Environmental Geomechanics
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Lecture 10
Recent Trends - I

We have been talking about the general introduction of environmental geomechanics, and I have given you a lot of logics until now about the scope, the philosophy, what are the issues which environmental geomechanics specialists or environmental geotechnologists are facing in the contemporary world and in particular, how to deal with these situations.

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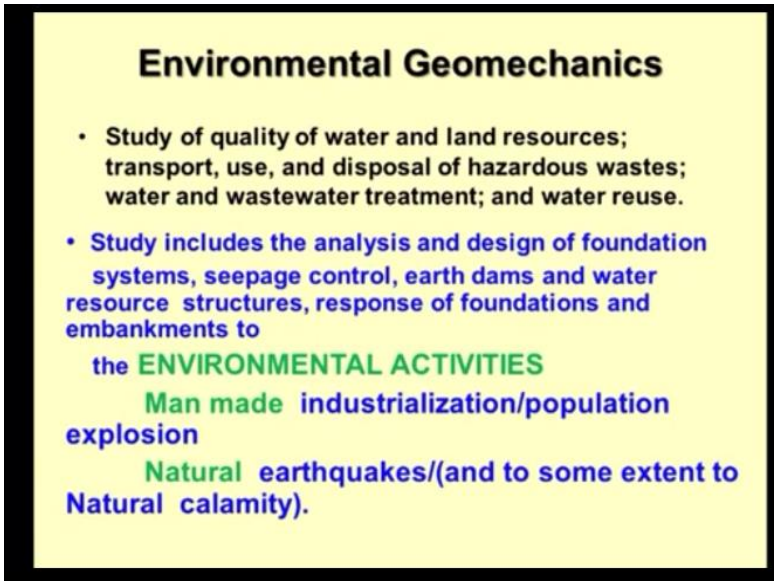

So if I sum it up, whatever I have discussed until now, the environmental geomechanics is a branch of engineering and technology, where mainly we study the quality of water and land resources. These are the basics or basic requirements for the sustenance of life. We always try to find out an optimal solution between the different constraints, which I have discussed in the previous lectures.

And another activity in which environmental geotechnologies are involved is the transport, use and disposal of hazardous waste and then treatment of the wastewater and water, earlier it used to be a domain of environmental scientists, but now I hope you will realize that with the recent

developments and technologies, which are being implemented, the role of environmental geotechnologists becomes very, very important and of course the reuse of water.

We also talk about the investigations or the analysis design of foundation systems, seepage control, earth and dams, water resource structures and we are quite interested in studying, what is the response of the foundations and embankments to environmental activities and these environmental activities can be grouped in two categories. The first one is manmade, and another one is the natural process or natural calamities, we call it.

So here I have given you some examples of what are the manmade activities, though we discussed quite in details. Primarily the manmade activities would be industrialization and population explosion, and once you talk about these issues, everything is part and parcel of this including the scarcity the land, which I talked about in the previous lecture. The second issue is the natural environmental activities.

And I hope all of you are now seeing that all of us are facing in a big way the disasters, which are occurring naturally or which could be manmade also. So this is what the point of discussion in what causes what. Ultimately the humanity and society are suffering, and we have to try to come out of this situation. So when we talk about the natural activities, which are responsible for motivating us, alright, to become an environmental geotechnologies and take up these type of assignments would be primarily earthquakes.

Anything, which comes to your mind apart from earthquakes, sees hurricanes. Tsunamis are playing a very, very important role. I have been dealing with several examples in our own country where post-tsunami, the rehabilitation part, particularly in Andaman and Nicobar area, became a very big challenge. Just to give you a very quick example tsunami brings a lot of sediments along with it and these sediments get deposited on the coastline.

And now the infrastructure on these type of loose unconsolidated sediments is going to be a very big question mark. So something of this sort is being done in the coastal areas of the country. Hence, the tsunami has become a very, very important thing to be studied, though I will not be

discussing much tsunamis in this course because I am not an expert on the subject. The other thing could be cloudburst, alright. It is a natural disaster.

So I hope you understand what is meant by the cloudburst. All of a sudden a tremendous amount of rainfall taking place in a limited time, alright. Mostly this happens in the (()) (04:27), upper reaches of the Himalayas or the hills, but nowadays it is becoming very common in cities also, alright. This could be the change in the climatic pattern. So in what way the cloudburst could be linked with the practice of environmental goemechanics as the height of imagination.

I hope you can make it out very easily. When cloudburst occurs, the chances of landslides become extremely, you know, severe and landslides is a subject which every geotechnical engineer would like to handle. So this is how things become interdisciplinary, and they get linked with each other. So hurricanes, tsunamis, design of foundations for extremely high wind velocities.

So until now you have been very conveniently designing the foundations for insignificant loads. I would say insignificant moments, but recently you must have seen when the eastern part of the country was hit by the cyclone, what was the name of the cyclone, Fani alright, very similar. So whatever disaster occurred and how to mitigate this, that means you have to revise the concepts of conventional geomechanics, where the moments for conventional buildings are not taken into account much.

So this is how the subject is getting evolved, you know. The moments are becoming more and more important on the foundation system rather than the dead loads. Volcanic eruptions, so we are lucky that you know we are in a country, where not many volcanic eruptions have been seen yet, except for the islands of this country, particularly Andaman and all, but think of the countries or the civilizations, which are on active volcanic regions.

So this is going to become a very big problem. One good example, which you can Google would be, how this Japanese train, the lava, so that it does not influence the rehabilitation. So they channelized the entire lava, and they are experts in this. So they are very good YouTube videos

which are available on this. So the volcanic eruption could cause significant problems as far as the human settlements are concerned. What else could happen because of the volcanic eruption?

Yes, I was talking about the molten state of the lava, which is flowing like a fluid. So a few years back you must have heard about a volcanic eruption, which happened in Europe and because of that the East got disconnected completely with West, why? No idea, check it out what happened. So when you have eruptions of particulate matter in the environment, the visibility and the density of air changes, you cannot fly through.

So for several months, the flights remain unoperational. Ultimately what happens it influences the economy of the nations. So suppose if you are totally disconnected from the rest of the part of the world, you are going to be severely affected. So these are the future domains of environmental geomechanics. I am very sure which you guys must be you know facing I would say. So the right time to gear up and adopt them as the future profession for geotechnical engineers.

Do not get limited to what you have been doing very conveniently because that part people have already mastered. So I hope you have understood there is a series of natural disasters alright and these are mostly manmade. They could be natural also. Avalanche, I think we have talked about. You know, movement of the snow on the hills. So this also a good example of how natural activities might create chaos, particularly in the upper region of Himalayas.

If you Google it, you will find a lot of information on how Avalanche influences these structures. Instability of the structure is caused by the movement of the Avalanche okay. So, unfortunately, we do not offer a course of cold region geomechanics in India, because we have ignored certain parts of the country. We never thought that they are part of the mainstream. It looks like, but I am sure one of you or some of you should really take up these challenges and try to consider the geomechanics of frozen soils.

So fortunately in our group, R&D group some of them are working in this area, and we are trying to see what is the response of the soils when they are subjected to varied environmental

conditions, alright. Anything which comes to your mind apart from this, floods, cloudburst. Floods, yes flooding also is a part of the most manmade nowadays, rather than you must be reading in newspapers every day what is going on and who is responsible.

There is a big debate, which is going on. So be a part of the central theme of discussion of the country. You cannot be isolated. Yes. "Professor - student conversation starts" Enormous snowfall can be there. Yeah, it will result in Avalanche. So the way you talked about NC OC materials normally consolidated, overconsolidated soils avalanche is nothing but over consolidated snow.

So imagine the layers of snow getting deposited and the next you know deposition coming over hitting the particles and the system becoming more and more condensed is what Avalanche is, alright. Fine. "Professor - student conversation ends" So snow mechanics and mechanics of the frozen regions is becoming a part of today's discussion. I will talk about this in details. Anything else apart from this?

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What are the recent trends, which we might or might not cover in the realm of environmental geomechanics, but my idea is to keep you updated on what is happening internationally, and this is what the present day scenario is in geotechnical engineering, which I do not know whether you are aware or not. So the list is very long, but what I have done is, I have tried to stuff everything

in few sentences and just to give you an idea about what is happening in contemporary world and what geotechnical engineers are doing.

The sky is the limit. So we start with material science. You know. The present-day geotechnical engineering is mostly about the materials, and these materials could be neo materials. Neo is the ones which are new, which are not conventionally existing, manmade alright. So fly ash, silica fume, slags, a different type of industrial wastes, which you are dumping are all becoming neo materials because I think we discussed in the previous lecture that these materials require very different and special attention of geotechnical engineers.

We are also talking about the nanomaterials, different type of resins, zeolites alright, different type of synthesized materials and this is where if you remember, when I was talking about the introduction of the course, I was saying that we talked about the interaction of geomaterials with the environment with a view that we would like to understand, how the geomaterial is altering, and this alteration could be physical, chemical, mineralogical, biological and so on.

So this has become out of the day, where people try to understand what type of alterations the material undergoes, when the interaction starts, and I think I have described interaction enough in the previous lecture, how the geomaterial contaminant or environment interaction occurs. So the perception is going to the basics of the materials, where we want to understand rocks, soils, groundwater, manmade materials as the basic materials.

And then we want to understand the mechanics of these materials alright. So with this in view, the characterization becomes very, very important. I will be talking a lot about the characterization of geomaterials in the subsequent lectures. Mining and mineral engineering has become a part of geotechnical engineering. So a lot of mining activities are being planned, executed by the geotechnical engineers.

And there are some people who are working in areas like geo-environmental issues related to mining. A lot of scope of understanding the materials, how do they react, and how I can use different types of materials to support the mining activities. I hope you can realize, slope stability

anybody can do. So when they come to a specialized surgeon, then the problem has to be different, alright. This is a quick answer.

So it is not only the slope stability, but there are a lot of other issues. Geohazard mitigation, I cited several examples of geohazard, anything which is related to geo, the earth is a hazard these days. I mean we have discussed so many cases. There are a big boom in the information technology and artificial intelligence and expert systems in the realm of geotechnical engineering. How many of you are aware of this?

There are a lot of expert systems. Abacus is a simple mathematical formulation, nothing else. Check it out on net SoilVision is the name of the company and their products are expert systems products, geo, SoilVision, alright and this was established by Professor D. G. Fredlund and his son, Murray Fredlund in Canada, SoilVision. So this is a system, which contains several modules and the question which you are asking about the mining.

If you get time, students originals are available online, and you can have trials, you can have tutorials, you can read a lot about it, and this is going to be a game-changer for you guys. The commercial versions are quite expensive, but as far as your stage is concerned at this time moment, you can start with the tutorials, which are available on the SoilVision and you can read about what is happening. Just to add quickly, what these IT and AI do?

Gone are the days, when I would like to do hundreds and thousands of the samples, the tests in the laboratory. We do not have time. Look at the infrastructure, you know the way it is growing. So how many labs in the country or in the world can really facilitate this type of testing, not many. So what is happening in today's world is, people are working on speculative modelling and that is what SoilVision does.

So if I know few properties of the soils, let us say texture, particle size and some fundamental basic property like specific gravity, I can speculate all other properties, shear strength, heat migration, contaminant transport, everything. So this is what is known as speculative modeling

in geotechnical engineering, where a lot of IT and AI is being involved. There are people who are working in neural networks ANN.

I am sure you must have heard about, artificial neural network. So there is a lot of people who are trying to train the soil properties by using ANN networks, the way your mind works, neurons in mind. Similarly, they are training mathematical models, by which if you give some information, you can retrieve the information. So some of you must have studied about SQL, that is a sequential query language, is it not?

So sequential query language is the one which is quite useful for geotechnical engineers, and this is where our profession interfaces with Computer Science guys. So the guys who are testing soils, they have a big data set of say about 7,000 or 8,000 soils and if I ask a question, my soil with these three attributes, how it would exhibit the engineering properties alright roughly. So this is what the speculative modelling is, query-based language, and in a sequence, you can ask the question to retrieve the answer.

Is this fine, SQL. So those of you who are interested should read about SQL, and this was going to be a good profession. So expert systems are becoming very useful. Structural people they used to use expert systems quite a lot for designing their bridges alright. So but now geotechnical engineers are not much behind they are also using quite a lot. This is something very recent bio-geo interface, which deals with molecular mechanics.

I do not know, how many of you would be having the taste of all these things, but many times this is forced, and many times it becomes a part of your personality to pick up something new and work on it. So in our group, we are doing a lot of bio-geo interfaces. We have done fundamental studies of how soils react to microbial attack, and the whole PhD is done to quantify this process to understand, what type of alterations system undergo, when the bacterial activity or the microbial activities attack the geomaterials alright.

This process happens in nature, and it is so sad that very conveniently geotechnical engineering people have forgotten about this. So normally what we do is, we bring the samples from the

field, we put them in the oven, and we create a different type of soil, which never exists in the field and this is one of the reasons which we were discussing that why the systems are failing because we are not doing the real-life modelling of the material.

We are not talking about the real property of the material. These are the altered state of the material. So most of the tests which you do in conventional geomechanics you have very conveniently saturated the material, clear to get rid of the third phase, which is air and that is the one which gives the most notorious characteristics to the system which has to be dealt with. So the bio-geo interface is the one, which is quite recent.

If you get time, you can go through it, and you will find that this is something which is going to be a game-changer, then all your conventional theories are going to get changed. Once you talk about the presence of microbes in the geomaterial and this is where molecular mechanics becomes very, very important to be studied by geotechnologist. Fire protection engineering, where do you think that this can be applied in geotechnical engineering? Any idea?

Do you remember what is 26/11? There is one good example of you know how fire protection engineering can be included in geotechnical engineering. There are ample examples. Another example would be, let us say, you are designing the foundation for foundries. Do you know what are foundries? Metal processing units, you are designing hammers or you say you know what do we call them as punching units, where something falls on a system.

Another good example would be, let us say missile launching pads, rocket launching pads, a lot of temperature gets generated and if the soils are not worthy of sustaining this high temperature, your simple shear strength theories are not going to help you in designing the foundations. So these are the issues. Another interesting thing would be those of you who are very, very eager to know what are the other scopes of fires in geotechnical engineering.

Forest fire, which is a recent topic, is it not? Every country is facing this problem. So what happens when the fire spreads in the, let us say, forest, what is going to happen? The vegetation gets burned, and because of that, the properties or soils also get changed. So again, you have

created something, which is not naturally existing. Now this fire could be manmade, or this could be natural, clear, but the whole idea is, what is the end effect of this.

The end effect of the forest fire is, it changes the fundamental properties of the deposits, and then the rains come, the chances are the erosions are going to be maximum from these type of deposits, clear. So, loss of vegetation, loss of organic matter from the soil, because the fire is becoming a very important topic to study these days.

So infrastructure engineering, creation of land, I think I discussed this in the class. So when you do reclamation, dredging and reclamation is something which is now catching the attention of people rheology of soils and why rheology of the soils, because when you do dredging and land reclamation, you dig out the soil from the sea or the of the water bodies, and then you spray it to recast it alright, to resettle them.

There are several examples in today's contemporary geopolitical situation. What is the geopolitical situation? Understand what is happening in the South China sea, what India is doing in the southern part of the nation in the islands alright. So most of the countries are very active, and this has become an interesting subject, where land creation has become a very big issue. Very recently, I do not know whether you are aware or not; India opened up a new container terminal which is almost in the middle of the sea.

That is in Bombay, Fourth Container Terminal. So check it out on the net. You just see the Google map and check it every year if you see that Google pictures, you can realize what the new addition is and that is the best way to learn, how much active the geological boundaries these days are. I will talk about these issues and the prevention, sorry preservation and restoration of monuments and old structures and the habitation also.

So wherever the minerals are involved, wherever the structures made up of soil, in the soil, with the soil are involved, remember geotechnical engineers have to be there. So most of the issues which archaeological society of any country faces would be restoration and preservation of the

monuments, is it not? How would you preserve the foundations of old buildings, how do you let them remain, the way they are. They should not deteriorate over a period of time.

We do not want to lose the history and heritage of the country. Is this correct? So the big bench of you know professionals, who are into these type of subjects and fortunately, I also got enough opportunities to work for some of the ancient caves in the country, where it was an R&D cum research project for us. This is something very interesting. I was talking about the arctic, and the cold region geomechanics and people have already started working on lunar and Martian geomechanics.

Are you aware of this? Check it on the net. There are so many papers. In fact, in our lab also we have published a paper on, I do not know whether you have seen this or not. There is a big crater in Buldhana district of Maharashtra, and this is where the meteorite fell long back, millions of years back, and then we were trying to study, how the soils got created what the peculiar properties are. So the time has come when people are talking about extraterrestrial geomechanics.

This is another interesting branch of geotechnical engineering, where a lot of work is being done, forensic engineering, where you know the legal issues associated with the problems, I have been talking about, are being dealt with failures, post failures, dams are failing. Floods are everywhere, the type of property damage and roads are getting washed out. So who is going to pay for this? These projects are insured.

Insurance companies, they do not want to shell out the money so easily. So what do they do? They appoint people like us. To evaluate the entire project and give us the correct picture. They call it as a root cause analysis. What is the root cause of the problem clear? Was the structure not designed for the floods, excessive rains, landslides, and so on. So this is also a very interesting area, in which I think some of you should take the lead.

Not many guys are present in the country, at least I would say, who are experts in the forensic engineering and what basically deals with is the engineering aspects of legal problems associated

with a project mostly. I hope you are aware of DPRs, detailed project reports. So if you check it on the net, what is the problem with DPR and you will get a lot of answers. You guys are blessed. Everything is available on the net. So you just check out what DPR is?

What are the implications, how the projects are suffering? You will get a lot of information alright and last, but not least is energy. Some of you are quite fascinated with gas hydrates. So I am going to discuss a lot about energy geotechnics. What energy, why energy is becoming a recent trend in geotechnical engineering? What it has to do with the geotechnical engineer practices? So how does this list look like?

How many of you are aware of how much about these subjects. Yes. "Professor - student conversation starts" Forensic engineering, Forensic Good, why? If we know how the problems are caused, we can like in the future; we can see that if you do this, this is going to happen, so. Very nice, I am so happy and then you should become an expert. So you should read the laws of the land first and then try to assimilate this with the practice of geotechnical engineering and try to find out the loopholes.

Suppose, if I construct a structure today and tomorrow it settles, who should be blamed. There are so many cases; I am sure you must be coming across Times of India, national network reports, lot of issues like this. Roads have been done and tomorrow road caves in, who is responsible? Good, Mitra. Maybe artificially intelligent and expert. Why? The data that I get, we can actually speculate the models.

Yeah, a lot of work is being done in this area as I said, predictive modelling. I will be using these concepts quite a lot in practice of modern-day geotechnical engineering. "Professor - student conversation ends."