Ground Improvement
Professor Dilip Kumar Baidya
Department of Civil Engineering
Indian Institute of Technology, Kharagpur
Lecture 44
Chemical Stabilisation (Contd.)

Hi everyone, once again I welcome you to this ground improvement lecture series and we have completed quite a few modules. I am at present on chemical stabilization and some of the aspects already I have discussed in previous 2 lecture and different types of stabilization we have already discussed. Most of the previous stabilization methods were basically mechanical modification that means, bringing the particles closer like densification then by removing water and then reducing the voids like that.

Whereas in the chemical stabilization already I have mentioned, that it is actually, will have some reactions and some bonding will be created and because of that it will be sometime beneficial to many soil properties like increase strength, decrease compressibility and sometime permeability also can be controlled by mixing different ways sometimes more than one chemical can be used to get successful result.

Here today I will be talking on mechanism that means how it works and affecting factors that means when you do lime stabilization to get the successful result and what exactly we have to do? These are the things we will try to cover today in this lecture.

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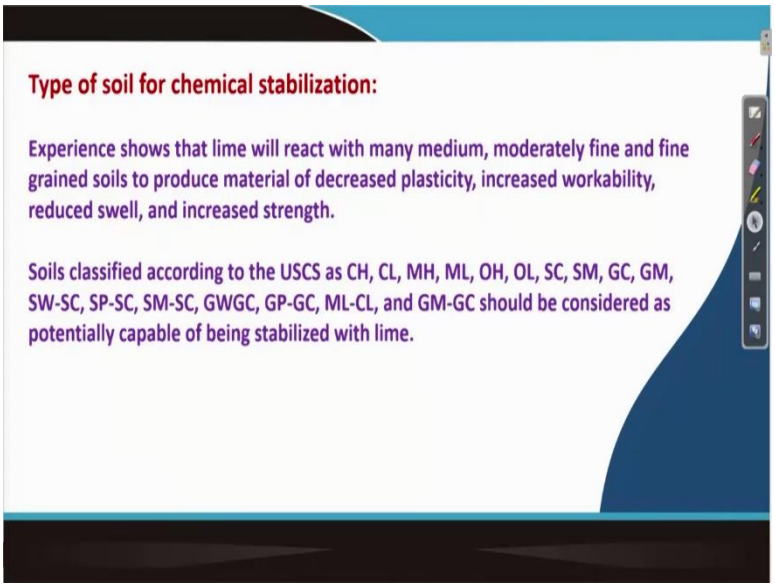

And you can see that type of soil for chemical stabilization. In the previous lecture perhaps, I have mentioned that you need to do the weight sieve analysis and why you need to do weight shift analysis to know the soil type and here exactly what type of soil is good for chemical stabilization, it is clearly mentioned here. From the experience we could see that lime will react with many medium and it is from moderately fine to fine grained soils to produce material of decreased plasticity, increased workability, reduce swell and increase strength.

This is that means many types of soil actually can react with lime and keep give some beneficial outcome and soil different classification systems are there based on USCS classification, there are number of soils is listed here you can see it is starting from CH, CL, MH, ML, OH, OL, SC, SM, GC, GM, SW-SC, SP-SC, SM-SC, GWGC, GP-GC, ML-CL and GM-GC.

What is the meaning of these? These are actually in the classification two letter system we use and in the two-letter system first one is the actual soil and how that soil actually, that is second adjective you can say, CH means it is clay with high plasticity similarly CL it is also clay with low plasticity, MH it is again silt of high plasticity ML, again it is a silt of low plasticity.

Similarly, OH is organic soil with high plasticity, OL means organic soil with low plasticity, SC means it is sand but mixed with some amount of clay. SM means it is actually sand but mixed with some amount of shield. GC means clay with some amount of, it is gravel but mixing with some amount of clay. GM means it is gravel again mixed with some amount of silt and there are again some classification SW-SC means it is well graded sand and clay

sand, these two mixtures actually, like that there are number of types of soil which we can get from unified classification system USCS based on that there are number of soils which are listed here they can be reacted, they can react with the lime and can give you some beneficial outcome.

Why I have mentioned that previously that you need to do sieve analysis, I think it is clear now. Because you have to classify the soil and then you can realize whether the soil will react with lime and give you beneficial results or not.

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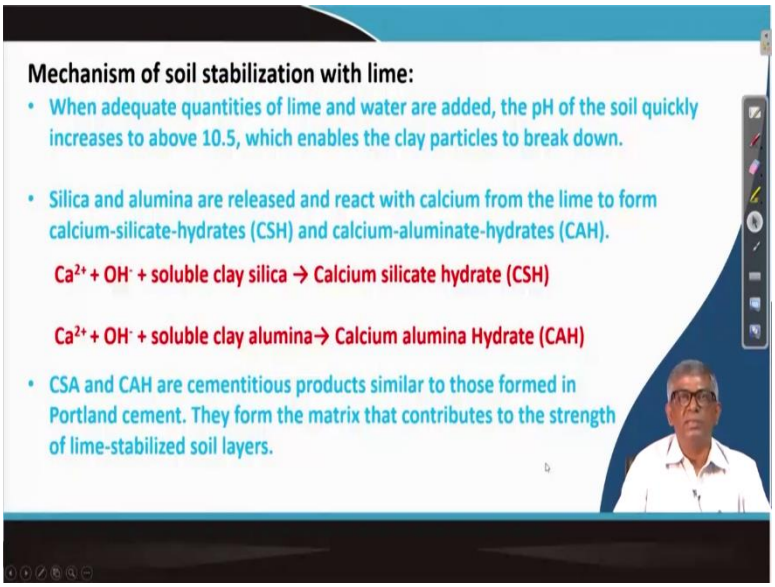

With this let us see the next slide so here actually mechanism of soil stabilization with lime how it works actually. As we have mentioned that we have to initially in the slow dose of chemical lime we have to add and slowly you have to increase and when adequate amount or adequate quantities of lime added and water are added, the pH of the soil quickly increased to about above 10.5.

It becomes alkaline, which enables the clay particles to break down. That means this one will become two alkaline that is 10.5 and above pH, then the clay particles will break and because of this breaking the silicon aluminium are released and react with the calcium from lime so from the clay particles when it is breaking down silica some soil will be silicate, some soil will be alumina soil, some are silicate soil so it will be released and that will again react with calcium which is available with lime and it will form somewhere it will be with reaction with silica then it is calcium silicate hydrides and when it react with aluminium, then it is calcium aluminate hydrates.

$$Ca^{2+} + OH^{-} + \text{soluble clay silica} \rightarrow \text{Calcium silicate hydrate (CSH)}$$

$$Ca^{2+} + OH^{-} + \text{soluble clay alumina} \rightarrow \text{Calcium alumina hydrate (CSH)}$$

These two things are developed or formed and you can see that that equation also I have shown here that that it is Ca_2 will be released and from calcium hydroxide then OH actually that become alkaline. So, this two will react and then soluble clay silica, from the clay what silica is released that also will be there.

These three will react and finally calcium silicate hydrate will form that is also known as CSH which we are I have used in the previous lecture and Ca_2OH this is calcium coming from that your lime and this is a soluble clay alumina that means after breaking down the alumina release, they will react and then calcium alumina hydrate which is also popularly known as CAH is formed.

CSA and CH are cementitious products similar to the formed in Portland cement, also these things are there, that is why it is so strong and strength is good. Similar materials are developed in the soil itself and they form the matrix that contributes to the strength of lime stabilized soil. The particular layer when you mix with the lime, it will become a very strong lime stabilized soil and would become very strong. That is the purpose obviously and this is the mechanism, how lime and clay, soil must have some amount of clay otherwise we can see the classification wherever I have shown, each and every soil contain some amount of clay so clay must be there then only this reaction will happen.

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Let us go to the next slide, this is affecting factors for the success of lime stabilization. The success of the lime treatment process is highly dependent on several factors and you can see listed here, one is soil type obviously we have shown there that the number of soils is there, some will be very good, some will be moderately good, some will be not that good and some of the soil will not be good at all, cannot be done actually.

That it depends on soil type, then it is lime type there are different types of lime will be there, slag climb, then quick lime and then many other types of lime or lime can be substituted by some other materials. Then lime content how much amount of lime we are adding that also will be affecting compaction and after doing this lime and soil mixing after reaction it will not be that compacted state, so you have to compact it and then you have to cure it because the reaction it will take place of over a period of time you have to give that time and you have to give some amount of water otherwise this reaction will not be there.

And then sometime add mixture then you can add some of the number of materials which will be again react further and give you better results. These are the things we will discuss now each and every aspect one by one.

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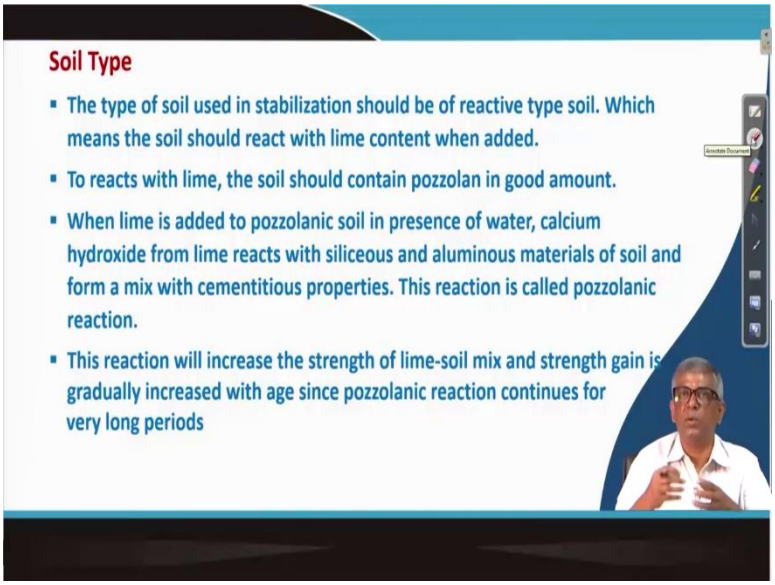

The soil type and you can see here the type of soil used in stabilization should be of reactive type of, reactive types of soil mean actually it should contain some amount of clay otherwise sand and other things they do not react with lime. If it is pure sand then it will not be useful, which means the soil should react with lime content when added. Lime when it is added with same then should reaction should take place.

And that to react with lime the soil should contain pozzolan in good amount, so that reaction will be there and when lime is added to pozzolanic soil in presence of water calcium hydroxide from the lime, reacts with siliceous and aluminous material of soil. From the calcium hydroxide from lime and that silica and alumina from the soil, they will react and form a mix with cementitious properties and this reaction is called pozzolanic reaction. Already we have shown in the mechanism one again it is repeated here.

Soil type when we are discussing, it is clear that there should be some reactive material and then how it reacts once again we are repeating here and this reaction will increase the strength of the lime soil mix and strength again is gradually increased with age since pozzolanic reaction continues for very long periods. Immediately after mixing maybe after one day whatever will strength will get after two days, you will get further more after one week you will be more like that, so with time it will be increased.

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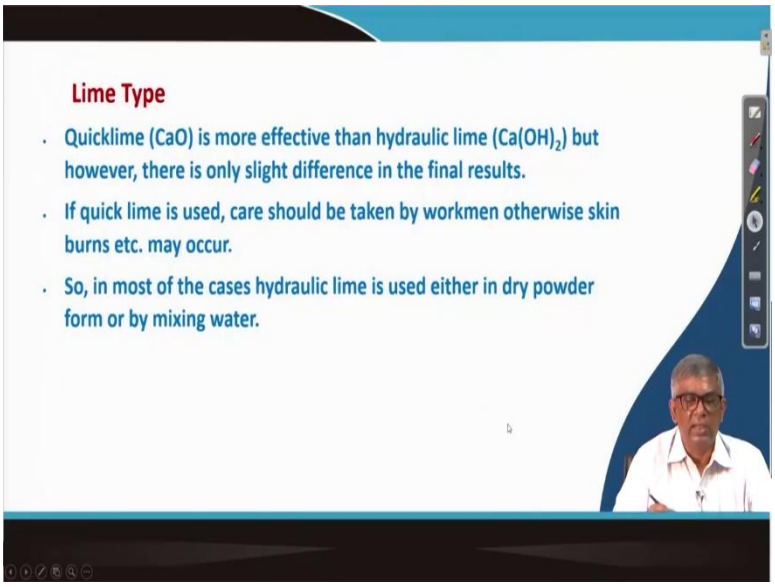

Let me go to the next one that is actually lime type, as we have mentioned that quick lime is more effective than the hydraulic lime that is $CaOH_2$ but however there is only slight difference in the final results. Instead of CaO if you use $CaOH_2$ actually final results will not much effect, but still directly if you have CaO there are some benefits and there are some disadvantages also.

Like if a quick lime is used, then lot of heat will be generated so because of that when quick lime is used care should be taken by workman otherwise skin burns etcetera may occur, we

have to be very careful. In most of the cases, in the lime stabilization construction generally hydraulic lime is used either in dry powder form or by mixing water ok. This is effect of lime type.

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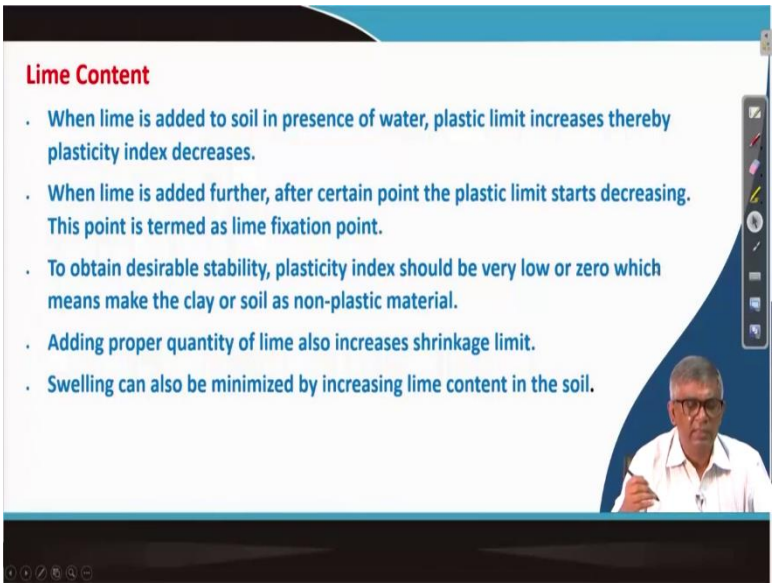

Let me go to the next slide that is lime content, that is how much lime is required so that is also important. When lime is added to the soil in presence of water, plastic limit increases thereby plasticity index decreases. When the lime is added in soil in presence water then plastic limit increases and if the plastic will increase then liquid limit minus plastic limit and that is plasticity index decreases.

And when the lime is added further after certain point the proximity limit starts decreasing and the point is termed as lime fixation point, that means for stabilization purpose, so we as I have mentioned in the previous session, that there are steps for lime stabilization where we have mentioned that there has to be a trial or test, that means you have to take 1 percent, 2 percent, 3 percent, 4 percent, 5 percent and mixed with soil and then you see the behaviour of each and where we are getting desired behaviour that percentage of lime will be the lime required for successful stabilization. That has to be determined so that is called fixation point of lime.

And to obtain desirable stability plasticity index should be very low or 0, that means to make actual stabilization of the soil non plastic soil always is good and stable we know and plastic soil is not good. When you are doing stabilization, you have to reduce the plasticity index significantly or you have to bring it to close to 0 and that means the clay or soil as non-plastic

metal that means by plastic soil, by treating with lime you have to convert into a non-plastic soil.

And if it is not fully possible at least close to the non-plastic soil. Then adding proper quantity of lime also decreases synchronous limit and soiling can also be minimized by increasing lime content in the soil. Both swelling and sinkage also can be controlled by maintaining a particular amount of lime so that is the lime content how it affects the lime stabilization.

Fixation point has to be derived actually, otherwise if it gives less amount of soil then there will be some amount of clay will remain without reaction and if you add more amount of lime, there will be additional amount of lime will remain in there and that actually create some problem, it will dry the soil and if you dry the soil then cracks and other things will form that is also not good. Fixed amount of lime is required to get successful results.

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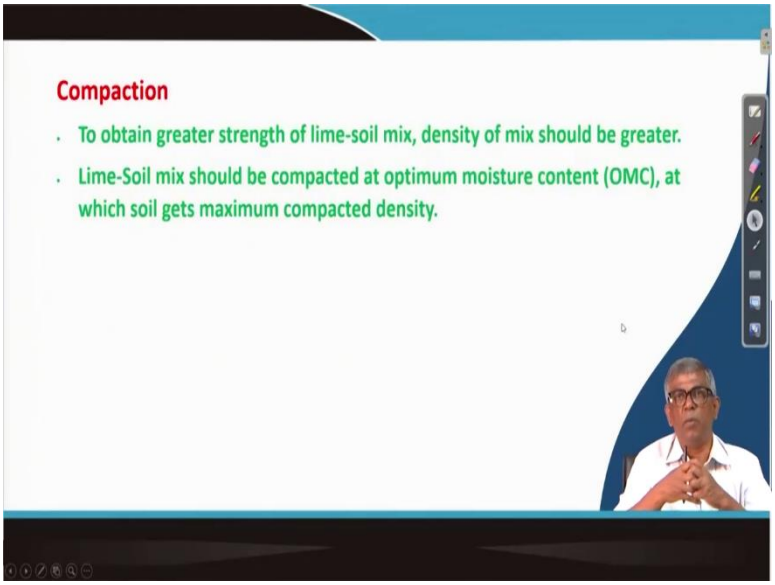

Let me go to the next slide, then compaction of course, is an important point. To obtain greater strength of lime soil mix and density of mix should be greater. How to the measure the good soil in the high dry density, which we are talking right from beginning that you have to increase the dry density and we do by compaction, we do by dynamic compaction, we do by roller and all those things we do.

The dry density increasing is important parameter and that you have to obtain. And lime soil mix should be compacted at optimum moisture content at which soil gets maximum compacted density, that also to be seen that ultimately you are mixing with lime and we do

carry out number of test and from there you have to see that where we are getting maximum dry density optimum moisture content, whether we are getting significant amount of strength or not.

By doing all those things you fix also maximum guidance and optimum moisture content. That means you have to after reaction also you have to compact it to get that, this is the compaction.

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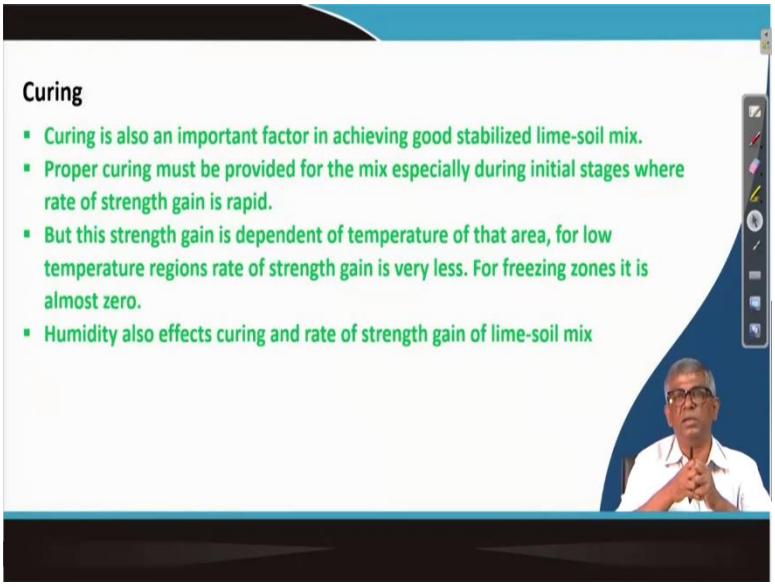

The curing, curing is also important because curing is also an important factor in achieving good stabilized lime soil mix and proper curing must be provided for the mix especially during initial stages where rate of strength gain is very rapid.

That means as we have mentioned that when you mix with lime, gradually with time strength increases but this increase of strength in initial time is quite high and slowly the rate of increase will decrease. For providing curing you have to keep taking enough care at the initial period at least and this strength gain is dependent of the temperature of that area, for low temperature regions, rate of strength will be very less.

For freezing zone, it is almost 0. If it is a cold area lime standard stabilization may not work well, so we have to keep that in mind. Humidity also affects curing, rate of strength gain of lime soil mixes so that also you have to keep in mind. These are all different aspect of the lime stabilization.

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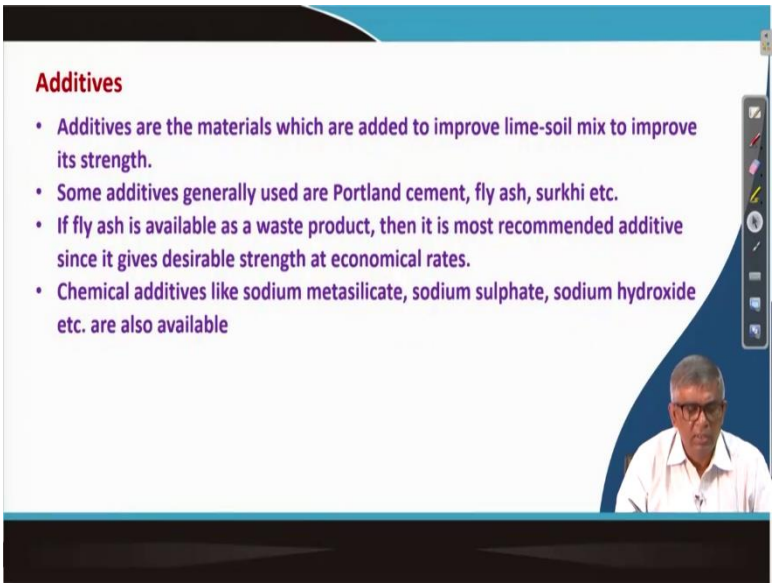

Let us go to the next one, then additives. This is also important because the lime can do something but its long-term behaviour can be changed by adding certain mixture. That is what it is mentioned here you can see the additives are the materials which are added to improve lime soil mix to improve its strength whatever strength can further be improved, if I add certain things and what are these certain things?

Some additives generally used are Portland cement. So, you can you can see that cement if it is added strength automatically will be increased so lime will give you certain amount of strength but if you need further increase then you can add cement. Then flyers can be also used, surkhi can be used, some other materials are also there which we will discussed later. Then if flyers are available as a waste product, then it is most recommended additives, since it gives desirable strength at economical rates. That means flyers is a very good additives for lime soil stabilization.

Then chemical additives like sodium metasilicate, sodium sulphate, sodium hydrate etcetera is also available. These will give you some other benefits like holding water and all, so that can be also be added some time to get desired result.

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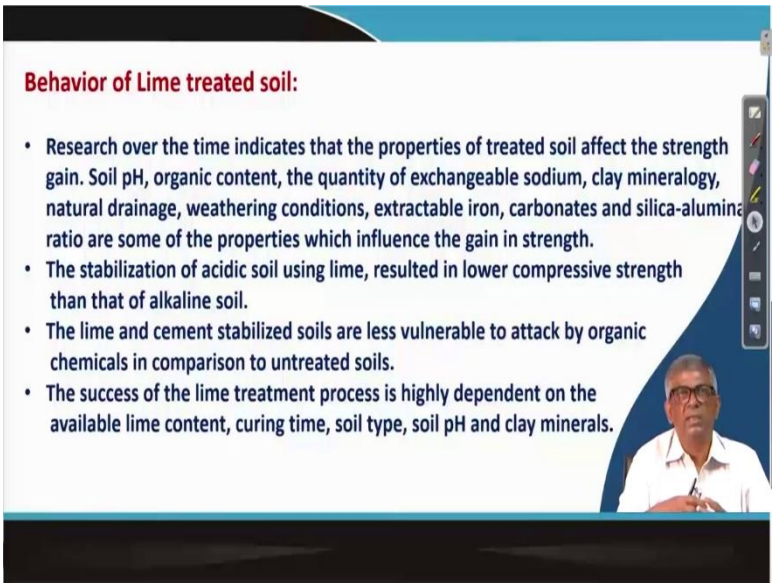

Let us go to the next one. Finally, the behaviour of lime treated soil. How it behaves finally. Researches over the time indicates that the properties of treated soil affect the strength gain. That means whatever soil has the property, it gives you or it depends on that actually, the soil strength gain.

And you can see that soil pH which we have mentioned that for reaction purpose certain value of pH is required, so soil pH is important. Then organic content, then quantity of exchangeable sodium, the clay mineralogy, natural drainage, weathering condition, extractable iron, then carbonates and silica aluminium ratio are some of the properties which influence the gain in the strength.

These are the things, the materials when you produce the mix, that mix actually affected by this that strength can also will be affected. The stabilization of acidic soil using lime resulted in lower compressive strength than that of alkaline soil. That means if the soil is acidic and then limestone stabilization will be less effective that is the thing is mentioned.

That has to be kept in mind and then lime and cement stabilizer soil are less vulnerable to attack by organic chemicals in comparison to untreated soil, untreated soil sometime because of the organic presence its strength and other things will be reduced or affected but when it is treated with cement or lime this organic chemical cannot do much that means, it will not affect much. So, that way it will make actually long-time stability.

And then finally success of the lime treatment process is highly dependent on available lime content, curing time, soil type, soil pH, soil clay minerals etcetera which I have already mentioned. These are all different things which I wanted to discuss on this lecture. With this I will close here, basically the lime stabilization mechanism and what are the factors it affects that I have tried to discuss in this lecture. Thank you, I will take something else in the next lecture, thank you.