Expansive Soil
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Lecture 01
Formation of soil

Hello everyone, welcome to the course Expansive Soil. The title of this module 1 is Introduction to Soil Mechanics and in the first lecture, I will be discussing about the formation of soil. So here, I will be discussing how the soils are formed, how these are deposited and how these are transported and what are the different kinds of soils which we can find in India.

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Basically, first going to the definition of the soil, the soil word has been derived from the Latin word 'solium' which means, the upper layer of the earth surface. Soil is a collection of disintegrated rock fragments of various sizes. Since the soil has been used by many engineers like agriculture engineers, geotechnical engineers, as well as geologist, the definition of the soil differs from person to person.

For an agriculture engineer, the soil is defined as the upper layer of the earth surface where the plant grows. Whereas for a geologist, the soil can be defined as the thin outer layer of the earth surface which is made of loose sediments. Similarly, for a geotechnical engineer, soil is a naturally occurring unconsolidated materials present on the earth surface.

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Talking about the formation of the soils, the soil can be formed in various stages, those we will discuss one by one. The first stage of the soil formation is known as weathering. In the process of the weathering, the rock which is known as the parent material of the soil, it's get broken into small pieces. So generally, the weathering process can be mechanical weathering or a chemical weathering.

Once when a rock surface gets exposed to the atmosphere for a long time, it disintegrates or decompose into small particles and thus soils are formed. So, in this picture, you can see at this point, the soils are formed and then it is transported to other places by various natural agencies. So, this mode of transportation can be like water, air, wind, and then once it transported to another place, it will be deposited at the place apart from its place of formation. This is known as geological cycle.

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The rate of weathering or the rate of breaking of the soils into different small fragments can be dependent on many factors. These are the size and composition of the parent rock, if the size of the rock metal is larger, then the rate of weathering will be higher. Similarly, the size of the exposed surface area of the rock. If the surface area of the rock will be more, then the rock will be exposed to various external agencies and it will break into small-small fragments. Similarly, the rate of weathering will also be large.

Then the third one will be the relative solubility of the rock mass. The fourth one will be the permeability of rock. In the permeability, the water can penetrate to the soil quite to the rock quite easily. If the water can penetrate into the rock quite easily, then it can get fragmented also at a higher rate.

Similarly, the chemical composition of the water also plays a significant role in the rate of weathering of the parent rock. If the water consists of different type of chemicals, then certain chemical reaction will take place inside the parent rock and as a result of which the rate of weathering will be higher.

The sixth one will be the temperature. The temperature plays a very important role in the weathering of the rock. If there is a large change in the temperature, then the rate of weathering will be quite significantly higher. So, these are the few factors which controls the rate of weathering of the parent rock.

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Now, once the soil is formed, if it is do not move to another place, then this are known as residual soil. If the soil moves away to another place apart from its place of origin, then the soil will be known as transported soil. Now, we will look into what are the different stages

involved in the formation of a soil. So, these stages are, the first one is weathering, the second one will be the transportation of the soil, the third one will be the deposition.

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So, here you can see this a parent rock. Since the soil is made of the rock, the rock is known as parent rock. Now, in the weathering process, there are two kinds of weathering; one is mechanical weathering, the second one is a chemical weathering. Mechanical weathering means different agencies such as change in the temperature, the wedging action of ice, the spreading of root of plants, abrasion plays an important role; whereas, hydration, carbonation and oxidation plays a role in the chemical weathering.

So, once the soil is broken into small-small pieces in the weathering process, the soil will be formed and then in the next step it will be transported or it may not be transported. If it is not transported, then it will be known as residual soil. If it is transported, then it will be known as transported soil. So, depending on what kind of agencies or how it is being deposited, the soil can be a glacial soil, alluvial soil, marine soil, lacustrine soil or aeolian soil.

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The rock from which the soils are made are generally divided into three ways. One is igneous rock, second one is a sedimentary rock and the third one is a metamorphic rock. In igneous rock, these are the form due to the solidification of magma. The examples are basalt and granite. Similarly, the sedimentary rock are the rocks which are formed after the deposition of weathering of other source rock. So, examples are sandstone, siltstone, shale and limestone.

The third one is a metamorphic rock. These are the types of rock which are formed in the process of metamorphism due to high change in the temperature and pressure. In this process the mineral of the original rock gets changed. The examples are Quartzite, and marble and schist and gneiss.

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We will go to the different process one by one. The first one is weathering process. In a weathering process, the soil gets formed due to the breaking of rock into small particles, the weathering process can take place two ways. One is mechanical weathering. So, in this

mechanical weathering, the different making mechanism which are responsible, breaks the small breaks the rock into small fragments. This forces which are responsible for mechanical weathering, are temperature change, wedging action of ice, spreading up roots of plants, abrasion.

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We will discuss all these factors one by one.

Temperature: Temperature is one of the most important factor which cause the formation of the soil. We know that rock has different minerals and different minerals has different coefficient of volumetric expansion. When there is an increase in the temperature, the volume of the rock will increase. Similarly, when there is a decrease in the temperature, the volume of the rock will decrease. If this process of expansion and contraction takes place for quite long time, then thermal stress will be induced in the rock. And because of this stress, the soil mineral gets weakens and the rocks are break into small pieces.

Next is the wedging action ice. We know that the volume of the ice is more than the volume of the water. The rock has many pore spaces and in those pore spaces the water can get accumulated and when there is a decrease in the temperature, then this water gets frozen into ice. So, here we can see, these are the pore space which are filled with water. And once the water inside gets frozen, it forms into ice. As the ice volume is more than the water, the volume of this pore space try to increase as a result of which it will apply a pressure all around the rock mass. So, because of this, the rock gets broken into small-small pieces.

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Then the next one is a abrasion. Abrasion takes place when rock mass moves because of the water, gravity, wind or glacier. And during this movement, the rock gets collided against each other and then breaks into small-small pieces.

The next one is the spreading of roots. As the root of the plant grows into inside the pore space of the rock, it widened the pore spaces and finally breaking the rock into small pieces.

So, we need to remember that in all these mechanical weathering processes, there will be no change in the chemical composition of the soil. The chemical composition of the soil which

will be formed will be that of the parent rock. The example of this kind of soil are sand and gravel.

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So, next one will be a chemical weathering process. In the chemical weathering process, the particles get broken into more finer particles, because of the different chemical reaction taking place inside the soil mass. When a chemical decomposition or chemical weathering of the rock takes place, the original rock minerals are transformed into a new mineral by chemical reactions. The soil form not possess the properties of the parent rock. The rate of chemical weathering depends on the surface area, temperature, presence of water. Presence of chemicals in the form of leachates and warm and humid climate produces high rate of chemical weathering.

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Different reactions which takes place inside a rock due to chemical weathering process are hydration, carbonation, oxidation and hydrolysis. In the rock, we have different rock minerals, which absorbs water and forms the hydrous compounds which results in the increase in the volume of the rock. Due to this increase in the volume the rock gets fragmented into small pieces. So, minerals such as silicates, oxides of iron and aluminium and sulphates adsorb the water molecules and this process is known as hydration process.

In the carbonation process, the carbon dioxide which is present in the atmosphere, react with water to form carbonic acid and then it chemically reacts with rock to decompose it. Here you can see the carbon dioxide react with the water to produce carbonic acid and this carbonic acid then decomposes the rock into small fragments. Then, the oxidation process takes place because of the presence of the oxygen in the atmosphere, which reacts with the mineral to form an oxide and then this process will break the rock into small fragments. Then hydrolysis process takes place between the H^+ and OH^- ions of the water and elements of ions of rock minerals. And again, this process involves the formation of the soil.

In the chemical decomposition process, the rock results in the formation of the clay minerals. The clay minerals are formed because of the chemical decomposition process and the properties of the clay minerals which are formed will be entirely different from the parent rock.

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Now, once the soil is formed, then it will be transported from one place to another place. So, there are various natural agencies through which the soil can be transported from one place to another place. Here we can see, through the water the soils are transported and gets deposited over here.

First the silts particles will get settled, then, sorry, first sand particles will get settled, then the silt particles, then the clay will get settled down. And once it will transport to another place then, depending on how it is deposited, this can be named as different soils. For example, if it is deposited in a lake, then the soil can be known as lacustrine soil.

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And if it is transported by wind, then it will be known as aeolian soil, example is Loess. Similarly, if it is transported by a glacier and deposited, then it will be known as drift. If it is transported by gravity and deposited then known as colluvial soil, the example of this is a Talus.

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These are the different kinds of soils which generally we can find in India. If we look into the soil, we have say for example, forest soil over here, we have alluvial soil. Then we have red soil covering most part of the India, red and yellow soil. Then we have a black soil, we have laterite soil which is marked in the pink color, we have arid soil and apart from this we have some marine soils.

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We will look into the soils one by one. So, generally, alluvial soil is present in the most part of the India, mostly in the northern state. And these are formed in different layers consisting of sand, silt and clay. And generally, the colour of these soils are varied from grey to ash and this soil is very fertile because it contains potash, phosphoric acid and lime.

The other soil, red and yellow soil, are generally present in central and southern and northeast part of India. It is characterized by a red color which is due to the diffusion of iron in

crystalline and metamorphic rock and looks yellow when it occurs in hydrated form. This type of soil is very poor in nitrogen, phosphorus and humus.

Then, comes the black cotton soil. The name comes because this soil looks black and generally it exhibits a volume change characteristics, that means, when it absorbs water, the volume of the soil increase. Similarly, when the water gets evaporated, the volume of the soil will decrease. And because of this change in the volume, the soil creates a lot of problem to the structure above it. Generally, there is a montumolite mineral which is responsible for all this behavior of the soil and this type of soil is generally present in central and some portion of South India.

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The arid soil is generally present in most part of Rajasthan state and mostly consisting of very fine sand and present in a loose state. The next soil is a forest soil which is present in the mountains and valleys of Himalayas. Then the laterite soil is mostly founded in Karnataka, Kerala, Madhya Pradesh, Orissa and Assam. This type of soil develops in area with high temperature and rainfall.

This type of soils are poor in organic matter, nitrogen, potassium, lime and potash and very rich in iron oxide. Due to the presence of the iron oxide, this soils are red in colour. And generally this soil do not poses any problem to the foundation. So, therefore, these soils are very stable.

The next one is a marine soil which are generally present in the coastal area of India, mostly contains organic matters and poses very low shear strength and high compressibility characteristics. And also because of this high compressibility characteristics, the foundation on this type of soil is very challenging.

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These are the summary of today's class. Thank you very much for attending the class.