Environmental Geotechnics
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Lecture - 07
Civil Engineering and Soil Mechanics

The sub topics which I want to cover in today's lecture are Civil Engineering. We will be talking about the definition of civil engineering and the connotation of this science or technology you may say. Again the Soil Mechanics revisiting the concepts of soil mechanics defining what is soil mechanics. Genesis of the subject that is the Environmental Geomechanics what is the cause, why people talk about this subject, why this subject is becoming you know need of the hour; we will be trying to understand under the sub heading genesis of the subject and of course, what is the scope of this subject. Scope will also include some applications.

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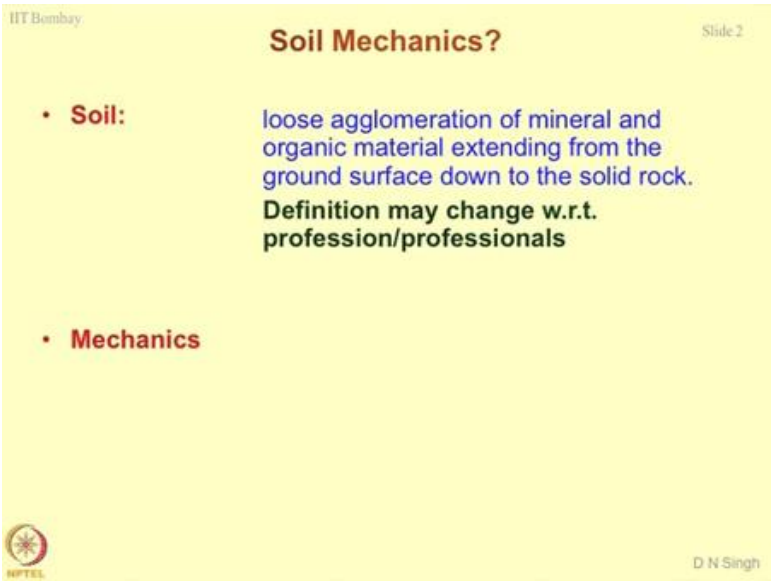

So, we were talking about what is soil mechanics and before we start understanding the term or the subject soil mechanics is interesting to understand what is meant by soil and what is the meant by mechanics. In the previous lecture, I was asking with the question how do you define soil and what we did is we define soil in this form that is loose agglomeration of minerals and organic material extending from the ground surface down

to the solid rock. And then I also point this concept that the definition keeps on changing or depends upon the profession and the professionals; how they are using it.

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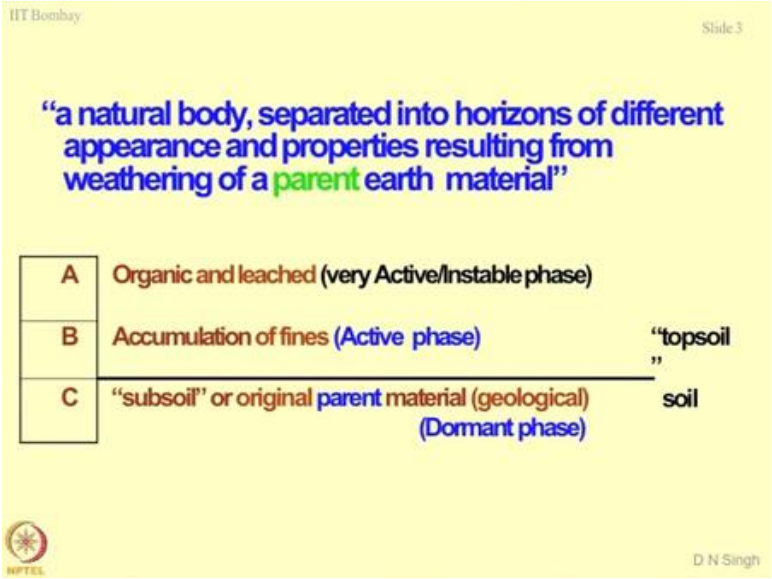

Let us continue with this discussion regarding soil. Another way of defining soils would be it's "a natural body, separated into horizons of different appearance". I hope you will agree that appearance is a very important. It has a very important significance in geomechanics of soil mechanics and properties resulting from weathering of a parent earth material.

So, this is the first time somebody introduced the concept of weathering; that means, this soil happens to be a material which is an outcome of some phenomena known as weathering. So, this is the weathering of a parent earth material which causes soil to get produced or generated. Now this is how you can define the categories A, B and C. The top most surface which has organic and leached material this soil is supposed to be very active. Why it is so and at the same time this is very instable. So, a material which is very active will be very instable or unstable; highly active hyperactive material. Why it is so?

Interacting with the environment (Refer Time: 03:02).

Exactly; that means, this material happens to be interacting quite a lot with the environment. So, this is the topmost layer which is exposed directly to the environment.

And when we talk about environment the basic attributes which we are referring to our temperature, pressure, humidity any other activity man made or natural. The second component of the soil would be accumulation of fines, now how accumulation of fines takes place, there could be because of migration of fines when soil mass interacts with water. So, any percolation which takes place in the form of precipitation or range, the tendency of rainwater is to flow away the fines and then all this fines get accumulated in this zone of the soil mass. So, this becomes again a very active face.

Now, put together these two phases, we call it as topsoil. I am sure that you will agree when we talk about agriculture, when we talk about aquaculture, horticulture even you know pot making, potteries, artistic work and so on handicrafts. This is where actually we talk about topsoil, but as an engineer, we never lay the foundations in the topsoil. We always they have a tendency to come down crossover from topsoil to the subsoil and then we use the word subsoil. We always talk about subsoil profile, why? Because this is the region which is protected cut off from the environment; it is not hyperactive, is a passive zone. So, this is where actually you like to you will sorry you will feel like link the foundations or doing some engineering in this zone that is a C zone. So, this is the subsoil or original parent material.

Now, there is a reason of putting A, B, C categories like this the C category happens to be leached active is a parent material. And when parent material interacts with environment the weathering takes place and because of this weathering, the formation of the soil takes place. So; that means, in other words the activity of the material would be increasing from C to A, clear.

So, most of the time when you talk about the coastal areas, the biggest problem is the soil which you get there is marine type and organic in nature. Why it is so? Because of heavy interaction with climatic conditions as well as sea water. So, sea water is a responsible for creating the humidity and degradation of the soil mass and this degradation results in the residual soils which are nothing, but organic soils, clear. So, this is how actually some people tried to define deformation of the soil or the soil types.

So, the subsoil happens to be of geological nature in terms of timescale, the life would be millions of years and then it happens to be a very dormant material. So, this is we are most of the engineering is done. You will never do tunneling in weather material, clear.

You will not lay the foundations open foundations or even for that matter piles in the top soil, you will always be going at least below the soil surface, subsoil and then you will be doing tunneling over here or piling work storage work or whatever.

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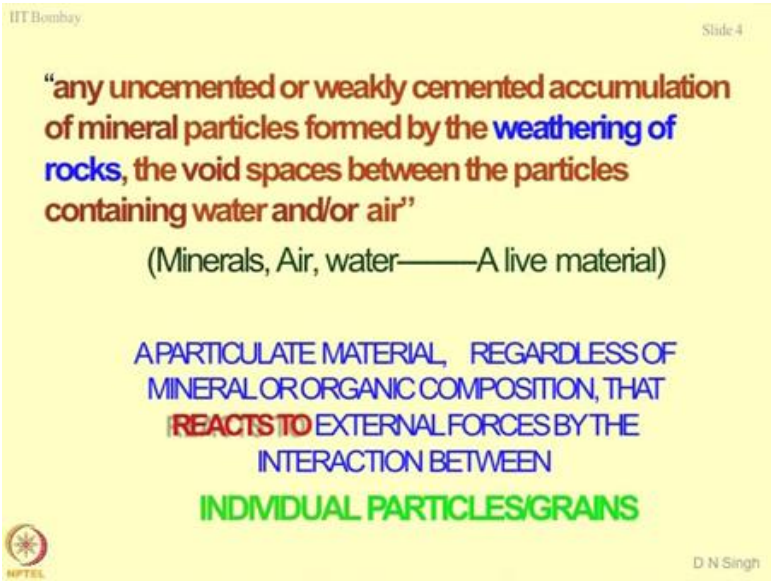

These are another definition which I came across for the soil any uncemented or weakly material weakly cemented accumulation of mineral particles formed by the weathering of rocks. So, weathering is the keyword. Now whatever weathering normally you talk about? So, coming back to this definition any uncemented materials or weekly cemented accumulation of mineral particles form by the weathering of rocks the wide spaces between the particles containing water and or air.

So, this again is a classical definition where people were not bothering about the contamination coming in to the soil mass. So, here the emphasis is that force or the voids in the soil mass are filled with water or air, clear. Nowadays, we are more interested in understanding all the phases of the soil; that means, you have soil mass, you have water, air and adulteration into these phases and so on. So, what happens when you have minerals, when you have air, when you have water associated with something this becomes a live entity like human body, is it not? So, what is human body made up of? So, it grows from soil and it ends up in soil, you are agree or no? So, that is the similarity you take lot of minerals in the form of everyday food intake.

Whatever you eat is nothing, but direct indirect form of some minerals which you are consuming, you breath air, you drink water. So, any entity which utilizes these three things becomes a live entity. So, this is where the philosophy is that soil should be treated as a living being; living material. Look at this; this is the first time somebody coined that what is meant by a particulate matter.

So, a particulate material regardless of mineral or organic composition that reacts to external forces by the interaction between individual particles or grains. How to define particulate material? You must have done undergraduate; you have coarse grain structure or fine grained structure. So, in coarse grained structures, you have mostly what type of structure cubic structure, is it not single grains. And when you talk about the fine grained materials, you have card of structure, flocculated structure, disperse structure and so on honeycomb structure and so on

Honeycomb structure.

Honeycomb structure and so on so; that means, why they say that this is a particulate material because given a chance this material has a tendency to show different types of grain structures. So, that is where the particulate mechanics that is what the genesis of particulate mechanics is; that means, the each particle has a tendency to form a system and that is what is known as grain system of grain structure. So, regardless of the minerals or organic compound compositions that reacts to external forces.

Now this is where actually I find an interesting enology that soil has a tendency to react to what the external forces. So, when you are designing foundation, what is the job of the soil? To bear loads and ultimately what happen when it be as the loads it deforms so; that means, soil understands that what type of load in going to come on it. So, this is sort of a reaction, you heat the soil mass what happens?

Shrink.

Its shrinks or it crumbles or it cracks so; that means, the material understand what is happening to it. Now this is where I say that this material has sentiments. So, when once you start understanding that there are sentiments it becomes very easy to handle this material. What is the meaning of this? We have to understand what are the external forces. Right now you might be doing 6 courses or 7 courses or 5 courses is a sort of a

external loading; the next semester, you do only 3 courses. So, loading is less and then comes your thesis work where you are not supposed to do any courses only thesis work so, the loading is much much less.

But again it depends upon your guide who may give you lot of work and the loading may become much more. So, till now what we have been doing is we have been talking about external force in the form of mechanical forces, but then there are lot of hidden forces in day to day life. One of the force hidden force would be temperature effect.

Why weathering takes place? Because of temperate climate or extreme climates where you have extreme temperatures humidity followed by rains and the cycle of rains. So, this is how the weathering starts. So, the first comes your winter season, then comes rains little bit, again summers, again rains again winter and so on. These are cycles so; that means, the material understands how it has to react under a given circumstances and these circumstances are nothing, but the external forces all right.

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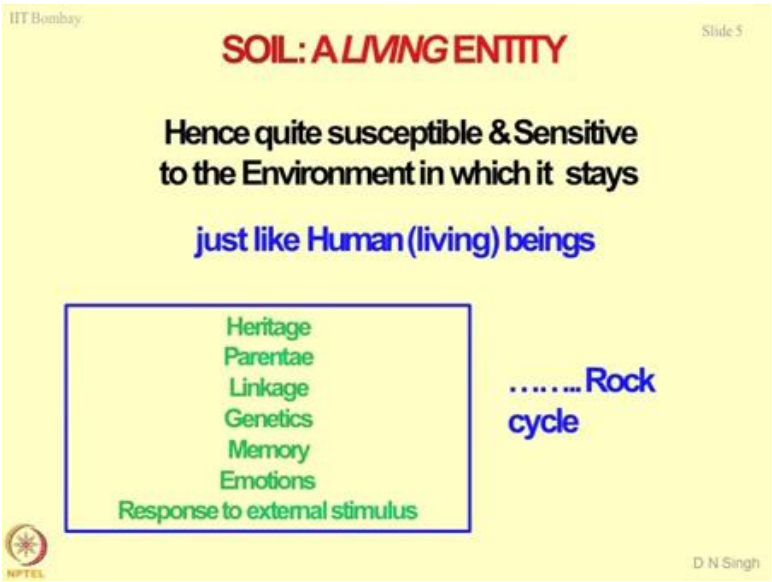

So, this is where I say that soil is a living entity and hence it is quite susceptible and sensitive to the environment in which it is sitting or staying. And this is where I say that again it behaves like a human being. So, the way human being behave; it is very hot and you always says it is very hot outside.

Then what happens? You feel thirsty, your skin gets dry; there is cracking in the skin also perspiration. What is perspiration? Sweating perspiration loss of minerals. So, you load the soil which is saturated, what happens? All the water comes out in the form of excessive pore water pressure. Do you find the similarity or not? So, you load the soils with the mechanical loading and you are getting loaded by environmental effects. So, the process is same. The mechanical loading causes pore of pressures to develop and water sweeps out soil becomes unsaturated. You start running in very hot climate, what is going to happen? You will run up to a certain limit, all the minerals, you will evaporate; they will come out of your body in the form of so it and ultimately you will collapse.

The lot of similarity is there. So, this is again an interesting thing. Every living entity has some heritage you agree or no? You must be having some heritage; heritage of your grand great fathers whatever. In what way heritage of soil is linked with the parent material? What is the parent material?

Rocks.

Rocks.

Rock.

So, all the genetics associated with the rocks has to be transmitted in to the.

Siblings. Siblings, agreed? So; that means, it has heritage, it has a history you agree or no correct. So, there has to be a heritage soil from gangetic plain, soil from peninsula, soil from lake. You have different names for these type of soils, you have a characterization scheme for these type of soils, you agree? That means there is a certain different between soil from one place to another place to another place. Why it is so? Because the parent material itself is different parentage is different.

The linkage, how do you link different phenomena? What is the linkage between you and your parents and their parents? The degree of weathering clear. The cycles which a system has under gone through of heating, drain, climatic changes, disturbances, deposition, excavation, redeposition and so on. Now this is nothing, but we call it as a extra cycle. In consolation tests, you load the system, bring it up to a certain point, unload it. This is one cycle from this point onwards, again you load it and unload it.

So, these are the two cycles are loading unloading. So, this is how the linkage gets associated with the system. We have genetics as I said just now. Memory we were talking about in consolation theory, the best example is it understands there is a hysteresis. It understands how it has to behave when it is being loaded, how it as to behave and it has been loaded up to an extreme and the next loading happens to be lesser than the loading which it has already experience in the past.

Emotions, we will see how these things can be linked further. I will explain them further and response to external stimulus any better example than this. So, if somebody agitates you what you would happened, you become emotional. Is it not? So, is something like that only it has response immediate response to external disturbances stimulus are nothing, but the disturbances.

Now these disturbances are nothing, but the external forces; it could be mechanical loading, it could be thermal loading, it could be electrical loading, it could be chemical loading, it could be radiological loading, it could be psychological loading, it could be psychological social loading and so on; political pressures. So, you excavate this soil throw it out somewhere and refill this place with some good soil; soil replacement technique.

But see what happens the soil which we have replaced in that plate understand that is a foreign material and within no time, you start realizing that the tension cracks will start developing their which will never occur in natural soil deposits. Why? This is what the synergy is. The system understands this not a part of the original system and there is a conflict you know of everything. So, that is how actually it becomes very interesting if you put these things in this form and try to see the similarity and draw the similarity between the two entities.

Now to best way to understand this is rock cycle. What is rock cycle? How the soils are formed? So, what is the difference between metamorphic rocks? What is the difference between the soils which are form out of metamorphic rocks igneous rocks and?

Sedimentary.

Sedimentary rocks. So, you will notice that they follow complete heritage and parentage; there cannot be any cross linking between them. You agree or no, Kunal?

Yes.

So, the soil form out of igneous rocks what type of soils will be having out of igneous soils igneous rocks disintegration and weathering?

(Refer Time: 17:12) granite weathers.

Granite if granite weathers, what happens? Go and check it yourself. So, then this becomes a complete different process all together which you must be doing in your geology courses. Anyway, I will not touch up on that. My idea was just to tell you that rock cycle is a good example of telling you that how these parameters or these attributes can be studied in the best possible way.

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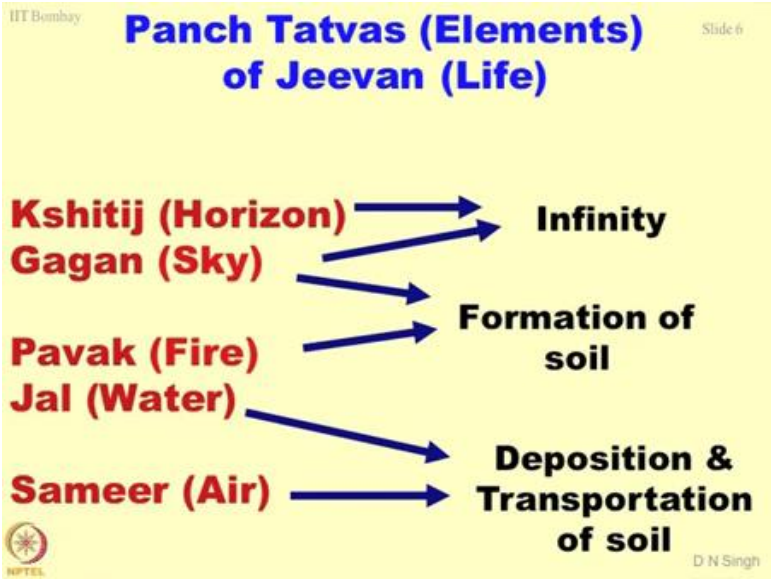

Now, this is where I at this philosophy to the Panch Tatvas philosophy. When anything which is living has to follow what you understand, what is meant by Panch Tatvas?

Itself.

Five elements of life.

What is meant by?

Exactly. So, we are the part of the nature and so, is the soil. So, everything has to follow these five elements of life. So, these are the five elements of life. What is the first element, Kshitij; I hope everybody understand Sankrit or Hindi.

Yes sir.

So, Kshitij is nothing, but horizon gagan. What is gagan?

Sky.

Sky, Pavak?

Fire.

Fire, Jal?

Water

Water, Sameer?

Air.

Air ok. Now if I put these two together, what happens in geomechanics? How geomechanics start, the first you know lemma or theorem is that we work in semi infinite soil mass. What is the meaning of this? So, this is what semi infinite is if you put horizon and sky together this is nothing, but infinity. And what we do? We work in the subset of infinity whatever is lying below the ground, we consider this as our domain. So, this becomes semi infinite.

So, any activity which takes place in horizon as sky is bound to affect the weathering process, the formation of the soil and so on. And the attributes of the soil later on, how it is going to react because everything is in genetics, clear. Now if you put this stroke together, what is going to happen? A sky and fire, what is sky rains and what is fire temperature? So, if I put these two together, what is going to happen is nothing, but the weathering, because these are weathering

Is the weathering process, you agree? What about the another combination of water and air? So, this is nothing, but deposition and transportation of soil. Why deposition? The

first is how the cycle goes, the rocks are getting fragmented, weathered ok; there is a sort of a.

Deposition

Abrasion effect.

Erosion, transportation.

Erosion, transportation and deposition that is right. So, both are transporting agencies. So, you have more flow of water, it becomes transported soil of gangetic plain. If you have less flow of water, the soils will not flow from one point to another point; they have a tendency to form at the same place get deposited as a same place. These become residual soils. And what about the air? Air may blow the soils which are formed and it may form a sort of a Aeolian type of a soil clear. So, this slide just was to show you that the philosophy is not so bad when we say the life is sorry soils are living entity.

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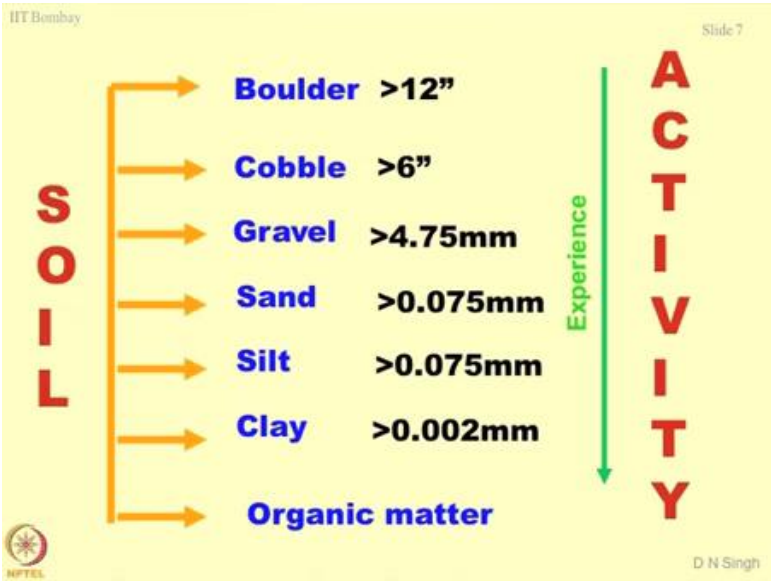

Now you extend this philosophy further. We will catch up from the point of transportation and sedimentation clear. Normally what we have done is we have classified soils based on their particle size. So, we have boulder, cobble, gravel, sand, silt, clay, organic matter. If I draw an arrow over here, what this will correspond to? Sorry.

Decrease in size.

Degree.

Decrease in size quantity.

Decrease in size all right in a philosophical way.

Grinding.

More grinding, what is the meaning of this? More seasoned, what is the meaning of word more seasoned? More matured more active clear so; that means, this is how the activity increases. Now this is we have the soil understands how it has to behave. Organic matter has a tendency to behave in a very different manner as compared to boulder. What is the reason? It has gone through the process so much.

It has covered a long journey in terms of time and geological history. From Himalayas, the boulder started weathering the soil form ultimately; it all got deposited in the Bay of Bengal. So, it has gone through so much of trauma. How many kilometers and how much time? So, the material has become so active; so sensitive. So, experienced clear and based on this you can say that the activity increases; that means, lesser the particle size, we say that activity of the system is quite high. So, it is matching with the concept of you know your geomechanics where you were assuming system to be passive. But truly speaking, there is a hidden effect we say that the system is not so passive it, is very active. So, each component of the soil mass has some activity associated with it, yes please.

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Yes sorry, sorry; you are right that is right. So, please interchange this sand and silt I am sorry there is a mistake that is true less than 2 microns.

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Less than 70. I think it is less than arrow it from, yes please; thank you very much. So, this is how the activity can be scaled. Now people are trying to work on the activity model, but till now not much successes there because how to define activity of the soil in conventional way.

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That is right.

E by i t of

Yeah you are right. Yes, please.

There is a ratio of the plasticity index of the percentage of clay fraction.

That is right. So, percentage of plasticity index divided by percentage of?

Clay fraction.

Clay fraction. Now do you think that this definition of activity is complete?

No sir.

Why?

Because we in this definition we include only clay, but some other is also that activity.

Lot of things are missing, we have just included the physical component that whatever passes through certain t size or is of certain size has been second as the attribute to define activity, truly speaking is not. We are all these things, your experience and the type of you know what should I say the history through which it has gone through has gone. So, there is no way to include all that. So, truly speaking the new classification scheme should include not only the physical attributes, but the attributes which are beyond physical behavior.

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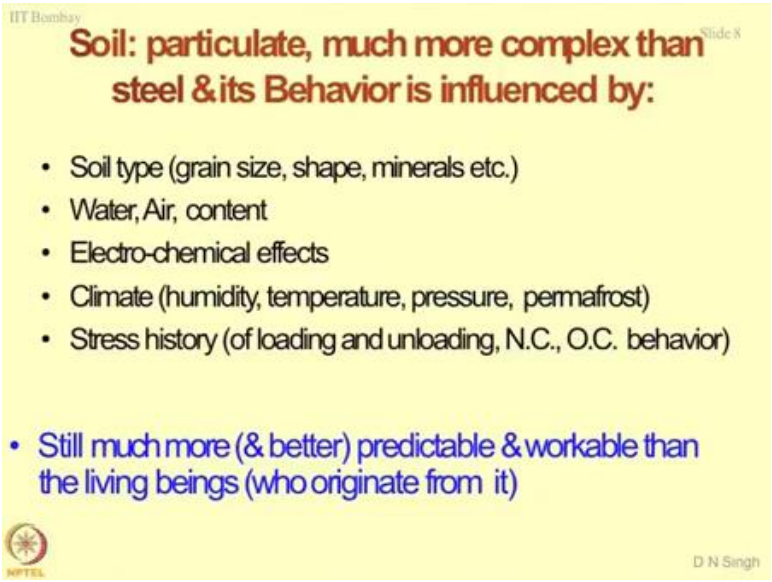

So, at least we can sum it up now as by saying that soil is basically a particulate material much more complex than steel and its behavior is influenced by so many factor. So, why we are comparing soil with steel? We are very much proud of steel, is it not? It is a man made material and we say that this is much more stronger than any other geomaterial, that's true. So, the best comparison would be if you compare soil mass with steel which is man made very controlled very homogenous process controlled and so on, but see the where we deal with the material is much more intricate; it is much more difficult, why?

When you say, its behaviour is influenced by these factors under what circumstances your behavior changes? When you see somebody with whom you are friendly your behavior is totally different when you see somebody who is not friendly with you your behavior is totally different and within the day itself your behavior keeps on changing every hour every moment. So, look at this the type of behavior which is soil is going to exhibit cannot remain same.

Now this is where actually you can pluck an analogy. As an engineer, what is your job? My job is as an engineer or as a technologist to tell soil how it should behave. You agree with this or not? You agree? What is the meaning of this? How you are going to tell soil to behave like this? When you say 95% compaction density, what is the meaning of this? You expect this soil to behave.

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In a certain fashion, clear. You add on this saying dry of optimum wet of optimum the properties change immediately. The same γ_d if you say dry of optimum wet of optimum, what is happening?

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The behavior is different. Now that is what I was saying even if one attribute is same the properties and the behavior of the system may be total different. So, here we talk about soil type grain size shape minerals etcetera and so on. A good example is whenever you do laboratory test; you always filter out soil by using 475-micron sieve, why? You are avoiding certain fraction of the soil which otherwise is going to give some interference with the results. So, you always work on the material which is more controlled. So, you are filtered out the things which you do not want and then you are trying to see the response of the system.

So, soil type basically talks about grain size, shape and the type of minerals which are included in it. Then comes your water air content, it should not be any comma after air; it should be water air content. So, depending upon what is the saturation limit? So, saturation will take care of water and air both we have to talk about electrochemical effects. What is the effect of adding electrolyte in to the soil mass? So, which is doing is PhD on this topic. So, he creates different type of compositions and the state of the grain structure by adding different salts and then is trying to see how the grain structure gets modified how the matrix get modified, how this how the, what else you are studying.

Fabric.

Fabric is getting modified and so on. It is a good example whenever is present in please attend its seminar where is talking about electrochemical effects and their influence on the matrix of the soil mass or fabric structure of the soil mass. And then biggest question is how to study this fabric structure.

Well, we have talked about this quite a lot the climate which is nothing, but humidity, temperature, pressure, permafrost they affect the system a lot. Stress history, the type of experiences which the system undergoes through loading, unloading, type of loading, unloading and so on. This is where you have normally consolidated material over consolidated material and their behavior and I hope you can understand this concept. Is it

not? So, it is still is much more and better predictable and workable than the living beings who originate from it. Did you get this or not? Though all these uncertainties are there, but is still it is more predictable than us. So, that is what I have written here still much more and better predictable and workable than the living beings who originate from it, okay.

So, this is what actually the whole point is. So, you will notice that this is a matrix of what is to be done and this you may say is the foundation is stone for this subject where you talk about different types; what type of water, what type of air, what is electrochemical effect, what type of climatic conditions are going to affect and what is going to be the effect of these climatic conditions on the material and stress histories. Like Seema is working on the topic where she is not talking about stress history, but she is talking about the effect of climatic changes. So, how climate influences the properties of the soil? We call it as wetting and drying cycles of the soil.

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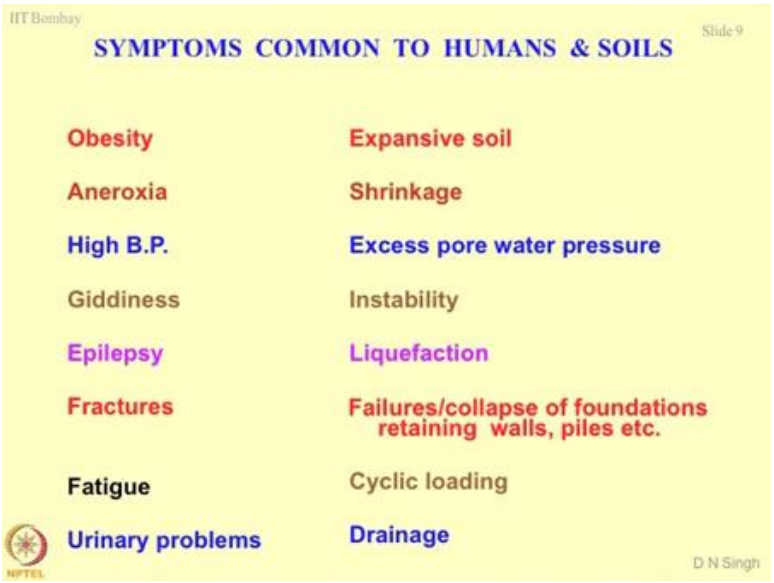

I thought of giving you some fun by saying some symptoms which are common to humans and soils. Obesity, humans are susceptible to obesity.

Yeah.

So, are soils and a mechanism which comes to your mind which can define obesity?

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That is right, anorexia ok. Let us list all the symptoms high blood pressure, giddiness, epilepsy, fractures and fatigue and urinary problems. So, let us find out what is the commonality between soils and human body. Well most of you could guess this, these are the expensive soils have a tendency to take more water become obese anorexia.

Shrinkage.

Shrinkage all right, high blood pressure?

Excess pore water pressure.

Giddiness, what is giddiness?

Instability.

Same thing what you are saying like this is nothing, but the instability, epilepsy?

Liquefaction.

Liquefaction, fractures?

Failure.

Failures collapse of foundations returning systems, fatigue?

Cyclic loading.

Cyclic loading and drainage. So, in any project you have to take care of all these aspects together. So, I find that there is lot of similarity between the system on which you are kind with which you work and our body. So, when you are not keeping well what do you do?

Take medicine.

Take medicine, but not just you take any medicines?

Prescribe.

Prescribe, how prescription comes?

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From diagnosis. So, there are lot of diagnostics. So, how do you do diagnostics?

Testing.

Laboratory tests the same thing you do in the lab. So, our profession is very similar to the profession which medical?

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You know professionals are adopting, but you are not realized about this.

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So, challenges and concerns, what are the challenges and concerns? Geotechnical Engineering Professionals are involved with so many things. Let us list them out the first is diagnostics. So, you go to any a specialist, doctor I am talking about medicine profession. What he says? He will prescribe you few tests. So, the same thing we do; you bring any soil sample, any problem; first thing is do all the tests. Then we will go through all the samples and their results and then we will say this could be one of the reasons.

So, the first thing is diagnostics and when you are trying to diagnose something, what are this diagnosis about is the diagnosis of symptoms a swelling type of soil; that means, it has a tendency to retain more and more water. So, this is the diagnosis, this is the symptom and what are the abnormalities? So, you always go to the doctor you narrate

that these are the problems I am having. So, these are the abnormalities which I am having.

So, similarly your client comes to you and he says that I have a problem in this project for which I want to appoint you as a consultant. So, what is the role of a consultant? He is a doctor, qualified doctor. What is supposed to do? With proper diagnostics, he is supposed to recommend a prescription. And what is prescription? Prescription is nothing, but adequate corrections.

Improvement.

Sorry.

Improvements.

Improvements. modification that is right and then ultimately what do you do? You try to go for prolong monitoring under observation. So, you always keep the patient under observation. So, this is where actually we talk about instrumentation in projects. You make an embankment, you insert lot of piezometers there, inclinometers there settlement gauges there and so on, why? Because you want to monitor how settlements are taking place how proportional is dissipating weather embankment is flowing literally or not.

So, this is nothing, but a prolong monitoring. So, our profession is very similar to govern which medicos are following. I hope you can you will agree with this, how good and how bad you are following this profession makes all the difference as for as the condition of the patient is concerned, all right.