Ground Improvement

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Lecture 43
Chemical Stabilisation (Contd.)

Well, let us continue with this chemical stabilization and in the previous lecture we have just discussed the different types of stabilization and giving steady stabilization is one of them and in the chemical stimulation different types of chemicals like lime in different form, cement, then flyers can be used and again out of that I have just started that lime as stabilizing agent and lime can be utilized or it can serve three different purposes, it can be used for drying purposes, it can be used for modification purposes and it can be used for stabilization purposes.

And what is stabilization purpose is used then, when it is modified, modification purpose used with a short time, there are some changes that take place within the soil and it also reduces plasticity then reduces the optimum moisture content, then reduces the soil sink behaviour of the opponent of the soil, all beneficial but they are not permanent. When high doses of slime are used and then there are some reactions happens and because of that some stable material is developed and that actually permanently improve the plasticity characteristics and it reduce your optimum moisture content and also it reduces the soil sink potential of the soil.

That is permanent so that is the things actually we will try to discuss further that use of lime. What reaction is taking place? What are the different kinds of reaction is happening and finally how this will be utilized in the construction that means the construction also you need to follow or such a method that all required chemical reaction to happen and we get the desired soil?

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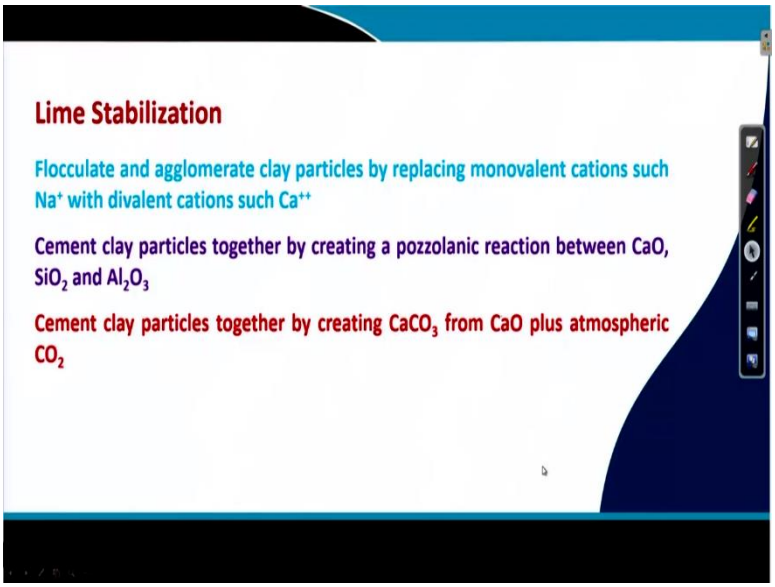

For this purpose, let us continue with the slide which we have discussed in the previous one actually you know, that clay particles will have charged particles and it will have some…it is also having some cation exchange capacity, different soil will have different cation exchange capacity and when will add lime it will make the alkaline environment and then some monovalent iron will be changed with divalent cation. Sodium will be replaced by Ca, this happens and then further some chemical reaction will take place and stable material will form.

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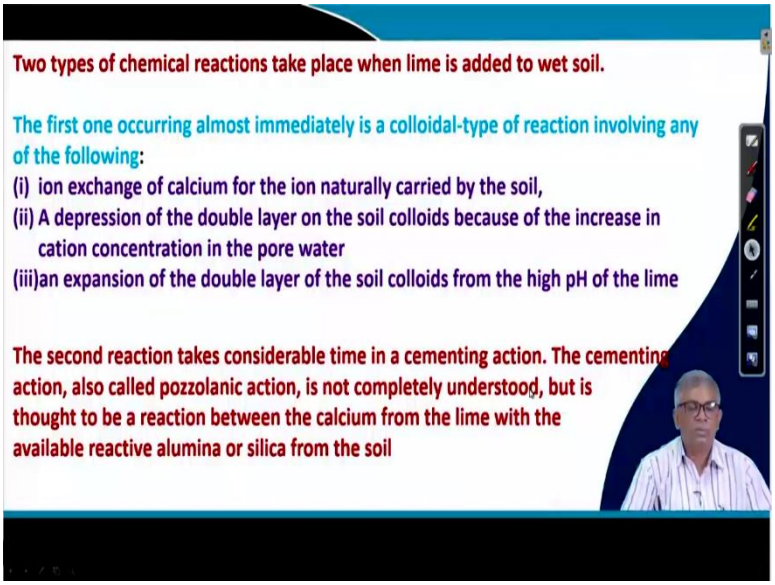

Let me go to the next slide, so two types of chemical reaction take place when lime is added to wet soil and first one occurring almost immediately that out of two, the first one almost

immediately and is colloidal type reaction involving any of the following. There are three different types of things can happen during that, iron exchange of calcium for the iron naturally carried by the soil.

Either sodium or similar other cation will be there, it will be exchanged by calcium that can happen and a depression of the double layer and the clay layer will have that double layer, that depression of double layer on the soil colloids because of the increase in cation concentration in the pore water, that also can happen and third one, an expansion of the double layer of the soil colloids from high Ph of the line.

Three things can happen ion exchange can happen, depression of double layer can happen, expansion of the double layer also can happen. Three things happen and that can be happening almost immediately of the adding of lime and second reaction will take a considerable time in cementing action and the cementing action that is actually cementite, that cementing action is called pozzolanic action and is not completely understood how it happens but is thought to be reaction between the calcium from the lime with the available reactive alumina or silicate from the soil.

Soil will contain aluminium or silicate and lime contents calcium so between this the reaction happens. That is one and that is by large you call is a pozzolanic action and it takes a long time and it is a cementing action. So, there are two reaction that is one, stage one and this is stage two, here some changes will happen and here actually this some cementing action will happen. By this process finally some stable material will form.

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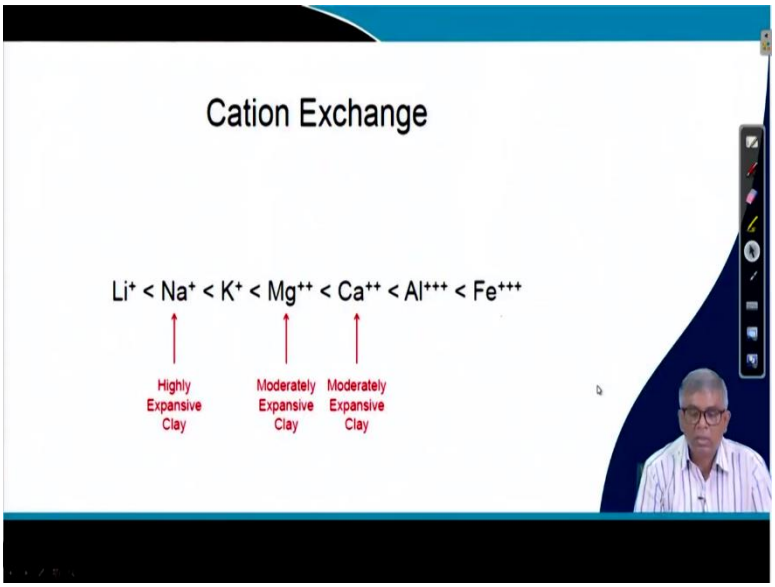

This is the one cation exchange as we have mentioned you can see they are all monovalent and this is highly expansive that is montmorillonite. That is sodium montmorillonite, it may have sodium. These are all monovalent and then it will be exchanged, the particle clay particles it will happen, it will be there and will be exchanged by these are divalent and they are moderately expansive or very less expensive. When it is exchanged because of the reaction during exchange that will help to reduce the soil sink potential of the soil.

Cation Exchange

$Li^{+} < Na^{+} < K^{+} < Mg^{++} < Ca^{++} < Al^{+++} < Fe^{+++}$

$Na^{+} \rightarrow$ Highly Expansive clay

$Mg^{++} \rightarrow$ Moderately Expansive clay

$Ca^{++} \rightarrow$ Moderately Expansive clay

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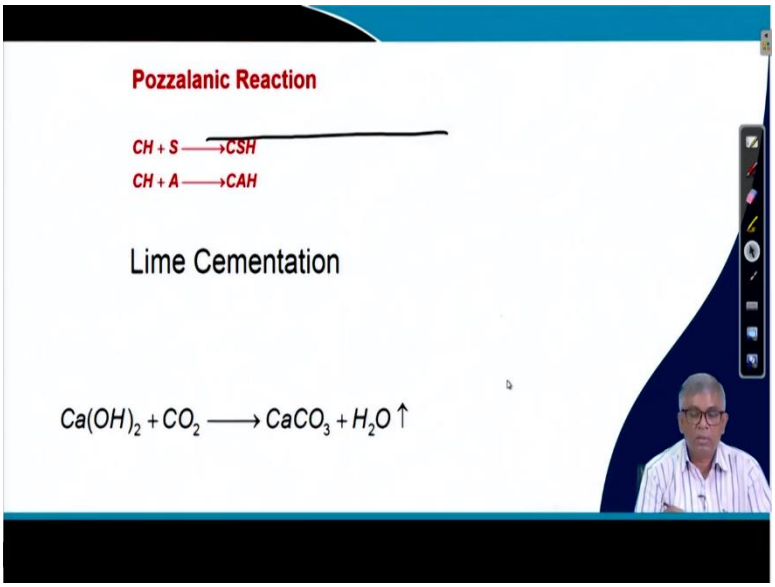

And as we have mentioned before that this is symbolically written actually calcium hydride and silicate CSH, this is standard form which we will use CH and aluminium. Actually, with lime and the silica present in soil or alumina present in soil, can react with that and then it will form a stable CSH or CAH and again another reaction happened with the carbon dioxide with this, the calcium carbonate form and water will form. So, this is also helps to stabilize the thing

Pozzalanic reaction

$CH + S \rightarrow CSH$

$CH + A \rightarrow CAH$

Lime Cementation

$\mathrm{Ca}\left(oH\right)_2 + CO_2 \rightarrow CaCO_3 + H_2O \uparrow$

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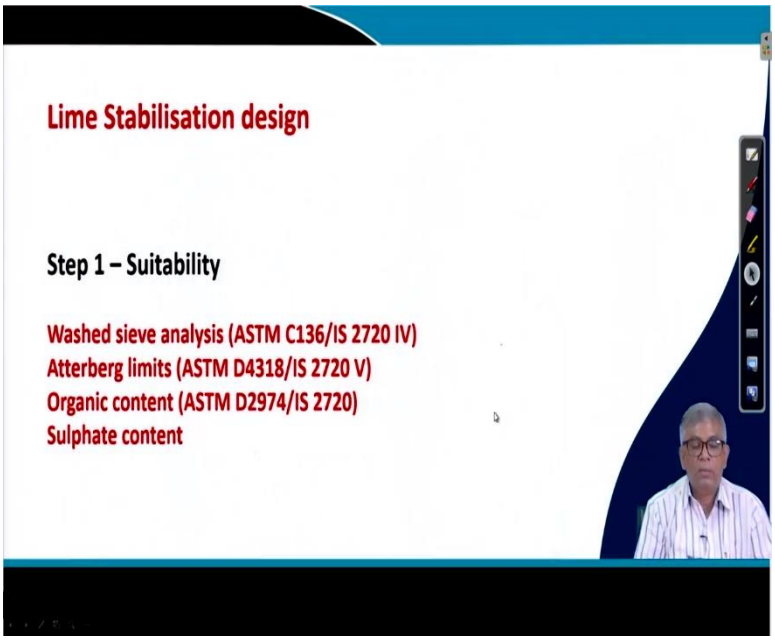

And for lime stabilization design that means if you want to use lime stabilization technique for improving the soil you have to design this, design means what? What dose to be used and for what soil it will be used first of all you have to know, secondly at what quantity you have to add? How to add and etcetera. How long it will take, all those things actually by the trial or test actually you have to first find out. Of course, right now we need not do because already established people did that and it is already available in the references, people can use that and see that and directly can use.

But suppose one has to design the lime stabilization system, then what exactly one has to do we can see here that step one, first of all suitability check has to be done. Suitability check means what? The soil type which you have at hand or which you have to improve then whether it is suitable for lime stabilization or not that to be checked and for that what you have to do? Wash sieve analysis, what is wash sieve analysis?

This is actually that lime stabilization will applicable only for fine grained soil so how much fine-grained soil is there and that has to be determined and for that, there are ASTM standard is there, then IS standard is there, so that method can be used and it can be analysis can be done.

Similarly, Atterberg limit by that actually plasticity characteristic of the soil has to be determined because by doing lifestyle stabilization we are modifying the plasticity characteristic of the soil. If it is not plastic already then why we need to do? Because of that whether the soil is plastic or not that to be determined then Atterberg limit test has to be done and for that there are some standards we have to follow and do the test. Then organic content

if there is organic soil present then whether it is good or bad, that is also known and what is the amount of organic actually suitable or not suitable, you have to know that.

For that you need to find out organic composition presence of organic content in the soil, for that there are some standards IS and ASTM and then sulphate content, say particular amount of sulphate if it is there, sometime it will be applicable and if it is more may not be applicable. All those things are available also in the form of guidelines that what should be the sulphate amount? What should be the organic amount? What should the plasticity? What should be the grain size? All those things are available in the form of guidelines. For the time being what I want to mention here that in the step one, you have to carry out these are the things ok and you have to find out what it is actually exactly characterize the side soil so that is the suitability test.

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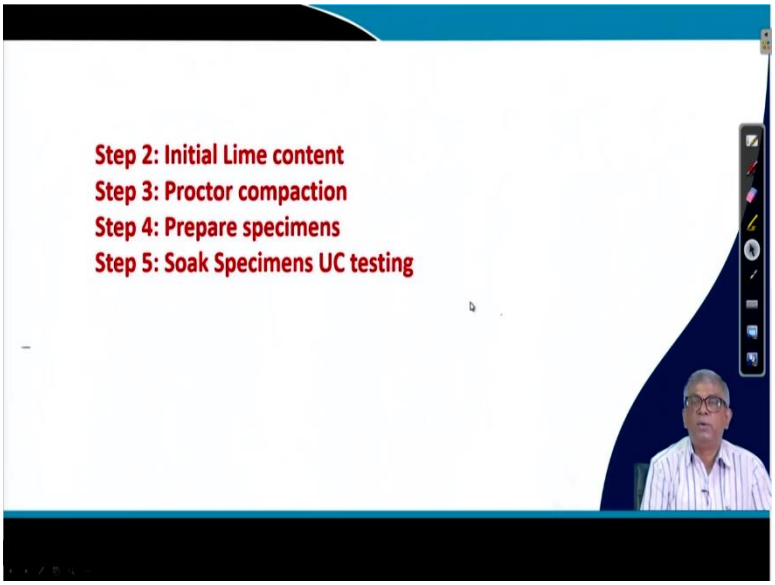

Next there are number of steps you can see that initial lime content that means how much quantity of lime is good for this stabilizing the particular soil which has to be modified. So, therefore that actually obviously when it is not known the soil is totally new type, then one has to prepare a scheme of mixing soil and lime with different parts proportion like 2 percent lime, 3 percent lime, 4 percent, 5 percent, 6 percent, 8 percent, 10 percent like that different percentage of lime to be mixed and then sample will be prepared and for those sample again you need to carry out proctor test and then you have to see optimum moisture content or maximum dry density, then we have to prepare some specimen for different test like strength

test and where we are getting optimum strength that may be the suitable proportion or percentage of lime that has to be adopted.

So, again prepare specimen and most of the time this soil stabilization of work is used in road work and when you use in the road work, many at times it will be under water and because of that when the road is under water, during rainy season again how it will behave? That is the worst situation, so to simulate that worst situation generally after doing this stabilization with slime, then you have to keep it in show condition for some time and then you have to carry out test or different tests like California bearing test or some UC test and then you have to see where actually exactly it is fulfilling your requirement and at that percentage of lime will be the actual lime which has to be used in the construction.

That means first one you have to know characterize the soil, what it is? What are the different proportion etc., and then you have to different percentage of lime to be added and prepared the sample and carry out all sorts of tests and finally you see that which percentage of lime we are getting the optimum everything, optimum everything means too high strength but plasticity is not improving too much or it become too brittle?

All those things to be optimized. Similarly, optimum moisture content also then maximum dry density also everything to be seen and then based on that you have to choose a particular percentage of lime as design percentage of lime and which has to be added to the soil to get the stabilization work.

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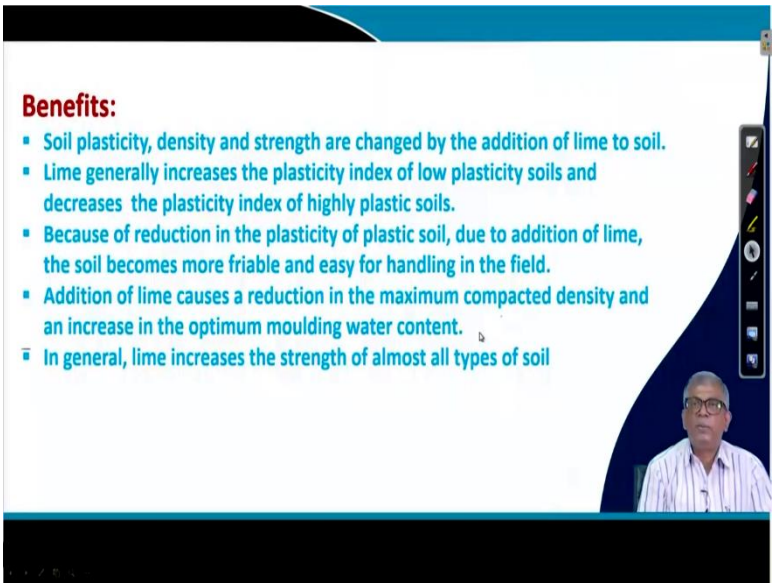

The benefits, what benefit we get if we add lime, you can see the number of benefits you get, soil plasticity, density, and strength are changed by the addition of lime to the soil. So, soil plasticity change means actually highly plastic is no good so plasticity to be reduced and density change means what side it should be better side. Density reduction will not help, similarly, strength what side is increased? All plasticity decreases, density increases and strength increases by adding of lime to the soil.

Similarly, lime generally increases the plasticity index of the low plastic soil so it generally increases the plasticity index of low plastic soil and decreases the plasticity index of highly plastic soil. So, highly plastic soil if you add then lime then actually your plasticity index will be reduced. Whereas if it is a low plastic soil, the plasticity index will increase. That is the one somewhere it may be required if the strength requirement is sufficient that may be sometime will be used and then because of the reduction in the plasticity of the plastic soil due to addition of lime, the soils become more friable and easier for handling in the field.

That means by mixing of lime, the soil become friable and easy for handling. That is also required if it is a tube long form, the soil is there, it is not good for compaction and all. That is actually the advantage then addition of lime causes a reduction in the maximum compacted density and an increase in the optimum moulding water content. That water content reduction that is also important and in general lime increases the strength of almost all soil if we use the lime, that is actually most important requirement, strength that is totally ultimately has to be improved. That is the most important thing, almost all soil when you add lime the strength will be improved whereas we can see that the different soil, when I add soil, sometime it will

be beneficial sometimes not beneficial also but ultimately, we have to optimize which is most required actually that to be seen. These are all number of benefits actually you can get by adding lime to the soil.

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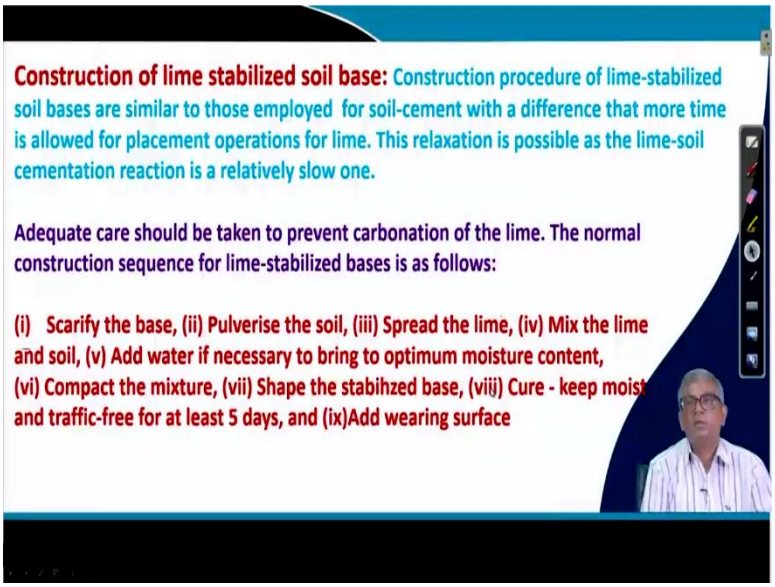

Construction of lime stabilized soil base and how we can do this? There are certain steps actually, the adequate care should be taken to prevent carbonation of the line. The normal construction sequence for lime stabilized bases will be a number of them there are 8 or 9 steps are there you can see, scarifying the base, that is scarifying the basement surface, first of all by using some you have to make it rough. And surface will be scrap and then you have to make it actually soil lamp form.

And then pulverize the soil again, if it is a too big lump then you have to pulverize then then spread the lime over that, after pulverizing the soil level it then spread the lime on that, then mix the lime and soil. When after if you put the slime on the surface then only top soil will be reacted with lime but it will not react with the soil in the bottom. That has to be mixed by some means then add water if necessary to bring optimum moisture content after drying, spreading the lime, then water can be added, sometime the lime slurry can be directly used.

Otherwise dry lime and then water to be added and then compact the mixture, once the mixture is formed reaction will take after some time. Then compact the mixture, the same way stabilized base that means you have to surface properly giving the shape and then cure it that keep moist and traffic free for at least five days. Immediately after that if you start giving load worried then this will not work.

It will create actually problem; you will not get desired strength and stability. See, curing is required after doing up to stage 7, you have to cure it for keeping it moist and traffic free for at least five days. Sometimes, while doing the road work sometime after doing some portion of the work then allow the traffic by movement of traffic sometime get compacted but when the lime stabilization is there it should be completely stopped otherwise, that reaction etc., will be disturbed and proper stabilization will not happen and finally add wiring surface. This is the by and large the steps.

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Let me now show some figure photograph how it is done in the practice, you can see here this is actually stage of scarifying the soil, you can see here by surface by doing some anchor type of things, the soil will be disturbed in the surface like that is actually called scarification of the soil and by there will be some equipment by that the way actually we prepared the soil for cultivation purpose almost similar way it has to be made and up to some depth. It cannot be too deep because then a particular amount of like shallow compaction we used to do 30-to-40-centimetre height.

Similar to that here also some guideline is there, it cannot be too deep, you have to use that similar type of the agricultural equipment type of things that scarify the surface soil up to 6 to 8 inches or even slightly more.

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And then you have to spread the lime, of course after scarification if there is two big lamb formation is there, then you have to pulverize it. Otherwise, the big lump surface soil will react with lime but inside it will not react.

Because of that you have to pulverize it and after pulverizing and levelling it, you can thus spread the lime you can see the surface is white because the lime is spread over this one and as I have mentioned that after spreading the lime, you have to add water but instead of doing that sometime as I have mentioned that we can use the lime slurry.

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This is one photograph where actually you can see that lime in the form of slurry is applied on the surface for this purpose.

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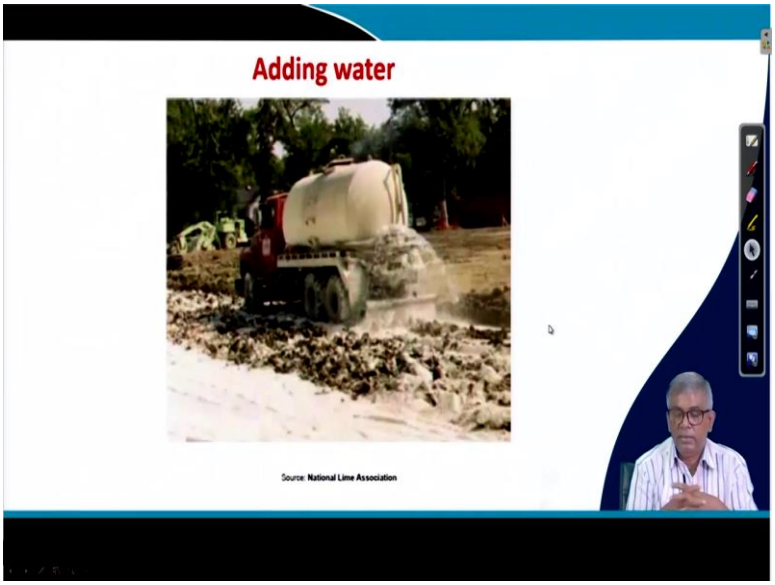

And then you can see here water is added here, if the slurry is not used then you can add water also after a lime. You can see here that water is added here, particular amount also that it will have optimum moisture content for having reaction with lime and soil.

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Next one, after doing this you can see that mixing as we have mentioned that, when the soil and lime and then if you spray it on the surface only it will be there and it will react to only surface soil, it will not react soil below. For that we have to have mixing so mixing can be

done this way and then the soil below also, some amount of lime will reach at the below and for the reaction and by that way the stabilization will take place.

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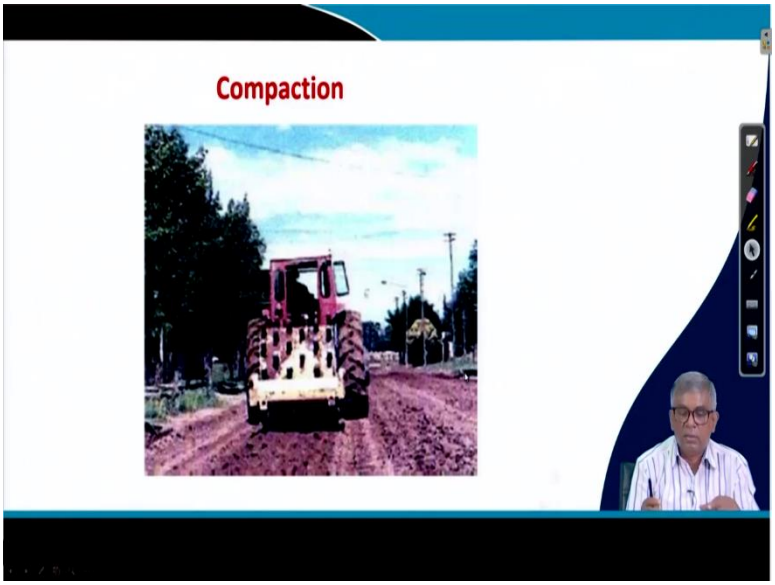

And at the end finally what you have to do? This is actually generally this lime stabilization is done most of the time for fine grained soil and when it will be added with lime, after reaction still soil will be fine grained soil and its compaction already, we have discussed before that for fine grained soil compaction will be efficient only if you use the shift food roller.

Why is shift food roller because the shift food roller also helps to give some kneading effect that means soil will be mixed properly that is one thing and second thing is when the roller is passing over the soil that roller weight will be resting once a few spikes on the roller and as a result that it is resting on the spike that means contact area will be reduced and because of that, the pressure on the soil will be more.

Because of this high pressure the compaction will be better, so because of that it generally after lime stabilization the soft soil or fine-grained soil, this type of shift roller is used for compaction purpose. After doing this of course then the surface will be level and then there will be wiring surface will be prepared for the entire or the desired like if it is embankment work or if it is some other type of work for construction of some other similar facility, then surface will be accordingly prepared.

This is by a large lime stabilization and construction technique using lime so then there are other types of chemicals are there which I may take 1 or 2 and how they actually change the properties of the soil and how we can use in the construction and there may be some results from the literature, which one will be the most effective. Like that I may take 1 or 2 lectures on this and then we will go to the next module. With this today I will close here. Thank you.