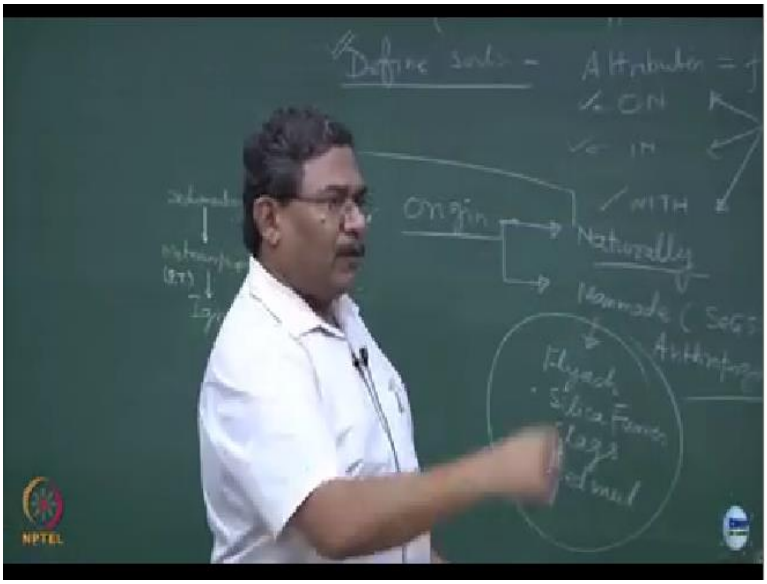
Geotechnical Engineering I
Prof. Devendra N. Singh
Department of Civil Engineering
Indian Institute of Technology-Bombay

Lecture-03
Classification of Soils-I

So, when we talk about naturally occurring soils and there have been a lot of questions regarding this.

(Refer Slide Time: 00:24)



These are basically from disintegration of rocks which we discussed sometime back. There are 3 types of rocks you must have studied very good sedimentary. Then why I have written like this metamorphose or metamorphic, so this is basically rock cycle is it not sedimentary to metamorphose or metamorphic and further action of pressure and temperature and all the agency which you have discussed, you know, the carriers.

Mostly this is P and T pressure and temperature condition. So, sedimentary is the one which is, you know, remember Himalayas a lot of weathering process going o, big boulders getting form. They keep on hitting each other, they get fragmented because of the flow of water, each fraction further keeps on becoming smaller and smaller by the time it comes to the gangetic plains and then something happens from the gangetic plains up to the Calcutta Hooghly all these areas what happens.

Even the small particles become much more finer alright. So, conversion from very big size to medium size to the final size and this is a journey with the material is falling. In geological terms scale timescales. So, sedimentary is something please understand this concept carefully, this is going to be useful forever. You have seen Delta's alluvial fan formation Sunderban is a beautiful example of the delta which has got created you know at the junction of Bay of bangle and Hooghly river. So, what has happened suppose if you do the mechanics of this problem.

(Refer Slide Time: 03:05)

So, the river is bringing sediments what are these sediments, these sediments are the disintegrated form of the rocks, which are coming all the way from Himalayas, mountains clear they have been have been traveling so long in terms of time, in terms of distance and they got fragmented, they got super fine, weathering process somebody was asking what is every. So these rivers have lot have suspended loads.

We call them as sediments alright mostly this is freshwater. Try to capture the attributes. So for an engineer, the attributes are very important. So the key words which I use now, what did I do, I said river and then I said suspended load from your suspended orders coming from all that, but then causes agreed. And then suddenly I brought in the concept of freshwater. What fresh water has to do with in this context.

Density of the fluid clear, so the freshwater, let us say because I am sure all of you know that from the stretch of the Himalaya up to the southern portion, where the Ganga has comes, water can be just drunk without filtering it. And then the human activity start in the water becomes polluted, clear. But then there was a time when people used to bring it up to Varanasi, or a Lava or Gaya and Prayag and what not clear.

So this is the freshwater density is going to be less and this suddenly comes and meets the Bay of Bengal, I am sure many of you would be taking it up as a research project in your career in whatever form I do not know. So it is very deceptive you guys you think I will never do this ultimately you end up doing this even if you become a CEO of a company, you will realize that most of the development is going on now in these areas in the country clear.

Most of the companies are establishing themselves over here. Now what I am going to tell you is this is typical sea water, what is the emphasis, why I am saying this sea water, salt is fine density, correct density contrast. So if this was row 1, this has become row 2 where row 2 is better than row 1 clear. What is going to happen. A lighter fluid entering into a denser phase what is going to happen. Sorry say it loudly no.

Yes, someone else what are the attributes of the system this system is freshwater having a lot of suspended lows imagine you all of you must have realized the turbulence in the aircraft. When you travel why do you face turbulence generally becomes why. So you are going from a lighter phase of the air into a denser phase clear particularly when you land when most of the problems come and when you take off.

Imagine close your eyes. What you are doing, you are going, are you are moving into a denser liquid and again coming out into the lighter liquid is this correct. So, same things are happening over here. The rivers carrying suspended load and these suspended sediments are entering into a denser phase what is going to happen velocity reduction number 1, the moment velocity reduction occurs all these elements will have a tendency to settle correct segmentation process.

Is this part clear, the rocks which are formed because of the sedimentation process. Now, what are the major players in the formation of the sedimentary rocks, simple process like this you know loads of sediments which are present in the freshwater they are entering into a system which is denser sediments have a tendency to settle down. Now, look at the micro mechanism what will happen.

So, if this is the riverbed or ocean bed or whatever it is I will say water body there. So, this is the bed of the water body clear and imagine this is the freshwater normally water we depict like you make a triangle and draw something like this, this becomes a water level clear, connotation is like this. For soils, we show a horizontal line and this. This is the ground level it is okay. So, all these elements mostly coarse than materials. They keep on settling.

Initial process, next load of sediment comes, it gets deposited like this. The whole process is happening under gravity clear. Nothing else, in the process, somebody will ask you what bacterial action might be a situation where the bacteria starts secreting something and they all become a cohest material. Cohest means cohesion. Individuals grain is now getting glued because of either microbial activity or it could be because of physical activity also.

Suppose if I take 2 particles, take 2 balls and press them hard, hold welding what happens is a contact with your creator very high pressure clear and low temperatures alright. Otherwise everything is going on with self-made. Later on, I will use this concept to define the state of the material and engineering aspects, that how you are going to make buildings on this type of formations clear.

Now, this system gets metamorphosed because of several things, pressure, temperature conditions, chemical conditions, temperature, fire, whatever becomes metamorphic. Under extreme temperatures and pressure this becomes igneous. It becomes magma, you know it becomes highly uniform system. So, these are the igneous rocks. I hope you are aware of some of the examples you can write.

What are examples of sedimentary rocks, sand stones, clay stones, lime stones, model stones, shell, conglomerate, fine. I will repeat sandstone, limestone, mud stone, shell and conglomerate, should I write or it is okay, it is okay. What are the examples of metamorphic system yeah, so we were talking about this metamorphosed or metamorphic rocks. So when the temperatures are very high, you know the type of rocks which are going to get found is marble and quartzite and when pressures are very high what will happen.

Then you have slade and schist, slate see if pressures are very high I write normally like this, if the pressures are very high then you have marble and quartzite. And when temperatures are very high what is going to happen, sale and schist. And I think sedimentary rocks I have given several examples. All sorts of limestone, sandstone, clay stone you know they form this category. Igneous rock under acute pressure and temperature conditions any examples of igneous rocks.

Basalt, granite, alright they form the category of igneous rocks. Now soil could be form because of the processes which we have already discussed out of any of the 3. So, A let us use S M I. So, you have a triangle sedimentary to metamorphic, igneous and for the disintegration of igneous might get resulted into the sedimentary also clear and at any stage of this you might find soil getting inundated.

Only thing is that this is the functions of pressure and temperature the conditions is this okay. Now, what this has to do with the definition of the soils, you remember. you are talking about the attributes profession and we were talking about you know users that we were talking about what is the origin and now we have to talk about the transporting agencies, is this fine, one question which comes automatically is what is the difference between rocks and soils.

Any idea, again this has to be profession dependent. Again, it has to be process dependent, by thumb rule if I need to cut anything or if I do need to blast anything, you were talking about declamation is this correct, okay. So, if I have to cut something or if I have to blast something that means the hard system. Normally rocks are cut and blasted. There are different type of cutters, right now metro work is going on in the entire Bombay city.

You can go and visit what is happening there, how they are cutting the entire rock mass, what are the tools is they use to cut the, you know, we call them as tunnel boring machines, TBMs, there are very good videos which are available on the websites, YouTube and all you should be you can watch them. I would not advise you to go inside because sometimes back when I took some of the student there one of them printed at 80 meter depth.

Most of you are not physically very fit is it not. There is a phobia, there is a blood pressure and a lot of other diseases which you guys have and under these you know sub environmental conditions mostly people get panicked. So it is not a very advisable thing to carry everybody there and ultimately inviting a lot of problems for yourself. It requires a lot of mental strength I would say you know.

Anyway, so coming back to the point rocks are the ones which need blasting and cutting. Normally soils are not of that range they are mostly excavated okay, so this is not a difference as far as a very layman's language is concerned that rocks need cutting and blasting soils normally do not, but it must to happen that soils also might require some cutting, but definitely not the blasting operations.

You must have studied the most scale of the hardness of these materials and so on I can say that these are apparent material, these are the offsprings and hence the matrix you understand the matrix, matrix means texture, texture is okay. This texture is very fine as compared to the one which you are wearing. So, the physical appearance, alright, so, the texture is different, rocks are mostly I cannot use the word very smooth because sedimentary rocks are not going to be smooth clear.

So, they are basically made up of stiff metrics okay as compared to the soils. This is another way of defining ordinary differentiating, but it so happens that the mineralogy is going to be same why that is DNA. The linkage is going to be between the parents and the kids, genetics clear. So, the mineralogy of the system is going to be same as the mineralogy of the system. But somebody was asking here about that the mineralogy may also get altered.

I do not remember but somebody had hinted on this you know, so, it just so happened that chances are that whatever minerals are present in this form in a very intact form, dense form clear, would be present over here with or without abnormalities. Agreed, but not in that much dense matrix. Is this okay, now, this is what you are asking is a research idea. So I remember long, long back then India was initiating this mass mission.

ISRO had some send some samples of the sorry muds and soils missions was to my laboratory. I was a part of that mission. We were testing those samples alright. So I was trying to understand myself that what was the relationship between the 2, you got it that is what NASA does. They will take out the samples of the rocks and they will send some rock rovers, land rovers, and what do they do.

They will detect by using some X ray or some non destructive way to find out the mineralogy clear. And that mineralogy if I can relate to this, my job is done. I have created a linkage between the 2. Carbon dating is one of the ways to find out whether the origin of these type of soils is what, you got the answer to your question. Read more and more about this is a very interesting topic of research and many people are working in these areas.

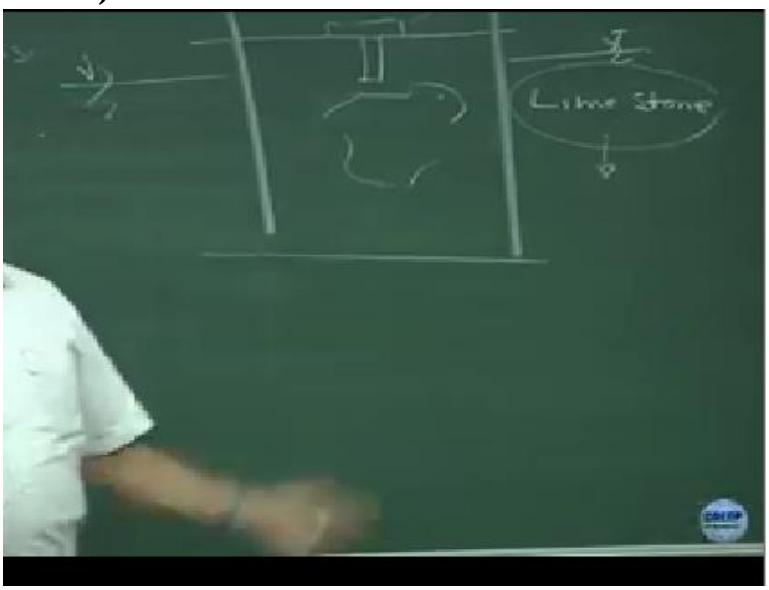
Particularly the guys who are into offshore engineering, those who are into hydrates is it not the origin of soils in which the hydrocarbons are present or a particular type of mineral which you are looking for. So, as I said you have to take care of this and your intentions put these 2 together to deal with the material got it, this becomes more of a intuitive task. Now, let us enter into the classification schemes of the soils.

When we said types of rocks alright and I linked it with the naturally occurring soil, which is the origin, let me talk about this is the classification scheme for the rock. Now, let us talk about the classification schemes which are used for soils. If you remember in the beginning of the lecture, I said, creation is one thing, transporting agency and another thing which at reduced lot of knowledge into the system.

And ultimate thing is how it gets deposited remember 3 stages, origin, transportation, and then deposition. And then I tried to give you some hints somebody goes outside gets exposed to the environment, society more and more as compared to the one who remains confined to one place residential systems clear. So we will talk about this now. Yeah, these are naturally occurring processes.

You can contain you can slow down, you can retard the process, that is an engineering that is the technology. So, if you go to middle east if you get a chance to work over there. Middle East is famous for having big, big cavities in the formations, you know subsurface strata which I was talking about. So, if million dollar question there is check it on net, why it is difficult to lay foundations in Middle East most of the regions in Middle East.

(Refer Slide Time: 22:12)



So, suppose if I lay a foundation over here you never know there will be a big cavity over here, what is this cavity. Look at this another example of you know the chemical process okay. So, see coming back to your question and the one is you ask these type of sub surfaces of the deposits are very notorious, mostly they are limestone alright and they are sitting on the in the coastal areas clear, what sea water has to do with this.

Now, this sea water ingresses into the foundations or the strata has a tendency to eat up the lime stone and create cavities under a very special condition of pressure and temperature and humidity. Now this what is known as lime dissolution. I was a consultant to bend over the

ceiling. I do not know whether you are aware or not. So all the foundations have been designed and verified by me in 1998 99.

A big problem was this, you might be laying a foundation over here. And you never know there is a big cavity waiting for you. Hope you understand what is going to happen caving in. So the moment traffic goes on the system, the entire pair of the bridge or the foundation might sink into the cavity. So UAE, Sharjah, Middle East, Oman, all these places the big problem is lime dissolution because of the sea water under very specific conditions of pressure, temperature, humidity clear and salinity.

Chemical process and your question was repeat your question now and link it with this. Yeah my question was that whether the conversion of rock to soil is a desirable process. So, here I have given you a phenomena we have what has happened to the limestone, it has got dissolute another extreme clear. Now whether it is so the discussion was that nothing is in your control. Remember, this is what we are discussing is a natural phenomena.

I cannot stop it, there is no way I can put a containment like this is can be done only on the blackboard. In real life, you cannot do it. Why, water will come from down alright is this, okay. So you cannot control it. You have to live with it. Now where is the engineering, engineering is fully knowing the facts that this will happen. I should be having a strategy in my mind to counter it. So that if the entire system is going to sustain itself for 20 years, I will add another x years to this.

That is my engineering and technology, you got this point. That is it. So what technologies are doing. They are providing techniques like surgeons, what do they do, they do colon surgery clear. So they will cut your intestine and they will connect with the pipe. What I have done this is the sea water. I have not done the same thing. I have cut the access of the sea water from this structure by providing some bypass are you getting this point no.

We will discuss this in details alright, yes another thing, can you tell something about what is happening run off catch I mean, there also the entire thing covered of a salts. So, he says

something like this soil is somehow meant change in some way by the sea, rejuvenation of deserts, read this topic write it down rejuvenation of desert areas alright and second is when you come down towards Bhavnagar and all these areas which are run of catch tie what you are talking about ingress of salt water into the soils clear.

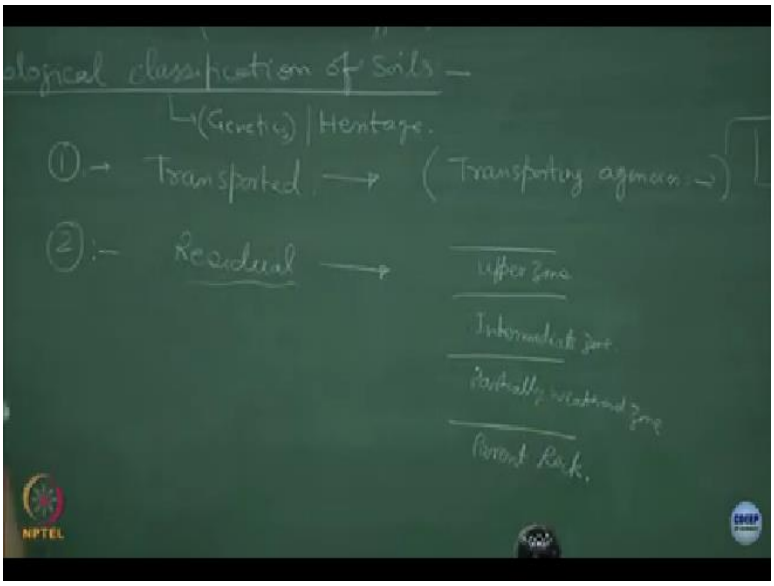
So how would you stop this. How would you rejuvenate the entire land. Have you been to these areas, why from all the way from eastern part of the country to the extreme rest of the country. Recently been around of catching so what did you saw there, what did you see there in the festival. So, again festival which happens in winters, so, I have been there to visit a lot of India's atomic energy program depends largely on the bentonite which comes from that area.

You know this and I think I told you today was 1 and half hour back, the bentonite is not there, you cannot run your atomic reactors understand. So run of catch is very famous for minerals. And nowadays you must realize if you have gone towards the Pakistan border Dakshineswar temple is there, I have not been there Google Play you can check. So from there the border is hardly 35 kilometers.

Now, this is the area where most of the mining activities are happening and most of the industries are being set up. I am consulting at 2 of the places their extra deep mind somebody was talking about the mining. In this sector, you know, somebody was talking about the mines. So let us start the mines when you do what is going to happen, saltwater intrusion, saltwater getting flooded into the pits.

And you do not know what to do to survive this corrosive water clear. So do something okay, so let us talk about the geological characterization of soils.

(Refer Slide Time: 28:19)



Many this whole thing is including genetics into it. The heritage their family tree family heritage. Is it not we call it a genetics, genomics, whatever you may call it. So, most of the time geological classification is carrying a connotation of the geo morphological features of the soils. Geo is earth, clear geo geotechnical techniques, which are going to be used to understand the materials which are lying inside the earth or on the geotechnical, clear and engineering with those materials.

So, when we talk about this, the first thing that comes to the mind is these are 2 broad characteristics. The first one is transported and I think you are all aware now, what transported soils are and the second one is the residual soils. Transporter soils after weathering is over, they get transported from one place to another place by transporting agency clear and we discussed about 2 3 things. So the transport thing agencies say it again what are the transporting agency we were talking about.

Water, wind not air wind there is a difference use right language water, wind, gravity sorry you want to do oh very nice, the one with your powered in is ice clear is another form of water but ice is also a transporting agency why Avalanche, how many of you have seen Avalanche not only in Hindi movies and Hollywood, Bollywood movies, but in real life how many of you have been to Manali and Rohtang and all these places.

We have also seen Avalanche snow Avalanche, what are the properties of snow Avalanche, these also geo materials why anything which is resting on earth even we are also geo materials agreed, we come out of it, we live on it. We spend some time on it and again we go back into it. Perfect example of geo materials and in the process, what not we do all chaos we create do you agree. It is fine. So Avalanche is also a sort of as geo material.

Water vapors getting deposited in the form of the snow, and settling down over the upper reaches of hillocks or hills and under extreme low temperatures and high pressure from vasopressure is coming. The first layer I was talking about sedimentation process that was a river induced. Now what happens the first layer of snow comes, the second layer, third layer and self weight, compaction consolidation earth.

We will discuss about this quite in details later and ultimately this whole thing becomes so hard. So the moment temperature changes, calamity conditions change, it breaks and it is lights. It is something causes a disaster alright. So transporting agency are earth you are gradually saying water, wind, ice, this could be any other human activity, gravity and so on fine. Now like human beings, you know, we are in different continents agree.

So why ice becomes a very important carrier or transporting agency you go to another continent is Scandinavian countries, Norwegian countries, the countries where most of the time, the entire thing remains no bomb. There is no free water on the surface clear. So, it is not possible that the rivers are going to carry anything from one place to another place clear. So, this is totally because of the ice affects the transportation could occur.

The another logic come as another migration would be the soil mechanics which you are studying should not be confined to only Indian context. Ultimately, what you want to become you want to become an international guy. So, geography should not bound you know, not geology, geography should not bind you. I am not talking about geography I will talk about the others is this okay.

Now, if you look at the attributes of these materials which have been transported, attribute mean let us say color and shape how many have been to gangetic plane Brahmaputra river or say Ganges or Yamuna and all those. So why I am asking like this transported soils depending upon the transportation agencies. They will have peculiar attributes in terms of their shape, articles, texture, color why.

So, if what was the carrier agency was going to happen. All these particles will be getting washed. I do not know how many times in their entire life what will happen shining particles you know and the more and more abrasion takes place because of the rolling effects, I hope you understand rolling is taking place because they are coming from higher reaches. So, what is going to happen. The water acts as a abrasive it gives the abrasive effect.

So, the particles are going to be mostly perfect the spherical in layman's language, not microscopically typical sands. Sands are one of the varieties of soils. Somebody was sitting here said mud last time. Oh, yes. So mud is the layman's language clear. So technically when he say soils one of the variety of the soils would be sands clear round particles, why when they got broken because of the physical, chemical, biological weathering, they were all distorted.

But look at this the moment they started traveling from A to B, remember there were so many rolling which are occurring water is washing them, ultimately what happens they all become minimum surface area or maximum surface area. A sphere has a minimal surface area maximum surface area minimum sure why not maximum because that is the law of entropy. So, that means these particles are going to have the minimum possible surface area inert in nature.

Anyway coming back to the point, this transporting agency is also going to shape up the whole morphology of the particle. What is morphology, shape, size, roundness, irregularity, you know this is a perfect sphere, I could have drawn a sphere like this the particles are like this also irregular shaped clear, there could be a particle like this clays okay. So, it all depends upon which transportation agency is acting to transport the weathered material which is coming out of the rocks.

It is expected that the water is going to create a system of the particle which is near spherical shining very good looking, fresh, quartzes, pinkish color, peculiar properties of gangetic sands alright, mostly aerobic processes controlling the whole process. I hope you understand what is aerobic processes. Now I have interlinked environmental engineering with the geotechnical engineering.

So, this answers your questions of bio activity and you know what is happening and why and all those things clear. So, the texture, the shape and the color gets guided by the transportation agency. So, bead water, now, tell me if I replace water with wind what is going to happen, what do you expect fine particles good fine particles. The most important attribute would be when associate wind very good light, excellent.

So, weight of the particle clear, we call it as a specific gravity. So, when wind is playing an important role what is going to happen, particles will not be so smooth why wind is not so abrasive in nature as compared to water you agree, is that is correct that means here the chances are that the particles are going to be more irregular but lighter in nature. So, what is the problem associated with pollution in NCR which you are reading a newspaper and what solving any guys can do, what role they can play.

This can be a good question, what could be the role of a geotechnical engineer in stopping the pollution of NCR you are a civil engineer, you are a geotechnical engineer, what are your views on this, this answers your point also. So, when wind is playing a roll particles are going to be mostly not very rounded number 1, they want to be lighter so that they may become airborne other they will not get lifted up alright.

So, these particles are going to be lighter as compared to the particles which are being carried or transported by water differences clear, they form dunes there is a go to the places called some you must have been several times, you are studying all time, alright Barmer, Rudali and all these Hindi movies, you must have seen all the show big, big glumes and they keep on migrating from one place to another place clear.

What are the challenges associated with this, let me complete this part of the story I will forget. So these particles are going to be lighter. The structure is like that. So if you take a particle and put it beneath the microscope SCMLS it is kind of electron microscope, you will see that they are very furry. Furry you understand, they will have an partition purse why they want to they have to become airborne, they have to be get airlifted clear.

And they form aerosols. So half of the problem of NCR is because of in summers, the storm in winters these particles remain in the air. They form aerosols, agreed and that is the problem. How to solve this rejuvenation of what deserts clear. How is a big question. But we are talking about some process by which I can convert soil into rock. I can use this over here also to get rid of this problem.

Try this at a global level not in the laboratory, in laboratory and of experts have been done. Read about that clear. These are the answers to the question that you are asking. So, mostly these type of soils are known as alien. I will talk about all those things. Do not worry. Just you understand the concepts right now. Okay, how about the size when they are getting airlifted airborne particle size have to be extremely small clear.

So next time when you go to these deserts and all these places where the dunes are you test the sands and if you rub it too much the chances are that you will cut your skin and you will bleed. Why irregular shape these are very sharp edges. Okay. So they are so irregular shaped very sharp cutting edges. Okay, so the moment you touch them, rub them on your palm, the chances are you may bleed. Okay, what about the color there so no washing going on with water.

So color is going to be muddy. Not so is popping shining, you know pure form of the colors. These are going to be mostly brownish and dirty looking colors alright done. How about the ice we will talk about this very special category. So water, wind and gravity is again a sort of a you know combination of rock wall but normally we do not consider gravity as a transporting agency.

And then manmade, what we were talking about, the second category is residual. So, again I will repeat, geological classification of soils says like soils get formed because of weathering and then a transportation agency comes in the picture it transports the material from its original place or the formation place to the another formation which is deposition, I am using the word formation 2 times, 1 is a process formation another one is a deposition of and the formation which is because of the deposition it is okay fine.

In residual it is a different story altogether. Incidentally, these are very good building materials. Lot of learning activity, read my paper on desert sands of India. I do not remember the exact title but this is written. I did not long back the classification of desert soils you just check it on my web, alright but there is a paper on this in engineering geology and that paper is quite a demand because most of the guys who are producing cement, they want to use this technology for using directly the sands into making concrete.

We are negotiating alright, now the residual ones are the ones as I said they were formed very unfortunate. Nobody allowed them to move out they got created there clear, they form there and they got disintegrated also there. But in the process, these are the best soils air as far as the economy of the nation is concerned, any guess, no, another guess economy is always what hydrocarbons, oil and gas nothing can be that. You agree. It is okay.

So these are the soils which are the best deposits of what does deposits of what, hydrocarbons, oil and gas why, they got form, they could not get transported. They remain deposited there. And they got disintegrated because of microbial biological activity. So these are the ones who are storing maximum reservoirs of hydrocarbons. Now tell me which one is good or bad. No one, I think this is what we are discussing during break, agreed.

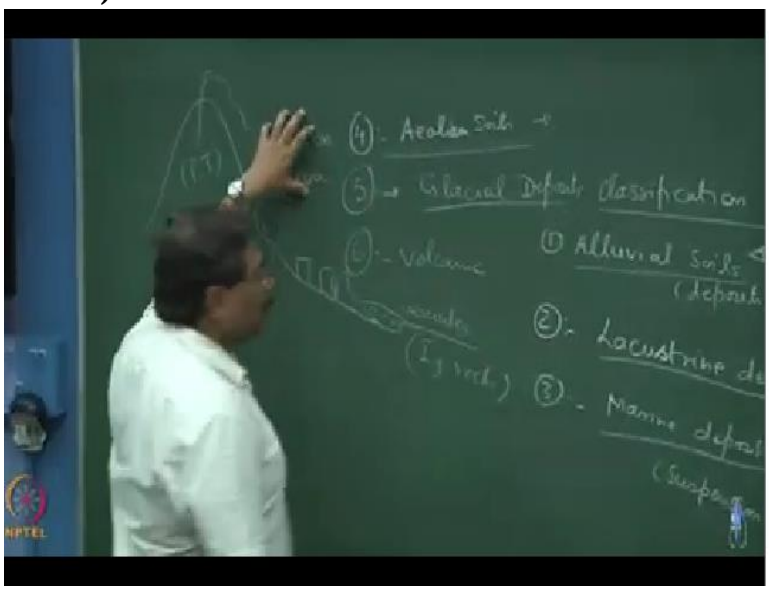
Intentionally agree with example. So my job is whether this is with me or whether this is with me what I am supposed to do, I can always change switch over my dharma. Here, I will be a beautiful geotechnical engineer. And here what I will do, I will try to help the guys who are into hydrocarbon exploration, because without my help, they cannot do any exploration remember. So I can hand both ways.

That is the art of practicing geotechnical engineering, is this part clear I use the word art of practicing geotechnical engineering that means, the concepts remain the same, what I have to do I just use this material the way I can and here my strategy will be changing. So, I will use different strategies, so residents soils are the ones who remain deposited after getting generated at that place.

So, there is a typical way of showing this on the upper layer is known as upper zone okay, and then it is followed by the intermediate zone. This is the schematic diagram for depicting the residuals soils followed by partially weather zone and this is followed by the parent rock alright. So, this is how the depth varies, this is the extent and this becomes a strata for me. So, most of the regions of Bombay coastal areas where we are right now.

If you have to learn geotechnical engineering the best places are coastal areas not the gangetic planes. So, this is a subject which flourishes in coastal areas why okay, any questions, so here we will have size, shape texture angularity, this petroleum geotechnologists have to learn from you, is a miss to see the role which civil engineers and geotechnical engineers have to play alright, so let me give you now few examples of classification of transported soils now.

(Refer Slide Time: 51:08)



So, different types of transportation soils transported soils. The first one is depending upon the transport station agency, all these groups have been created you know what is alluvial soils.

Sometimes you may say that these are the deposits are there, what is an alluvium, what is alluvium, the soils which have something to do with the water clear alluvium, check the dictionary meaning of the word alluvium, check the meaning of all these words which I am going to write clear and try to remember them. Yes Manan what is the meaning of word alluvial, correct. That means, the soils are the deposits which have been created by running water.

Running water is important you see each and every word is important you know why suppose if it becomes a stationary water class changes immediately. So, as far as stationary things are concerned, it becomes a different class altogether. So, running water is very very important why because running water will give that abrasive effect, cleaning effect alright the particle will be very strong because it has undergone all that hydraulic pressure starting from Himalayas up to that point.

Imagine how much robots the particle would be especially gravity is going to be good, clear, heavy particle, then only it is going to get suspended. I hope now you are getting a feel of how the attributes are interlinked with each other. What lawyers do, legal advisors, what do they do, they catch a words. No, you agree or not, in crime series and all these serious what do they show the whole thing will start with the word and then will end with this analysis of that word.

So in our subject the terminology and the words are very, very important immediately I objected that it is because of the running water not because of the stagnant and stationary water clear. So water was getting form in Pawi lake is different. Okay, though this is also water but this is stagnant water and I am sure with your knowledge of environment engineering now you can interlink very easily that this process is going to be linked with aerobic and anaerobic, is this okay.

The second one is this is my s Lacustrine, Lacustrine deposits check it on next dictionary what is Lacustrine. Basically the term lac has come from lake. So, all these deposits are in the freshwater lakes. So, a Lacustrine deposit of the soil is freshwater lakes is this okay. The third one is marine deposits. It is so happened that the marine deposits could fall in both the categories. They could be transported as well as they could be residual.

You know, particularly in this deck and trap I hope you understand the word deck and trap. The deck and peninsula of the country starting from let us say Nagpur onwards up to the Cape of Cameron. This is your triangular portion, we call it as deck and trap. All along this deck and trap the soil which you get in the coastal regions are marine deposits. It could be because of delta formation we were discussing.

Suspended particles coming and because of the density contrast of the flood, they get deposited and they get formed over there. We will talk about the marine clays, again when we talk about the residual soils, granite gets decomposed fine. Somebody was talking about black cotton soil in this sector. I am not hinting on that. Granite getting decomposed because of temperature, pressure, salinity of the water, the way the dissolution of limestone was taking place agreed.

There is no agency which could have transported it because it seemed waves cannot really transport sentiments though people study sentiment transportation. So please do not misunderstand what I am saying. Those of you will be taking courses off engineering will realize this very soon that these slides are the ones which got created because of the weathering of the granite of the salt clear and they remain there they had lot of organic matter in that themselves they got disintegrated because of backfill activity and they got converted into clays.

Clay is another variety of soils, what you were referring to mud or slush, slush and mud are not technical words, clear. So, we have introduced 2 words today one is sands, another one clays fine. So, the residence soils are also one of the types of the residual soil would be marine clays and in marine deposits also we can have transported marine deposits. Mostly, these are the suspensions in seawater.

Then we have fourth category as aeolian. We call them as aeolian soils. What are Aeolian soils, aeolian a e o l i a n Aeolian, aeolian has something to do with the air, clear arrow. These are the soils which have been lifted up by wind activity and very fine particles they got deposited and hence aeolian. So most of the transported soils which you have in the Jaisalmer, Barmer, Reckoner the western part of the India.

These are aeolian deposits, clear. I do not know how many of you are aware of or not. There was a time in Bombay I used to produce most of the oil for the country when I was a student. Now, what is the scenario. I have entered everything 90% hint I have given to you, check it on the net. The western part of the country particularly the deserts are the places where now most of the oil companies are started their production why, what are desert earlier, geologically.

Answer this question for yourself. So, most of the oil companies are now concentrating on the western part, the bordering area of Pakistan and India. At least there are new 9 fields, oil fields which have been identified and the work is already going on in a big way. Imagine when you seen in Hindi movies is use migrating from one place to another place, what is the biggest challenge sorry. Direction of what, no, that is not a problem. Okay technical issue.

Yeah, they are rolling dunes, is it not, they keep on shifting. How to make a structure stand on this. I said oil production is being done. How to create the facility, infrastructure storage stance where you will produce something you have to store it somewhere you know I was seen oil tank. No. Go to wooden side there are big, big tank forms more we all over the country the entire coastal area where you have marine deposits.

There are these are the places where the oil is stored, anybody here from Vishakhapatnam nice why Vishakhapatnam is famous as far as petrochemicals are concern. What is that, I am talking about something different. I am talking about see you connect with the context of the discussion. Yes I was talking about the oil industries being operational in that region. And then suddenly I asked you a question how many of you are from Vishakhapatnam.

What is the meaning anything I was discussing about where to store the oil, I mean, naturally, I am trying to hint you at what is happening near Vishakhapatnam . Alex such thing cannot be done on sure. This is a place where big, big caverns have been created inside the ground, where the oil from the entire country crude is deposited. And from there again it is chanted to refineries, so that become a big money chest for the country.

You know what is money chest you know what is money chest check on the website of RBI. What is money chest where they keep the money safe clear. Lot of civil engineers are involved in that. So, these are the places where most of the oil is deposited. Why big question, so, what are you producing, what I was saying is that these deposits are very good in hydrocarbon. Even this deposit was a very good in hydrocarbon why.

Then I asked the question what are the similarity between coastal areas and the deserts geologically okay, so, try to understand this question and try to get the answer to this. Okay. Next one the common linkage is hydrocarbon. And the question is, if these deposits are not very stable how I am going to create infrastructure on top of it, so happened after you have created a oil tank which is normally 60 meter in diameter.

60 meter diameter is minimum 45 meter is the height. This is the height of a typical crude oil storage tank fine. Now, you measure it and realize how big the size would be. You can play cricket inside easily. Now, these systems are going to set on this deposits because just now I said that there are 9 fields of hydrocarbon very actively people are working on them to extract the hydrocarbons.

Now, how would you make them stable is a technology, it is not engineering because people do not have much idea about how to do this type of work. So most of my clients are from BPCL, IOCL Indian oil shell Burma and all this. So, I designed most of the foundations for the tanks for them. And right now in India is a big movement, you know, everywhere every city, the major issue is, India should be self reliant as far as the energy is concerned.

Because our need for the energy has gone up so much. You must be a kid when there was a big discussion in the parliament on whether India should go nuclear or not. Dr. Manmohan Singh was the Prime Minister at the time. Try to find out what your technical engineers have to do in this context. That will be another role which will realize what geotechnical engineers have to play okay. Then comes the glacial deposits.

I think I have given you another enough idea about glacial deposits. Anything which is form due to ice. The sixth one is volcanic. You can say volcanic deposits why not the from a volcano when it erupts, what is going to happen and a very high pressure and temperature you know the rocks they get molded this thing starts flowing. So this is your molten lava. And what happens this molten lava comes and settle somewhere over here.

And forms the igneous rocks and many times because a lot of air or the gases get trapped in it there are rescues We call them as vesicular you know igneous rocks. This is the process of formation. If you get a chance to go to Japan or the countries which are quite heavily affected by volcanic activities, what comes to your mind would be a big challenge to geo technology engineer.

In this context, you will be having a lot of settlements over here is it not a lot of buildings and so on. So, I was talking about the management of the lava alright. So, what happens is, I hope you can realize big task would be how to safeguard the settlements, against the lava which is going to come up imagine what will the temperature. So, most of the guys are doing river training work.

If you check it on net, what is meant by river training where you know they may turn the river entirely one of the examples of the river training what would be in Germany they have done beautiful work, just take it what are the cases where they are bypassed the entire village and they have done a colon surgery have in fact answer to answer the questions are very close to colon. What they have done is they have trained the river in such a manner that village is to get flooded every now and then.

So the whole river has been shifted. Check it on net and that has been made as a now canon, which is being used for commercial purposes. So let us talk about quickly the residual soils. What I have already discussed, most of these soils are you know, upper zonal, intermediate journal, partially weather soils, they might be having a lot of organic matter in them. A good example of this is Muskeg.

I do not know where these deposits are in India. Check it, why this is important just to sum up what we have done today before we go, see, I have given you a complete philosophy of what this material is clear and geotechnical engineering we are talking about the materials which are either soils or rocks and I have given you a complete philosophy and overall picture of how they are getting form, what are their attributes.

What causes them to resettle somewhere clear and how to utilize them. In other words, I have talked about 3 states of the material, past, present and future. So, future is all about the engineering. The whole idea of this discussion is to give you enough background about the material so that tomorrow you can use it the way you want to use it.