Environmental Geomechanics
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Lecture – 14
Soil – Water – Environment Interaction - I

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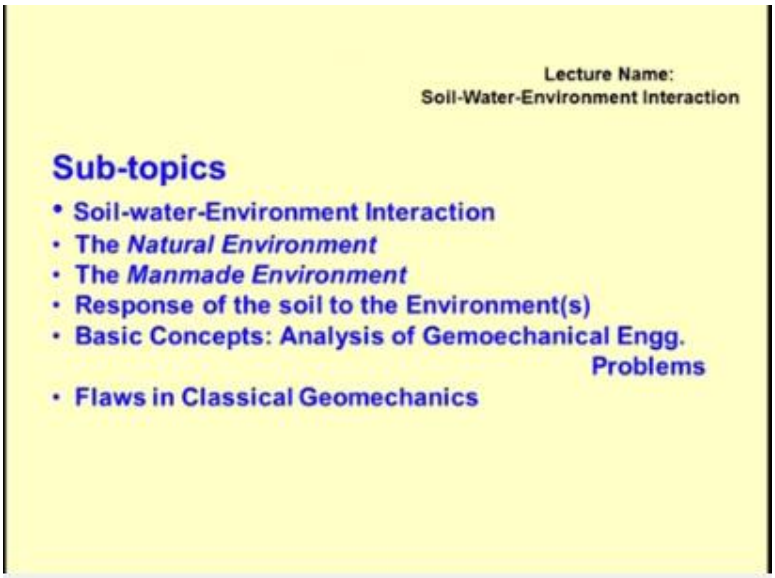

Having discussed lot of things regarding environmental geomechanics now, this is the time to start formally the concepts which are picking up in this domain, and I will start a discussion on soil water environment interaction, this is a very contemporary topic which is being studied by a lot of people all over the world until now, you have discussed mostly soil water interaction in your undergraduate course.

Remember, whatever experiments you are done, you have created an interaction between soil and water, starting from the hydrometer test where you allowed water to interact with the soil, and then you try to analyze how this interaction occurs and how the settlement of the grains of the soil takes place. A beautiful example of soil-water interaction is the Atterberg limits.

When soil comes in contact with water whether it loses its shear strength or not, is a very interesting philosophy similarly, the plastic limit, shrinkage limit indirectly these are the philosophies which deal with the interaction of soils with water and then we have

hypothesized liquid limit, plastic limit, shrinking limit and so on to characterize the soil in a better manner. Similarly, compaction characteristics, how soil and water when they react with each other, interact with each other.

And when external stresses, the impact loading comes on them and what happens, when the material gets compacted is another interesting example of how compaction characteristics can be utilized to define soil-water interaction. So, if you look at the compaction curve on the y-axis, we plot γ_d though we have added water, but mathematically, we have filtered out the water to convert it into γ_d.

And we plot γ_d with respect to moisture content; it is also an excellent example of how soil water interaction occurs. Consolidation is another interesting example, where soils are saturated and then you are interested in knowing how the pore pressure develops when the soil in the saturated state is externally loaded, and of course, the shear strength theory which all of you are aware of dry soils would not have much strength.

Of course, you can have shear strength provided their OC materials over consolidated materials, now what I am going to do is I am going to superimpose on soil-water interaction, the influence of environment and you must have realized the way I have defined environment is, or the attributes of the environment are nature mostly, solar cycle, humidity, temperature, pressure different type of environmental conditions which can be replicated.

So, now we want to study how soil water environment interaction occurs, and this is more comprehensive as compared to the soil water interaction which you have studied until now. So, with this in view, we need to deal with the first of all the definition of soil-water interaction, environment interaction, the natural environment, all of you are aware of this how human activities have modified this to the man-made environment.

We will try to understand what are the components of these 2. Of course, what is the response of the soil to the environment, different types of environments, elevated temperatures, high pressures, low pressures, low temperatures, different types of chemicals coming in contact with the soil in a saturated dry or a semi saturated form and so on. Then, of course, we will be talking about the basic concepts analysis of geomechanics problems, how geomechanics; conventional geomechanics deals with the issues.

What are the basic concepts and after having done all these things, we will bulldoze the conventional geomechanics, so we will find out what are the flaws in conventional classical geomechanics which have to be rectified if we want to study soil water environment interaction in a better manner? I hope by this time must have been clear to you that the conventional subject is not very, complete.

There are a lot of loopholes, and I have been specifying and trying to highlight this concept until now so that you assimilate this thought.

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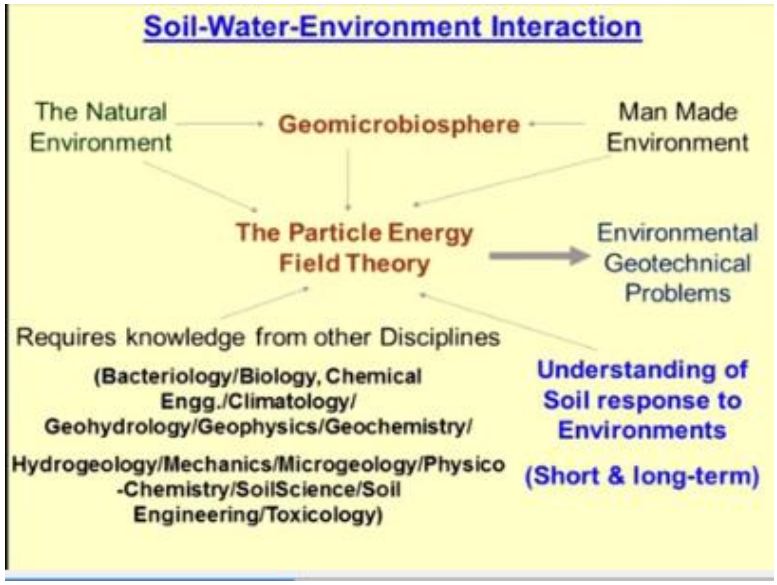

So, let us start with this now, this is the matrix which I would like to share with you that what is the genesis of soil water environment interaction. So, on the one hand, we have the natural environment, and on the other hand, we have the man-made environment, and both of these are influencing the geo micro biosphere, if you remember some time back I had used this word geo micro biosphere which is the complete sphere, the sustenance occurs in this.

Geo is something which comes out of the ground, and the micro biosphere is the one which constitutes most of the processes or most of the mechanisms of the soil mass itself so, if you remember the weathering process of the soils itself could be microbial, alright and so this is a genesis of the material. Now, what we are trying to understand is how natural environment and man-made environment influence the geo micro biosphere.

And to quantify this concept because until now, I think we have spoken a lot; everything was abstract, we have not used any sort of a hypothesis or a theory, people have proposed the particle energy field theory and the pronunciator of this theory was professor H. Y. Fang who has considered the geomaterial the particle which is sitting in an energy field alright.

So, for a quick example, I am sure you must have realized, how a charge sitting inside a parallel plate capacitor behaves, you must have heard in your 10+2 physics, for that matter even in an x-ray cathode tube, the x-ray beams are travelling, and then you have electromagnetic force or electromagnetic field, and you have electric field and magnetic field, so this is the electromagnetic field.

And then you want to find out what is the path traversed by the electron alright, this is a beautiful example so similarly, this concept we will now extend to the soils or the geomaterials, this could be rocks, this could be soils, this could be groundwater, and we want to see what is an influence of different types of energy fields and energy fields are going to depict environment alright.

And the whole idea is that we would like to use this concept to solve the problems of the environmental geotechnical engineering or geoenvironmental issues, which are bothering society. Now, if you want to deal with this theory basically, we have to understand the response of the geomaterials in 2 forms; one is the short term or another one is the long term so, most of the practices of conventional geomechanics were short term.

The consolidation also was completed within few days but suppose, if I want to study in a prolonged manner what is happening after let us say, 1 year of testing of the soil sample in a falling head permeameter, alright and particularly, when the permeant; permeant means the fluid which is passing through the soils is not pure water, it might be having contaminants.

And if you remember the attributes of the contaminant which we have defined are elevated temperature, very high concentration of chemicals, very high radioactivity, microbial activity, it could be charged also, electrical charges so, all these things constitute to the contaminant. So, imagine a fluid which is having all these attributes is now passing through the porous media, and I want to understand the short term and long-term behaviour of the permeation.

So, I am sure now with this concept, and whatever background I have given to you, you can realize this is going to be a very intricate subject to study. So, the challenge is how to model the behaviour in the short term and long term to, by using the particle energy field theory to get the solutions to the problems which we are talking about. Now, it so happens that when you are dealing with this particle energy field theory, you will realize that the background from different subjects is required.

You must have got a feel of this, the way I have been discussing, it is a multidisciplinary subject alright, it is not confined to a particular stream as such so, to my knowledge when you deal with particle energy field theory, the knowledge of bacteriology; we were talking about how bacteria migrate from one place to another place in the porous media.

And just now I gave you an idea that the fluid which is passing through the porous media in a falling head testing device might be containing pathogens, might be containing bacteria might be containing microbes whatever so, I want to see how the concentration in the microbes is changing in the porous system with respect to time and with respect to the distance, alright.

So, bacteriology, biology, chemical engineering, climatology, geohydrology, geophysics, geochemistry, hydrogeology, mechanics, of course, you cannot be forgotten, micro geology, physico chemistry and soil sciences and soil engineering and toxicology, so these are the subjects which have to be dealt with when you are talking about the application of particle energy field theory.

So, this is what explains or with this what I am trying to do is; I am just trying to set the tone for the discussion on soil water environment interaction.

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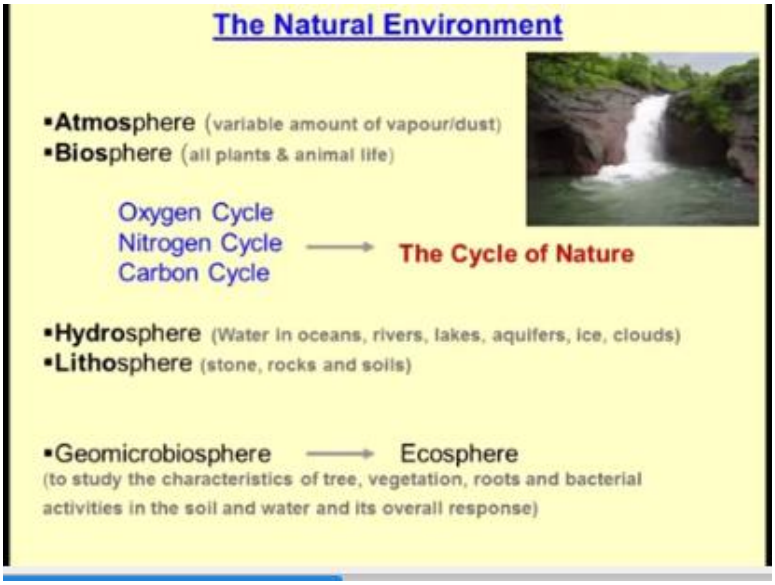

If you try to understand what is meant by the natural environment, I think we can define it easily whatever nature had given us beautiful, a stream of water, if you go about 10, 20, 40 kilometres away from Bombay city, you will find very serene environment particularly, when it rains it looks so beautiful and so this type of serenity is getting lost alright.

Because of the whatever genesis we have talked about of the environmental geomechanics now, this is what we say the atmosphere, so atoms, Atmos, it is the vapours or the dust, atmosphere consist of the vapours and the dust, and we talk about the biosphere, so biosphere is the one in which flora and fauna survive, and this survives because of the oxygen, nitrogen and carbon cycle.

And these cycles are basically, the cycle of nature, you must have studied in your 10, +2, I just remind you, so then we talk about the hydrosphere; hydro is water and the water is present in different forms, and these forms are it could be in the oceans, it could be in the lakes, it could be in the aquifers, it could be in the form of the ice, or it could be in the form of the clouds.

So, if you remember we have talked about all these things; frozen state geomechanics deals with the water in different states, in the geomaterials. We talk about the lithosphere; lithos is the stone alright so, we talk about stones, rocks, soils and hence the natural environment consists of atmosphere, biosphere, hydrosphere, lithosphere and geo micro biosphere.

So, what is geo micro biosphere? This is basically, ecosphere which consists of the entire thing. Now, what we would like to do is; this is something which is of interest to the climatologist, those who talk about the climate sensors. Now, we are more interested in starting from this as a benchmark what has happened because of industrialization, because of overpopulation, because of land scarcity, because of the resource scarcity and so on.

We would like to understand first what the natural components are, what are the components of the natural environment and then we will try to see how these natural components have got shifted or changed because of the present-day civilization. So, geo micro biosphere or ecosphere talks about the trees, vegetation, roots, bacterial activities in the soils and water and overall response.

So, sometime back I was citing here that the contemporary geomechanics deals with soil, root zone, microbes, environment interaction so, if you have studied this editorial which I wrote you must have realized that this is where the more emphasis is right now, and people are trying to understand how vegetation can be utilized for stabilization of the slopes alright, these are bio-inspired geotechnical engineering practices.

So, if roots can stabilize the soil and if the soil cover stabilizes the slope, can I use this concept to do reverse engineering or bioengineering to make the system stable.

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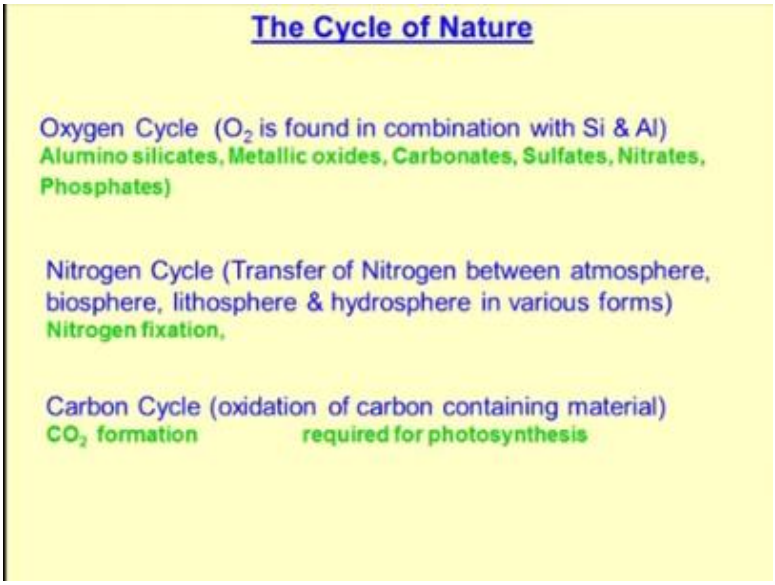

So, coming to the man-made environment, what human activities have done sorry, before that I will discuss the cycle of nature which I am sure you must be aware of; oxygen cycle is

something which is the genesis of the oxides, which are present in the soils or for that matter in any matter. So, most of the time as a geotechnologist, we are interested in oxides of silica and alumina and iron and magnesium and sodium and potassium and so on.

And this is what is analyzed by using XRD analysis; I will talk about the x-ray diffraction analysis, so most of the silicates, aluminates, metallic oxides, carbonates, sulphates, nitrates and phosphates which we are using these days in the name of fertilizers or discharges which are coming out of the industries are a good example of oxygen cycle, alright.

So, these materials or the metals got oxygenated, oxidized and hence these oxides are formed. The second thing is the nitrogen cycle, so nitrogen is also an element which is useful for the survival of flora and fauna, so this is how we talk about the transfer of nitrogen between the atmosphere, biosphere, lithosphere and hydrosphere in different forms, alright. So, we use the examples of nitrogen fixation alright.

You must have talked about eutrophication of the lakes and the water bodies, then comes the carbon cycle, so oxidation of the carbon which is present in the material, so carbon dioxide formation and this requires photosynthesis, so this is the natural cycle. I hope you can realize that as a geotechnologist, environmental geotechnologist, we try to utilize these cycles in a better manner, alright.

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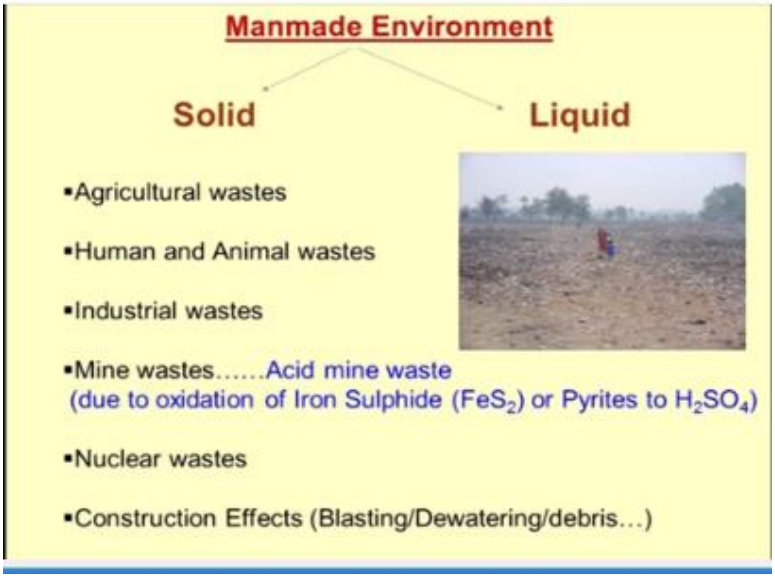

Just as a refresher, I thought I will just discuss these things with you now, if you take the man-made environment, this is quite alarming. So, first of all, this is the picture a dire

contrast against what I showed to you some time back, litter, litter everywhere and this is how most of the cities can be defined right now, in the heart of the cities, you will have landfills and landfills are the place where the people survive and so on.

So, what are the components of the man-made environment you normally, talk about the solid phase and the liquid phase alright, gaseous phase as I said we normally, do not consider in our subject and this is something which we live for the environmental scientists or maybe the second logic could be whatever goes in the gaseous phase will come back, once the precipitation occurs, not a bad idea.

So, this is the list of man-made environment, we have different types of agricultural waste, agriculture was supposed to be a very neat and clean activity but no more because of the dumping of a lot of manure or the fertilizers, we are over-fertilizing the land, we discussed this some time back, and what are the social consequences alright, this is shown very well depicted in some of the movies that nobody is interested in agricultural practices.

And hence what is happening in this whole, here is a disorder in the society, so any type of agricultural remains create man-made environment, human and animal waste I think I gave you ample examples of biosolids, the sludges which are coming out of different treatment plants, water treatment plant, sludge treatment plant and I think I cited these examples that the big question is if you do not clean up your lagoons or the septic tanks or the water holding ponds or sewage holding ponds, you cannot sustain the processes, sustain the society.

So, sewage has to be treated, water has to be treated, and these are the places where the sediments which get deposited in the lagoons or in the ponds have pathogenic activity, microbial activity, bacterial activity alright. So, the question is if I have to clean up these lagoon's or the ponds, how and where I should dispose of the sediments? So, this becomes a man-made system.

I think, I cited one example and one of my PhD scholars also worked on this topic, Dr. Susmita Sharma, she is presently a faculty member at NIT Meghalaya, so we coined this term as SEGS; socio-economically generated sediments alright, something interesting which flashed in our mind, then let us talk about SEGS; SEGS that is socio-economically generated sediments.

So, every country because of its social-economic condition produces the sediments, clear and now the big question is where to dispose then. Similarly, another example would be biosolids so, biosolids see, again the question is they are pathogenic in a; so another issue is the biosolids where you are going to dispose them, how you are going to handle, so I think I asked you to search on the Google also what is being done with the biosolids particularly in countries like Australia and India, we do not have any clues.

And again, these are the sediments which are to be handled by geotechnical engineers, environmental geotechnologies. **"Professor – student conversation starts"** like, if you go to an STP like today sir, they have like all the facilities to treat the sludge and these biosolids, they make like anaerobic, like anaerobic processes they do to dewater the sludge, and then they make cakes out of it and sell it to people that I have.

Everything is confined to the books; the fact is this and the treatment also; aerobic, the anaerobic treatment also requires time, do you think that in our society we have so much time to wait for anything to happen, imagine the tons and the millions of tons of the discharge which is being done every hour alright. So, the ground realities are different; you should; if you are very serious, you should be looking on the net what is happening with these materials.

And why they are becoming a big issue, so animal waste is also becoming a very big problem particularly, related to the agricultural sectors particularly, the animal Karakas after they die what to do with the dead bodies in flash floods particularly, there was a situation like this which happened in Bombay a few years back, I hope you are aware of this, and then the biggest issue was that the lot of animals died and what to do with their Karakas.

"Professor – student conversation ends" then, of course, industrial waste which will be handled separately because this is beyond imagination and the volumes are so big that cannot be discussing just as passing remarks so, we will be talking about this separately. Mine waste; you must have heard about the acid mine drainage.

So, the acids which come out of the coal mines and the type of hazard which it creates and the reason is known that most of the time the coal has FeS_2, iron sulphide and this gets

converted to H_2SO_4 or this could be pyrite also so, these 2 things might get converted into acids and these acids drain out and they form draining; acid draining mines, a big problem, you cannot leave the mines unattended.

"Professor – student conversation starts" Is it possible to collect it and commercially used that sir, well, you can, but the biggest question is most of these mines are in remote areas, so that is what the first question is whether people like you should be going there or not, where the most of the mining is being done in Kokrajhar district of Assam so the volumes of the acids which are getting discharged, how would you pack them.

And concentration is a big question and then purity, then the question is somebody has to run an industry to maybe create concentrated acids and then use them, but again the purity is going to be a big question alright, your idea is good, so maybe you can think of some start-up, and you try to convert acid mine drains into acids, it can be of some commercial application. **"Professor – student conversation ends."**

But we are trying to do is; we are trying to marry the acids which come out of the mines, and we want to neutralize some industrial waste by using this concept. Then comes the nuclear waste of different types, I think we have discussed a lot about this, and I will not touch upon this now much more.

Because except for citing some examples what has been done by us in the past and to show how guidelines can be developed by scientists to safeguard the geoenvironment against radionuclides impregnation and of course, the construction effects; blasting, when you do a lot of destruction occurs, tremors, micro tremors that produced you do dewatering for different projects.

And the construction and demolition debris are a huge issue, what to do with this, a city like Bombay how many multi-story buildings we will be having and what is the life of the concrete in a city like Bombay because of heavy chloride impregnation, so this is the corrosivity of the concrete which I am referring to, and every 15^{th} year the building requires refurbishing.

So, the volumes of C&D waste which you are creating or got forbid if an earthquake comes and if buildings get uprooted alright. So, how to handle the C&D waste, it is a very big question now, these are the issues which people never thought about earlier, but now I am sure that society is forcing here to think like this.