Integrated Waste Management for a Smart city
by Prof Brajesh Kumar Dubey
Department Civil Engineering
Indian Instiute of Technology Kharagpur
Lecture 40
Landfill Disposal

Ok, so let us we will get into this last kind of chapter on landfill disposal in terms of municipal solid waste management part of this particular course. So if you remember in the beginning we had a big overview may we had a first week and part of the second week we looked at the big overview where we talked about landfill disposal.

I also showed you from a global prospective how the landfill is still being used in many places around the world whether we like it or we do not like it landfills are going to stay there so as a Engineer or as a Waste management professional we need a good understanding of a landfill.

Even in the Indian contest if you look at we do want to have waste energy plant we spend lot of time on waste energy in last several videos. We want to have composting on anaerobic digestion but at the end of the day even after doing all this treatment systems we will have some residual which needs to find place in a landfill which you cannot really recycle which you cannot do anything with that.

So may be in future our children and grand children will be able to do something with that, but right now we do not have technology we do not have know how to do anything with that. So those kind of material cannot be just thrown anywhere so it needs to find a place and that place is a landfill. And so we need to build in the contest also we need to build landfills and there is a concept of regional landfill is also coming up.

I have been involved with looking at DPR of several ULBs in the country and where like we reviewed the technical merits of the DPR and also helped in preparation of some DPRs and they are all were in terms of the swatch Bharat mission and this is per and those kind of organisation right now the focus is more on making the land like a regional landfill.

So rather than say Kharagpur town where I am right now it is Kharagpur will not have its own landfill may be Kharagpur and nearby cities nearby towns will get together and make a one regional long landfill and which will have the waste coming in the non recyclables non

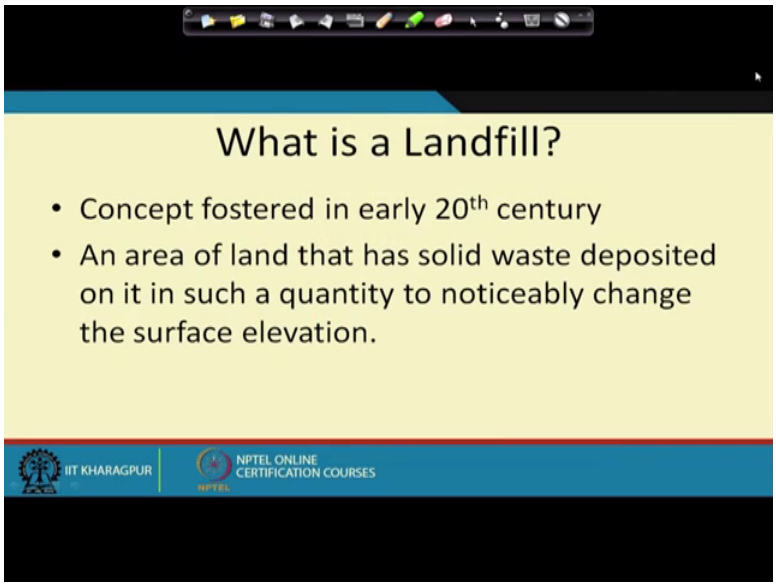
combustible non organic waste coming when I say organic it is a bio degradable coming to these landfills sight.

So that is the kind of the thought process behind it of course we need to make it happen. So this particular set of videos is starting from now and probably few after this I will be focusing on this landfill disposal. What is a Landfill? How the landfill is made? What are the challenges? What are the design aspect? What things we need to consider? Those things we will talk about in this set of slides.

So let us get started and so we have can we take just a quick recap? We started with the collection we looked at what is in the waste in the composition the quality characteristics then the collection part transfer and transport treatment in terms of the biological treatment thermal treatment those things are done.

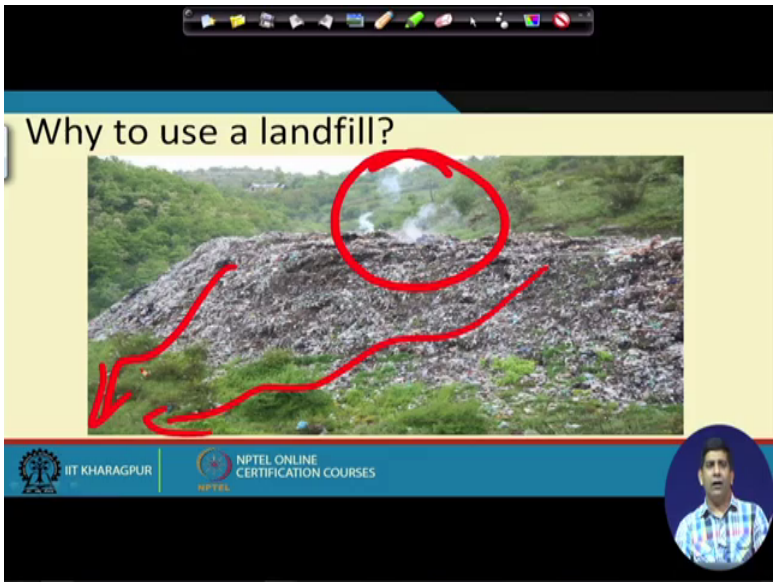
Now this chapter say that after all the treatment is done whatever is possible the residual has to go in a engineer scientific like a scientific landfill which is Engineer design. So that is what we will be looking at in this particular case.

(Refer Slide Time: 03:38)



So Landfill is a concept in early 20 th century so it is specifically an area of land which is you deposit some solid waste and you has a noticeably change on the surface elevation. So basically you are making a small hill kind of that, so that is what Landfill is all about.

(Refer Slide Time: 03:57)



why to use a Landfill if you do not use a Landfill properly and then you dumped the waste on the side of the road as you can see this particular picture that creates lots of nuisance here there is no gas connection system you have this emissions going into the atmosphere so that is also a problematic stuff.

Then surface water can get contaminated and if you have a rain water perculating through and by going into the ground water or it can also go in a surface water nearby. So there are lot of problems if improper management of waste like go throughout the country like in India you find so many dump sites like small and big many many dump sites at several places within a town.

So those things creates lots of nuisance it creates problems in terms of the air pollution it creates problems in terms of course the asthetics and the cleanliness that is there it breeds different kind of mosquitoes and other things and then those creates health problem we have storm water drains gets choked because of this waste from this dump sites getting into our storm water drains it stores plastics in the storm water drain then chokes the strom water drain and then we have this rain event.

If you remember just like a in this particular rainy season we had floods in Ahmedabad and lot of part of Gujarat, part of Rajasthan and even West Bengal, Assam and many places of course there is too much of a rain, so we had this flood. But in the urban centres what is happening today is improper management of waste is also done is, if I say that improper

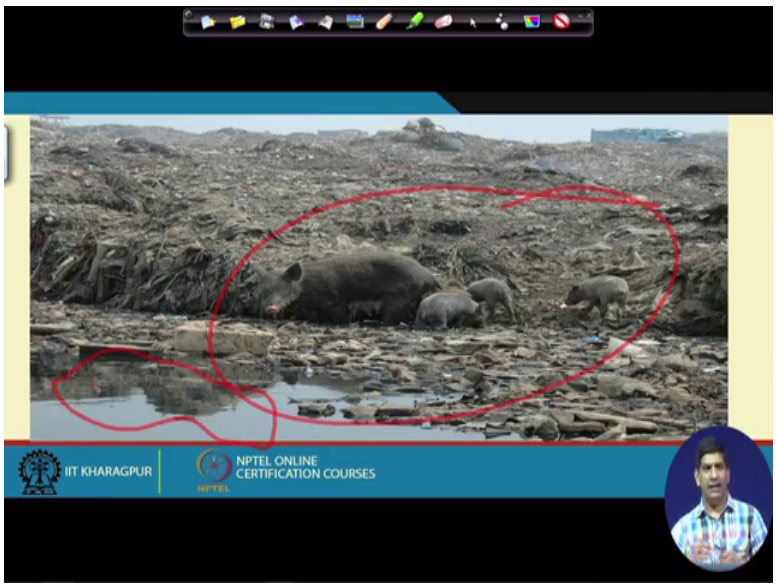
management of waste is responsible at least partly for the flood situation you may not come to it directly but you just think about that say if our storm water drain gets totally choke up by this plastics and other material where the water will go.

Water will start pounding up on this storm water drain on our streets and then that leads to all the water logging and all those things happening around it. And that is of course it is a termporary like a flood kind of problem but then also leads a problem to if the water gets on the surface of the road for a long period of time the road gets damaged.

Just in the during the rainy season right after we had a 3 4 days of big rain in this particular area and after that when I was going towards the Calcutta air port I saw the road is already kind of part of the road is already damaged. So it is just improper management of waste is partly responsible for road damage as well. So things are all connected. So we need to make sure it is.

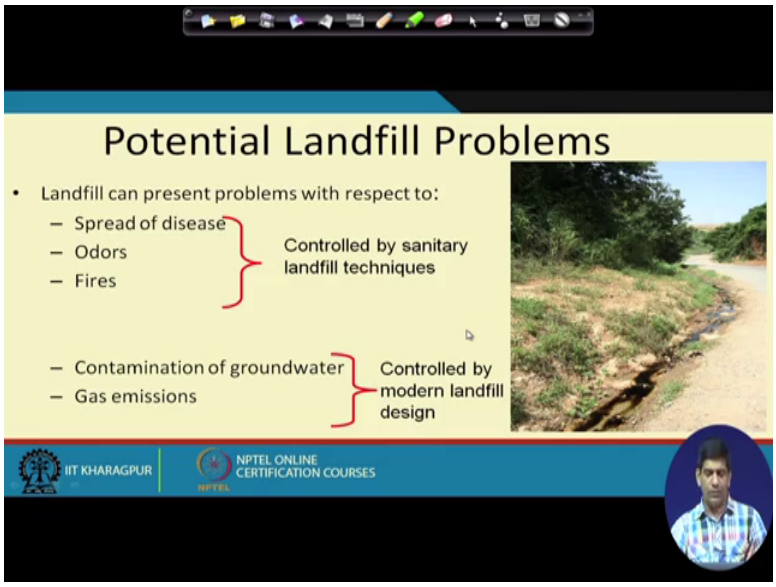
Another thing which cannot be treated and if I am also of the view that even if you do not have the treatment system in place and you have a engineered landfill in place let atleast put it in the Engineered Landfill. Although I advocate that we should have treatment system but in an event like that where the treatment system is not up and running until now, but we have a good engineered Land fill. Let us at least put in a good engineered Landfill so that we do not have any other problems associated with improper management of the waste.

(Refer Slide Time: 07:12)



See another scenario like where the waste is not being managed properly this is a dump site as you can see in this particular picture, dump sites lot of animals in there trying to and they all just leachate this is what we have the leachate very nasty material and these animals are consuming this and they will also get sick and they will carry some germs and then they will carry in our residential areas as well.

(Refer Slide Time: 07:38)



So what are the potential landfill problem, landfills they do present problem in terms of the spread of disease. There is a spread of disease there is a smell problem fire problem and those things can be controlled by sanitary landfill technique. You can do sanitary landfill stuff for that, then you can have contamination of ground water or gas submissions that is controlled by modern landfill design.

So those things are done by modern we will have in terms of the land fill designs you will see in this particular section when we see in this or subsequent videos where this ground water like leachate collection system which is the ground water to prevent the contamination of ground water, the leachate collection system and the gas collection system those are actually very very good those are very essential component of a landfill design.

And those of you if might be the IIT Delhi as part of this NPTEL program at this particular time as well in professor Manoj Dutta from IIT Delhi is offering a course which is running parellely and which is more talking about the Geo Environment stuff and there also he is

talking about the Landfill design. Infact I am registered in that course just to see what kind of material he is covering.

So it is a the Geo Environmental aspect because the landfill design is a Geo Environmental work, it is a lot Geo Technical aspect goes in here and as well as the environmental. And so Professor Dutta basically being a Geo Technical Engineer he will be he is focussing more on the Geo Technical aspect. And in this particular module we are focusing more on environmental aspect.

So if you have registered both the courses actually you have a big picture you are getting a much bigger picture of both like a more detailed picture of Landfill design.

(Refer Slide Time: 09:34)

So in terms of sanitarian landfill it could be excavated and filled you can even excavate and fill it you can make some hole. It all depends on how low is the ground water table.

If the ground water table is very high you will probably start at the ground level, you will not dig and go down. But if the ground water table is low what you can do is , this is the surface that is the surface of our surface you kind of dig a little bit and you start from the lower side this sketch is not scale but do not worry about it.

So you go down and you start from here and the Landfill goes up along that you can feel existing depression, if there are some existing depression you can use that, that can be used here it can be built up from the ground or it could be combination of all these as possible.

Then we do populate this as a control by hawk and what kind of control you use cover soil why to use cover soil landfill at the end of the day this engineered landfill facility when they are operated in a scientific way at the end of the end say it is the Landfill works from 8 am to 5 pm at round 4 o clock it will stop getting any more new garbage.

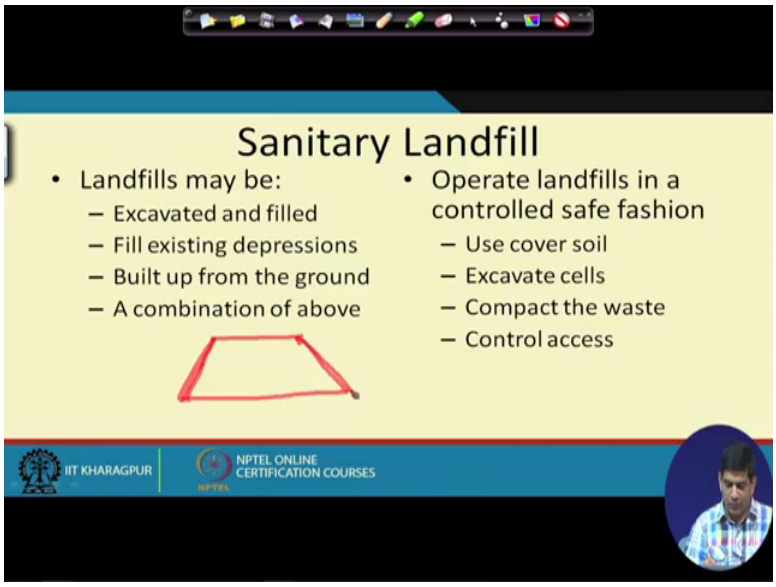
So the trucks coming into the landfill they know that if I reach there after 4 I am not be able to put this garbage into the landfill today. We have to wait overnight over there so many times actually they do not come. But upto 4 o clock say they will accept the garbage after 4 they put a layer of daily cover on top why this because if you as I said I think earlier if you want to really watch birds go to a landfill.

And because the birds get attracted with all this food waste another stuff even if you have source operation and all those things going on is still you have some of these material in the landfill the waste which they dumped into the landfill which attract these birds. And so to reduce those attractions and then also to control the smell otherwise things will smell.

So you put the thing on top where it also helps in terms if you fill plastics and those kind of material in the case of wind they will start blowing away. So if you put a layer of cover soil on that it tries to keeps it down and then also it like it does help in terms of any any rodens vectors and those things trying to get attracted towards this waste.

So you can use cover soil we can ascorbate cell if we have do that like we can go down and do this as cell a compact the waste. Why the compaction? Compaction helps in improving the Geo like a C and 5 values remember this from Geo from your soil mechanics class because landfill is as I said it is a slope of the landfill.

(Refer Slide Time: 12:21)



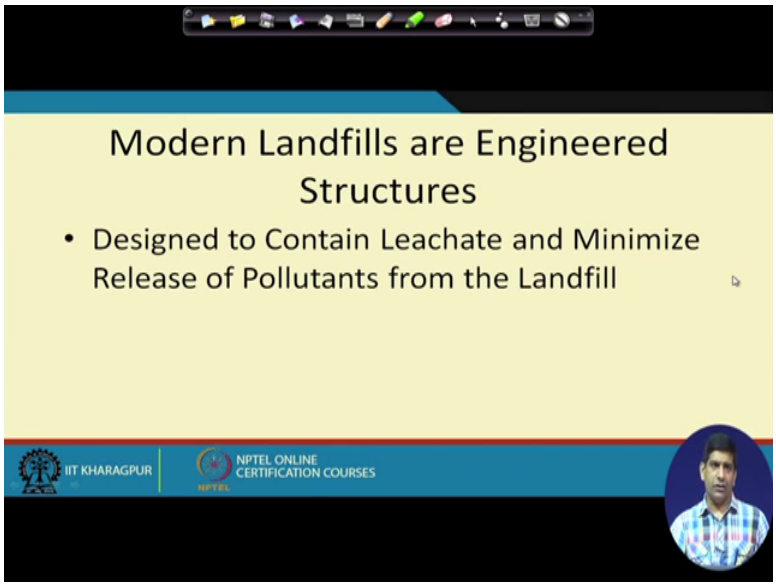
So the landfill typically if you look at the cross section of a Landfill its something like this so you will have the bottom and you will have a side slope then you have a top and then you have a side slope here as well. Both sides the slope will be the same. May not be in my picture by essentially this is how this landfill will look like.

If you look at the cross section of the land fill so there has to be a structural stability of this Landfill's structure say otherwise you will have a failure you will have a landfill failure. So that to prevent that we need to compact the garbage. So because to make it compact to make it close so that our C and 5 values are good.

And then if the waste the landfill is not collapse on its own. And then the control axis just to make sure that things does not because it is a produce methane gas things can catch on fire it may explode and there are issues of like people can at some there is history of that it was the dead bodies were dumped there and so that is why you need a control access.

You need to fence it keep it closed and have some sort of control going on in terms of a like a you have a camera going on or something like so that you can monitor the facility.

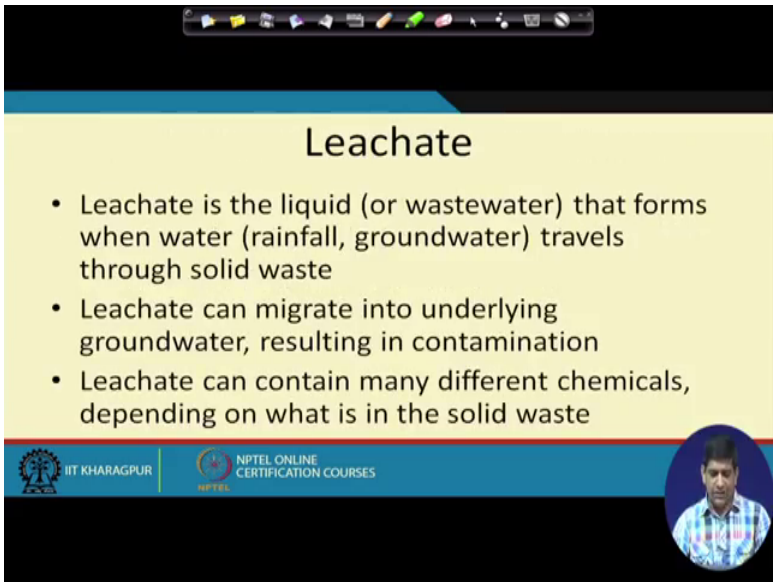
(Refer Slide Time: 13:37)



So modern landfills are engineered structures they are not like a dump site they are engineered structure they are designed to contain the leachate and minimize release of pollutants from the landfills. So you have to contain the leachate and at the same time you are minimizing the pollutants coming out of the landfills.

So you are minimizing the pollutants so you have to take that if leachate is collected so we have to remove the leachate and if the gas is collected we have to remove the gas. And we have to come up with the system to do that.

(Refer Slide Time: 14:10)



So leachate is the liquid of the waste water its kind of industrial waste water. So if you have taken the waste water course, so leachate all the treatment and leachate quality all those things are pretty much similar. And how it get forms when we have the rain water because of the landfill is working, landfill is accepting the garbage its exposed to air, exposed to natural environment.

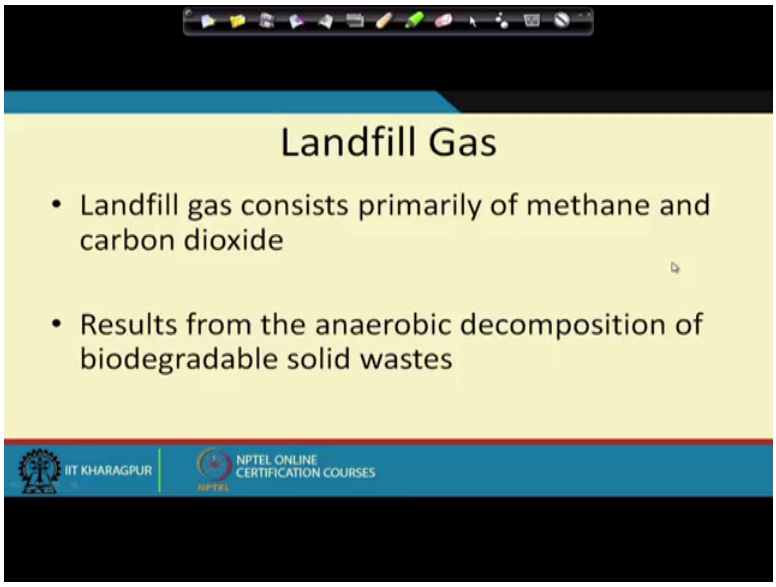
So here the rain water percolating through the garbage and then coming down because of gravity and that becomes the leachate as it crosses that when the waste degrades if you remember from the anaerobic digestion chapter that we have talked about the waste degrades moisture is also produced.

Moisture is also one of the part product of waste degredation is just anaerobic environment, so thats moisture becomes part of the leachate. And then it travels through the like solid waste and the leachate can migrate, so as so if you had as I was telling in the previous slide if you this is the landfill so just to make a small cross section of the landfill.

So if this is our landfill now the leachate is there, leachate will have a tendency to go down and then if we have a ground water table somewhere here it will try to go and contaminate the ground water. But our goal is not to how it happened. So what we will have? We will have a leachate collection system at the bottom over here on top of the liner.

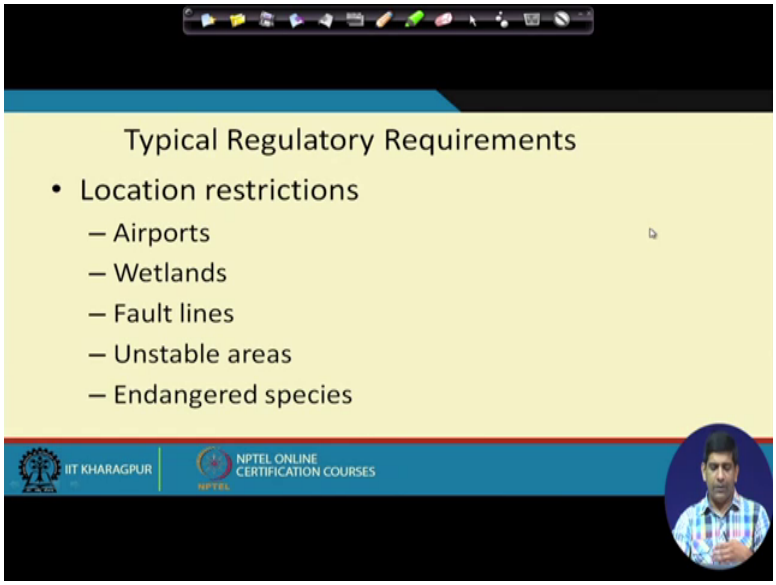
So we will and also you have better sketch of that. So we have leachate collection system which remove the leachate. So leachate can migrate resulting in contamination, so we cannot let that happen so leachate and it contains different chemicals depending on what is in the solid waste.So depending on type of solid waste you will have different chemicals coming out different chemicals present there.

(Refer Slide Time: 15:58)



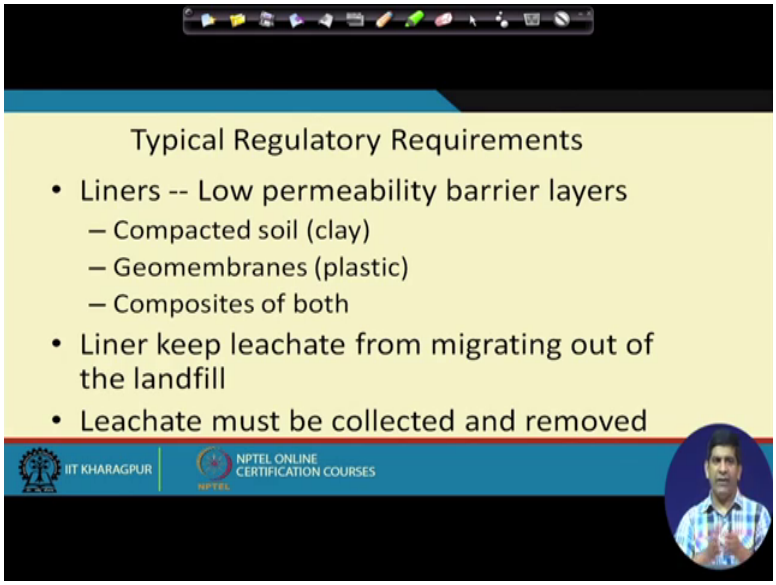
Then other thing is the landfill gas, so those are the two majors stuff leachate, landfill gas. Landfill gas is primarily methane and carbon dioxide and it results from the anaerobic digestion of biodegradable solid waste, so that is what this gas is produced.

(Refer Slide Time: 16:13)



Typical and then there are some regulatory requirement that location wise you cannot be too close to airport as I said because it attracts lots of birds. You cannot have closer to a wet lands because of any sensitive species , fault lines, Unstable areas, Endangered species so those are kind of typically are normal stuff for that normal requirement.

(Refer Slide Time: 16:35)



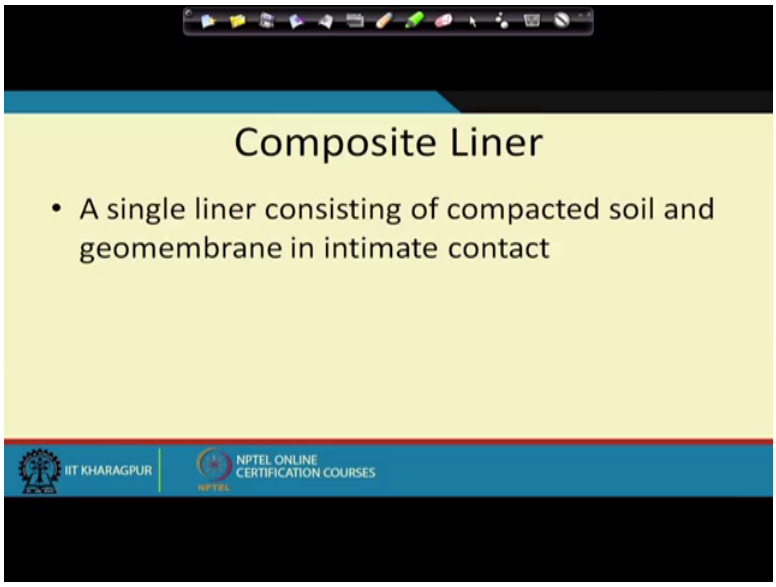
Then you need to have Liners because if you are keeping Leachate into the landfill you need to remove the leachate. So the liner keeps the leachate and magnetic out of the landfill leachate must be collected.

So for the liner we have the low permeability layer. Liner is basically not let the water pass through. So you can have a compacted soil which is a clay to the Geo memberane which is plastic or a composite or both.

So many times you see especially have composite or both liner will keep the leachate from magnetic landfill and it is basically becomes an imperbeous layer like a polythene bag the huge polythene bag at the bottom and then the leachate will stop pointing out.

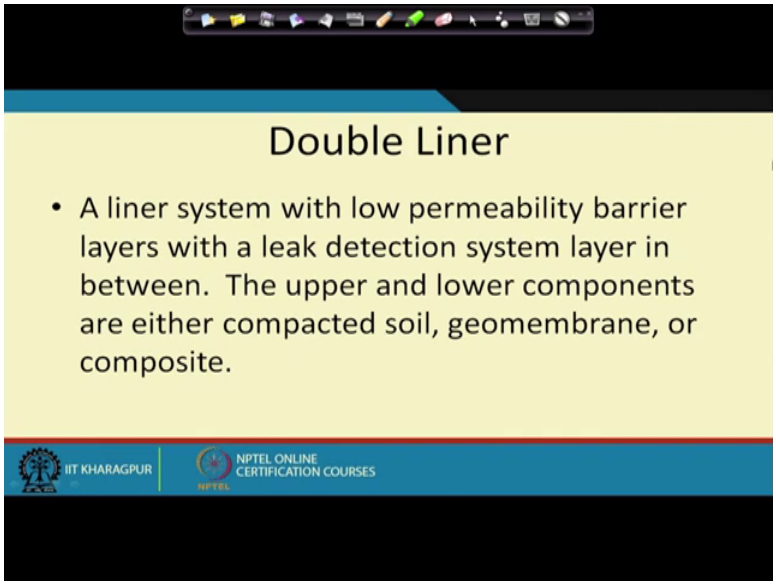
So we cannot let the leachate point out too much because as water pressure will build up our slopes definitely problem will come. So we need to collect this leachate and remove it within a set of pipes and that is what is essentially a leachate collection system.

(Refer Slide Time: 17:24)



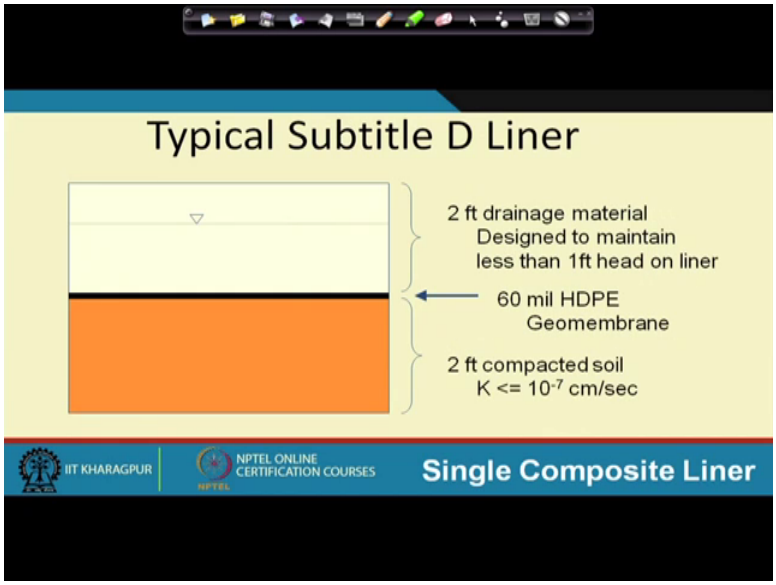
So there are in terms of the liner like a one liner consisting of one packet soil or geomemberane that is the single liner system. You can have a composite liner when they consisting of both compacted soil as well as the geomemberane in intimate contact thats you see more popular.

(Refer Slide Time: 17:42)



Then there are double liner so we have a liner system with low permeability with barrier and then in between we have a leak detection system. So upper and lower components are either compacted soil, geo memberane or composites or both either of those things will be there.

(Refer Slide Time: 17:54)



So this is a typical subtitle D liner, subtitle D is basically what is called solid waste this term subtitle D came from USCPA. So its a USCPA there we call it subtitle C and subtitle D as part of the RCRA which we talked about very beginning in this course. RCRA is a resource conservation recovery act, so that is the resource conservation and recovery act its a RCRA thats from the RCRA we got this subtitle C and subtitle D.

Subtitle C was for hazardous waste, subtitle D is for solid waste one is called solid waste. So as per that requirement then follow in India pretty much the same requirement here as well. This is what is the typical liner requirement for a municipal solid waste landfill.

So here we have two feet of compacted soil then we have 60 mil HDPE geomemberane so its 60 mil 1 mil is 0.001 inch so its so 1 mil is so its so we can find out what is. So in the sense it is not too much it is around like points 6 millimetres so it is less than a centimetre thickness.

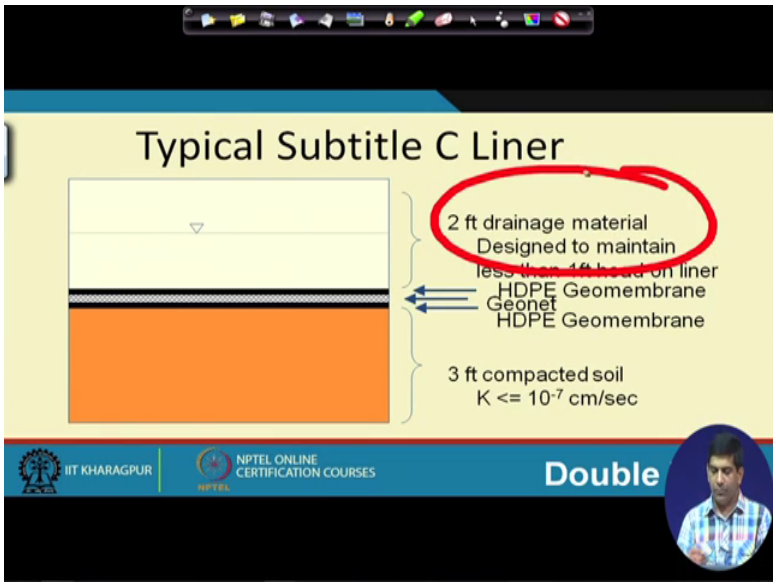
So then you have a 2 feet of drainage material that is which is there on the top So see here the point is if the leachate tries to go through liner will protect it if somehow the liner has its breakage because of this clay, because of the clay layer here with a permeability of less than 10 to the power of minus 7 centimeters per second, the water will not really pass through and it will take a long long time to pass through.

On top if you are putting this barrier layer here so that water will start pounding up and so we need to remove the water which is pounding here which is essentially the leachate so we put two feet of drainage material so that is your two feet of drainage material here and that

drainage material will essentially help in terms of all the leachate will be set of pipes on this side.

So the leachate will go into this set of pipes there will be a perforation in these pipes and someone like this its kind of if you look at this section cross section the pipes are going this way into the landfill and I have a picture of that to show you. So those pipes will collect all the leachate and take it outside the landfill. So that is how the whole system works.

(Refer Slide Time: 20:21)



So that is for MSW landfill then for subtitle C which is the like a hazardous waste landfill which is a double liner system we have again two feet of drainage material for same concept for removing the leachate to design and we have to have less than one feet of head on the liner we donot want too much of head of the liner being built as well one feet less than head of the liner.

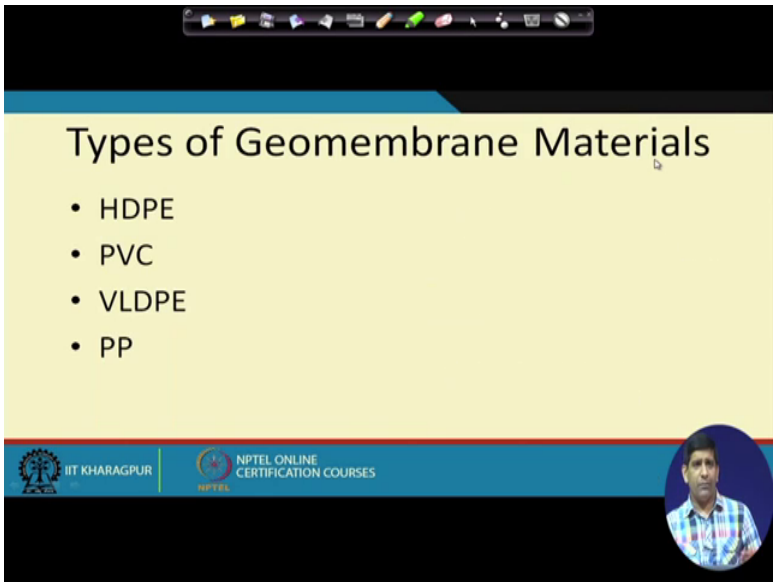
Then we have HDPE geomemberane one HDPE geomemberane other HDPE geomemberane in between we have the leak detection system, sorry yeah,So we have one HDPE geomemberane then we have the second HDPE geomemberane in between we have this leak detection system that is seen in the middle.

So that is leak detection system we call it like the geonet, so then the two HDPE geomemberane so even if the liquid process to the first one it would be cut over there it does not get cut it will still will have the other geomemberane to net let it pass,

Even if it passes through that then we have this clay we can here since the hazardous waste more requirement 3 feet of clay and then k is same less than 10 to the power minus 7 centimeter per second.

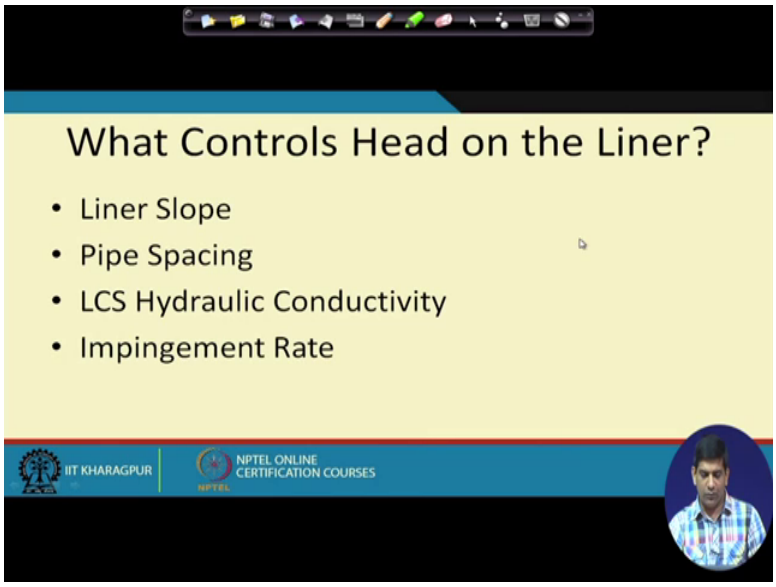
So that is also called the double liner system. So that was the double liner the earlier one was the single liner system.

(Refer Slide Time: 21:48)



So there are different materials could be used the most popular one in terms of the liner is HDPE – High density Polyethelene so that is what is used in most of the places in terms of the liner requirement.

(Refer Slide Time: 22:05)



So that is done for that part and then what controls the head on the liner, the liner slope, the slope of the liner the pipe spacing LCS hydraulic conductivity, leachate collection system hydraulic conductivity impingement rate- impingement rate is the rate at which the liquid is coming to the leachate collection system so that is the impingement rate.

The (())() are the more common like liner slope the spacing of the pipes because higher the spacing of the pipes more will be the head on the liner. Because if we are looking at say this is our kind of section or like a part of the landfill at the bottom.

So if we have one pipe here one pipe here and if we have one pipe say if we have more the space between the pipes more the tendency of the water to pound through if they have less space between the pipes the water will actually go away quickly.

So more the pipes less the head which is kind of obvious, liners slope in terms of the slope that calls up for the water coming in, the hydraulic conductivity of the leachate collections system. So whatever is the material in this area this is the leachate collection system area what is the material in this area if it is of a high permeability then the water will pass through quickly through that and goes to this pipes and get out of the systems.

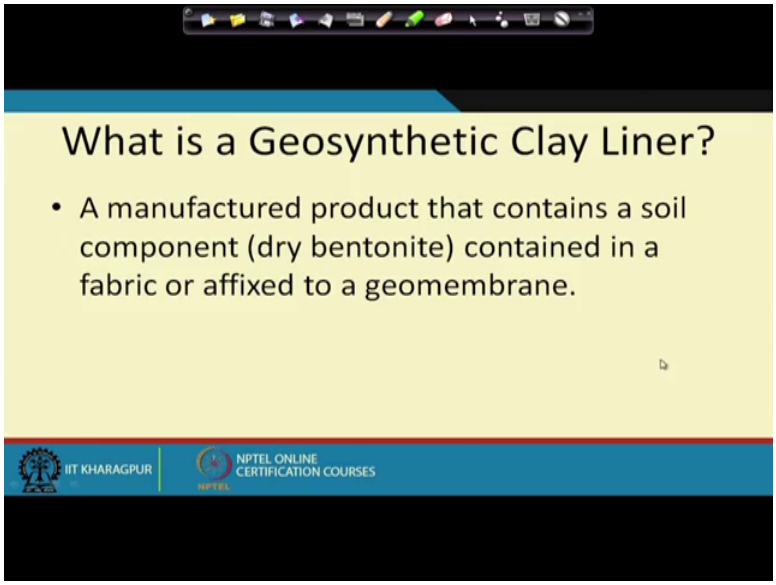
So that is the hydraulic conductivity of the leachate collection system is important then the impingement rate is the rate at which the liquid is actually coming to this area to the leachate

collection system in what weight it is coming it also will depend on the type of waste that we have how much moisture there in the waste if there is a rain event going on?

So all those different things will kind of factor and if the landfill is still accepting the garbage it is open to the atmosphere so rain water can come in so those things will kind of influence in terms of head on the liner calculation. And we have we can do that there is actually a model which is known as the help model hydraulic evaluation of landfill performance.

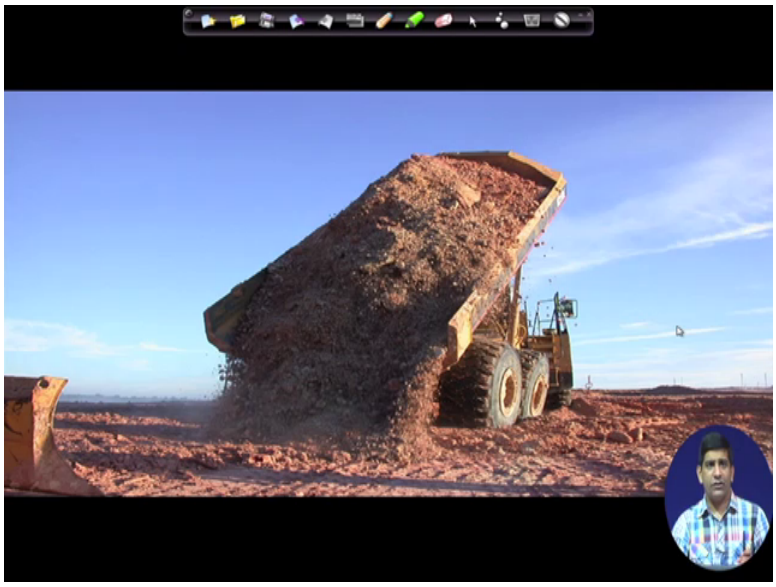
So that model is used to kind of do this leachate collection how much leachate production prediction so we can introduce you to that model towards the end of this particular chapter.

(Refer Slide Time: 24:22)



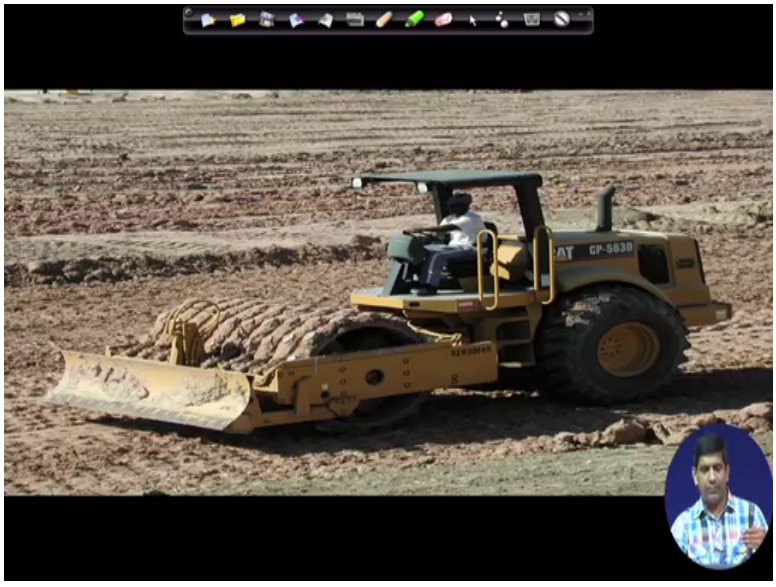
So then we have geo synthetic clay liner which is a soil component which is on dry it is a soil component dry bentonite contained in a fabric fixed to geomemberane. So that is also it is another a liner system.

(Refer Slide Time: 24:36)



So let us look at some pictures of how a typical landfill is constructed and then so this is this place if you do not have the clay in house so you bring the clay from outside so here the clay is being driven to the side. So this is a bentonite clay or the clay is being dumped on to the site.

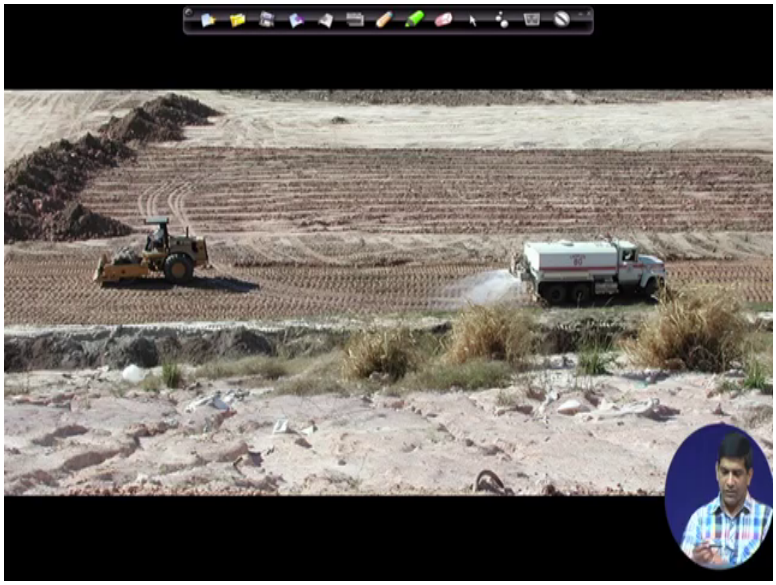
(Refer Slide Time: 24:52)



So once the clay is dumped you start compacting because we have to have what you remember from the liner requirement we need to have 2 feet of clay permeability less than 10

to the power minus 7 centimeter per second. To achieve that permeability and to have this 2 feet thickness you bring this clay you start compacting them.

(Refer Slide Time: 25:12)



And when you are compacting as you can see on this particular picture where the compaction is going on , this gentlemen from this truck is spraying water and those of you who are Civil Engineer should immediately give this things to stick in your head immediately that why this water is been added.

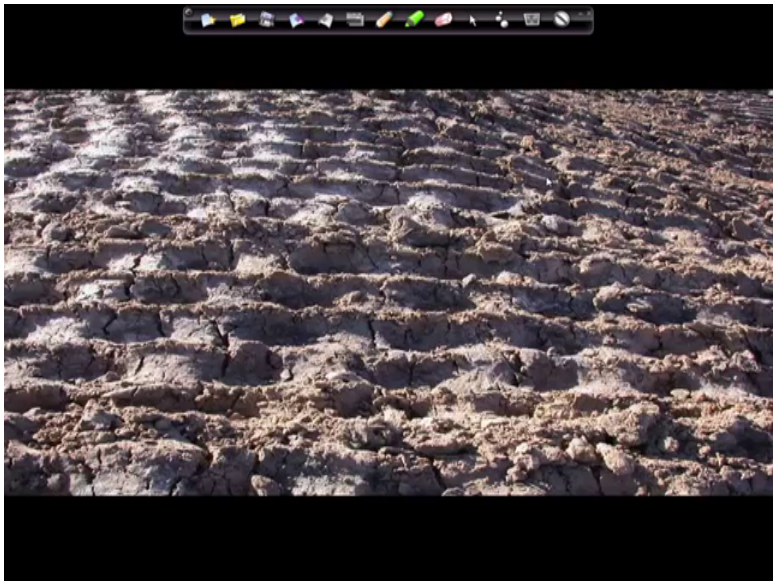
And if you that is like think about that what why we need this water when we are trying to do the compaction. Remember from your soil mechanics lab that when you did this proctor compaction test so there what you get? You had an OMC curve what is the OMC curve? Optimum moisture content. So if you remember from that we had a you had the effective dry density here effective dry density with the moisture content and the draw of something like this.

And that is your maximum dry density and that is a certain moisture content. So what this gentlemen on the truck is trying to do? He is trying to find this particular this moisture content and he knows how much moisture is there in the clay. And then he is adding enough water so the speed of the truck is kind of trying to in a such a way so that the water added in this area reaches towards optimum moisture content for the clay.

So that is the typical OMC that you generate it if you are a if you have taken the soil mechanics class. So again everything that you do like landfill design is specifically geo

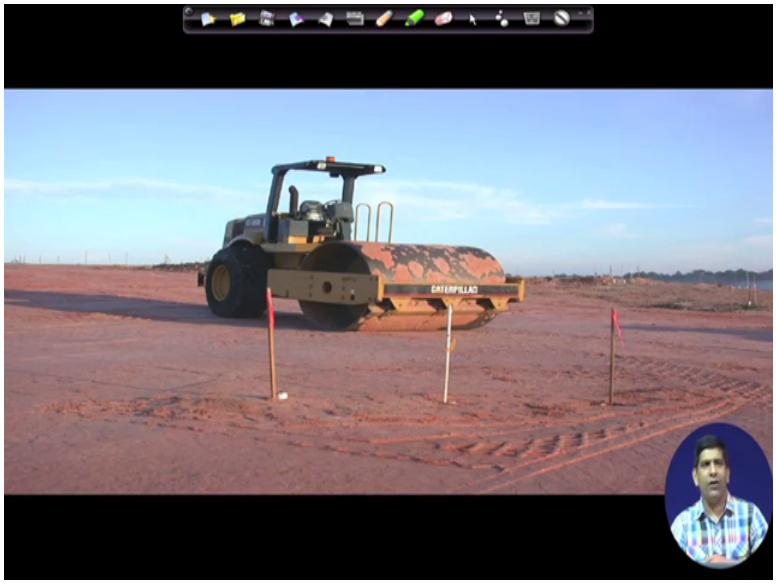
technical, geo technical concepts are very very important, so we use those geo technical concepts and all in landfill design.

(Refer Slide Time: 26:53)



So let us look at some more how this construction is done, so once that it is compacted this is like a final phase but since if you put the liner on top like this the liner would be undulated because it is not smooth, so there would be lot of undulation there.

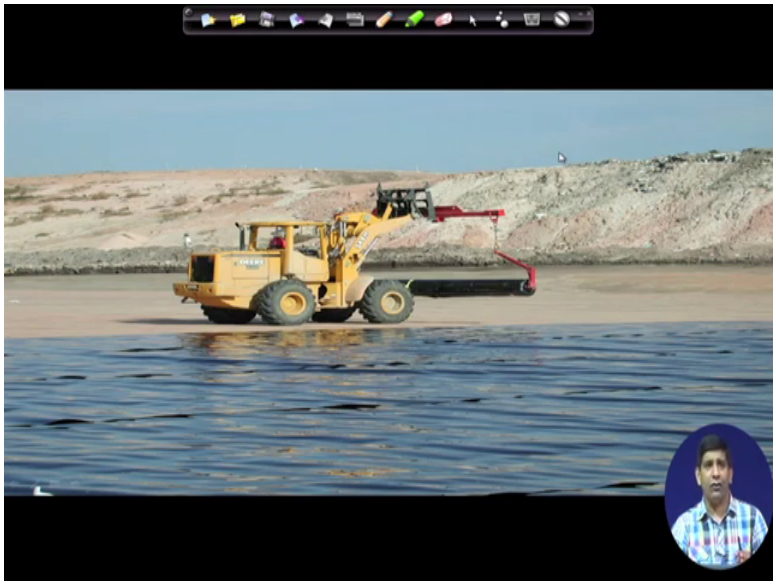
(Refer Slide Time: 27:05)



So to avoid that what you put a fine layer of clay on top. So you see a fine layer of clay, very smooth layer of clay on top of that you have some rolling is going on. It looks like very

similar to the roller they use for the cricket match.If you remember in between the innings they roll to the pitch so it kind of looks the same.

(Refer Slide Time: 27:24)



Then you lay the liner on top and you see the liner you can see the HDPE – high density polyethelene Since the liner comes in certain sizes you need to well them as well so you can the liner is being laid. This is again another picture you see the clay at the border on this particular side they have clay at the bottom this is the you can see the clay here in the bottom.

(Refer Slide Time: 27:51)

And then this is the you see the clay at the bottom and the liner on top and then we have another same picture from a distance the liner is still being laid and the liner is totally laid for that particular cell now. And since you have to this liners comes in the specific size we have to well them.

We have to make this entire area as this entire area will be one piece of this HDPE. So we have to make this well lake along all these edges.

(Refer Slide Time: 28:16)

So that is how this whole thing is done so let us I will continue this discussion in the next video, so and where we will look at the how the the leachate collection system and the gas collection system, how to predict the leachate production? How to predict the gas?

And towards the end we will also do may be in subsequent videos we will also do some math in terms of the basic landfill design. And the detail landfill design is not part of this course and hopefully in future we will try to offer a course just on landfill design because that itself is a full fledged semester long course because you have to look at a lot of different information.

So with that again I think that you guys are enjoying there this course keep the discussion code active I see some activities going there we would like to have more activities on the discussion board. And any questions ask us we are here to help you and that is the whole goal and of this course is to make more and more people technically aware of Municipal solid

waste management which is unfortunately not that much its lacking in Indian contest it is lacking globally as well.

As I have worked in many countries around the world I see that understanding of waste management system is not as much as you would see in waste water treatment or waste water treatment plant. So we need to increase the capacity building we need to do and this course is part of that. Ok so thank you and I will see you again in the next video.