Environmental Geomechanics
Prof. D. N. Singh
Environmental Geotechnology Laboratory
Department of Civil Engineering
Indian Institute of Technology-Bombay

Lecture No. 27
Geomaterial characterization-III
(Morphological characterization)

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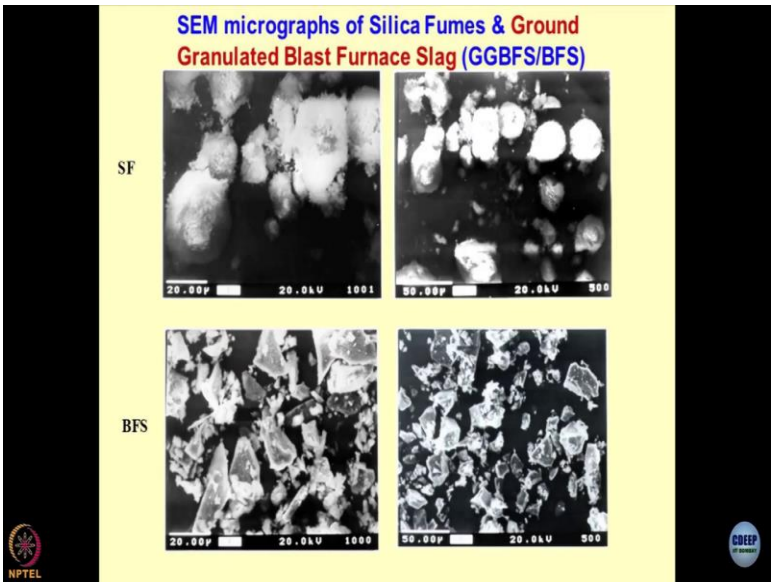

This is a view to show you how the most of the geomaterials which are man-made it looks like we have been talking about blast furnace slag we have been talking about the silica fumes and so on the previous lecture and one obvious question and if you want to understand how to use a material for it for a specific project, you have to look into is microscopic structure. So, we were quite excited to see that silica fumes look like this. Remember sometime like I said that these are very light material, specific gravity would be .5.6.7.

So, transportation is a big issue as we discussed in the class why this happens because if you look at the surface of these particles, these are very furry structures, they have protrusions on the surface. And these protrusions or the furze they create these materials very light and airborne. So, one of the significant issues associated with silica fumes is that this material becomes airborne and people may inhale it and because of high activity of silica if it goes in your lungs,

what it will do, it will suck all the water from the levels it will produce dead cells in the lungs. It could be cancerous.

So, these are very hazardous materials so, industrialization versus the health of the people and the environmental chaos. If you are trying to understand these type of things become useful. We were dealing with the blast furnace slag also in a big way because in some of my storm physicists, we have been talking about blast furnace slag as a man-made resource, and rather than mining for calcium from the mines, I wanted to use the calcium which is present in the blast furnace slag.

So, we were thinking of a process by with the calcium oxide can be extracted from the slags. Now, this is a very philosophical word, I mean, I might not be able to take out calcium oxide, but what I can do is I can break calcium in the ionic form. And I can remove that is calcium ions from the system and induce them into the marine clays on this concept Ganaraj has a patent where we have used the new material for stabilizing the marine clays. And if you follow this, as you will realize we published a paper also on, I think these are the materials which are non-chemical stabilizers.

Nowadays, you cannot insert a chemical inside the ground; that self is hazardous. But in the long run, these chemicals will react with the wrong water, and they will get transported from one place to another. So, these type of teams is coming in ground modification, soil augmentation, soil rejuvenation. And remember my dream project this man-made soils, so I wanted to create my man-made soils. I do not want to use natural size because these resources are quite limited.

Now how to convert all these industrial byproducts and the waste material into a resource is a challenge which you are trying to address and work on. So, the blast furnace slag usually looks very angular. Remember, this comes out of the steelmaking process and then once you grind it, pulverize it, it becomes GGBFS that is a ground granulated blast furnace slag which is cement and very active cement, and you can create PPC out of it by substituting in 30 40% of PPC.

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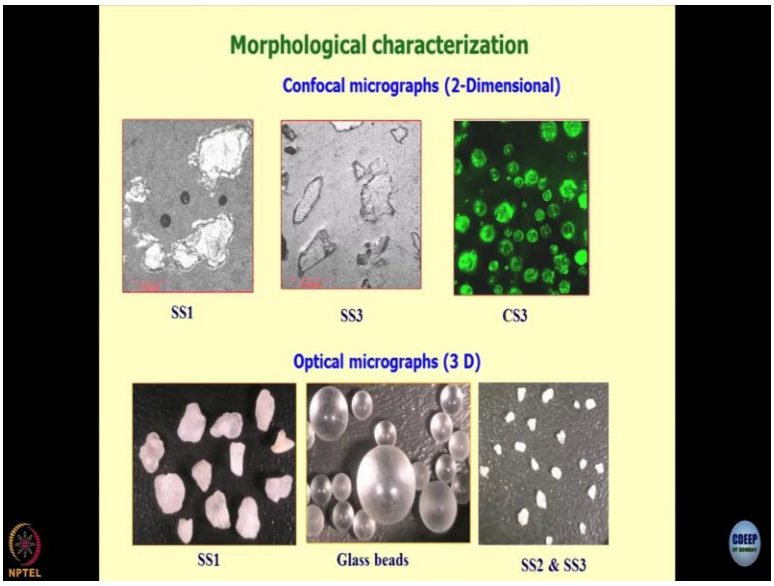

Now I will discuss the morphological characterization of geomaterials; morphological characterization is basically shape, size, dimensions, regularity, irregularity. So, normally morphological characterization is done by using two techniques, one is a 2-dimensional technique, and another one is the 3-dimensional technique. And you will be surprised to know that we have shown that will be velocities and the liquefaction potential of the sands and the shear strength depends upon the morphological features.

So, these are the thoughts which take the subject of what exists. So, the standard science which you are using and which you are teaching to undergraduate students by saying that these are standard spherical materials do never question how spherical they are; we question this. And to our surprise, we realized that these standards and which you use as spherical materials are truly like this, none of them is a perfect this sphere, these are as flaky as possible.

So, these are the 2-dimensional sections, you take the particle and cut it, and then you take the images. Micro-morphically the material looks like this. So, SS1 is the coarse sand SS3 is the fine sand, and these are the spheres which have peculiar characteristics. In 3d, if you do the imaging, these are normal optical micrographs. This is how science and the glass bridge looks like.

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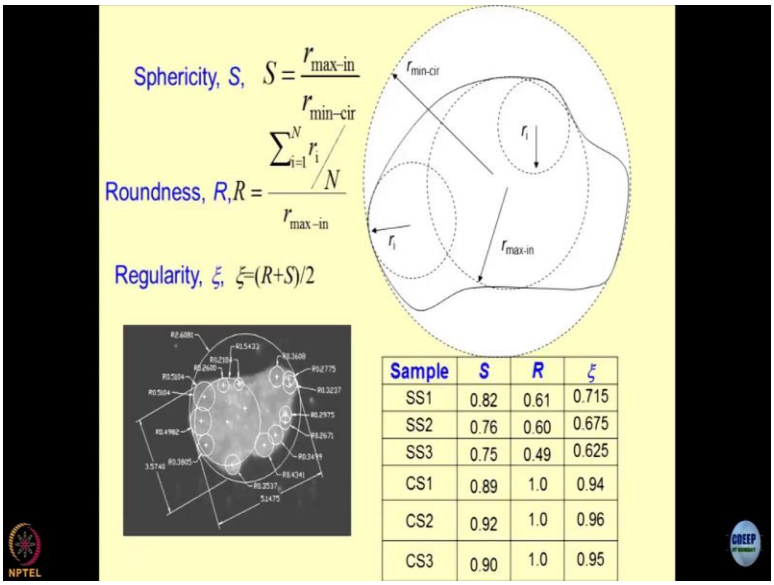

Sample	S	R	ξ
SS1	0.82	0.61	0.715
SS2	0.76	0.60	0.675
SS3	0.75	0.49	0.625
CS1	0.89	1.0	0.94
CS2	0.92	1.0	0.96
CS3	0.90	1.0	0.95

What we have done from this information is we went too much into the morphological characterization of the material. Each grain has to be photographed. So, what you see over here is this is one of the grains of the sand on which you are working. And then we inscribe as many circles as possible, it is a game of patience, you have to sit down and analyze each of the images which you take and then one circle has subscribed the particle, and once these dimensions are known, you can define this veracity roundness and regularity of the particle.

So, this is the best way to characterize the morphology of the materials at the microscopic level. So, I mean, I would not go into the details of all these things, if you are interested please read the papers which are written by Anjan Patel and Prasad Bartake. We have used this concept also to define the crushability of the sense crushability of the particle or the crushing strength of the particles, what they call it is crushing and strength, a lot of application in different industries right now, I mean, you should appreciate one fact that industry understands that we are the experts in the minerals and soils.

So, they approach you having in full faith that you are the only one who can solve their problems. So, where these type of issues become useful Rheology? Yes, if during site investigation, the data is very erratic, so, can we use like for a certain type of area, the morphology of the sense we can say it more or less the same. So, can we use it use this morphologic characterization to predict the behaviour of my like given area engineering

behaviour. It depends upon whether you are having an outlook of macroscopic models or microscopic model.

So, this is an interesting question that how particles of random sizes and shapes would create a metrics through which let us say this can be compacted through with the percolation of water may take place or through with shear wave velocity will travel it will travel contaminants will travel and so on bacteria will travel. So, these are the questions which you have to really sit down and plan the crushability you just have to focus on engineering behaviour macroscopic mechanical like can for a given area from the morphologic point of view can predict the sphericity is very close to unity one, that these slides are going to liquefy very easily because you cannot compact them.

So, everything is related to the RD value, relative density, e_{max} and not only to that even your friction angles internal friction angles are also a function of the true friction angle plus dilution angle plus-minus depends upon how you are defining this what do you call it as interested know, how all your defining that true friction angle would depend upon the dilution angle and the real friction angle asperities angle of asperities. So, angle of asperities of to get added up to the friction angle or it has to be subtracted depending upon how the shearing process taking place.

These are the micro detailing of the materials, which conventional geomechanics also talks about? This is what R&D is where you go too much into the details of the material and try to see this, but these are very simple ideas but later finally realized that they have a lot of application industry. I might have done several projects from the companies which make glues, adhesives to place different types of pumps which are packed in the tubes because ultimately it is all rheology, different types which you use for sealing the cracks of, the in the corporate and so on.

Becomes very interesting **"Professor - student conversation starts"** that this morphology data can be used for already existing structures. I mean for like their liquefaction several papers if you check it on the net where now people realize how shear wave velocities would depend upon the 3 parameters sphericity, roundness and regularity. So, truly speaking these 3 parameters are defining the morphology of the material quantified form. **"Professor - student conversation**

ends" So, V_s is the function of s r and epsilon. So, RD the function of all they see there is a shift in the concepts which you have been studying in the basic soil mechanics.

I am sure that somebody must be working on RD as a function of all these parameters, not only e_{max}, e_{min}. Because e_{max}, e_{min} would have been a gross in just with the material. I hope you can realize. So, when you redefine the system. Then the interesting thing is those who are designing chips for that IC circuits where you are packing the spherical particles. So, what you see macro-level compaction, is going on at nano level and they are also a spherical particle.

So, how would you compare the spherical particles at that level? And what type of distortions and defects can come in the system is a very big subject where the electronics guys have to sit with us to learn the theory of compaction theory of packing up the nanoparticles because see we are experts we have learned maximum below how the particles can be packed or they can be compacted. If they are round like their void ratio cannot be less than .3.34.35. So, if there is some alteration like if, it is not perfect around that you can take below it I mean, once you understood the concepts.

How are you going to give a solution, I do not know whether you guys realize this or not the new concept in the market liquefaction is being tackled by purging gas bubbles, they create the specific size of bubbles in size, which are liquefied. So, what is bubbles are going to do they act as a spring between the sides. So, when the earthquake comes, as if you have introduced some sort of shock absorbers and hence the particles will not liquefy a lot of papers which have been publishing these concepts.