Environmental Geomechanics
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Lecture No. 28
Geomaterial characterization-IV
(Morphological characterization)

I have been talking about the characterization of geomaterials, and this is where we have talked about the need for geomaterial characterization, geotechnical characterization, mineralogical characterization.

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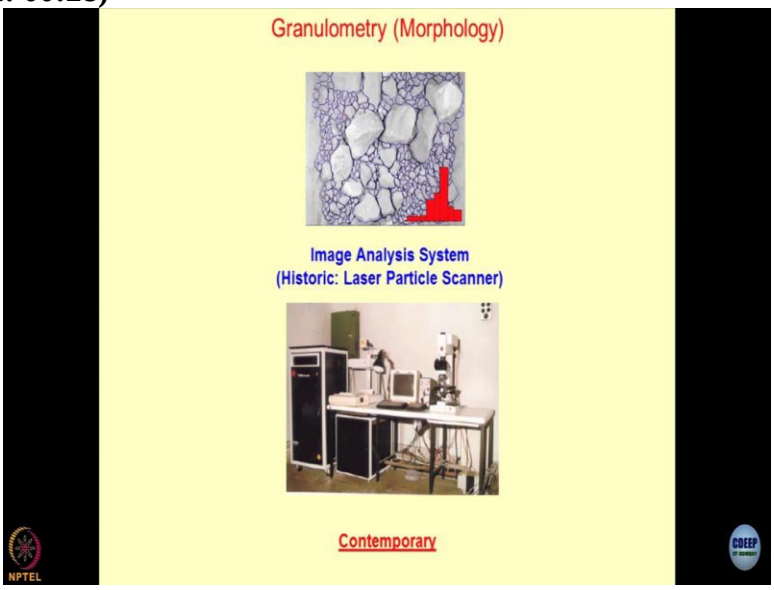

Morphological characterization, the morphological characterization, is also known as Granulometry. And there are a lot of people who are working in this area, very interdisciplinary subject. And you will see now, that this is a subject which is at the peak of its advancement, both in terms of electronics and in terms of applications. So, what I have done is intentionally I have included a lot of gadgets which are being used internationally for understanding the morphology of the soil grains, of course, this is valid for the coarse-grained materials not for the fine-grained materials where the life becomes very difficult.

So, by Granulometry or the morphological examination, what you intend to do is if symmetric of the geomaterial, you have different types of particles, both in terms of sizes in terms of shapes, in terms of their surface features, and then you want to develop a histogram to show how the particles are distributed in this matrix. And this is where the concept of soft scanning, which is known as image analysis terms very useful.

And historically if you see that this is how we started our carrier, maybe 20 years back. There used to be a laser camera and the microscope There used to be a flatbed an on this flatbed you sprinkle some of the particles of the geomaterial and with the help of laser scanner, you can see the morphology of the particle for your information is laser is a least a scattering ray. So, it maps the image of the particle in a precise manner this is historic and now, what exists in the contemporary world is mind-boggling. Just visit the site where you have.

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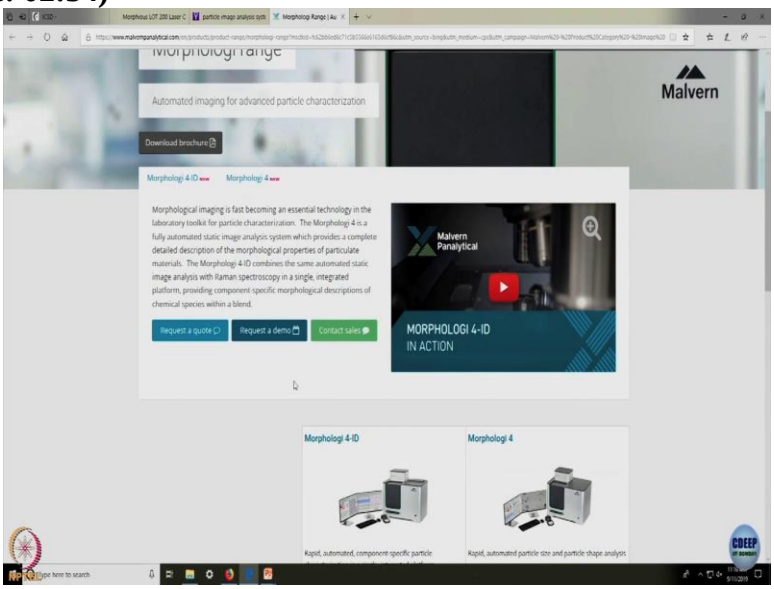

Different type of particle analysis systems, which are available commercially in the market. These are known as the main analyzers or particle characterization. So, gone are the days when people used to do all this analysis, and they used to be happy the type of questions you have been asking in the last lecture, what all can be done once you have studied the morphological features of the particles lot of strategies can be developed. And you must have realized from my discussion in the previous lecture that nowadays, particles are being used for creating additional parking space on themselves in terms of absorbance or catalyst.

So, what I showed you in the previous lecture is on the quartz ball of fly ash, we have deposited by chemical process materials which are highly porous and which provide extremely high parking space for environmental parameters. This could be microbes; this could be cations this could be water, this could be gases, I can park on them at the same time, what I can do is I can include these particles into the soil system so that they will have a tendency to extract all sorts of contaminants from the soils.

So, both ways, you can use these particles. So, this is a very interesting process, which is basically geotechnical engineering-centric, but people from different walks of life and subject are utilizing this. So, if you some whenever you get time, click over this website and you can see, this is the future of particle imaginary have different types of systems which are available in the market. And you can have different types of measurements, chemical identification, particle shape, contaminant detection, particle size, image analysis, morphologically directed Raman spectroscopy and everything can be done.

Very expensive tools, but very precise in today's R and D. Sometimes they also call us 3d or 4d imaging with respect to time also you can measure the processes. So, this is the latest in the particularly majorly right now, some of the few gadgets, which I thought I would show you, which are being used for doing the Granulometry or

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the particle size analysis and these scenes are not ordinary sieves, these are 3-dimensional sieves, which are known as ultra sieves. So, when you come to the lab next time, we can show you how these seams work these are also based on the 3-dimensional motion of the sieves which is generated due to the vibrators located at the base of the sieve sets. And the beauty of this type of systems is that you can do the sieving dry sieving in the inner 125mm to 20µm. 20µm is mind-boggling is it not.

Because nowadays the research is mostly focused on the particles which are less than, 4µm, 5µm, 10µm, which are the most active phase of the geomaterial, which earlier has been ignored completely in conventional mechanics, there is another interesting gadget, which is known as eye wizard, 3D surface laser typography generator. So, what you see over here is that there is a laser beam which is falling on a sample which is kept in a dish.

And then with the help of the laser beams, I can do complete the scanning of the particles. These are commercially available instruments. So, if you click over here, you can learn what these systems do.

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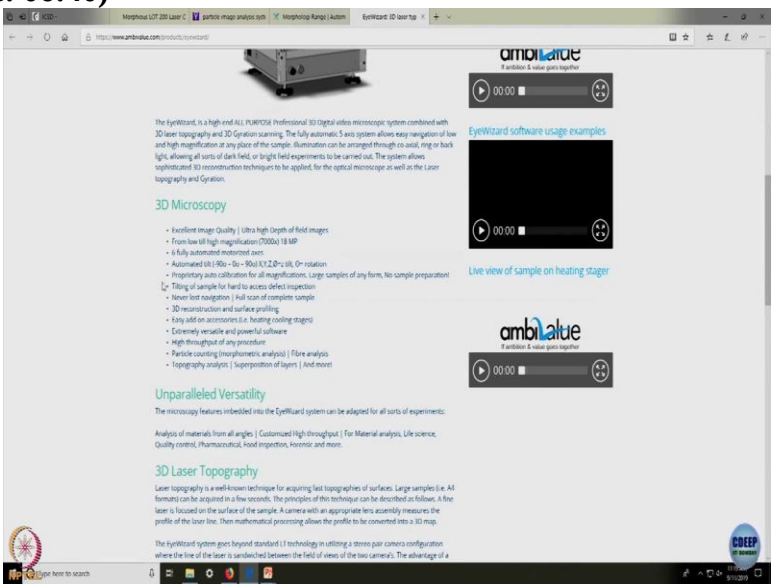

This is ambivalue the name itself suggests that this is the eye vision or eye wizard, they call it so it is a 3-dimensional microscopy, where you can see the features on the particles. So, most of the research is being done to understand the morphology of the grains of the sands. Sands are no

more a black box, everybody wants to realize what are the features on the sand grains and so that I can utilize it as an engineering material, these are the shifts in the subject.

So, you can see this surface granulometry surface features bio influences in the geomaterial, typical type of processes which are happening on the surface extrusions different types of protrusions and all those things can be studied. And as you can understand when you use a laser beam, you can do 3-dimensional sectioning also you can cut the sample photographically or demographically and then you can study the features of the material.

There is another interesting device which is known as LOTM, which is being used and my students have used, and we have published papers also, and this is where we have utilized the concept of LOTM What is this known as his laser obscuration time method, and if you go to the website of equipment, it talks about I can see how the particle.

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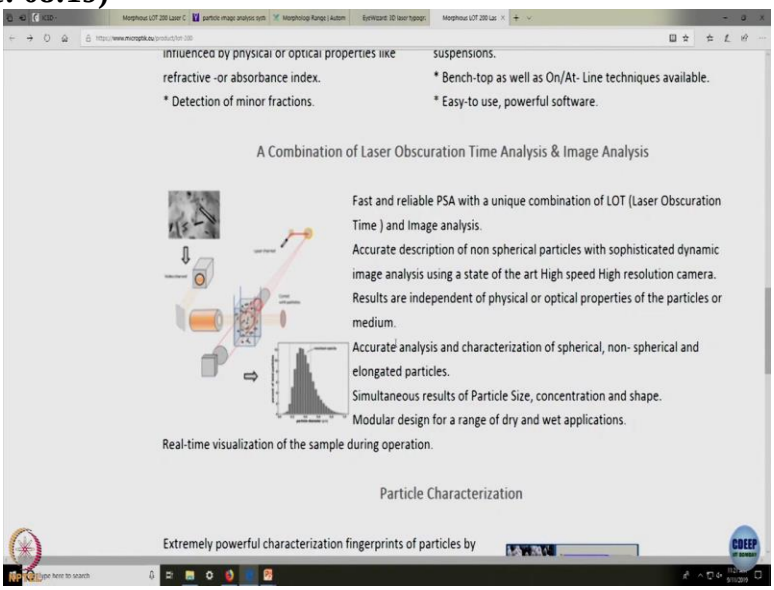

The entire particle can be mapped the way it falls in the water column. So, in hydrometer analysis, you are simply talking about the macro aspect the particle falling in the water column, but here if I want to see the surface from all the sides, and the features of the particles that can be captured, these are all tools for advanced characterization of geomaterials, geomaterial geotechnical engineering is not so obsolete as people think well.

This is the branch of civil engineering, which is quite advanced and keeping, pace with the time how things are changing and how the whole applications of different concepts are becoming more and more demanding.

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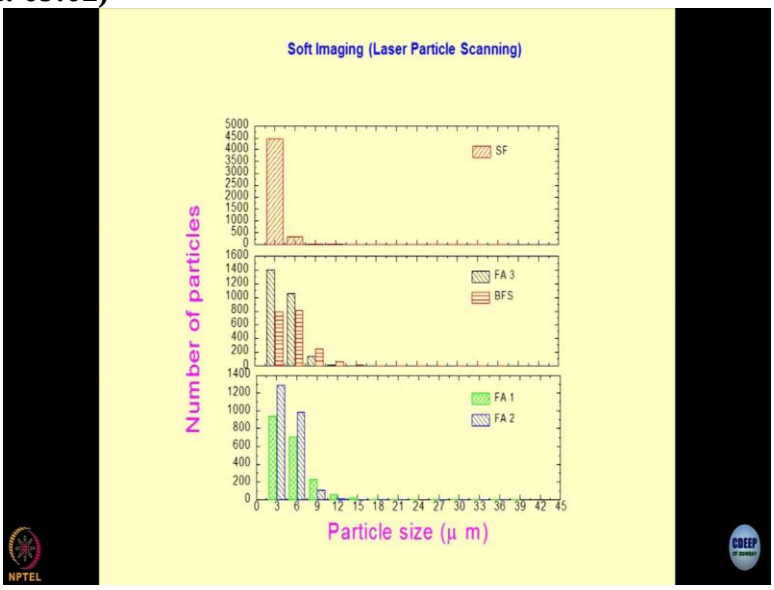

The typical result of the laser particle scanning, there was a time when my students are to sit down, and they used to count 5000 4000 6000 particles which cannot believe takes control volume of the sands and any geo material used to spread it on that laser particle scanning system. And now you can see on the y-axis mentioned clearly how many particles have been counted and what is the particle size.

Very soon you will realize that a lot of limitations of hydrometer analysis and one of my student Dr Shanta Kumar, he has published a paper in an ASCE where we have dislodged the concept of hydrometer analysis, we have written that it should not be used. And the simple reason is that you are allowing the interaction between water and geomaterial, which alters the properties of the material and hence, the results which you are going to get from hydrometer does not look realistic.

So, these are the shifts in the recent world where even particle size, which appears to be a very routine and mundane exercise is becoming so intricate. And the reason is very simple because the industrial applications have become tremendous, and people are using this concept of packing of particles to create a different type of objects.

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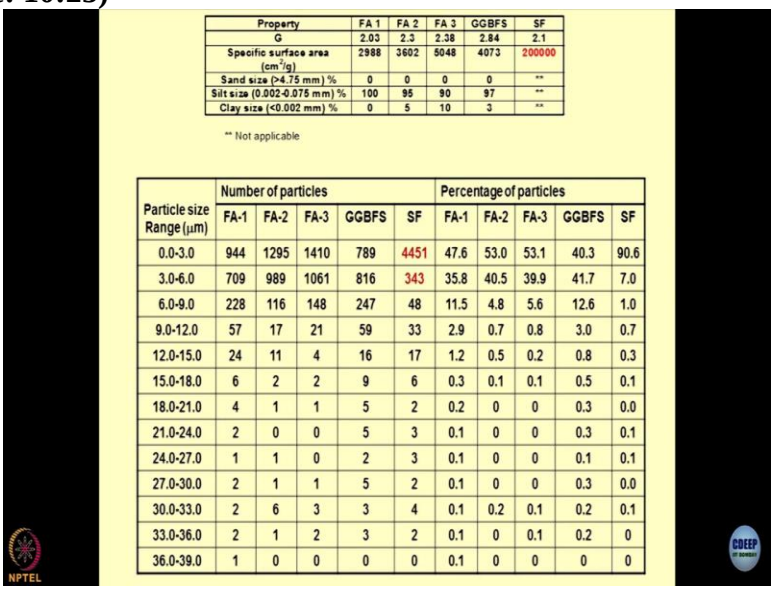

Property	FA 1	FA 2	FA 3	GGBFS	SF
G	2.03	2.3	2.38	2.84	2.1
Specific surface area (cm^2/g)	2988	3602	5048	4073	200000
Sand size (>4.75 mm) %	0	0	0	0	**
Silt size (0.002-0.075 mm) %	100	95	90	97	**
Clay size (<0.002 mm) %	0	5	10	3	**

** Not applicable

Particle size Range (μm)	Number of particles					Percentage of particles				
	FA-1	FA-2	FA-3	GGBFS	SF	FA-1	FA-2	FA-3	GGBFS	SF
0.0-3.0	944	1295	1410	789	4451	47.6	53.0	53.1	40.3	90.6
3.0-6.0	709	989	1061	816	343	35.8	40.5	39.9	41.7	7.0
6.0-9.0	228	116	148	247	48	11.5	4.8	5.6	12.6	1.0
9.0-12.0	57	17	21	59	33	2.9	0.7	0.8	3.0	0.7
12.0-15.0	24	11	4	16	17	1.2	0.5	0.2	0.8	0.3
15.0-18.0	6	2	2	9	6	0.3	0.1	0.1	0.5	0.1
18.0-21.0	4	1	1	5	2	0.2	0	0	0.3	0.0
21.0-24.0	2	0	0	5	3	0.1	0	0	0.3	0.1
24.0-27.0	1	1	0	2	3	0.1	0	0	0.1	0.1
27.0-30.0	2	1	1	5	2	0.1	0	0	0.3	0.0
30.0-33.0	2	6	3	3	4	0.1	0.2	0.1	0.2	0.1
33.0-36.0	2	1	2	3	2	0.1	0	0.1	0.2	0
36.0-39.0	1	0	0	0	0	0.1	0	0	0	0

So, if you sum up all these things, you will get a table like this, where you will get the number of particles and percentage of particles and these is fly ashes of different types GGBFS if you remember ground granulated blast furnace slag, and the silica fume, is a very fine powder, but even then we could do the softest scanning imaging. And what you will observe is that most of the particles fall in the category of almost less than 3mm. We are typically you would have liked to use micrometre but because of the specific gravity of the material, you cannot use it meter because silica fumes are very light as compared to water.

So, you cannot allow them to settle in the water GGBFS The problem with this is you will realize very soon that this has self-cementing properties, it has a lot of calcium oxide in it. So, the moment it comes in contact with water, it sets it pumps lumps, and hence the GGBFS can also not be characterized by using hydrometer analysis. Just a look at the other properties, if you see the specific gravity of the flyer shares could be varying depending upon their source and composition GGBFS shows very high specific gravity and silica fume shows very low specific gravity, but not the density is absolutely low.

What I wanted to show here is that if you compare the specific surface area, it will find this very surface area of silica flumes is extremely high is it approximately 20 m^2/g imagine is a 20-meter square that is approximately 4.5×4.5-meter area, per gram of the sample. So, this much activity

the material shows because of its inherent characteristics because of the mineralogy or because of the surface features.

How do we get rid of the population before counting the actual number of particles, you have to spread them as thin as possible so, your point is correct. So, if you read Santha Kumar paper, you will realize that we have used some plastic balls to break the clotting of the particles. And that paper is published in ASCE where we have shown the particles of admixtures which are charged, like fly ash, silica fumes, even sieving cannot be done. Because the moment you do sieving these particles form clots.

So you use some external materials to break this clots at the time of sieving it is a beautiful paper, characterization of fly ashes and something written by Santha Kumar in ASCE Journal of Materials.

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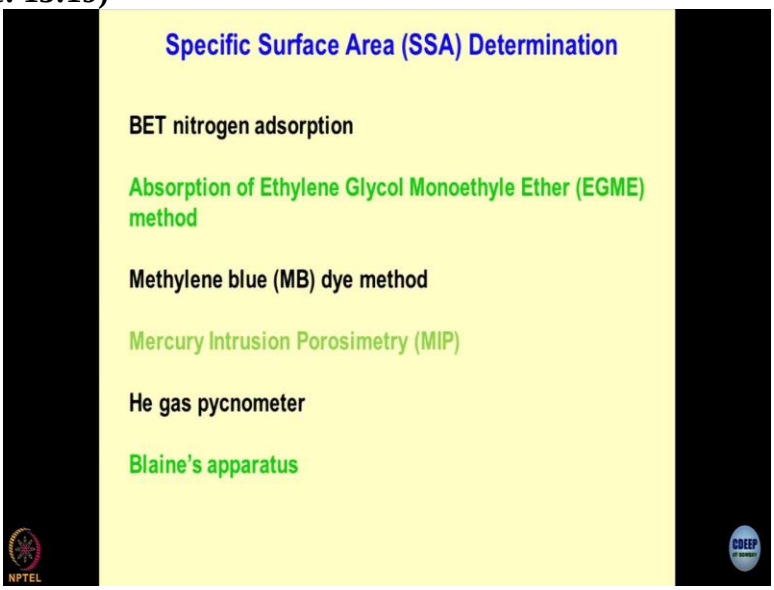

Now, let us talk about the physical attributes of the particular physical characterization. So, in physical characterization, the most important parameter is the specific surface area. And because this precise surface area is the parameter which guides interaction between the geomaterial and the environment or even water, so, anything if it has to interact with the geomaterial, the first thing which becomes important is specific surface.

So, this is a very important parameter in normal geomechanics lot of efforts have been done to capture SSA of the material optimal again this is very high-end equipment, very sophisticated instrument which is known as BET nitrogen absorption method why nitrogen gas is being used because this is non-melting liquid for non-reactive fluid. And the basic concept is the way you use spectrometer bottles. So, you wanted to find out what is the volume of water displaced by a certain weight of the geomaterial, and that is what you use to convert into specific gravity.

The same concept is being used here rather than using water they use gases to interesting, effects; one is the molecular size of nitrogen gas is extremely small. So, this can penetrate into the material into the smallest pores. The second thing is in a non-melting fluid. So, basically, you are forcing nitrogen gas to enter the surface and the pores of the particle and then from there you can compute what the surface area of the material is. I am not going into the details of these techniques because as in when you require, you, please follow the codes or the procedures which are specific for an instrument.

But in today is world everything is electronically controlled, and life has become simple. The second method is what is known as EGME, and this is the absorption of Ethylene Glycol Monoethyl Ether EGME the excellent paper which is written by Dr Dali Naidu He is a faculty member at IIT Delhi sorry at Chennai, and he was the author of this paper, and we have compared their different methods of surface area computation and we have shown which method is the best.

So, it is so happens that when you coating of each particle of the geometrical by using EGME, it is a sort of a dye then EGME tends to give you the total surface area of the total means the one which is exposed to their posture or environment and the second area is internal because EGME dye penetrates through the particle and it gives you the total surface area of the geomaterial. Read the paper if you are more interested in knowing how the entire things is done.

There is another method which is known as epsilon blue dye method submits and B is also a dye, and this principle is the same. You mix MB dye with a geomaterial of non-weights and then put it for evaporation beneath electric bulb energy is good enough to accelerate the evaporation

process of can be whatever gets retained on the particle can be identified by using a sort of a spectrophotometer you must have used in your environmental engineering lab photos spectrometers.

So I can calibrate for the known concentration of MB dye and what remains absorbed onto the particle, I can do mathematical computations and I can find out what is the surface area, more advanced technique for finding out the specific surface area would be MB is also in our laboratory. And in our laboratory, we follow all these methods depending upon the material. As the name suggests, the mercury is intruded in the particles at very high pressure.

And this I will be teaching you separately also when we discuss the pore sizes distribution of the geomaterials and mathematically I can find out what is the sulfur surface area there is another one which is known as helium gas spectrometer. Helium atomic size and dimension is much smaller than nitrogen also. So, for extremely fine particles, we try to use helium in place of water because of the density contrast and because of the non-wetting fluid.

So, helium gas spectrometer also gives you the surface area of the particles. These are techniques which are being used. Yes please **"Professor - student conversation starts"** in one case we are using the lighter method nitrogenous another case we are using completely different techniques. Gases cannot be compromised at high pressure because they are liquefied. **"Professor - student conversation ends"** So when you are applying pressures intrusion process. So, when you are forcing fluid to enter into the force to take care of two things, one is poor structure does not get altered.

And the second thing is the fluid which you are forcing in at very high temperature does not get liquefied. I hope you understand this. So, these are different issues, different techniques. So, depends upon what is your objective, but I read this paper by Dr Dali Naidu it is SSA determination of soils and we have compared all the methods for different geomaterials, and we have established that which method is the best.

Do we have to do which method how do we know? Well, so the best thing we you perform all these tests on different types of soils and then apply logic which one gives you the correct result? Unfortunately, in R and D, you will realize very soon that there is nothing known as an absolute test or absolute methodology. So, a lot of judicious thinking has to be done to make things, prove by the International identities. Because each of these methods would have their own limitations and their own pros and cons. So you have to understand all those things first.