Geotechnical Engineering I
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Lecture-04
Classification of soils-II

So, we have been discussing a lot of things regarding geotechnical engineering one starting from origin of the soils and rock cycle, different type of soils, their classification system. We have talked about how do they originate, how do they get formed and how do they get deposited. Now, in today's lecture in continuation with whatever we have been discussing, I will give you some examples of the transported slides which are quite useful in modern day geotechnical engineering.

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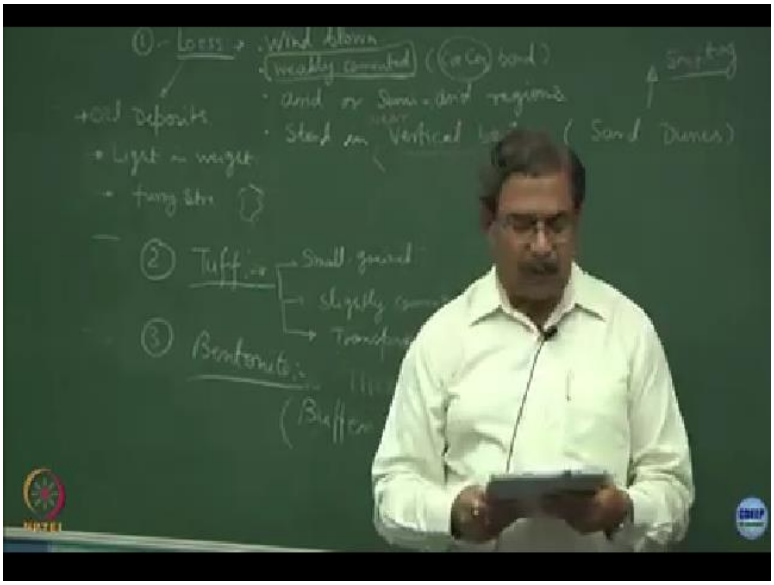

So if you remember geological we had differentiated between 2 types of groups, one is transported another one is residual. I think I cited examples of residuals soils. And in today's lecture I will be talking about the transported soils and some of the examples. See the first category is loess. We discussed about this in the last lecture also. So truly speaking these are the wind blowing deposits, sometimes we also call them as aeolian. They are weakly cemented for all practical purposes these are the used materials.

And when we talk about the cementation mostly this is the calcium carbonate bond, sometime back I had talked about why dessert sands can be utilized as the construction material, particularly in concrete. I think now you can get the answer that most of the aeolian deposits are the loess soils, they have weekly cemented calcium carbonate bonds and this calcium carbonate can be utilized for making concrete alright it because of the pores in city.

Normally, these type of soils are form in arid or semi arid deposits. So arid regions are the ones where you have dry climate particularly like deserts. And the beauty of these types of deposits is that these deposits stand in almost vertical banks. So, most of these deposits are almost vertical. So if you see the sand dunes the whole intention is that whenever you get time, please go through it and some of the questions that you are asking about the reclamation and you know, land creation.

I think I have given some example. I think I also gave you an example that most of the oil deposits in present day circumstances are located at these type of soils. So, the big issues are how to make these infrastructures which are going to sit on this default table because the key word here is and I say weak cemented material. And if you remember, when you were talking about the fundamental properties of the grains.

These are grains which are very light in weight alright. And particularly if you look at their micro structure, which will be discussing maybe after 2 or 3 lectures, you will find that they have a lot of furry structure on the surface. So if the surface of the particle is like this, it is not going to be as smooth and as spherical as the river transported sands would be. Here you will find lot of furs on the surface.

If you look at the microstructure of this particle and this has them in getting airborne alright when wind comes and therefore a near vertical bank, let us introduce the word near vertical. The biggest difficulty here is these systems keep on moving you know, sand dunes, they keep on moving or shifting and because of this it is very difficult to lay the foundations on them or make a structure on them, is one of the reasons why there is no clear cut boundary between the 2 nations, our neighbors and ourselves.

I hope many of you understand this was interesting project, which was you know, I was contacted by the arrow. But then the difficulties are I hope you can understand we are not very much accustomed of living in dust storms. So you have to spend some time over there. So, when the sand dunes keep on shifting, the big problem is how to lay the foundations of alright. And that is one of the reasons that why we do not have a clear cut demarcation of the boundary between the 2 nations.

Geologically, I hope you will realize that most of these deposits are coming from the desert which used to be a water body. So that is the connection between see the question one of you should have asked from where the calcium carbonate is coming in this type of soils. So, that is the link and long that one of you had asked this question regarding, you know, pressing the rock minerals, the soil minerals.

So, this is a key word, I will make sure that the soils are calcium carbonate, so calcium carbonate is a peculiar mineral I will say I am using the word mineral clear not the oxide and the salt. Now, this mineral is coming mostly from the marine environment and hence this becomes a part of the anti loess system. The second in the category is what is known as a tuff have ever come across this word ever no.

Check it on net and find out apart from the soil where else has been used this is coming out of this has to factious soils check it in the meantime and there was a very famous case also which was going on related to the tuff did you get it. It used to be a denim cloth and there was a company known as Tuff alright and then there was an interesting litigation going on and read all those stories there.

These are basically small grain slightly cemented volcanic ashes and they are mostly transported by either wind or water. Try to check out whether we get Tuff deposits in India or not. Whenever you get time, please go back to your hostels and check where these deposits are located, though I have given you a link also and you may try to understand which part of the country you come from and what are the soil deposits at that particular location.

Sometimes, like I was telling you in modern day science and technology, you know, after asking your name, the second question would be you come from this place, what type of soil you have then what are the challenges, what are the problems, in case you have to continue in this profession. So, that becomes an introduction. You understand the context changes very fast after your name, the place which you belong to.

Now by virtue of your studies you are from Bombay. So, you should be aware of the geo morphological conditions which prevail in Bombay city alright. The third in category is bentonite. I think I have already given you enough history about when bentonite, these are the deposits which are mostly available in the western part of the country. Bhuj area is very famous for this atomic industry depends a lot on the bentonite and even the construction industry also depends a lot on the bentonite.

Why because of the thixotropic behavior. So, this material is thixotropic in nature, what is thixotropic suppose if I take a small sample of this material in my palm, add 2, 3 drops of water alright, and then let it become saturated. And if I temp it like if I disturb it, what is going to happen. The water gets oozed out. That means there is a segregation of water with this material which is bentonite and again if you leave it for some time the material again gain strength alright.

So, this is a fundamental property associated with the minerals and incidentally bentonite happens to be belonging to the family of modern night, we will discuss about this later alright. So these are the type of minerals which are very notorious and in conditional subject, they have always been termed as unwanted materials not bentonite the monolithic material. So, those of you who come from weather by region central part of Maharashtra, MP, Karnataka, you know, you must be seeing black cotton soil there.

So, the constitutional black cotton style would be a cousin brother of bentonite, but by virtue of this material having thixotropic effect, this has become a boon in the nuclear industry. And we will discuss about this if time permits. So, if you want to dispose the atomic waste, which is

having very high radioactivity, which is having very high chemical concentration, which is having very high temperatures.

These deposits are going to the best deposits or I can create a system where I will use this material as a buffer material. Check what is the meaning of the word buffer if you read some papers on the net. There is a lot of research going on internationally in the subject. So, Government of India spends a lot of money in characterizing the bentonite from different parts of the country and checking their worthiness as a buffer material for waste disposal, which is highly toxic and hazardous alright.

Now buffer is something I am sure you must have used this term in the chemistry alright, if I want to maintain the pH of a system I have a buffer tablet of 7 9 6 8 whatever. So truly see in this case what happens is the buffering is between the waste unit canisters which are made up of lead, I am sure you must have done your 10 +2 physics or chemistry because lead happens to be retarded.

So I will contain all the waste in the lead, canisters. Canisters are nothing but the containers. I will breathe deep inside the ground, 150 meter, 200 meter depending upon the type of activity which I have in the waste, and then cover it with this material. To make it more workable I am using a word workable. That means on its own this material cannot be used much alright. I like to add something to this.

Now this becomes engineering with the soils clear. So I will add something to this will make good buffers and this becomes the best possible disposal place for atomic waste. Read more and more about this I would not be getting time to discuss much about these things. But the second course which I offer for PGs and earlier undergraduates, there are used to teach about the geomechanics of atomic waste disposal.

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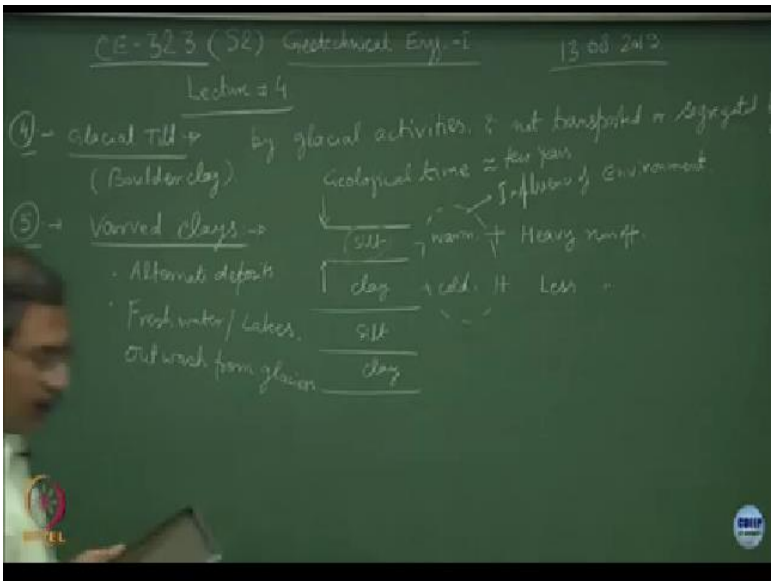

The fourth category or the fourth transported type of the soil would be a glacial till, tillage is something which is known as this remains tillage alright. So when you say glacial till this is the remains which is coming out of the glacial activity, in one of the lectures we were talking about avalanche, if you remember. So avalanche is one of the reasons for causing the glacial tills. So, in the mountainous regions if you go towards Manali, Rohtang pass and all those areas, a big problem would be and how to deal with this type of soils.

And I will show you some of the situations in today's lecture. There is also known as the bouldering clay. So those of you come from Himachal Pradesh in particular alright or maybe upper reaches of Himalaya or the lower reaches of Himalayas you will realize that the big difficulty there is to lay the foundations why. Because these type of materials are having a combination of a clay fraction, which is very fine particle and boulders which are very big in size clear.

So I cannot sit on a boulder, earthquakes comes, these type of deposits are going to get destabilized very fast. So that is the reason that unfortunately most of the cities and towns in the hilly regions of the country have remained undeveloped or underdeveloped, are you getting this point, these areas have been ignored completely. So, these are deposited by the glacial activities. Try to find out what are the major projects which are going on in the Himalayan regions nowadays, can you name some of them major projects very important question alright.

You should be knowing all these things, big, big tunnels which are being inaugurated or which have been inaugurated recently, remember those names alright, so this is all about the application part which cannot be taught in the classes such. So, these glacial tills are the glacial activities and not transported or segregated by water, very difficult deposits are the soils to handle. Then comes the varved clays.

Any idea what these type of clays are see nature also does miracles. I hope all of you will agree with this. And if you really want to enjoy the miracles of the nature, the geomechanics, geotechnical engineering or the soil mechanics is the right subject to study. Now, what happens over here is, nature shows patterns of formation. So, what happens is there will be a layer I think we should start on the bottom most portion.

There will be a layer of a material, second deposition on the layer, third and fourth. And this happens in a pattern and this pattern is dictated by the climatic conditions. So, if you have selt, clay, we will discuss in detail is that what is meant by salt, what is meant by clay. So, today what I have done is I have introduced another term in the realm of soil mechanics that is selt. To understand quickly, selt clays, boulders are nothing but the sizes of the soils or soil particles clear.

So these are types of the soils depending upon their physical attributes nothing more than that. So, if I use the classical system that how the particle size looks like or what is the particle size or the shape, what are the morphology under this category, this type of a deposit comes now, it so happens that whenever there is a warm weather selt gets deposited and whenever there is a cold weather the clay gets deposited.

So, every 6 months you know when the weather changes the deposition pattern also changes. So, these are basically alternate deposits, the thickness of these deposits could be substantial, few 10s of meters even, I think now you can realize what are the influence of the environmental activities on the formation of the soil alright. Normally these types of things happen in freshwater and lakes alright.

This could also be the out wash from the glaciers, whatever gets washed out from the glaciers, now selt deposition occurs when the system or the environment is warm plus heavy runoff. However the cold weather is during, sorry, the clay formation is during cold and less run off. Truly speaking this type of the policy will be forming in few years. So you might be having a geological time associated with this which could be of the order of few years.

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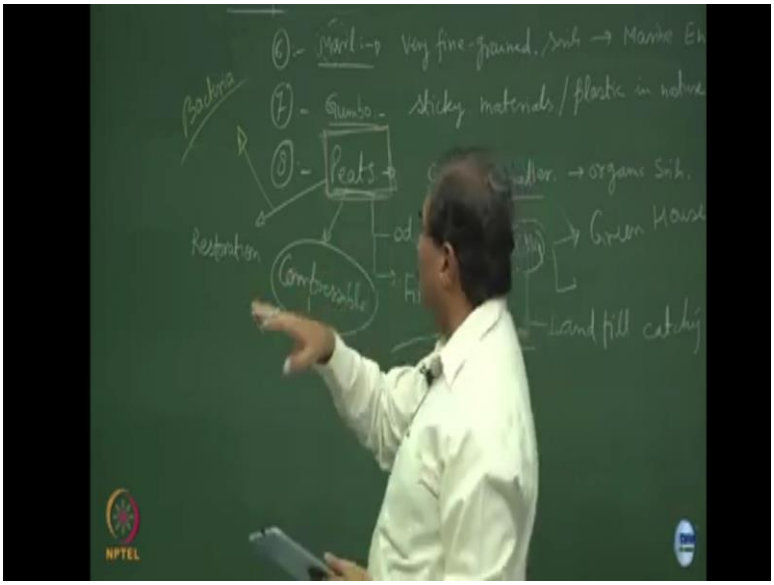

There is another category of the transported soils, which is known as marl, check what is the dictionary meaning of the word marl, marl basically corresponds to the marine environment alright and what is marine environment. Bombay region is a marine environment alright, wherever you have coast, wherever you have seashore clear, so, the land side is known as onshore and towards the sea it is known as offshore.

So marl soils are very fine grained materials, and there origin is marine environment, there is another category which is known as gumbo g u m b o. These are very sticky materials and when soil is going to be sticky, it is also going to be plastic in nature and dark colored. See, I have initially used the word here plastic, you must be wondering what is meant by this plasticity of the material.

So we will studied in details about the plasticity of material. Plastic material is the one which can be molded the way you want. So, when you were a kid is still you are a kid not out, but when

you are very small kid what do you sue us to take a soil, add some water and then you must have make a ball out of it is it not. So, that comes because of the plasticity of the material. For the guys who are in agriculture, the way they differentiate between a good soil and a bad soil for agriculture would be simple test.

They do not require very high-fi laboratories, they will take soil, add some water and form a let do out of it clear or a ball out of it. And then what we used to do when your kids used to throw it and let it stick on the wall, is it not. If you are not done it, do it right now, the right time to learn about the materials. If it remains stick over there it shows that it has some properties which are plastic in nature.

After some time, it may remain there or as the moisture go out of it, it may fall down clear. So these are the properties which people will like to look at when they do construction with the soils and remember soils are the materials clear. I can use them the way I want to. I can create a situation and I can use it. I cannot say that I am not going to do my engineering over here in this type of deposit, is this correct.

And that is what the engineering with the materials like soils would be. I use the word dark colored in nature. Remember sometime back I was discussing the difference between transported soils which are crystal clear particles, very fresh looking pinkish, brownish color, yellowish color, but now there is a situation where transported soils of gumbo nature are dark colored also. The reason is look at the history of formation.

They got sticky property, very plastic in nature, and they might be in trapping lot of bacterial activity in it. And that bacterial activity under anaerobic condition might be giving the dark color. This is also situation. The other interesting category of the size which is known as peats, have you come across this word if you get a chance to go to Scandinavian countries and you got to live over there.

Check it out on net. It is a beautiful phenomena where peat deposits, they get disintegrated. So imagine today your Gymkhana ground is intact. Clear, but tomorrow morning when you get up

you will realize that some part of Gymkhana ground has vanished. There are a lot of videos which are available on YouTube. Check it out where these type of deposits are. Now this type of disintegration happens because this material is of highly organic in nature.

Lot of organic matter is present in this type of soils alright and this organic matter disintegrates. So we call them as organic soils. For me there is no difference between these types of soils which nature has produced and the soils which I am getting out of reclamation and rehabilitation of landfills is this ok. So nowadays, the businesses to rehabilitate the lancets, check it, it gives you a very good opportunity to start your business, rehabilitation of the landfills.

How many make a landfills India would be having right now. Every city would be having at least 1 or 2 Delhi is a blessed city, how many landfill's it has 3 4 major ones which are always in highlights national network. Why, so what happens. In the last lecture we are discussing about the issues related to the organic matter. So the more and more organic matter decomposes what is going to happen. Yes one of you very nice, excellent.

So this is the source of very good and what will happen yeah, so the more and more CH 4 emission takes place what is going to happen. Sorry, true, one is greenhouse effect next as a civil engineer, geotechnical engineer I am really not much interested in this. I am more interested in omega problem. So the other landfills who are falling, they become unstable. They catch fire, clear. So, most of the time these landfills are burning.

So what is going to happen if they are burning all the time. So next time when you go to Delhi these 3 famous landfills what do you notice there, why should they are burning and when they are burning was going to happen. They are emitting carbon dioxide rock socks and the environment and particularly the cold climate during November to February what is happening then, major problem.

So I do not do go to natural deposits see, as a human activity I have created more and more storage of peats, or peat like material clear. Fabulous 2, 3 example of what peat type of material would be your agri material, could be naturally deposit forming a peats, manmade activity CH 4,

the landfills might catch fire is this okay. And once it catches fire, it becomes unstable. It is okay. Peats normally would have odour.

One of the interesting things about the peats is that these are fibrous in nature. Whenever a soil or material exhibits lot of fibers present, what is going to happen we were discussing the other day, what is the problem associated with this. The presence of fibers organic content, they have water holding capacity. I think we discussed in the last lecture. So the more and more organic matter you have in a soil mass, it will be holding more and more moisture, is it good or bad.

Why, you are right, it is bad, but why, yeah, so there is no absolute answer. Remember, the profession changes and good or bad changes. So the guys who are doing you know, forming of let us say, rice. You must have seen the way the forming of rice is done. What do they need, they excavate the soil they put a lot of organic material into it, why it should be holding more and more water.

Go to the northeast where tea gardens are present. So I am sure you must be aware of that tea gardening requires a lot of water and that is the reason tea is normally produce in the regions which are having high rainfall. So, whenever you have this type of materials, which are fibrous organic in nature, they would have very high water holding capacity. The more and more water holding capacity is the more and more disintegration is going to happen.

The more and more disintegration occurs all these issues are going to become major problems is this okay. As far as engineering is concerned, these types of deposits are real challenge to handle. Why, because they are extremely comfortable. These are extremely comfortable materials. So no wonder when you hear you know some of the buildings settling down the first floor, second floor, going inside the ground floor alright.

The first indication would be that the soil which is present at that location must be organic type, okay. For R and D guys, this is a bless those who are into R and D, check it out on net. There is a big group which is working on restoration of peat soils. Restoration of peats is a big challenge

and become an expert in the subject. There are not many guys in the world who are working in these areas.

And I am sure that you will realize very soon that most of the countries have a big challenge in terms of the peat deposits. So the big question is how do, we restore them. I think this is a UNDP program also, where they are trying to safeguard the cities and the countries which are mostly located on peat deposits. Now, one of the ways of doing this could be I am just giving a very vague idea. I do not put me tomorrow anyway, alright.

What would be the vaguest idea to stabilize this type of deposit cut off the supply of oxygen, how will do that. Wrap them in a polythene, how do wrap the entire soil mass on with the big buildings are sitting in the polythene. Imagine are you realizing, now this is not the surgery required. So, most of the geotechnical engineering guys who are the profession become surgeons of the soils and the situations.

Because what you do you have to give a solution. So there are very interesting ways of dealing with this material and try to read as much as you can. What bacterial is going to do on agri matter. I think now you are understood. So the more and more bacterial activity you expose this material to you are inviting more and more problems clear. So that is what I was saying you contain the whole system, cut off the oxygen.

These guys can survive there agree unless they are anaerobic, are you getting this idea. So the moment they become anaerobic, different problem, the more and more you are going to produce this, you cannot do anything, then you will do something different. So suppose if you are doing this activity, make sure your answer was incomplete. You say that my answer was incomplete. It is not incorrect.

So what I will do is I will create a situation where this activity happens to be under anaerobic systems, greater depths where the oxygen supply is less clear, but it is still they will disintegrate. Another thing very early for you to catch these concepts of the subject, precipitation of any

system because of the bacteria in fine grained soils like clays is going to be absolutely difficult because the pore sizes are extremely small.

Somebody wanted to ask about this pore size or something I asked you to write on the back of your notebook. Anyway, this is one of the answers clear.

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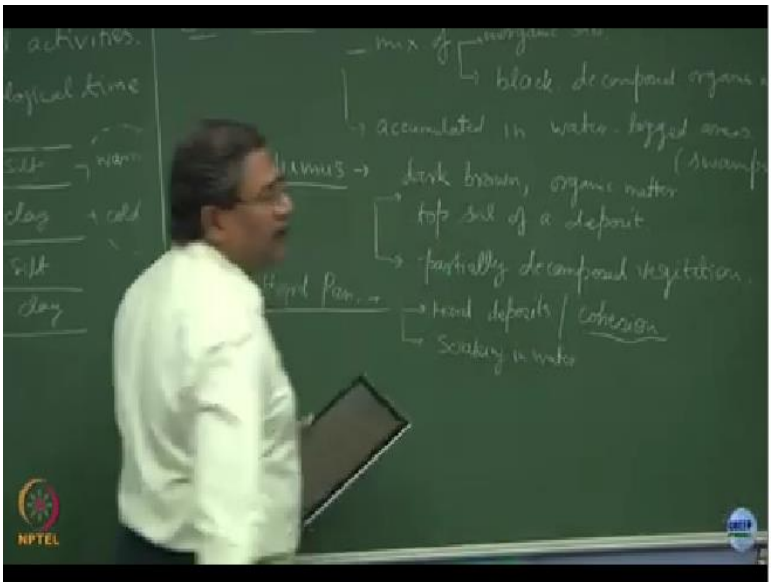

So, another category is muck. These are basically fine particles and this is the mixture of in organic soils, see muck is a term normally we use it as a misnomer for slush is it not, the mucke thing. Mostly these are black decompose organic matter also.

So it is a mixture of in organic soils and black decomposed organic matter. Normally these type of systems you will find them accumulated close to waterlogged areas alright particularly on sands. There is another category which is known as humus. So somebody asked you a question what are the organic soils that you have come across peats are number 1, muck is number 2, humans is also organic material alright.

These are mostly dark brown. These are organic matters and this is the normally top soil of a deposit The one of the characteristics of this material is that this would be having partially decomposed vegetation in it. One interesting thing on a philosophical side, I hope you can realize

that the soils are normally made by nature or natural process, but nowadays people are talking about the manmade soils also.

So, the moment this municipal solid waste comes in the picture, you know, the humus is normally occurring naturally, but most of these characteristics are also present in the remains of municipal solid waste clear. And hence, there are many guys who are directly rehabilitating the landfills and they are using the remains of the landfills as agricultural material. It is a big business. Then there is another category hard pan.

As the name suggests, these are going to be the hard deposits and sometimes mistaken as the rocks. Later on we will study one of the tests to confirm whether a material is soil or rock is to take a small sample and soak it in water. If it disintegrates over 72 hours, it falls in the category of the soils. If it does not, it falls in the category of the rocks. So you were asking this question the very first lecture where to lay the foundation.

It may so happen that when I am doing investigations, I may come across this material or deposit. It is very hard and I might mistake this as a hard a strata rocks clear, but subsequently when you excavate the soil, it might get disintegrated very fast, okay. So this is the property though it is a hard deposit having cohesion, I hope you understand the word cohesion. Cohesion is something where the particles of the soils are, you know cohest they are bound with something.

So, that is what is known as cohesion alright. So, if 2 particles suppose like a glue, I have 2 particles, I will put glue on both the particles press them, they form a matrix. So, this material shows cohesion, cohesion is something which indicates that the particles are glued with each other. And the acid test of this material would be soaking in water. Acid test means you are to differentiate this material with the rocks.

And this is one of the best ways to differentiate. There is another category of the size which is known as calluvial soils. Check it on in the dictionary what is the meaning of the word calluvial.

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The other day we are talking about calluvium now it is calluvium, what is the meaning of the word calluvium, so when you travel through Bombay on Pune Express highway and Nalagarh is very famous for rock debris falling during the rains, is it not.

So, we rain induced slope failures. So you are right the calluvial soils are the ones which are formed because of the accumulation of rock mass when they get detached from the parent body and the parent body is nothing but the rocks alright, and they get deposited over there. We call them as accumulation of rock debris, what are debris discards alright construction debris for that matter. We also call it them as talus, this is the name of the soil talus.

And mostly they get deposited at the base or the foot of a cliff. You know what is the clif? Almost a vertical system of rocks, alright near vertical. Those of you might have gone to substring a very close to nothing. The rocks are cliffs near vertical. So suppose if I draw a system of rocks like this, alright, now this is cliff it is not a slope. So, the beauty is that most of these are the disintegrated accumulated, rock debris at the foothills also known as talus.

You are from Uttarakhand which place Dehradun very good. Have you ever driven from Deradun towards higher reaches let us say towards Badrinath, Kedarnath, and all these areas, yeah so what do you find, is there some similarity between what I am discussing and the type of

problem these guys are facing in the regions of upper reaches of Uttarakhand correct. Whatever difficulties you have huge accumulation of these materials.

So you cannot even get the foundation you can make the buildings. This is manmade also; by the way, they are chopping out all the hills. Okay and another category would be mine tailings. Anybody in the class from let us say eastern part of country like Bhilai, Jamshedpur. You are from this place, what do you see normally when you pass through railways on both soils of the railway track, what do you see during nighttime particularly nights you are not observed.

See civil engineers are all about observations. So, if you do not have observations, unfortunately, nobody can make you a good engineer and technologist an civil engineering, what I am trying to hit that is most of the mining activities alright, thermal power plants are in the vicinity of them Jamshedpur. So what you see is when you pass by the railway track, both the sides of the railway tracks are having huge dumps and some of these dumps might be you know having fire.

Some of these dumps are the mine tail. So, you take out the mineral from the mines, process them extract the you know good part of it which is useful to you 80% remains unutilized throw it somewhere clear human activity soils form because of the human activities. So, mine tailings are the one mostly these are silty materials anybody in the classroom Jharsuguda area, Jharsuguda no check it on net.

Why Jharsuguda is so important for India being a muscular nation, you understand what is the meaning of this India being a muscular nation still makes you muscular. And apart from that those days are gone. When is still used to make muscular, now what is happening nuclear power nuclear energy, weapons, medicines clear radiotherapy different types of radiations which you are using for agriculture and so many things.

So, Jharsuguda is the place where most of the whatever minds are available, link the 2 things uranium very good clear, so the more and more uranium India wants what is going to happen, I use some figure I said 30% 25% is useful rest is all discarded, tailings clear, the more and more mining you are doing any type of mine. The more and more discards you produce, so these

discussions being just dumped, anybody that from Raipur, Korba have been to airport near Korba very good.

So what do you see in Korba region, manmade mountains you have seen are not very good. I am sure I am happy. At least one person is aware of what is happening. So the more and more mining happens the more and more manmade hills are getting created. So I am sure your kids will not go to Himalayas for whatever amusement. They will say these are the Himalayas created by same people alright NTPC guys and so on.

And this is a big business by the way. Start rehabilitating these mountains. This is what is coming in practice now. People are trying to rehabilitate them and leasing them out for different amusement purpose. So it so happened that the mine tailings are the silty materials and they are hydraulically filled and read this hydraulically I do not know whether you are aware or not conveying soil hydraulically is filling of the mine tailings.

So if I am transporting the soil hydraulically and creating a beach is reclamation, alright the principle remains same. So I will take a pipe I will mix the soil, I will pump it, I will fill up the line, the mine tailings which are coming out of the industrial process, very fine particles. I will deposit them in ponds there, hydraulically this becomes mindedness, a lot of similarities are there.

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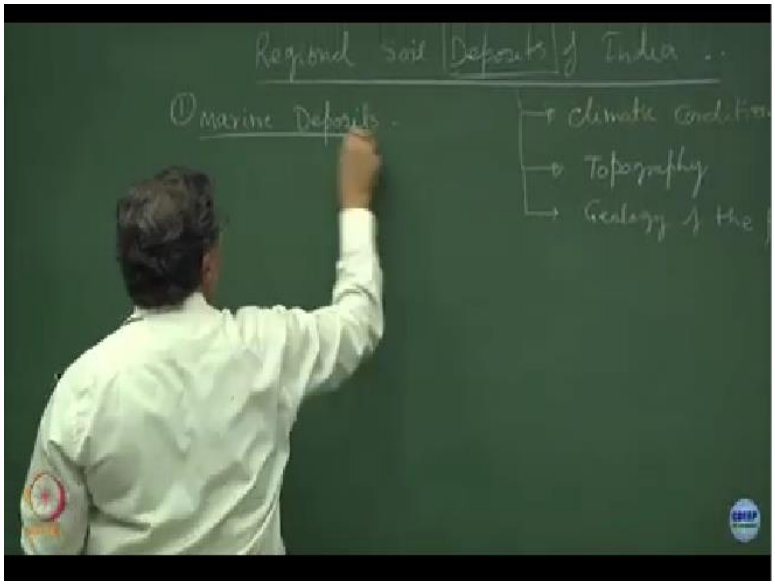

See it is very interesting when politicians meets to talk about politics, when 2 geotechnical engineers meets to talk about the soils let us please come to our place and I will take you to the deposits of these type of soils you understand. So this becomes a dharma. See when we talk about the deposits of the soils, regional India is an interesting place you know why because in our country we have several deposits of soils which is very, very rare.

You would not get these type of deposits everywhere in the world because most of the countries are so small that they would not be even setting on one deposit of the naturally occurring soils. So, these deposits is mostly depend upon the type of climatic conditions. By any chance you who is from indoor this side you are from Indoor, Indoor is becoming a hub petrochemical hub of the country, you agree with the statement.

So, it depends upon the climatic conditions. It depends upon the topography and this also depends upon the geology of the formation. So first in the category would be marine deposits because we are sitting in Bombay in coastal region and.