Environmental Geomechanics
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Lecture – 15
Soil – Water – Environment Interaction - II

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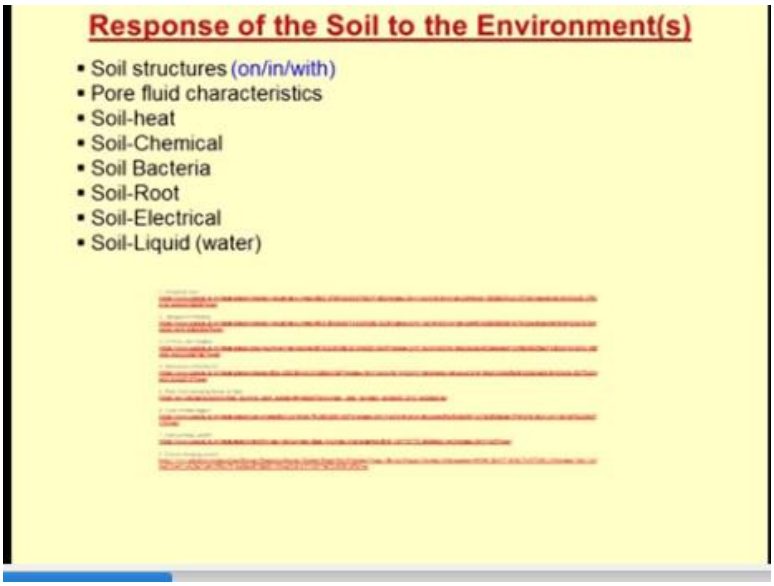

Now, comes the issue that how what is meant by the response of soil to the environments; different type of environments, I think I had discussed about soil and structures, we interact with each other, we call them as soil-structure interaction and soils are used to create structures and sometimes, structures are created in the soil mass or sometimes where structures are created on the soil mass, clear.

So, laying the foundation is on the soil mass, making embankments, a different type of returning structures with the soil mass and when you are creating conduits, cavities, tunnels, this is inside the soil mass. So, soil-structure interaction is a fascinating question, which people are trying to address. Yes, each of these statements which I have talked about on in a web has environmental attributes associated with it, clear.

So, when you are talking about the aerobic, anaerobic conditions as deeper you go in the soils, you will have switch over from organic to inorganic situation, alright, these are a good example. So, a different type of environmental conditions might be associated with the systems which you are talking about. Now, pore fluid is the one which is present in the pores in the form of either gases or liquids or the combination.

And the present day, way of looking at this is when you derive a parallel or equivalent between a human body and the soils is; if I can diagnose you by taking some sample of your blood, alright similarly, I can diagnose the soils or geomaterials by taking a sample of pore fluid. So, pore fluid is the one which is present in the pores either in the form of the liquids or in gases, we will discuss this in detail, how to extract pore fluid.

Because there your syringes may not work what doctors do, is it not, challenging to take out pore fluid from the soils. So, what type of techniques are used to sample pore solutions from the soils and the geomaterials, it could be concrete, it could be rocks, it could be soil, this has to be studied in a very, very different manner. In other words, the pore fluids also depict the state of the environment, which is present inside the soil mass, clear.

The temperature, the pressure, the humidity, the type of bacterial growth under aerobic, anaerobic condition, the type of gases which are getting form are an indication of what type of processes and the mechanisms are happening in the soil system. So, pore fluid characteristics are becoming very, very important to discuss. Interaction of soil with heat, I think I gave you ample examples.

When soils come in contact with elevated temperature, this could be a forging unit; this could be something like you might be having a furnace, the foundation for a furnace or you might be having a rolling forging unit somewhere in an industry, where the drop; hammer drop produces a lot of heat, rocket launching pads, different types of cables which are buries inside the soils for industrialisation.

And most of the time, when you do ground improvement, you inject chemicals in the soils, and these soils might react with the chemicals. Nuclear waste disposal is a good example of how soil heat interaction occurs; nuclear waste is at elevated temperature. Similarly, leachates which are coming out of the landfills might also be at elevated temperature, and this might react with the soils, alright.

So, I am sure you must be realising that these issues, these types of interactions have not been discussed until now in the conventional subjects because the conventional subjects are devoid of the environmental conditions in which the soils are living or located, alright. So, soil chemical interaction I am sure now it is clear to you, contaminants getting discharged either inside the soil or on the soil mass would create a soil chemical interaction.

And you want to see what happens after the interaction occurs, soil bacteria interaction, I gave you ample examples, pathogenic discharges, these sludges are not treated properly, and if you take out the sediments and pile them up somewhere, this is going to become part of the geoenvironment. Soil root interaction; I think we discuss this so, those of you, who might get a chance to work in the stabilisation of soil based on vegetation is picking up.

And this is being done at several places in my consulting also I have used this concept of soil root interaction at different tailing ponds in the country and where I have recommended vetiver grass if you aware of vetiver grass; vetiver is the name of the grass, it grows very fast, and the roots penetrate through the soils, vetiver, vetiver, so this is the variety of the grass which is quite commonly available, or you can transport it, and you can grow it on the slopes of or embankments.

So, the beauty is the root acts as a reinforcement, and it holds the soils, you check the photographs, I will also show you it is a good example of how soil root interaction occurs. If you look at the physics behind this, roots produce suction, alright and when suction gets created, truly speaking this becomes a soil suction interaction, clear, a 3 phase system that means the pores are now filled up with air, water.

And this dynamics of the air and water guides the properties of the soil, similarly, soil bacteria interaction also does the same thing, bacteria might be producing gases because of decomposition of the organic matter, and once these gases produce and they remain in the soil, the whole system becomes very susceptible to temperature and pressure, alright. So, this type of dynamics people is studying.

Then, of course, soil electrical; electric or charge you may say interaction, so soil heat and soil electric phenomena could also be coupled, the passage of current through a conductor produces heat, alright, so this is a very interesting mechanism where people would like to study what happens. Water present in the soil is a dipole, clear; it is a polar material, polar liquid. So, now if the polar liquid gets exposed to the electric magnetic field, how the properties of the fluid themselves will change?

Alright, so these type of things become very important when you are talking about different types of sensing tools which you are using them whether electrical signals are used to detect something in the soil mass, I will talk about this separately in the form of electrical characterisation of soils, thermal characterisation of soils, chemical characterisation of soils, biological characterisation of soils and so on.

The last in these series would be this soil and liquid, water interaction so, I am sure you must have come across that the soil which contains water and this water is of different types, you call this as an environmental water also, we call this as a gravitational water, free water, water, bound water, adsorb water, so these concepts are becoming very, very pertinent in discussion nowadays.

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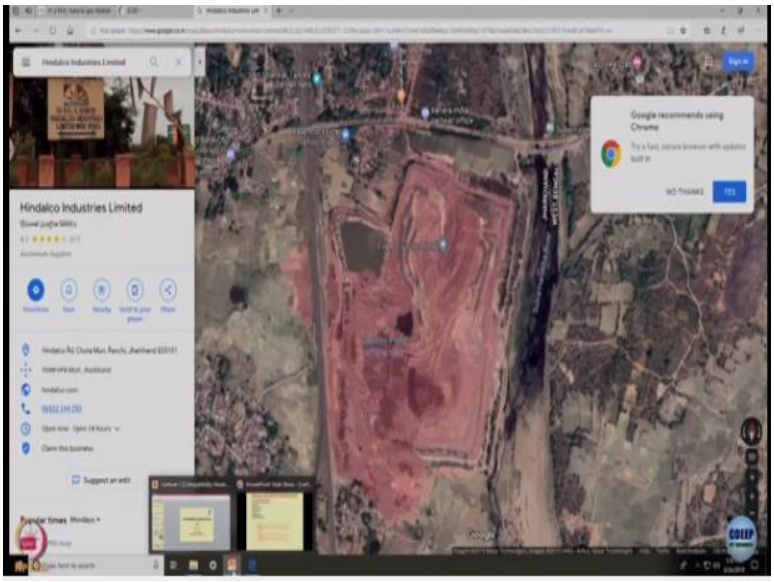

So, just to show you some of the examples of how this is being done, I think this is what I had been talking about, I will show you few cases where the type of problem which I am dealing with this is the beautiful example of the problem with which most of my students are related right now. Hindalco Industries is the largest industry in the world which produces alumina and production of alumina is because of digestion of bauxite.

So, whatever residues are leftover, this is known as red mud, now the question is; where you are going to throw the red mud, so this is becoming a big problem for the society and hope you can realise that a lot of dust is there and the disposal places have to be defined very clearly and if you see, these are the red mud ponds and I do not know how many of you have visited such type of red mud ponds.

A huge area is about 100 acres land where the height of the landfills or the height of the disposal ponds would be 40 metres; it is a huge challenge, the more and more bauxite which you are digesting to produce alumina, the volumes of the red mud which is an industrial by-product is increasing and if you research on this subject, you will realise that red mud contains a lot of caustic in it, so its pH is about 12 to 13.

So, you are stacking material on the surface of the earth, which is highly basic in nature, clear so this is a hazard associated with this. Now, the question is how would you handle this, how would you; dispose of it, whatever, these are the challenges which we are supposed to handle.

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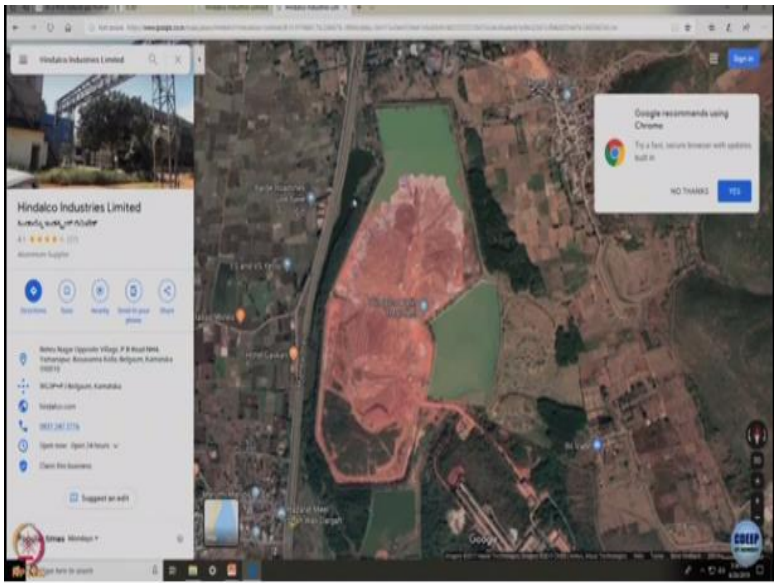

Now, look at the second situation which I have included over here, they have several units in India which are operating, and this is from Utkal no, this should be I think from Belgaum, I do not know whether you have seen this or not, this is the refinery; alumina refinery and when you drive from Bombay towards Kerala or Karnataka, then on the way, you will realise that there is a big stack of red mud and this is the National highway, Mumbai highway you can see.

So, handling disposal maintenance of this type of huge disposal facility which has been created as a consequence of modern-day civilisation is a big challenge, brainstorm your session; to brainstorm and give the answers to the industry.

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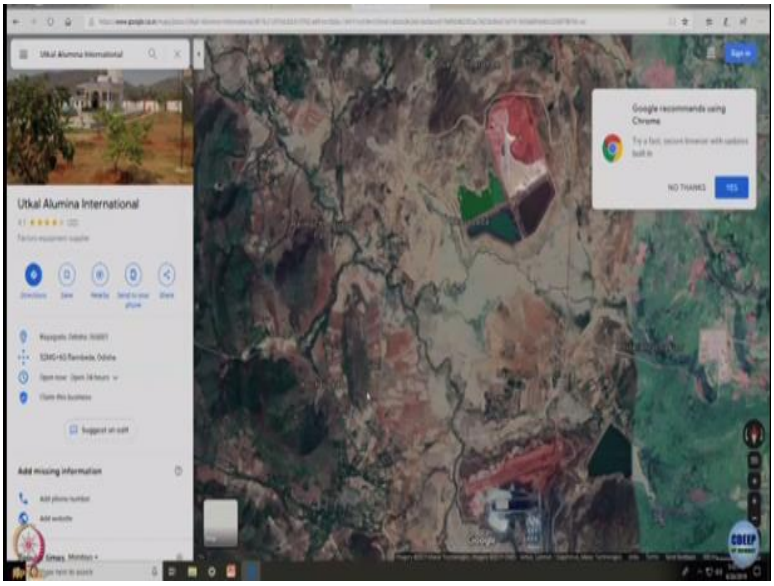

This is the eastern part of the country, from Utkal which I have taken, I do not know how many of this place, it is in Orissa, so this is a unit where the processes being done and the disposal is being done at several kilometres away, so piping, pumping of the red mud or the industrial by-products which are coming out is a big issue.

So, designing of these retention ponds is a big question, big challenge, unfortunately, not many people are aware of the practice of dealing with the waste which is chemically activated, had it been soils 200 years, 500 years, 1000's of years, people have the experience of handling with these soils and making retention system but when it comes to the chemically active systems, how would you handle them, how would you use them, how would you create something out of this is a big question.

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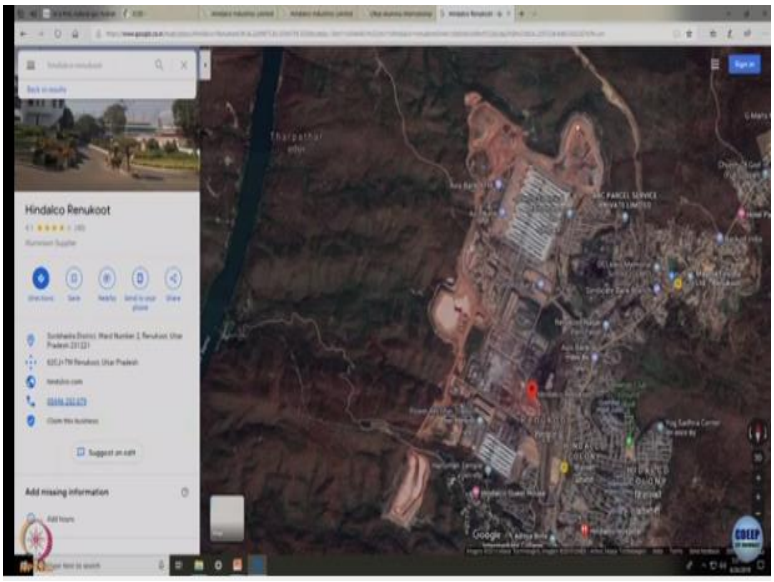

Another example I thought I would show you is of again Hindalco; this is from the Renukoot of UP, so look at this, I mean these are the; so this is the Renu river and this is the belt, where most of the thermal power plants or a lot of mining is going on, and this is the huge plant where the alumina refinery is Renukoot and look at this the way the red mud is being disposed, and now the question is how to tackle it in a scientific manner.

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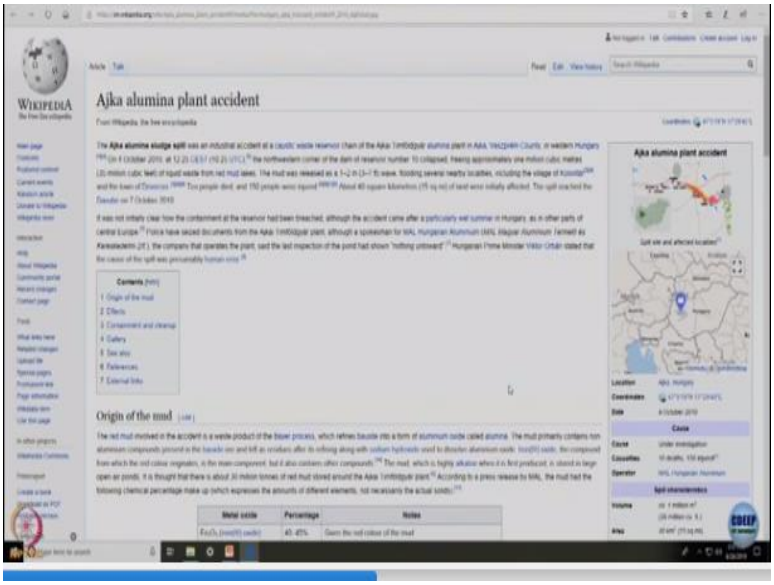

And you should read about this accident which occurred sometime back, Ajka aluminium plant, which happened in Hungary, so these are the slope stability issues which you should be dealing with as an environmental geotechnologist. These are all soil, water environment interaction examples.

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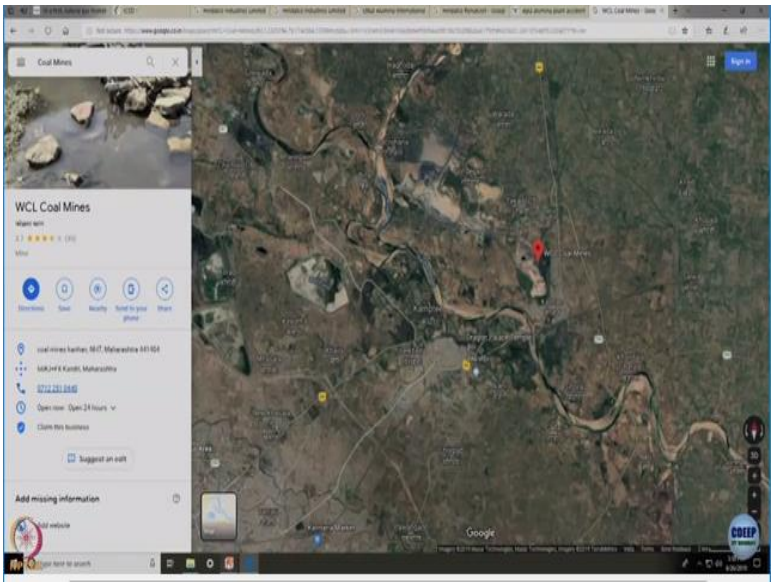

So, WCL coal mines, where a lot of acid mine drains and drainage is taking place, if you see, zoom this system, you will realise that lot of mining is going on, these are the extra deep mines or which WCL is trying to do, and this is where I work on the mining issues, geoenvironmental issues let it to mining operations, these are the extra-large mines, the diameter would be about 7 to 10 kilometres.

And they are trying to go up to several 100's of metres deep in the ground to excavate the coal, so these types of problems you can realise now to see, you can imagine that a large portion of this soil has been cut, so these slopes remain unstable most of the time, you have to stabilise them, I am doing a project right now at WCL Bhanegaon project, this is what is known as Bhanegaon. I hope you can realise that if I tell you the intricacy of the things, this is the river.

So, most of the mines are in the vicinity of the rivers, alright, look at this, this is the confluence of the mine for the rivers, this is one river and this another river and this is where the mines are located, so a lot of discharge takes place when you excavate, and that becomes a very critical issue that how would do mining against excessive discharge. Remember, these are simple slopes of stability problems.

But when they are having an issue which is associated with an environment, it could be seepage, it could be chemicals, it could be temperatures, it could be bacterial pathogenic, and so on, so we are talking about the different type of situations, while these are the challenges which we have to face as geotechnical engineering in today's world.

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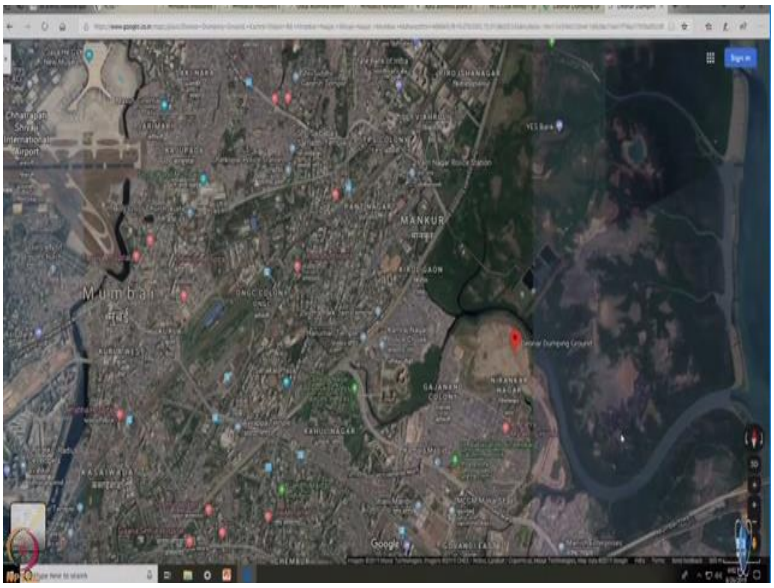

This is our landfill, extremely close to IIT campus; this is the Deonar dumping landfill, when you go towards VT from the eastern express highway, you will realise there is a huge land and when you are landing inside the Bombay city when the pilot announces crude stations, landing ex-stations, so point if you start looking at down, then you will realise you can see some part of the landfill quite clearly.

So, this is another issue where landfill fire took place in the recent past; the whole Bombay city had a tough time, you must have seen the photographs which were released by NASA about 2-3 years back show the magnanimous nature of how much the landfills are responsible for polluting the water bodies if the designs are not done properly, so what you see over here is this is the Deonar dumping and look of the population; the population is just right up to the brim of the landfill, they are in fact living over there.

Because they do not find the land, so this is the modern-day civilisation which we have so much proud of, I hope you can realise, look at the densely populated areas in the vicinity of the landfill,

and then there are water bodies, streams of water which are getting polluted because of landfills, leachates, or the gases which are coming out of it, alright. So, this gives you about an example of what type of interaction we are talking about.

So, I have talked about different sectors, industrial processes and even at the municipal level also the type of pollution which is becoming a big threat to the modern-day civilisation, mining, dredging; we will talk about all these sectors slowly and slowly. **"Professor – student conversation starts"** Actually, you are saying that you are working with WCL sectors in case of mines, so what is the actual problems they are facing, can you please mention.

All problems and problems and problems, nothing which is not a problem there starting from site selection to dumping of the overburden to creation of the material for reclamation of the mines to stability of the mines, to seepage in the mines to toxic water which is coming out of the mines, where to discharge it, how to treat it, how to put it back in the rivers to social issues, political issues, agricultural lands lost so, many things how to minimise the area where this stacking can be higher that is what everybody wants.

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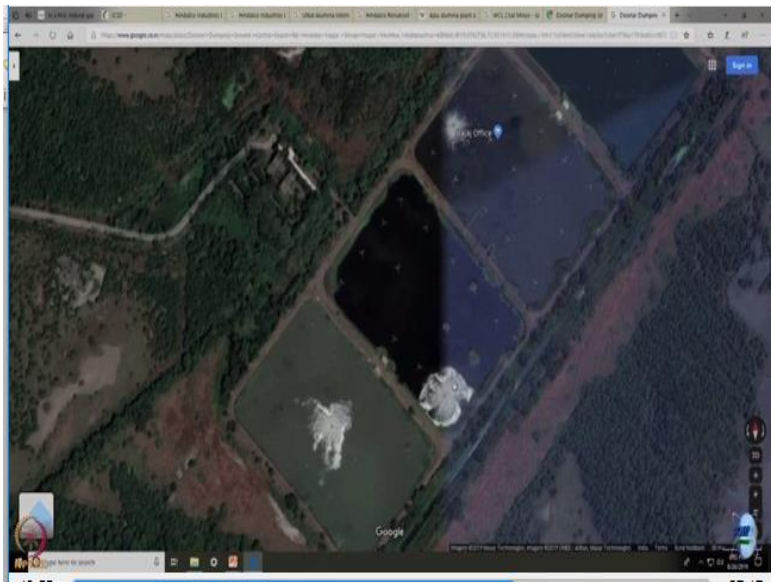

Then, how to utilise this material for other purposes, **"Professor – student conversation ends**" yeah so I think I can show you the lagoons also in fact in Bombay, this is the Ghatkopar lagoon, have you ever seen a lagoon, so these are the aerators, which are aerating yes, mixing and

aerating, so that these water gets cleaned up, so these are the aerators which are installed over here and yeah, **"Professor – student conversation starts**".

Sir, is it possible to quantify the strength that is provided by the vegetation, roots, is it possible to quantify the strength; quantify, yeah, of course, yes, lot of papers are there, it is a new subject altogether, so they do; you will be surprised to know that the geotechnical engineers take out the roots and they find out the tensile strength of the roots also and they implement it in the models which they have done; 3D models, so this is where the subject is.

All sorts of interactions are being modelled now in your software's, how the properties change over the period of time, I remember I had written a proposal where I wanted to see how roots migrate in the soil, I wanted to capture everything electronically by using a set of sensors and then I want to relate it to the growth of the canopy of the tree, somehow this project was not funded, all this happens, so I wanted to study.

Because see as I said farmers will never study the mechanics of the problem beneath 200 to 300 centimetres, alright, maximum, so that is the zone in which they are interested, beyond that is our realm, so we have to understand how roots migrated, for me it is say tensile strength of soils when the roots migrate into it, reinforcement of the soil because of secondary, tertiary roots and so on.

So, my perception of looking at the problem is different, yeah, yes, quantification has been done, please read the recent paper. Sir, one more question is that you said about the acid draining while mining, is it possible through non-mining activities like some construction of tunnels or something, yeah, so wherever you have pyrite or iron sulphide and when it gets exposed to the atmosphere, oxygenated, oxidised, then sulphuric acid is going to get form.

And how long will the effect lasts, how long means, no once the acid comes out and starts flowing in the water body, you read about what is happening in the Assam, most of the rivers are polluted, people cannot drink water, so these are the issues, so these are the contemporary issues

you should be aware of, what is happening, how would they do cultivation because the acids are present in the water, this water cannot be used for vegetation.

Yes, please, sir, if we compare the strength of the roots of the plants, will that be like comparable to geomaterials, sir, geotextiles, Reshmi, the biggest issue is without a plant, without roots, what is the strength of the material and if I grow them what is going to happen, so an engineer always talks about pros and cons, clear, so sometimes back I said that roots can be used, grass can be used to stabilise the slopes.

Now, if I want to quantify the whole thing, I would like to see from the initial condition, how much the material has got upgraded or it has deteriorated, you never know, the roots might deteriorate the rocks. Also, you must have seen, sometimes the vegetation on the concrete creates cracks also, so this is where judiciously, you have to understand the mechanism, so maybe very opened answer to your question is that you have to observe what is happening.

And then you have to understand the whole mechanism, so that's why I say where most of these mechanisms, the process require a lot of time of your life. Sir, can we use all type of plants means for water; no, there are different types of varieties, I mean you should read in, I mean I am not a plant pathologist; some are good for the soil and some or not, yeah, groundwater depletion, I agree with you, yes, yes, yes, so that is a big subject.

What type of vegetation and weight of the vegetation itself is going to be a big problem so, suppose you are stabilising the slopes, and if you plant a mango tree over there, it is going to be suicidal. Recently, I read in Punjab there was a problem related with groundwater depletion due to paddy cultivation, correct, not paddy, there are few trees which uptake lot of water particularly, eucalyptus is one, there are different type of tress.

So, this is where you sit down, and you have to talk to the plant pathologist, the guys who are experts in subjects; particular subject, so this is what we do so, like my laboratory we talk about the nutrition of the soils and with this nutrition on the soil, what can be grown, sometimes the nutrition can also be changed, I can create a nutrition depending upon the requirement that is

where the science or technology of the soils comes in the picture catering to the requirement of a project, you create something, alright.

So, you have to do all these, if the subject intrigues you when reading more and more on different types of varieties of plants, yeah, so another example of the question could be some time back when I was dealing with contaminated soil, and we wanted to rectify it, so I had recommended some varieties of the plants for phytoremediation, so phytoremediation is a very big subject in geotechnical engineering on which a lot of people are working already.

So, what species of chemicals can be logged, alight, logged in the sense that once you grow these type of plants, they have a uptake capacity and they will sorb all these types of heavy metals, concentrations of chemicals and this chemical concentration cannot move from one place to another place, passivation, so these are big, big subjects, people like you should come forward and study them.

Sir, we have seen that soil interaction with heat, chemical etc., what about the magnetic field, yeah, so this is less studied but my student one, Dr. Susha Lekshmi, so her thesis if you see in the paper which she has published is the magnetic characterisation of soils, this was published about 2 years back in ASTM, go through that paper and I think our lab was the first to talk about the magnetic characterisation of the soils.

And generalise the magnetisation behaviour of the soils, so we are trying to classify the soils based on their magnetic characteristics, and why we are doing this because we want to understand the soil moisture content, so you might not have thought by this time that how critical the soil moisture content is and soil moisture content depend upon the magnetic characteristics of the soils. **“Professor – student conversation ends**”.