Ground Improvement
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Lecture 26
Drainage

Hi everyone, I welcome you again to this Ground Improvement class. I am going to start today a new module. So, far we have discussed Densification starting from shallow deep, different types of densifications and, and of course sort of deep replacement we have discussed. Now, in the, there is another problem happens in during construction that as we have mentioned in different time that the groundwater is sometimes is a problem of for construction and if the groundwater table is close to the ground surface some of the activity is difficult to do.

And we often I have mentioned before that under such condition dewatering may be done before doing the schedule activity and what is this dewatering actually that I will try to discuss through this model. And now, before going to do I will just give you introduction on drainage and then I will go to the dewatering.

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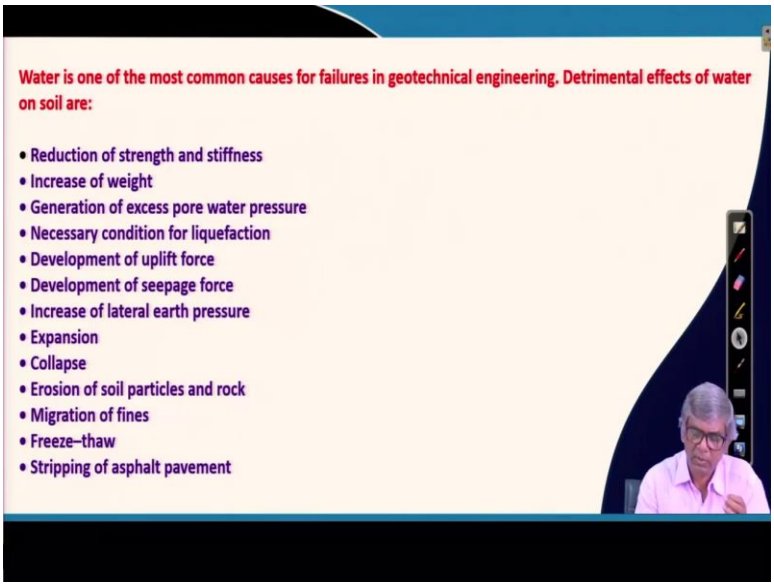

So, drainage we know that water, soil when it is dry, it behaves differently from that when it is wet. The wet soil and dry soil behaviour is totally different and that because of that, we have the seen also presence of water in the soil created many, many problems and that is why we have to

take a lot of care and if with care if you can manage it is good otherwise, sometimes we have to lower the water table. So, that is some time requirement.

The first thing objective is that if there is a building or structure or even anything, so we, the water source of water is the rain or sometime melting of snow like that. Different sources of water are there and that water when come to the surface and if you do not want them to infiltrate those area, then you have to provide proper surface drain and we are to provide some arrangement to discharge somewhere else, if I want to protect a particular site.

That is the requirement that means you have to proper surface drain and proper providing proper surface drain in some problem can be solved, but when after doing that also is not enough then we have to do some other mechanism like you have to make barrier that water should not go, so that you can make a barrier like that there are something we will discuss one by one and so water has a lot of problem and you can see water is one of the most common causes for failure of geotechnical engineering.

If there is a foundation failure is there, if there is retaining wall failure is there or if there is something else, anchor failure is there, some slope failure is there and if we investigate many times you will get the cause of this failure will be water and most of the time you will be hearing that that is a landslide during rainy season, why rainy season because water is a problem for soil and when water enters and so it becomes heavier and also sometimes shear strength also reduced all these together it trigger landslide and similar other similar type of phenomena.

So, that means this water is the most common cause of failure of many geotechnical engineering problems. And there are many detrimental effects actually; even failure may not be there but there maybe performance also become pore. There are a number of them. We have listed here you can see, reduction of strength and stiffness obviously, a strength seem how if there is a pore pressure develop, then obviously, effective stress is losing and effective stress is a function, strength is a function of effective stress.

That is why strength and stiffness both will be reduced. Increase of weight as I have told that landslide et cetera during the rainy season soil become heavier and that so you unit weight increase is a problem sometime. Generation of excess pore water pressure that is of course, the

cause of reduction of strength, the necessary condition for liquefaction, when it is saturated, even it is not saturated same soil may not liquefy, but if it is saturated it will be liquefy so that means necessary condition, it supply necessary condition for liquefaction to take place.

The development of uplift force, there is a dam suppose, and then water is there, this side is higher the side is lower and then we will tendency will be there to move one side to the other side and then there will uplift pressure. The development of seepage force, the increase of increase of lateral earth pressure then, because if there is a retaining wall and this side water is there, then obviously, it will increase dry soil and if it is a saturated soil is there obviously, your pressure will be increase.

Then expansion will be there, sometime collapse also, sometime also erosion also will be there sometime, migration of fines, if the water start flowing through or through channels then fines also will be traveling with water the fine particles and it will be migrate, the Freeze-thaw can happen if there is a water then sometimes will be freezing, sometimes it will be melting and that seasonal change or variation of this condition also cause a problem in the soil.

Then striping of asphalt pavement that is also another problem creates by water. There are a number of them what actually can cause a problem in geotechnical engineering water can create problem in geotechnical engineering.

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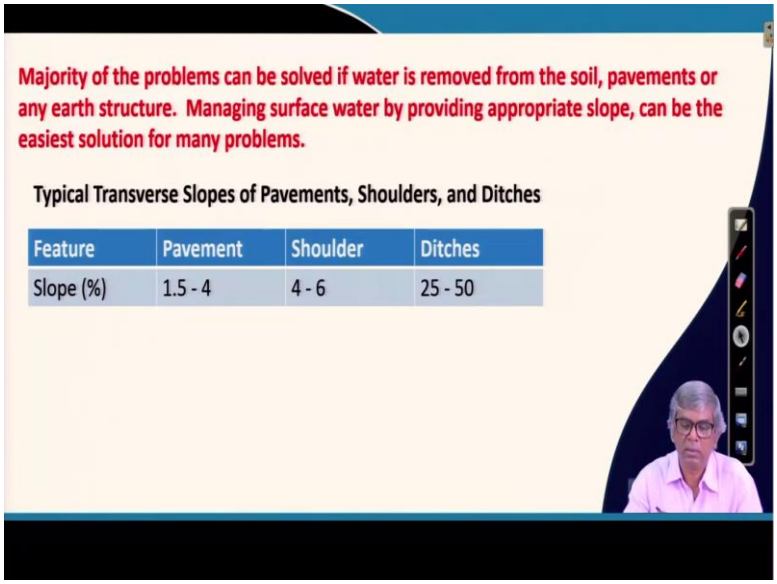

Here actually majority of the problem can be solved as you have mentioned before if water is removed from the soil and payments or any earth structure. Soil payment these are all structure that has to be protected, if you can remove the soil from that sometime problem can be solved and managing so, that means when surface water has to be managed. How to manage the surface water you can provide some sort of slope and by proper appropriate slope we can manage the surface water.

And if you can manage surface water many times the problem can be solved those typical slopes infer by which you can manage the surface water is actually different for different condition, you can see hundreds of pavements only the 1.5 to 4 percent slope is required whereas it is a shoulder the next to that, then there will 4 to 6 percent of slope is when it ditches then this 25 to 50 percent slope is required otherwise, there will be a problem.

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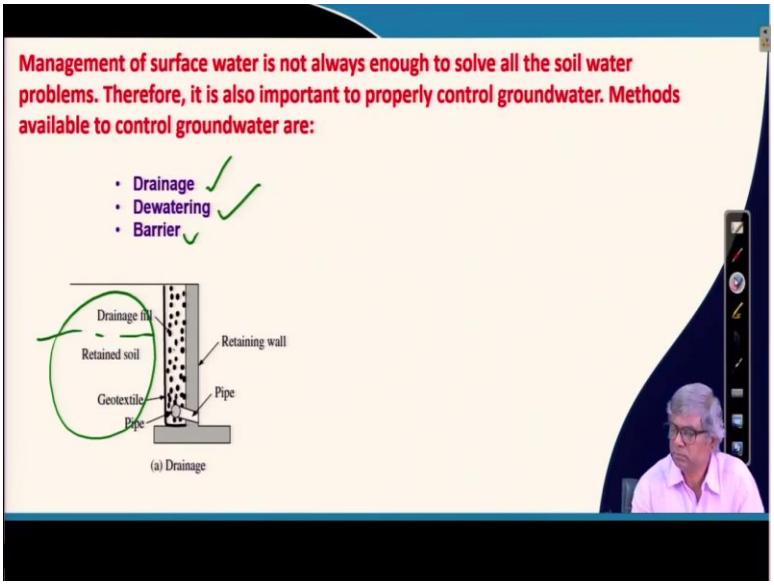

As you can see that as I mentioned majority of the problem can be solved by managing surface water but it is not always possible to completely eliminate the problem. Therefore, it is important to properly control groundwater and how to control there are different methods again, and methods are actually there is a one method which is a Drainage, there is a Dewatering as I mentioned, which will be discussed in length, dewatering and then Barrier.

Mostly dewatering I will go I will discuss in language before going to dewatering I will talk about I will give some more information, then only I will go with the next lecture dewatering. So that means the groundwater how to control groundwater? Suppose surface water is cannot be managed it is going to ground then even it is going to ground then how to manage the groundwater from the structure.

That is what it is a drainage can be provided or dewatering can be made and barrier can be provided. There are three different ways groundwater can be controlled and you can see here first one is shown this picture or photo figure is a drainage controlled you can see here that is this is the backfill of backfill of the retaining wall and we know that backfill is generally done cohesion soil and if it is free draining cohesion less soil.

And if it is and compared to that though if it is free draining still just behind the wall there can be additional proper draining material can be provided you can see here that drainage fill is close to the wall and there is a geotextile is provided here and this is a soil. And you can see there is a perpendicular to this there is a pipe maybe and that and that is also maybe perforated pipe and through this water will be entering to that.

Then that water can be again taken out from this pipe. So, then otherwise, if this prohibition is not created then because of this water here it will infiltrate this soil will become heavy and if there is a water table form here that also water because of this hydrostatic pressure also create on the wall and as a result we have to make very, very strong wall.

But if you provide proper drainage, you may not make such a strong load. For example, okay of course, I will not discuss that part here. This is actually the provision of drain by providing drain proper drain we can reduce the load on the on the retaining wall or you can say you can protect the wall from failure.

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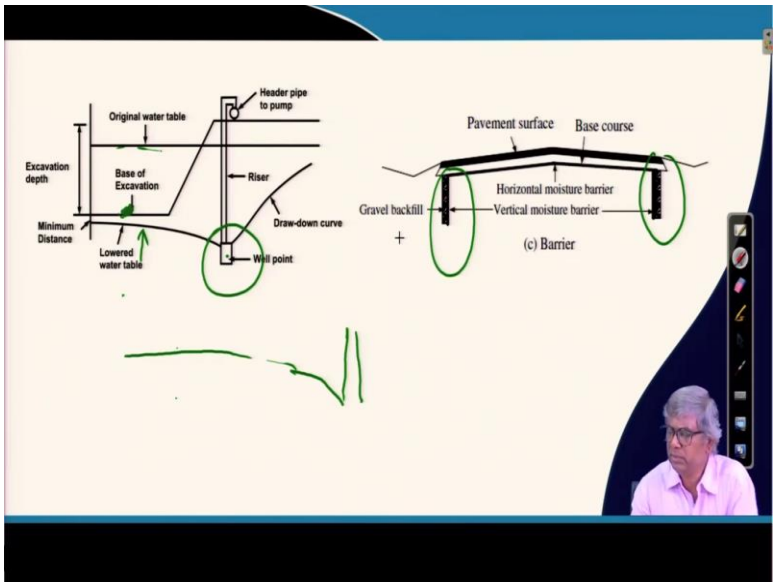

Let me take this is one actually you can see here dewatering as I mentioned, dewatering as I have mentioned already you can see here the original water table was here and your excavation level is this, your excavation level is here and if you want to excavate under this much water then this very difficult cost will be more and is managing water again and again here to maybe pump water to excavate all sorts of problems area will be muddy all sorts of problems will be there and because of that,

You have to make a basement here then what I can do I can make some dewatering program that dewatering is what actually you have to make there are a number of methods suppose this is a dual point method here it is shown there is a this is well is made and there is a pump will be there header pipe and pump here and see water from the surrounding soil will be entering here and it will be pumped out and continuously if it is now several hours or several days actually to pump out within a good number of wall point.

Then automatically slowly this water table will be coming down. Of course, water table will not be uniformly come down close to that suppose this is the wall point then water table it will be here at lowest but it will go as far away from the well it will be the drawdown or lowering will be reduced and at some distance there will no lowering of course, you have to do in such a way that that your project area groundwater will be lowered. So accordingly, you have to design.

Here actually you can see that your basement level is this. You have to lower the water table at least 3-4 meter from the basement level. So that is why by this arrangement, you can see water table lowered at this level. So, this is much below a little below then your basement level. This is actually is a dewatering technique by which entire water table can be lowered for the convenience of your work.

And this is actually you can see is the barriers you can see here drainage barrier. Gravel backfill will be there and these are the this is the pavement area and if the water enters here the soil will become soft and if the soils become soft, then it may have some adverse effect on these pavements. Because of that there will be gravel layer, while did here through which you can if there is water it can come through this. This is the way actually groundwater can be managed.

This is by a large three methods, we will not discuss in length all of them dewatering will be discussed in length because that is one of the typical ground improvement techniques is that is considered as one of the typical ground improvement technique.

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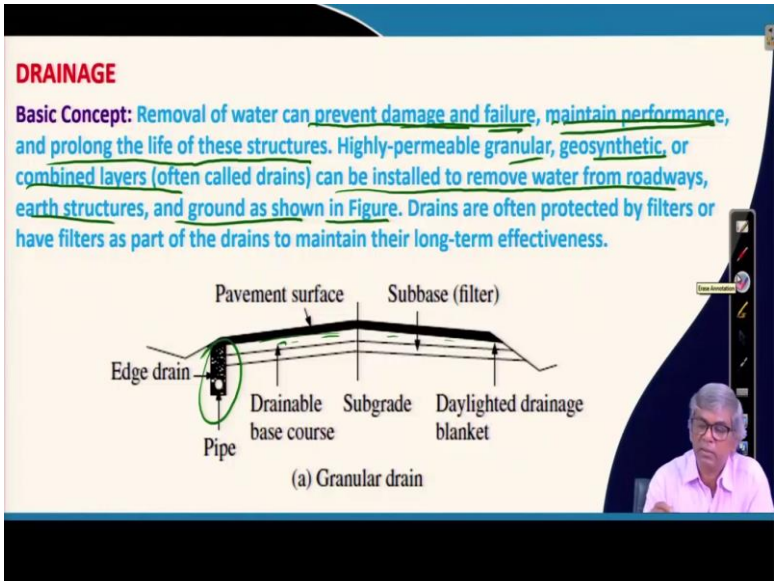

Here actually you can see drainage is what is the basic concept. You can see that removal of water can prevent damage and failure that already you have told in the beginning prevent damage and failure the maintain performance. Here actually, if I do not properly maintained drainage then because of the water this the surface condition may be there, cracks and all will

happen and that can so that meant that performance will be affected and, and prolong the life of the structure.

If you do not manage this groundwater properly and then it made damage frequently and you repair frequently that ultimately its life will be reduced. You have to if you can remove the water, then it can prevent damage and failure, maintain the performance and also it can increase the life of the structure. That is the thing is a drainage purpose. And highly permeable granular geosynthetic or combined layers can be installed to remove water from roadways, earth structure and ground as in figure.

This is the one you can see these are things are given here, pavement surface and drainable base course actually you can see here the drainable bass course is given here and these are all again edge drain, all water can be collected from here, that it will not enter to the main structure of the of the pavement. This is the basic concept.

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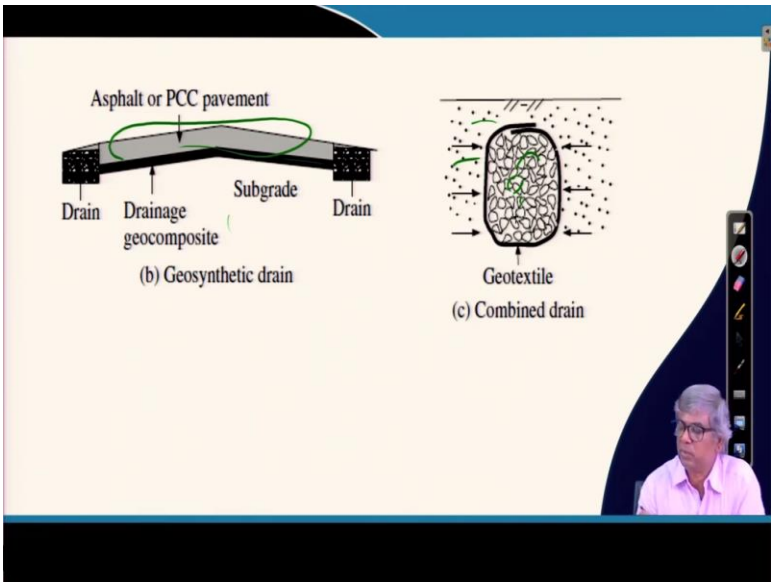

And you can see that another type of drain is here, this is another type of drain and this is also drain just below this pavement, this is drainage and is connected to this, entire area will be intact free from water and then there can be another drain can be like this, this is a geotextile wrapped and inside granular material and then since you the geotextile, the water can enter through easily

and then it can be transferred through somewhere in a perpendicular board and then that water can be collected. Then the different types of drain actually shown here.

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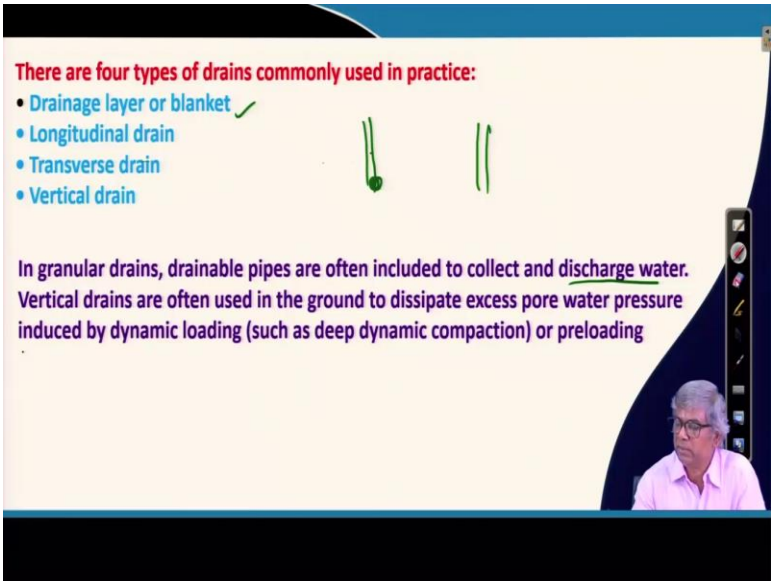

And next is, there are four types of drains commonly used in practice, one is drainage layer or blanket, which we have shown, there is a below the pavement, longitudinal drain, transverse drain and vertical drain. There are four different and in granular drains, drainable pipes are often included to collect and discharge water. Vertical drain. It is there and then somewhere actually there is a pipe and that pipe can be water can discharge or water collect and discharge water through this. This is vertical drain; whatever water is coming through this pipe again it is discharged. Vertical drains are often used in the ground to dissipate excess pore water pressure also. That already we have mentioned that if there is a saturated fine grain soil liquid during liquefaction it can have highly liquefaction potential. Because of that to minimize the liquefaction potential contraction and sand drain, sand drain is nothing but vertical drains. So, these are the bio lads wanted to mention here.

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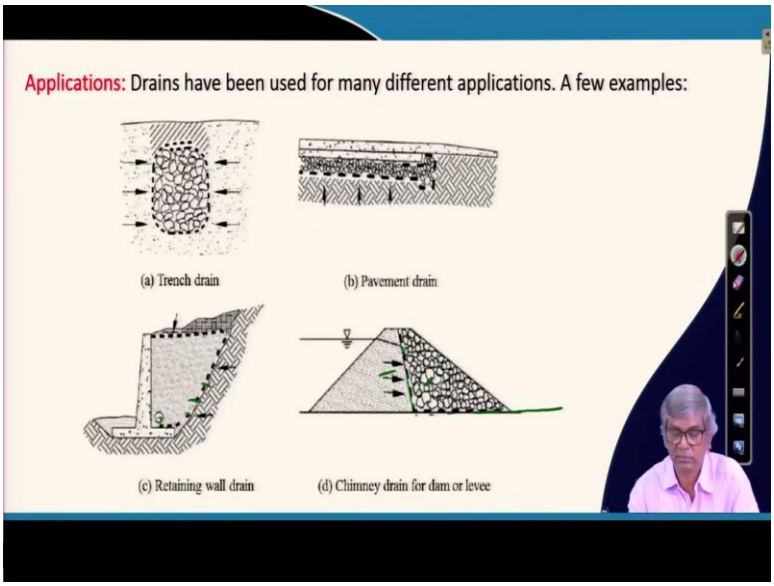

And you can see here drains have been used for many different applications. Few examples are here actually you can see this is Trench drain. This is called Trench drain. Water will be connected and then and this is actually Pavement drain below the pavement this can be the granular layer can be kept and there will be geosynthetics can be provided. That the mixing of this granular material with this will not happen and it so that it drains layer will be really will be there as a drain.

This is another drain and this is actually you can see the retaining wall already have shown that these are all actually proper granular material if you use at this side and this side there are different types of material is there. You can see that the water here is a pipe is kept here with the whatever water comes here that water can be collected on this pipe at discharge somewhere so, this is another retaining wall drain like this will be provided and this is actually chimney drain for dam or levee.

Here actually you can see this is a earth portion and this is a rock filled portion and here actually the water the through these actually if it there will be drain layer and that water can move along otherwise it will have tendency to move like this and then there will be through this body water when water will move and then there will be a problem actually, instead of water is allowed to flow along this along this.

You can see here so drainage layer is provided here, that water are comes here are immediately entered to this and since this is a it is a free draining. Entering here actually compared to before that, they are getting an easy path.

Because of that, they will follow like this and will be entering this way similarly, here also this even this, this layer, this soil, when water comes from different direction, these are all draining geotextile or similar material is there through this water only allowed to enter not soil and that water finally will be going to this and it will be discharge. These are all different types of drainage and two more types are there. Let me discuss

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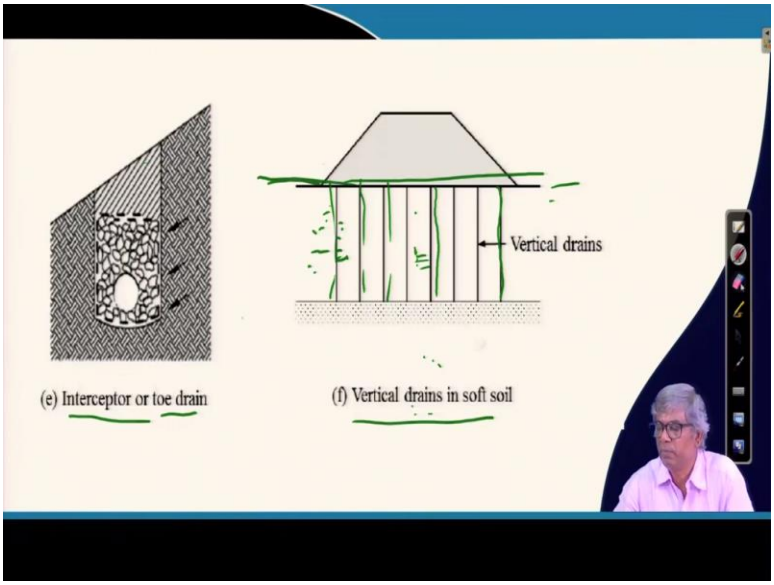

And you can see, this is another type of drilling is a interceptor or toe drain, you can see this is one another, this is a slow and when water moves like this, and then there is a tendency will be there slope failure, if you can have like this with a drain like this, then, there will be, water will be easily move through this instead of water traveling up to the toe then it will be stopped in between and water is carried somewhere else, then there will be pressured, this is called interceptor or toe drain.

And this is of course, very well known and this is a separate topic of course, we will discuss later on. This is a vertical drain and to this type of vertical drain is used to or one example, I have

mentioned that to mitigate liquefaction another is actually for fine grained soil lose saturated soil what sometimes it can provide drain can be provided to mitigate liquefaction.

Whereas, in soft saturated soil during liquefaction of course, not only liquefaction it can have increased the strength what you can do soft saturated soil it will have large amount of consolidation when you apply the load. Before applying load what we can do we can consolidate it, how to consolidate this one?

Then you can provide vertical drains and when you provide these vertical drains and you put surcharge are then the water from different zones actually entered to these drains enter to the drain and then it will be coming out vertically like this coming out vertically then this water can be taken out from here and here.

This is typical vertical drains in saturated fine consolidating accelerate consolidation in saturated fine grain soil. So, these vertical drains are you constructed by using sand column that is what another one we have discussed sand column also you have mentioned not only it takes load it also uses as a drain.

Here also same here the typically they make a borehole and then fill it with sand and then when you because of the surcharge load there will be pore pressure development in this because of that development of pore pressure water will have tendency to enter to the drain and once it is since it is a pre draining material, water when it will be entered to this when the excess water will be there through this it will come out and it can be taken out from here.

And other than sand drain nowadays there are some new types of drains are available at this manufacturing in the factory that is called pre fabricated vertical drain. There is strip like that can be pushed in sub making a borehole and fill it up with sand that strip can be driven inside the soil up to the desired depth and then surcharge can be applied and by that way through this drain vertical strip drain the water can come out and then it will discharge from here.

This is actually what he showed there are typically typical six different types of drain I have shown here there can be some more. Let me come to next slide.

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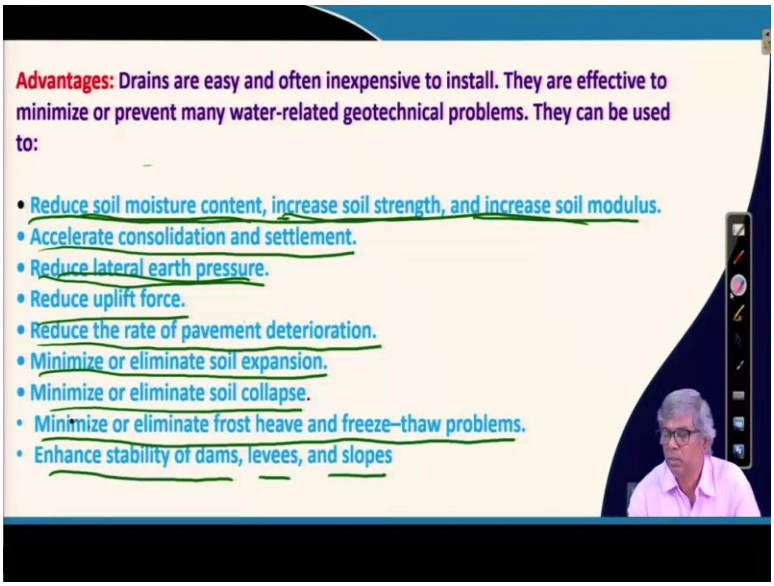

Advantage when you put drains are easy and often inexpensive to install and they are effective to minimize or prevent many water related geo technical problem so if you provide drain of course providing drain during construction there will be some technique will be required, but it is not so, difficult starting from the construction if you plan you can provide the drain without any difficulty some special material may be used and but if you do not provide it may cause the failure but if you provide it can help to prevent the or minimize the many geotechnical problems actually.

This can be used that drain can be used for different views actually. Reduce soil moisture, reduce soil moisture content. Foor moisture content so, if I have a drain, if I do not allow water to enter then automatically moisture will not be added. The reduced soil moisture content is one that increase soil strength, if there is a moisture the strength will be reduced and increase soil modulus.

If the with water against soil modulus also be reduced. Because of that there are first important function of using drain is that the soil can be made stronger okay reduction in moisture means it will be stronger then accelerate consolidation and settlement that whatever we have shown that when is a point when saturated soil then if I can provide this type of drain then we can accelerate the consolidation of course by surcharge itself we can do the consolidation but suppose your

project, project to be completed in three months, but by using surcharge, it may take several years for two years or three years. We will not be able to wait that much.

To accelerate that consolidation, you can use different kinds of drain. Then reduce lateral earth pressure if I produce if I use the drain as I have already have shown the entire water whatever coming during rain rainfall or all if it is stored behind the wall then the because of the saturation and water table formation the additional load will come to the water in the retaining wall. By providing rain you can reduce that the reduced uplift force if, if you do not allow water entered the base of the footing then obviously our foundation then obviously uplift will be reduced.

The reduced rate of pavement deterioration you know the one of the most important reasons for deterioration of pavement is the rain in the below the pavement if they went out, water entered then it softens and sometimes some soil is there because of the contact of water it fills sometimes it sinks that also creates the damage in the surface. That the reduce the rate of pavement deterioration this is another so if a proper draining etc, if you arrange and if your main body of the pavement, if you prevent from entering water, then it will be deterioration will be reduced.

Minimize or eliminate soil expansion. As I have told you though, sometimes some soil will have the tendency of expansion because of particular claim mineral presence. If we come in contact with water it swells. If I provide proper drainage and do not allow water that could be also minimize, minimize or eliminate soil collapse, minimize or eliminate frost heave freeze thaw problem but water is not there, there will be no problem.

Then enhance stability of dams, levees and slope. Already we have shown some photographs, figure there how it helps, already I have shown so this also the by providing drain we can do many advantageous work in the geotechnical problem or geotechnical activities.

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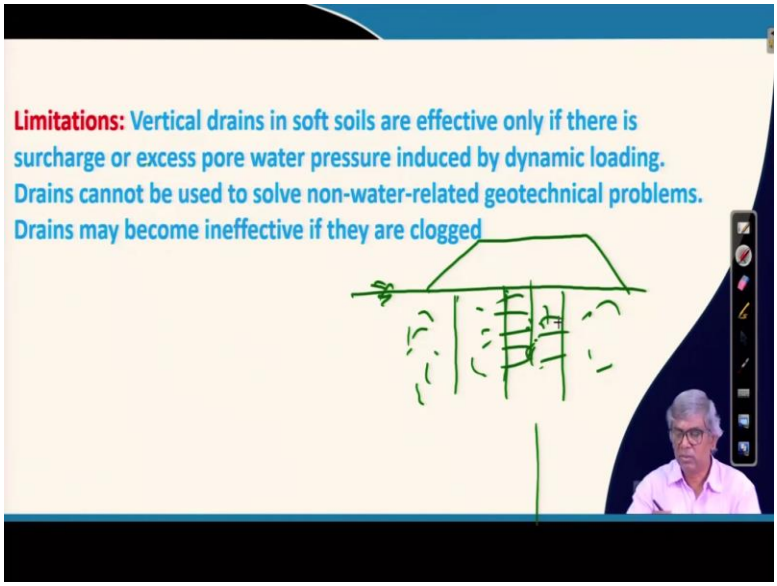

The limitations when there is a drainage when there is an advantage obviously, there will be some limitations. Vertical drains in soft soils are effective only if there is surcharge or excess pore water pressure induced by dynamic loading. As I have told that the vertical drain when you are doing this vertical drain and it just soil here, we have done vertical drain and then do not do anything there is no effect.

Only effect will be there well there was some surcharge because of the surcharge load and if this is saturated, then pore pressure will develop everywhere and because of this pore pressure development of pore pressure, this pore pressure development that p pore pressure will try to dissipate how to dissipate when water comes out then it will be pore pressure will be reduced. That coming out of water actually will how then will help the water from here actually instead of traveling here or their next general layer that will be difficult reach instead of that close to this drain, it will be entering and dissipate the pore water pressure.

That is also that is why the discernment in vertical drain soft soil effective only when there is a surcharge or there is a dynamic loading. For example, as we are told that saturated cohesive less, deep dynamic compaction or vibro compaction it helps because during that certain application of load, the soil liquefies and that helps actually to densify also finally. And drains cannot be used to solve non water related geotechnical problems.

Water related problem only it will help by providing a simply even there is a no water problem provided drain it will not give you any additional safety to the structure and of course, we you design the drain and install the drain in the different geo technical structure, but problem sometimes the drain has to be maintained because sometime the drain maybe may clog. Clog means sometimes continuous flow of water, then some fine particles in between can arrest and because of that efficiency of the drain may reduce.

Time to time this drain has to be maintained also otherwise, because of this clogging effect of the drain. Again, sometimes though drain is there, but still the because of ineffectiveness of the drain, the actual protection will not be there. That also sometimes is a disadvantage, we know that drain is there, but drain is not effective. That is the bio large of a few disadvantages of the drain. And with this today, of course, I will close here.

Next last, I will try to start with your dewatering activities, how to do there is a method different methods of dewatering calculation, what are different dewatering methods and they are design, calculation and then how to do proper procedure then what is the quality control all those things like previous chapters, whatever we have discussed similar way. I will spend some time next few classes that dewatering about dewatering. With this, I will close here. Thank you all. Thank you.