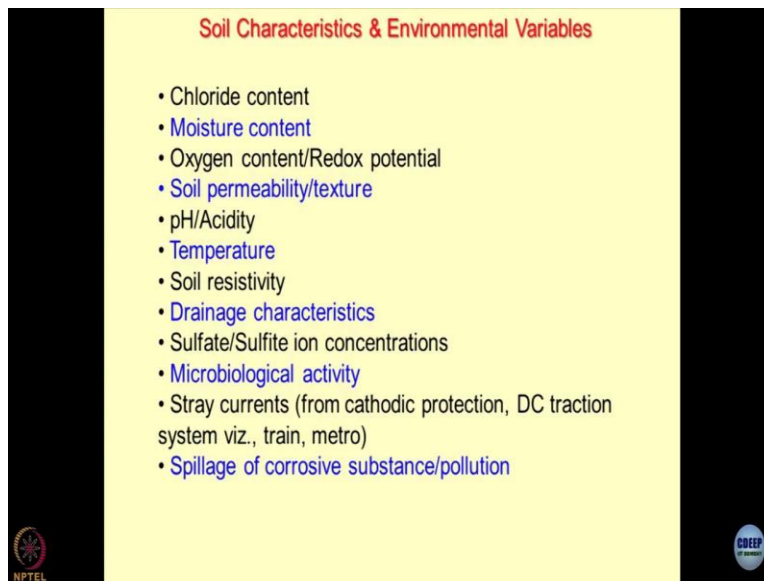


Environmental Geomechanics
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Lecture No. 37
Soil characteristics & environmental variables

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So coming back to this issue, what are the properties of soils which are playing a significant role? And what are the environmental variables which play a vital role? As far as the corrosion potential of the soil is concerned, I am going to list it. It is so unfortunate that the research could not be adequately done in this subject, but we could initiate it. And this is a topic on which definitely, you guys should work because this is going to be a big boon for the industries if we can help them in solving this problem.

So the first thing is the chloride content of the soils. Now, the second issue is moisture content and its variation. So just now we discussed, as long as the system remains submerged, it remains cut off from the oxygen, the type of bacterial activity will not survive or will not multiply, and hence the system remains safe. The problems come when there is a cycle of wetting and drying. So, oxygen content and the redox potential I think that redox potential must have studied in your 10+2 chemistry that is a reduction and oxidation potential of the material.

This is a parameter which is being used very significantly in today's practice of geotechnical engineering, soil permeability and texture I think this answers your question that when you are dealing with a certain system of soils, which are either in disturbed or undisturbed compacted less compacted state, there is permeability plays a very important role, and texture defines the permeability. I hope you can understand the texture of the soil is a sort of a USBR classification system, and from there I can make out whether the soil is clayey or sandy or silty.

And accordingly, we can link the texture with the air permeability or the gases which are getting formed inside the soil mass and when it comes in contact with let us say buried utilities which are at elevated temperatures. So, imagine the organic soil has been used as a backfill material, and you are laying a pipeline which is either at elevated temperatures or at sub-zero temperatures. So, what is going to be the effect of continuous temperature gradients which are acting on the soils is a big question one has to study.

Similarly, if you take to let us say a power cable, where the current is flowing through a lot of heat gets generated and the chances are the organic material might get decomposed because of excessive heating. So these issues are becoming very very critical and not easy to answer. pH and acidity of the soil is also a big question of how the soil will be here because at the parameter which controls the bacterial activity quite a lot. Okay. So, dropping pH of the soil, or the backfill covers which are being used even for placing the foundations.

So, what do you do in shallow foundations you dig a pit place the foundation cast the foundation and then cover it and then compact it? So, imagine if you are using the soils of very low pH values are very high pH values, it is not going to be good for the health of the buried structure. This type of thinking was not done in the past, and hence it is becoming very important now, or this may happen because of the act of god or it may happen because of the act of human beings.

So, you have a storage facility somewhere where a lot of contaminants have been stored, and they are leaking, and all these leaking material is entering into the foundation pit. And if the pH changes what type of alterations in the bearing capacity and the compressibility of the soils are

going to occur is a big question that we are trying to address. Temperature, so, basically temperature would influence the bacterial activity, soil resistivity.

This is electrical is with the soil electrical activity gives a direct indication of what is the state of the soil and how the size would get affected due to the environmental activities and what is going to happen to the systems which are buried inside. So, we will talk about this. Drainage conditions and drainage conditions and soil permeability and texture are interrelated. So, imagine a situation where most of the time, water remains waterlogged low permeability.

So, under these circumstances, when water cannot go out and come out of the soil matrix, what is going to happen. So, low permeabilities are also not good. So, imagine you have cut off the entire system from the environment by putting his soil which is extremely low permeability in nature. So, water which gets trapped inside cannot come out the decay of the soil will take place and these type of soils will have extremely high thermal resistivity which we will study later.

So, I am sure we realize that all these subjects and topics are becoming interlinked. Clear. And that is the main component of environment and geomechanics which has to be studied for practising, the concepts in the modern day world. Is this part okay? Then, of course, sulphate and sulphide ions which are present in the soils. So sulphate and sulphide ions are directly controlling the pH of the soils then, of course, microbial activities which I have discussed a lot of stray currents.

Now, you must be wondering that we are geotechnical engineers are going to be using this concept any guess where they will be using this concept. Stray currents are directly related to cathodic protection. So, most of these underground utility pipelines are provided protection, and that is what is known as cathodic protection. So, the entire pipeline is charged externally why, particularly negatively charged why, because mostly the bacteria is negatively charged.

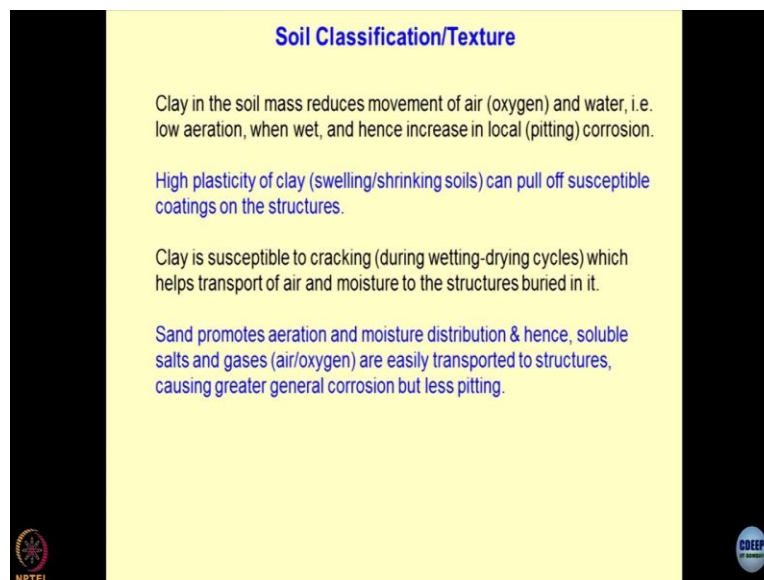
So, that is why the cathodic production is done on the pipelines, there is no fun in the linear pipeline a few thousands of kilometres and every year digging it out and replacing it you can understand particularly when you are talking about the train and metro DC tractions also where

the voltages are very high. So, this is where the stray currents will get generated go to a power station, know where you have gadgets which are used for augmenting stepping up or stepping down the voltages.

So, I do not know whether you noticed or not. It is a big question, how would you lay the foundations of the structures over there transmission towers, there is a very interesting article on the net, you should read that, how to design the foundations of structures in the power stations or the grid stations where the power is supplied to the entire vicinity. Another good example would be the design of tiles, petrol pumps when you sit in the aircraft; they announce when fueling is going on, you are not supposed to use your mobile phones all these things are interrelated these are all stray currents.

So, these stray currents are quite difficult to handle. And of course, these spillage of the corrosive substances are the level of pollution which might come. So these are the parameters which constitute the matrix which you people are trying to study. I hope you can realize this is a very complicated subject and not much of the research has been done in the Indian context. But this is a topic of great importance to the industry, and hence people should work in this area.

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Soil Classification/Texture

Clay in the soil mass reduces movement of air (oxygen) and water, i.e. low aeration, when wet, and hence increase in local (pitting) corrosion.

High plasticity of clay (swelling/shrinking soils) can pull off susceptible coatings on the structures.

Clay is susceptible to cracking (during wetting-drying cycles) which helps transport of air and moisture to the structures buried in it.

Sand promotes aeration and moisture distribution & hence, soluble salts and gases (air/oxygen) are easily transported to structures, causing greater general corrosion but less pitting.

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So, I will quickly go through some of the parameters which have been understood a bit by the researchers the in geotechnical engineering, soil classification and texture is the most important

thing because everything is aligned with that. So, as the rule of thumb of rule is that the presence of clay is a big deterrent as far as the supply of oxygen is concerned and water is concerned. Now, this is where low aeration may cause different types of issues as compared to high aerations.

So this is one example where low aeration when the soils are wet, would increase the pitting of the pipelines because of the bacterial activity. Now if you have high plasticity of the clay that is the minerals, the swelling and shrinkage become a big issue. And what swelling and shrinking is going to do most of the time, and we do piling we use a different type of epoxies you must have come across this particularly what type of piles, driven piles or precast driven piles.

So, what normally is done is that after the piles have been cast, there is a coating which is given on the piles to enhance their life, particularly in environments which are extremely aggressive offshore environment particularly. So, when you have given this type of coatings to the piles, to the buried structures, this could be culverts also this could be the foundations also if the soil is shrinking and swelling soils what is going to happen every time the soil comes in contact with the epoxy, it has a tendency to rip off the epoxy.

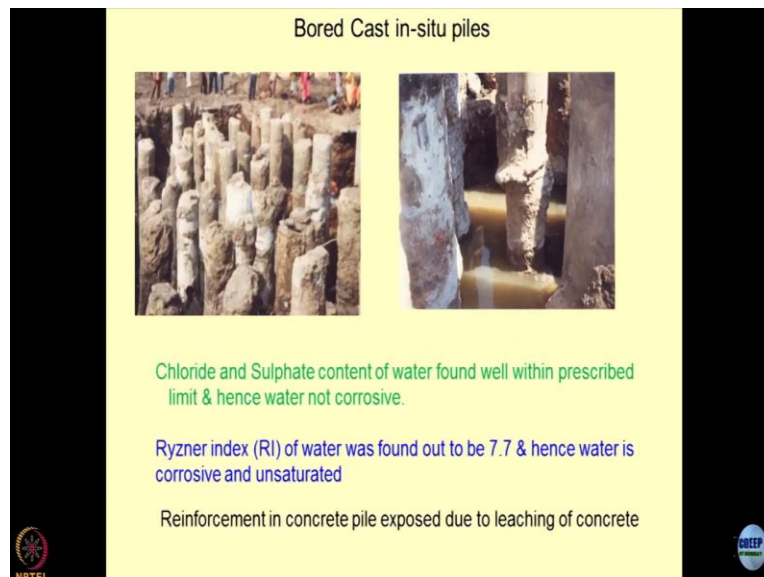
So, this becomes detrimental. So, soils which are having swelling, shrinking behaviour, apart from the storage of water as their fundamental property. They also are detrimental to the coatings which you are doing on these structures, and this becomes a difficult game. Clays. Whenever you have clays, they will crack and inside whatever is buried might be conveying some temperature gradient to the soil mass. So, imagine soon after burying the utility the entire backfill cracks clear very unwanted sign very unwanted situation. So, these type of situations has to be avoided.

So, clays which are having minerals where the wetting and drying is important or they are very active as far as wetting and drying are concerned. You have to be careful when you use them. So, on the contrary, when you use sands, what do you do the problem with the sands densities. So, if I use sand as a backfill material which is the ideal situation, I cannot achieve the better densities is it not? But at the same time you to study sometime later that sands have high permeability, high thermal diffusivity, thermal resistivity is going to be less. And hence, they are the better

material for using as backfill apart from the geotechnical aspects where we have said clays cannot be compacted.

And if I use clay in the backfill tension cracks will develop, you agree, and then the chances are that the entire system will consolidate after some time. So, this is a lot of discussion between fine-grained material, coarse-grained material but coming to the point, sands would promote aeration and moisture distribution properly. And hence the corrosion potential of the sands is going to be less. So, it is a pure research area, you take the soils, create situations and try to study the combination of the buried utility and the soils how do they behave? So, because we were discussing the bored cast-in-situ piles.

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I will just show you what has happened in one of the sites. So this is a place where piling is going on, and if you have a close eye on this image, you will realize that half of the piles are quite whitish in nature any guess why they are white colour this is the oozing out of the calcium from the concrete. Why this happening sort of. The same thing happens in human body also. As we grow old what happens, the calcium absorption of the body and the bones becomes less and then what happens from the body calcium starts oozing out osteoporosis, very dangerous disease, lack of nutrition, lack of absorption of calcium in the body and so on.

And the same thing is happening here also in the structures you can observe and why what is the reason for this, which has been ignored. Look at this; you designed a pile for certain dimensions and the capacities. So what has happened here? What this portion tells you the concrete has got corroded completely, what is the cover of the concrete which you put on the reinforcement 15, 20 mm, I hope you can get from here what was what would have happened to the reinforcement itself.

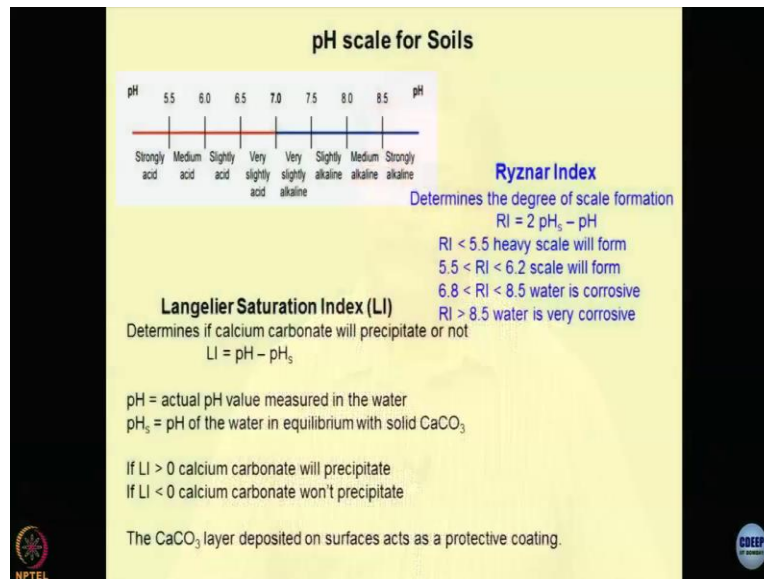
So, if you check on that, you will find it is an eye-opener that this type of ignorance which was prevailing in the subject has been overcome now, and people are designing systems which are more environmentally safe and compliant. So, chloride and sulphate content of the water found well within prescribed limit & hence the water was not corrosive, but there is something known as Ryznar index RI, which is found to be 7.7 and which says that the water at this site is unsaturated, unsaturated water means with calcium ions.

So piles are acting as a source of emission of calcium ions like your body from where the calcium keeps on oozing out, and then the water is unsaturated in terms of salinity, or calcium ion concentration. And this situation becomes very, very problematic. You are agreed what should be done then to overcome this type of situation? That is a big question that is a case study. So when you have osteoporosis, what is done? As a kid, what you were given as a supplement for the proper growth of your body and bones, calcium supplements, what I should be doing here, give calcium supplement to the groundwater.

But the question is this groundwater is flowing. So, this problem becomes an interesting problem to perform surgery on. Are you getting the point? I think now you can realize you are talking about the case studies, give a solution to the client and show that even after 20 years of your treatment, there is no nothing untoward happening to the foundations. I am sure you have realized that these type of concepts are not discussed earlier in the subject or be bothered is bearing capacity.

And it thought that bearing capacity is always going to be same for time immemorial. But now, what you are realizing is the more and more industrialization is occurring, the more and more pollution is getting stacked over this is a threat to the existing structures.

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So, this forces us to study the pH of the soils and the pH of the groundwater and calcium, concentration of the groundwater, and so on. So, all of you are aware of the pH scale, which is used for defining the acidity or basicity, clear. So, the scale of 7 is neutral, and less pH becomes more acidic system, high pH becomes more alkaline system.