition of waste what happens is this big molecular weight organic compounds they get converted into different forms of acid. And that is called volatile fatty acids. You here term VFA so for VFA stands for Volatile Fatty Acids it is a group of acids Acetic acid, Propeonic Acid, Butric Acid, like Acovelorik acid and there are different types of acids out there. And they are all together is called Volatile Fatty Acids.

So let they get converted to VFA, so more and more acids are formed and do you have the anaerobic group of bacterias which is active and making those things possible. So once these acids are formed the next thing what happens is finally this acid gets converted to CH 3 COOH. So this particular thing where there are two group of bacteria first we have this acedogenesic we have acedogenic bacteria and then after that we have this acetogenic so there is a to and there is a do earlier we have do here we have a to.

So there is acetogenic bacteria actually converts everything to acetic acid and from acetic acid you start getting methane being produced by the methanogens that is also that is called methane forming phase or methane forming bacteria which creates a methane out of that. So that is how things typically work in a landfill.

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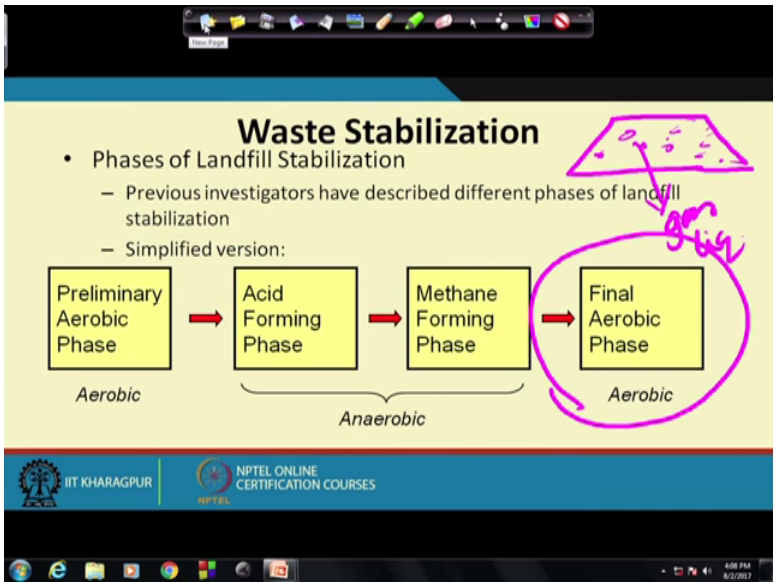

And once a waste degrades over time and what happens is your say you had this landfill where you had some waste and the waste degrades over time. So the solid inside here is getting converted to either gas, either getting converted to gas or to liquid so the solid mass is

reducing, so if the solid mass is reducing if you think about this is a huge polythene bag where you had think all nicely compacted.

Now you are losing some of those mass so what will happen you will start having like a air pockets in the air because the and then the air will try to come into those air pockets. So that is a if there is a breakagae in the liner or somehow air can intrude through so air can come into those packets and that is what is kind of a in vision in this final aerobic phase because air getting into those pockets it can create aerobic situation.

So that is how its different phases of landfill stabilization can be explained and based on the landfill phase of stabilazation you will have your leachate collector stake as well as the gas collector keep on changing.

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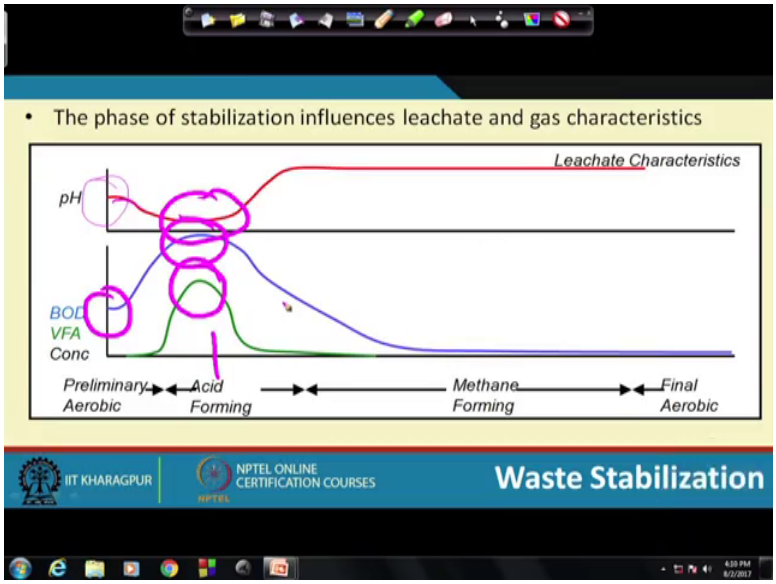

So if you look at here initially we start with a low like a slightly like a pH of around 5, 5.5 something around that or may be selecting more than that you start from there and then as you have more and more asset being formed the pH will have a tendency to go down because pH more like low low pH means acidic condition then very high pH means alkaline condition.

So as the acids are formed the pH goes down, so pH goes down and the acid is being consumed to convert it into methane and other products it starts getting back into into the normal range around 6.5 to 8.5 that is a typical range for the pH. And similarly for BOD initially its a low BOD to start with. Although there are lot of organic material but they are

not readily available organic material although it is there but the micro organisms cannot access it, once this high molecular organic compounds is broken down to low molecular organic compound the microbes get accessibility so the oxygen demand goes up, so that is why you see a spyke on BOD.

And then since lots and lots of acids are produced you see a spyke of the FA as well. And then once this acids are started getting consumed so then you have BOD requirement goes down and if you reach a matured leachate phase where it kind of mostly treated your BOD requirement will still be very very low. So that is in terms of the pH.

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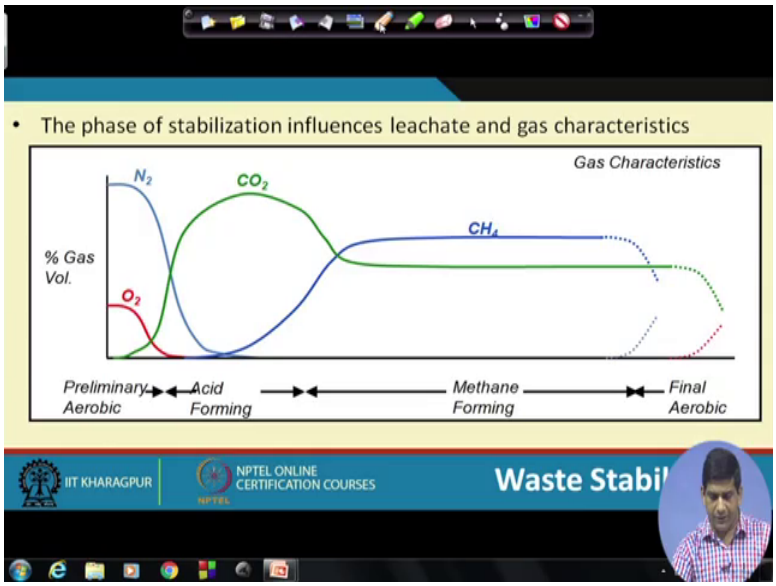

Similarly for the gas will finish will wrap this particular video with this particular last slide. Similarly for the wastage stabilization in terms of the gas initially if you have a preliminary aerobic phase, aerobic means it has a air so air is there so air is there means we have a if the air is present that means we will have some nitrogen, we will have some oxygen showing up.

And then as you have wastage started degrading and anaerobic condition starts taking place or even before that aerobic condition is taking place in terms of waste degradation you start the pick it lets CO 2 starts getting picking up. So CO 2 is well pickup and then you will have a pickup of methane as well. So methane and CO 2 both or kind of nearly 55-45 percent gas in terms of bio gas and there are some other gases in their tube.

Under the hypothetical scenario of finally final aerobic phase you may start seeing another oxygen coming back again nitrogen coming back again and this methane and CO 2 kind of

going down. So that is those are because methane is a it is a all like a reduced product it is not a oxidized product methane is a reduced version of carbon.

So that is in terms of how this particular thing works. Ok So let us with this we will try to let us see what we have ok so let us stop here. So in terms so what we have done so far in this particular video is we looked at this how the leachate is collected we talked about how how what are the like a basics of leachate collection system. We also looked at the model very brief overview of the model we will come back and spend some more time on the model in one of the videos this week.

And how this one of the basic concept around this particular model and then we also talked about in terms of the wastage stabilization different phases and how this leachate quality or gas quality will change under different stages of waste stabilization. So that is with that let us wrap up this video and then I will see you again in the next video. Again keep communicating use the discussion board and we will more than happy to assist you to learn this course as good as you can.

Thank you!