And if you are not able to predict the length requirement accurately, we can make some adjustments at this site but for the precast piles which are made in the factory. So, such kind of adjustments are not possible at the site, you can go for either cutting or splicing, and that is very difficult with the concrete piles. That is why when you go for precast piles, we have to accurately determine the length of the pile needed.

So, that is why we need to do a thorough prior investigation you have to carry out the pile testing program. So, you have to do some preliminary pile testing to know the exact length needed and also to assess the load bearing capacity of the pile. And also, you should know some geotechnical investigations to know the complete soil profile. So, you need to know the various end bearing strata and also you need to know carryout all the tests.

Say for example, you need to know the standard penetration test. All these tests will help you to know the soil behavior which will help you in the pile design. That is why prior pile testing is very much important before you do the actual piling operation in your project site. So, in addition to this, there is also other methods where, they use this bentonite slurry for the piling method, what they do is?

They use of bentonite slurry to act like a foam up to the soil. So, this will be more cost effective when compared to the steel formwork. So, soil has a pore bearing capacity, they use this bentonite slurry, so that it will help to stabilize your soil and prevent the collapse of the soil. The bentonite slurry also helps in flushing you the borehole. So, the thing is, you can have a thorough flushing of the borehole.

So, that there would not be any muck or the left-out material at the bottom end which may reduce the end bearing capacity of the pile, so that is advantage of going for bentonite slurry. So, this is also one of the commonly accepted methods for cast in situ concrete piles.

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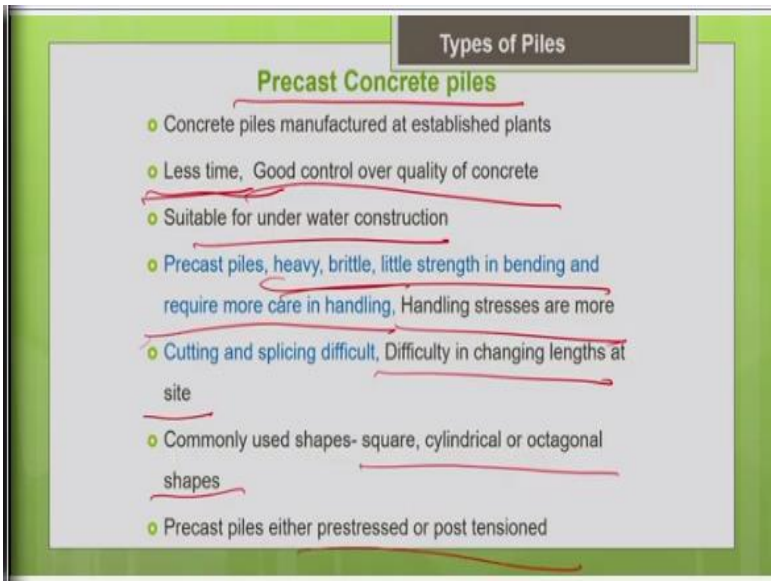

So, far we have discussed about the cast in situ concrete piles. So, there are two ways you can go for the displacement method there is the driving method or you can go for the non-displacement that is boring method, and we have discussed about the auger boring. So, now we are going to discuss about the precast concrete piles. So, they are going to be made in the factory in control condition.

Since it is made in the factory you will have a good quality control, you will have a good control over the quality of the concrete than at the construction project site and you will be requiring less time only productivity will be high in the factory. This is because you can even go for accelerated methods of curing, extreme curing to accelerate the strength gain process. So, you need less time when compared to the real cast in situ process.

And for complicated concreting procedures like underwater concreting it is preferable to go for precast concrete piles rather than cast in situ which is more complicated. But what will be their demerit? Demerit is these concrete piles are likely to be very huge, so it will be very heavy. Handling of the piles is very difficult, so particularly, when you handle the concrete piles, they are likely to be subjected to more amount of handling stresses and they are likely to be damaged.

So, that is why handling has to be done in a very careful manner. And you have to provide some additional reinforcement to take care of the handling stresses, that is very important. But for the

cast in situ pile, we do not need additional reinforcement for the handling stresses. But for the precast pile when you design it, we have to add some additional reinforcement for the handling stresses.

And we cannot go for a very lengthy pile, you know that concrete is weak in tension and it has a very poor bending strength. So, that is why there is a limitation on the length of the concrete pile also. So, that is what is given in the slide also, heavy, brittle, little strength in bending and require more care in handling, so handling stresses are more. And another important thing is, it is very difficult to do cutting and splicing with a concrete pile.

That is why we have to accurately predict the length needed. So, properly do the soil investigation to look at the end bearing strata and decide the length of the pile because there is difficulty in changing the lengths at the site. So, there are different shapes available square, cylindrical, octagonal, so different shapes of concrete piles are available. And another important thing to be noted is we can go for this pre-stressing method**.**

To improve it is load bearing capacity and to improve it is resistance to handling stresses, and it is improved implement in resistance to the deflection we can go for pre-stressing method pre-stressed the precast piles are very common.

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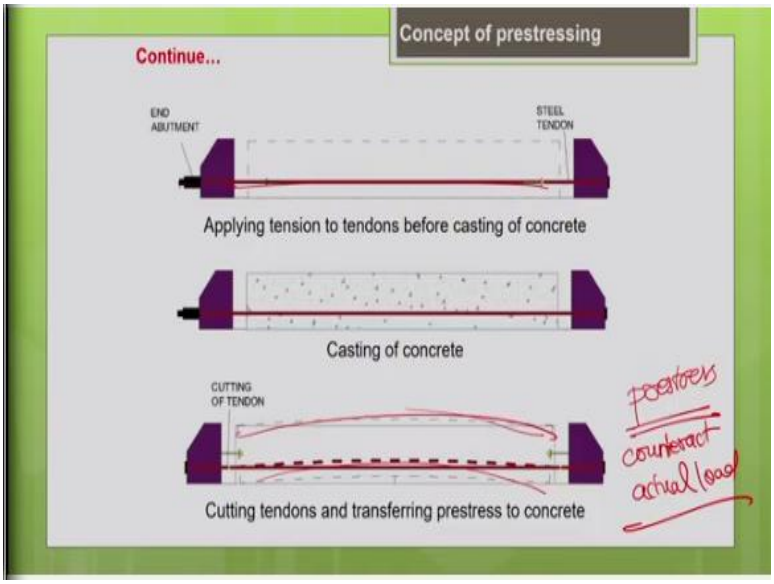

So, what is this basic concept of pre-stressing? I will just introduce to you what is the basic concept. Basically, what we are trying to do is we are deliberately introducing some internal stresses in the concrete. So, that before the external load application, we are introducing some internal stresses So, that later the structure can counteract the external loads when it is subjected to the load application.

So, these internal stresses will counteract the external load, that is what is a basic concept of the pre-stressing. So, what we are doing here is, we are applying tension to the tendons you can see you are applying tension to the tendons with the help of a stressing jack. So, now do the casting process, now the concreting is done. Till the concrete attains the minimum strength desired strength say 24 MPa, you are not supposed to release the stressing.

So, once the concrete attains it is minimum strength desire strength of say 24 MPa, you can cut the tendons and release the stress. So, once you release the stress what is happening? The tendons will try to come back to it is original length, but the concrete which is already hardened will prevent that. So, it will transfer some amount of stress into the concrete, that is called as pre-stress.

So, we are transferring stress into the concrete, even before the load application you can see how it is subjected to stressing. So, what happens is, when it is subjected to the actual load, so this pre-stress develop will counteract the actual load. So, that is why your load bearing capacity will increase as well as if these piles cannot undergo deflection easily and the handling will be easier. It is not easily subjected to handling stresses, it can easily take the handling stresses, it is not susceptible to damage during handling.

So, that is a main advantage of pre-stress concrete pile. So, if you are going to apply the tension before the casting is done, it is called as pre-tensioning. If you are going to apply the stress after the concrete casting is done, it is called as post tensioning. Both the ways you can improve the load bearing capacity of the piles. So, basically when you go for this pre-stressing method, you can increase the length of the pile.

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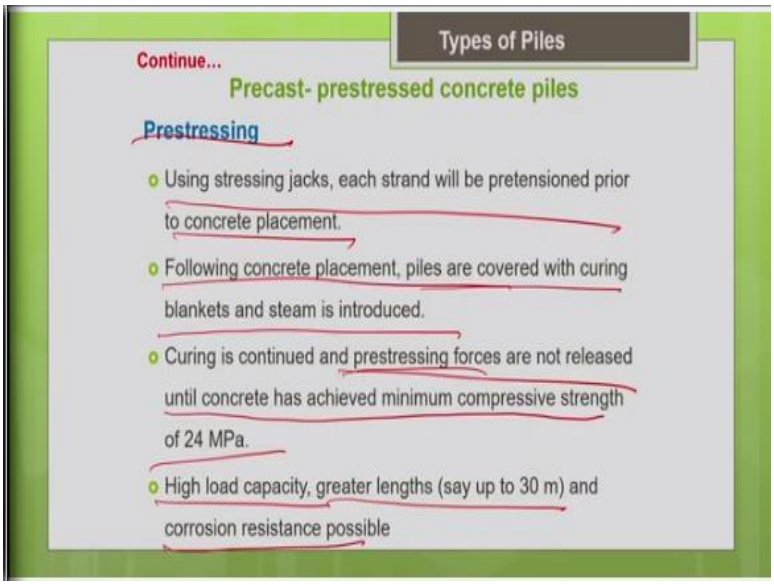

Because as I told you concrete piles, say for example, the precast concrete piles, it is a normal conventional reinforced concrete pile. If the length is say, now commonly we do not go beyond 15 meters. But if you go for pre-stressing method, we can even go up to 30 meters because you can easily resist the handling stresses, so that is one advantage of pre-stressing. So, let me summarize what we discussed earlier in the previous slide.

So, here what are we doing pre-stressing, using the stressing jacks, each strand will be pre-tensioned prior to the concrete placement, that is why it is called as pre-tensioning. So, following the concrete placement, the piles are covered with the curing blankets and steam is introduced they accelerate the curing process. You continue to curing and the pre-stressing forces are not released until the concrete has achieved minimum compressive strength of 24 MPa.

Till that time, you should not release the stresses it will be under the stressing jack only. After the concrete attains a minimum strength of 24 MPa, now you release the stresses. So, as I told you once the stresses are released the tendons will come back to try to come back to the original length which will be prevented by the hardened concrete. So, this will result in development of pre-stress in the concrete which is going to counteract the external load when the structure is subjected to external load application.

So, it results in high load bearing capacity and you can go for greater lengths say up to 30 meter and also it results a better corrosion resistance, when compared to conventional concrete piles.

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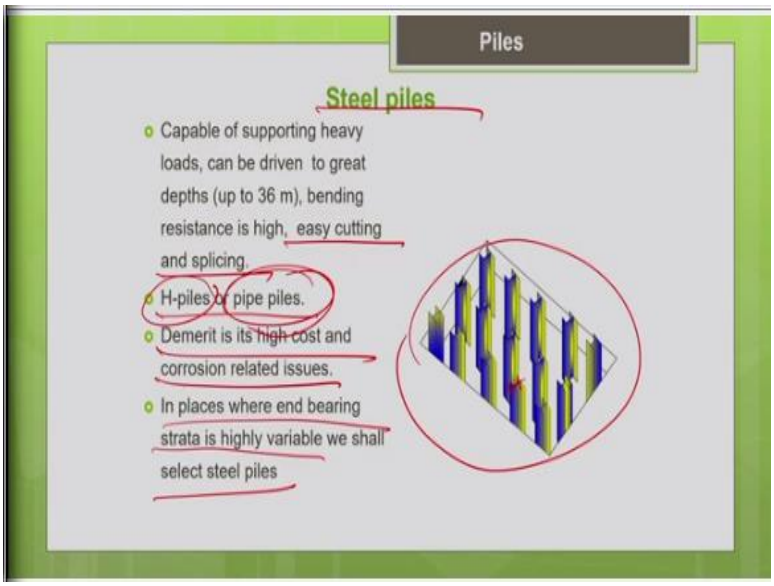

So, with this let us move on to the steel piles under the concrete piles we are discussed about cast in situ as well as precast concrete piles. So, now let us discuss about steel piles, the main advantage of steel piles is, it is load bearing capacity is significantly high when compared to concrete piles**.** Particularly it is a unit load bearing capacity, it is going to be very high.

And it has a very good bending resistance that is why you can go for a very greater depth even more than 30, 35 meters, I can go for steel piles. So, very commonly used in the say marine environment where you need greater depths. Another advantage is cutting and splicing is very easy with the steel piles, that is why if your end bearing strata is going to be highly variable, it is not easy to predict the length of the pile.

In that case, it is preferable to go for steel piles, because cutting and splicing is easy with the steel piles when compared to the concrete piles. So, the most commonly adopted forms or H-piles or the pipe piles, so very commonly, you can see the H-piles and the pipe piles usage. And one thing to be noted is the H-pile is very good in driving, even in hard soil conditions you can easily drive this H-pile into the hot soil.

So, in marine environment, we always prefer this steel H-pile at least the tip should be the steel H-pile because it is very much needed for hot driving. But the demerit is it is high cost and corrosion related issues you know that obviously for the steel pile. So, that is why commonly what they do is, they increase the cross section of the steel, so that it can take into account the corrosion related damage.

And also, we can go for other methods of corrosion protection measures like corrosion resistant coatings or cathodic protection, there are different measures, we can also go for it. As I told you already in places where the end bearing strata is highly variable, you cannot predict the length of the pile needed correctly, then go for the steel piles because it is easy to cut it and splice it. Another important thing you should know that with this H-pile, when you drive the H-pile, the amount of displacement to the surrounding soil will also be less when compared to the pipe piles.

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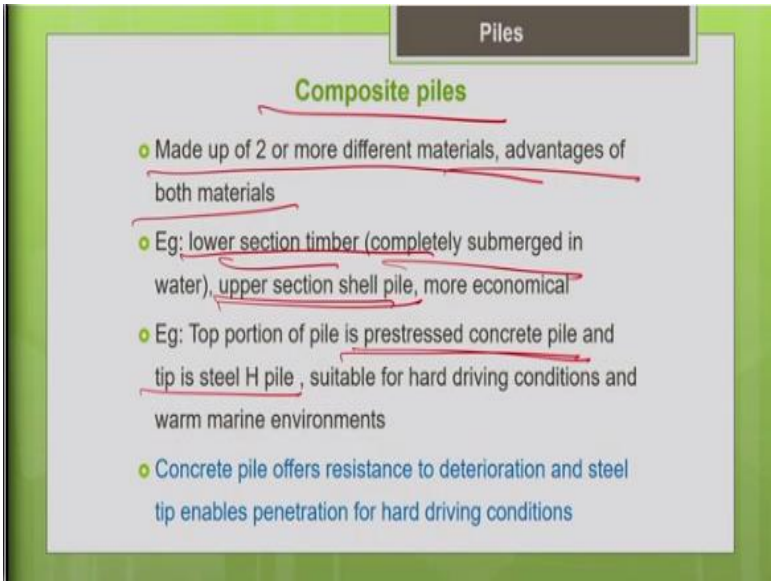

Next is about the composite piles. So, nowadays people are very much interested to go for composite materials, so that we can take the benefits of both the materials in the same pile. So, it is made up of two or more different materials, we are able to enjoy the benefits or advantages of both the materials in the same pile. So, the commonly used composite piles I can give you some example.

Say timber and steel combination is also used, say the lower section, I can go for timber. Because as you know that, say for example you are going to select the pile which is going to be submerged in water, the portion which is going to be submerged in water you can go for timber pile. Because when it is completely submerged in water, timber is not susceptible to rotting or in a decay.

That is why for completely submerged portion I can go for timber which is more economical, but for the top portion you can go for the shell pile or the steel pile, so this way you can economizing the cost. Another example I can say which is more commonly use is pre-stressed concrete pile with a steel H-pile or the tip at the bottom, why do we go for this steel H-pile as a tip?

Because it is very good for hard driving conditions, as I told you for sea for marine conditions when you need hard driving go for a steel H-pile tip, it will be easy to drive. So, on the top you can have the say pre-stressed concrete pile which is more economical as well as it is load bearing capacity and the corrosion resistance is high. So, these are the common combinations, there are many other combinations also of composite piles.

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Now let us see what is the basic selection criteria for the pile, how will you select a pile? Obviously, it depends upon the type of soil, so that is why you need to do the proper geotechnical investigations to know the soil profile. So, whether it is going to be clayey terrain or it is going to

be a sandy or silty or rocky or it has and what is the complete profile you need to know it, so before you select a pile.

So, the pile type depends upon the soil type and also the availability of material. So, whether the material which are going to use for making the pile is available in that locality that is also important. It is always preferable to use the material which is available in the local place, so that you can do the cost optimization. Length of the pile needed, that is very important, as I told you, there is a limitation in the timber pile length.

There is a limitation with respect to the precast pile, pre-stressed precast piles and steel piles, everything has it is own range of length possible. So, depending upon your length needed and you have to go for the pile type selection. Construction schedule, your productivity, sometimes we do not have much time to make cast in situ concrete pile. If you want to speed up your project, in that case you have to go for precast piles.

And what type of structure it is to be supported by the pile, so how much design load it has to take? So, what should be the load bearing capacity because obviously the first for a steel pile, pre-stressed concrete pile and timber pile. So, according to that we have to base upon the design load expected you have to make the selection. So, obviously we have discussed all the merits and demerits, you have to look into that and make the selection. Finally, everything is going to be govern by the cost. So, that also has to be taken into account when you make the selection.

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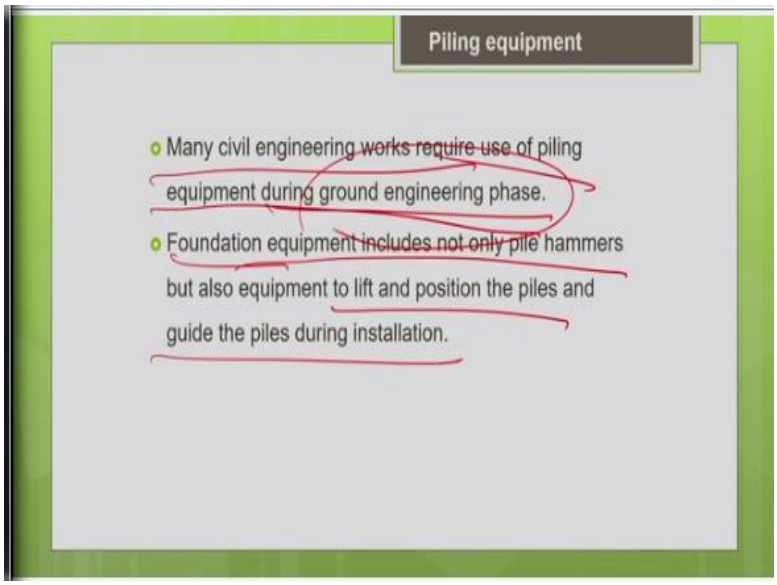

So, I have just given you a brief overview about the pile types, because we are going to spend more time to learn about the pile driving equipment in this particular course, that is why I have limited the time spent for the types of piles. So, let us now see what are the piling equipment needed. So, the pile hammers are the piling equipment, so they are pile hammers are not only the piling equipment, we need a lot of supporting equipment for the pile driving operation.

So, like you need the cranes to hold the pile and the pile hammer and also to hold the lead, everything in the right position for holding it and lifting it we need lots of supporting equipments. Everyone knows we use a pilling equipment particularly during the construction of the foundation or the basement, that is during the ground engineering phase.

So, you can say this usage of pile driving equipment in many civil engineering works, particularly during the ground engineering phase. And this foundation equipment includes not only the pile hammer, but also it includes the equipment to lift and position the piles and guide the piles during the installation. So, a lot of equipments are involved, we will be discussing that in the next lecture in detail.

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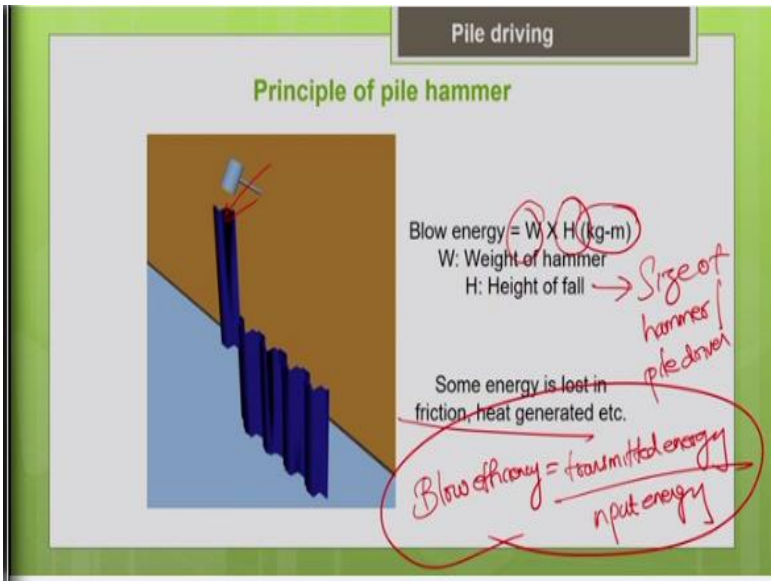

First let me introduce to you what is the basic principle of pile driving. So, it is just like how you drive a nail into a wall with a hammer, the same way you are going to drive a pile into the ground with a hammer**.** So, you are going to blow the hammer on the top of the pile, so what is the blow energy? So, it is going to depend upon your weight of the hammer and the height of the fall of the hammer, so that is what is going to give you a blow energy in Kg meter.

So, this is how the size of the hammer or the pile driver is commonly pile driver or pile hammer it is commonly expressed in terms of blow energy it can deliver. Obviously, it depends upon your weight of the hammer and it depends upon the height of the fall. So, one thing we know it already is the entire energy what you deliver it is not going to be transmitted for the driving operation.

Because some will be lost in friction, some will be lost in the heat generated and some will be lost in the rebound of the hammer. So, only some portion of the energy maybe transmitted, so that is what is called as blow efficiency. Blow efficiency is nothing but it is a ratio of transmitted energy to the input energy. So, we always prefer to maximize this blow efficiency, so that will help you to maximize your productivity.

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