Environmental Geomechanics
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Lecture – 16
Soil – Water – Environment Interaction - III

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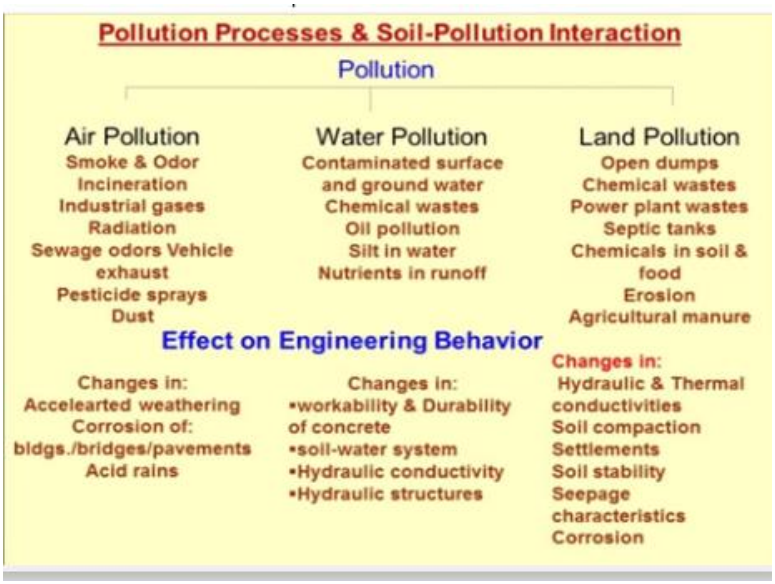

These are the different processes, pollution processes and soil pollution interaction so, pollution occurs in 3 ways or these are the 3 pathways; air pollution, water pollution, land pollution alright and when we talk about air pollution, this is the smoke and odour which is big issue incineration of solids will cause these industrial gases are a big issue, radiations are a big issue, sewage odours, vehicle exhausts are a big issue.

Pesticides sprays and dust is a big problem when we talk about the water pollution contaminated surface and groundwater, chemical waste, oil pollution, silt in water because of runoff, nutrients in runoff, there was the time in nutrient, nobody is talk about but now nutrient is also becoming a part of the geotechnical engineering because if you remember a good example would be C and Φ parameters depend largely on the nutritional capacity of the soils, cementing property.

And C parameter depends upon, different types of chemicals which are present in the soil, particularly carbonates and sometimes sulphates which are bonding the soil particles together.

Land pollution; we talk about dumps, chemical wastes, power plant waste, septic tanks you are talking about, chemicals in soils and food, erosion and agricultural manure.

Now, what is the effect of these type of pollutions on the engineering behaviour, when air pollution occurs we have accelerated weathering of either concrete or cement, we talk about the corrosion of the buildings, we talk about the bridges, pavements and acid rains recently, there were a lot of bridges which were failing which had failed in Calcutta, I hope you must have and if you see my report which was published by the local papers have made pollution as the main reason responsible for the collapse of the bridges poor maintenance of the bridges.

These are worth reading examples, so this is all the subject is involving earlier people used to say that these are only the strength of the concrete, the strength of the concrete is getting affected because of pollution ingress, if the water is polluted and if this water you are using for making concrete, then durability and workability of the concrete will change.

The soil water system is going to get influenced; hydraulic conductivity is going to be different and hydraulic structures get affected, an excellent example of acid mine drainage which you are talking about is; if the water has a non-neutral pH value, it is going to change the shear strength parameters of the soil, enough studies which are available in the literature particularly, for water happens to be acidic, what will happen to this calcium carbonate which was present in the soils as a binding agent.

So, the pH, which is less than 7, acidic water influences the cohesion of the soil and hence particle become erosion-prone and the more and more erosion occurs, there will be the first void, and later on, there could be a collapse. So, when you talk about land pollution, this is what explained just now because of the pollution of the soil, hydraulic and thermal conductivity is change.

This is the first time I am using the term thermal conductivity, and later on we will realize that why thermal conductivities are important because these are the fundamental behaviour how heat migrates through the system, soil compaction changes because of the presence of contaminant, settlement, stability, seepage characteristics, everything changes, this is a big matrix, how pollution changes the fundamental properties of the geomaterials.

And whether it is in the air pollution form, water pollution form or in the land pollution form, you are aware of most of these issues.

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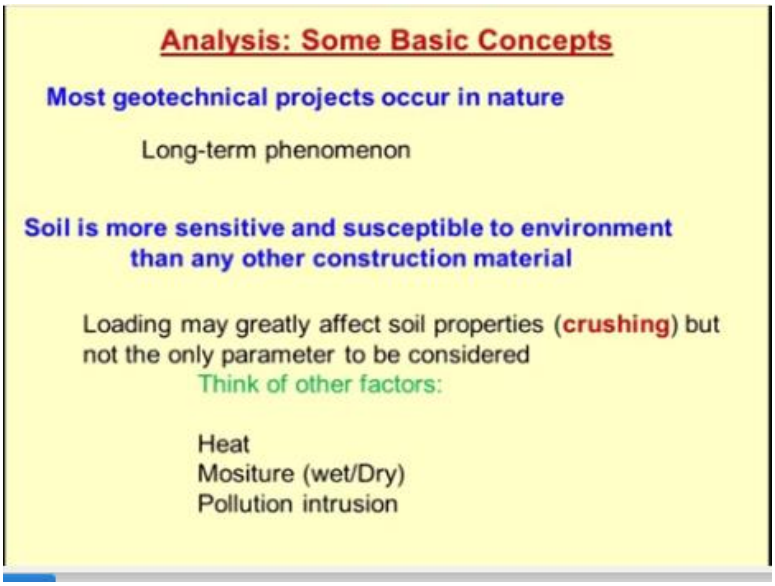

Now, let us hit at the conventional geomechanics alright because if you want to include all this discussion which I have been doing, we have to go into the micro details of what are the basic concepts of the analysis in geomechanics. So, the concept number 1 is that most of the structures in geotechnical engineering occur in nature alright, they are not shielded, so they are exposed to nature, sunlight, water, a different type of attacks of chemicals and so on.

And hence another concept is that the soil is susceptible to the environment as compared to other construction material. One good example is the presence of organic matter so, if organic matter is present during very high temperatures or low temperatures and humidity, this combination is going to be very critical. So, when systems are sitting in nature, we have to talk about long-term performance.

Experiment which you do in the laboratory for a few hours or few days is not going to give you a complete response, so this calls for long term testing and long term testing could be for few 10's of years, you will find data which is which runs of the experimental plant for few 10's of years or 100's of years even. The second one is the soil is more sensitive and hence what we should be doing?

We should be talking about various factors which are influencing its fundamental behaviour like a stress-strain relationship, crushing characteristics so, these factors have not been directly included, so I will be very eager to understand when soil comes in contact with elevated temperature, low temperatures how their elastic modulus changes, Poisson's ratio changes, how their constitutive laws change, the stress-strain relationships change and so on.

What is the influence of the moisture? So, when soils get exposed to high temperature, the moisture is going to change, and severe temperatures would also create the dry state of the material, so there is a loss of strength starting from saturated to dry to totally partially dry state whatever, so it is very important to study what moisture ingress does to the system.

And what moisture egress comes to the system and of course, the basic agenda is to see how pollution interacts with the geomaterials and what ultimately happens to it alright. So, these are the basic concepts which one has to understand of the analysis.

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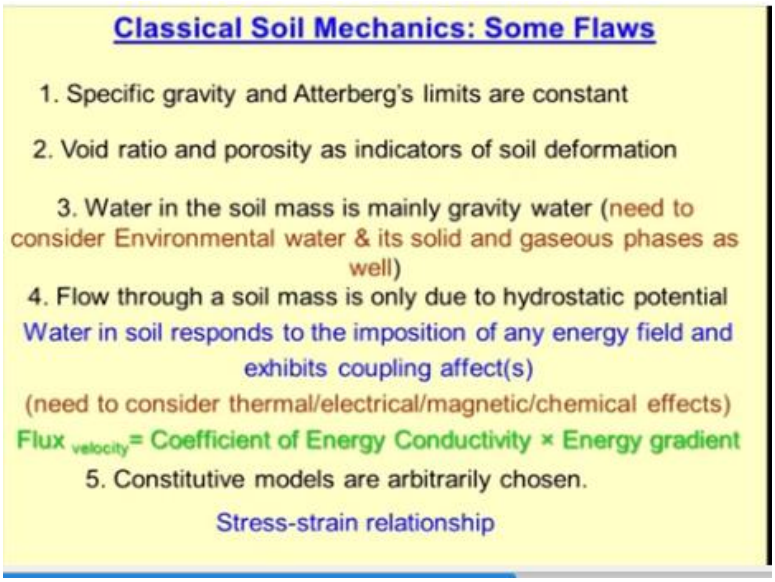

And then let us talk about what are the flaws in the conventional geomechanics and when I say flaws, why I am using the word flaws because the conventional geomechanics cannot take into account the issues which we have discussed until now, so now the time has come to understand the limitations and once you understand the limitations of the status of the subject, you try to go beyond this.

And you trying to complement this with your knowledge or with your experience, so now presently what happens is; I am sure you must have realized that specific gravity and

Atterberg's limits are always constant we assume, we never thought that the interaction is taking place and the material is changing, and hence specific gravity is changing.

It could be dissolution, it could be crystallization taking place in the soils of different types of chemicals or compounds, and hence special gravity does not remain constant alright and the second issue is that your Atterberg's limits will also change because if the water and its constituents change the Atterberg limits cannot remain constant, this is what has been overlooked.

Another thing is that we always treated the porous media as a standard porous media, we never bothered about the decay of the voids, we never talked about the decay of the material, we never talked about the up-gradation of the material through what bacteria does, I think you have cited ample examples where the bacteria eats of the soil mass and hence creates voids. So, void ratios are changing; porosity is changing; this does not remain constant.

And when the void ratios and porosities are changing, the shear strength is changing; compressibility is changing, consolidation characteristics are changing, everything is changing this is correct. Now, sometime back I gave you a hint in today's lecture that the way we have considered water in geomechanics, conventional geomechanics is not correct because the water cannot be only water; water is basically environmental water.

Because it is an attribute of the environment present in the system and this water could be in different forms, vapour form, stream formation so, when soil comes in contact with let us say high temperatures what happens; a certain fraction of the moisture which is present in the soil gets converted into vapours, and these vapours tend to migrate through the voids, clear, solidification of water, freeze and thaw cycle.

So, the water we have not dealt with properly, we have always talked about the free water, the gravity water in the present in the soil mass, you mix something which remains in the free form in the soil, and that is what we have dealt with, so contemporary geo mechanics deals with the bifurcation of the water which is present in the soils. There are techniques by which of course, very advanced techniques by which we can differentiate between 3, 4 types of water which is present in the soils.

And that is what we will deal with subsequently; now you must realize the subject is becoming slightly more intricate, is it not so, I am sure unless you like chemistry and the chemical processes which occur in a matter, you cannot deal with these type of issues because the water which was present in the pores at a certain temperature now gets converted into several phases of the water, it is a chemical process.

And this chemical process might trigger because of letting us say dumping of some industrial by-product on the soil mass, so there is a chemical species which might exhibit exothermic reaction. So, when it comes in contact with the water, the temperature gets enhanced, elevated, and this process might trigger the temperature in the soil mass, and this coupled phenomena method.

So, most of the time, the landfills and the waste which is being dumped in the landfills when suitable environmental conditions get created, they become reactors, sometimes explosion also occurs in landfills, why; the gas has got trapped inside and they blast alright or the temperatures of the landfills are so high, it is just like a furnace which you are designing which is going to be sitting on the surface of earth or ground, alright.

So, these are the intricate issues that you have to deal with as the environmental geotechnologist. We have a very simplified way of dealing with the flow of water, Darcy's law is it not, we just defined the hydrostatic potential which causes the flow of water to take place, now slowly and slowly you will realize that it is not the hydrostatic pressure which only causes the flow of water through the soil mass or the mass flux.

Soil water intrusion is a big example, whenever you are exposing the soils to an energy field that flux migrates because of the flux gradient, so we have ignored all other types of flux cells which the soils might get exposed except for one which is hydrostatic, you agree. So, now the time has come that we should be talking about the chemical flux, thermal flux, electrical flux, magnetic flux apart from the mechanical flux, which is $\Delta H/L = i$.

So, you have to now talk about the flux velocity as the coefficient of energy conductivity multiplied by the energy gradient. So, in Darcy's law energy gradient is I; $\Delta H/L$, coefficient of energy conductivity is the hydraulic conductivity k, and V is the velocity, alright, seepage

velocity. So, similarly, this influence of all the energy fields has to be taken into account for realistic situations.

I have not included here bacterial flux remembers because what bacteria does in the soil is a wonderful thing, it might create a lot of exciting and intriguing things, alright. Now, another thing is the constitutive models; constitutive models are stress-strain relationships, so I am sure you must have realized in 1, 2 and 3 are valid, the constitutive models cannot remain constant.

So, truly speaking sigma and epsilon and the coefficient which is balancing the 2 are all a function of time, is it not, so your constitutive models are going to change when these conditions get violated. So, stress-strain relationships are also going to change because the material has changed, you cannot use the same stress-strain relationships, so unfortunately in the conventional subject, there is no way to imbibe all these concepts.

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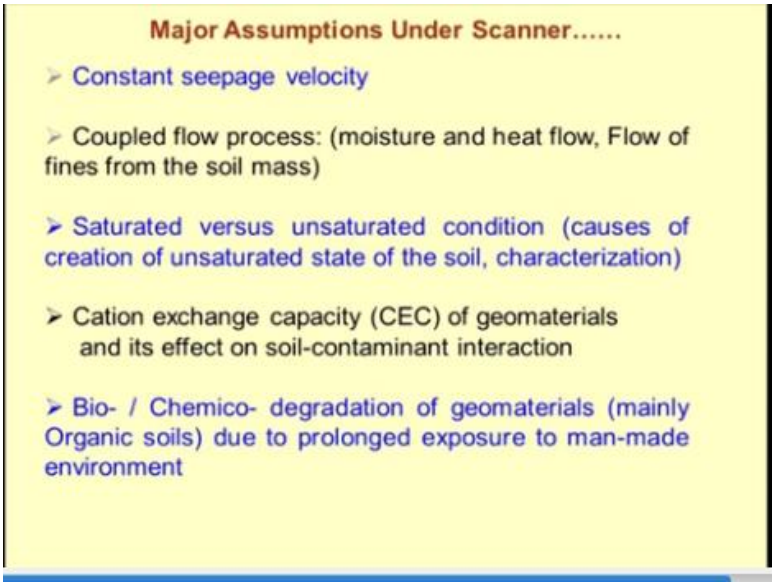

And hence you have to look for something interesting, some other issues which are under scanner, the constant seepage velocity when terzaghi geomechanics say that the velocity and hydraulic coefficient and the CV do not remain constant, coupled processes we have ignored completely because we have never talked about the heat and moisture flow together, we have not talked about the fines migrating out of the soils, this is the mass flux alright.

So, I gave you ample examples that acidulated water or water at a lower pH is detrimental to the health of soil mass be it embankment or whatever, so the chances are that the coupled

process may occur, the mass flux may take place or the energy flux method. Another good example would be let us say, the soils which are what do you call them as dispersive soils.

So, you must have come across double hydrometer test which is done on dispersive soils to get their particle size distribution, saturated versus unsaturated conditions alright, in the soil mass, this is a big subject where we talk about the unsaturated state of the soil mechanics, we have treated soils as inert, but soils are not inert, so this is what has to be depicted with the help of cation exchange capacity of the soils.

The mineralogy has to come in the picture how a certain mineral is going to behave with a certain cation or anion which is present in the soil mass and of course, the biochemical degradation of geomaterial which we have not talked about which is very, very important for the case when we are dealing with the soils and of course, everything which is time-dependent, so how this degradation and up-gradation is going to occur as the time goes up.

So, I am sure you must be realizing now, the environmental geomechanics a scope is quite tricky and very vast, the sky is the limit, whatever comes to our mind you can include it.

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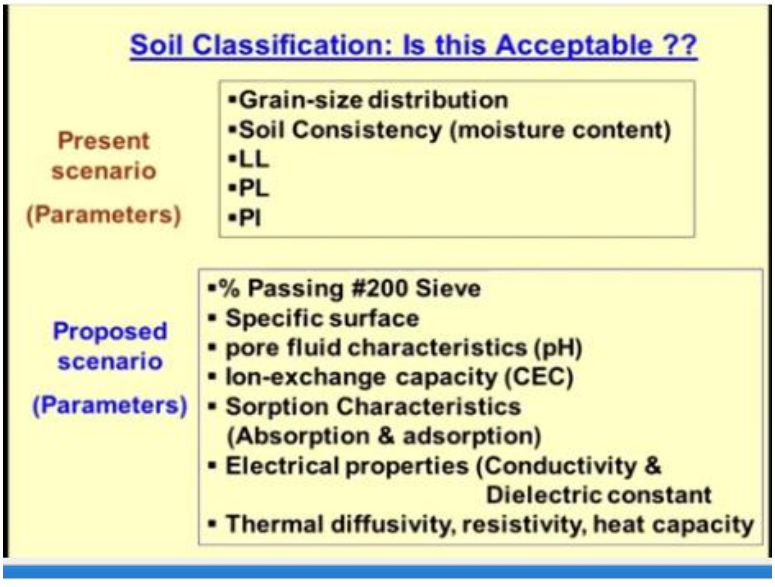

Now, the question is; whatever soil classification you are following whether it is acceptable or not so, presently what we do is we are including these parameters for classification of the soils, we talked about grain size distribution for coarse-grained materials, and we talked about the fine-grained materials the parameters like consistency limits, LL, PL, PI mostly and this is the guiding criteria for understanding the fundamental properties of soil.

The gross injustice with the material like soils which we have studied and used by this time so, the question is what should be the scenario, how many parameters we have to include to understand this material in a comprehensive manner and the answer comes from here; the physics of the material is passing through 200 number sieve, then if you want to quantify the physics of the material, then you have to talk about the specific surface area.

And the specific surface area I hope you understand is the total area divided by per unit weight of the material and then comes the pore fluid characteristic, the pH particularly of the soil, so chemistry part of the material, then ion exchange capacity, cation exchange capacity again, this is a chemistry of the material. So, physicochemical processes; these are the physical processes; these are the chemical processes.

How the interaction occurs with the environment is the sorption capacity, mind the spelling clearly, this is the sorption, and this sorption includes absorption and adsorption, so we will talk about these processes. So, one is a physical phenomena absorption, adsorption is a chemical process, and so on and then we have to talk about the electrical properties like conductivity and electric constant of the material.

Because conductivity itself is a function of dielectric constant and dielectric constant is mineral dependent, and this is a question which you are talking about, so truly speaking when you talk about the dielectric constant of the material, the magnetic properties get inbuilt in the system, alright and of course, thermal diffusivity, resistivity and heat capacity. So, if you include all these parameters, then only, we are doing justice.

Of course, you can always say that I have not taken into account the effect of radiations here and I have not taken into account the effect of biological processes here, so the more and more you add over here, the system becomes more and more comprehensive, so I am sure that you will realize that this subject is going to grow for several years. Today, I hope this must have given you a fair idea about why environmental geomechanics is a must in today's context.

"Professor – student conversation starts" Sir, why have you taken that 200μm only, that is a physical property just the crane size only in shape, like why 200μm, practice, yeah 475μm is equivalent to 200 sieve size, so this is nothing but the what is written in the literature, so 475μm is equal to 200 sieve size. **"Professor – student conversation ends".**