Environmental Geomechanics
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Lecture – 23
Application of Industrial By-Products - I

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In today's lecture I wish to talk about the application of industrial byproducts. This is becoming a very contemporary topic though a lot of research has been done in the past also. But the main thrust area is how to deal with the industrial byproducts, how to utilize them, how to handle them, how to dispose them, how to transport them and so on. So in this quest of dealing with the industrial byproducts I have created a memorandum of understanding with CII and our lab has been converted into a laboratory for geoenvironmental research innovations.

The main theme is that to appraise the industries what are their issues, how they should be dealing with and having done a lot of research in this context the focus is to create policies for the country through the central government. So I am sure you will realize that based on my discussions in the earlier class people are aware of the problem. But the main question is who will bell the cat.

So this is where my endeavor is those of you who are interested in learning of about what is happening in this context you can visit the website. Now the subtopics which I intend to cover here are what are the applications of industrial wastes or byproducts. As I said in the previous lecture, we do not use the word waste anymore these are the byproducts we talk about fly ash, silica fumes, rubber tires, glass aggregates, dredged material.

And from here the question would come before I start utilizing these materials how would I understand what their potential is how they can be utilized in the modern-day concept how value you can be added to these materials that is the valorization and this is where our lab has been working in the concept of pursuing the concept of man-made soils also which I was talking about some time back.

Now how to decide whether a certain industrial by-product is useful for a certain application or not this is based on a series of tests which are done, and this is where I will be discussing in details from next lecture onwards the ways of characterizing the materials, geomaterials and these materials could be man-made or these could be naturally-occurring. So the characterization schemes remain same and from this point onwards the idea is to create value addition to the geomaterials.

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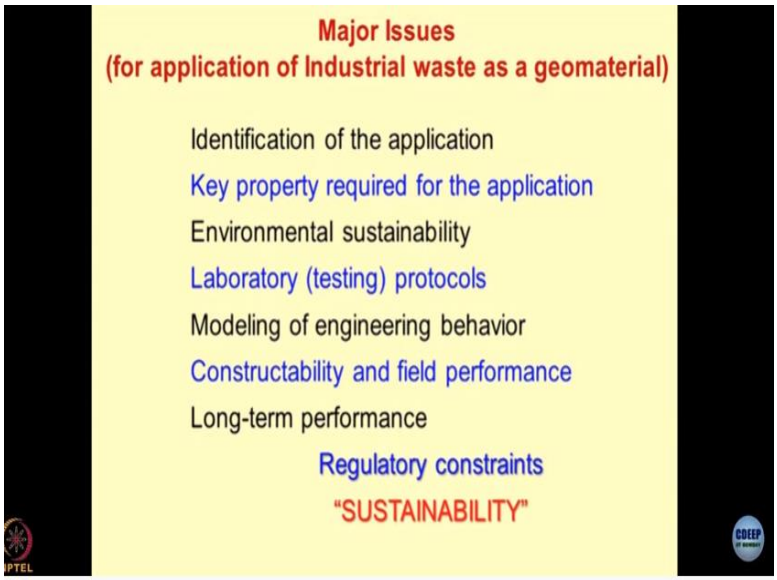

So first we start talking about the industrial byproducts the question is that what are the major issues which are bothering us and before I start using the industrial byproducts as a geomaterial man-made geomaterial. The first thing is that identification of the application is not very clear. So we have to create this we have to create the applications for a certain industrial by-product.

You must have realized that. I have been talking about mine tailings, I have been talking about the mill tailings, I have been talking about the slags which are coming out of the industries, red mud I think I discussed about in one of the lectures which is coming out from the refineries where the alumina is being extracted from the bauxite. Similarly, the minerals which are being processed from the mines these are major issues like the volumes of industrial byproducts must be in trillions of tons all over the world and humanity is facing a big issue.

Now what to do with this and this is where the identification of the application becomes very important. Second is I will be requiring the key properties of the geomaterials before I can use it in conventional geomechanics we talked about coarse grained material, fine grained material and we differentiated between the soils. So something of this sort has to be done in case of industrial byproducts also that we have to understand their key properties.

What are the key property then how to use that property as a positive of the material strength of the material and at the same time I have to understand what are the negatives or the weaknesses of the material? As far as weakness is concerned this could be a threat to environment geoenvironment. So, we have to make sure that the material when it is utilized for any application should not be contaminating the geoenvironment that is the main area main thing to discuss.

We had also talked about the environmental sustainability. Sustainability is the key word in today's society contemporary world we want sustainable solutions we are discussing about this in the previous lecture also how to make a sustainable situation and talk about this in details today and then what are the testing protocols which can be developed in the laboratory.

So when you are treating a material as a new material you have to understand how this system is going to behave under a given circumstance what will be the response of this material to different energy fields. So we have to perform laboratory experiments to develop the protocols sometimes from laboratory we might have to take these results to the field also then we have to model the engineering behavior and this engineering behavior can be modeled in the by conducting suitable laboratory experiments.

Shear strength is a good example of what is the engineering behavior of a geomaterial compressibility would be another consolidation characteristic would be third one compatibility would be another permeability could be another engineering behavior plasticity index could be another engineering behavior heat migration through the material could be another engineering behavior and so on.

Then the question is that when I am selecting a material major issue is the constructability issues and how the system is going to perform you remember long term monitoring which we were talking about some time back whether the system can be constructed or not. It may so happen that the industrial byproducts which you are using are lighter than the native soil or at the same time they could be heavier also. So when we talk about let us say slags where the specific gravities are extremely high 3.5, 3.6, 3.7 as compared to these soils which are of 2.6, 2.7.

Then the question is how to balance these two systems the industrial byproducts sitting on the soils and this is where the geo mechanics of the contacts interaction again starts. So, field performance is a big issue, constructability is a big issue long-term performance is another question how the system is going to perform in the long run. So, if I am utilizing the dredge materials for making the roads.

I was talking about in the previous lecture there are beautiful examples of land creation in the country and we discussed about some of the projects in the last class. So, the question is that if a system which is with the geomaterial which are not similar to the naturally occurring your materials if I am using them for doing some engineering how would they behave in the long run particularly their decay decomposition deformation disintegration.

So all these terms become very important when we talk about the long term performance. So this is a big challenge I am sure you must be realizing that I have opened up the pandora box and these questions have to be answered by scientists and by the industry guys by the planning commission guys in the country and each and everyone in the society then comes the regulatory constraints.

"Professor - student conversation starts" sir my question is like can we accommodate decay like can be allowed decaying of the material or we always have to shield against decaying see previous lecture I gave you an example where I wanted to shield the material again decaying by cutting off the oxygen supply. But there could be lot of situations like MSW municipal solid waste, landfills where you want them to get decayed.

If I have to use this for a engineering purpose let us say for a road construction or a railway embankment, then that I cannot afford like my question is I cannot afford to correct. So then I think you have to do something of the sort which I told you in the previous lecture that you have to shield it against the environmental actions and decay which is induced because of the environmental activities "**Professor - student conversation ends"**.

So regulatory constraints become very important before you do a planning of how you are going to use the material and most of the time these regulatory constraints are from the pollution control boards or from International Atomic Energy if you are dealing with the nuclear waste IAEA International Atomic Energy Association. So when you are talking about the nuclear waste these type of agencies are there.

Otherwise domestic waste, industrial waste CPCB, MoEFCC in India these are the organizations which take care of this a lot of NGOs which are taking care of the activities of the government and the industries and they are trying to put them on the right track. So regulatory constraints could be of different types then comes the question of sustainability which is very big issue how the system which you are trying to develop is going to be sustainable or not.

So I am sure you can add lot of other issues here in this list and make it more robust. The volumes of the industrial byproducts whether they are available or not for a particular application their transportability is another question and so on. So when I was dealing with the airports design and the reclamation in the sea particularly in Bombay city, I wanted always to bring this material from other parts of the country but then there are issues related to the economics time and so on.

So the huge reclamation which has been done to create Navi Mumbai International Airport and I was a consultant.

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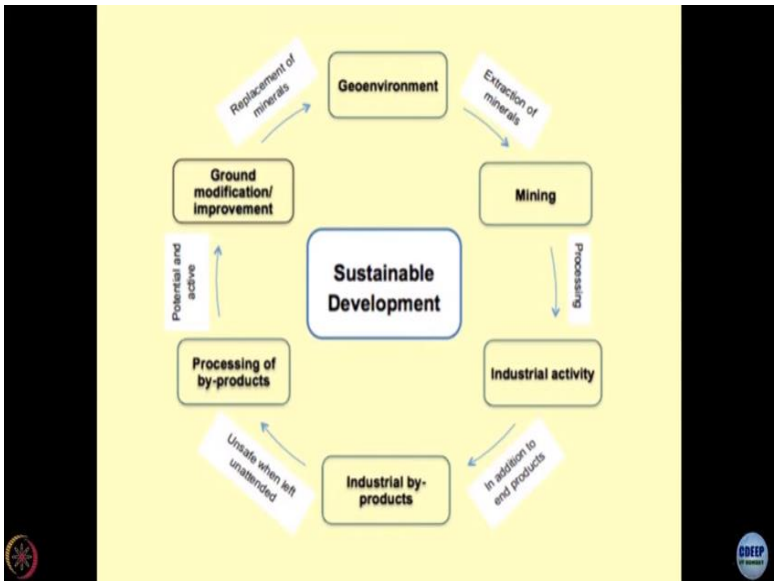

So if you look at the sustainability cycle this is how the sustainable development looks like and on this concept some of my students have already worked. So please check out the thesis by the Prathyusha Jayanthi, Ganaraj who is still working on this, but he has published papers where we have talked about the utilization of K Ganaraj. So where he is talking about how to utilize the mill tailings mine tailings for sustainable development read these papers which have been published in very good journals.

So if we talk about the sustainable development what it is we have geoenvironment and basically this is the soils, rocks, ground water and mining activity is number one it leads the entire issues associated with what we are talking about so when you do extraction of minerals by mining you

do processing of the minerals industrial activities and you produce end products by products. These are known as industrial byproducts which you are talking about these industrial byproducts are unsafe when you leave them unattended.

We have discussed about several issues stability is an issue, leaching is an issue, fire is an issue, mosquito breeding is an issue and so on. So what you have to do is you have to process these byproducts and if you can utilize their potential and you can activate them you can use them sometimes for ground modification and improvement also and then what I can do is this type of an activity is a sort of a replacement of the material which you mined out and whatever left over again it is going back to the geoenvironment.

So this becomes a complete cycle of sustainable development. Now this concept seems to be very interesting right now and, in our lab, we are actively working on rejuvenation of soils which are barren, or which have low fertility. Idea is by utilizing the industrial byproducts you can create a situation which could be a win-win situation for everybody. However, a lot of research is required in this area.

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So if you go back to the history of civil engineering pozzolana is something which is known to everybody. Mostly pozzolana is the material which has come from a place in Italy called Pozzuoli and the property is that if you add few drops of water it sets it becomes hard cement is a

pozzolana fly ash is also pozzolanic material depending upon its fineness its activity and so on and the percentage of life in it.

In Hindi in the northern belt we call it Surkhi I do not know what about the local language which you use in other parts of the country. So if you compare the activities of the natural volcano and the man-made volcano, I think you will realize that this processes are quite similar. Therefore, yesterday was talking about the industries which are emitting lot of dust, ash fumes in the environment and what volcano does?

Volcano also does the same thing there is a lot of similarity between what nature does and what we are doing as far as the influence to the geoenvironment is concerned. The issue is simple the sediments which come out of volcanic activity which they are deposited after the lava is formed or before the lava is formed could be rocks or could be the fine dust which is very fertile and here whatever we are creating in these industries is the sort of a fly ash, slags they could also be nutritious.

And if you go through the published literature you will realize that lot of work has been done to show that fly ash have lot of nutritional value and there is no surprise because our villagers and the farmers are quiet intelligent and they have been using ash for rejuvenating the lands if you remember this is a common practice after every crop they incinerate the residues they mix it with the soil they make it more fertile because after incineration NPK gets balanced in the soil nitrogen phosphorus potassium magnesium and all sorts of minerals.

So this happens to be an interesting material on which people are doing research of course this becomes an interdisciplinary area where a lot of bio-geotechniques and material science geotechnical engineering applications, concrete technology, process engineering is being taught about.

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I am sure you must have come across different types of application of the fly ash. So normally people have used the fly ash for stabilization of roads increasing their CBR pavement and subbases their properties. People have used fly ash for reducing the swell pressure of the soils so by addition of the ash into clays and particularly the clays are swelling type you are neutralizing the swelling effect as well as very high liquid limit and plasticity index.

So this is a very interesting application which people have been practicing since long and once you do the plasticity modification the material becomes better for compaction. CBR modification is one of the good examples of how the fly ash have been used for creation of pavements and nowadays they are using this material as the fill material for embankments particularly RE wall.

So in the absence of the granular material what people have been doing is they take the granular fraction of the fly ash which is lying either in the ponds which are known as lagoons or they filter out the coarse fractions which is sandy silty fraction or sometimes the bottom ash which is available in the hoppers is utilized for this purpose.

So I have been associated with the big business houses of the country where we have established that the fly ash which is lying unattended can be utilized as a sustainable construction material for different applications and good example was I got a project from BSES, now its reliance

energy and the question imposed was that can be decant the fly ash ponds to accommodate the fresh ash which is coming out of the units.

So these type of discussions and these type of engineering practices are being done in the country these are good examples of the application which you were talking about people have used fly ash for creating different types of cement mix also and fly ash is used in creating the PPC also Portland pozzolana cement by blending it with the OPC.

So this is prehistoric lot of research has been done nothing but subsequently when I talk about the material characterization, I will show you what type of chemical processes which we have given to the fly ash to convert it into much more value-added material and this is where we will be talking about the cation exchange capacity enhancement of the fly ash by hydrothermal treatment.