Ground Improvement
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Lecture 37
Grouting (Contd.)

Hi everyone, let us continue on grouting. Some aspects of grouting already we have discussed in the first lecture. Now rest of the things let us continue and we are talking about in the previous lecture grouting, grout characteristics and to find out the grout character there are number of parameters, one of them is a groutability which we have discussed.

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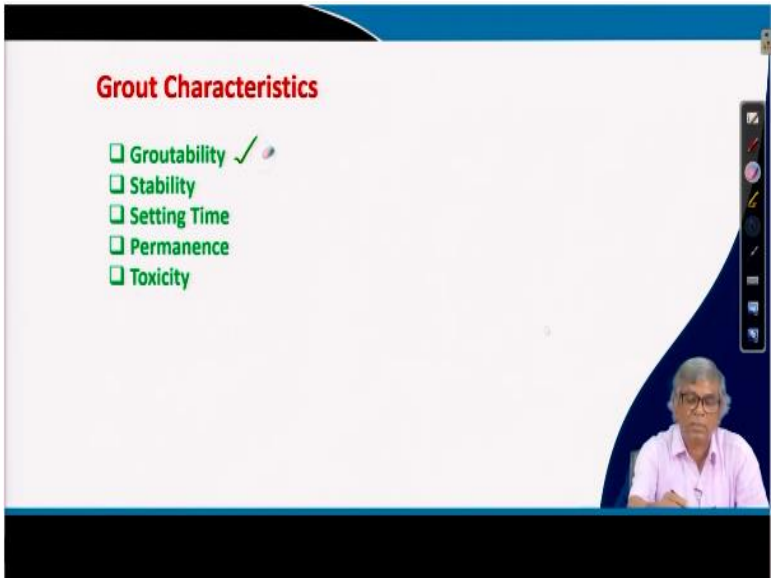

Let us, this is the one the groutability we have discussed and rest of the things like stability, setting time, permanence and toxicity these are the things we need to discuss so let us take one by one.

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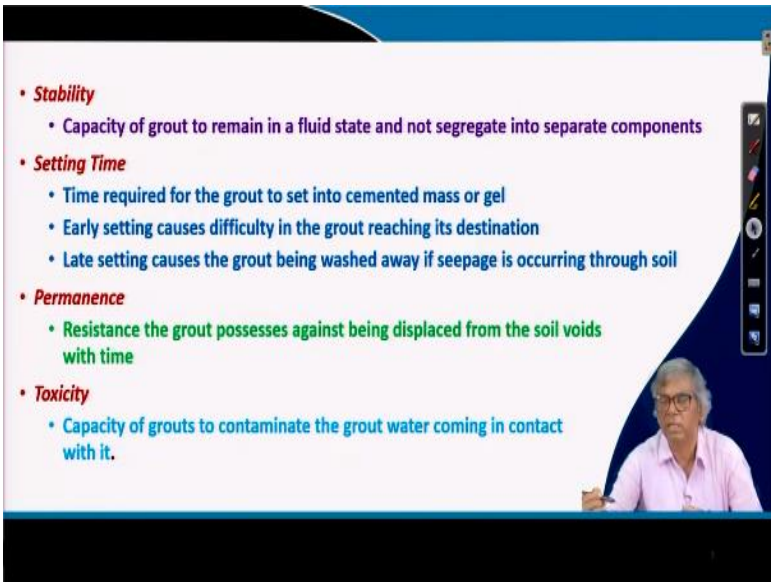

The stability, stability means exactly what? Stability means capacity of grout to remain in a fluid state and not segregate into separate components. That is stability, you have to prepare the grout material in such way it will be in a particular, remain in a fluid state and like if I make a solution and after sometime the solid part settling and liquid part coming up that will not be a good grout material, when it will remain in suspension that is actually the stability of the grout material.

Similarly, setting time required for the grout to set into cemented mass or gel, that is actually setting time and again for different work different setting time will be like cement different purposes we use different setting time, here early setting causes difficulty in the grout reaching its destination.

If it quickly sets, particularly permeation grouting which is going through gravity and it sets very quickly then it will not spread in a particular area, which you desire to do and similarly late setting causes the ground being washed away, if seepage is occurring through the soil.

That is also, so we have to optimize the both if it is a early setting that means I want to flow over a half an hour time or 20 minutes or 10 minutes time up to some distance slowly but if setting time is 5 minutes then it will not reach that is one problem and

second probably if this is too late, that means the suspension from if it is there in the remain in the soil mass and if there is a seepage.

Suppose sometime we use grout to prevent seepage and in under that situation if it is a very slow setting time grout is used then with seepage it will wash away and instead of doing the purpose it will be washed away, that is actually setting, you have to optimize the setting time and for different work you have to find out what is the suitable setting time that may be their guideline we will discuss later on.

Then permanence, that is actually resistance, the grout possesses against being displaced from the soil voids with time that is a permanent. When actually grout is injected and then solidified and then over time if it is this get displaced that means it will not serve the purpose, it sometime holds the particles, hold the rock, two rock parts and if it is not there over the time then that permanent, if it is not permanent that is not suitable, so that is also another, characteristics to be examined and selected.

And toxicity already is a very, very important that ultimately, we are injecting to the ground and there are some time groundwater and which we are using sometime as a drinking water or any other purposes and if I use the grout material which has high toxicity and then it will mix with ground water and ultimately it will pollute the ground water, which will be very much dangerous.

That also to be seen that, there may be a good grout but if you close to the ground water, if you use that if the pollution of ground water will be a concern and that to be taken care. That the capacity of grouts to contaminate the ground water coming in contact with it so that is what is the toxicity that you have to avoid to use highly toxic material for grouting purpose. These are the characteristics based on these, you will be selecting the ground material.

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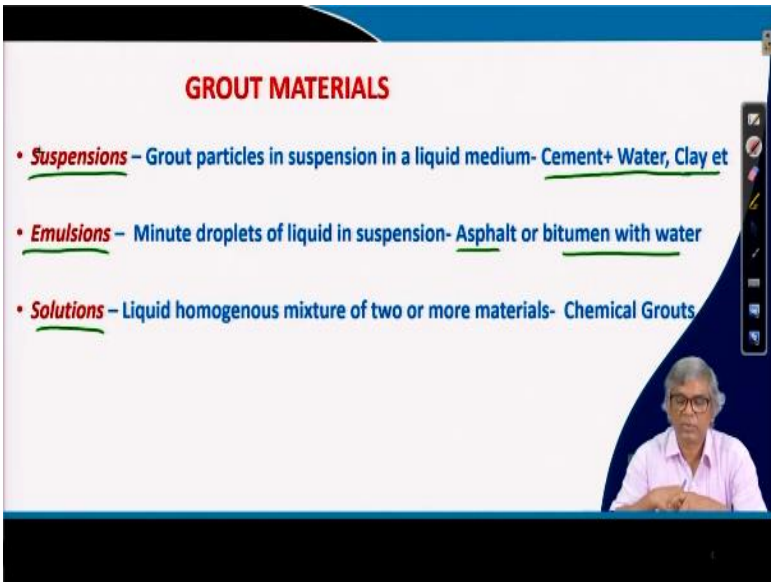

And then groutability you have done this, now grout material then again, we have understood that there is a suspension in the liquid form to be injected and then what are the different forms of grouts available and we can see here, there are three different, one is suspension grout, other emulsions grouts, another is solution grounds.

Suspension grouts is actually grout particles in suspension in a liquid medium, so it will be cement, water, clay, etc., This is actually cement and water or clay etcetera can be used and it will be in a suspension, that means in water cement if you mix, cement water suspension or sometimes clay in water suspension can be made, that can be used as a grout, so that is what is a suspension grout.

Then emulsion, that is actually minute droplets of liquid in suspension. Some materials small droplets will form and that will be in suspension that is emulsion grout, and this is asphalt or bitumen with water, if you do that is actually emulsion grout.

And similarly, solutions, liquid homogeneous mixture of two or more materials, so this is solutions are generally chemical grout, there are number of chemical grouts available commercially in the market and they are actually homogeneous mixture of two or more materials. There are three different categories of grout materials available or we can

create actually suspension, we can create emulsion, we can create and solutions which is actually commercially available, it is a mixture of two or more materials.

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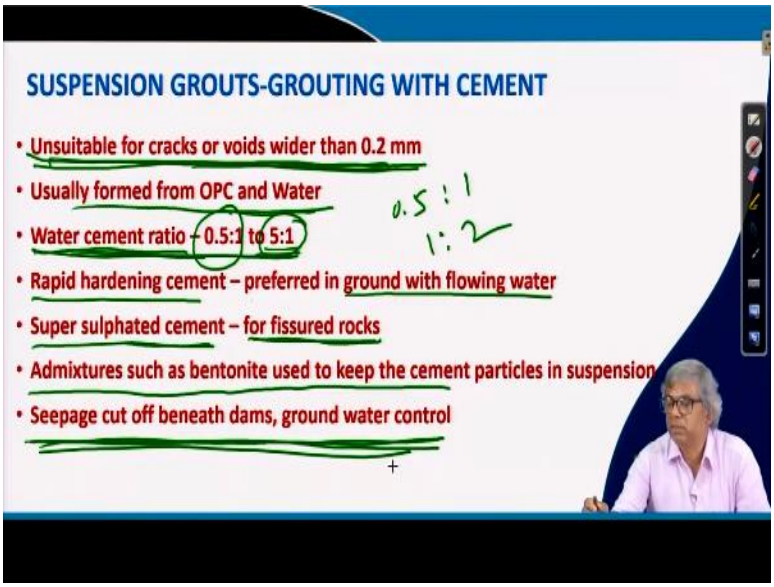

And let us further discuss about their characteristics and about suspension grouts. You can see suspension grouts and grouting with cement generally, suspension grout mostly with cement and sometime with clay also and if it is then it is where we can use or where we cannot use that some sort of discussion.

Suspension grout with cement if you have unsuitable for cracks or voids wider than 0.2 millimeter. If there are cracks if you want to like hydro fracturing or something you have mentioned, if there is a cracks or voids wider than 0.2 millimeter this type of suspension grout is not suitable.

Usually formed from OPC and water, the ordinary product is cement or water, by using these two-material suspension grout is generated and it is prepared with water cement ratio 0.5 is to 1 to 5 is to 1 water, cement, water is 0.5, cement is 1. This is and another is 5 is to 1, so depending upon your requirement that water is 5 and cement is 1, sometime water is 0.5 and cement is 1 or if you 1 is to 2 actually you can say.

This is actually the how the suspension grout, what is suspended, where actually if the cracks is wider than 0.2 millimeter is not suitable it is prepared from OPC cement and

water and generally water cement ratio in this 0.5:1 means 0.1 means it will be 1:2, 1:2 to 5:1.

Then the rapid hardening cement preferred in grout with flowing water, as I have already mentioned that setting time is important, rapid hardening cement will be used when actually ground with flowing water that area if you want to use grouting then rapid hardening to be used.

Super sulfate cement for fissured rocks, cement is to be used as a suspension but different areas you can use to choose different, super sulfated cement will be will used on fissured rocks. Admixtures such as bentonite used to keep the cement particles in suspension. bentonites are a particular material commercially available it is a montmorillonite clay it has a very typical characteristics and, in the construction, different ways actually to be used.

Here actually this bentonite is used to keep the cement particles in suspension that is. So actually, bentonites volume expanding volume and that helps cement particles because it takes lot of water and as a result it will helps to keep the cement in. And seepage cut up beneath dams, ground water control.

These are the application area typically this is the where we should not use and where typically used this type of grout is mentioned here, this is about suspension grout overall characteristics how we can prepare, where we use what and what is the application, what is the limitation about the suspension grout this is given here.

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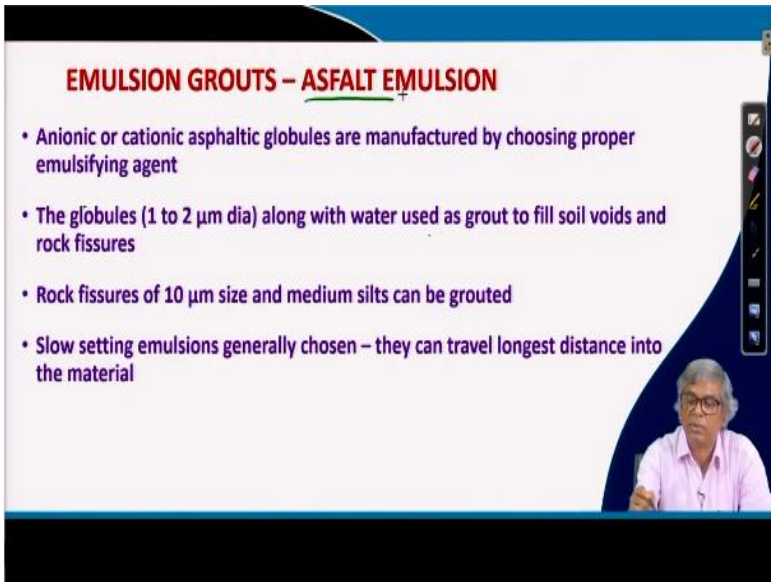

Then emulsion grout, anionic or cationic asphaltic globules are manufactured by choosing proper emulsifying agent. That is the manufacturing process, the globules 1 to 2 micrometer diameter, that is the size, along with water used as grout to fill soil voids and rock fissures. They are used actually to fill the soil voids and the rock fissures and size is 1 to 2 micrometer and they are droplets in the water. Rock fissures of 10 micrometer size and medium silts can be grouted also.

Slow setting emulsion generally chosen they can travel longest distance into the material. The characteristics of grouting is after injection they supposed to set or solidify, here likes when you cement rapid hardening, low hardening can be used here also, slow setting emulsion also has to be used and if you use that and your purpose is to fill the voids etcetera, then it can travel longer distance, that is the characteristics of emulsion grouting or emulsion grout. Asphalt here we are talking typically about particularly about asphalt emulsion.

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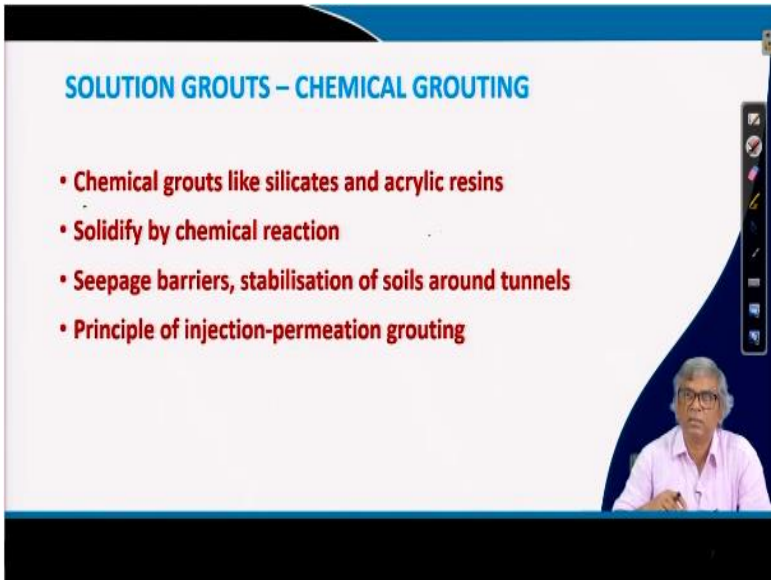

Then solution grouts, and here you can see solution grouts is a commercially available chemical grout, two or more materials are mixed, chemical grouts like silicates and acrylic resins. They are actually available, we will discuss later on also and it solidify by chemically reactions with soil sometime and they are used as seepage barriers, stabilization of soil around tunnels and most of the time these solution grouts out of there are several modes, generally permeation modes are used.

Principle of injection for solution grouts is generally permeation grouting, this is about the solution grouts characteristics and how and where you can use this one.

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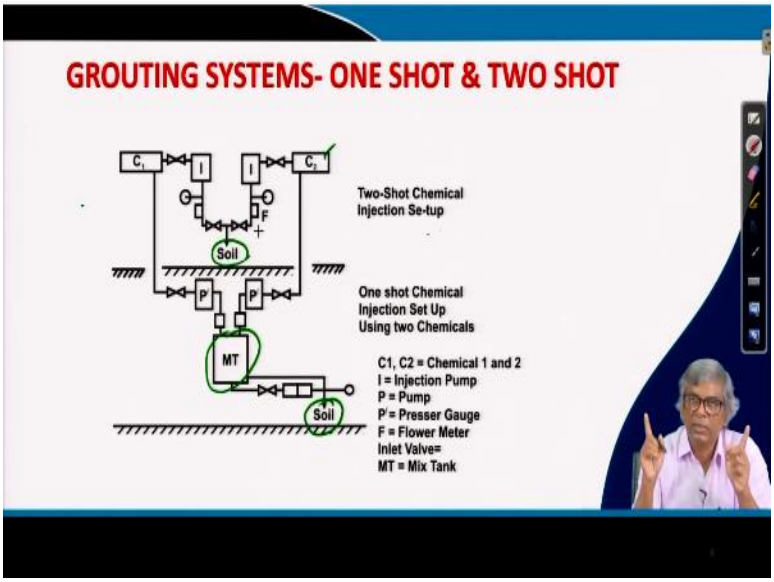

Now when you make the grout, there are two ways the grouting can be there, can be made. One is called one shot method and another is called two shot method. The primary difference between these two is, one shot means it will be mixed beforehand and injected to the soil together once, that is one shot and two shots means it will be injected once a, first one solution and after sometime again we inject the second one, that is two shots, twice we have to inject.

Schematically it is shown here in this diagram, in this you can see this is the one injection, C1 and C2, that means C1, C2 is a chemical one and chemical two, then injection then this is a pump, F is the flow meter and there is a pump also, it is injected here and injected from here and soil, twice we are injecting, this is two shot system and you can see that again suppose one shot method is a chemical one chemical two and two pressure grades, through that a particular quantity to be mixed here, this is a mixed tank or mixing chamber and from here we are directly injecting the soil.

That is the before injection we are mixing and that is single shot and before mixing or when we are mixing it after injection that we initially we make one chemical then inject second chemical and then after inject both together will inject then later on, they will have reaction or what are mixed together to form the solid or improving soil strength, so

this is the bylaws difference between the two-shot method and single shot method. So here actually in a two-shot method we are we have to inject twice, whereas single shot method you have to mix beforehand and inject together once that is the difference here.

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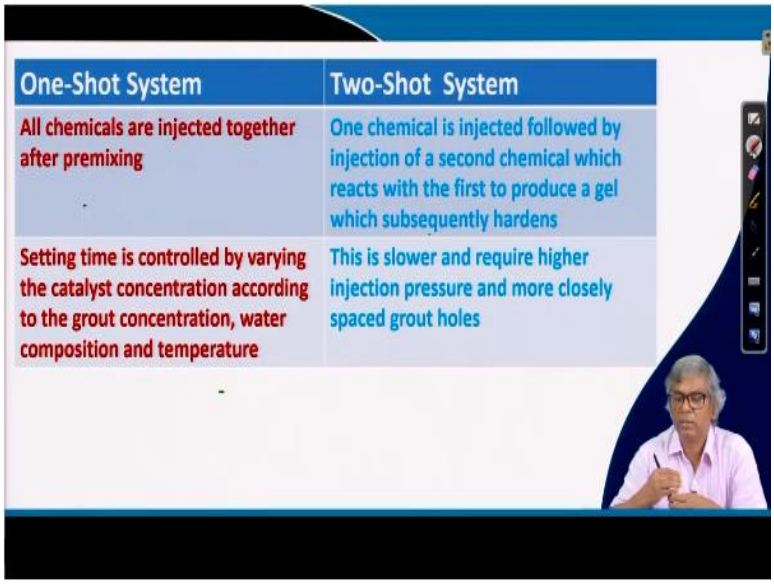

Once again whatever I have told is given in the table form, difference between these two. One shot system, all chemicals are injected together after pre mixing, which I have already mentioned, chemical one, chemical two coming in a mixer and then injected and setting time is controlled by varying the catalyst concentration according to the grout concentration, water composition and temperature, so this is again of course, it has to be designed and but by and large the difference is in the first one.

And two shot system is one chemical is injected followed by the injection of a second chemical which reacts with the first to produce the gel which subsequently hardens, that is the two-shot system and of course, this is slower and require higher injection pressure and more closely spaced grout holes are required, for this two-shot system. This is by and large the difference between these two.

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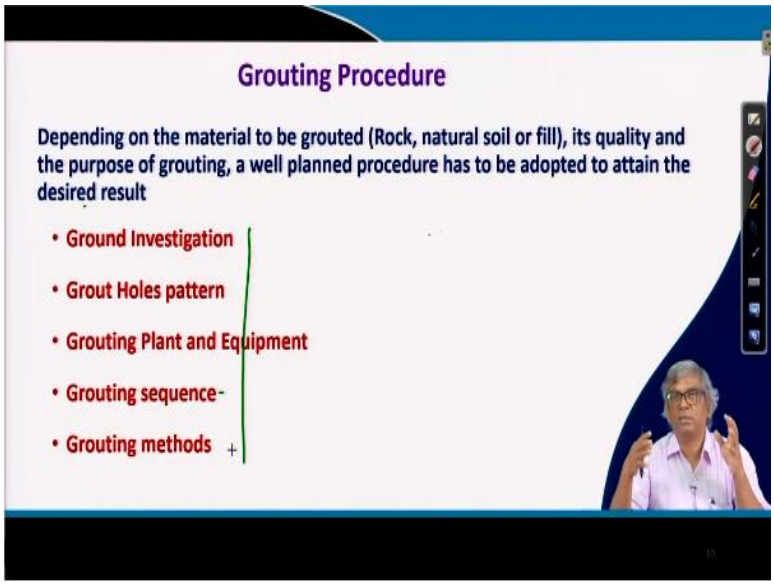

And grouting procedure. At a particular site suppose a grouting is chosen as a one of the ground improvement techniques, then how will you proceed, just will not go to the site and inject the chemical, it is not, you have to have certain procedure depending on the material to be grouted, whether it is rock, whether it is a natural soil or it is a fill its quality and the purpose of grouting a well-planned, procedure has to be adopted to attain the desired results.

This is the, that means it is not, it depends on what type of material we are going to use it and what purpose that to be seen but by and large before doing any grouting activity you need to plan this. First of all, you have to do the ground investigation, through the ground investigation what will be knowing, we will get the formation and that means the type of materials available, whether rock, soil or it is fill.

Groundwater location and many other things will be obtaining from the ground investigation and then you need to plan a grout hole patterns how will in a particular area to be grouted, then you have to particular pattern you have to plan, that and you have to see that entire area is covered and densified or improved.

Then you have to grouting plant and equipment that also hard type of whether ones or two shot and what type of mechanism to be used all those has to be a grouting plant and

equipment has to be decided. And grouting sequence and grouting methods, that means grouting methods means whether it is a compaction, permeation and similar like that, you have to decide.

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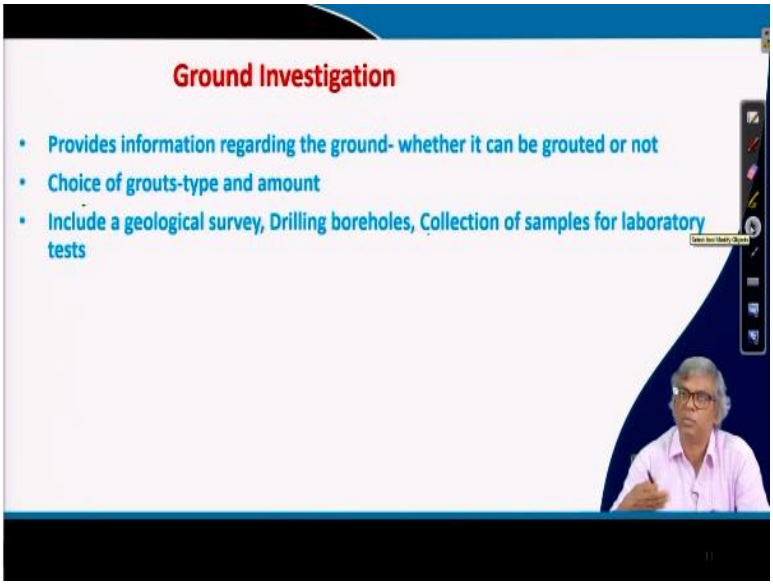

Next is ground investigation, under these so ground investigation, so here it provides information regarding the ground whether it can be grouted or not. That means first of all if the material is a typical one and where grouting is done, groutability that whatever we have mentioned that define all those calculations to be done after ground investigation.

Based on that we can find out whether grout able or not, that groutability ratio whatever I have mentioned and we will get a number and that number based on the number we can decide whether grout able or not grout able. Then choice of grout type and amount, based on soil type you can choose grout types and amount, how much is required and again include a geological survey.

Then drilling boreholes, collection of samples for laboratory test etcetera, that means geotechnical investigation means all those things in addition to whatever we are doing, existing survey, results, map and whatever is that that to be also referred and you need to do boreholes, need to do some sample collection and do laboratory investigation.

This is under any ground investigation it includes all those things which I have mentioned again and again similar here also to be done of course, when there is a strength is less or permeability high, compressibility then only we plan for grouting those things obviously will be coming later on, obviously will be included in this.

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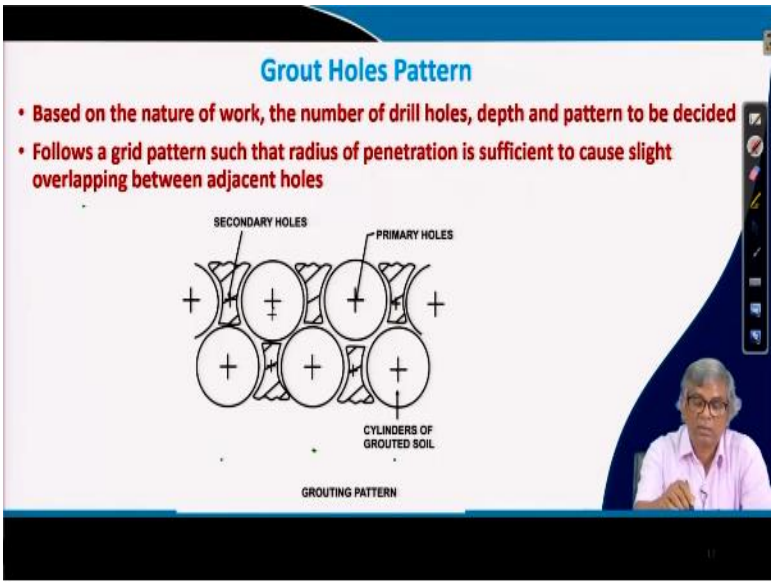

The grout holds pattern you can see here like in deep dynamic compaction or plate, repeated plate, impact load, then whatever other methods of grouting there actually we have shown that pattern and different, even preloading also if you make the different patterns, here also we can have similar different types of patterns.

Based on the nature of work the number of drill holes, depth and pattern to be decided, you can see follows a grid pattern such that radius of penetration is sufficient to cause slight overlapping between the adjacent holes. you can see here that a particular pattern is given and so if you have like, this and we can we can calculate based on some theory which I will discuss later on, that how much it can permeate, that means radius of permeation.

You have to plan the grout location in such a way that the one grout, if grout point how much it is covering and next one will be such that it will be little overlap, that entire area will be grouted. It is similar to that it will be there is a triangular pattern is shown here, it

can be done mostly it will be done like this. Cylinders of grout soil, this is actually if you do this then ultimately cylinder of grout soil will form like this and then this entire site will be stronger. This is a grouting pattern that means we can make a triangular pattern here which I have shown.

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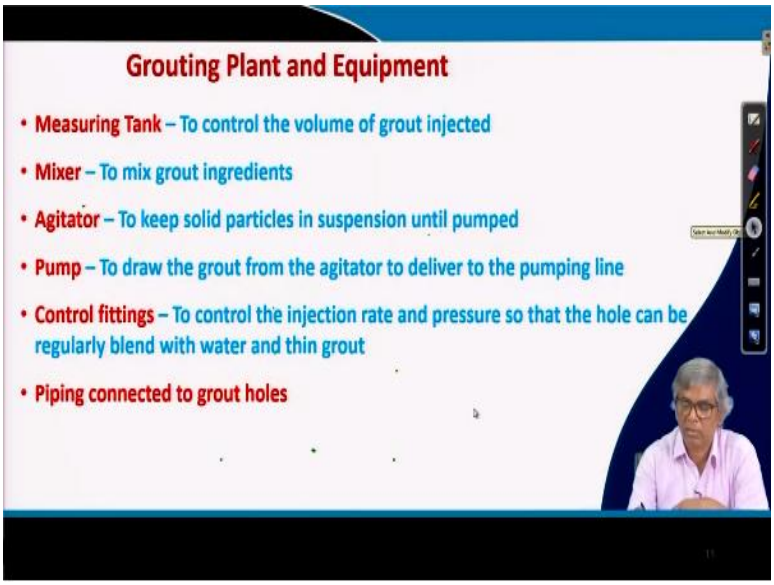

The grouting plant and equipment, so it will have a several components, the measuring tank to control the volume of grout need to be injected, so it has definite amount should be there. Mixer, to mix grout ingredients, then agitator, to keep solid particles in suspension until pump, you might have seen also ready-mix concrete when it is transported from the factory to the site there will be drum always will be rotated because to keep the agitating.

That is why agitator will be there, there will be pump to draw the grout from the agitator to deliver to the pumping line, then control fittings, there are number of fittings will be that to control the injection rate and pressure, that the hole can be regularly blend with water and thin grout and then piping connection to grout holes.

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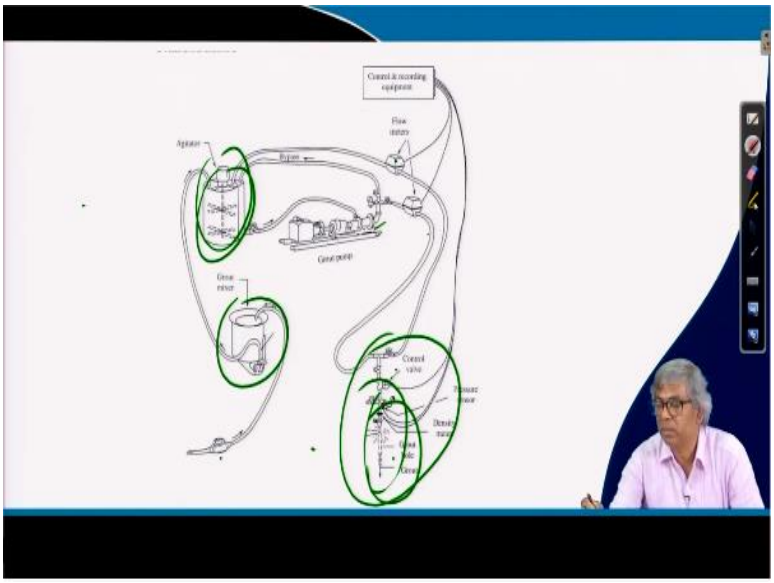

These are actually plant, there are various components and I will show the overall sketch of this plant, you can see here number of things will be there, this is the, you can see here finally grouting will be done here and it is grout mixer and you can see this is agitator, after mixing we can put it here and it will be if it is not pumped then it will be kept on agitating.

That will be in the suspension from, if it is in the steel condition then there is a chance of getting separated, and you can see here from here grout will be coming to here it will be pumped and through this it will be ultimately pumped to the, injected to the soil and there is a control valve and if there is excess it will can go back here and control and recording equipment.

There are number of equipments here, how much going, how much returning and etcetera there are something but main thing is this is a mixture, this is a agitator and whenever it will require it will be pumped from here and through this it will be injected here and some controls will be there and recording etcetera will be there and in between some of the quantity will be coming here.

Some of the common entity will going back here and some quantity after here also can go back in this also, so they have connections. This is by and large the grouting plant at the

site when you will go, we have to go with this and then the different materials to be mixed, it looks simpler maybe it will be much complicated and two materials or two more than materials, two materials to mixed and will be transferred to kept in this.

This is basically the waiting chamber where the material will be kept ready but it will be agitated so that will not be separated and whenever it is required it will pump through this and then it will be injected through this line here. This is by a large the plant and whatever component we have mentioned these are the different pipes and all it is here.

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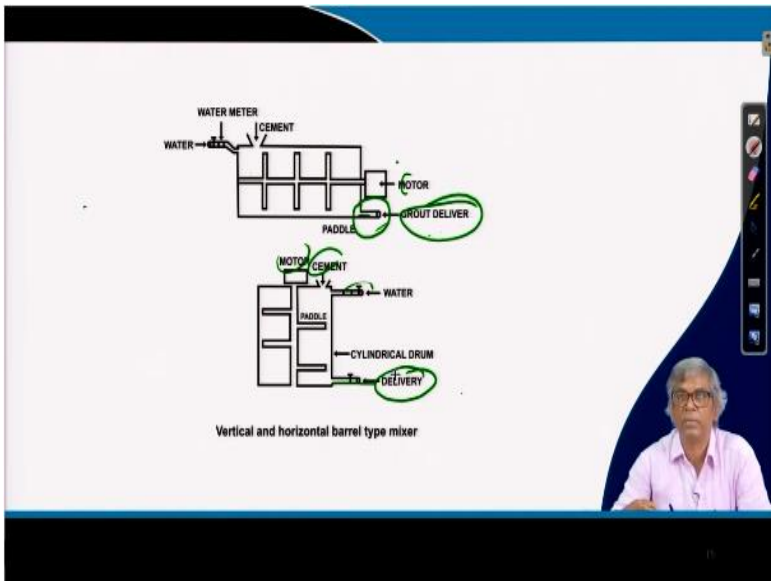

And these are some details about the mixture, so this mixture you can see, this is vertical mixer, you can see here water is coming from here and cement mix here and these are our paddles are kept here, it will be rotated then it will be mixed and when it will become from entering from here and all are rotating and will get mixed, when it will come here that the delivery point and this through this motor it will be rotated, so when it will come here it will be a proper suspension, mixer, mix it will be coming here.

Similarly, if it is a horizontal type will be there, it will be cement from here, water from here, motor here, the pedals are here, they will be again agitating and when entering from here and point will be because of this rotation and when will be coming to this delivery

point again it will be a proper suspension, from here actually it will be taken to the pumping pump and then it will be injected in the site.

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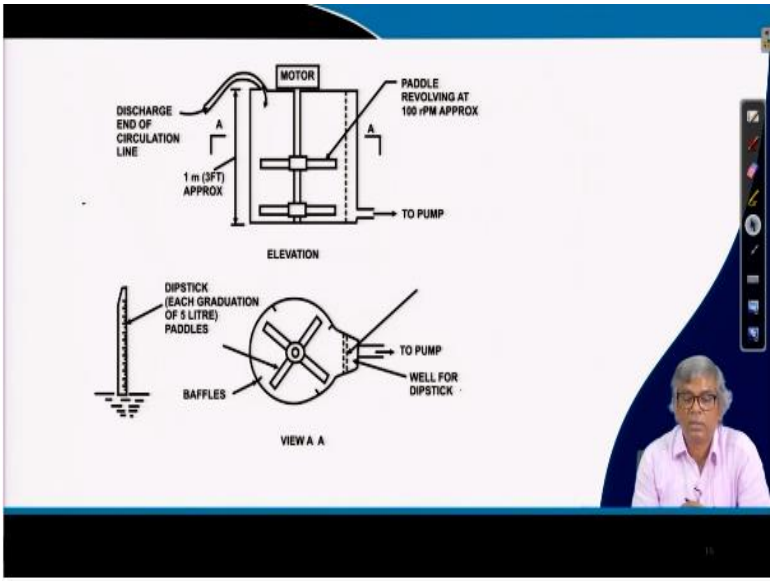

And this is again further details of those, maybe this is not so important, so I will skip here. There are certain things, with this today I will close and maybe as I have mentioned that the permeation grouting or compaction grouting up to what distance if I make a grout hole, up to what distance effect will be there so there should be some calculation.

We will try to do some analysis, that means some calculation regarding what should be the pressure and all related to that, how much what should be the diameter, injection point all those things, relating all those things some analysis will do related to grouting, maybe in the next few lectures will be there, try to do some more application-oriented discussion and some more analysis, that means grouting is a chemical and we are injecting.

There must be some calculation like how it will be the pressure, what should be the quantity, what should be the diameter, what should be the area of influence all those things, relating all those things will do some analysis maybe in the next one or two lecture, with this today I will close, thank you.