**Geosynthetics and Reinforced Soil Structures**
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**Lecture - 40**
**Landfill Engineering Systems**

A very good morning students, today we have Mr. Venkatraman from Garware Wall ropes Limited, who will talk to us on the landfill engineering. And by way of introduction he is currently the vice president of the International Geosynthetic Society, India chapter. He has more than 40 years of experience in both civil engineering and geosynthetics. And he has pioneered very innovative applications of the geosynthetics in India. And let us listen from him on the topic of landfills engineering.

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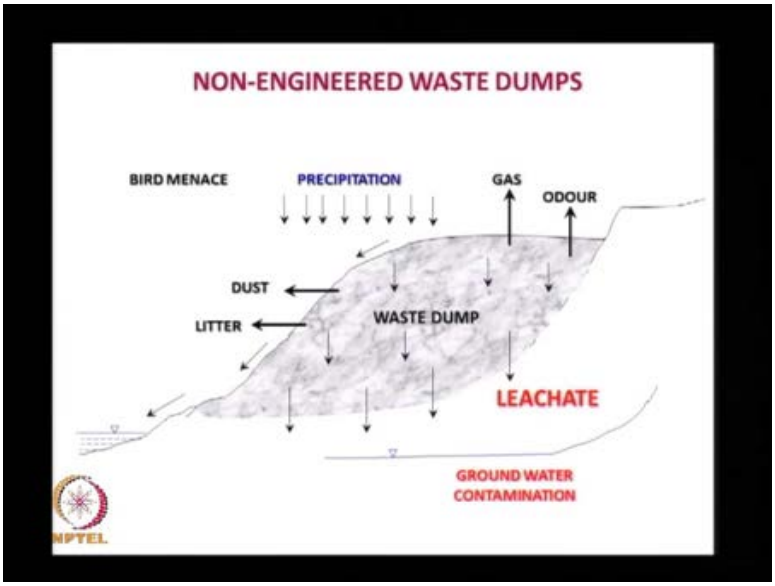


A landfill engineering systems. Non engineer waste dumps, once they are put in a unprotected manner they result due to the precipitation a leachate is created. And the leachate goes down and pollutes the ground water. Then the gas fire hazards all these things are there becomes and it is also creates some dust pollution. And litters the odor everything is created. So, this is how the un protected waste is created.

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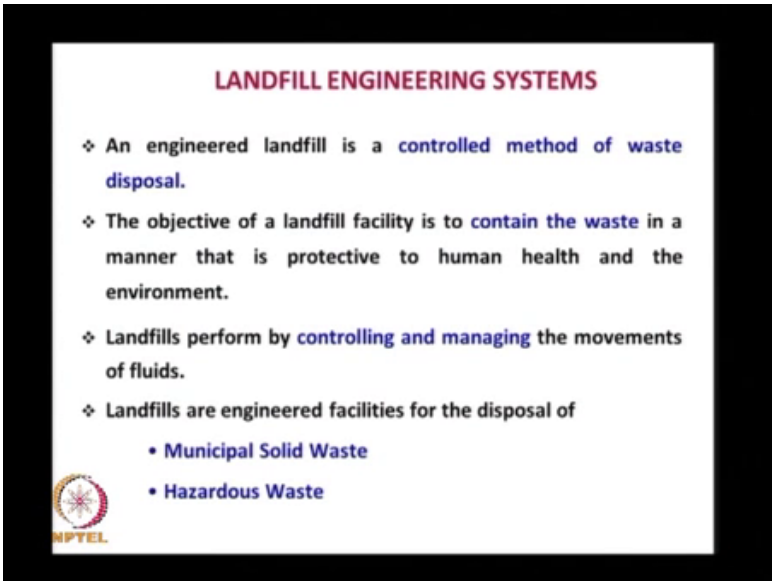


Landfill engineering system, an engineer landfill is a controlled method of waste disposal. The objective is the landfill is to contain waste in a manner, that is protecting to human health and the environment. Landfills perform by controlling and managing the movement of fluids. Landfills are engineer facilities for the disposal of municipal solid waste as well as hazardous waste.

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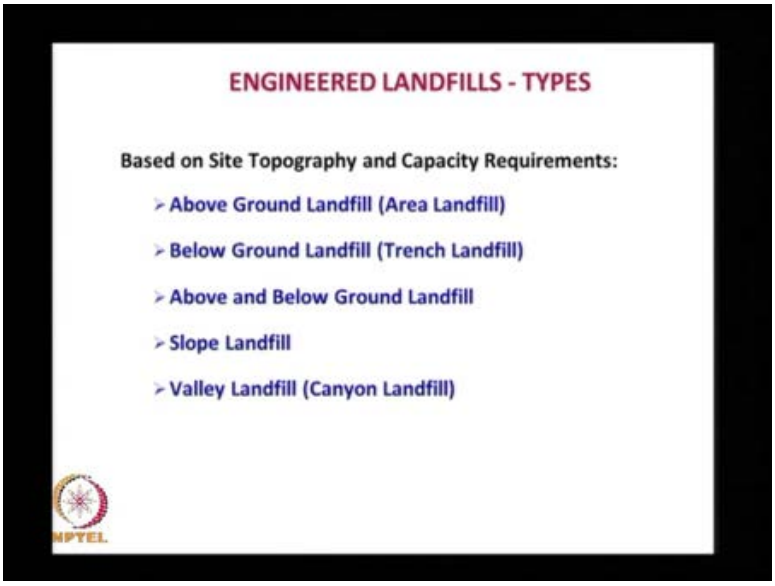


Now, we will look in to that how, before we go into the actual landfill engineering how the assessment of your site selection, all these process have been done. Based on the site

topography and capacity requirement the landfill can be classified as above the ground landfill below, or above and below which is a combination of both some place the area available is only in the slope adjoins in your slopes. So, a slope landfill is done.

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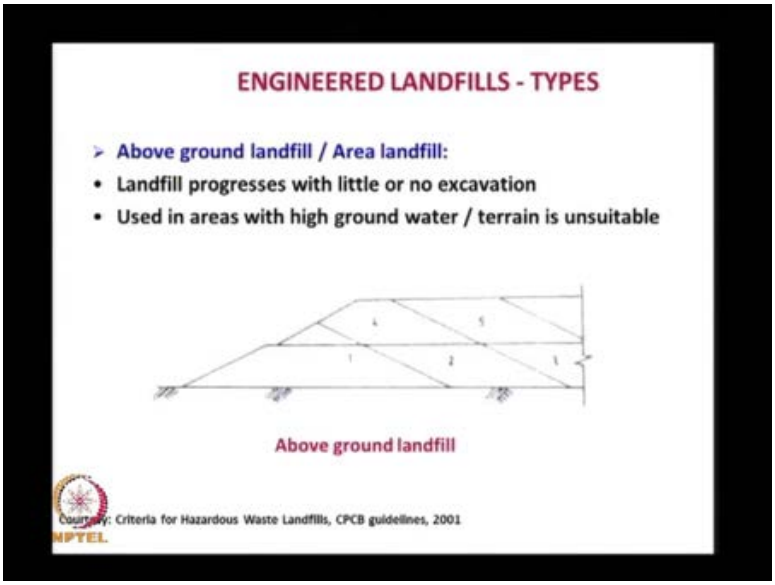


And the valley landfill that you have got hilox and there is a valley in between then the landfill is accommodated in the valley. So, that is called a valley landfill, some of these examples are shown in the pictures below. Now, above the ground landfill area of the landfill, you see it below in the picture is a above landfill.

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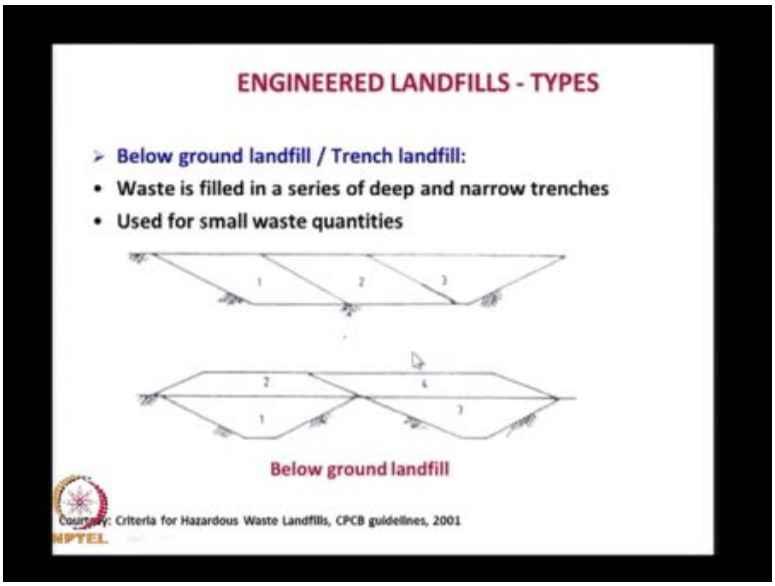

And this is an example of below and above you see that both the thing that is below the ground fill as well as above the ground fill.

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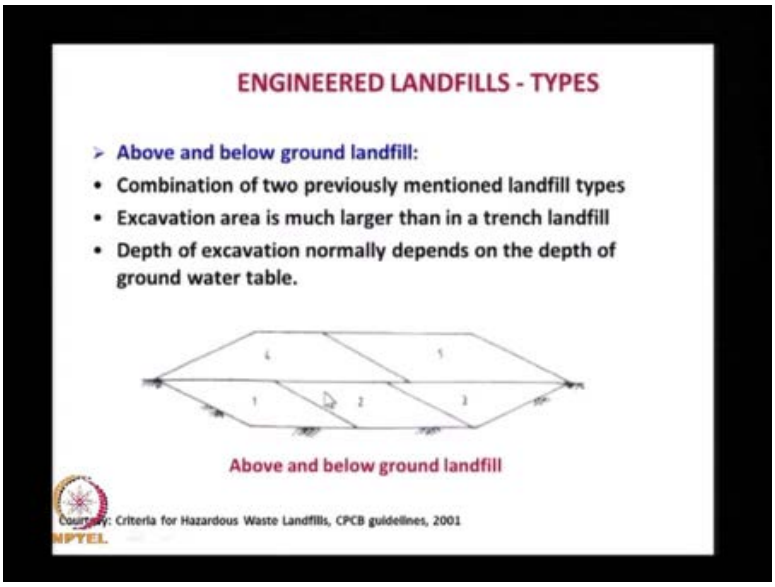


Now, accommodation of two previous methods, landfill excavation area is much larger in the trench. And the depth of excavation normally depends on the depth of the ground water table. That is a most critical thing in this selection the valley landfill you see here the valley portion and this is your the landfill is accommodated.

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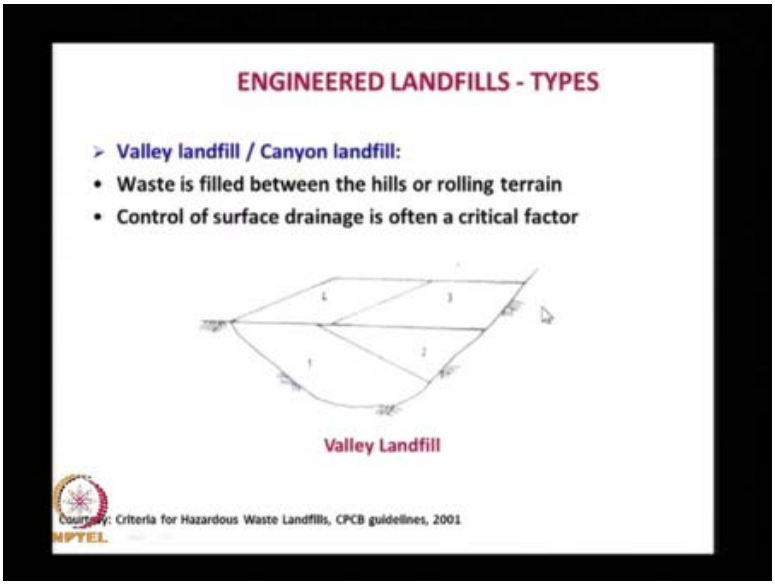

This is the slope if the landfill is this slope. The waste is dispose adjoining the slope it is called slope landfill.

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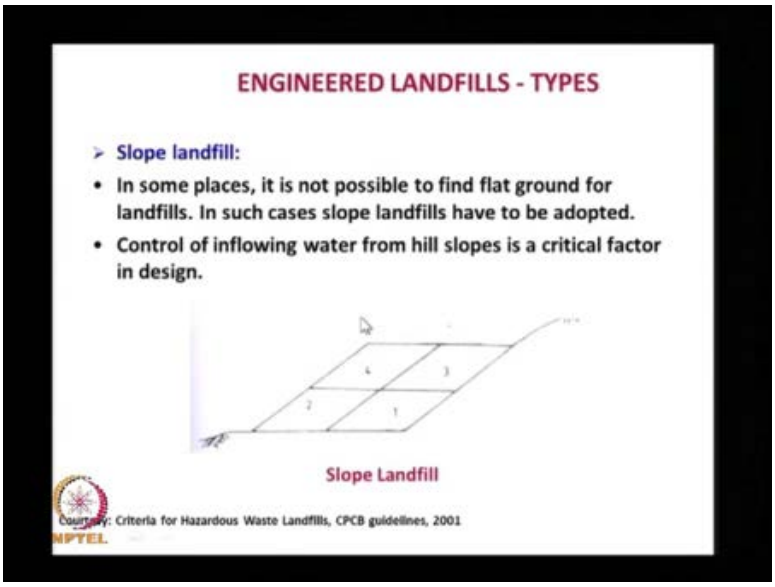


But you have to take into consideration, the characteristics of the landfill whether you will be able to retain that particular slope formation that thing is the engineering challenge.

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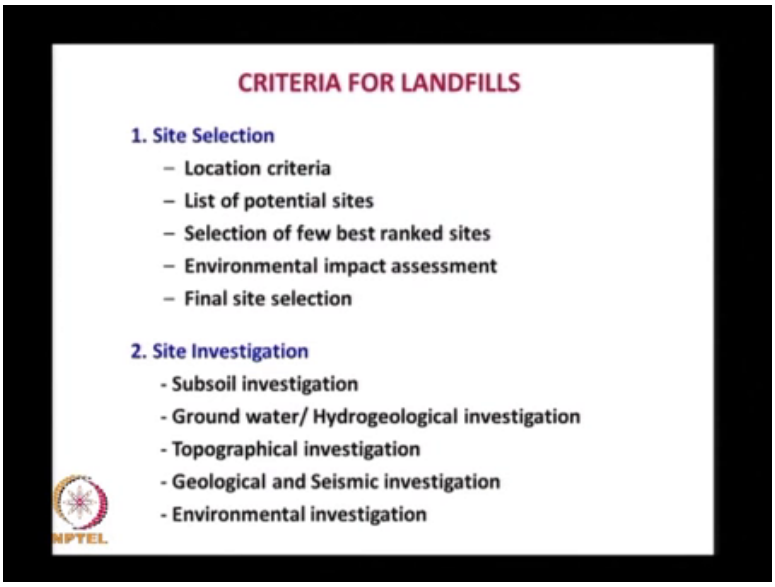


Criteria, then site selection local criteria that is list of potential sites we take a lot of list of potential sites. Selection of the few best sites and you have to make a environmental

impact assessment of the sites. And finally, narrow down to the one single site. And based on this selection we have to do a thorough site investigation a subsoil investigation ground water hydrological investigation, topographical investigation geological and seismic investigation and environmental investigation. All these are must before we make this final site as the most suitable thing for a landfill. Then the planning and design of landfill.

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Essential components of design life, it depends on the waste characteristics as well as the storage capacity based on that the design life of the landfill is decided.

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Waste volume, waste compatibility and landfill. Landfill layout and section phased operation in sometimes we will have the whole area select it identify, but the landfill will be clear to the in phases phase 1 phase 2 like that. So, that is it is identified as the total, but creation is done in phases that is the disposal of waste is done in phases part 1, part 2 like that.

That is the estimation of leachate quantity it is very important. Leachate is that which is created any waste you dump in a landfill area due to rain water, and the creation of moisture within the system, the water populates down and that leachate has to be collected. If this leachate is allowed to go and mix with the ground water then a pollution takes place that is a leachate quantity. So, if you know the leachate quantity only then the drainage and the collection of the leachate system can be prepared.

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So, that is a very important and liner system. Liner system depends on the waste material, but mostly these are prepared in India at environment moment by sometime pollution controls both regulations. Manuals are there, the guidelines are there, they clearly specify how the disposal of waste has to be done depending on the nature what are the conditions what are design methodology what is do's and don'ts everything has been specified by CPCB guidelines. And liner system leachate drainage collection and removal.

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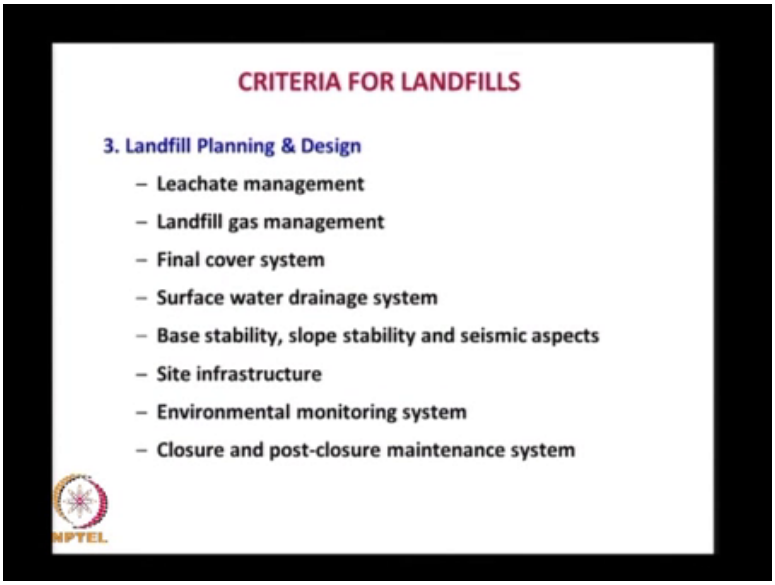

Now, planning and designing leachate management, as I said you know the quantity you know how. You collect the leachate and not only you collect it then you have treat it before you dispose it off that is important. So, in some cases that could be a gas generation, this gas has to be collected it has to be let on, I mean it has to be dispose in a proper way by either by planning or using it for productive purpose like power generation and other thing. So, that is a gas management.

Final cover system, you create a landfill it is used for the dumping the material, but after all the usage once it is full you have to close it. That is the caping system that is a cover system that is also has to be done. And surface water once you create the caping you have to ensure that is the surface water drainage system, base stability slope stability, seismic aspects and the infrastructure that is during the operation as well as after closure environmental monitoring system. Landfill is supposed be there for 20 years, 40 years since the time it is created. So, it has to be monitored closely whether it is functioning the way we wanted it to function without polluting the environment. That has to be very clearly checked and that is the monitoring system.

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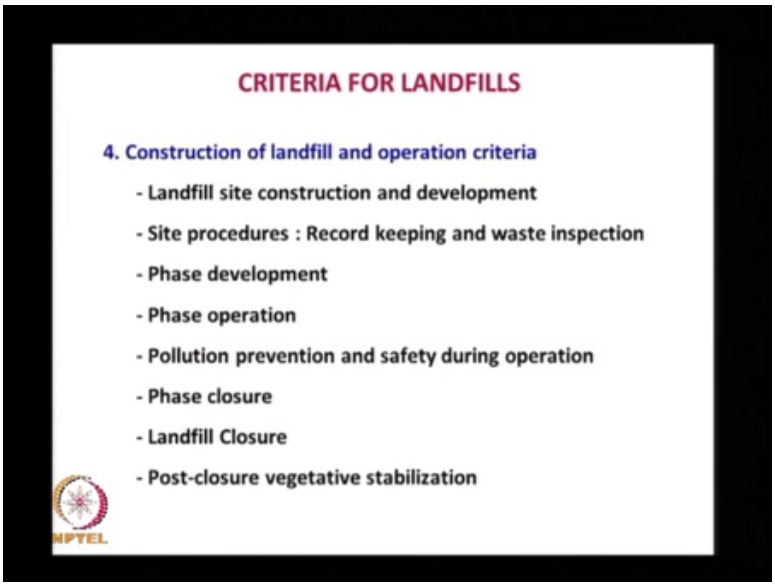


Now, construction of landfill, landfill site construction and developments site procedures record keeping waste inspection, phase development, phase operation pollution prevention, phase closure, landfill closure, post closure, vegetation stabilization.

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Everyone is important inspection and monitoring and record keeping criteria during the construction of liners and covers, during the operation, during the closure period and post closure period environmental monitoring system and post closure criteria. All these things what I am referring or the points which has been very clearly identified in CPCB guidelines and manuals.

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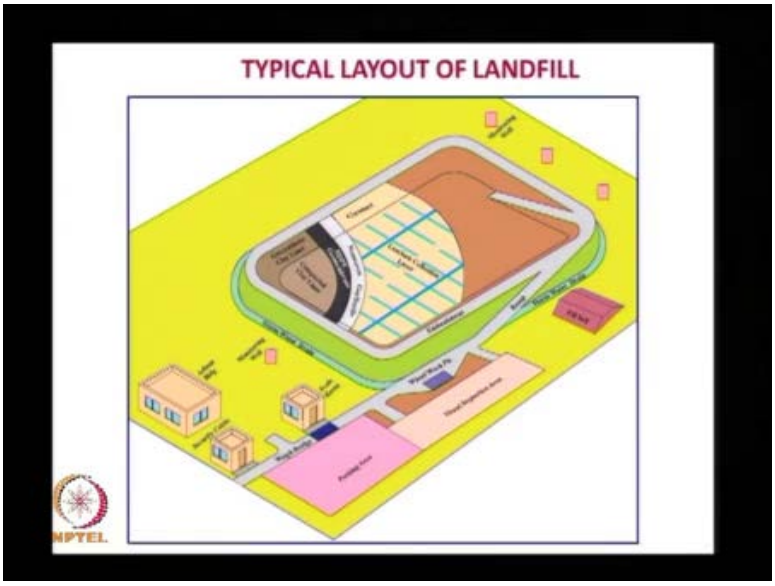


Now, typically you look at that landfill is a typical landfill layout where you create there is a periphery which could be a earth wall. Sometimes we also create a boundary wall for

a landfill by using the waste material itself. Later on we will see some of these examples how. Then there is a disposal and the methodology of placement of waste the solid waste in a each section. And for that also the ramp has been provided here for example, you can see the ramp here to take the trucks inside it takes it down inside. And there are laid out methodology. So, that in each area the dumping is done.

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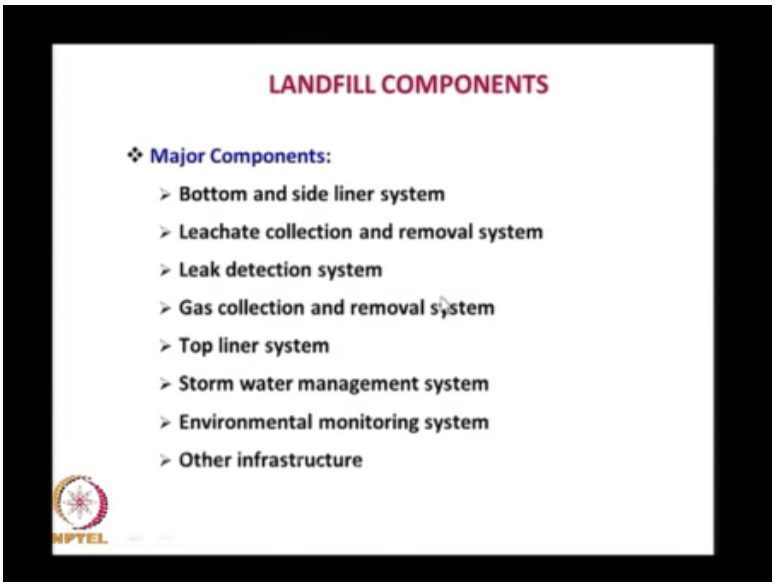


Major components of landfill, the most important is the bottom and side liner system. Initially, the US environmental pollution control also recommended as a clay, the mineral layer as the most, but later on they found when you dispose the waste material some of the chemicals in these wastes react with the clay. And then it lay to a situation when there is desiccation of the clay layer. So, they said the clay alone will not be sufficient even if you use a mineral layer, an h t p liner which is a inert material to most of the waste toxic substances is ideal one. So, that is the combination.

So, bottom and site the liner which the h t p membrane is used. In some cases we will see how even the clay layer can be replaced and what advantage we will see it later. Then there is a leachate collection and removal system leak detection system. Now, when you create a landfill it is a one single operation you create a landfill, but if make a mistake during the creation of landfill there is no solution to that. So, before you disposal your waste material into your landfill having created it you have to ensure the landfill which you have created is very secure. For that you have got a leak detection system.

There are various ways of the in the leak detection that we will see the improved. There are methods which are grid lining methods which can continuously monitor during the operation of the landfill to say whether your leak is occurring or not. So, those methodologies are there. Then gas collection removal, then top liner system. The top liner system will come into operation once a landfill is filled. And storm water drainage because surrounding area the rain water. So, storm water environmental monitoring system and other infrastructure.

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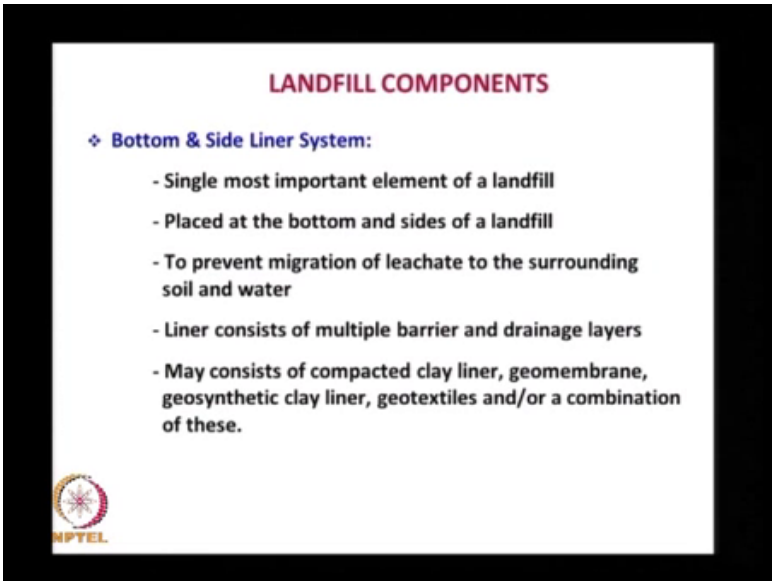


Bottom and side liner system, single most important element of a landfill which is placed at the bottom and sides of a landfill to prevent mitigation of leachate to surrounding soil and water that is the purpose. Liner consist of multiple barrier on drainage layer. That we will see is the subsequent stretches many consist of a compacted clay liner or the mineral layer as I said that is geomembrane. Then the geosynthetic clay liner sometimes we use a geosynthetic clay liner which called g c l geotextile or a combination of these.

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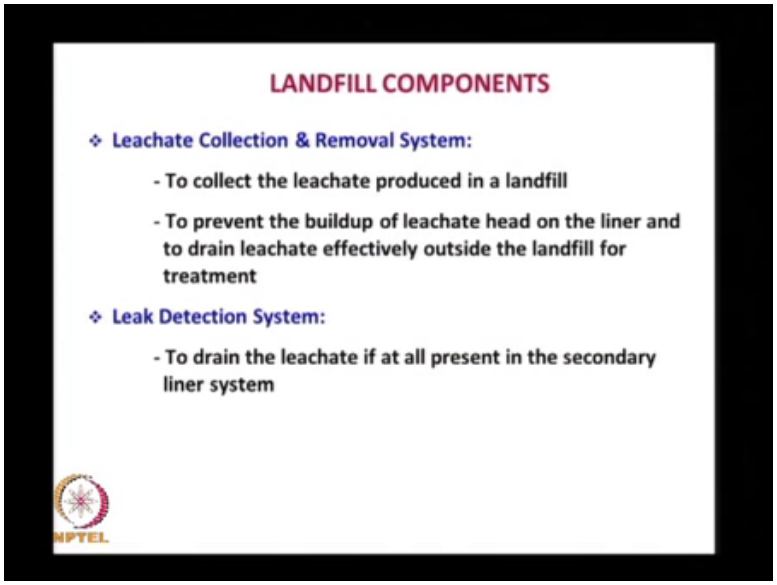


In the leachate collection, again to collect the leachate to prevent the built of leachate.

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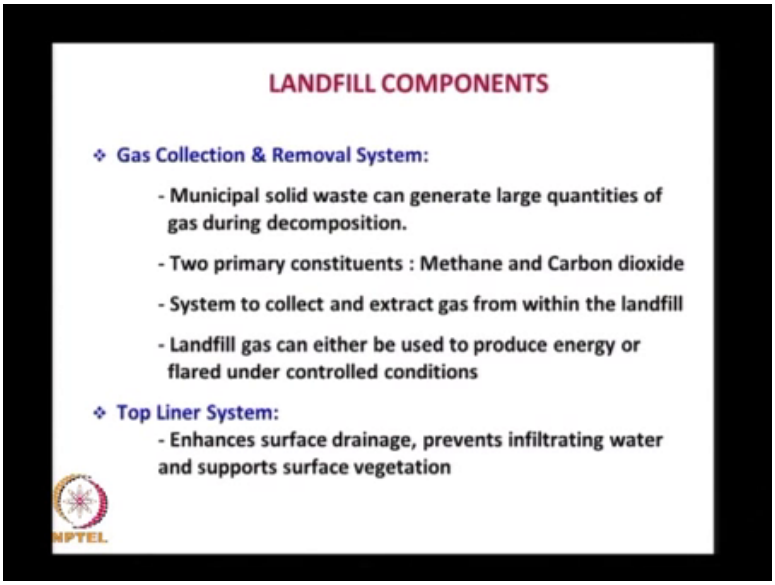


And to drain the leachate if at all present in the secondary liner system. Gas collection, this is more particularly in the municipal solid waste. Generate large quantity of gas during the decomposition to primary methane and carbon dioxide or possibly created. This system is to collect the extract the gas from within the landfill. The landfill gas can be used to produce energy as I have already mentioned or flat under controlled condition top liner system I have told it already.

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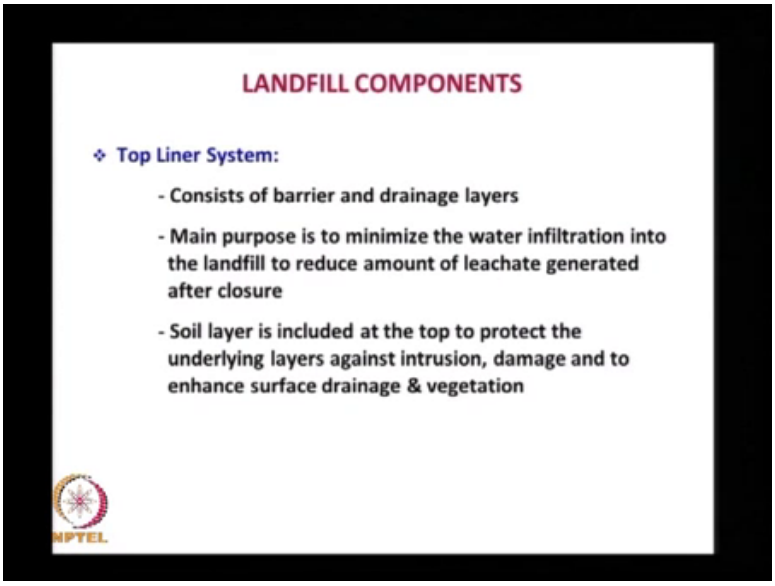


Consist of a barrier and drainage layer again it has contained a barrier it is all most mirror image of the bottom layer. Again it consist of a barrier on the drainage layer. Main purpose is to minimize what are infiltration from the top once the system close the top into that. And soil layer is included at the top to protect the underlying layers against intrusion of water damage to enhance the surface drainage system.

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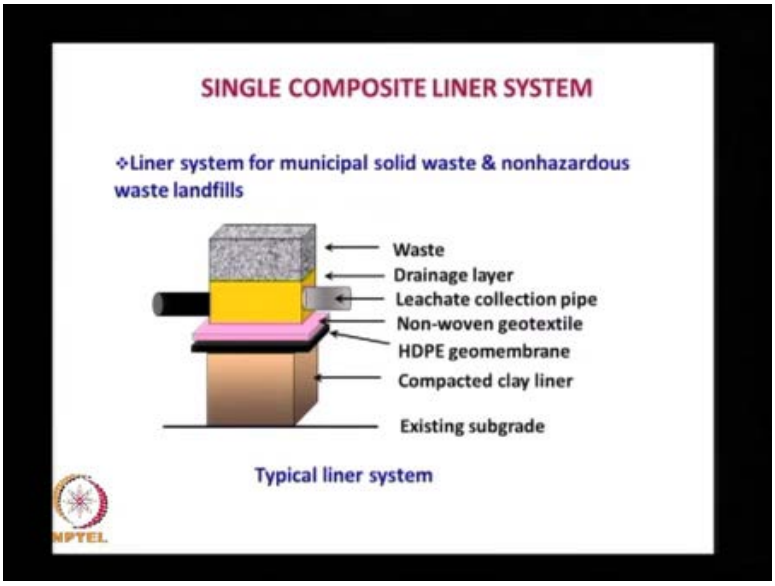


Now, single composite liner system, there are two methods. One is a single layer system other is a double layer system. In a single layer system we start with a compact clay liner

existing separate over that the compact clay liner. As I said clay is originally it was only clay then we found because of the designation of the clay material the membrane whereas, huge. So, that is the h t p geomembrane over that a non woven geotextile. The nonwoven geotextile has got two purpose. One is the drainage material in landfill its also used as a cushioning material to cushion because over that membrane on this nonwoven textile there could be other drainage carry materials which could be aggregate sand and other thing gravels.

These material should not puncher the membrane, in fact it is said the geotextile in a liner system should lost for one day more than the basic liner. That is it is to protect if it is 100 years is the life of the h t p liner it should last a 100 year plus 1 year is the textile. That is the requirement in a simple way to say. So, that is a very important component a nonwoven textile then the leachate collection system. You have got with the pipes which is basically a perforated pipes surrounded by a textile we will see that. And then a drainage layer and then the waste material.

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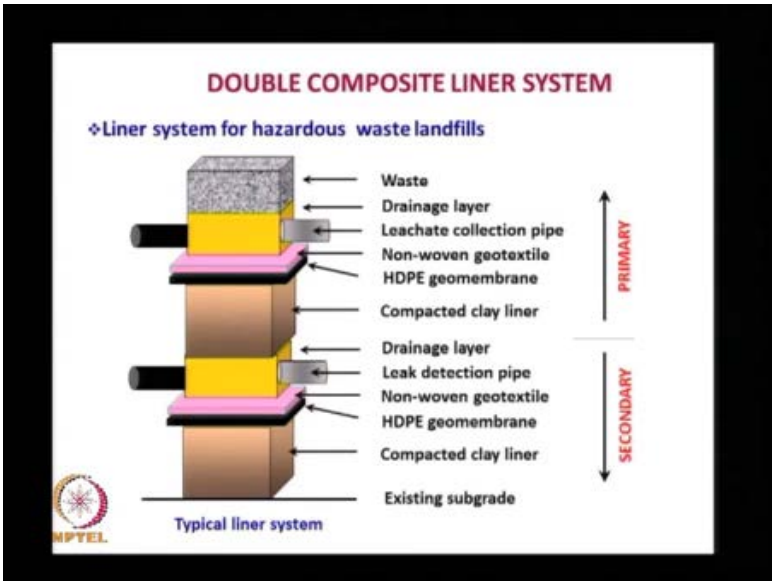


The double layer system, the double layer system most of the components repeated in two times because in liner system what is that we do not want the waste material or the leachate to go and pollute the ground water rather environment. So, we always say thicker the better, the more cushion then it is more the better. So, that is the way if you look at it first as I have seen the compacted clay liner membrane, nonwoven textile the

leachate collection system then compacted clay liner it repeats itself. Then h t p membrane, nonwoven textile again leachate collection system drainage layer and then the waste it is doubly.

So, double liner system and the double liner system is mostly used in the case of hazardous waste material, which are toxic substances which are durability from non hazardous solid waste like a municipal waste top liner system. Once a landfill is filled suppose it is meant for 25 years service it has to 25 years landfill is filled, then we go for the top liner system.

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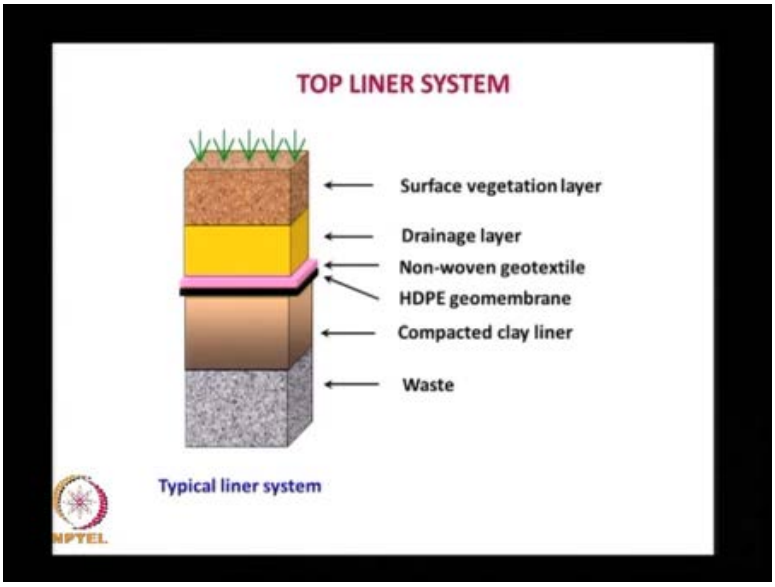


So, here we start with the waste material which is already there and over that comes the compaction clay liner which is a normal clay membrane, nonwoven textile, drainage layer and surface vegetation layer. Here we put the normal soil and create a vegetation. And if you see a landfill once the closure is done as per with using the top liner system it is a environmentally fondly area it is like a park.

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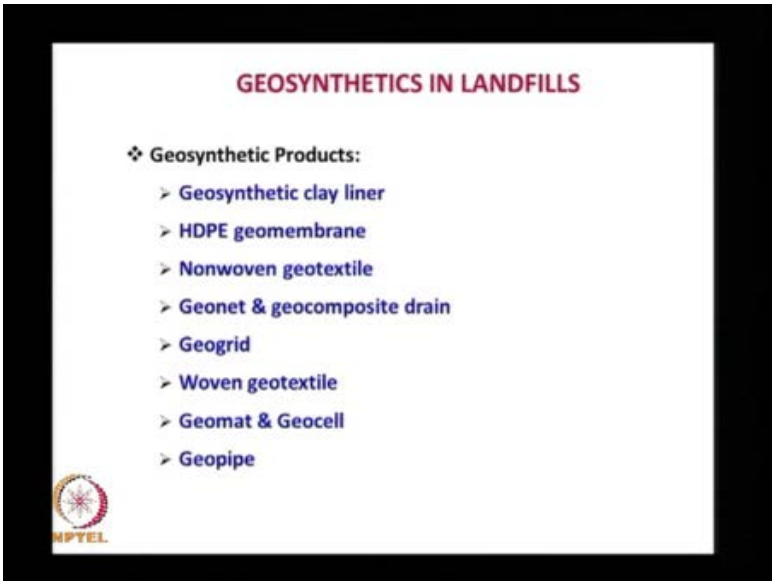


Now, the geosynthetic products we talked about most of the time about a geomembrane g c l liners or the thing. So, what are the geosynthetic material generally involved. If you look at it g c l geosynthetic clay liner. The importance of geosynthetic clay liner is sometimes you can replace even an ordinary clay the mineral or compacted clay liner by a synthetic clay liner. A synthetic clay liner is made of three components. It consist of a woven textile, a bentorate layer and a nonwoven textile. All the three are needle punch to there to create a clay liner which is equivalent to a normal clay liner. And it is better than the normal clay liner how.

If you say a normal clay liner the permeability aspect is around 10 to the power of minus 7 to 10 to the power of minus 9, but in the case of a g c l it is of the order of 10 to the power minus 11 that is almost 100 times. It is more impovival than the normal compacted clay liners. And then you create a normal clay liner you have to go from 30 to 1 meter or 1.5 meter that is the thickness, but here a 9 to 10 mm is equivalent to above more than half a meter of clay. And the most important point of the g c l liners are even if they are puncher during the construction or a insulation process within 24 hours it has got the ability to meant the holes.It will automatically meant the holes. So, that is the very important.

And the whole geosynthetic usage in this thing is one of economy apart from technical aspect how because you create a landfill by spending so much of money, but when you

use the geosynthetic material which are thin planar elements. Two dimensional elements compared to the third dimension which is very thin you create so much extra space for storage of waste material. So, in the same area by using geosynthetic compared to a drainage layer you use sand gravel and other thing instead of that you use a nonwoven textile or a geonet.

If you use a compacted clay liner instead of that you use g c l you use a membrane. Then you know the extra space created itself will make a economic sense in the creation of a landfill. So, that is a most important use of the geosynthetics material in a landfill apart from the technical aspects. Then g c l h t p membrane we are seen generally the h t p membrane used in the municipal solid waste and the hazardous waste is around 1.5 mm thickness as per the guideline we do not use anything less than that.

Abroad if you go even to the extent of 2 mm that India we are restricted minimum 1.5 mm nonwoven textile it depends on the waste height and the characteristics of the waste. So, that that much load is coming. So, it has to provide a cushion and in the nonwoven textile it is normally a needle punch textile is better because so many nonwoven textile is, but a needle punch textile gives you a better cushion. Geonet is nothing it is a spacer bar used between two textile. So, it gives a space for a flow of water in the horizontal.

Geogrid, geogrid can be used either in a soil reinforcement when you place a geosynthetic material, membrane other thing on a slope see the sub grade material of the slope, the membrane, the textile all these things got a interfacial friction between one and other. Depending on the slope geometry if they reach a point they may slip between one another. So, to prevent that in a soil very methodology the geogrids are used to take the tension create the tension. So, that the slipping is prevented that is one way.

Then the other way of using the geogrid is, the side embankment above the landfill that you are doing the side embankments can be created using the geogrid after reinforce earth, that means for a same height you can use a very inferior material as the fill material. You can create a steeper slope. So, all these things are possible with a geogrid. Then woven textile woven textile is used in the final cover layer. Geomat, geomat is the material which is used for erosion control on the outer periphery of the boundary wall. And geopipe, geopipe is used in leachate collection.

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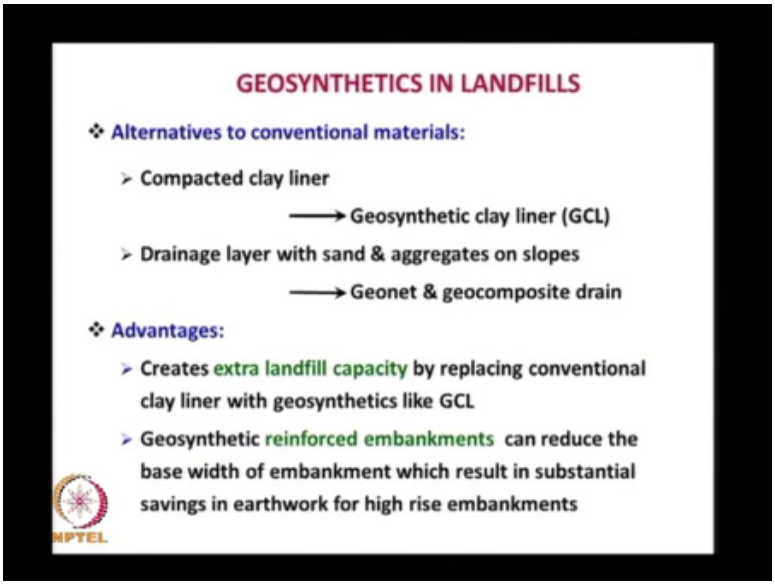


As I said the compacted clay liner is a replacement to the conventional material. Drainage layer sand aggregate this is replaced by geonet geocomposite drain. So, that is against space consideration. Advantages creates extra landfill capacity by replacing conventional clay and geosynthetic reinforced, embankment can reduce the base width of the embankment which results in substantial savings in earthwork for high rise embankment.

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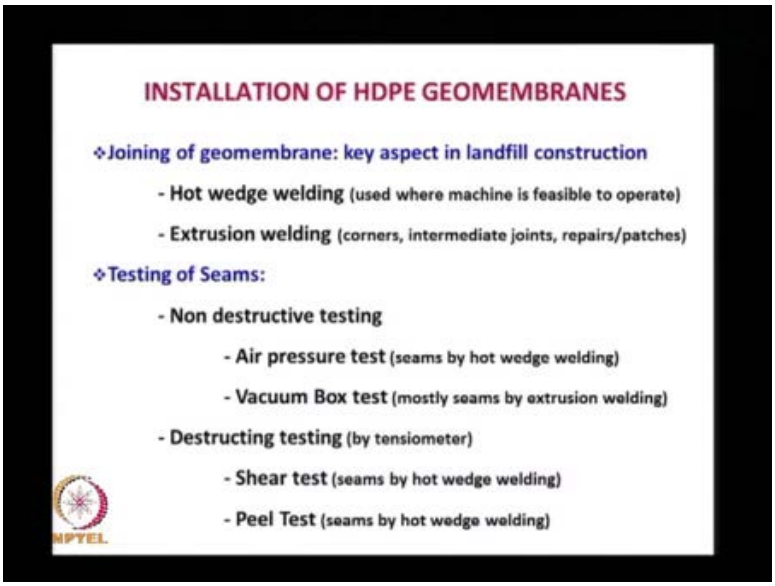

Now, installation you have selected the site you have arrived at the critical criteria of the material what are to be used, but how you go about installation. The installation is the most critical aspect of a thing because as I said earlier. If you create a landfill if there is a mistake you do not get a second chance to rectify it once the waste coming to the system. So, you have create it first time the right. So, for joining membrane hot wedge welding is used and extrusion welding is also used in some cases.

And non destructive testing once a joint is made the strength of the joint is checked by non destructive testing and the destructive testing there methodology is somewhere. There are protocols every bounding the machines have to be separate, the welding has to be done during the period when the day time is not very hard, that is early morning or late in the night only the installation can be done with a membrane that is the ideal time.

Because the h t p membrane with a rise in temperature will expand and night it will contract. So, you have to these installations at a time when the temperature variation is not much. That is either in a temperature like India or other places you have to do it either in the early morning or in the late ion the evening and night not during the hot during time.

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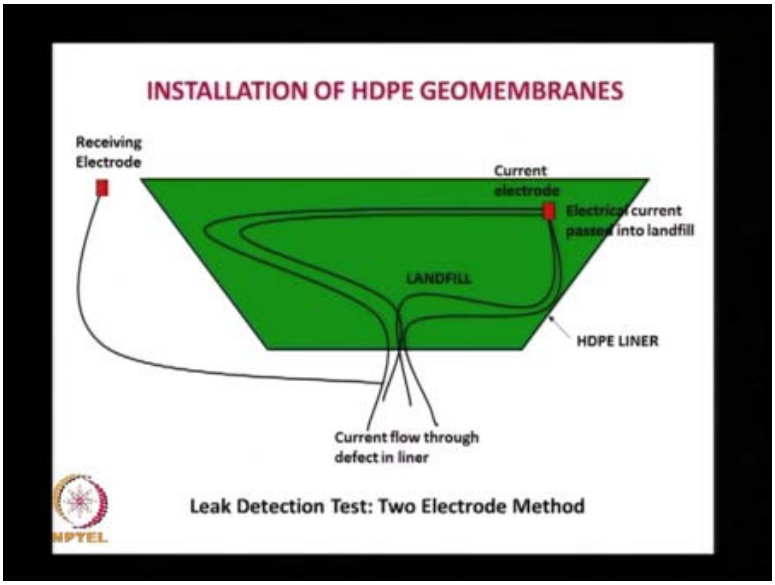


Then after installation there is final thing is that heat detection methodology because during the construction, there is possible you must have done something which create with a hole, to check it there is a great there is electrical conductivity the whole area is

filled with water. Then you use a anode and cathode kind of thing that there is a potential difference you know there is a hole. The hole is rectified by creating a extrusion building joint and geomembrane you see how they do it.

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You what you see here is a machine, hot wedge welding machine which automatically moves. I will show you the better arrangement this is how the machinery are used these are used to test the scenes that are created during the process.

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Now, if you look at the top here these are the two weld joints which are created during the h t p during the wedge. And here annular hole is created in this hole an air is passed act of the scene is when an air is passed. And it is by ASTM method, it is tested using a gage pressure gage. It is inserted into that air is pumping and there is ASTM phase.

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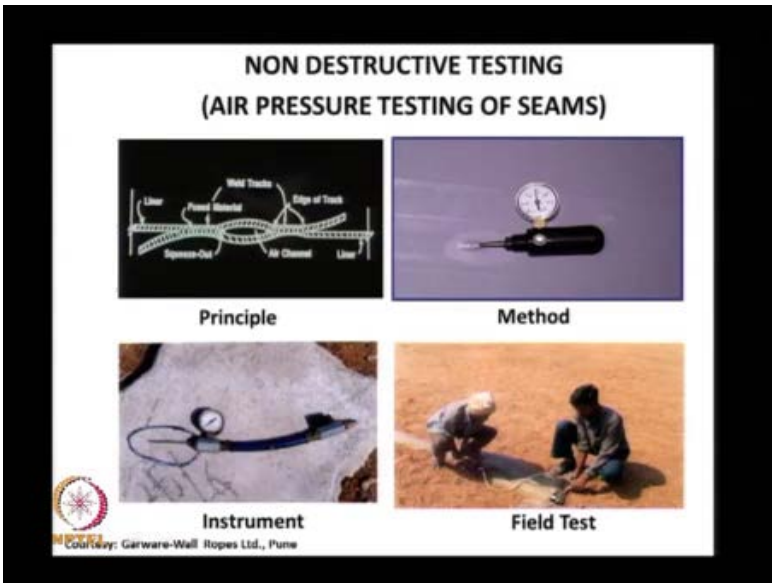


So, many ways the pressure should be maintained constant. Then if it is done then there is no leak, if it is a leak then you have to that total length is 10 meter you spilt in the middle and you repeat the test. You know either in this side meter or in this side meter the leak is there you go on by trial and error method till you locate the leak. Once you locate the leak you have to do it an extrusion welding. Extrusion welding is like similar to your earth welding in the conventional welding. You got a h t p earth use that h t p earth do it.

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And after doing that welding you have to do a vacuum box test. Put the soap bubble there apply the vacuum and see if the bubbles are coming. If the bubbles are coming air leak is there, if it is not there the joint is perfect.

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These are restrictive. Every morning before you start the welding 2 pieces of membranes of welded after specification put in here and tested as per the standards of Peel and other test.

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Now, clay liner, clay liner is much simpler than the product terms marking on the edge. You have to use a betonies paste as that above 300 mm is the overlap. You place 1 geosynthetic liner layer over other at the 300 mm overlap and just to have a small handle roller on, roll it that is all. The installation is very simple.

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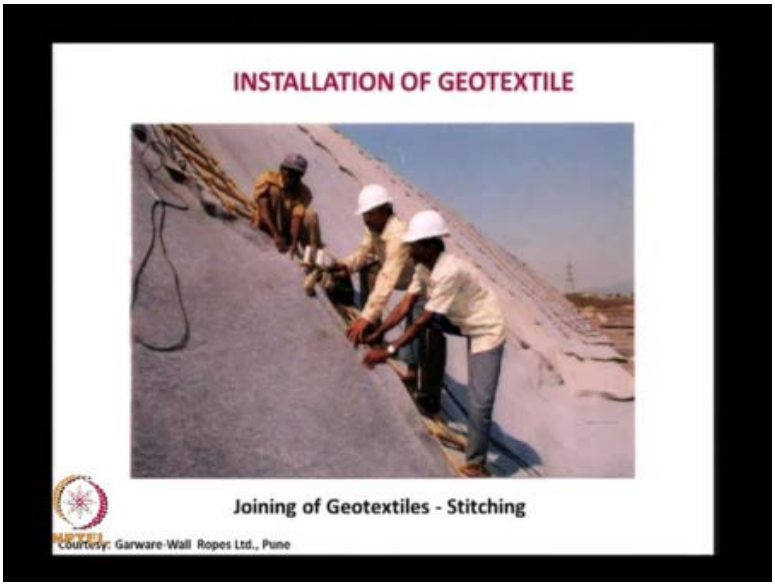


There is textile, textile is done two method, either the seamen is done the overlap criteria has given 150 mm or 300 mm. Depending on that either a sieving is done or some hot air

is used to join the geotextile. See, we have to use a ladder also to do the welding and the slope portion.

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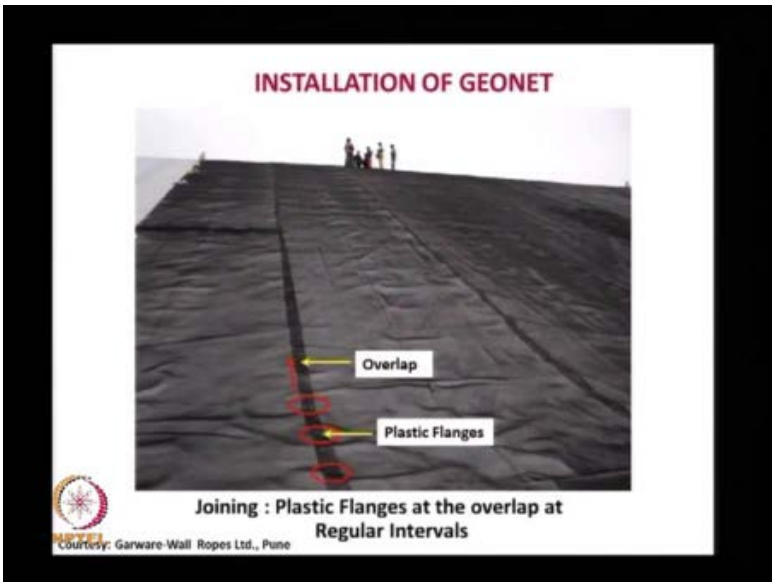


Now, overlap plastic flanges how it is done. This is for the geonet, geonet is a cable type is just to use to the hollow material and do it.

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And these are pipe and sometimes you may be using a bringing a slurry, you not say slurry into that. Then both sides has to be joined together. So, that is done by a mirror joint and joining of pipes. Each one is the specific methodology is there.

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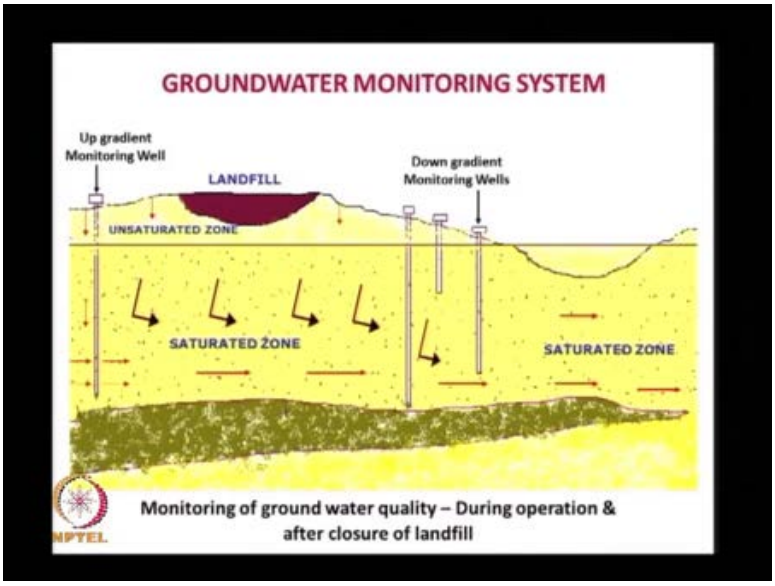


Once a landfill is completed, you have to monitor it. You cleared some bore holes in the adjoining areas, in the adjoining areas you create a bore holes. You start before the start of the landfill, you take the water quality and test it.

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And after that you take the water and periodically test it. So, see the quality includes and not dataries its pressure then you know the landfill is functioning properly, but while I am talking about this I am also constraint to say. There are some opinions in the international field, no landfill is free from holes. Please understand even all the precision,

there could be still some holes could be there in the landfill, but that does not affect the performance in spite of that, they give you the very best performance.

Now, I am going to explain to you some case studies which you have been created. I had the privilege of the experience of being associated with more than 100 landfill in the last 10 years. Some of them I am going to which are critical, and which are most useful, and which are quite different from the routine runoff the will, those case studies even explain. They include the municipal solid waste, hazardous waste and landfill capping. So, we cover the entire gambit of application.

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Now, this is a Jaipur municipal solid waste site. This is just to be started with a clay liner installation site. There is a site is prepared, you know by removing the abstractions, other thing leveling the ground the everything.

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Now, after that the geomembrane installation is progress. Generally depending on the larger width of the membrane, it is more better because when you have the least number of joints. In some cases and in most of the cases in India we have using 9.4 meter width membrane, but it has got its own associated problem. To take a 9.4 meter width membrane and to install it, it requires some capacity to handle it. It is not as simple as handling a 5 meter or 8 meter. So, every opportunity has got some problem also.

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Then you have got the drainage and leachate collection system. The pipe is laid in a particular pattern. And here the gradation of the landfill bottom is also taken into that because the flow is almost taking by gravity in the leachate. Then the geonet, at the side slope you use a geonet that is drainage composition sum, which is a geonet is a spacer bar kind of material with a textile. So, that the liquid gets collected and flows through that.

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Now, we will see another landfill example picture PCMC, Pune.

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Here the preparation base, you have seen the base preparation.

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Then liner installation.

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It is almost the liner installation is complete, the entire area is covered with a membrane.

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And then in Indore, another municipal solid waste.

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Here you see the base as well as the sides are covered with membrane. And over that Rampur.

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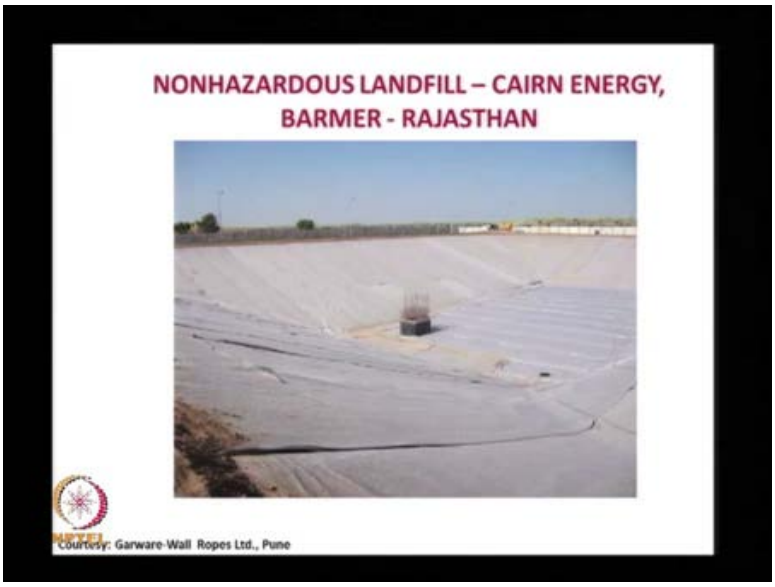


This is a cairn energy Barmer, which is for oil waste at Barmer for cairn energy. Now, hazardous waste landfill. Hazardous landfill as I said is a double layered system. And here we are going to see a first something and I will explain to you in detail.

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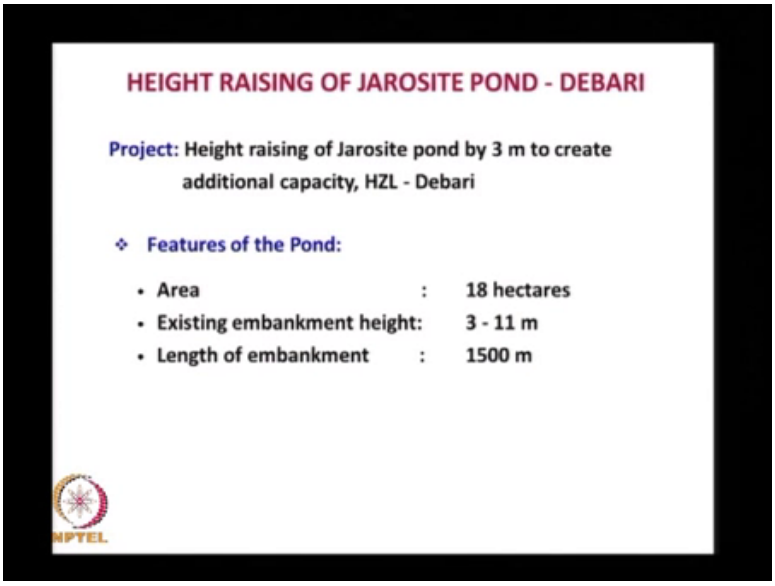


We had a landfill which is created in Udaipur about 12 years back. The landfill has come the capacity created has been justified and there is almost to the brain, but they wanted to create the additional capacity. There was no site available, no space available. This were geosynthetic was used to its most advantage. The area was 18 hectares. The existing embankment height was 3 to 11 meter. The length of the embankment 1.5 kilo meter or 1500 meters.

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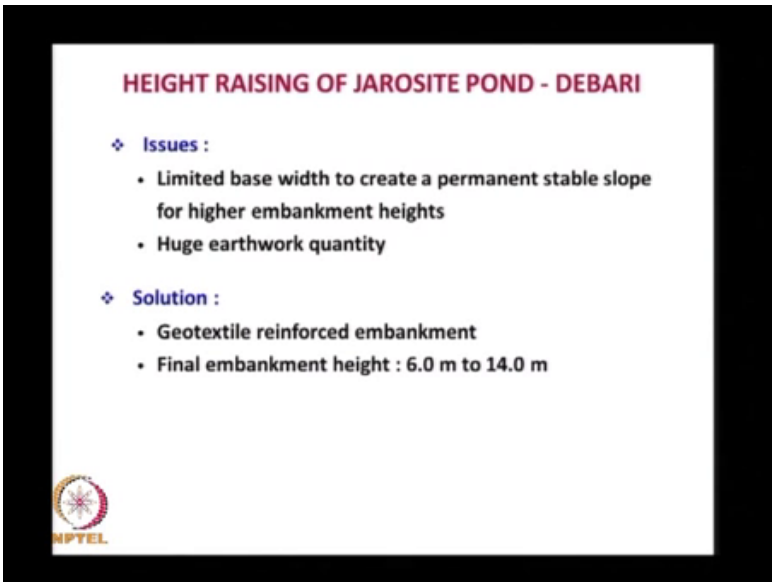

The issues are limited base is to create permissible slope for higher embankment. If I use the same embankment higher then the huge earthwork quantity. The solution is geotextile reinforced embankment. The final embankment was 6 to 14 meters. We said 11, from that it went to 6 to 14 meters. Now, you will see here in detail how it has been created.

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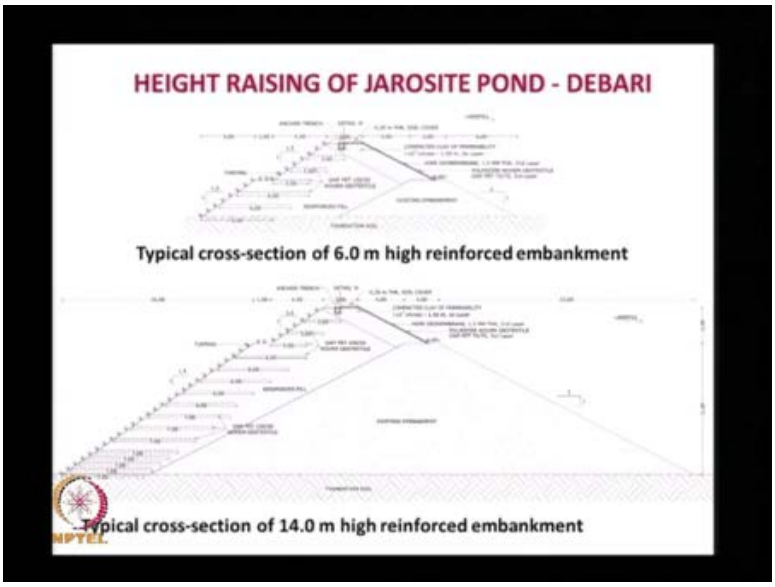


There is a existing embankment. You can see here at the bottom there is a boundary of a existing embankment. And over that from the outside because inside is filled with waste material. So, outside a rapper on geotextile reinforced technology has been created and this is how it has been done. And then this is the height which has been created over the existing embankment. And then this liner which was originally installed here has been removed. Fresh liner has been put, these two are joint on this much of extra height has been created for storage. This is the beginning of that, you see the existing embankment. On the other side you are using the material, to create the new embankment.

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The embankment construction is in process is almost ready 14 meter height.

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The maximum height was created. And then this is the interior.

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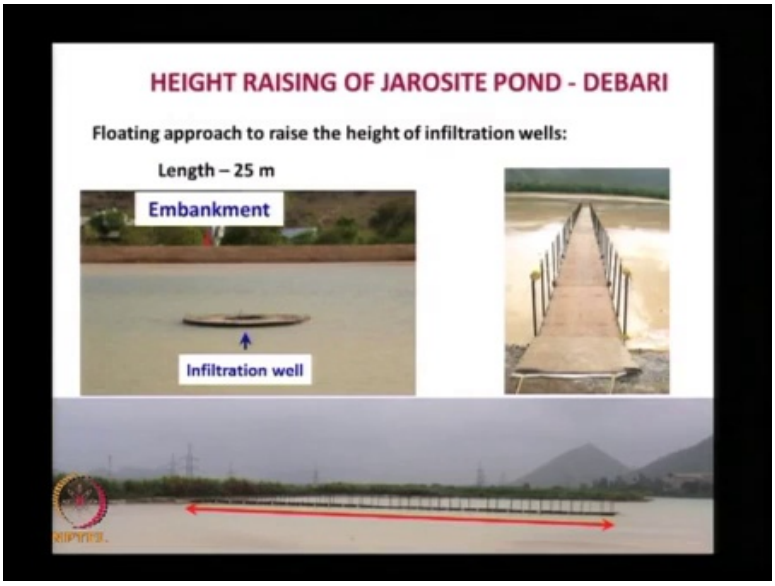


You see this the hazardous waste thing, inside there are some infiltration. Wells have been created for the drainage purpose. Now, you see one such well, it is because the waste is full up to height. There is no space and you cannot reach this place. Now, I have to create a extra height. We have gone up to 14 meter. So, for that we create it here temporary rope suspended bridge and prefabricated a gallery. And this is what you will see is the embankment, this is a well in the center. We create it and we prefabricated it took it and fix it on the top and the same site.

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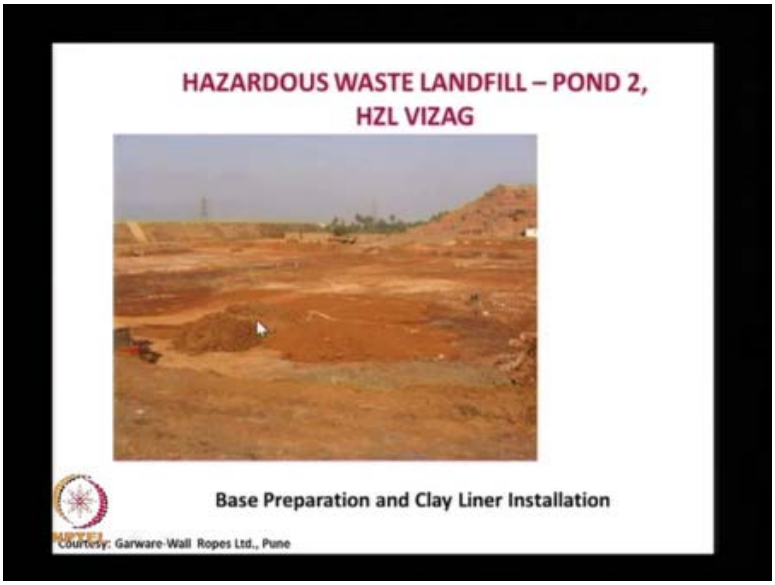

Now, in this I am seeing Vizag, the first landfill was created at hazardous waste which is called Zero site, in the year 2000 it was completed.

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There is initial here the embankment was prepared by using a reinforced earth technology using a geogrid.

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Now, you will see here base preparation is a clay liner installation. Then this I am talking about the second pond, first pond we completed it was full. Then we created the second

pond to accommodate the extra material which are coming. And then you see here pond 2 was completed.

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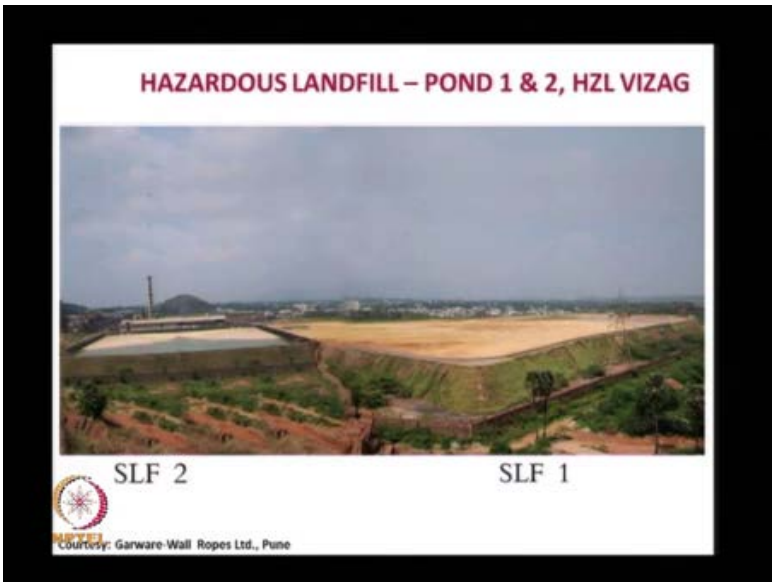


You will see here both pond 1 and pond 2 created simultaneously. There is a pond 1 and this is almost full. Now, we went and created this pond 2 that is, this is a common wall the 3 sides used a additional material by reinforced earth. In this also we use a geogrid, but the embankment was created using the zerosite waste itself, which has got a p h a value of 14 degrees.

Using a 14 degree frictional value material by using their reinforced earth, we create an embankment of 8 meter height almost a slope of 1 and 1. So, what is the benefit here. Here the benefit was you have not brought extra good material from outside whatever it is available it is used it. So, that is a efficiency, that is the cost economic, that is the technology.

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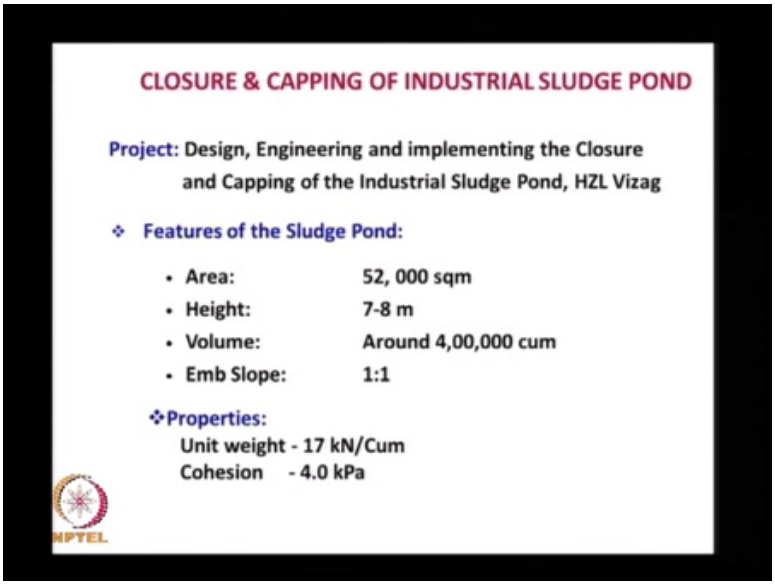


Now, is the cane energy you see that. I will show you now the capping. See it takes the lot of time to do the capping because first you have to create a landfill. And the landfill may be an old 10 years, 12 years. It has to be in operation. Once it is full only you go for capping. So, not many capping situations have happened in India. There are only few things have happened or we will discuss one such thing. This is at Hindustan Zim Vizag. I said in the year 2000, created the first landfill, first zerosite waste. The area has 52000 square meter, the height is 7 to 8 meter, embankment height 1 in 1 slope. It was reinforced earth embankment volume was around 4,00,000 cubic meter and the properties 17 kilo Newton's and coefficient value is 4 k P a.

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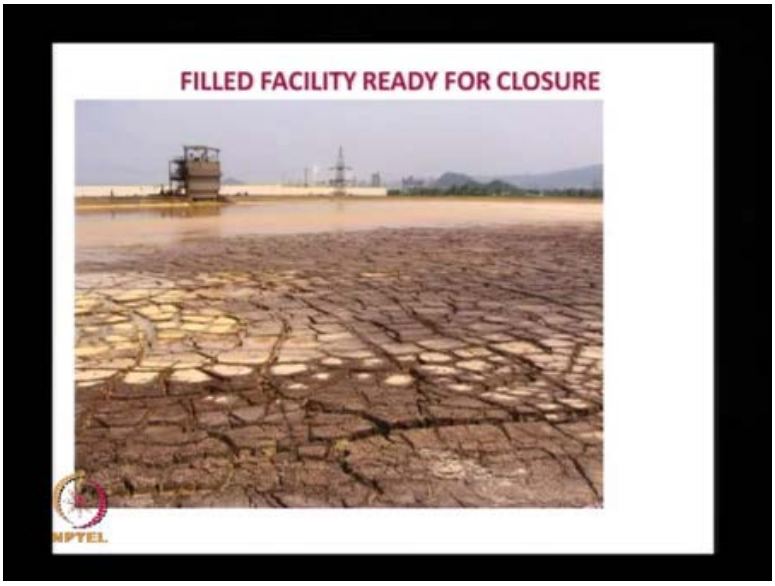


Now, you will see closure look of the filter closure, this is a closure. Now, this is contains some moisture also. So, this layer what you see at a top is very soft zerosite. So, if you go for construction it will start sinking automatically. So, some cases you may have to do bearing capacity improvement before you start doing that. What we did was especially in method. We use a high terns textile.

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Because this is how see we moved the initial equipment it was all shrinking. You can see in the top corner that equipment. We cannot reach it.

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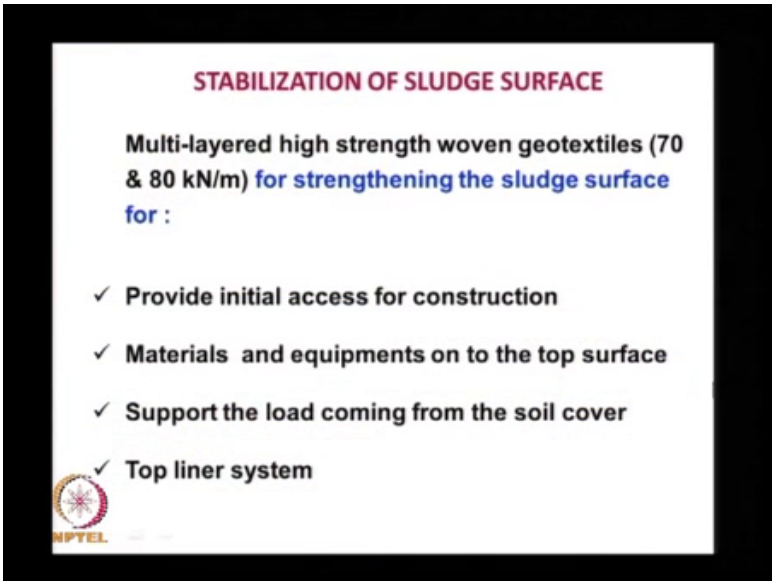


So, what we did was? We use a high tensed textile about 80 kilo newton provided the initial access for the construction and materials, other thing support load. And then soil cover on top liner system.

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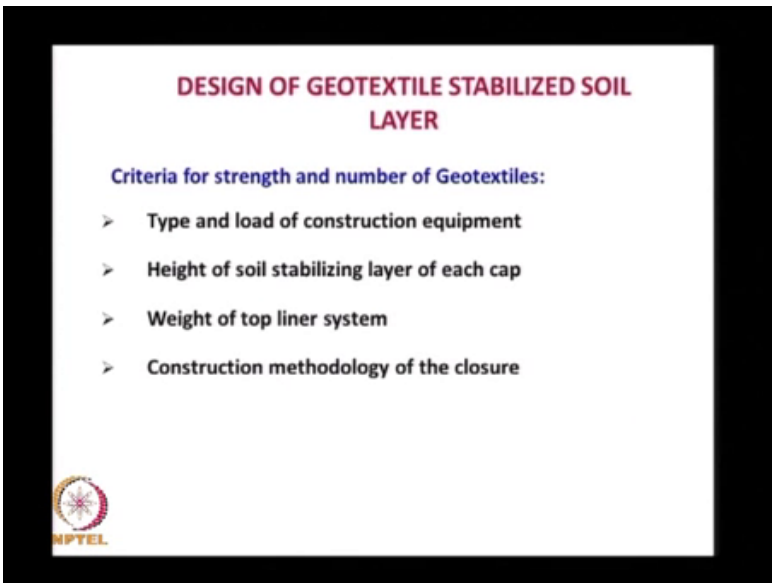


Now, type and load of equipment height everything has been accessed and calculated accordingly the selections have been made.

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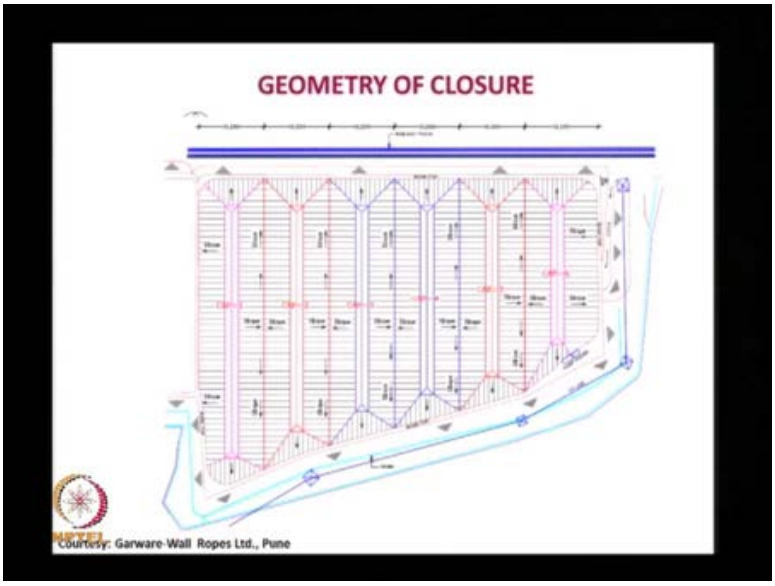


This is a geometry and layout of what we used geometry for the closure.

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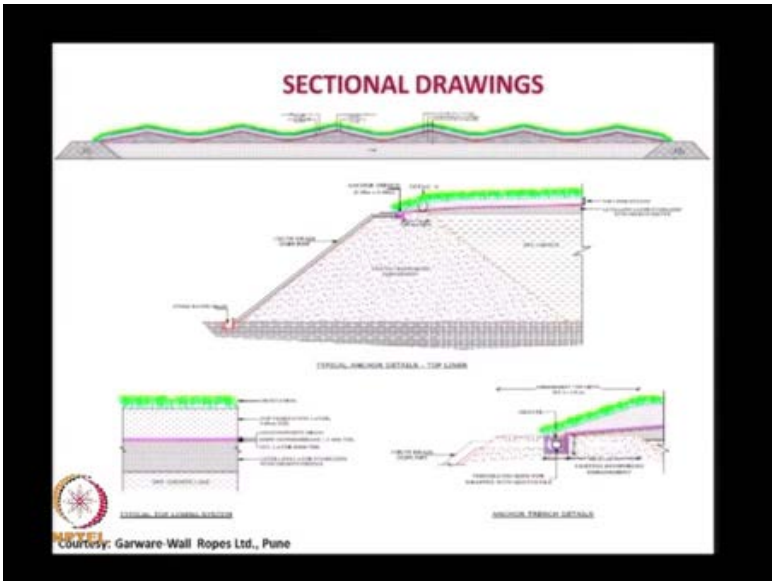


So, here we use something called this has the sectional drawing, which you can see. These humps and valleys are got a load because if you know the geotextile or a geogrid, it is a strain controlled material only when it is stretched its strength is mobilized. So, what we did was we created a hump kind of thing or fingers while movements. So, that it is stretched and the strength is mobilized before we could place the final materials.

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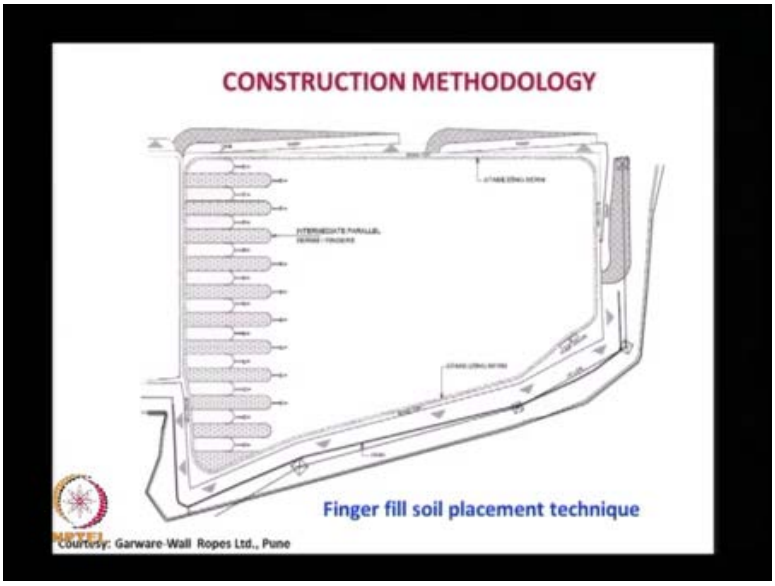


So, this is the movement you can see here very clearly the moment. This is the past direction of the movement. And these are the places where it got filled and to laying the textile and that created the sufficient tension, then this intervening portion are filled with materials.

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This is how you can see one portion. Other portion in between there is nothing so here it takes a tension happens here in both side load.

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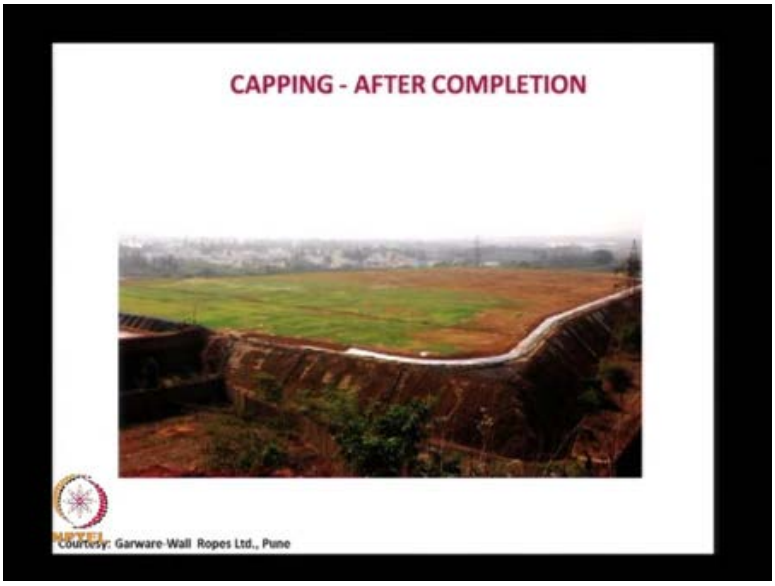


And by this process the whole thing was completed. And here the system is I am not going in detail, but I have shown you a top liners system is a replica of the bottom line single liner system. It has got a clay material then liner, then you have got a drainage material other thing. Finally, you have got a top soil with a vegetation group that is a erosion control mechanism. And that is what you can see the vegetation happening here.

And this is one of the major capping installation for hazardous waste done in India. And the IIT where the proof consultancy for this project IIT Madras. And we are grateful to IIT Madras also because it is a mutual learning for both of us in there. Now, the way the technology is going I just want to show only one more minute and tell you. Today the carbon credit other things are there, the way the technology is going is such that, apart from this we have to create more money more value.

One of the system is in Jarjia, they have done a model study. In the top liner system they have used what is called photovoltaic textiles. These geotextiles have got copper wires embedded into that. These are used on the slope in the final layer both the sun rays fall on that then electricity is generated. Then they have got the special equipment to draw that sun light to convert it into like you know photocell. Similarly, a textile embedded with a copper wire the technology is there. They create the electricity and then it is used.

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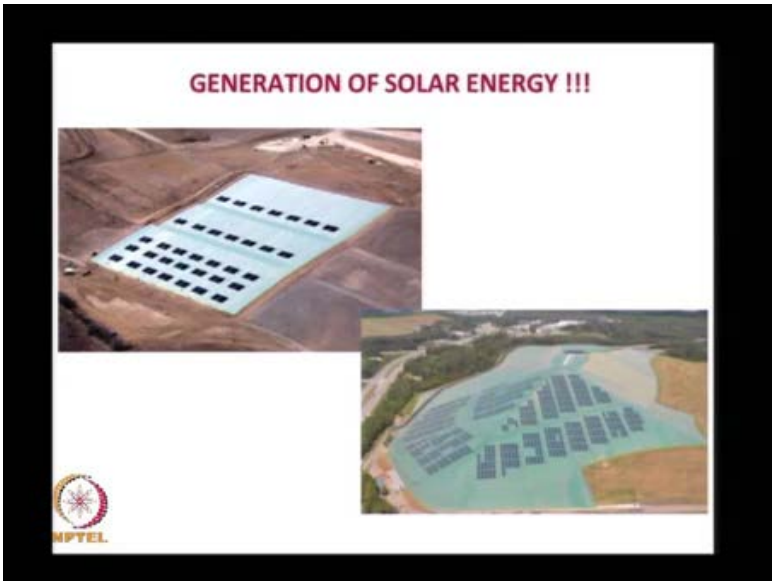


Because most of these closed landfill, if you take hazardous waste it must be inside a factory area or other thing. So, it is well protected, there is no vandalism other thing. And the space is ideal that is land space is not use for any other purpose, but if you can use it for producing electricity then that is the best thing that can happen. You can get the carbon macadam other thing. So, if you look at it the geosynthetic in landfill its not only solves the Toady's existing problem, it provides a sample scope for future in create more value also.

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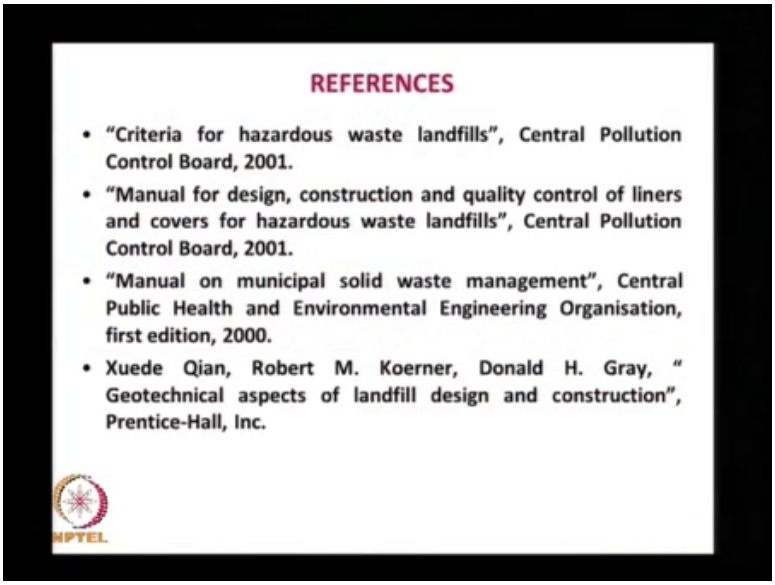

And the references here is I have given. The most important is the criteria for hazardous landfills CPCB guidelines. Each one of you should be going through that, if you want to learn about it, it is a complete document which is used. And the landfill is one sector where there is no confusion in geosynthetic because the guidelines other things are very well laid out. So, it has to be implemented in that way only, there is no issue on that. There are other references manual for design and construction in quality control.

Again by CPC publication and later on a municipal solid waste publication also has come and M. Koerner book which is most important. Now, I thank you very much for your patient hearing. It is a pleasure to share the experience and to give you a brief birds like view of the entire landfill gambit. Thank you very much. Now, PBT has come into always higher projects. Is there any PBT model for landfills?

For that PBT model is there, but it is there only for municipal corporations. Like we have got in Hyderabad and in Cochin. And in Cochin there is a industrial which has been created, but it depends on if the user industries which are all the industries which are in a area. And they do not have the facility to create a individual landfills, they all joined together and then they request the government agency and other thing. One individual party comes in, he follows all the technical other things are followed.

And then the only issue here is because they are located in different areas the waste has to collected and brought to that particular site. These things are happening now one is to contemplated in Cochin, already some are in operation in Ankaleshwar area in Gujarat. As well as municipal solid waste is concerned also in Gujarat, they are planning because small-small municipal corporation, they have to select a site which is all that. Then they combined together and then nobody wants it.

There what is happening is the collection of the municipal solid waste, their segregation, their transportation. Then creating whatever methodology is used creating it to manual. And then dumping that balance portion into the landfill is an operation, but not many has been successful because there are certain financial issues. And most of the corporations are not in sound financial situation so they are not able to fulfill the requirements. So, that is the whole thing problem, but the concept is very much impress. Both were hazardous as well as municipal solid waste.

In fact what we have done for Jaipur, Indore, Rampur, which I have discussed the case studies. They are all in that kind of a thing, but it is a little combination they allowed us to create and they also give us. If we want we can operate it from 3 years, but there are certain issues. See in any municipal corporation there are existing land pickers. If you trans it give to an industry house to do for all these job, the existing land pickers are thrown out of job.

So, you have to absorb them and take it into your system and create it. Otherwise you know there is a lot of social problems which is happening right now in Pune PCMC municipal corporation. So, these things have to addressed, these are all small things. You can displace a person who is working out and pushing out of the job because you are taking over as a company. So, these things have to be addressed very delicate issues. Is there any landfill that is closure and monitored for its performance in terms of the leachate collection and then the leakage?

No I do not think, there is any scientific monitoring. As far as the history goes they have been fortunately no major failures which are non record. So, everything goes on that. In fact some of the projects which has been created has got a warranty and guaranty period of 25 years for the product and installation that is the thing, but the initial few years is always the origin. Once it settle down and start functioning then there should not be any problem.

And the earliest landfill for the hazardous from our experience is the Hindustan Zim Vizag, which has almost crossed 12 years and closed and the capping also has done. So, that basically I do not think there should be only thing because the design, the manuals are there cannot be any issues. The product selection, you have to use the best product if you do that the only worrying aspect is installation. If you do the installation and before you put the landfill into operation you have to make a thorough check.

So, there is not defects in the layers which you have created if you ensure that there should not be any problem, but we are a long way from doing this scientific monitoring. We have some monitoring arrangement pollution control board, but it is not that much. Because abroad as I said the inter of things there are a method called grid layer method, where the cables are laid below the geomembrane at the time of creating the landfill. And each one is fed to a computer well that thing.

And throughout the service period of the landfill it is monitored in a computer center to see each cable and other thing gives in that pattern area. If there is any leak or anything, it is deducted that is a very close monitoring. Those kind of things are not because it cost lot of money. So, here people have does not have enough money to spend for the creation of the landfills. So, they not willing to do that.

Student: Instead of engineered landfill most of it is waste dumps just dumping in a large open site. Is there any chance of converting it to landfill?

There is only one way, see you are already started and dump. There are two methods we can do either you have to remove, create a new landfill. And remove all these material and dump it there, that is the one way which could be very costly and other thing, or at the most you can do whatever pollution to takes place has already taken. A lane water, the leachate, ground water pollution you can only thing is recreate the slope stabilize it cap it.

So, that further percolation that depends two things you have to take how long the waste has been there? what is the current status of the waste? does it need further protection? That you have to estimate and you can do a capping that is the only thing you can do. There are two methods as I said remove it to a site, create another landfill, dispose could be difficult or the existing place itself cap it and provide the drains and other thing. So, further pollution does not take place. There you can solve all the problem as I shown in the first slide. The odor, the bird bines, the leachate all these things can be solved by that. That is the only thing.

Thank you so much.