Environmental Geomechanics
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Lecture No. 36
Geomaterial characterization-XI
(Corrosion Potential of soils)

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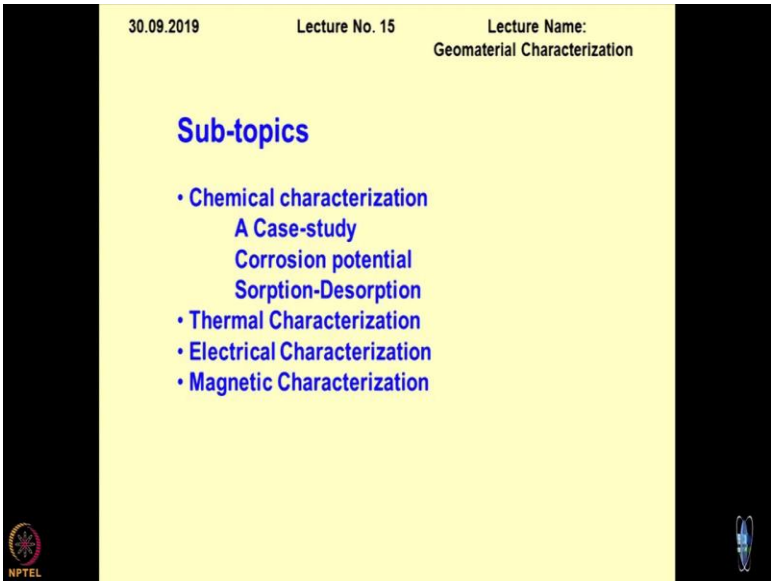

We have been talking about the material characterization and particularly the chemical characterization, and this is where I will cite one example a case study which was done by us a few years back followed by the corrosion potential which is a very important topic in today's world and a lot of industries, we have been piping, and the underground or buried structures are installed require studies to be conducted in this context. Of course, after this, I will be switching over to the sorption-desorption and followed by thermal electrical and magnetic characterization.

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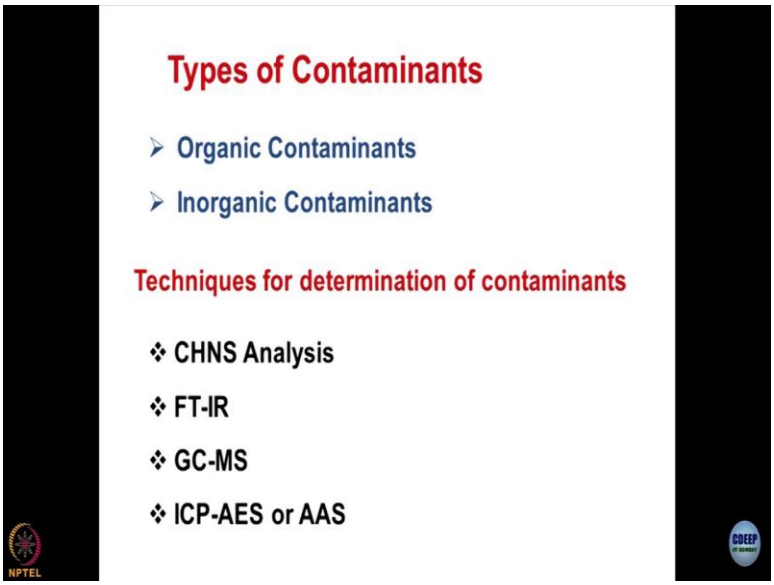

So, to begin with, the case study normally, when you come across these type of situations, the questions you have to ask yourself, are what are the types of contaminants that you are going to deal with? Because depending upon the contaminants type, you will have a strategy in your mind, or you be involving a strategy, which would help you in understanding what the extent of contamination of geomaterials is and how to remediate that.

In other words, the first question which comes to mind is whether these contaminants are organic in nature or they are inorganic in nature. And this question is asked, because of the obvious reasons that the detection tools or the equipment which you are going to use or the strategy which are going to follow will depend upon the basic nature of the contaminants. So, we have discussed different techniques in the previous lecture.

And what we can reiterate is that normally CHNS analyzer is required this is the carbon-hydrogen, nitrogen and sulfur analyzer is required this an equipment which helps you in finding all the CHNS components of the geomaterials. And then what type of alterations these components are going through or the elements are going through in the process of getting contamination of soils that can be detected and quantified. FT-IR is the Fourier transform infrared spectroscopy.

This I have talked about in the previous lecture and followed by GC-MS that is gas chromatography with mass spectroscopy and of course, ICP-AES and AAS so, these are tools which are normally used. So, just to show you how the.

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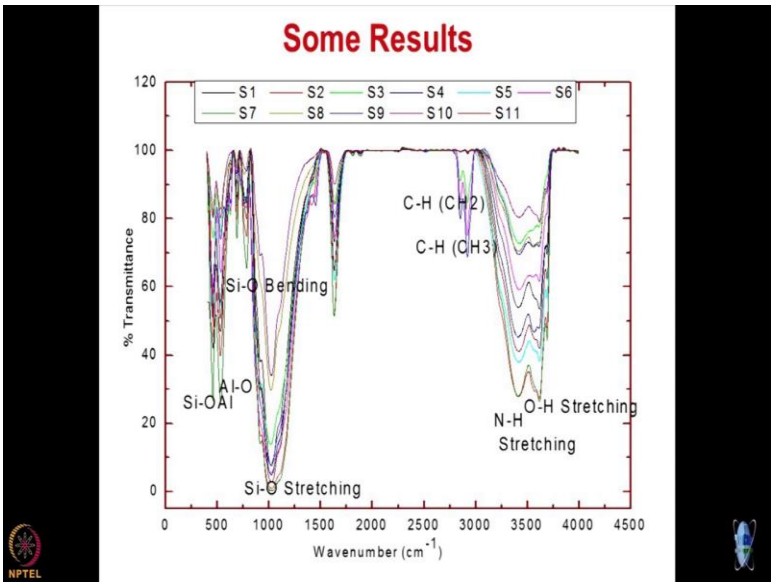

Results would look like; these are typical results, which convey from the FT-IR analysis, which you get what the extent of contamination of the soils is. So, S1 to S11 are different codes of the soils depending upon either the time or the location from where the samples have been withdrawn, and on the y axis, we have percentage transmittance, and on the x-axis, we have the wavelength. I hope you understand from the basic background of chemistry, that wavelength is associated with the bonding between the two elements.

So, what you are observing here is a typical pattern which shows what type of bonding and the nature of the bonding is available in the soil mass or the geomaterials. So, for that matter here, I have written it as I say silica oxygen stretching. And here the silica oxygen is in the bending. So, this is a sort of a bond, and if you remember our preliminary discussion, the whole trick is about how to break these bonds so that the soils can be decontaminated. So, FT-IR happens to be a good tool where we can at least qualitatively; we can identify the presence of foreign elements, particularly contaminants in geomaterials.

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GC-MS Results

Retention Time (min.)	Identified Compound	Intensity (%)
9.9	1-Tetradecane	3.55
10.1	Naphthalene, 1,5-dimethyl	3.68
11.5	Benzoic acid, 4-ethoxy-ethyl ester	22.07
11.7	Heneicosane	3.31
12.4	Diethyl Phthalate	3.72
13.0	Hex-adecene	3.74
13.1	Tridecane, 6-propyl	2.36
14.5	Eicosane	2.07
15.7	3-octadecane	3.61
16.2	1,2-Benzenedicarboxylic acid, bis (2-methylpropyl) ester	5.41
17.4	Dibutyl phthalate	6.48
18	Benzene, 1-acetyl-3-ethyl-2-(2-ethylene-6 ethylphenylazo)	2.48
18.1	Hexadecanoic acid, ethyl ester	1.86
18.3	1-Nonadecane	2.48
20	9-Octadecenoic acid ethyl ester	1.17
20.1	9-Octadecenoic acid ethyl ester	3.64
24	1,2-Benzenedicarboxylic acid, mono(2-methylhexyl) ester	0.53
24.1	1,2-Benenedicarboxylic acid, diisooctyl ester	11.67
29.7	Squalene	13.05

The second analysis is the results of the GC-MS, which I am showing here. So, as I said, this is the gas chromatograph-mass spectroscopy. Depending upon the retention time, I can identify the compound, and we can quantify by using the MS component associated with GC-MS. What is the extent of intensity? Intensity can be correlated with the percentage of these compounds which are present in the system. So, there is a big list of compounds that you can identify based upon their in print in the geomaterials, these type of analysis are all part of forensic examination of the geomaterials nowadays.

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Remediation Techniques

- ✓Air Purging
- ✓Electro-remediation
- ✓Bioremediation
- ✓Phytoremediation

And then comes once you have identified what is that qualitative contamination present in the system or quantitative contamination present the system you can plan the remediation techniques. So, some of the remediation techniques which I am going to list over here are number one is the air purging, I can twice the air inside the soil mass this is what I was talking about in the previous lecture also, where the compressed air or the compressed oxygen is pumped into the geomaterials to oxidize the contamination which is present.

And this could be a very good solution for the soils which are oil contaminated or hydrocarbon contaminated, where you can break the bond between the soils mass or the geomaterial and the hydrocarbons by purging the air. The second one is electro remediation, slightly complicated technique where, with the help of the electric field, you can decontaminate the soils electrokinetic processes one of the processes, another process could be electro-osmosis.

So, these are two processes which people have tried in the past. Of course, these methods have their limitations and strengths, which you should study by going through the papers, which are available in the literature. And sometimes these techniques become very difficult to employ on the site because of the cost of the paraphernalia or maybe like electro remediation method is the biggest question would be if you are passing a huge amount of current or the voltage is might be unsafe for the people who are working over there.

There is another interesting technique by which you can do the remediation of geomaterial which is bioremediation, and this is the upcoming area where a lot of research is being done. And I would suggest all of you go through the literature, particularly on Google a lot of papers which are available on these techniques, their utilization, how to employ them what are the limited And what are the strengths and so on and where we are as a nation are internationally another method which can be tried I think some of you talked about this phytoremediation.

So this is also a very interesting technique of decontamination of the soil. Now, one thing you should realize over here is that it is a chicken egg story where the soil gets contaminated first or the groundwater gets contaminated first this has to be decided because many a time it so happens

that the soil becomes contaminated first, and then because of the leaching of these unwanted contaminants or species, the groundwater table becomes contaminated.

However, the reverse process is also possible, because non-water table is a part of the geomaterial system. And in case there is a flux of contaminants which is present in this in the groundwater or the pore solution. The chances are that the geomaterials will be contaminated. So, when we do remediation techniques, both the aspects are kept in mind that is the contamination of the soil as well as the groundwater or vice versa.

The only thing would be taking out a sample of the groundwater will be easy. And this can be directly analyzed by using ICP-MS or GC-MS. However, when you are dealing with the soil phase of contamination or the solid phase of the contamination, then you have to extract the solution. That solution has to be analyzed by using different techniques.

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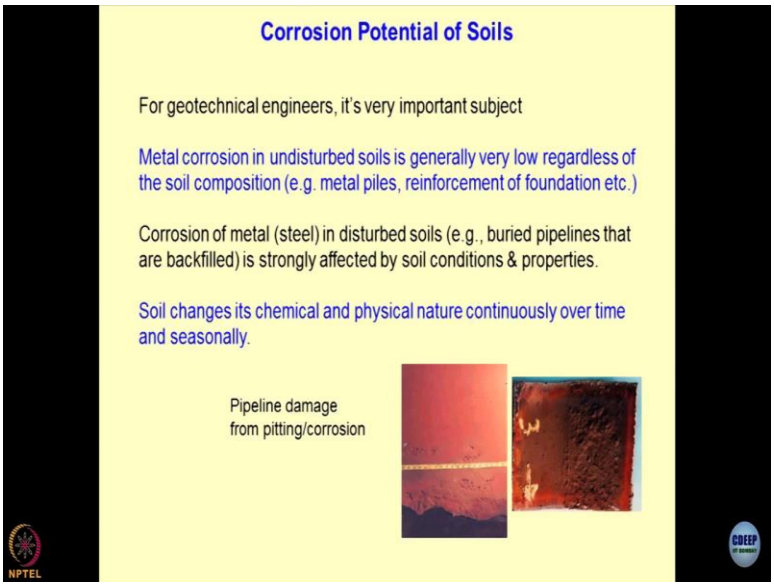

I will start now, a discussion on corrosion potential of soils and as I said, some preface I have given you in the previous lecture, why this subject is becoming more important in the realm of geotechnical engineering. Most of the foundations and underground structures are exposed to the environment, particularly subsurface and this is where the chances of contamination of the porous media are very very high and once you have contamination which is present in the soil or the groundwater.

It may so happen that the underground structures might be under threat as far as their safety or their structural health is concerned, why these studies are becoming very important for geotechnical engineers because metal corrosion has become a very important thing in undisturbed sites. Particularly when we compact the soils when we talk about the soils which are under In-situ conditions, and we insert a lot of elements like foundations or sheet piles of the pipes in the ground.

And you did like to see what really happens to the cover of these elements in the form of the concrete or it could be a metal and the reinforcement which is lying inside. As I said, the buried pipelines and the backfilled soils have to be characterized properly when you are using them for different industrial applications. So, the industry is facing two problems number one is how to convey liquids underground because overhead conveyance is extremely hazardous and difficult.

And the second thing is that if I have to lay the pipelines, I have to backfill the soil to compact it is it not? So, from where this type of soils will come, which are supposed to the best soils are the geomaterials, which would be safe for the health of the buried systems. So, I hope you can realize that this is directly coming into the realm of geotechnical engineering and here the pretext is that soils change their chemical and physical nature over a period of time and depending upon the climate.

So, these issues have been ignored earlier. And when I say climate and time, I hope the connotation you can understand is, this is because of the bacterial activity. So, the bacteria which harps in the soils get activated or may become supercritical or may become dormant depending upon the environmental conditions. So, these are the situations which are bothering geotechnical engineers, when we talk about the pipelines, this is the pitting sort of a system, and this is the corrosion.

So, excessive pitting might leads to the corrosion of the metals. I have come across some of the cases where there was litigation going on between the client and the contractor where, big pipelines were installed. And I hope you understand that the pipelines are extremely expensive

utility items. And it so happened that by the time the pipelines was charged, charged in the sense when they were opened for fluid flow, people realized that the conveyance of the liquid was 0.

So, when we when they open the walls, they realize that nothing came out from that particular pipeline, and then the litigation started, and then the inquiry started and what we realize is that the entire pipeline was eaten up by the soil. And this is one of the piece of the pipeline which I collected, and I brought to the laboratory to do further analysis of what went wrong. So, these issues are becoming very, trivial and very critical in the in contemporary society.

I hope this connotation is clear when you have disturbed soils; the densities are going to be different as compared to the density state of the undisturbed material. And hence the air permeability and water permeability and the form the rains is going to be different. And once you have ingress of fluids in the buried systems, this could be problematic because wherever oxygen is present, the tendency of the oxygen would be to oxidize the things.

So, this is the answer to your question. So, permeability gets affected strength gets affected, durability gets affected and at the micro-level, if you really analyze this issue, hope you will realize that the question to be considered is that how microbial activity will grow in less compacted soil or more compacted soil, and this is where we talk about the concept of aerobic and anaerobic bacterial activity.

So, compacted soil acts as a barrier for the air to communicate with or the environment to communicate with the buried structure. I hope these logics will help you in understanding why this subject is becoming important. Yes, please **"Professor - student conversation starts"** In the past, we have used wooden piles for this purpose. Now it possible to use so you are talking about the monuments where the wooden piles have been used. And I am sure that you must have realized that it was made sure by the engineers of that era **"Professor - student conversation ends"** that these wooden piles will not get oxidized, they do not get exposed to air.

That means most of the time the system remains under submerged condition. So if you go to our most of the monuments where you have boudies we call them in Hindi and Urdu. I do not know

what do you call them in your language. Then there are several structures; monuments were 2 3 stories remain always submerged in water. So, when you cut off the supply of oxygen, the system would not get oxidized. And wood is a classic example of this wood under the wet form, which is pretreated is always much more durable than concrete. So this is the answer to your question.