Environmental Geomechanics
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Lecture – 13
Soil: A Living Entity

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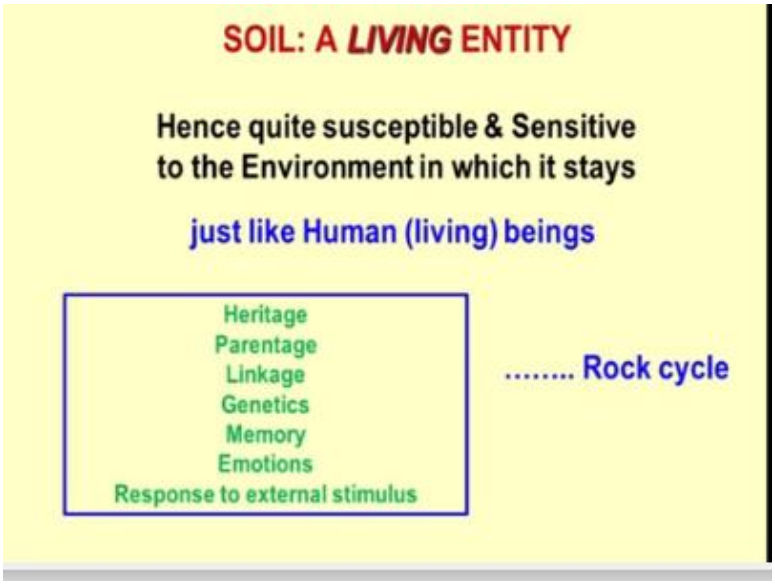

Today's discussion is now having discussed all these things; you must have realised that, soils are no more an inert material, they are not a dead material, lot of things are happening inside, the moment bacteria comes, it becomes a dynamic system, for human being beings we will say know, your career is a function of time and the place where you would be, will be in a different continent, after 2022, you will be flourishing or you will be doing something, clear.

Soils are also like that; I emphasised most of the time that the properties of science are a function of x, y, z and t and the best example I gave you, so truly speaking, science are living entities, they are not dead entities, we have treated them always like dead materials, so you bring soil from the lab from the field pulverise it, put in the oven 100℃, bake it, you have to remove a lot of things which were present and which contribute to the properties of the soils.

So, you filter them out for the sake of your convenience, so whatever practise of engineering you are doing is only partial, it is not full, so the soil is a living entity, and hence it is quite susceptible and sensitive to the environment in which stays. We call about; we talk about sensitive soils, is it not, we have given you; I have talked about several examples where how the environment is influencing the characteristics of the soils, you change the pressure-temperature conditions, depressurisation occurs something starts leaking out of it, human body, clear.

Emotions; something changes, something says something and look at this your pore pressure is starts dissipating through your eyes, so all similar. So, environmental influence is very, very important, we will talk about this, just like human and living beings, you know, and then, of course, I like saying this that there is a lot of heritage, parentage, linkage, genetics, memory, emotions and response to an external stimulus which we have to take into account.

If you want to do contemporary geomechanics, it is so unfortunate that most of the time we do not bother about all these things, for us soil is an inert material, it is not so, clear. So, now ultimately, this answer comes from the rock cycle, the way you are found, the way the soil was found. So, heritage; heritage, parentage is nothing but the way you are formed in which family you took birth; all the bank account goes in your name, clear by virtue of taking birth in that family.

Linkage; the linkage is between your parents' offsprings, rocks, soils, mineralogy is same, only the composition of the minerals is different because of the formation or the recreation of the soils. Genetics; we talk about genetics also, we talk about memory effect in geotechnical engineering, the statistics, loading, unloading, you know you do one loading, load versus sediment curve and reloaded, what happened; that point of over consolidation remains unique point, correct.

So, you do number of cycles of consolidation plate load test what happens; material remembers that it has behaved like NC, OC, again it becomes NC, so beyond this pressure, it has to behave like normally consolidated, clear, now this is the memory effect, it remains in the memory of the

material how it has to behave. Exposure to certain stresses and the material recognises it immediately; I should behave like normally consolidate, not like OC behaviour, is this correct.

Emotions; I just give an example of what emotions are, I will say something to you harsh, you start crying dissipation of emotions, clear. We have several examples; consolidation is a good example of this, we will talk about this. As the same time, I say something very good; you feel elated, joyous, face glows, emotions that will be reflected on your face, is it not? Swelling and shrinking behaviour would be one of this, and you can look at it like this.

Responses to an external stimulus that is what actually we are trying to study, so we are trying to create a matrix of all these traits which are similar to the human body, so for us, the environmental geomechanics, one of the important things is that we should treat this material as a living material, clear, we should not say that this is a bad material, there is no life in it, it is not so, leave marine clays for the certain time what do happen? They decay.

This question I asked in the very first lecture and you are trying to answer that despite the best possible sampling, despite the best possible testing, despite the best possible software's, which we can think of why our systems are failing; this is the answer now we are getting today, hope you remember the question, which we discussed sometime back, so everything is best possible; the best possible sampling, very understood sample you have taken, you got the best possible parameters clear, best possible computer course we are using to get the answers to questions.

But is still when the systems are in place they fail, why? Because the properties are time-dependent which you did not take into the account, they decay, they may become better; also, they get also upgraded, microbial activity, so this is the issue which we have completely ignored, but in real life, you will observe that these activities are playing a very, very important role unless you include them, things are not going to happen properly.

And that is what calls the new era geomechanics you know the environment, the soil is not going to interact with the pure water which we use in the laboratory, you are interested in solving the problem, where the landfill leachates are getting intruded into the foundations and they are trying

to heat up the foundations, clear. So, these are the situation which we have to study, is this part clear.

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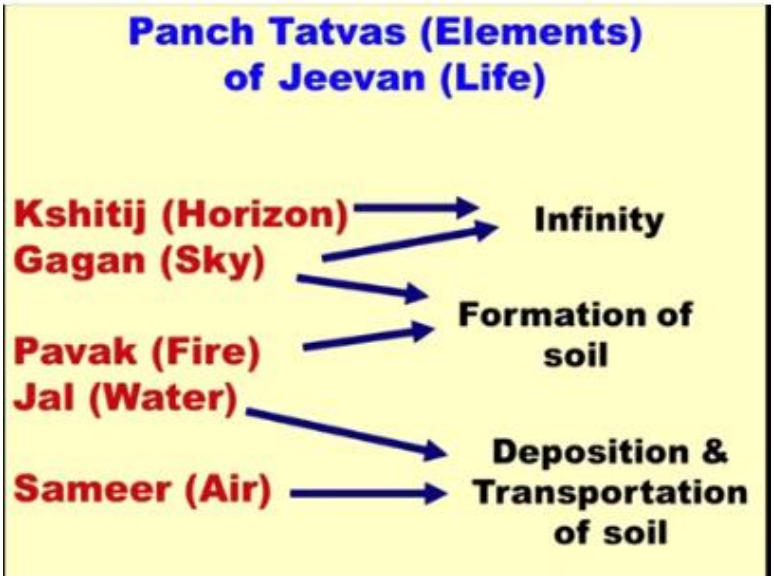

So, when we talk about all this, you know this thing I enjoy talking to my PG students, are you must have heard about Panchatantra's the 5 elements of life which we; which create the life in you language, you must be using different language and different terms to define this, so Panch Tatvas is the the elements and Jeevan is life's, so you know Kshitij, it is the horizon, Gagan is sky, Pavak is fire, Jal is water and Sameer is Air.

The interplay of all these 5 elements creates the entire geomechanics that is very interesting, is it not? When you are kids, you are taught all these things, when we have become professional, we have forgotten all these things, that is the only thing we are unable to handle the situation properly. So, what these first 2 elements do, any guess? Infinity, the first assumption in all your models is semi-infinite soil mass, whether it is Rankine, whether it is Boussinesq.

So, you have cut across the 2 the entire hemisphere; you said the bottom portion I am only interested in not the top portion which is the atmosphere environmental scientist would take care of, so you say semi-infinite, beneath the ground only you consider that is the domain in which you work. Horizon and sky; the sky is nothing but the environmental conditions; weathering conditions, you remember where they get deposited, horizons.

So, soils after disintegration after weathering, they get deposited somewhere, alright, now what happens with sky and fire? This is the formation of the soil; environmental conditions at elevated temperatures, the disintegration of the rocks, the formation of soil, clear and this formation of the soil is taking place in the semi-infinite domain. Now, if I consider water and air, these are the transportation agencies; deposition and transportation agencies.

So, I like this philosophy, now, if you start looking at the material with which you are dealing that is the soils and if you know the genesis of the material now, your angle changes, perception changes looking at the things the way you do is changing, correct.

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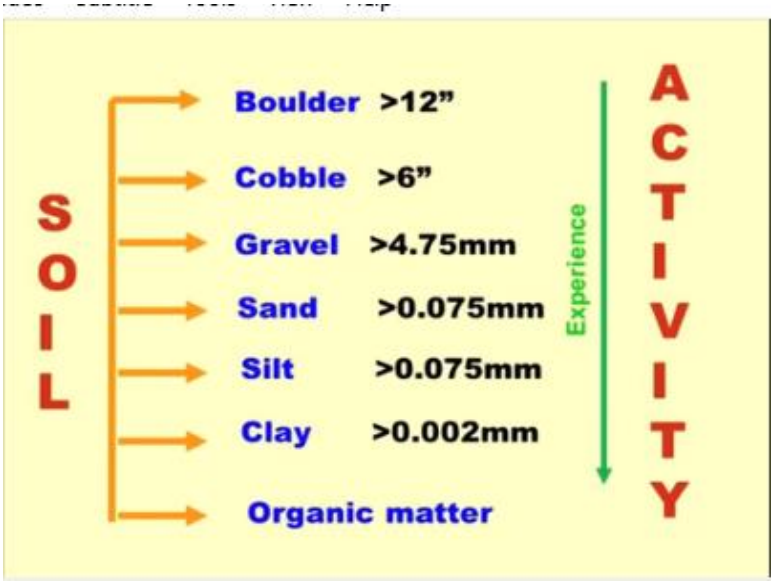

So, you think of totality now, so if this is a situation you know what happens; we have defined soils in different physical terms, physical only, you know these are all physical terms, particle size nothing more than that. So, most of the geomechanics which you study is blend of anything which is beyond physics of the matter; we do not give much value to the chemistry, mineralogy, biology, biotic activity and so on.

The whole classification system is based on particle size, so Boulders, cobbles, gravels, sand, clays, silt, clay, organic matter based on particle size. One exciting thing in the philosophical thought is the way the size decreases, what happens with the activity of the material; it enhances,

correct, so this is how the experiences; the more and more experience you are, the more and more refined you become, clear, you become.

And then what happens, the activity increases, percent become more productive, it is so unfortunate that we do not talk anything about the organic matter much in geomechanics, why? All your tests are related and are valid until 2 microns, stokes law, less than that is the, what form of the material; colloids and colloids are the ones which control the properties of fined grain materials maximum.

I think we are having this discussion sometime back, so you will realise that the role of the organic matter and colloids is so much, it governs almost 99% of the properties of the fine-grained material but we, unfortunately, ignore it, why? Because we do not have tools to characterise it, it is so sad, are you realise it, the limitations are there, and the logic given to the limitations does not consider them, this is not correct.

So, modern-day geo mechanics concentrate mostly on less than 2-micron fraction why? Because this material is the most notorious, most active and most creative material that creates what you want to, you are getting this point so, this is a very interesting fact and you will realise that because of the limitations of detection of a certain phase, we are ignored it completely, are you getting this point.

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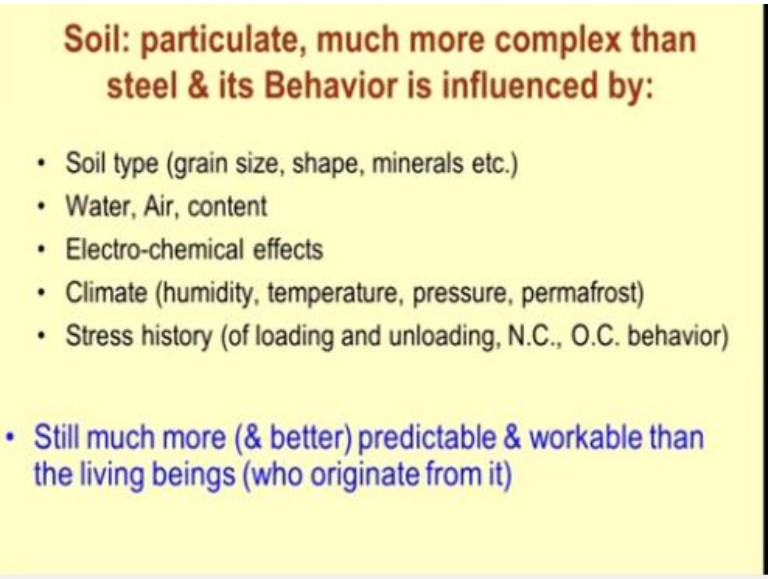

So, look at few symptoms, I am just trying to draw a relationship between you know, the human body and the soils with which you are working, rocks we are not working remember, because as I said that they are the parents, the chances of they are getting contaminated, adulterated, delineated, clear, affected are less, as compared to the offsprings which are in nascent, young, might get affected more, clear.

So, we are trying to draw a relationship between or understanding between you know soils and the human body because once you understand the human body, then soils can be mastered better, most of the tools are same by the way, so the soil is the particle material, all of you know, and still it is much more complex than steel; steel is made by human beings correct. So, between us and soil is what; steel, because we created steel, rocks are naturally occurring, standard material created by nature, a standard material created by human beings is steel.

Then human beings and soils, it is a 4-phase system, now you try to see what happens. So, most of the time you must have realised the properties of soils depend upon soil type, we always say what the soil type is, size of the grains, shape of the grains, what are the minerals which are present in it, agreed, then we talk about what is the second thing which we are going to talk about; water content, air content, degree of saturation.

The way you divide the studies is conventional geomechanics 2 phase system, unconventional unsaturated soil mechanics 3 phase system and today; I introduce in the lecture, multiphase system. Electrochemical effects; we will be talking about them, climatic effects; I think I have given you enough indication about how humidity, temperature pressure, permafrost conditions influence the properties of the soils.

Stress history; this is what you are discussing sometime back, memory effect, so soil understands what is the OCR, what is the UCR, what is the NC material and what is the precursors and pressure so, look at the response less than pre-consolidation pressure, it is OC material, more than the pre-consolidation pressure, it is NC material, you keep on repeating the loading, unloading, what happens; the NC behaviour becomes almost uniform, clear, it is a continuous curve, whatever perturbations have happened in between, they become a loop, hysteresis I was talking about.

And that goes into the memory of the system that it has been exposed to this much pressure in the past, still in my opinion, predicting soil response is easier than predicting human beings' response, why? Human beings' area much more complicated, but what do we do; we try to understand the reaction of soils in an accelerated environment, decelerated environment, extreme environmental conditions, and so on. Why?

Because these type of condition exist somewhere, so the main emphasis of environmental geomechanics is to simulate all these things, and the logic is soils are more workable, you know than the living beings and living beings have come out of the soils., so this is the complete logic.

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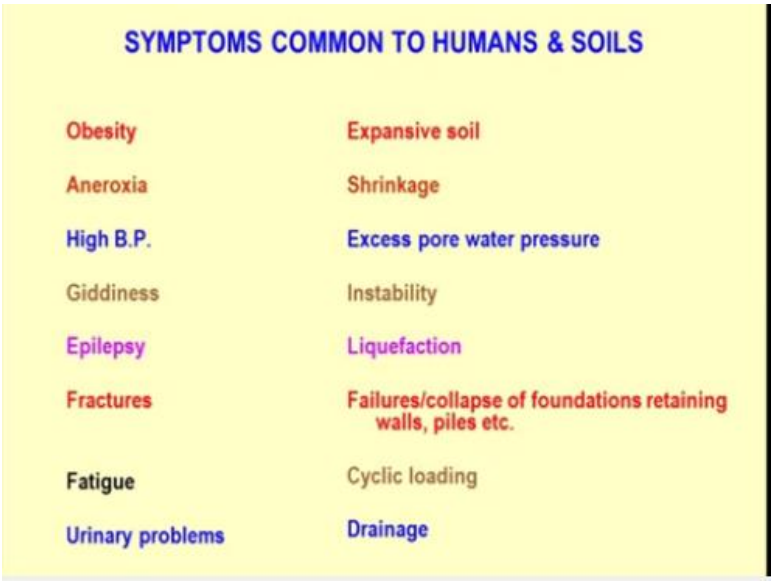

Look at the symptoms which are common between human beings and soil, just to make sure that what we are discussing a lot of similarities, you know obesity. People like us; me, mainly, what is this anorexia, then we talk about high blood pressure, most of us suffering from that, then we have giddiness, agreed, then we have epilepsy, then we have fractures, then we have fatigue and the last but not the least is urinary problems.

A geotechnical engineers deals with all of these issues in particular, the last one much more, seepage problems, everywhere so, obesity is expansive behaviour of the soil, you eat too much, you absorb too much water soil, anorexia, shrinkage, clear, instability, high blood pressure over a pressure, then we have giddiness, instability of the system, epilepsy; liquefaction, loss of sense, so adequate start boiling.

Fractures; failure, is it not? Failures of different types, the collapse of the foundation, retaining walls, a structure which we are making on the system, what is fatigue; cyclic loading, so keep on doing cyclic loading 550,000, 10,000, 1 lakh, this is all you design your payments, you want to see what is the resilient modulus of the system, when it collapses, a clear and urinary problem which I have already I talked about, drainage conditions, for us it is very, very important, otherwise everything will be in a less.

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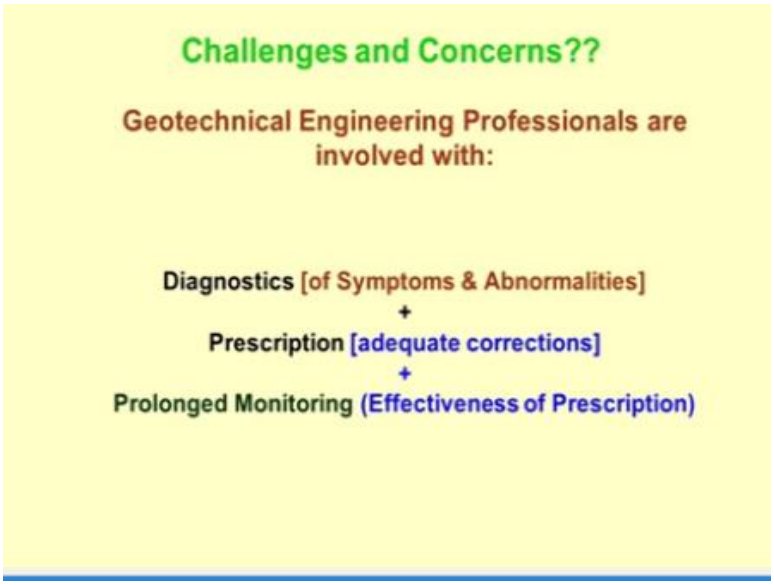

Look at the bodies of the dams; we design filters, drainage conditions and so on, so what are the challenges and the concerns which we are facing in a professional, any idea? The bottom line of the whole discussion today is that I cited few examples, there I was trying to show you that systems with which we are dealing, soils are live number 1 and when we understand the human body better in today's world, you know medicine and surgery has advanced quite a lot.

But not our subject, our subject has not advanced so much, is still we are talking about the old concepts, so there are challenges, there are concerns, how to first of all change the subject itself, how to lay the foundations of new concepts and some of the new concepts I have discussed in today's lecture. So, what geotechnical engineering professionals should be involved with; what they should be doing?

Three things; diagnostics, so look at your soil mechanics course, the way it is taught, first 5 lectures are only testing, you know classification, how soils got formed, how they were depositing, residual soils are like this, transported soils are like this, fined grained soils are like this, coarse-grained soils are like this, 100's of tests are done to characterise them, even the shear strength theory is also diagnostics under the action of normal stress, confining stress and shearing, how the material will go to behave?

So, when we say NC, OC behaviour, we forget about the material, whether it is sand or clay, we do not bother, we simply talk in terms of the state of stress, it is in material whether we are dealing with the sands or we are dealing with the clays, so diagnostics is very important like medicine, medical sciences, most of the efforts are being made by geotechnical engineers particularly, environmental geomechanics guys to understand the material.

Symptoms and abnormalities; your profession is mostly going to the site to try to understand what is happening and unfortunately, we would not find any of these things written in the books because subject is young, the type of pollution which you are producing from your industry might not be similar to the one which has been produced anywhere in the world. So, the interaction with this system is going to have with the soils and the rock is going to be absolutely different as compared to the one, which I ever been studied.

So, this becomes more of a case study type of subject, evidence-based, are you getting a feel of this; so take each case as the way a medical practitioner takes a human body, each patient is different, the medicine which might work on me will not work on you, we are different in constitution. So, here most of the effort is on understanding the symptoms and the abnormalities and once you have understood this, and this is diagnostics for which there are several tests, we will spend lot of time studying the geomaterial characterisation.

I will spend lot of time in making you understand how physical characterisation is done, how chemical characterisation is done, how mineralogical characterisation is done, how biological characterisation is done, how thermal characterisation is done, how electrical characterisation is done, how magnetic characterisation is done of the soils. So, this is going to be very intricate, and then once I have done the diagnostics characterisation, I have understood the problem a bit.

I will start treating the material clear, after diagnostics what medical practitioners do; they prescribed you something, they write down the prescription, so take this, this medicine and see me after 2 weeks, 3 weeks, 1 month, clear and slowly, and slowly it tapers down medicine also, so first is adequate correction and then comes prolonged monitoring, follow up, the patient is

very serious putting him or have in ICU, so we want to monitor, you want to see how effective the prescription is.

So, most of the techniques which are used nowadays in geotechnical engineering are monitoring, and monitoring is done with the help of either satellite or with the help of sensors or with the help of electronic gadgets, it could be x-ray based, it could be SEM-based whatever, we will discuss all these things quite in details, alright.