Environmental Geomechanics
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Lecture 08
Scope of Environmental Geomechanics - II

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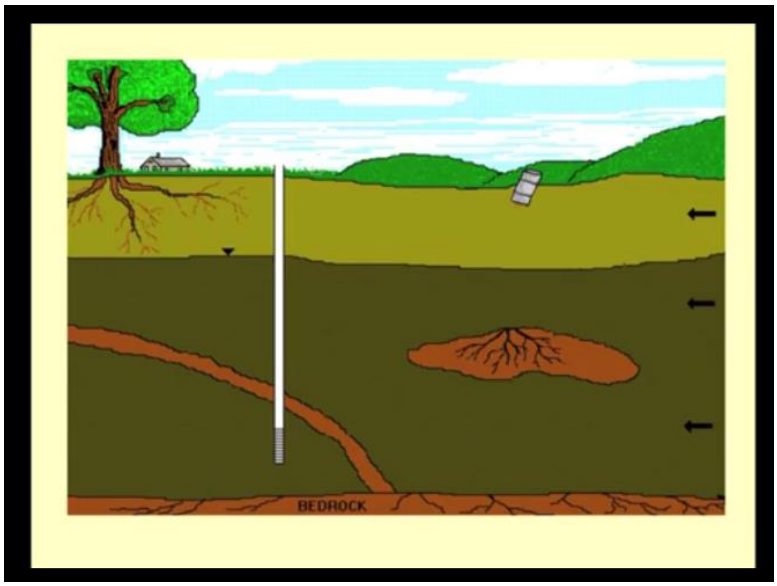

See this is a scenario, what is happening in today's world, alright. You know, you are seeing the waste being dumped. I have shown red colour to depict its toxicity, hazardicity, clear. So intentionally, I have shown you two domains. One domain is the atmosphere, clear. Another one is the subsurface environment because we are going to tackle this portion or this domain much more, being a geotechnical engineer, clear.

We normally do not talk about the aerosols much and atmosphere much. With our philosophy that whatever pollutants are there, when the rains come, everything will settle down, and it becomes a beautiful problem associated with seepage in porous media. I can handle it, agree? So here what is happening is the waste is being dumped in the subsurface on the subsurface, and this is how the spread of the waste is being shown, what we have been discussing in the previous slide.

There arrows depict the movement of the water table, and this is stagnant or the standing water table, alright. Because of the pumping operations to sustain life, you do pumping out of water or the resources. Now when you are dumping this waste material over here, what happens? This waste material interacts with, first of all, the first zone of the soil, which is above the water table and knowledge of geomechanics says that this layers of geomaterial could be variably saturated depending upon the depth of water table.

The bottom-most portion at this point is going to be saturated, as you move up, the dry portion starts. We call this a variably saturated zone. We also call this zone a vadose zone. In simple language, we also call this zone as unsaturated soil, clear, or partially saturated soil. You should not get bogged down by the fact that anybody uses the word vadose zone or partially saturated; it is simple to understand.

That means saturation is a function of depth, location of the water table and the material properties, clear. So the first interaction, which is going to occur because of the disposal of the waste, is the waste is going to interact with the soils, which are partially saturated. This could be dry also. It could be saturation 75% also. So this is also partially saturated, but not fully saturated. Then comes the water table. This is the aquifer which I have shown.

Mostly, the aquifers are fractured rock mass, highly porous systems, so that they can store freshwater in them. Now, this activity does not remain confined up to the upper layer of the soils, and it might migrate into the second layer of the soil mass also, which is submerged and saturated, clear. However, there is a possibility that if the first zone is the extremely thick, very high large extent in-depth and if the soil is of a certain type, that it acts as a barrier.

We use the term attenuator, attenuation, clear. So if this soil mass has the properties of attenuating the waste components, retarding them, stopping their migration, chemically the soils are so active that they will not let contaminants to migrate from one point to another point to another point to another point, and they sorb everything and hence the intensity of the waste reduces from top to bottom, clear. I have used a lot of technical words here.

So the way I was describing this layer is if this layer of the soil is quite deep or it contains the minerals, which are hyperactive, whose sorption capacity is very high, clear. Under those circumstances, this waste will not encounter the second layer. These types of systems could be naturally existing or these type of systems can be engineered. Is this fine? So this is what the engineering is. Technology application is as far as the waste containments are concerned.

The recent name, which is given to this type of professional activities is waste mechanics. So you will find, if you check it on net, there are several schools, you know in the western world, which offer a full course on waste mechanics. They do not offer a course on soil mechanics, rock mechanics only. They offer a full course on waste mechanics. Because I have used a lot of words, technical words and each of these words is so intricate, it requires several hours to discuss, to understand and to assimilate.

And that is what actually we are trying to study now. Is this part clear? Have you understood this? So there is layer number 1. This also answers your question, somebody was saying, it can be dumped. So you were saying that there are pits; I can drop something over there and my objection was nobody is going to allow you to prove this right now. You know, why, because now we have certain amount of knowledge and this knowledge is in practice and there are rules and regulations, which will forbid you to do all these type of activities, clear.

So then, we talk about the engineered systems, engineered landfills, sanitary landfills, and so on. We will discuss all these things. Is it okay? Now, look at the second situation. "Professor - student conversation starts" In my home also, there is a pit and waste are dumped there. So I was just thinking, what can I do? So all these places are culprit, accumulated, you know, whatever percolations are occurring, ultimately this becomes a huge effect, that is it. "Professor - student conversation starts."

So each and every leaking pond, the storage area is a culprit, knowingly, unknowingly, ignorance, whatever. We have talked over all these things, clear, in yesterday lecture. So look at this situation, now this is saturated material, saturated geomaterial and there is an interaction of

the waste with the saturated soils with a flow of water, ultimately this hits the fractured rock mass, because this happens to be an aquifer.

By virtue of fractures, what will happen? All these activities will enter into the aquifer. The most vulnerable situation would be when the intake wells also get affected because of the activity of the waste, which is being discharged, because this is what you are directly going to consume. So this is what the whole system is right now and what we are supposed to do is, we are supposed to deal with this situation. Dealing with the situation is a very good term, do you understand?

You just deal with the person and let me know how to handle or how to come out of the situation. I have also shown a beautiful tree here and what I am trying to show you is that the roots are getting affected. So because you have read the editorial, which I wrote, I hope you can understand. This is a new branch of geotechnical engineering, which is evolving in today's world, where we talk about root, soil, bacteria, atmosphere, interaction.

Huge R&D is being done, because everybody is ultimately bothered about sustenance, clear, and these types of situations are occurring everywhere. So the chances are that whatever commodities you are consuming, they are adulterated, fish, meat, vegetables, everything. Now if you read the papers, you realize that those who are vegetarian versus non-vegetarian, all that discussion is going on.

They have data that most of your water bodies are adulterated. They have never been treated, and then you are consuming creatures, which are part of those water bodies, so there is a diffusion from the skin and arsenic getting accumulated, mercury getting accumulated, god knows. From the environmental monitoring and assessment, there is a big journal of Elsevier. Most of the papers are related to this only. If you get time, please go through.

There are 100s of papers. All over the world, people are working on it obviously. Anyway, so this is the situation, which describes the scope of environmental geomechanics very well. So challenges are quite enormous. Dupuit's theory, all of you have studied. If I give you a problem,

there is a well, and you find out what is the discharge everybody can solve. Now, what has happened? The more and more industrialization, the more and more waste being discharged.

The more and more environment interacting with this type of waste and this type of situation getting created, apply your Dupuit's theory, a big question mark. Why? We have ignored the influence of this extra activity on the soil very conveniently. The chances are that this material could be so aggressive; it may eat up the entire soil mass. The soil mass has a lot of organic matter in it.

That means, rather than having a compacted dense soil, I would be having a lot of whites over there. The soil mass, which has been eaten up the contaminants, chemicals, agreed. There might be some chemical reaction, which is going on in the system when it comes in contact with the moisture in the soil. There might be bacteria associated with this. Look at this; this is not only the chemical activity, which is flowing from one point to another point.

Just now I said that the ponds or the lagoons where they store the industrial waste might be leaking. So what about the sewage disposal lagoons or the ponds, you know, the sewage water is percolating in the ground, and sewage water is going to carry along with it pathogens, bacteria, microbes, clear. So in the process, the entire thing is also migrating and which knowingly, unknowingly we are consuming.

So when we talk about contaminant transport, the domain has become very, very big. Is the chemical species present in the contaminants? It is a radioactive species, which is present in the contaminant, it is a temperature at which the waste is being dumped. It is a microbial activity, pathogenic activity, clear, fungal activity, which might be present over there and put together, I want to see what is the contaminant transport from one point to another point, is this okay?

Then comes uptake capacities of the plants. So meaning thereby, you require a lot of information about each and every aspect of this picture, which I have depicted in a very, very simple manner. Hydraulics is involved. Geochemistry is involved. Pathology is involved. Agriculture science is

required. Soil science is required, and so on. Climate science is required. We will be talking about this also. So let me ask you a question.

Do you have tools by which we can answer, what is going to happen, when, where, why, how?. So, this funda is correct that every case is independent, isolated, clear. You cannot journalize anything, very nice. What is the impact of this activity on this house, environmental impact assessment? What is the activity going to do to the water, which I am going to take out for my agriculture, for my drinking and so on?

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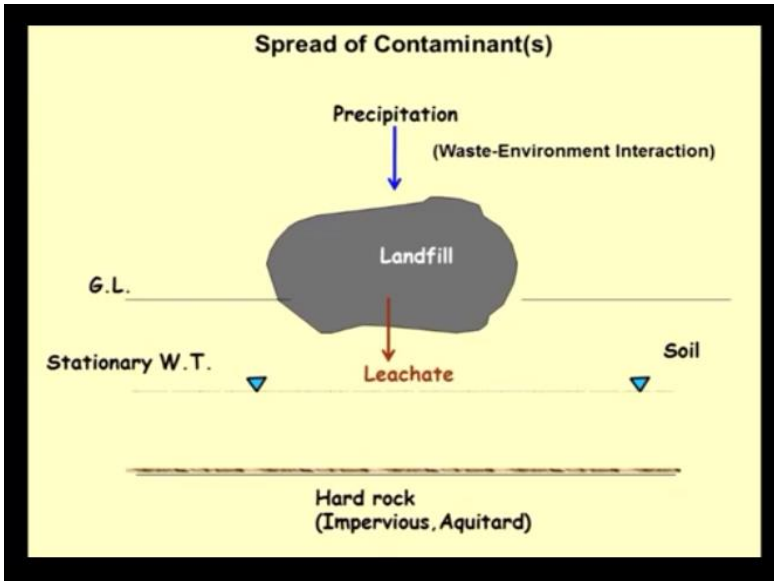

Now I am starting maybe a bit of modelling of these situations. Until now, I have been speaking only. So now from there, I have created a case, as he said and now, we are going to quantify a bit more of whatever we have said until now. So, take the example of a landfill. This could be municipal solid waste landfill. It could be an industrial waste landfill, alright. It could be a toxic waste landfill also. The only thing is the type of engineering, which is done is different.

I hope you agree that landfills sometimes are sitting on the ground, and sometimes they go deep inside the ground depending upon the bearing capacity of the strata, agree. Which one you will prefer, above the ground landfills or beneath the ground landfills. On the ground, on grounds means what? Have you designed the landfills for that bearing? Where is the answer? Why are they failing? Bhalswa landfill, Times of India front page, so when you people died.

This happened, that happened, why, alright. So what is the answer? Should we go deep down? Should we remain on the ground? Should we go above the ground? Not easy questions to answer. So one thing you have to learn today onwards is answers cannot be given so easily. Do you agree? You have to treat each case as a case in isolation. You have to study, and that is where the science, technology, intuition, understanding of the subject concepts.

So right now, this is a simple bearing capacity problem, settlement problem, agreed. Most of the landfills are in the marshy lands. The lands which are not used earlier for rehabilitation, obscure places in the cities. Within the due course of time, what has happened? Cities have spread so much that landfills have become a part of the city now. A beautiful example is Kanjurmarg, our landfill. Now, what has happened? Kanjurmarg is right in the middle of the city.

The CG of the city is changed these days, clear. The geography is also changed. Nothing is stagnant. Earlier days, there was a time that you see the atlas of the country and atlas used to remain fixed for 50 years, no more, 3, 4 days what has happened. The geography of India has got changed, agreed. So things are changing so rapidly. You cannot choose the same concepts what were being used 20, 10 years back. Everything is changing, very fast, very rapid electronic age.

This is the age of knowledge. So let us come back to the situation. So landfills, a big question mark is, what should I do? Should I go above the ground, beneath the ground? So beneath 53 meters, above 53 meters, which is the better way? Why you have so many problems, fire, instability of the landfill, stacking of the waste, compacting it, rainwater and these landfills are in acres of land, 100 acres, 150 acres, start doing one interesting exercise henceforth.

Whenever you are not enjoying life, go to Google and just keeping on zooming, each and every corner of the country. Learn what is happening in the country. Courtesy Google, you can right be there at the spot where you want to be. I hope you understand this. Try to understand what is happening. So he comes from a certain city, you just keep on zooming, zooming, zooming and go up to that place and see what is happening.

This is the best way to learn what is happening in our country, alright. So, question number 1, bearing capacity, settlements, these are the attributes associated with the soils. Now, what dimension is added to this? I said there is a landfill getting generated over there and I want the integrity of the landfill. This is a different material than soil. It is going to decompose over a period of time. A lot of gas is going to get entrapped in this. It might catch fire.

It may become unstable due to high temperatures, vapour pressures, gas pressures. It might explode even. So whatever you have done until now, the shear strength stability analysis of the slopes cannot be used, why? The material is different. The type of parameter which are going to influence the stability of the slopes is totally different. Have you understood this or not? Your C and phi vanishes, both underground as well as for the waste, which you are dumping over there.

Why? Because the system has become a reactor, is getting exposed to temperatures, pressures, microbial activities, disintegration, and so on. Unfortunately, we never talked about these things in a conventional subject. There the material never disintegrated. The material properties always remain intact, which in nature never going to happen, agreed. So, a very big question mark, how to deal with these type of situations?

Now, this is the precipitation does, environment elements, elements of the environment, water, rainwater, clear. So rainwater penetrates to the landfills, this is waste environment interaction. Until now, you might have heard about soil structure interaction only. Soil water interaction only, clear, when you design dams, seepage theory. Solid structure interaction, the pressures, the settlements, the stressors which are acting at the base of the foundation, which you have talked about.

Now, these are different situations. There is where I am talking about the waste environment interaction. How the waste is going to interact with the environment, and I have defined these attributes some time back. So all your environmental agencies are going to alter the properties of the geomaterials, which were naturally occurring or which are manmade. So naturally occurring geomaterials are the soils and rocks and manmade geomaterials are the ones, which I have stacked over there.

Why geomaterials, everything has come out of the geos. What are geos? Earth, so all industrial byproducts are coming out of the mining, processing, stacking. Their linkage is from the earth. So, we have talked about two situations, geomaterials, manmade and natural and all of them are getting influenced because of the environmental. This is a big question, how to study waste environment interaction because once you can quantify this interaction, a substantial amount of the job is done.

Simple seepage test, which you are doing by conducting constant head and falling head test was a good example of soil interacting with water, agreed and you did seepage analysis. Now suppose if I say this water contains chemicals, inert chemicals, sodium chloride, potassium chloride, seawater. Suppose if I do the same test by changing the percolate that is water by seawater and if I ask you to do the analysis and give me the hydraulic conductivity, what is going to happen?

What has changed? So density got changed. The second thing is the seawater has different attributes. It has a lot of chemical activities in it. So those chemicals are going to react with the soil, the interaction starts. I will add further complications to this. I will say the seawater is at elevated temperature. So now you have chemical activity and temperatures also associated with this and then if I ask you, find out the hydraulic conductivity of the soil mass.

Now the question is that, what is the concentration of the chemical species, which is present in the sea water and what is the temperature range you are talking about? We never asked these questions earlier. For us, the system was so strong that nothing is going to alter this, but look; now we are asking several questions. So, the simple question is, an industry which is passing out the effluents, discharging the effluents at what temperature, it should be showing the affluence in the geo-environment.

Is there a rule, regulation on this? Otherwise, what is going to happen? The water from the industry, which was used for running the turbines, is being discharged in the sea. Who is going to get affected maximum, the marine life, aquatic life? I hope all of you are aware of this. So these

things make a lot of sense. So everywhere there is a question mark, alright. Hope you have understood, what are waste environment interaction and the waste mechanics.

So in the process, what happens is that leachates come out, which we were discussing some time back. So leachates are the species of contaminants, which are present in a waste matrix, alright. When the waste comes in contact with water, this matrix yields the substantial amount of the; I do not want to use the word, contaminants here. A substantial amount of the unwanted attributes of the waste get washed out, and that is what the leachate is. It could be in colour.

It could be an odor, it could be chemicals, it could be radioactivity, it could be fluids at very high temperatures, alright, and so on. Now, this is what is going to be a couple of phenomena. What is coupled here, what is the meaning of the word couple? A couple means something which is interlinked with something or in association with something. So, when I have used so many attributes, the chances are that everything might be coupled with each other.

High toxicity associated with high temperature associated with the fluid phase, and in fluids, we may have liquids and gasses both, which are coming out of the landfills and then if I ask you a question, find out what is the hydraulic conductivity of the soil, when this leachate migrates through it. That is what we were discussing 5 minutes back. This becomes an interesting problem, real-life problem, rather than only water passing through the soil mass, which is never going to happen in nature ever.

And your wish, if you want to make it more complicated, you say the leachates are also carrying microbial activity in them, and these microbes are not going to sit silent over there, because they get a lot of nutrition. So they are free to do their own dynamics, is this okay. Give me an answer to this, and this is what environmental geomechanics are doing.