Environmental Geotechnics
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Lecture – 06
Recent trends and Subject organization

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The most important out of all this is energy. I think last time in Goa conference Prof. Santamarina is spoke about this topic. If you want to go through the slides of course, I can't present those slides here because that is will violation of copyright act, but I have a copy of this his lecture and if you are interested you can go through.

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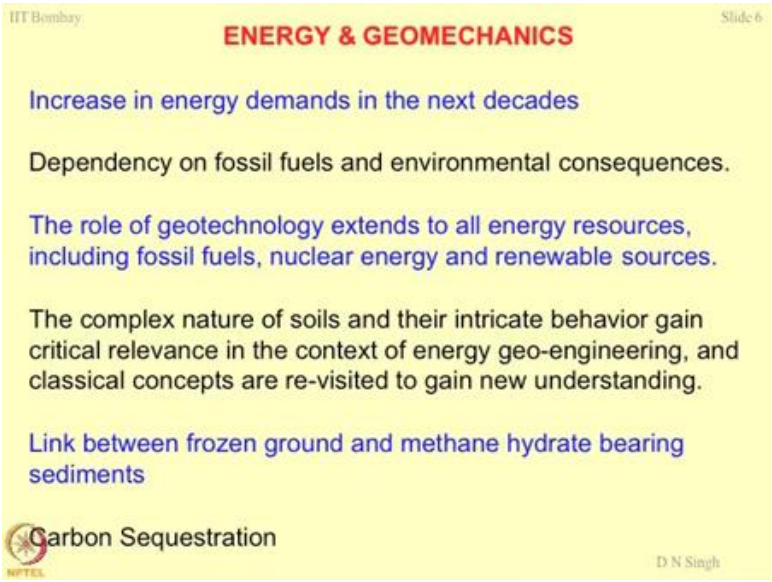

Well this is a very thought provoking concept in recent trends where you talk about energy in geomechanics. I think this is the subject which will keep you occupied for another 50 years at least.

We understand that there is a increase in demand of energy in the next decades and unfortunately what we have done is we have already exploited the fossil fuel enough. So, dependency on fossil fuels and environmental consequences are very well known to everybody. You take what is coal ash fly ash, you burn coal to produce electricity industries and whatever you are dumping out is nothing but the waste, you do not know what to do with this waste, the magnitude of the waste is so much that you are helpless.

So, fossil fuels are depleting environmental consequences are increasing. So, what we should do next? Now, this is where actually geotechnical engineering can come into the picture. So, the role of geotechnology extends to all energy resources including fossil fuels, nuclear energy and renewable sources. Any idea? Have you heard of few words which are in being used quite often these days? Kunal, sorry?

(Refer Time: 02:17) No that is all right, but it will not give you energy. So, that is actually we were talking about the materials. So, as a material you can utilize as a geomaterial. So, fly ash can be a neo material, silica fumes can be a neo material, the industrial glass fibers can be a neo material which you can what he was talking about carbon fibers can also be a neo material, which can be used for civil engineering

practices. Here what we are talking about is something different. Here we are talking about the materials which are going to give you energy.

Now, this is where actually we should remember that the soils are very complex in nature and their integrate behaviour gain critical relevance in the context of energy geo engineering and classical concepts are revisited to gain new understanding. How? This is one of the links, we are talking about the frozen ground and methane hydrates. So, gas hydrate is a very big and very new subject in geotechnology nowadays. This is where you require the help from physicists, chemists, material scientist you know, cryogenics and geotechnical engineers.

I will talk about methane hydrate bearing sediments which are also known as gas hydrates in the next slide. Now these are the future source of energy. Once you have exploited entire hydrocarbon in the form of petrol, the next layer in the ground would be methane, hydrates water hydrates; when you take water put it in the fridge what happens? It gets hydrated, crystals are formed these are the crystals of ice because same thing is happening in nature where the ice crystals are getting formed and methane gets trapped into them. Clear?

So, if I am not very wrong the government of India's budget on gas hydrate project in the year 2007 was 25,000cr on which ONGC is working and Reliance is working and I think in India your KG basin is the place where Krishna Godavari and some parts of northeast where you have lot of gas hydrates potential. So, this is the very good topic for research; the type of laboratories which you require for this are mind boggling. You have been doing tri-axial testing. Now what this requires is tri axial testing along with the methane gas present into the sediments.

So, this becomes a multiphase system where you are talking about methane gas, water and sediments and then you are trying to find out the shear strength of the sediments.

Carbon sequestration: Kunal, I wanted you to answer this point yes. So, carbon sequestration is a very big subject in the present day engineering society, everybody is talking about carbon sequestration; whatever carbon dioxide is present in the environment.

We have the carbon from the directly from the carbon dioxide and we can use that carbon for utilizing to generate energy.

How?

Directly making some instruments we can trap carbon dioxide, we can separate that carbon part and oxygen part separately and we can utilize the carbons.

Well you need not to go so complicated, the best thing is you trap the carbon dioxide and force it into the aquifers. So, the aquifers which are carrying water you think of aquifers which are full of carbon dioxide, clear. So, what is going to happen? You are recharging the aquifers with carbon dioxide and this becomes your fossil fuel for tomorrow. So, this is where most of the researches going on right now. This is known as carbon dioxide sequestration or carbon sequestration and so on.

Sequestration is nothing but forced penetration of something into an aquifer or in the ground. So, I have given you lot of ideas where geotechnical engineering profession can head to; all right. You want to say something more about carbon dioxide sequestration?

This direction, Sail India these all are the company other company that we already know.

Yes, basically a promising area. Let me go further to explain to you what is a gas hydrate and lot of research why geotechnical engineer should adopt this type of ideas and research activities.

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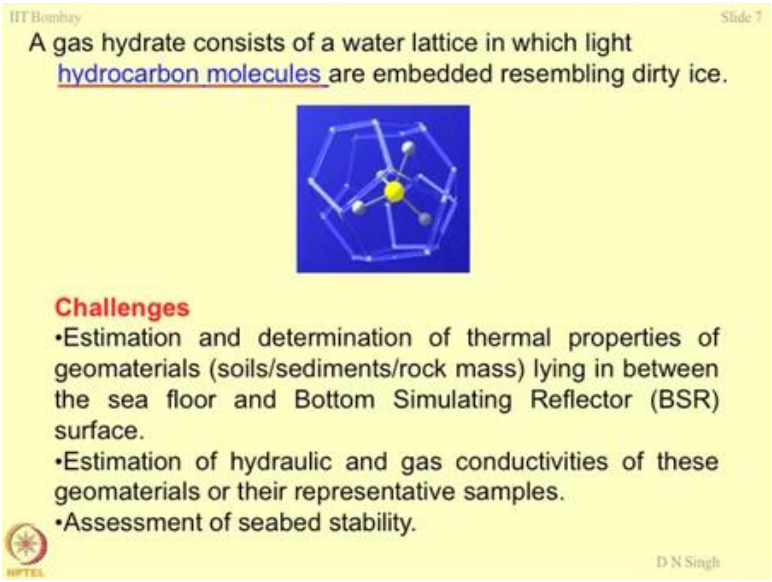

You should be proud of taking geotechnical engineering by now I am sure. So, basically a gas hydrate consists of a water lattice in which light hydrocarbon molecules are embedded resembling a dirty ice.

So, this is how you know the hydrocarbon molecule gets trapped in a cage like structure and is nothing but the hydration of the entire thing. So, this becomes a crystal. Now what happens is that these crystals are lying below the sea surface and normally the temperature at which they grow would be -27 to -40°C. The complexity and the beauty of the engineering should be that you take out from a depth of 8 km 10 km 15 km and so on or even less in such a way that their melting does not take place. If you can trap them at a depth of approximately 12 km 8 km 10 km you can get energy from these type of structures.

So, what are the challenges, can you speculate what will be the challenges if you try to tap the energy or if you try to tap gas hydrates?

Temperature

Good. So, temperature is a very big issue. Now if you do excessive mining what happens to the ground? Sorry? If you take out excessive water, petroleum gas what happens to the ground? Subsidence, you must have heard of subsidence.

Subsidence.

Is it not? This is nothing but land subsidence. Now if you take out too much of hydrates from the ocean bed what is going to happen? This will be the subsidence of seabed. So, you wanted to tap all gas hydrates, but if you are not cautious and your technology is not very good what you will do? You will destroy the entire energy source in the form of gas hydrates. So, this is a very very interesting area of research.

The challenges are, in fact, this was the proposal which I had submitted to IOT-ONGC for my own research. The challenges are estimation and determination of thermal properties of geo materials, soil, sediments, rock mass lying in between the sea floor and BSR.

The BSR is nothing but Bottom Simulating Reflector surface. This goes up to a depth of almost 2 to 3 kms below the ocean bed where the temperatures would be you know is interesting the water column as you go deep down the temperatures becomes almost 0. So, somewhere very close to the bottom to the sea floor the temperatures would be of the order of 0 to 2°C, but if you go further deep down in the sediments the temperature starts decreasing, it becomes -25, -47, -50°C.

So, this is the zone where these type of crystals or hydrates will form. The geotechnical aspect of this is estimation of hydraulic conductivity. We talk about hydraulic conductivity only till now, is it not? Water moving out of sediments in soils or rocks, but now the days have come where we have to talk about gas conductivity. You are not any more interested in water alone. So, you should talk about the gas conductivity in sediments. What is the meaning of this? The hydraulic conductivity void should get replace by gas conductivity or truly speaking you will have soon coefficient of fluid conductivity not coefficient of hydraulic conductivity.

So, that is a absolute world. So, we normally do not use in our research coefficient of permeability, we never use this word. You agree or no Sujith? What is that we use nowadays? We always use the word hydraulic conductivity because we are forcing water only to seep through the porous system. You replace it by petroleum, gas, crude oil, whatever it becomes the fluid gets changed. Clear? And that is where the difference is in hydraulic conductivity is small k and incipient conductivity capital K of a system. If you remember the small k equal to capital K multiplied by what? Rho by mu; density divided by viscosity. Clear?

So, this is how actually the good application would be when you talk about estimation of hydraulic and gas conductivities of these geomaterials or their representive samples. Clear? And ultimately what is the idea? The ultimate idea is that we should be able to access seabed stability. So, this is where actually because I have been working in thermal properties of soils and rocks, I think they approached us to solve these problems where what should be the flux induced into the sediments, which is just sufficient enough to deep freeze the hydrates so that they can be collected in a fluid form.

Unfortunately, this product project did not get materialized because of some other reasons. You talk about landslides; you talk about slope stability. Now here the emphasis is the stability of seabed. Why seabed stability is required? One of the reasons I told you if you are doing something which is very aggressive you may lose the entire reservoir of methane which is nothing but a cooking gas or source of energy. The second thing is ultimately where the vessels are going to stand or where your jack ups are going to stand? They are going to a stand only on the seabed.

So, you induce any sort of instability in the seabed, what happens? Further production process or engineering process gets affected. So, this is how actually this is becoming a very important issue which is going to govern the economy of nations. So, most of the people we will find a working I would say good researchers have adopted this type of activities in their profession, and they are working on not three phase models they are working on multiphase models. So, where you have soil, water, ice and air. Clear? So, this becomes a four phase model.

Now, let me make it a seven phase model, how? Your air is contaminated with some chemical fumes and solids are also contaminated with some solid form of the contaminants all right. So, I have added two more phases to this. Now ice may be of different properties depending upon its freezing point and so on. So, it becomes a multiphase system. So, basically the need of the hour is to develop the mechanics of the material which is a multiphase model. So, be ready for that as a professional. Any suggestions? It looks like a star war serial. Say something; is this coherent or becoming very incoherent? Sneha, yes please.

Let us take a few minutes' pause yeah let us sum it up what we have discussed in today's lecture till now quickly. Any suggestion, any idea? Yes, please Ravi or shall I proceed further, this for just to wake you up.

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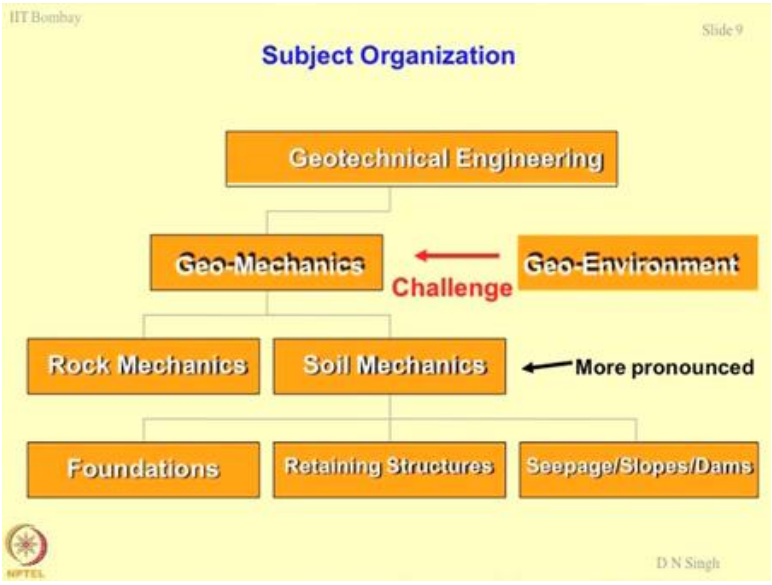

Now let us come to the subject orient organization, we are students of geotechnical engineering and where we talk about geomechanics. And geomechanics has two components rock mechanics and soil mechanics. Most of us do not talk about rock mechanics much, I do not know why, but the fact is this. Rock mechanics has not got much due as compared to soil mechanics. Any reason for this, this subject is very tough or what?

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Only is the degraded form of rock only.

So what is going to happen?

So, most of the time we are searching for some plain areas, where we can easily rest upon our infrastructure, we do not explore or it like we do not expect of building to be on mountainous area.

Okay.

You are saying something, Kunal?

Yeah zone of interest as soil engineer is close to the surface rather than going much deep inside that is one of the reasons ok. Wait for some more reasons in the due lectures and let us see what is the main difference, why we will do not talk about rock mechanics much. Well in soil mechanics we deal with foundations, retaining structures, seepage, slopes, dams and so on. Now this is where I have kept geo environment all right. Of course, geoenvironment constitutes of both, the rocks and soils and the ground water.

Now, what happens is this fellow geoenvironment it constantly threatening or challenging geomechanics, why? Soil is a young material, he was talking about weathering and soil formation from rocks, the matured person is not going to get affected much by what nature or what society or what circumstances you know are, but; however, the young material like soil gets definitely affected a lot. Any easiest possible simple example comes to your mind it shows vulnerability of soil to nature?

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That's much much complicated.

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Sorry.

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Much much complicated. Take some dry soil in your palm, add drops of water what happens? All the properties have changed. The color changes, the odor is starts coming out of it, you feel some burning sensation in your palm, if it has more calcium. So, the idea is you did not to go to all those complexities I am not talking about that, what I am simply saying is the soil is the very young nascent material and very very vulnerable to environmental changes. Add some water dry it again clear? It gets solidified, apply a bit of pressure it breaks stumbles it has no strength. Go to the beaches. Dry sand you cannot walk, a wave comes all the sand gets wet you can walk you can run you can build a building over it, but again when it dries up everything is lost, clear?

Look at the activity of the material. You agree or no? Is no more a passive material, is basically we have not given it much due we think that what soil is going to do ultimately truly speaking it is a very intelligent material it knows how to behave in a given

circumstances. What are the circumstances? You have add water, water it knows it should express its anger, heat, friction you know that smell comes out and so on. So, this is what I say the effects on soils are much more pronounced and the reason is it is a new material in terms of when you talk about geological cycle, how soils are formed rocks are million years ago soils are quite young.

So, they are more you know vulnerable to changes and that's why we talk about changes affecting the behavior of the soil when environmental conditions are quite aggressive. Clear? So, what it indicates? This indicates that this type of material should be treated in a very different manner. So, this is what my practice is my idea is when I discuss with these concepts so all of you with all of you and the likeminded people who are doing research in this area all over the world, they treat soil as a very active material; be it stands, be it clay or whatever. Any other idea which comes to your mind which should be included here ok? Let us proceed further.

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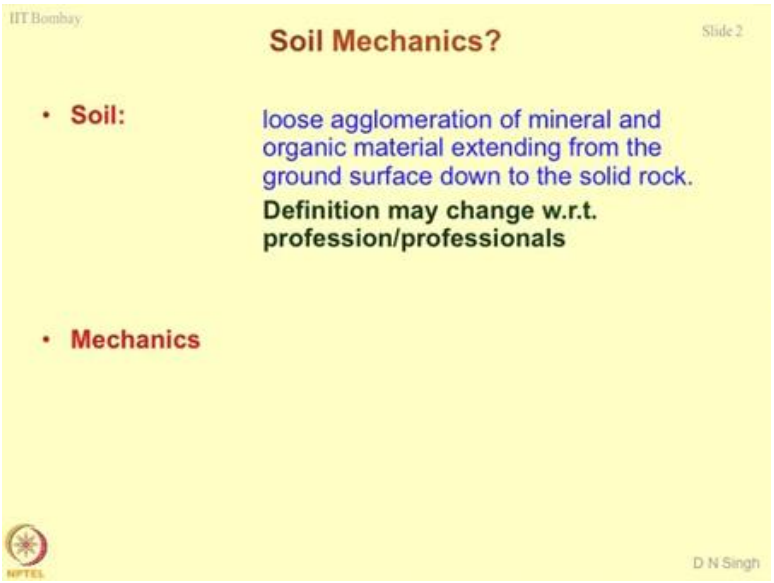

So, now the question is can you define soil mechanics? So, if you want to understand what is soil mechanics, you have to define what is meant by soil or what is soil. Try some of you, how do you define soil? Benil sorry? Soil does not understand what is consolidation.

(Refer Time 23:04) Sir it is the upper most crust of the earth weather which is formed of where whether it is rocks sir.

Benil?

(Refer Time 23:30) Let us see the definition. It's basically a loose agglomeration of mineral and organic material, which is the extending from the ground surface down to the solid rock. Anything which is lying above the rock is weathered, but what are its constituents? Its constituents are basically minerals and organic inorganic material; clear? So, when you say that the marshy lands or the marshy soil or the organic soils, they are having a big amount of organic material in themselves and every soil will be having some minerals. So, basically the process is very important. See it is an algorithm where the process are inbuilt in the material. Clear?

So, when you say a soil is of alluvial type, everything is you know tag to this that alluvial soils will behave like this. Did you follow this point? The soils which are blown up by air they have very fine particles which can travel hundreds of kilometers and they get deposited. So, many things are imbibed into the properties of the material, material understands that what it is from, where it has come and what how it has to behave and alluvial soil will always remain suspended in the atmosphere. It will create mist you know in the different type of seasons. If it is very hot the mist remains in air and if it is very cold it becomes fog.

It knows how it has to behave, you cannot change that property at all, the activity remains you know tag to it. The second thing is the location. The location is from the surface of the ground to above the rock crust or earth crust and so on. Unfortunately, there is no proper definition for this material. So, it keeps on changing with respect to the profession and the person who is using it. Any example to substantiate this? That is right.

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Yes. So, what is the difference between a rock and a soil? How do you differentiate between rocks and soils? Have you heard of Mohs' scale?

Mohs' scale.

Mohs scale that is one of the ways to differentiate between rocks and soils. For diamond what is the Mohs' scale number?

10. Okay

10; what about your nails? What is the Mohs' number?

1.5 sir.

I think 3 I am also not very sure its 3 I think. So, between 3 to 10 normally things will fall in, but this is the.

It is talc.

Its chalk talc.

Talc, talc.

Talc is one ok. So, the question is this is a very abstract way of defining the things. So, is there any definition which is more befitting when you define soils? You talk to a farmer, he does not bother about clay and silt and gravel and stones and all these things. He only bothers about a fertile and non fertile land. You talk to a potter who does pottery, for him this soil can be use for making pottery this soil cannot be used for making pottery. Clear? You talk to a person who is a aquaculturist or the people who are doing paddy plantation. So, they love a certain type of soil, for them other things are all useless. Clear?

How about the horticulturist those who are into the plantation of ornamental plants, roses and so on? So, the idea is depending upon the profession everybody has own liking disliking's and the definition for the soil; clear? So, truly speaking there is no definition as such where you can say that what is soil what is rock but then the question is very confusing to civil engineers what is soil and what is rock. So, one is Mohs number another one is sorry.

Other can (Refer Time: 28:14).

Yes I think you have very close to what it should be.

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But what is the difference? See the difference is if you see it in day on light or if you see it in night the difference should be very pertinent. One of the ways to differentiate is hardness whatever requires cutting explosion is.

Rock.

Rock and whatever does not fall in this category is soil, you agree? So, this is a simple definition, but quite practical as far as civil engineering profession is concerned. I think time is also over. So, I will continue in the next lecture.