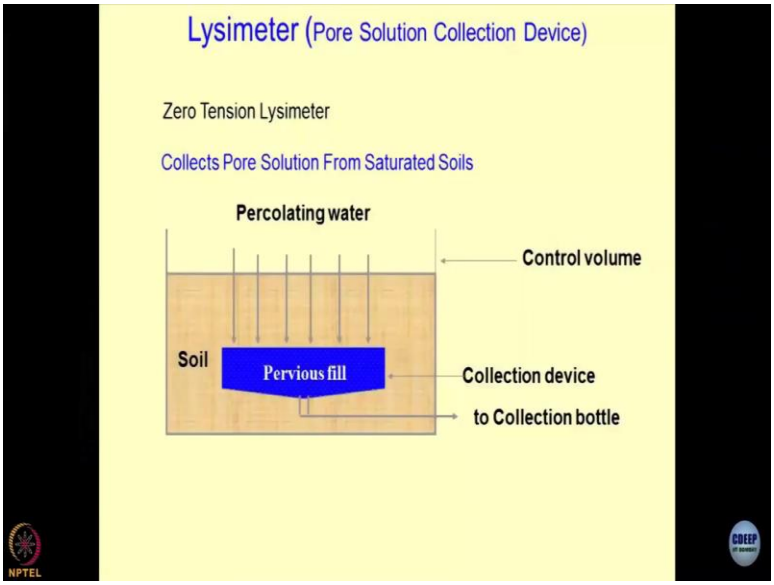
Environmental Geomechanics
Prof. D. N. Singh
Environmental Geotechnology Laboratory
Department of Civil Engineering
Indian Institute of Technology-Bombay

Lecture No. 32
Geomaterial characterization-VIII
(Chemical Characterization)

(Refer Slide Time: 00:16)



So, as I said lysimeter is a pore solution collection device, and there are two varieties of this zero tension lysimeter which is collecting the pore solutions from the saturated soils. One of the ways could be used saturate the soil sample and then squeeze or do a consolidation test. So, one good example to the question that you are asking or the answer to the question that you are asking would be, I will saturate the soil sample, and I will compress it in a regular consolidation ring, and I will make arrangements so that the rather than keeping the water inside the ring, I will allow the pore solutions to come out so, I can dissipate the pore water pressures.

And the pore solution which comes out would be nothing but the pore solution from the saturation soils. This is a simple device which you can device all that you have to be careful about the chemical activities and its reaction with the tubings and the oedometer material which

you are using, and you have to be very careful. Otherwise, the chances are that you will be contaminating the pore solution externally.

So, most of these studies require clean rooms, you have to maintain the utmost cleanliness, and you have to eliminate the chances of external contamination of the sample. And these type of labs does not look like conventional geotechnical engineering laboratories. So, they are clinical laboratories where you do the clinical examination and where these type of studies are becoming more important right now is when somebody hires you to help the industry or the organization to fight a legal case.

These type of cases are becoming very, very routine nowadays, allegations or violation of the environmental norms where you could be under severe threat, including the imprisonment. I hope you are aware of this type of norms, which are prevailing under the environmental acts of the republic and the countries. So, this is a simple model I hope this explains to you what the lysimeters would look like. There is a control volume which has to be created, this control volume could be stainless steel, this could be aluminium this could be perspex or inside the ground, this could be the soil mass itself.

And they are what we normally do is we excavate. This much soil and we fill up this space with the pervious fell. And the previous was could be the sands, or it could be the gravels, or it could be the mixture of both of geotextile depending upon what type of precision you require, and then at the bottom of this there is a drain which is taken out, and once I do artificial rainfall. So, this could be done in the field also this could be done in the laboratory also you can do artificial rainfall,

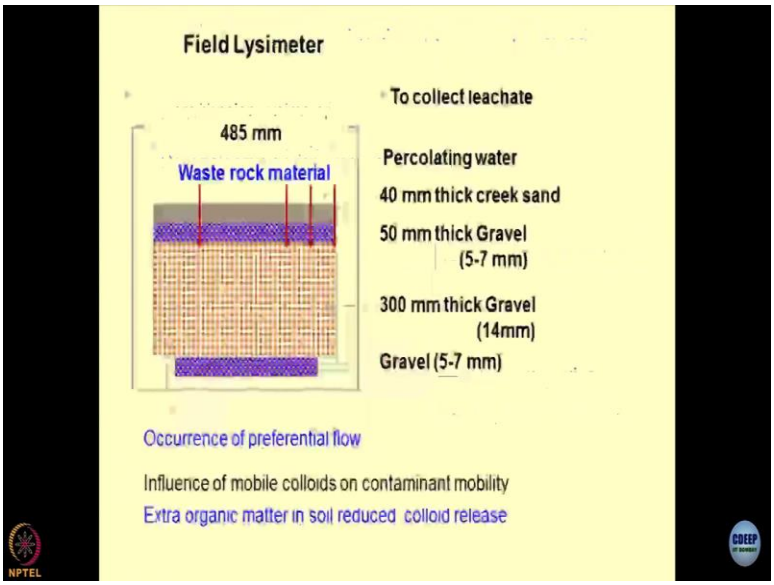
You can sprinkle water sometimes you can waterlog this whole sample by flooding it and then as a when percolation takes place, this soil that you have recompacted becomes saturated and the percolation occurs all the pore solution gets accumulated into the previous fills, and then you can drain it out from here to a collection bottle. And this collection bottle is similar to the one which normally nurses use for storing your blood sample. We call them as vials they also call them as vials.

So the analogy is simple. I am sure you must have realized that the though It appears to be a very simple device, but this can answer a lot of questions which we ask, first of all, we can study what the soil is doing over there we can also find out the hydraulic conductivity. So, there are papers which have been published by my ex-students, you should refer to where we have determined the unsaturated hydraulic conductivity of soils.

Sneha Kurian and Hanumantha Rao and all these papers you should be going through to realize that how the lysimeters can be utilized to obtain unsaturated hydraulic conductivity fine and here I can do some more experiments, if this water which I am using for artificial rainfall, I can contaminate it with some chemical species and then I can see what type of percolation is taking place and what type of percolates are getting deposited in the previous fill.

So, this is what is going to tell me how much is the sorption capacity of the soil under in-situ conditions what is the attenuation can the properties of the materials and hence I can use lysimeter for characterizing the soil must be alright. So, this is one of the ways of taking all the pore solution is this part clear of course, this process is very time-consuming. So, what I can do, I can make a small miniature setup, and I can install it in the centrifuge, and I can accelerate the seepage process by n square times is it not? So, this type of tricks people is going to take out the pore solutions.

(Refer Slide Time: 05:39)

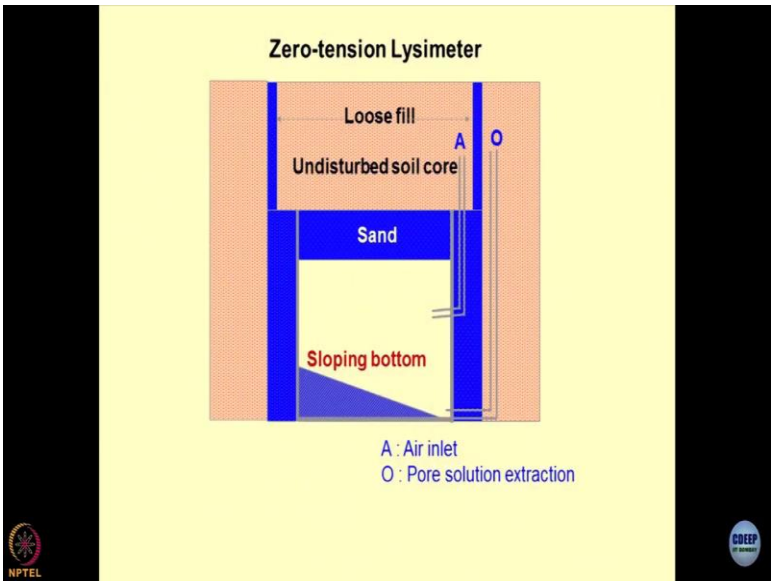


There is another interesting example of how the field lysimeter looks like. So, in this case, you take out the sample in the undisturbed from the field, and you can place it over here. And then we cover it with the gravels on all the sides and what happens is the percolating water which is passing through this and then some mechanism by which we have connected the gravels to the outside environment in the form of wells. And from here I can put an electric electrically operated pump which will pump out the pore solutions which can be collected in the leachate. So, there are different designs of the lysimeter.

The whole idea is that you create a system which is having high permeability and packet on the top of the on the below the soil mass. However, as you are aware the limitations of the falling head test and the constant head tests are that there could be percolations from the contact between the surfaces of the geomaterials which you have used and the lysimeter itself. So, this is not a very good way of studying the lysimetric behaviour of the geomaterials, and of course, fines may get washed out.

So, when we talk about the collides and the contaminant mobility that has to be studied into this. Similarly, another problem is that organic matters might react with the water. And that might also get altered because of prolonged interaction with the water.

(Refer Slide Time: 07:26)

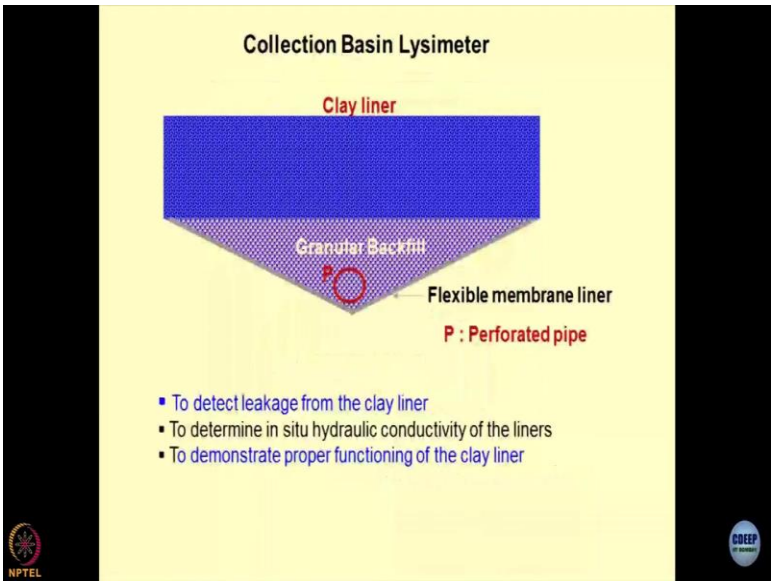


Then you will find this type of zero tension lysimeter also in the literature do not draw them. These are all available on the net you can see them and as I said, these are all prehistoric nowadays, such as images are not being used. I wish to show you a very state of the art lysimeter. And you will be surprised to know that the cost of that the lysimeters run in few crores tens of crores, so Germans are the best in the world in designing the lysimeters. So sometimes when you get time, please visit Germany and See how lysimeters have been installed for different projects. So, this is something interesting worth seen, you check it on the net, and you will find that there are some German companies who are selling lysimeter.

So you just type the word lysimeters and German companies, and you can see its unimaginable, there will be a big hall like this inside people sit and observe what is happening in the fields or in the on the in the project on the project site. So, this appears to be a very complicated type of a system what has been done is that you have to install a sand layer and then there is a sloping bottom.

So that whatever percolation takes place from the undisturbed soil core passes to the sand gets collected over here and the air inlet which has been provided, and there is an outlet which has been provided. So these type of systems is very complicated. Design under field condition, but yes these are design and use some once upon a time.

(Refer Slide Time: 09:06)



There is a simple example of what collection basin lysimeters are undisturbed or unsaturated without altering the density no γ_d remains constant. Why γ_d should change γ_d then plus we would not be getting the exact concentration of the contaminants that are present right. So, one thing is when we are like adding external water, external water contaminant let us say in that case the sample is getting disturbed right how in the form of concentration of the contaminants how much will be the static pressure even for one-meter water column on the soil sample which is exerting. How do you do the falling head test? So, did you ever take the effect of one-meter height of the water which is standing in the tube? So falling it is also you have done on a compacted sample.

So, once you have done the compaction, you have already created a state of the material corresponding to a density and the void ratio. Now, this density and the void ratio cannot be altered by one-meter water column unless you apply very high pressures on this. So, your question is correct as long as the percolate is not pressurized, I do not speculate any changes in the soil samples, and the logic is this because I have already compacted it clear. Fine. Sir, lysimeter, when we are leaching through leaching, we are obtaining the solution,

then the concentrations will be altered only the constituent like we will be getting so basically your question is about how to maintain the concentration of the contaminant, in your consolation also you talk about different types of stresses the different combination of stresses different types

of training conditions, one side closes one side draining one side partially draining another side partially closed. So, many conditions I can create is it not?

Are you getting this point? So, I can create a C not condition which could be variable with time also, which will remain conservative time also precise by maintaining a very high concentration of the fluid. So, delta C is going to be extremely low. I can do all sorts of technical manipulations. Yes, sir, can we check the chemical attenuation potential of the contaminant even soil by this chemical attenuation potential. Sorry. Yeah, of course.

So, sometime after today's lecture and when we will be discussing sorption desorption technics we will be using a quantified term there R retardation coefficient, and that R is basically attenuation coefficient of the material, by this method by this method. Yes, yes, yes, exactly, that is the whole fun. So, now you are into the thick of it, and now you are talking about the philosophy and then, later on, comes the quantification of the process will do everything.

So, this is a collection based in lysimeter, and normally this is designed for checking the vulnerability of the clay liners which are using the landfills vulnerability against what number one is the percolation of water, number two against percolation of contaminants. Third, what else it could be temperatures you see we have discussed so much that the liners which we are placing at the bottom of the landfills might get exposed to high-temperature gradients, why? Because of the chemical reactions which are going on inside the landfills.

So, these are the barriers which might also act as a thermal barrier under any circumstances sorry under no circumstances the clay liner should crack either because of chemical reactivity or because of physical damages when you are laying and compacting or because of swelling shrinking or because of chemical reactivity or because of extremely high temperatures and so on. Fine. So, here what we do is we put a clay liner on the top of granular backfill, and we place a perforated pipe at the bottom.

And why this is known as a collection this and because you are creating a V sort of a system. So, the percolates will get collected at the bottom-most point which is triangular, and from here,

which is a perforated pipe system, you can suck out all the leachates. These type of mechanisms or systems are normally prevailing and provided in landfills. So, when you see the landfill design, this type of Clay liners are designed. Now, what I can do is I can expose this whole thing to the rains artificial rains.

Let the water percolate through it and then I can find out what is the permeability of the clay liner under in-situ conditions and what type of contaminants are going to pass through it as a function of time all that manipulation can so, as and when the pore solution comes, those are the properties corresponding to time. So, leachate characteristics after filtration would depend on the time of interaction also. Fluids with different viscosity will travel at different rates. Excellent.

So, If we going to create artificial rains. Is there a chance that the water we supply is going to be collected before the contaminants? Yeah, you are right. So, yes, there could be a chance that has to be mathematically modelled. So, imagine if this was confinement if this was kept in a whole confinement thing. And if I allowed rainwater to get accumulated over here, so concentration, are you trying to say that the concentration is slowly building up? That is what your concern is; it is not about the concentration even before the contaminants start to flow.

Let us say this boundary, is water capable of coming even faster than the contaminants? No, but contaminants are in the liquid form. So they are dissolved in the water itself. Is water the carrier? So your point is correct. So these contaminants are dissolved in water and you That solution is percolating through it, or it could be reversed way, if I want to see what is the level of contamination of this clay liner, I will be washing it through with the more purest form of the water clear and then let me see what gets percolated.

So, this is not a washing experiment decontamination desorption experiment, and then I would like to study how much the soil would like to retain into it clear agricultural scientists will be very happy to do these type of experiment in the lysimeter why because he is going to grow a crop and he wants to see even if the extreme flooding occurs, what are the chances that this soil will retain nutrition into it even after let us have one year of flooding of the entire system.

See I have changed the context of the problem, now. But, yes, this is what agriculture scientists would like to study. So, this is where you require very high new attenuation capacity of the soil is also clear, so very high sorption rates are good, very high disruption could also be good for something else for another situation is this what you are asking? So, the thing was, I was assuming the contaminants to be fluid form and water, and the contaminants are going to be having different viscosity contaminants are mostly heavy metals, mostly because you are interested in knowing how heavy metals would leach and cause what type of havoc to the porous media. Clear?

So, either you can take the leachates which are coming out of the landfills, and you can pull them over here, and you can simulate a condition what type of clay linear should be designed at what porosity made up of what soil made up, how much depth thickness all these things. So, it depends upon what you want to do. So, I can use pure water. I can use contaminated water; this is what is known as artificially created contaminants.

So, if you understand that these are the heavy metals for which you want to see the response or the clay liner, I will use that particular species of the contaminant in the water dissolve it and make a solution and let it pass through it, or I can create a competitive contaminant migration also. So, I will have different species of contaminants in the solution form multi contaminant system I may create, and then I would like to see which contaminant is coming faster.

So, and which has higher sorption capacity on the soils. So, all these things can be done; this is the bigger picture of the whole studies. Sir, what is the efficiency of collection of this porous solution, what is the efficiency? How can we make sure that the entire pore solution is getting how the entire pore solution is getting collected where in this, this is a sloping area, is it not? So nothing would stand as it is somewhere here or the whole idea of making a sloping ground is that whatever is percolating will come and get collected over here, whatever is percolating is collected.

But how can we make sure that nothing was getting percolated, I need not to wait for that, because most of the time, how the sampling is done, you may do sampling with respect to time

or with respect to special distances. So, I will do maybe ten times sampling for ten days or 20 days or 30 days or one year. And that is it I mean, I need not wait for the entire system to get dried up or whatever. Write down this question.

And my when I am discussing the breakthrough curve, please ask me this question. You will get a better picture. So, **"Professor - student conversation starts"** like any preferential draining paths are there in clay liner then it will affect the contaminant? Like the collection, you are right. So, that always remains there. So, that is the biggest limitation of creating these type of systems where the interface came lesser-known devil when I was studying about the MSW landfills liners, in which the chordal provision is like you have a 1.5-meter clay liner.

So, is it like 1.5 meters set like for a particular nature depth, so they have given the consideration they actually did that for a typical landfill or is it just a casual number? See, again, as I said, these are the thoughts which are under scanner. So, if a person like me is a consultant, I cannot afford one-meter storage space in a landfill for creating a liner system. The second question is in today is the world; I do not have so much of the clays from where I am going to bring them when there are strict. **"Professor - student conversation ends."**

Warnings and what do you call as strictures that you should not excavate soil from so, all this is the neo concepts, where I would like to decrease the size of the liner from one meter to 2 centimetres. GCL CCLs so first of all the concepts is required, and second is an alteration of the concepts will make your ideas more contemporary. In all my consulting projects right now, I am going for what is the thickness of the lightness, which I use? 3 mm, I cannot lose one-meter space of storage multiplied by the whole area of the landfill.

How much volume? This would be one year or two years of storage of the entire Bombay city. It is not 12,000 tons per day what you are talking about 8000 which has come down to now 6000 per day in Bombay. So are you realizing the concepts and what can be done by using these simple experiments big, big questions can be answered? Suppose somebody asked you a question that creates a thermal barrier.

For my building, I can use the same concept what I have to do, rather than percolating the water, what I will be doing, I will be exposing this surface to a thermal gradient, and then I will measure temperatures over here to tell you whether the whole thermal barrier is intact or not. So, I got it to PhD thesis based on this concept where we have designed thermal barriers for defence. These are the applications of modern-day science and technology.

This type of systems is also used for finding out the efficiency of the clay liners how much they are leaking over there cracking and determine their hydraulic conductivity which I have already discussed. Whether they are properly functioning or not, I can put an electronic sensor also at the bottom of the clay liner. So, the moment a certain species of contaminant comes, I can detect it, and this can produce a sound or light, or some sort of an alarm. And I know that the line that has failed. So, these type of techniques is being used in the contemporary world.