Ground Improvement
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Lecture 42
Chemical Stabilisation

Hi everyone, let me welcome you once again to this Ground Improvement lecture class and today we are in 9th module, already we have completed 8th module and there are different types of ground improvement we have discussed. Sometime when there is a soft soil and then how to improve it, when is the loose soil how to improve it, when the soil is not good at depth how to improve it, if the soil is not good near surface how to improve it.

If the soil contains too much water that means it is under ground water table and ground water table is close to the ground surface then the working is difficult then how to remove water and make it workable. All these types of things we have discussed. Now some sort of mechanical modification we have done, mechanical modification in the sense when we have done compaction and then we have tried to force the particle, bring together or closer together and reduce the body fats and whereas that is nothing but mechanical modification that means you are applying some energy and because of that energy that particles are coming closer.

And when there is a fine-grained saturated soil and because of that it has inadequate strength and other large compressibility, in that case we also made some arrangement to remove water and once you remove water then particles come closer and the ultimately it reduces the void ratio, that is also nothing but mechanical modification that means by some means we are reducing the voids.

Like that every application whatever you have done some other ways, some sort of mechanical modification we have done in the soil and now we are going to talk about some sort of modification, chemical modification. When the soil is soft and contains lot of water, high water content, in that case we can use different types of chemicals or sometimes binders and that will react with the soil particles or with the water present and sometime binder, if you use binder then you will give some additional binding effect between the particles. That is the way the overall the characteristics of the soil will be improved. Improved means what? Its strength may be increased, its compressibility may be decreased, and its other property is also accordingly suitably modified to our requirement.

That is by applying certain amount of chemical, we are trying to modify the soil characteristics and that is actually called chemical stabilization. That is the topic we are going to start today. And first lecture I will try, to this will be comparatively small module it can be made big because plenty of research is going on because of this addition of different chemicals with the soil water system and how the soil properties are changing and actually there are plenty research work around the globe is going on.

If you talk in terms of that, we can spend a long time however we are not going to do that, I am not going to do that instead I am trying to discuss certain things which is in practice that means certain things actually already established and people are practicing that means the particular soil has particular characteristics present and then what type of chemical and what amount to be added and what construction process to be used, and similar type of things we will discuss and do try to finish it briefly and quickly so that we can take other things a little better and more amount.

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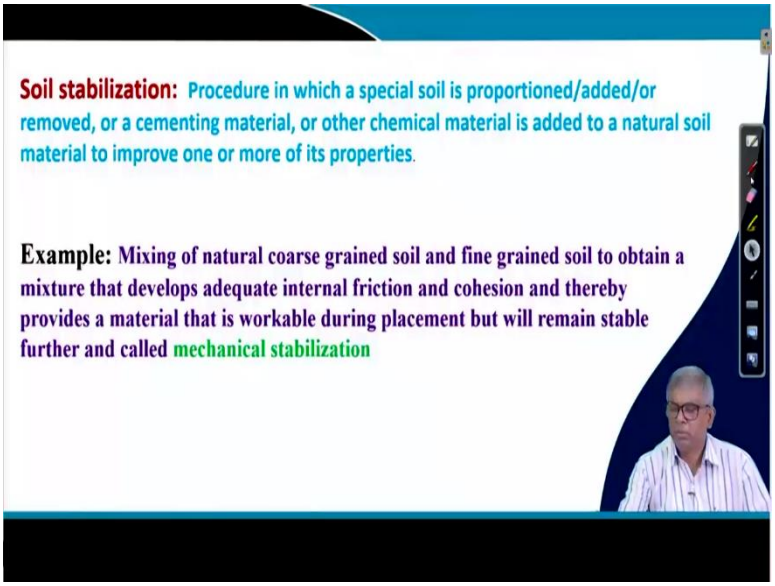

With this let me start with introductory slide. Let me start with what is stabilization? And here actually you can see that we have mentioned here soil stabilization, soil stabilization means already different type of stabilization is possible where it is chemical stabilization and we have mentioned that we have to add some chemical which will react with the moisture or clay mineral present with the water as a soil and it will form some better or stronger material which is or whatever we desire. Briefly we can say that soil stabilization means the procedure in which the special soil is proportioned that means certain type of soil we can proportion it

or we can add certain amount or certain things can be removed from the soil or a cementing material or other chemical material is added to a natural soil material to improve one or more of its properties.

There are number of properties, composability is one of the properties, then your strength is another property, permeability is one of the property, like that there are other properties also index property and other things. By doing this either by proportioning or by adding some material or by removing some material or chemic by adding some binding material or something semantic material or some chemical by adding to the soil or natural soil and purpose is to improve one or more of its properties so that is actually soil stabilization.

And one example is here, mixing of natural coarse grain soil and fine-grained soil. If you can mix a coarse-grained soil and only fine-grained soil, you may not have enough strength or enough friction so when you make a coarse-grained soil and fine-grained soil to obtain a mixture that develop adequate internal friction and cohesion and thereby provides a material that is workable during placement but will remain stable further.

That means you can say the fine-grained soil alone or coarse-grained soil alone because of the too much of voids sometimes it may not have enough friction angle. If we can mix coarse and fine proportion it properly, it may give high friction value and as a result it will give more strength and that more strength means the soil will be not only it will work at the currently, it also will be stable for future also.

This is the way if you improve the soil characteristic that is actually nothing but mechanical stabilization that means several soil particles so sometime it may be washed away sometime may collapse, it may shear so to all those things actually will be reduced if it is proportioned by coarse green and fine-grained soil at a particular proportion.

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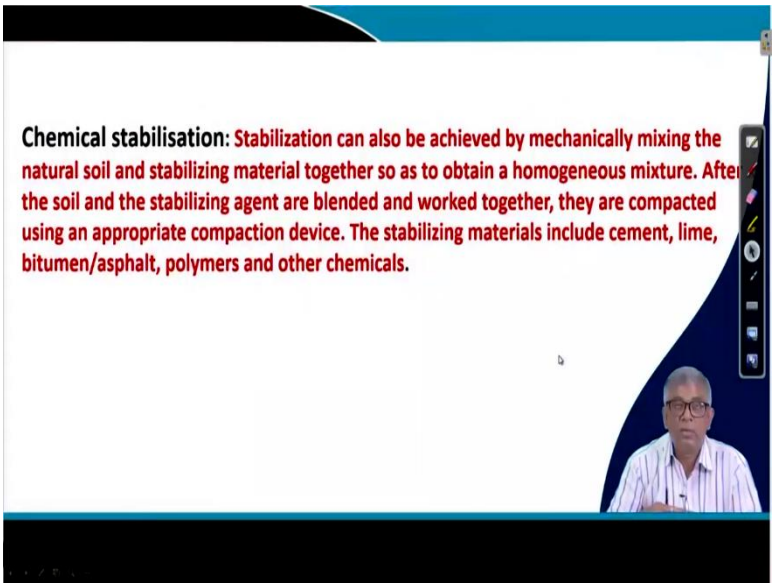

That is actually if I do that it is called mechanical stabilization. And similarly, we can think of chemical, when it is a chemical stabilization, it is achieved by mechanically mixing the natural soil and stabilizing material together so as to obtain a homogeneous mixture and after the soil and the stabilizing measurement are blended and work together, they are compacted using an appropriate compaction device.

This is the one, that means first of all you have to mechanically mix the natural soil and stabilizing that material and then after some time if there is a reaction possible then it will happen within that and after that, it will be compacted properly. And this stabilized materials whatever we use for the chemical stabilization purpose one of them is cement another is lime, bitumen asphalt, polymers and other chemicals.

More popular is cement and lime is more popular in soil stabilization work most of the work. Sometimes bitumen and asphalt will be used, sometimes some polymers will be used sometimes other chemicals are available like in grouting also we have seen here also similar to that cement lime, other than that there are some chemicals are available which can be used to stabilizing the soil.

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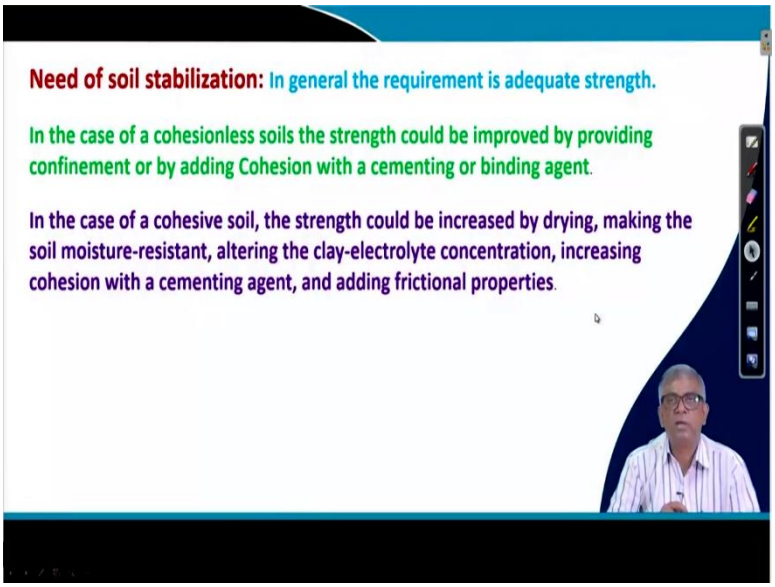

The need of soil stabilization - why we need soil stabilization? Like previously whatever improvement we have said in terms of many things why we want to do? Similarly, here in general the stabilization purpose is to give the adequate strength that is the main purpose and, in the case of cohesionless soil strength could be improved by providing confinement or by adding cohesion with cementing binding agent. When it is a cohesionless soil there no reaction is possible. In that case generally by giving some confinement or by adding some cementing material, friction angle or cohesion can be increased and by that way strength can be improved.

Whereas in case of cohesive soil, the strength could be increased by drying that means the water can be removed making the soil moisture resistant, that means the soil moisture resistant that means it will not allow to water to absorb and altering the clay electrolyte concentration that means clay electrolyte, that means clay soil that particular is called electrolyte, that concentration can be changed increasing equation with cementing agent and adding frictional properties. These are the things actually can happen for cohesive soil so that means it can be by adding chemical, soil can be dried or by reaction.

By making the soil moisture resistant or changing the electrolyte concentration and by this way it increases the soil cohesion and with the cementing agent it can add some frictional properties and by that actually its strength can be improved. This is when the cohesive soil there is no possibility of reaction so because of that only confinement and cementing or binding agent can be added whereas in this soil cohesive soil strength could be increased by drying that means some chemical to be used to do that, making the soil moisturization.

There also to make that you have to have some chemical, then to change the clay electrolyte also you have to use the chemical and increasing cohesion with cementing agent also you may need to add some chemical and adding frictional proportion.

All those things actually finally add some frictional properties. This is actually the need by and large, actually we have to give adequate strength, when it is the cohesion soil how we can add and when it is the cohesive soil how we can add. This is the example which is given here.

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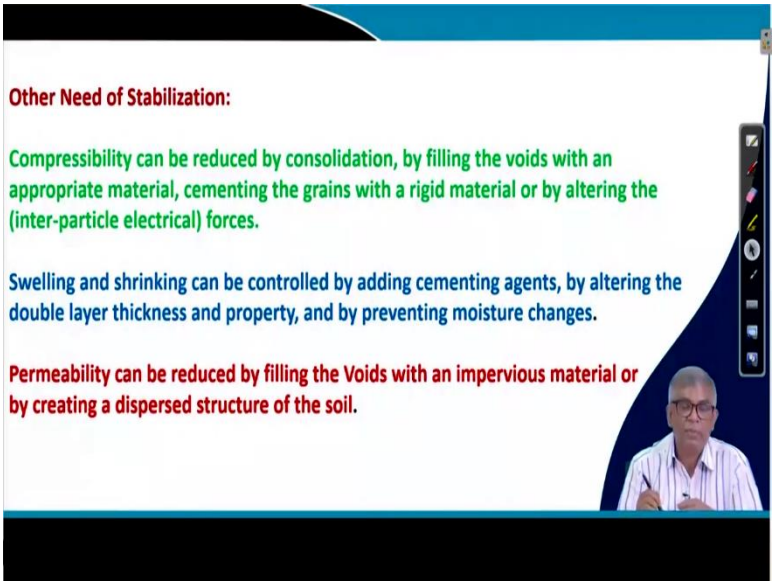

Now, many more needs are there like soil not only required strength, it should have a reasonable compressibility if it is high compressible then it will be unsuitable, so compressibility also can be reduced by consolidation which we have discussed by filling voids that means by grouting which we have discussed, the cementing the grains with rigid material or by altering the inter particle forces, this is the one we will discuss here and swelling and sinking can be controlled by adding cementing agents that also will be doing here by altering the double layer thickness property that is also where the clay particles will have this particular double layer phenomena that can be changed and by preventing moisture changes actually.

This is the way that is another need so compressibility is another need, soil sinking to control soil sink that is also another need, permeability control also another need and can be reduced by filling the voids with an impervious material or by creating this dispersed structure of the soil. So, there also some chemical may be used so all those things will be discussed under this

module. And some of this this compressibility etc., some part we have discussed in some way and we will discuss some of these here itself.

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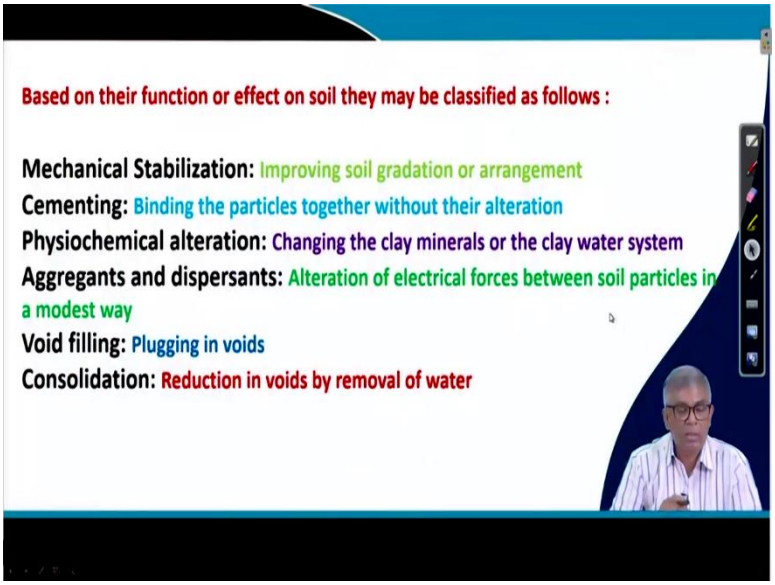

Now the way we modify the soil either by applying energy, by applying using water or by some other. They are based on the function we do it can be classified again differently which we have done perhaps in the in the beginning also once again I am just repeating here. There is a mechanical stabilization where actually improving the soil by gradation on arrangement, then gradation means we can mix the course and find with appropriate proportion or by applying energy we can may change the arrangement of the particles so that is mechanical strength.

By mechanical method we can change the soil characteristics that is the mechanical stabilization and cementing that is actually binding the particles together without their alteration so like some grout. So, when there is a feature, we can put grout or there is a high void ratio highly porous soil is there then we can permeate grout and that grout entered the voids and then finally some cementing effect, the particles will be bonded so that is cementing stabilization.

Then Physiochemical alteration, that by changing the clay minerals there are the fine particles actually fine soil will have of a prime soil will be consist of number of clay particles and they are chemically charged and this three minerals, the changing the clay minerals or the clay water system that is actually physiochemical alteration that is called an aggregates and dispersants, the alteration of electrical forces between solid particles in a modest way so that is another method we can be used and void filling that is plugging in voids there are some

methods we have discussed that wherever there is void you can fill the void by some means and consolidation that means voids are there but you have to reduce the void so that is consolidation. So, these are different types or different ways of stabilization.

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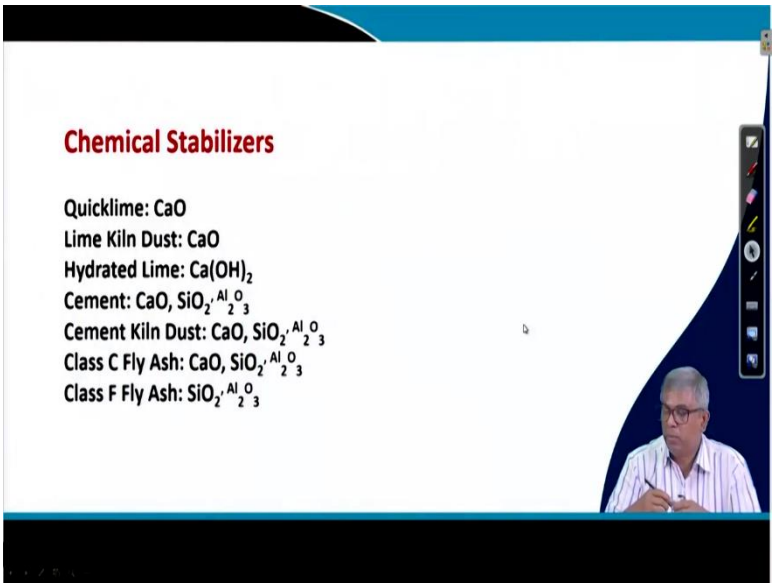

We will try to concentrate now on chemical stabilization. When you do chemical stabilization then actually some different kinds or different types of chemicals will be used and that is actually lime is one of the most important chemicals which is used in stabilizing soil.

Different types of lime again you will be there you send a quick lime will be there, a lime kiln dust will be there only Cao, hydrated lime Ca(OH)2 also can be used, cement can be used, cement clean dust can be used, class C flyers can be used, class F flyers also can be there. They are different with the composition that what it contains, class C flyers it will have calcium oxide and silicate and aluminium oxide and whereas class F fly ash the CaO is absent.

These are actually, you can see the class C flyers and cement clean dust they are basically same and class F flyers in little different, calcium oxide is applied absent. These are the different things which can be used in stabilizing the soil.

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We will try to see now what are the way we can do this. Treatment with lime, now I will try to concentrate on use of lime in stabilizing the soil and you can see, we have mentioned that if the moisture is reduced from the soil, generally soil characteristics will be improved so drying by applying lime we can dry the soil and we can by applying lime we can modify the soil and by applying the lime we can stabilize the soil. So, these three different ways lime can be used for improving the soil.

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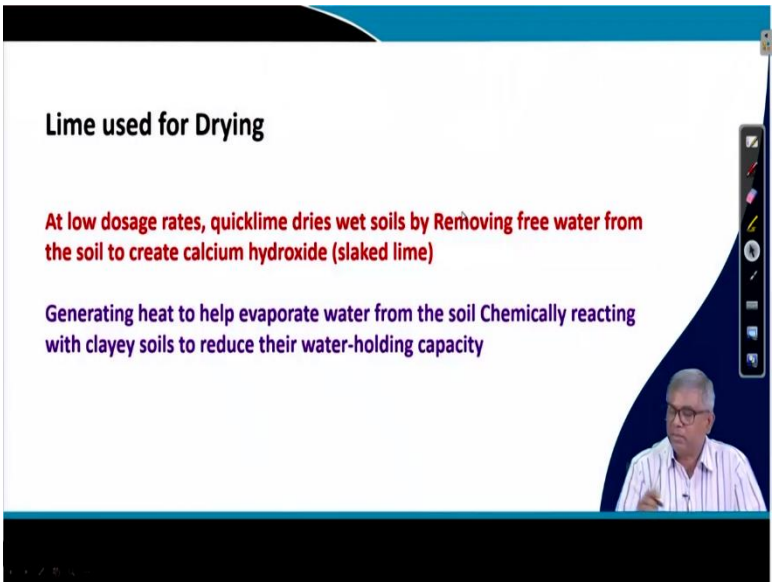

Let us take one by one, so lime used for drying, when you use it for drying, it will low doors will be used and quick lime dries wet soil. Actually, when the wet soil if you add like quick lime then it will help to dry the soil by removing free water from the soil to create calcium

hydroxide. This is one and while doing this reaction it generates heats and that heat cycle to help to evaporate water from the soil chemically reacting with clay soils to reduce their water holding capacity.

This is the use of lime for drying purpose, that it will be used in low doses, it will help to dry the soil and how it happens actually it react with calcium oxide with water it form calcium hydroxide and heat.

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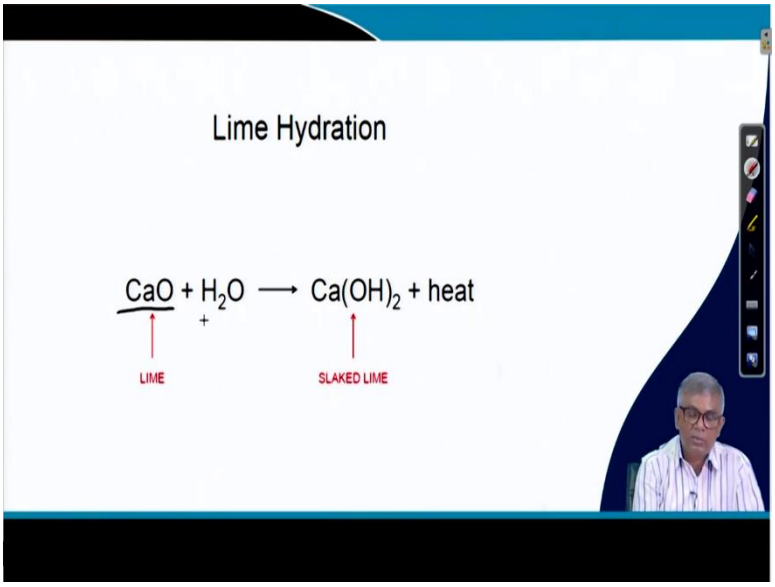

That reaction will try to show you here you can see that that calcium, which is nothing but lime and it will be water present in the soil, when react together and then it will form Ca(OH) which this is the equation perhaps we have all learnt in school and that is used here for some beneficial use of lime for the soil strength improvement. So, here actually Ca(OH) is actually while doing this chemical reaction, it generate heat and that heat actually helps to, that way it is utilizing some amount of water here again because of the heat also you overt water. So, that is the way actually soil will be improved.

Lime hydration

$$CaO + H_2O \rightarrow Ca\left(OH\right)_2 + heat$$

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Next one is the lime, when it is used as for modification, again it is a low dose, quick lime and select lime modify plastic soil by changing the chemistry of the soil water so the clay particles agglomerates and flocculate. That is done, this is the one by chemical reaction this happen agglomeration and flocculation happens and this reduces the soil plasticity and decreases optimum moisture content and reduces sink soil potential. Sink and soil potential, if this happens the agglomeration or flocculation happens this reduces the potential sink and soil characteristics of the soil, it also reduces the plasticity and decrease the optimum moisture content. Decrease the optimum moisture content means actually when we compact that optimum moisture content will be lesser amount of water, we can achieve better dry density.

And the improvement in soil properties occurs over one or two days and may or may not be permanent so whatever happens the low dose and this flocculation etcetera force them to happen and because of that temporarily its plasticity will be reduced and its optimum moisture content will be reduced then potential soil sink will be reduced but at this improvement will take only, this reaction will take place within one or two days and whatever it happens or improvement happens, may be permanent, it may not be permanent also after some time again, it may become as it is. When temporary improvement is required, this is the way it can be done but when it is a permanent improvement is required you need to do something else.

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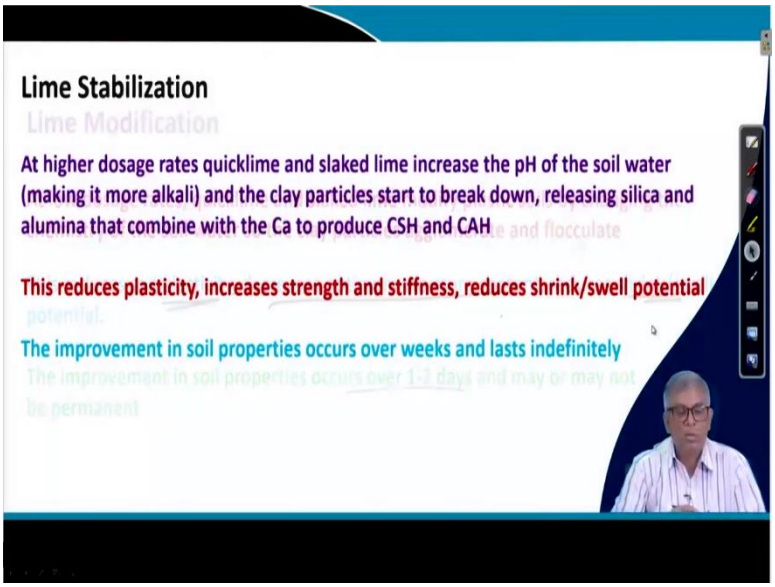

let us go to the next one, so lime the stabilization 3rd one, one is modification and drying modification and stabilization at higher dose rates of quick lime and select lime increase the PH of the soil water, that will be making, it more alkaline and the clay particles start to break down releasing silica and alumina that combine with Ca to produce CSH and CAH. This is some permanent and product CSH calcium silicate hydride, calcium aluminate hydride, so this is CSH, this is chemically, this is a well-known CSH and CAH so high dose actually when it will be added. So, this will become more alkaline and finally it will produce CSH and CH more stable one.

This reduces plasticity and increases strength and stiffness and reduces shrinks well potential also. Previously when you are doing modification there also it is happening same it may not be permanent and this improvement is proper occur over weeks and last independently. Once this happens, it is permanent and this requires a longer time you can see this equation and limes is again.

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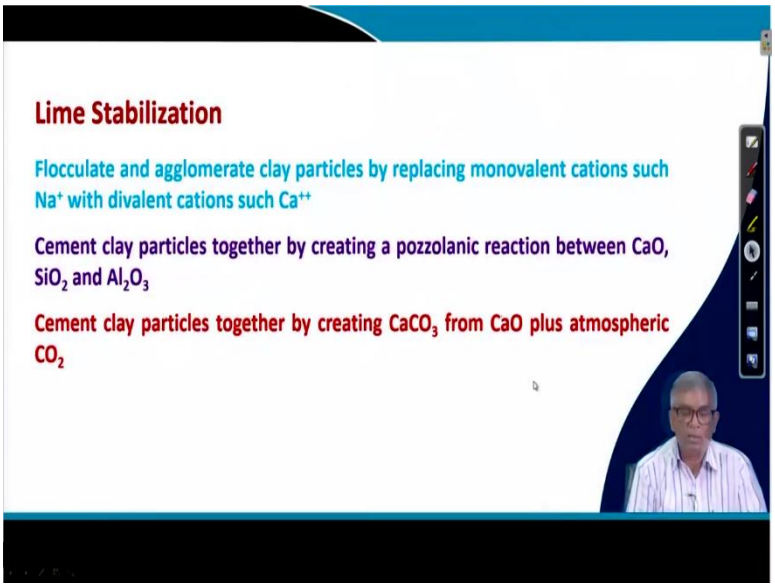

You can see that flocculate and agglomerate clay particles by replacing monovalent cations such as Na with equivalent divalent cations so that cation exchange also happens and that means when there is a monovalent and it will be replaced by divalent and cement clay particles together by creating pozzolanic reaction between CaO, SiO2 and Al2O3 and cement clay particles together by creating CaCO3 from CaO plus atmospheric CO2. So, this is the things also in between happened during this process. For further details we will try to discuss in the next module, I will just close here. Thank you.