Geotechnical Engineering II / Foundation Engineering

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Lecture - 01
Quick Review of Soil Mechanics

Good morning. I welcome you all to this first lecture of Foundation Engineering or Geotechnical Engineering II. In fact, many of you might have attended my first course Soil Mechanics or Geotechnical Engineering 1. And, I was also requested for this second course of foundation engineering and because of that I have again taken up this course though I have a bit too much difficulty to do it, but for the benefit of you I have taken this course this time.

And, as I have told you that in the in the civil engineering out of 5 sections geotechnical engineering is one of them and in that 2 major courses. One is soil mechanics another is foundation engineering, and sometime it is classified as soil mechanics geotechnical engineering 1 and geotechnical engineering 2. So, foundation engineering is under we can say geotechnical engineering 2 and also I have mentioned that, soil mechanics is the foundation of foundation engineering. This is the very important that to learn foundation engineering we need to learn first soil mechanics. I hope all of you already completed this course.

And this the foundation engineering again we have basically under foundation engineering means what actually below the earth, whatever infrastructure we will do that actually comes under foundation engineering. This can be of the footing of a building, then it can be a earth dam, it can be an embankments, it can be earth retaining wall, it can be a retaining wall, or just flexible retaining wall, or it can be similar tunnel it can be, but of course, tunnelling is a very advanced subject and we may not be able to cover under this. But, otherwise other type of foundation problem like foundation for buildings then again there are different types of foundations.

Then there will be earth retaining structure, the deep excavation, then little bit of vibration there may be foundation for dynamic loading, we will cover under this course. And of course, as I have told you that the your soil mechanics is the foundation for foundation engineering. So, I hope all of you taken, but once again before going to the

foundation engineering, I just quickly review the soil mechanics part; mainly because that some of the things will be used frequently, but we may not able to discuss in length.

And so, that so, you should not have any difficulty because of that, what are the important aspects very frequently we use and which we may not able to discuss in length, that I am thinking of taking very quickly; and so, that that first week mostly I will divert on quick review on soil mechanics.

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And this so, first slide will be I will be of course, first session or first module I will be covering this that is origin; that means, in the foundation engineering first step is to understand the soil. And, understanding of soil can be done in different ways and of course, full understanding cannot be done by a single step.

There are various ways of understanding and one of them to understand the soil is seeing the origin; that means, from where the soil is originated, it will be original from the rock. And, what was the parent rock? And, what was the agencies or what is the cause the rock modified to soil. If, we can go through that then sometime we get lot of information. For example, if it is from organic source; that means, if the soil is formed from the organic matter, then that soil is generally is a very difficult soil and we have to take care of it properly.

Similarly, some soil will contain some of the chemical parts which can actually react and it behave totally differently. So, and that we know from, what is the source and that type of soil as originate. So, that is what that if you know the origin some time will be able to get some of the behaviour of the soil. So, origin is the first step one of the way we can one of the ways we can understand the soil. And, then again classification the second step is the classification. And, this classification again soil can be classified in various ways.

For example, as I have mentioned that based on origin soil classified, based on grain size it can be classified, geologist also classify the soil one way, then engineers also classify the soil another way. So, like that there are number of ways the soil can be classified and, but we need to know only engineering classification and which actually universally used across the globe; that means, if the soil is classified by some name. Then, every engineer civil engineer should understand what type of behaviour the soil can have.

So, that is the one that classification part also I will be going through very quickly, but this is also very important. And, then another third aspect that is weight volume relationship, that is actually you know the soil is a 3 phase system; that means, if I take a mass of soil and if I assumed or idealized, and if draw a diagram, then we get a 3 phase diagram and that 3 phases are what one is air and water and solid. And based on that we could we could give number of definition like; void ratio, porosity, degree of saturation, water content, all those things and how they are related to some of the important parameters of soil like unit weight and all that will also discuss quickly.

And, then another very important aspect is that effective stress. And, very very frequently actually we will be using this in the in the foundation engineering various calculation. And, and this effective stress though looks very simple; that means, effective stress is what actually; that means, if I consider a point at a depth of suppose 3 or 4 metre or 5 metre. And, what is the effective stress I want to find out, then actually entire weight above that point to be considered and if I consider unit weight, then that weight divided by unit weight will give you the pressure.

That is simple understanding of pressure, but when the soil is under water; that means, when the water is soil is saturated by water table and all, then what will happen because of this head of water, there will be your pore water pressure. And, pore water pressure

you do not know it will act in all direction and because of that, we can calculate the effective stress, whatever the total stress minus the pore water pressure that become the effective stress. And, that effective stress is very important in all calculation almost every calculation, because strength and all related to this effective stress of the soil.

So, that part again it looks very easy; that means, unit weight multiplied by depth, that is your total stress and then unit weight of water multiplied by depth of water table at that point. And, that difference of these 2 is effective stress looks very simple, but still we have seen from our experience that student frequently do mistake in this. And so, because of that I will again explain this part and quickly go through some calculations. So, that you do not have any problem in future.

Then another most important perhaps the shear strength, and shear strength actually ultimately the soil has to take the load and when you apply load, then and it will be soil will be stressed and if the strength of the soil is less than the stress applied by the external load, then soil will going to soil is going to fail. So that means, to prevent failure you have to ensure that soil has enough shear strength. So, that actually; that means, we cannot actually shear strength of the soil cannot be changed.

Actually, it is in that is actually in the in the natural form whatever form the soil is in that form you have to characterize the soil, and based on that characterization and you have to find out the strength of the soil. And, then finally, while designing the foundation or others infrastructure, which will impose the load on the soil, you have to make in such way that the stress because of these will be much below than the actual strength of the soil.

So, that is the way that mean everything ultimately our aim is that build something, but it should stand it should not fail. So, to make sure that you have to estimate the shear strength there are various methods. And, of course, foundation engineering it is you need not discuss in length, but some quick review we can do on that on shear strength. And at the last, but not least the more important parameter is the compressibility of behaviour of the soil. What is this compressibility behaviour of the soil? Actually when you build something over the soil and then soil will be stressed. And, when the soil is stressed then; obviously, as you know that soil is of 3 phase, that there is a air void there is water and the and also soil can be treated as a elastic material. And, when the elastic material if you

apply load, either when you apply tensile load it will be elongated when you will give compressive load it will be shortened or compressed. So, soil most of the time will be subjected to the compressive load and then settlement will be compression most of the time.

The soil will under grow we will undergo, actually the settlement under loading and that settlement will be consisting of several things one is actually the elastic property of the soil, that is called elastic settlement which takes place within some day or 2. And, there is a another settlement called consolidation settlement, and which is actually if such phenomena for fine grain saturated soil and that of course, mechanism and everything we have discussed, but some calculation quickly which will be frequently used we will review again.

And, there is a third the type of settlement that is because of creep and secondary consolidation, that is also there solved together there will be total settlement. And, that settlement actually depends on the compressibility behaviour of the soil; different soil will have different behaviour. And of course, when we build something on the soil and then as per codal provision, we restrict the settlement that particular for example, for a common building the settlement should not exceed suppose 30 30 25 or 30 millimetre and why this restriction?

If you have excessive settlement, that is can be several problems there may be likely problem of in the building. And, that to prevent those problems, generally we have to restrict the settlement, not only settlement sometime the building may have a number of foundations or footings, and different footings may have different loading also, and because of that loading some time different footing will settle differently, and that cause actually some differential settlements. So, all those things actually comes under that restriction in different settlement also is there. So, all together the actually the compressibility behaviour of the soil so, that also will be very quickly it will review.

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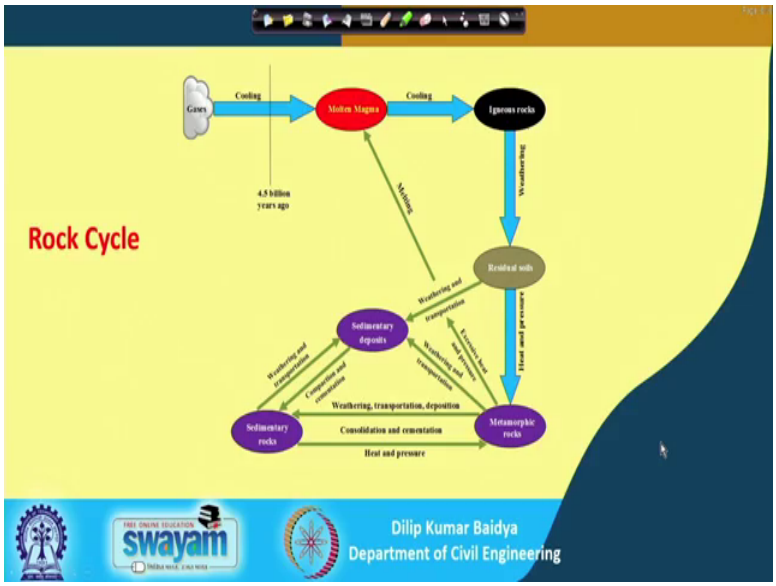

So, next let me go to the next slide that origin we have to see that is your this slide actually I have also used in soil mechanics you can see that, that the soil before forming the soil originally that the earth was in the in the in the gas form and then under cooling, and here you can see it is written 4 to 5 billion years ago, it was in the gas form and then subsequently it become molten magma and then from there under cooling it become igneous rock. And, this igneous rock you can see then after weathering or some other effect it become residual soil. And, again from the residual soil again by under heat and pressure, it can again form like a rock that is metamorphic rocks.

And, again directly from residual soil, you can see from residual soil; from residual soil directly again under transportation or weathering, it can be it form a sedimentary deposit and from that again sedimentary deposit that can be (Refer Time: 15:38) soil sedimentary soil and that sedimentary soil again under compaction segmentation, it may form sedimentary rocks again sedimentary rocks can by weathering and transportation it can becomes sedimentary deposits.

So, like that this cycle also continue and again from residual soil by heat and pressure it become metamorphic rock, and again by different processes you can see it can either become sedimentary deposits or it can become sedimentary rock. And, again sedimentary rock 2 again heat and pressure it can become metamorphic rock, like that entire process will continue.

And finally, the rock masses will be decomposed into small fragments, the particles, and when it become that particle that we treat as soil. And, then that different rocks again the rock will have different minerals and based on that from which rock each originated, and if I know then some time will be able to characterize the soil to some extent. So, that is the reason why I want to review on origin of the soil.

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And, now we can see that rocks as I have mentioned that rocks made of different minerals, made of made from various types of minerals, and minerals are substances of crystalline form made of from a particular chemical combination, and the main minerals in rocks include quartz feldspar calcite and mica there are many, and we get frequently in the soil these type of minerals. And, as I have shown that there are 3 different types of rocks that igneous metamorphic and sedimentary and metamorphic, and again further by different chemical or weathering affect the rocks deform into small particles and that become the soil.

And, under that you can see igneous rock, there are important igneous rock you can say there are it is granite, basalt, gabbro. They are all used in building various building activities like granite and basalt will be used in railway tracks and many other places. And, similarly there are many other use of this igneous rock. Sedimentary rocks are under these actually shale, sandstone, and chalk. And, metamorphic rock shale, slate, quartzite, and marble and you know the marble one of the very important building

materials, we use for various decoration purpose flooring purpose. And so, these are the 3 important rocks, which are also used in the in the in the in the building activities, but our interest is not the rock actually from the rock when finally, transform into soil. And, then the what the soil contents, that actually we have to see and then based on that we will characterize.

So, what is the definition of soil? Definition of soil actually we can see that the action of frost, temperature, then gravity, wind, rain and chemical weathering are continuously forming rock particles; that means, initially rock mass and then from that to rock particles and that rock particles with eventually, when become smaller and smaller become soil. And, there are 3 types of soil, when considering mode of formation modes of formation; that means, as I have told you that different agencies are there how it transform a from rock to soil. And, because of different mode of formation, we can mainly divide these into 3 parts.

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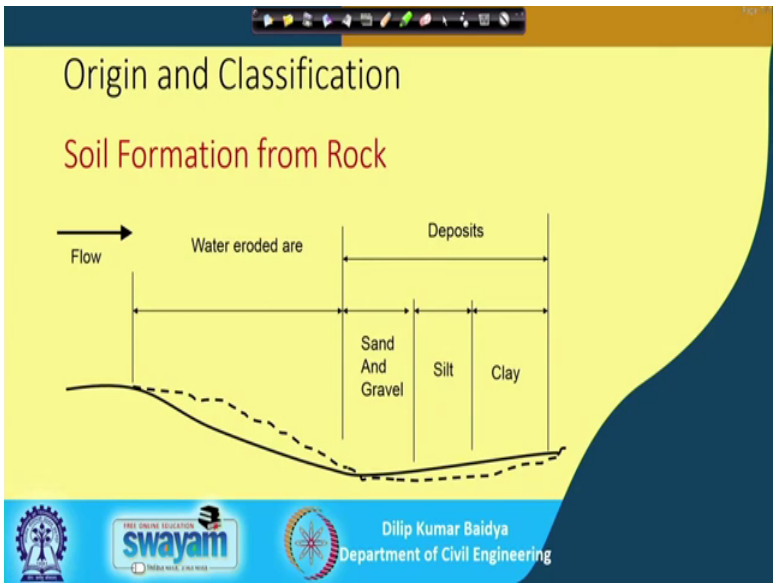

And, we can see next, next this one of the example I will show here I am showing here, that when the river flows. Actually, suppose if the direction of flow is this, if the river flows in this direction. Then, what happens actually this is some upper up stream side and this is downstream side, and then when river flows and velocity is high, then what will happen this suppose this was the original ground or rock surface. And, then while flowing this flow of water will cut this portion of rock and it will be rolling or flowing

with water. And, wind flows along with water then it will be trying to it will try to deposits when the velocity will be reduced. And, that what will happen when it will happen it is towards the sea.

When there is the river met sea, the velocity will be reduce significantly and then it will try to deposit those particles. And, you can see that higher reach comparatively courser particle will be deposited like sand and gravel, and will go to the close to the sea the final particles like clay will be there and before that silt will be there medium sized particles. So, this is one of the examples that how soil rock is transformed into soil and this is called transportation transported soil.

That means, while transporting the rock mass is transported by water and it is deposited in different places and then soil is formed. So, although whether this sand gravel silt clay altogether are soil. Because, when the particle size is becomes smaller than something then we treat this as a soil, again soil can be sub classified as gravel sand, silt and clay all those things, but otherwise this zone is whatever deposited that is entirely called as clay soil.

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So, let me go to the next slide. Suppose I have mentioned that based on modes of formation that it can be classified different name; actually this is transported soil there are number of them I can you can see mentioned here, Aeolian soil, that dunes and loess lowest by that is actually formed by wind. Particularly this type of soil will be available

in desert, that the particles will be rolled over the because of the wind and they will form region like thing, and the way the soil deposited the sand particles they are in a very loose form actually there is not compact.

So, that this type of airborne soil transported soil is name actually typically known loess. Similarly, colluvial soil by gravity, because of the gravity gravitational action if the rock transform into rock soil then that is called talus that is a colluvial and special name is specific name is talus.

Similarly, alluvial soil when the water is transported by water and deposited as a soil, then that is called alluvial soil. Similarly glacial by ice and snow and residual soil there is another mode of formation residual soil; that means, laterite and saprolites, that is because of the chemical weathering; that means, if the rock mass because of this chemical weathering, the rock mass transform into a smaller particles and deposits there itself, then that can be considered as a soil and that soil will be called as typical name as laterites.

This is the specific name will laterites and saprolites, but based on mode of formation if you classify, the soil will be classified as residual soil. Similarly, there is third mode of soil formation is organic as I have mentioned beginning, if the soil is transformed or formed from the organic matter and then that that is called peat. Of course, it is a peat is a very special form when the organic matter is fully decomposed and it become a like a fine, clay particles, then only you can it can be called as peat.

Otherwise, it can be different form of organic soil amorphous and all I have discussed those things in detail in soil mechanics. So, this peat is a very special form of organic soil. And, you know that if there is a peat at a particular site, that the soil is problematic, that it go it will undergo huge compression. So, because of that if you find at any side the peat type of soil then you have to be very very careful while designing anything. So, this is about the about the classification based on mode of transportation.

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And, similarly there are other classification will be there engineering soil. Engineering broadly we classify the geotechnical engineering as cohesive or cohesionless soil, and sometime we also classify as granular soil, or sorry this is actually sometime we say cohesive soil, another is cohesionless or granular soil, another way we classify as coarse grain and fine grain. So, this is the way we can engineering classification will do, and under coarse grain we can see the 2 types I have mentioned here gravel and sand and under fine grained actually silt and clay.

And, again in the clay soil this is the finer finest particle in the soil and it can contain different clay particles and the most important clay particles, which we find there are many some more, but Kaolinite, Illite and Montmorillonite and they have a definite characteristics. And, if you find this type of clay minerals in the soil sometime some soil will be problematic, some soil will be not problematic, and if you find that is a problematic soil; obviously, you have to take care while designing the foundation because of that I am trying to bring this briefly here.

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And, then soil versus other engineering material; that means, you can see steel and concrete when you consider building materials, then we can see that manufacturer. So, steel and concrete manufactured can be produced with desired strength and stiffness and quality also can be monitored.

Whereas, soil is actually naturally formed and properly mostly not known or sometime after knowing many things we can characterize, but it depends on many factors, because of that soil is an very important that we have to understand the soil before doing anything. Because, not like a other not like other civil engineering material that which can be manufactured with proper quality control, the soil actually formed naturally. So, we can there is no control over that whatever we get we have to characterize and we have to access their properties and we have to get their strength compressibility and all before going to designing the any foundation system.

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And, then soil characterization again consist of this things permeability compressibility shear strength I have already told, I will not go in detail on that. The permeability one of the important property that how porous the soil is if the soil is more porous, then water will move fast if it is the soil is very less porous, then soil will not move and soil movement through water is dangerous that actually we have that aspect we have to take care.

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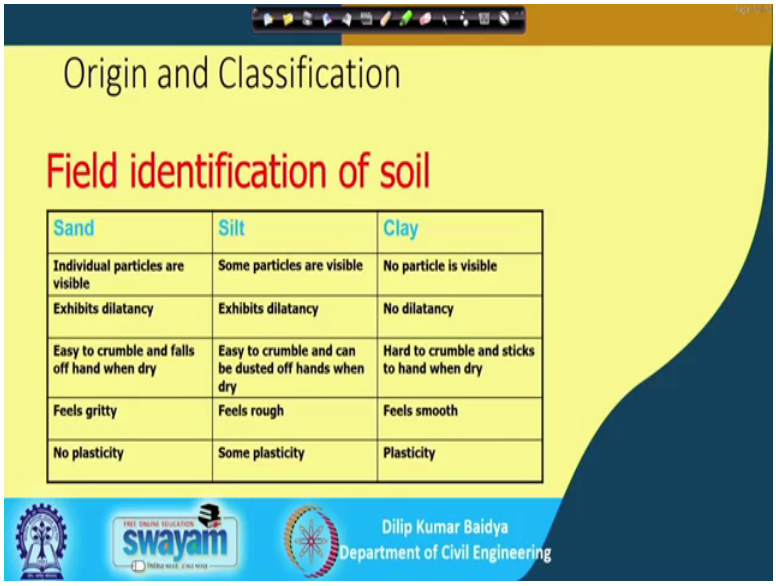

And, then of course, there is a when there is a (Refer Time: 27:49) civil engineering civil engineer professionals generally before build anything, they have to go to the site and they have to access the soil type of course, without any equipment in hand. So, at the site based on some physical examination we can access the type of soil. So, that actually I have done in soil mechanics also, we can see that the sand silt and clay out this 3 particles if you can identify properly we can get actually lot of things. So, because of that how we can identify sand silt and clay in the field, that is listed here that when it is the sand individual particles are visible whereas, silt some particles are visible mostly individual particle will not be visible they are so, fine and for clay not at all visible.

Silt sometime partly visible and sand exhibit dilatancy; that means, if you make a fine soil particle if you make a paste and put on you palm and make a pattern and then set like this, then we will see the water will come out and it will be shining. And, when it is sand and silt both of them will have this property whereas, sand it will be easily whereas, for silt we have with difficulty by shaking we can see the water in the surface. Otherwise both will have this property whereas, sorry and clay will not no dilatancy will be there for clay.

Actually, if you make a paste and put it on our palm and then shake it here like this; then will not feel anything on the, will not see any water surface. And, then when it is sand if the lump of sand if you take easy to crumble and there will be individual particle will fall automatically whereas, silt also easy to crumble and can be dusted of hand; that means, when it will silt if you take it hand, your hand will be dust will be the dirty, but this dirt can be cleaned easily by doing like this. And, if you do like this your hand will be cleaned whereas, if it is a clay and if you make a paste with water and then break it then you all the some particles will stick to your hand and after dusting of your hand will not be clean, you have to wash it. Then only you will feel that there is a clay contents are there.

Similarly, if the sand if you take between finger you will feel gritty and whereas, silt if you take between fingers and rub then you will feel rough. Rough and gritty they are different when you will become a specialised engineer we have to have that feeling. Similarly, if it is a clay soil if you rub between the fingers you feel very smooth actually there will no neither any gritty feeling nor any rough feeling. And whereas, if it is a sand

then no plasticity that we cannot roll it like that and whereas, silt; that means, we can make a we can roll it, but very thick diameter we can make.

Whereas, if the soil contains clay particles, then we can make a very thin rope thread like by rolling by rolling like this if you can make a very thin wire like things, then we can surely understand the soil contents clay particles whereas, if you cannot make at all then we can sure that the soil mostly sand. So, this is the roughly your field classification; that means, the field when civil engineer go to the field just by feasible inspection and doing this few physical thing, one can access the type of soil present in the site.

So, this is one quick review part 1, I just I will take next actually engineering classification; that means, how we can further classify the soil that is actually qualitative classification based on which we can understand, whether soil contains sand clay or silt. Whereas, to access the strength and other things we need to know many more things and we will subsequently discuss about those classification in the next slide onwards.

Thank you.