Environmental Geomechanics
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Lecture No. 29
Geomaterial characterization-V
(Specific surface area)

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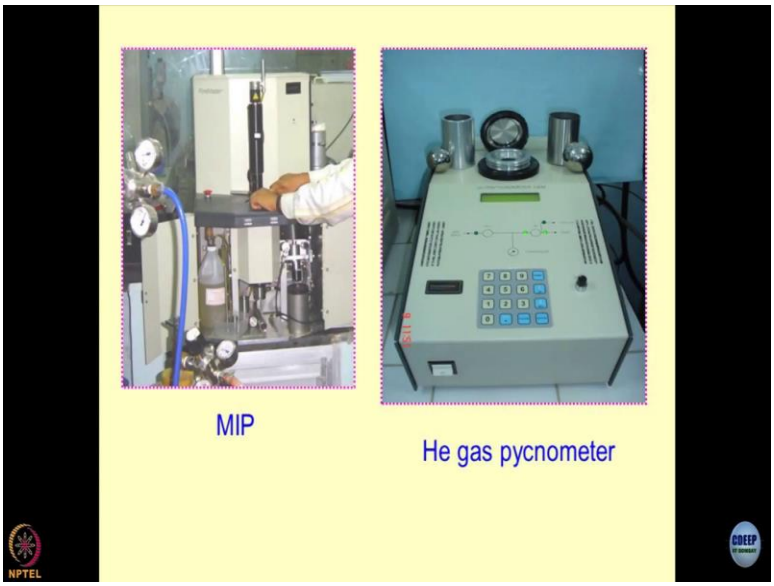

This is a typical MIP Mercury intrusion pycnometer. We have different types of low port pressure, port and high-pressure port. More than anything, these tests require a lot of patience. These are extremely expensive tests and setups. This is a helium gas pycnometer where you have containers in which you can heat the sample, and you can keep them in the control system. You can allow their interaction the helium gas, you can find out what is the volume of helium that gets displaced, and you can come to the bulk density and surface area. The balls that you see over here are the standard materials which are used to calibrate the setup.

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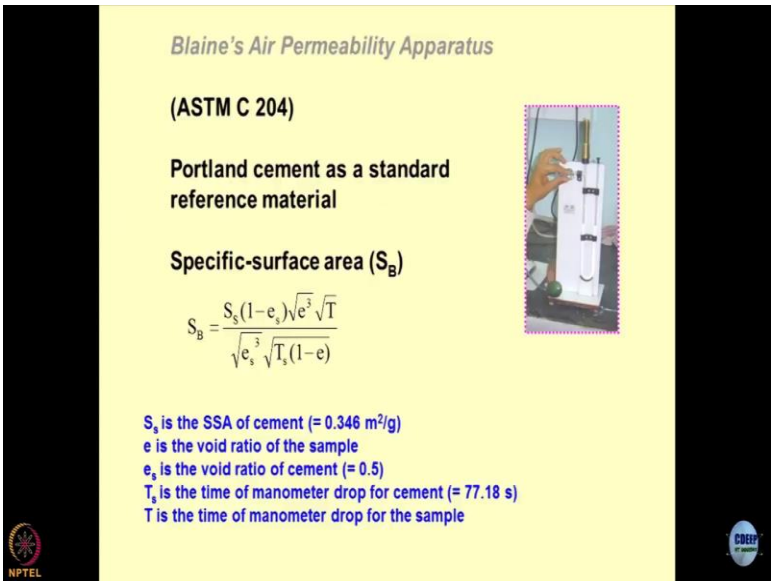

This is a Blaine's Air Permeability Apparatus you must have used it; this is a U tube, and in the U tube one part of the U tube is connected to pump air pump like the blood pressure machine, and this is a sample holder. So, in a hole weight of the sample is compacted in the sample holder, and this is attached to Blaine's air permeability apparatus. And what you see over here is the mercury column.

So, initially, the mercury is balanced. What you have to find out is that you have to find out how much time a material takes for allowance of a certain amount of air through it and that is why we call this setup as Blaine's Air Permeability. So truly speaking, the amount of air with passes easily or not easily is converted into the specific surface area. So, no need to remember all these equations and formula because they are all given the ASTM course, they just try to understand what it is.

So, if I create a sample at a given void ratio and 'e_s' is the void ratio of the specific material which is being used as standard material, 'e_s' is the standard material, which is normally cement PPC or OPC' t' is the time which is taken by manometer to drop when the sample is used, and T_s is that time which is the time taken by the standard sample to drop a certain amount of air through it a specific surface area of cement is known. Again the question now will you get it so, you can use different techniques to find it out.

The void ratio of the sample can often be and void ratio of the cement is known, and manometric drop for the cement is known and enhance you can compute the surface area earlier people who are working in the field of cement and concrete technology they used to use these devices. But now, the question in your mind must be that where are geotechnical engineers are going to use these concepts; you must have got a hint that present-day practice of environmental geomechanics is how finding material can be crushed.

It defined material itself to imagine if I want to pulverize clays and if I want to create nano-size particles out of it. So, this is a very different scale of the particle size on which you are traversing. Because of the accurate advantages, the particle becomes extremely small in size, surface area increases, activity increases, and so on. So, these things become an excellent environment filters, see if I can use them for cleaning up of different types of flue gases or the sludges.

So, this is where the profession is heading to so; I might like to use this material in the soils to decontaminate it. So, when you read the papers, you will find a lot of research is being done, and this is the need of the hour when you go from micro to nanoscale. As far as I know, like whatever understanding we have at the micro-scale totally changes to at the nanoscale that nano chemistry comes in. So for that, if we are granting it that fine, then we need to understand how we will have it because the difference there will be the difference in behaviour at the microscale and nanoscale is correct that right. So, your observation statement is absolutely correct.

And this is a challenge people are facing. So bentonites most of the bentonites can be activated for extra sensitive environmental projects, if I have to stop the leakage of let us say radioactivity then I have to make material, so fine, so active that nothing passes out of the voids of the soils or for that matter, even from the concrete also being used you come from a place very close to that in an army does all these things or you should explore thermal resistance blast resistant and impact resistant structures, this is what now India is doing a lot of geotechnics is a lot.

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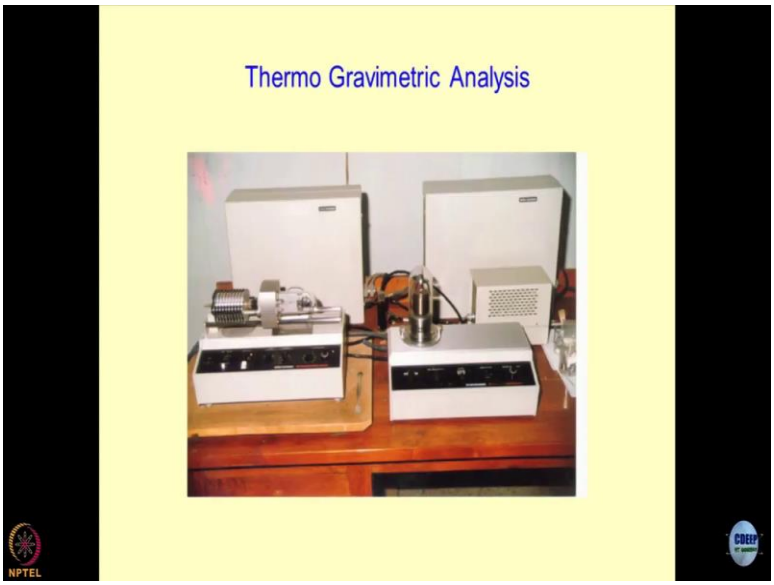

Another interesting device, you can check the thermal stability of the geomaterials because most of the applications we have been talking about are materials coming in contact with elevated temperatures. So, how would you make refer refractories how would you make bricks how to make tiles how to make different types of what to call them as refractory materials. Have you ever seen refractory materials in ovens? Normally, they create a layer of clay and which acts as a very good insulator.

But without that layer, you cannot bake the chapattis or whatever tandoors. So that is a refractory material. So, when you go to the commercial level industrial level there, they cannot do clays only then they have to use the refectories, these refractories have to be tested for their thermal stability, particularly the minerals which are going to use for making these things. So, you will be surprised to know that geotechnics has helped prevent the tile industry.

So some of my projects, which I did for different famous tile companies, quite educative. From there, only I learned what materials to be used to create a sort of a tile. So in this system, quick review for you. What we do is we do control heating of the sample in different environments. And this environment could be less oxygen, or it could be nitrogen. So, normally the heating of the sample is done in 2 different types of environments.

Which is one is you have a free supply of oxygen. So that all the material which has to get oxygenated oxidized. So, second is in the nitrogen, so that nothing gets oxidized. And then what you observe over here is that there is a balance microbalance attached to the sample where you can measure up to the third decimal place of the milligrams also, and you can plot a relationship like this.

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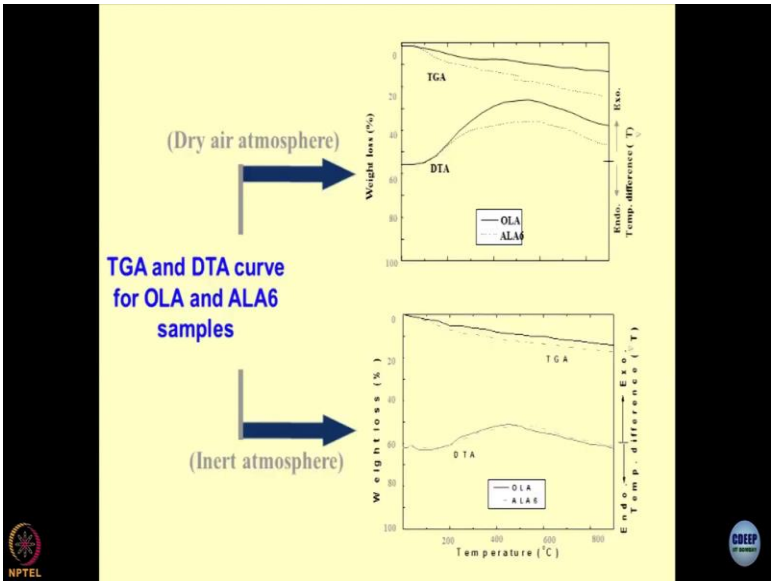

Which shows on y-axis the weight loss percentage, and on the x-axis is the temperature. So, let us first decipher the graph on the y-axis on the left-hand side and the temperature on the x-axis this is what is known as a thermal gravimetric analysis TGA. If you consider the first 2 parts of the graph this one and this one what it shows is as the temperature increases, this side temperature increases x axis percentage weight loss increases, I want to see how much a material can get rid of the moisture which is adhering on its surface number one.

Number two what our chemical reactions which might be happening in the system and I heat it slowly. So, for that, there is other equipment which is known as DTA differential thermal analysis, which is done. So, this is the thermogravimetric analysis and differential thermal analysis. So, as the temperature increases and the increase in temperature are controlled, that means, the rate of enhancement of temperature can be fixed by heating at a certain temperature.

So, depending upon the response which you get, I can define a reaction exothermic or endothermic reaction. So, there are a few soils or few minerals, when you heat them, they might become unstable, and they may start showing you exothermic reactions particularly when they come in contact with water. So, when you are designing different types of systems of importance there, you have to do all this test all right.

So, just to remind you, what we do is we do these type of testing in dry air and in the inert atmosphere like nitrogen. So, that we can compare the results and we can interpret the presence of a different type of wallet and materials in the geomaterials. So, suppose I want to differentiate between different types of coals. This is a very good method. See our subjects has become mostly consulting oriented like where you are to apply your grey matter in solving someone's problem.

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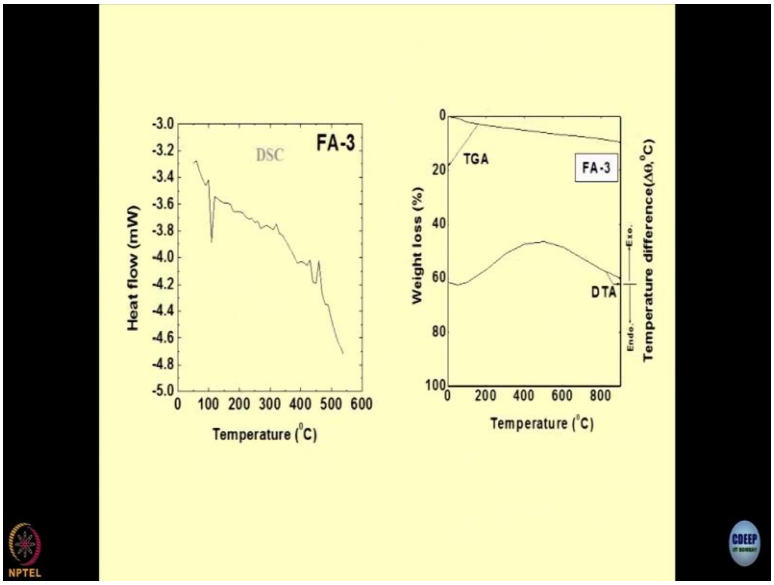

So, I am sure you must realize it is becoming more of diagnostics or the problem diagnostic of a material application of material for solving a situation or a problem. This is modern-day geotechnical engineering is so, if you look at this trend this is what is known as differential scanning calorimetry is another interesting tool which is used and when you talk about when you meet my students like Bhini and all these people who are talking about the phase changes, which are occurring in the materials during how much it goes into the system or how much it comes out of system multi-phase geomechanics when you talk about these type of studies become very

important. Again, it shows the instability of the system. So, if you look at this graph for DSC analysis, differential scanning calorimetry, which is being used by chemical engineers quite a lot at a given temperature, how much heat flow occurs in the material or outside the material?

If I want to see this, you will observe that this material behaves very dubious at a very small just extreme left to the centre given temperature that behaviour is different and on the extreme right the behaviour is different, it has too extreme peaks, these type of materials I do not want in my team, is it not? They may be very dangerous, extremely moody materials. So, I have to observe this I have two ways to eliminate this type of method either I do not select them, or if I select them, then I have to make sure that these materials will always remain exposed to a certain temperature range.

Because they are also you will see that there is a thermal instability. So, a lot of engineering has to be done with the material. That is what the science of technology of the clay minerals is a simple example is a new use different type of face packs on your face realized very freshness why? Because these are the minerals and you put them in water, and when they are at hand on the face they produce an exothermic reaction or another way in the mineral produces exothermic reaction you will be very uncomfortable. So, the minerals which are used for most of the cosmetics are the ones which give you endothermic reactions.

The cooler body most of the talc powders they are of that type so, this is how you can differentiate between the same thing is valid if I valid a barrier system inside the ground by using a mineral and if water contaminant comes in contact with them in them and a lot of heat gets emitted what will happen? The whole soil might get crack thermally crack is not a good situation. So, compatibility of the material has to be checked before you use this material for any thermal application compatibility.

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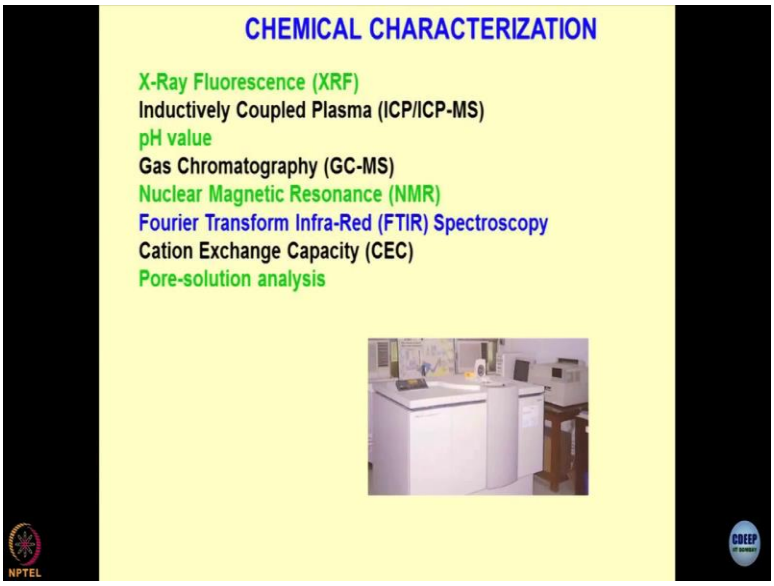

So, now, let me start the chemical characterization of geomaterials. How do you analyze the thermal properties of different particles in the field? How would you react to different philosophically only concrete technologies talk about the heat of hydration, to lisping we should also be talking about innovation? Because chemically cement and soils are saying if you look at the composition, the composition is the same only thing is the presence of certain chemicals is more in cement as compared to the soils.

So, when these type of questions come in mind that suppose if I had to evaluate 2 to 3 materials and if I have chalked out a strategy that whatever materials should be utilized and this is where we talk about the chemical characterization. This is an intricate subject. So, earlier we talked about XRD if you remember X-ray diffraction, now I am talking about X-ray fluorescence XRF. So, the XRF technique gives you the chemical composition of the material, it could be elemental analysis.

And the percentage oxides which are present in the material XRF we call it this is the unit which is used for finding out the chemical composition of geomaterials, rocks, science and science, a different type of admixtures. So, man-made geomaterials that will be in the advantage of geomechanics we utilize ICP extensively what is known as inductively coupled plasma you must have studied in your 10+2 physics, sorry chemistry, I am sure.

So, what ICP units are, they are used for determining the level of contamination of chemicals present in the solution of any geometry there. So, you take geomaterial, dissolve it in water make a solution, let the chemicals or heavy metals which are present in the system leach out in the solution, and then you analyze the solution to get the concentration of heavy metals which are present in. so, there are 2 versions of this testing 1 is only ICP where you just do qualitative analysis.

What are the heavy metals present there is something known as MS Mass Spectroscopy. So, mass spectroscopy also tells you the quantity is quantitative analysis pH is a very important factor as far as the chemical characterization is concerned, and I am sure all of you must have used electrodes which I will show you subsequently to determine the pH of the soil. In present-day environmental geomechanics, we use gas chromatography you must have come across this term GC-MS in environmental sciences course, I am sure you must use this.

So, when the soils are contaminated with organic contaminants, different types of gases or contaminants, which are organic in nature, hydrocarbons, oil-contaminated soils, a different type of organic contaminants contaminated soils and so on. In the present day industrial application, this type is very important so; we get a lot of projects from the industries, where they have to comply with environmental impact analysis EIA.

So, for conducting, these are the tools, and then you are to do a very comprehensive analysis, comprehensive analysis to show that the soils are not containing any contaminants and hence the environmental impact of the process the industry is following. Otherwise, you can submit a report to the agencies which are responsible for monitoring the environment, and they may serve a notice to close it down.

This is becoming a very interesting profession and very interesting. We use some time NMR also nuclear magnetic resonance; it must have studied physics course. This also tells you the type of bonds which are present between the soils and contaminants and the type of contaminants which you have, that can be obtained with the help of NMR. There is something known as FTIR spectroscopy; this is Fourier transform infrared spectroscopy FTIR.

So, these gadgets are very advanced gadgets, and they are utilized mostly to establish the bonding which is occurring between the geomaterials and the contaminants. So these are very sensitive issues when you talk about the environment and norms, we can establish with the help of these gadgets. One of the tests which is done to establish the chemical characterization or the potential of this geomaterials, whether they are chemically active or not, would be cation exchange capacity CEC.

I will be talking about this. This is a simple test. And it tells you quite with accuracy, what is the potential of a geomaterial to interact with the environment, how reactive it would be, how active would be knowledge or solution analysis, how the pore solution can be extracted from the soil. And this is what I enjoyed writing an analogy between blood sampling from the human body that you can take out the pore solution and the way you analyze blood to diagnose the disease and remediation of the disease.

Similar things we can do here once you have the solution of the soils and the geomaterials, what is why the soils are healing, and how to treat them, how to diagnose and how to do that rectification of the disease. These subjects are becoming very advanced, and a lot of gadgets and many efforts are being made to standardize all these things.