Environmental Geomechanics
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Lecture No. 38
Corrosion potential of soils

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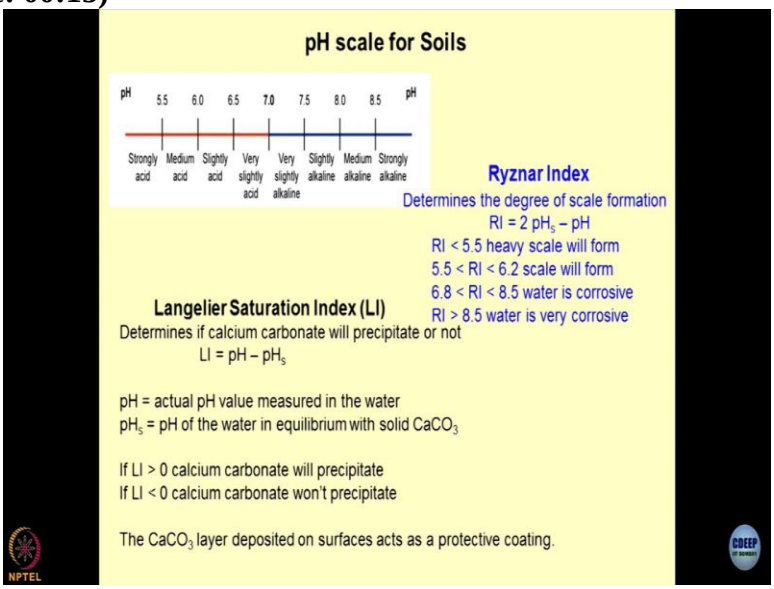

So, the LI of the Langelier Index this is defined as the pH of the water actually, then pHs is the pH of the water in equilibrium with solid calcium carbonate. Now, this shows how much unsaturated the water is in terms of calcium Ions. Now I hope you can understand if LI is greater than 0, that means pH is of the water is more than the pH of the water when it is in equilibration with calcium carbonate.

Calcium will lose out from the structures it will go into the outside environment and precipitate over there, and that is why you see the colour of files becoming white. However, if LI is negative, that means pHs is more than pH, calcium carbonate will not precipitate. So how should I put this in practice give calcium supplement to the groundwater, how to do that, I hope you realize the similarity between our profession and the medical professionals read more about the negatives of grouting, gone are the days when people used to grout and put cement or calcium into the soils,

Why? Because somewhere down the point, it is going to create some imbalance. See, this is how the subject is generating. I hope you realize that how the subject has got its value. So you cannot just do grouting somewhere why a person like me will come and catch you. I will monitor in the periphery of my utility or my property, and then I can prove that this is because of this activity and I can also trace calcium by using a different type of calcium tracers, that this is coming from this place and sue you yes this is the world.

This is what the practice is. There is something known as Ryznar index. So Ryznar index also can be utilized to study how the scales are getting formed on the buried systems. So, this is 2× pHs - pH, and you need not remember all these. The codes are available, so, you need not write down. Just try to understand the applications. And maybe whenever you are in the practice of the subject, you can use this.

So, if RI is less than 5.5 heavy scales will form. I hope you understand what is scaling carbonates getting deposited. Now, another issue which I think you should realize if any of these sorts of things happens and if the calcium content or the groundwater changes, what is the major impact? Who is going to challenge you tomorrow, agriculturist is those who are into the irrigation those who are using this water for irrigation purpose.

So, if you are grouting something and chances are that the calcium ion concentration becomes more what is going to change in irrigation water, what is the term known as. There is an index. You must have studied for irrigation water, what are the parameters calcium oxide divided by something something something summation of something that tells you what is the Yes. So, you have to be careful hope you realize you cannot practise your profession in isolation.

Why I am giving this example, and the second thing is happening where the calcium concentration is decreasing in water then, then also there is a problem and calcium concentration will decrease by due to precipitation. So, if I have controlled the pH of the groundwater too much, what will happen the chances are the calcium present in the groundwater might precipitate, and your water may become saline?

Now, imagine if you are drinking water every day what is going to happen not saline water. Sorry. Demineralized water. So, I hope you can realize now this is what is going to be a big issue. So, similarly, you can have different types of parameters of RI, and then there is a classification which informs you whether the soils are corrosive or not fine.

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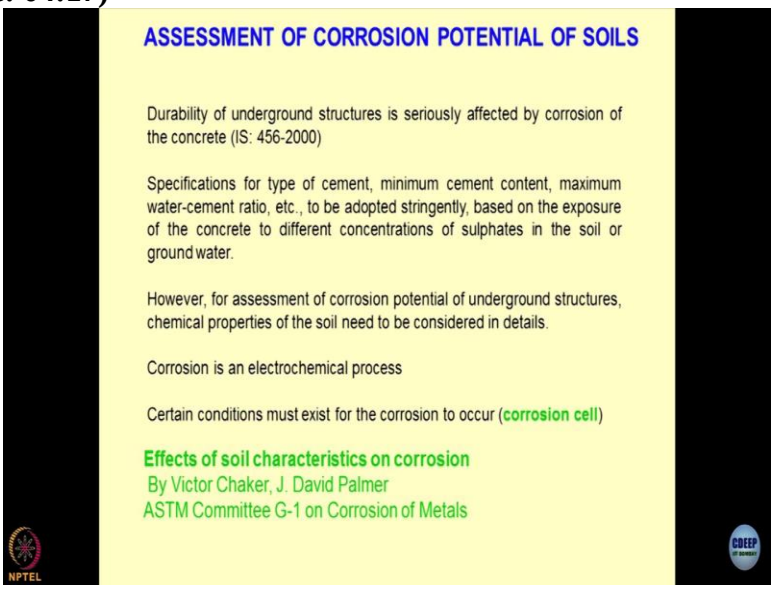

Now, whatever we did, I am just going to present the assessment of corrosion potential of size. So, when we talk about the underground structures and their durability, there is a code IS code 456 you must also studied 2000 on the corrosion of concrete. What are the types of cement should be utilized? There was a time, and some of the cement industries used to contact me for doing micro zonation of the soils, where most of the infrastructure is going to come up.

Why? Because they wanted to create cement and they wanted to launch it in the market by saying that this cement only can be utilized to counter the aggressiveness of the soil. So, these type of things goes on where the research and the industrial activities join hands. So, it will all depend upon the type of cement; I hope you understand what the meaning of the type of the cement, minimum cement content, maximum water cement ratio and what is the exposure condition to which the concrete is getting exposed and what is the sulfate and chloride contents which are prevailing at the ground water is.

So, then accordingly I can choose then the cement, of course, you have to analyze the complete soils to choose a certain type of cement to make concrete and hence, you can nullify the effect of

corrosion potential. So, sulfate resistant cement are quite prevalent, is it not in the market. So, from this point onwards, you should study what the corrosion of the material is. So, this is basically an electrochemical process, and there is a formation of corrosion cell, and I will show you what the concept of corrosion cell so certain conditions is.

Now, these conditions could be environmental conditions, or these could be the anthropogenic conditions also nowadays because we are studying too much of microbiology in geotechnical engineering under the realm of the bio-geo interface. We realize that there are bacteria or bacterial activities which might produce acids. So, the soils which are quite conducive for good infrastructure development might become very acidic because of the microbial activity or bacteria activity.

One has to be careful, and this is where the sensing techniques have become very useful. So, that means I should be aware of what is going on inside the ground. Now, these type of thoughts come to mind because when we deal with the professional world, when we come across the industry where the failures have occurred, and when we do postmortem analysis we realized that everything is right as far as the construction of the system is was concerned.

But then the question is why failure has occurred. And when you do back synthesis of the failure, which is known as you backward analysis of back analysis of the failure process forensic examination, then you realize that these type of activities which have been ignored are quite prevalent. Hope this gives you the idea about what is happening there is an interesting literature on the effects of soil characteristics on corrosion.

And this is the ASTM committee G-1 on corrosion of metals, which sometimes people refer to for doing the analysis. There is a very interesting article, how the buried fibre optic cables, they are getting influenced because of the corrosivity of the soils and in today is the world, everything is data agree if you want to supply data uninterrupted and the power uninterrupted then you have to study this subject quite closely.

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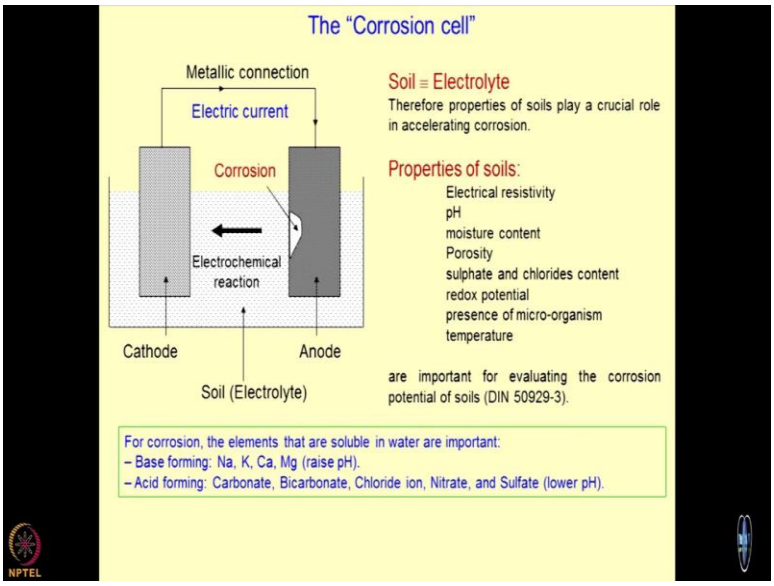

So, this is the conceptual discussion on corrosion cell. Now, what it indicates is that if I take the soil mass, which is not dry. So, maybe during rains, the soils will become wet. And once the sides become wet, the electrolyte gets developed over there. This could be because of the groundwater. Also, the moment soil becomes wet, there could be a situation where cathode anode might get developed, do not think that cathode has been inserted into the soil mass.

Because of the electrochemical reactions, the chances are that certain portion of the soil might act as anode and certain portion might act as a cathode that could also be because of the bacterial activity, concentration of bacteria at one place in the soil mass would connote to something different than another place. And if you remember I think I was talking about long back that nowadays people are studying the microbial flushing also. So, from one place, the concentration of microbes getting flushed out and might get accumulated or some other place.

So, by virtue of anything, if a situation of this sort occurs that there is a cathode formation anode formation in the soil mass which is wet and because of being wet the electrolyte is present in the soils, the corrosion of certain portion of the buried element. So, now, I would say that this anode is a pipeline or let us say or a foundation or a pile here. So, the moment this type of situation gets triggered because of environmental parameters, the chances are there a certain portion of the anode might get eaten up, and that is what the corrosion.

So, this is the conceptual model, which would depend upon so many parameters. And I hope now you realized that why we have included some of these parameters in the neo classification schemes for the soil when we are talking about what is available in the literature and how the classification scheme should be modified, keeping in view the environmental influences but right now the classification scheme is including these parameters, but what should be the futuristic classification scheme. What is required?

So, if you read this matrix of the material properties which are required, the first thing is electrical resistivity, because for the formation of the corrosion cell the electrical resistivity of the soil should be as less as possible. Thumb rule says when the soils are in the dry state, their resistivity is high when they become wet, the resistivity decreases, why? Because you have a pore solution in the system and the ionic conductivity become faster or easier.

This might force you to keep your system saturated all the time, but where is the water available to keep the saturated, particularly the foundation systems saturated all the time. This is the question pH plays an important role, moisture content, porosity, sulfate and fluoride content, potential redox response of microorganisms and temperature this is a big matrix, and if you come across this code for DIN 50929-3 they have talked about the corrosion potential of the soils.

But most of the systems are being designed by keeping these things in view, what is easier to control soils or to control the structures which are buried inside that is one of the ways of designing the whole thing. But then in the process, you are using more materials, and the cost of the structure is going to be extremely more. Another way of intelligently doing the whole thing would prove that the soils are passive or create a passive system of the soils in which you bury a low-cost structure, which is not going to get affected due to the corrosion potential of the soils.

So, this becomes an interesting practical problem. I hope you realize this: why not? Yes, isolation is a very good solution. We do base isolation against the earthquakes, please remember all these structures we are designing for several years. And our pretext was that all the systems are directly exposed to the environment. Look at the coastal areas, how would you protect your foundations against the seawater intrusion? Check it out on the net what type of disasters have

occurred because of the corrosion of the material. And then you will realize how many buildings have collapsed. It is not a small thing.

All this comes under the forensic examination. Which is the needle hour and then we have to talk about what are the conditions of the soils whether these are having base farming elements or acid-forming elements? So mostly carbonate bicarbonate chlorides, nitrates, sulphates, these are all acid-forming elements water-soluble when you have sodium, potassium, calcium magnesium this series this is basically raising the pH of the system. So, they are basic things both are problematic; these type of studies have forced us to consider geotechnics of contaminated soils.

Very soon you will realize that the soils which are contaminated will also get affected as far as their shear strength and permeability compressibility compatibility parameters are concerned. There are a lot of studies which have been done. If you are interested, please go through the literature, and you try to find out what happens to the soils in terms of the shear strength when they are contaminated. So, I hope you realize that these are the grey areas in the subject on which a lot of research has been conducted.

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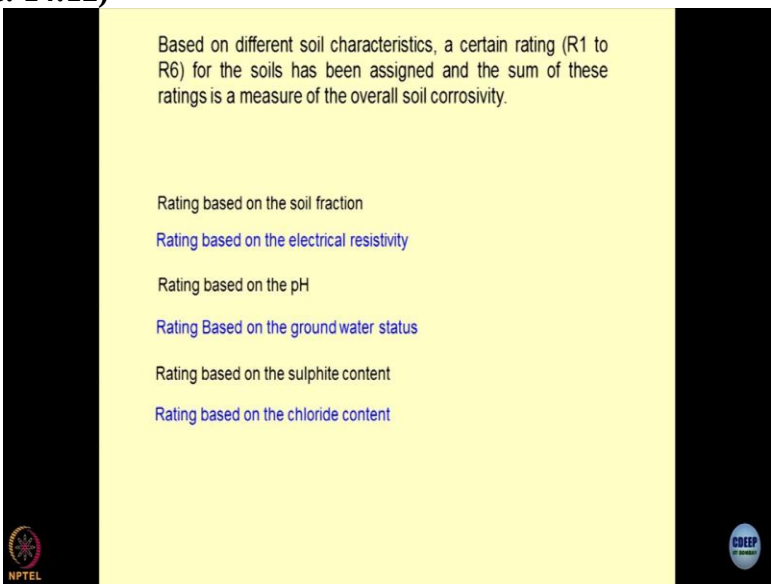

We tried to coin 6 parameters, depending upon the properties of soils and using this 6 parameters, we have shown that whether the soils are going to be corrosive or not, you are free to modify this matrix 6 might become 16 your case or 6 might become 16. In your case, it is all up to you. So, we have devised the rating system for soils, and the rating system is based on soil

fraction, which is nothing but the texture of the soil. Particle size distribution rating is based on electrical resistivity, then pH then groundwater status. The motivation behind using the groundwater status was the conventional geomechanics, where you use the d by d factor to reduce the bearing capacity of saturated, unsaturated soils if you remember correct submergence effect of submergence, so, you use that d by d factor to define the location of the water table and then you say, if this is less than certain value then the bearing capacity has to be reduced by half or something like that rating based on the Sulfate content and the rating based on the chloride content, so, these 6 parameters were used for defining the corrosivity of the soils.

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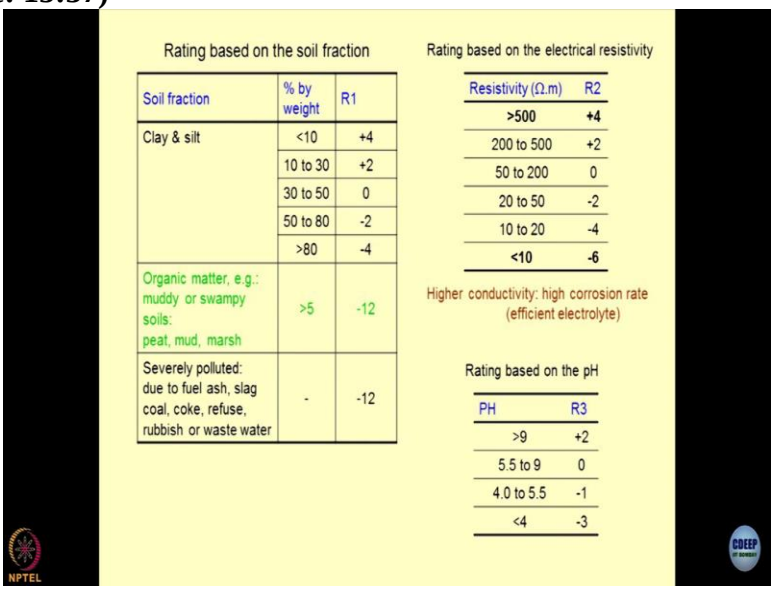

I do not write these numbers just try to understand how your research ideas are first of all coined and then practised, and then they precipitate in the form of the knowledge. So, we have defined this term R1 depending upon the particle size distribution characteristics, and these weights have been defined arbitrarily. So, if a situation is helping in reducing the corrosion, we give positive marks, but if it is aggravating, then we give negative marks.

So, if clay and silt contents are very high, the weightage is - extremely high that means, this situation is going to be a detrimental organic matter if it is more than 5% water retention will be more permeability will be less strength will be less compactibility will be less and hence extremely high negative weightage then severely polluted situations again very high weightage clear. The second is R2 resistivity electrical resistivity so, if electrical resistivity is very high.

Then this type of a situation has been given more weightage as compared to a situation when the distributor is extremely less then we have this effect of electrolytes that is the pH if pH is more than 9 less than 4 we have rated them in a different manner pH less than 4 is more acidic and hence the chances of corrosion are going to be more and hence – 3.

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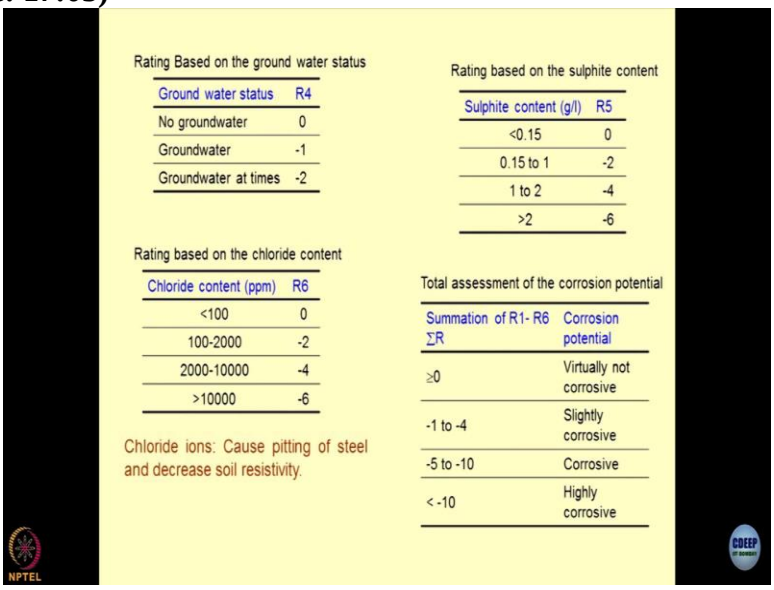

Rating based on the groundwater status if there is no groundwater, I will be very happy. But if the water table is fluctuating, then there is not a very good situation and if groundwater is there - 1, then similarly sulphide content and chloride contents. So extremely high values of sulphide content are not good. Extremely high chloride contents are also not good in coastal areas, you will have a very high concentration of chloride content, approximately 4000 10,000 12,000 depending upon the area in which you are working.

And ultimately, what we do is we sum up all these parameters, and we define the recommendations. So when you sum up from R1 to R6, this is what emerges out if r is a positive, very good situation, if r is the extremely negative, highly corrosive situation. So this type of thoughts we had proposed long back, and I think industries are using it and quite happy with this type of scheme. So coming back to the point that classification depends upon what I am doing, I am perusing I can create my own classification scheme, which when validated by using different case studies become universal.

So I am sure for some of you, it will be a very difficult thing to digest, that how the classification system can be evolved based on your requirements. But that is what R and D are, must have got some idea about how to do creative thinking and how-to professor ideas in practice.

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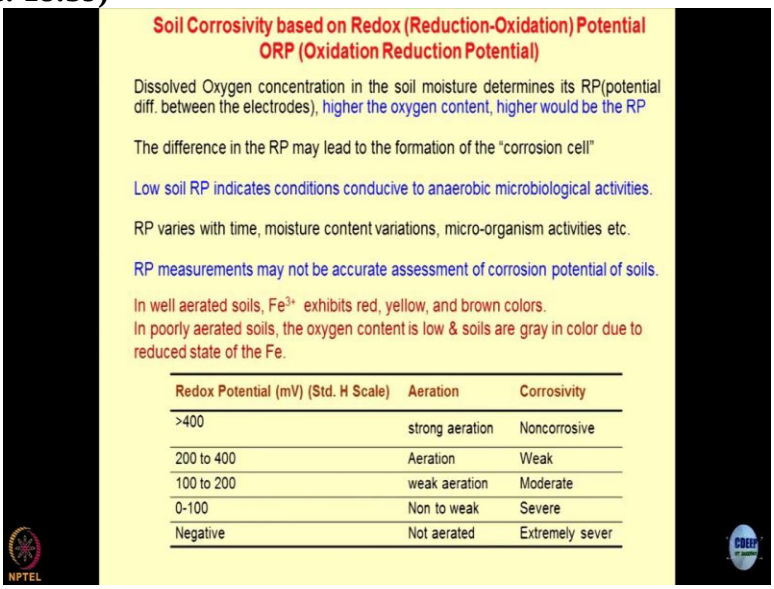

Then we talk about redox potential also is what is known as ORP oxidation-reduction potential of the soils, how easy the soils might get oxidized and they might oxidize or they might reduce depending upon a different type of constituents. And how easily the corrosion cell may get formed in the soils is what is known as a redox potential. Nowadays things have become simple because there are probes which are used to check the ORP potential of the soils oxidation-reduction potential of the soils on it. So, this becoming a pretty simple situation.

One of the good examples is how Fe^{+3} will get reduced, $Fe^{+2,}$ and this is a good example of how the reduction of the iron might take place what you are talking about in the buried condition. So, some people use this scale which is known as standard h scale, and this defines the redox potential of the soil in the millivolts redox potential depends upon the aeration property which you were talking about when the systems are buried all the time or are saturated or submerged in water, then the chances are corrosive are less. So, when the redox potential is more than 400, it is a strong aeration case, non-corrosive environment.

However, when you have redox potential as negative, there is no aeration. This becomes a case when anaerobic activities become quite severe in the soils, and the corrosivity becomes

extremely severe. So, again, these type of studies are being conducted by people, and they are trying to quantify everything.

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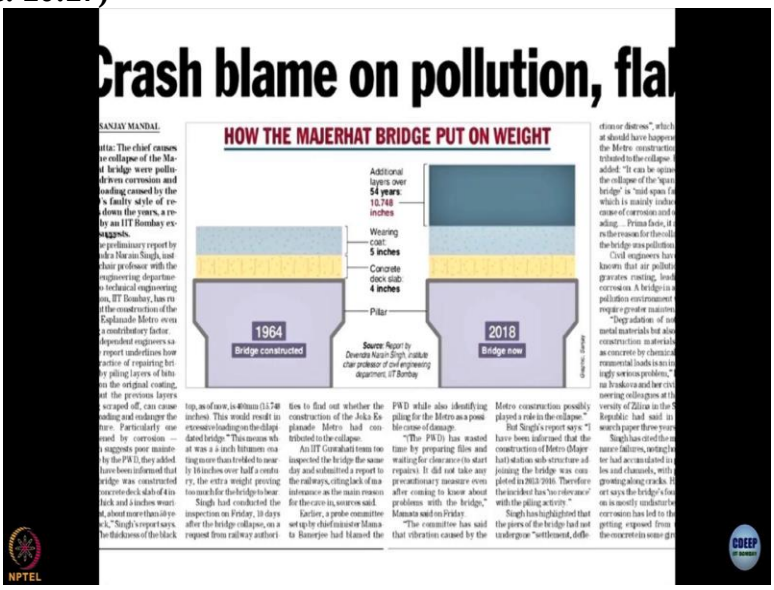

Just to show you a case which you are interested in seeing what is happening. I think this was a failure which occurred last year in Calcutta. Several bridges were failing, and they were collapsing. And it is so turned out that rather than the structural failure, most of the failures are caused because of the corruption. So, this is an interesting case where a geotechnical engineer has given a report related to how the corrosion of the foundation and the material concrete is more responsible as compared to the structural issues.

For this was a really interesting case with people are citing now. The more and more underground construction is going on in the country. The problems are becoming more and more. I hope this gives you some idea about where we are heading to fine.