Foundation Engineering
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Module - 02
Lecture - 19
Well Foundations - 3

Hello viewers, in the last class about this topic well foundation we discussed, various forces which act on Well Foundations and then we discussed that what are the various combination of these forces to be considered, while doing the stability analysis of well foundation. Then we saw, that the lateral stability of well foundation is an important factor, as far as the stability of these type of foundations are concerned.

And in that one, we studied in detail, the method which has been given by Terzaghi and we took up an example also and then we started, with the method which is which uses elastic theory, which has been recommended by IRC. So, now in that one, I am going to proceed in continuation of that, in the last class I have already discussed what are the two steps to be followed, in the elastic theory method by IRC. Now, let us start with the next steps of the analysis.

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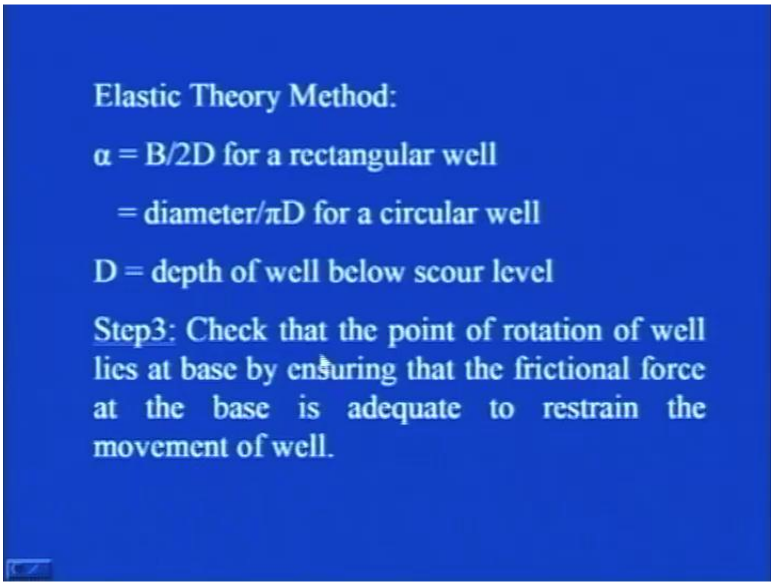

So, the step three is that you have to check that the point of rotation of well lies at base by ensuring that the frictional force at the base is adequate to restrain the movement of well.

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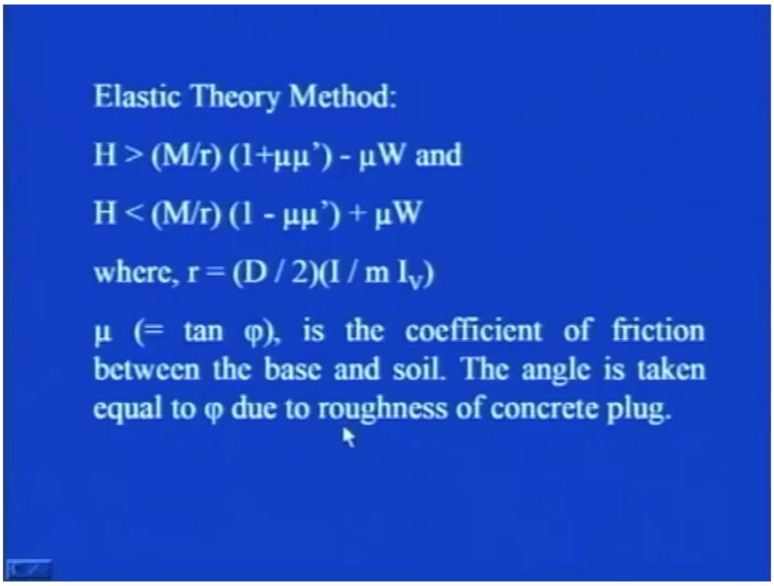

And, how it can be done, is that you have to see to it that the horizontal force H should be greater than M by r into 1 plus mu, mu prime minus mu times W and at the same time H should be less than M by r 1 minus mu, mu prime plus mu W, where this r is equal to D by 2 I by m I v and mu is equal to tan phi is the coefficient of friction between the base of well and the soil..

The angle is taken to be equal to phi due to roughness of concrete plug, when Ii was discussing about the components of well foundation we saw that there were two plugs one was top plug another was bottom plug and where the concreting was done. So, here because the bottom plug is made up of concrete, so the angle has been taken to be equal to phi, because are to take in to account the roughness of that bottom concrete plug. So, these two conditions together have to be satisfied.

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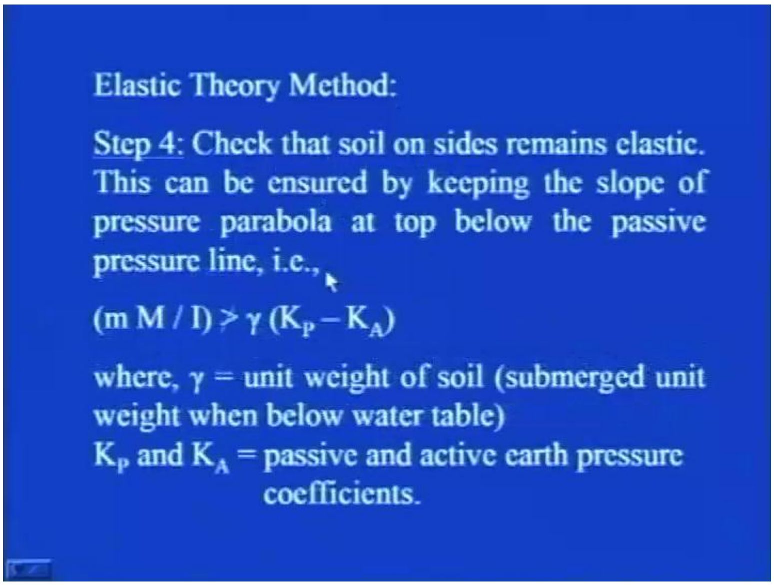

Now, step 4 is that, you have to check that the soil on sides remain elastic, this can be ensured by keeping the slope of pressure parabola at top below the passive pressure line, that is m M by I should not be more than gamma Kp minus Ka, where gamma is your unit weight of soil that is submerged unit weight, when it is below water table, then Kp and Ka they are passive and active earth pressure coefficients respectively.

So, in a step 3 you have to satisfy, those two conditions and in step 4 you have to check that this particular condition is satisfied

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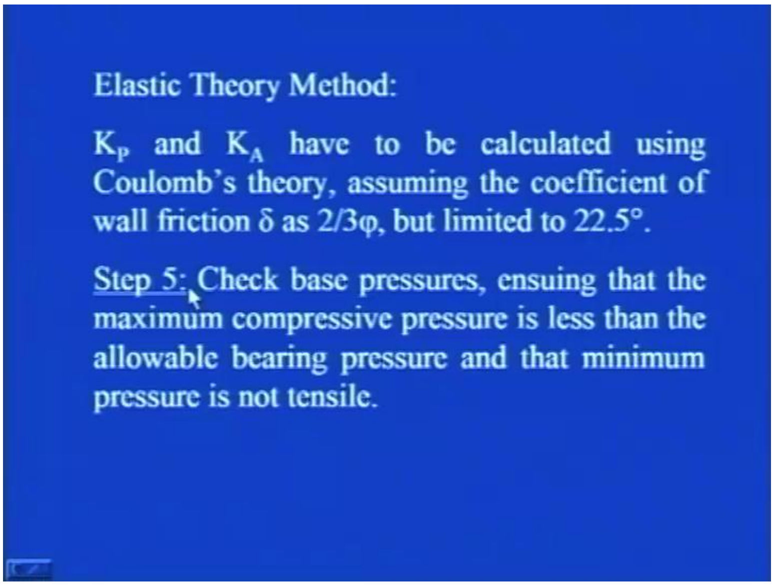

Then, as you saw that in Terzaghi's analysis this Kp and Ka, they were evaluated using Rankings theory, however, in this case this Kp and Ka have to be calculated using Coulomb's earth pressure theory and which it you have to assume in this, because when you use that Coulombs earth pressure theory, you required wall friction etc also. So, here in this case, you have to assume that the coefficient of wall friction delta as 2 by 3 of phi, but limited to 22.5 degrees.

So, in case this 2 by 3 of phi is more than this 22.5, so you have to take this delta to be equal to 22.5 degree, now step 5 is that you have to check base pressures ensuring that the maximum compressive pressure is less than the allowable bearing pressure and the minimum pressure is not tensile. You have seen, that in case of Terzaghi's analysis also we found out the base pressures in which one was maximum and one was minimum that is F maximum and F minimum.

So, likewise here also you have to do that and the maximum one should be less than allowable bearing pressure and the minimum one it should not be tensile; that means, how do we check, whether it is tensile or not in soil mechanics, we take or we take this tensile stress to be negative. So, in case if the minimum stress value is coming out to be negative; that means, that it is tensile, so, the minimum pressure should be greater than 0, this will imply that particular pressure is not tensile.

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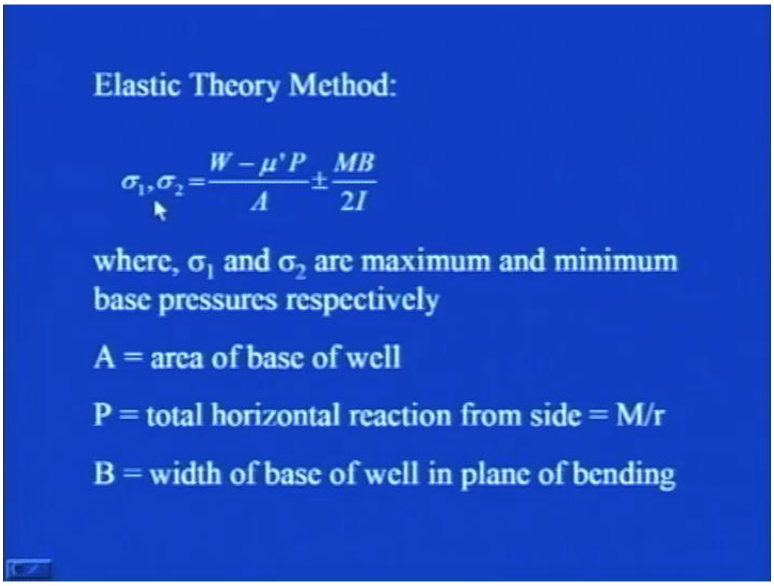

So, here sigma 1 and sigma 2, one is maximum and another one is minimum, it can be obtained as W minus mu prime P over A plus minus MB upon 2 I, where sigma 1 and sigma 2 are maximum and minimum base pressures respectively, A is area of base of well, P is total horizontal reaction from side which can be calculated as capital M up on r, B is width of base of well in the plane of bending.

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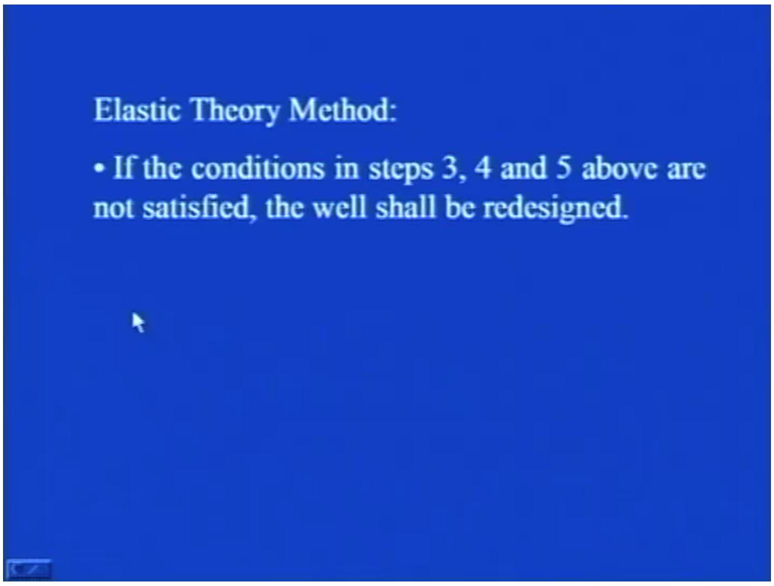

So, if the conditions in step 3, 4 and 5 they are not satisfied, then well shall be redesigned; that means, that you have to take the dimension of well foundation again and provide the checks, which have been given in these steps 3, 4 and 5 again. So, the well has to be redesign, so for a proper design of the well foundation all the things or all the condition in all these steps has to be satisfied. Now, we will take an example and let us try to get a feel, that how we can deal with the stability analysis as for as a practical problem is concerned.

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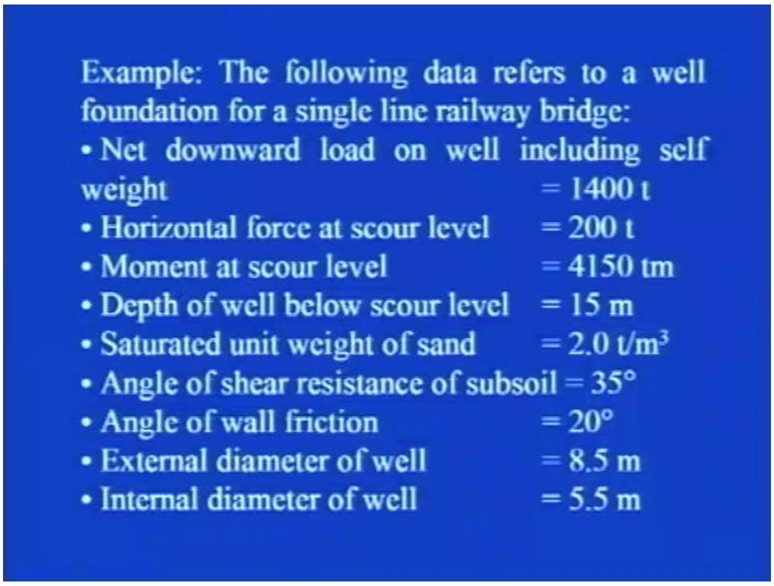

So, in this example some of the data has been given, let us try to see that what are these data and how these can be used in the lateral stability analysis of well foundation using IRC method and in into that we had two methods. So, here we will be employing elastic theory method. The following data refers to a well foundation for a single line railway bridge, First thing is given as net downward load on well including self weight is 1400 tonnes, then horizontal force at scour level has been given to be 200 tonnes.

Moment at scour level is 4150 ton meter, depth of well below scour level is 15 meter, then saturated unit weight of sand is 2.0 ton per meter cube, angle of shear resistance of subsoil is 35 degree, then angle of wall friction is given to be 20 degree, the external and internal diameter of the well has been given to be 8.5 and 5.5 meter respectively.

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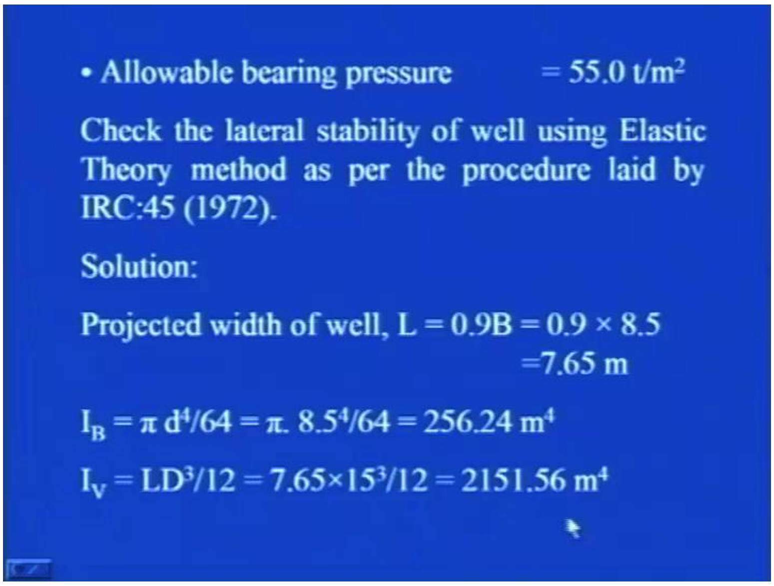

And allowable bearing pressure is equal to 55 ton per meter square, what it says is that you have to check the lateral stability of well using elastic theory method as per the procedure laid by IRC:45 (1972), so let us try to see that how you can proceed as for as the solution of this problem is concerned. So, first we will find out as I told you that projected width of well is equal to some shape factor multiplied by the dimension of the well

So, in case of the circular well that shape factor was recommended as 0.9, so in this case this projected width of well will be equal to 0.9 times B, where B is given to be you can see here it is the external diameter of the well which is 8.5. So, this L that is which is projected length of width of well will be equal to 0.9 times 8.5 and that is equal to 7.65 meter, then these geometrical properties we need to find out as I discussed with you in the last class, in the step two of this IRC method, that is elastic theory method.

So, IB is pi d to the power 4,64 and this will become pi 8.5 to the power 4 divided by 64 and this will result as 256.24 meter to the power 4, then another geometrical property which is IV is LD cube up on 12 it is equal to D is your depth of embedment, which is given to be 15 meter. So, it will be 7.65 L you have already obtained here, so this is 7.65 into 15 cube by 12 and this will be 2151.56 meter to the power 4. Then using these two geometrical properties IB and IV, we can find using this particular expression.

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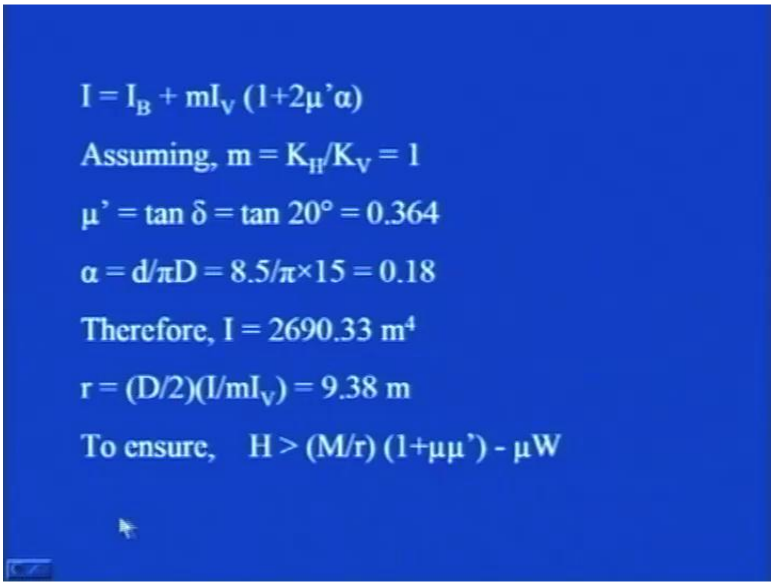

I is equal to IB plus mIv into 1 plus 2 mu prime into alpha, then assuming this m to be equal to m, which is defined as KH upon KV as we have already discussed in the step two, let us assume a value of unity to this particular parameter one, then mu prime is defined as tan delta, delta is given in this problem as 20 degree. So, tan 20 degree will become equal to 0.364, then alpha is defined as d up on pi D, which is equal to 8.5 up on pi into 15 and this will result into a value of 0.18.

Therefore, if you substitute all these values here in this particular expression, you will get I to be equal to 2690.33 meter to the power 4, now once this I is known to you, to ensure those conditions on H which we have already discussed in step 3, we need to find out this parameter r, which is defend as D by 2 into I by m I v. We know the value of D, we have found out the value of I, we have assume the value of m and we have found out the value of Iv

So, you if you substitute these appropriate values in this particular expression, you will be getting a numerical value of r as 9.38 metre. Now, as I told you in the step 3, you have to ensure this condition that is H has to be greater than M by r 1 plus mu mu prime by mu minus mu W.

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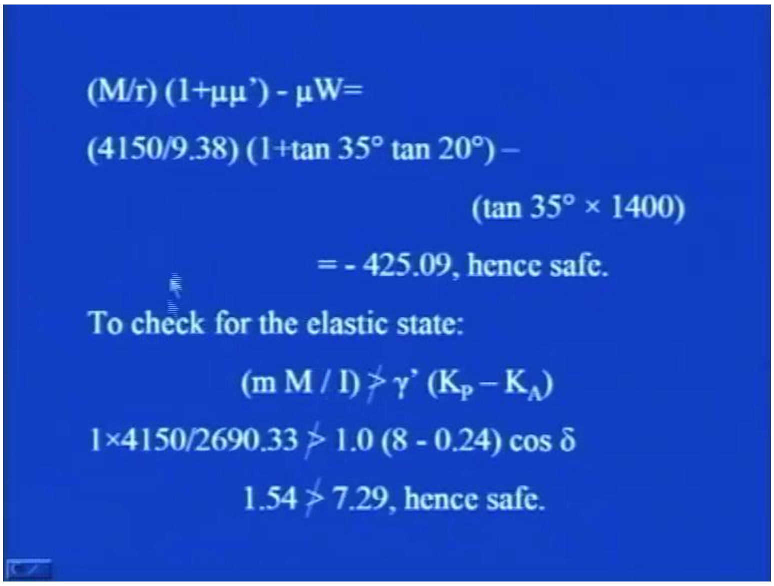

So, for this I am going to first tell you, that how you have calculated this value and then the value of H has already been given to you, so then you can provide a check, so first I take M by r 1 plus mu mu prime minus mu W and this value is equal to M value is given to you as 4150 and then r you have just now calculated as 9.38, then 1 plus mu is tan of phi which is equal to 35 degree, then mu prime is tan of delta which is tan of 20 degree minus this mu tan 35 into W, which given to be 1400 and this works out to be minus 425.09.

So, you see this condition, that this particular quantity has to be greater than H, so since it is coming out to be negative; obviously, it is more than that H value, so therefore this condition in step 3 has been satisfy, so therefore, we write as, hence it is safe. Now, we in the step 4 I told you, that you need to check that the soil is in elastic state and what is the expression for that is m into capital M by I should not be more than gamma prime KP minus KA.

Now, if I substitute the numerical value on both side of this particular expression, what I will get as m is we have assumed to be 1, then capital M is given to be 4150 divided by this I we have calculated at 2690.33 meter to the power 4 and this particular value should not be greater than this gamma prime, gamma prime is submerged unit weight. So, saturated unit weight of the sand is given to be 2 and if you considered the unit weight of water to be 1 ton per meter cube.

So, submerged unit weight gamma prime will become equal to 2 minus 1 which is 1 ton per meter cube, so that is what here we have taken, then corresponding to this phi to be equal to 35 degree using Coulomb's theory, this the value of KP and KA can be obtained, which have been written like this here. So, this value worked out to be 1.54 and this value worked out be 7.29, so we can see, that the numerical values in this particular problem they are satisfying this particular condition, that is 1.54 is not more than 7.29 and therefore, you can say that this condition is also satisfied, so it is safe.

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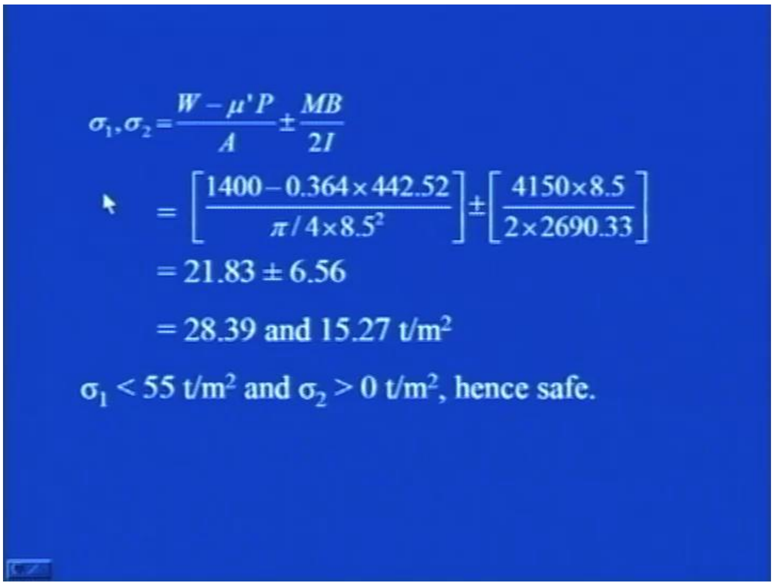

Then, when the conditions are satisfied, then we have to see to it the maximum and minimum base pressure, as I told you that the maximum base pressure should be less than allowable bearing pressure and the minimum one should not be tensile, so here I use this particular expression to find out the maximum and minimum base pressures, which is maximum one is sigma 1 minimum is sigma 2.

So, in this expression if I substitute appropriate values like W is equal to 1400 minus mu prime we have found out tan delta, that is 0.364 into P is 442.52 divided by area of base of the well, which is pi by 4 into 8.5 square plus minus 4150 into 8.5 divided by 2 into 2690.33, which we have calculated as the value of I, so we get two values one is 28.39 ton per square and another 15.27 ton per metre square. So, this allowable bearing pressure has been given to you in this problem has 55 ton per meter square.

So, the maximum pressure is less than allowable bearing pressure and the minimum one is greater than 0; that means, it is not tensile, so this particular problem whatever is the well foundation, things that you have taken that is whatever is the diameter and force and moment, whatever they are coming on the well foundation, the foundation is safe for those particular values. So, this how for a particular well foundation or any practical problem you can carry out the stability of well foundation.

Now, we will be starting with the new topic related to this well foundation very important topic as for as the construction of well foundation is concerned, that is the construction and sinking of a well foundation, various aspects are related to this. So, we will be seeing some of the salient features as for as construction and sinking of a well foundation is concerned.

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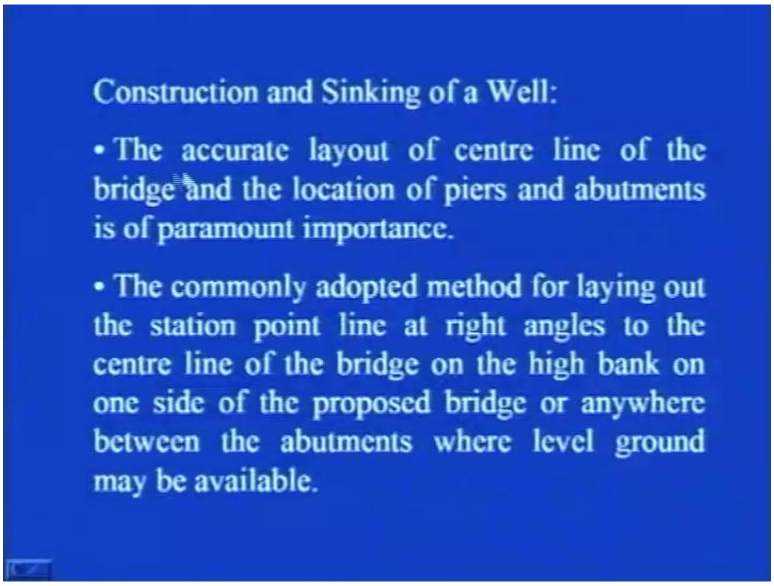

So, the first one is that the accurate layout of centre line of the bridge and the location of piers and abutments is of paramount importance, because till you have the accurate layout of the bridge as well as various piers and abutments location along that, it will not be possible for you to install or go for construction of a well foundation, so it is very important factor.

Now, the commonly adopted method for laying out the station point line at right angles to the centre line of the bridge on the high bank on one side of the proposed bridge or anywhere between the abutments where level ground may be available.

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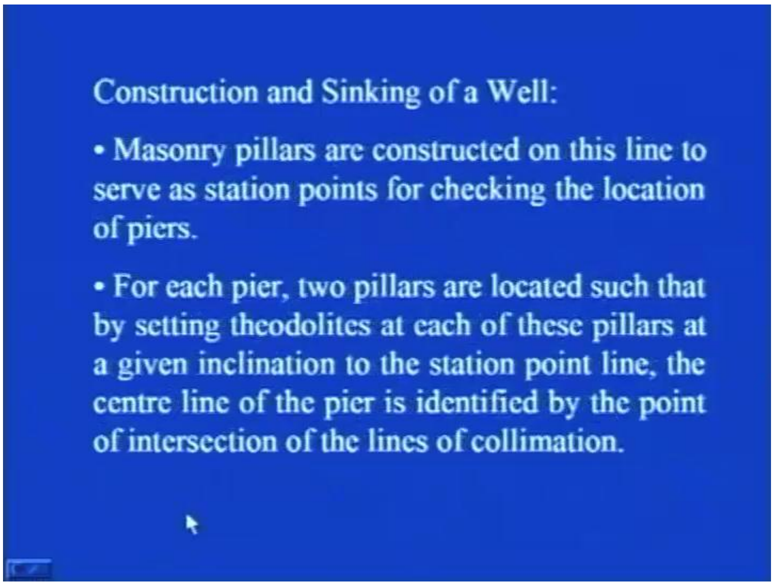

Which and this particular method is that masonry pillars are constructed on this line to serve as station points for checking the location of piers.

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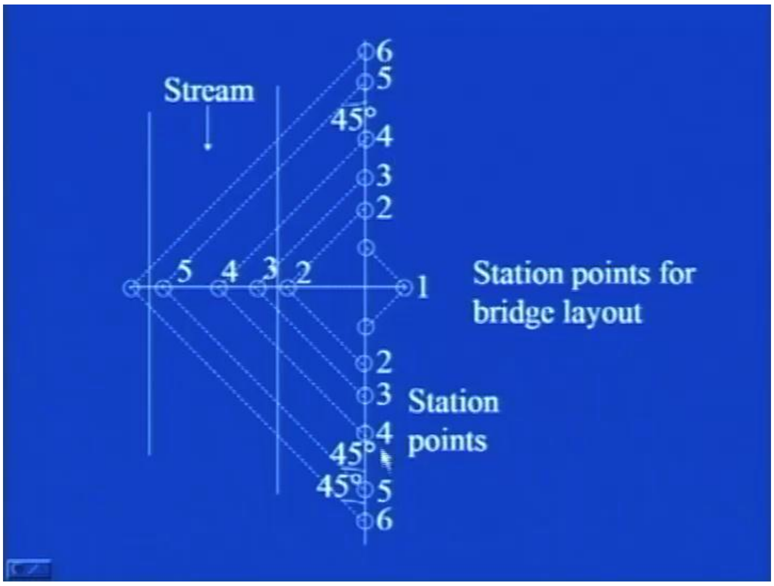

You, can see here in this particular figure that, these are the station points that is 1 2 3 4 5 and then, these are the various station points for bridge layout, so for each bridge pier two pillars are located such that by setting theodolites at each of these pillars at a given inclination to the station point line, the centre line of the pier is identified by the point of intersection of the lines of collimation. This statement will be more clear, if you look at this particular figure.

Now, let us say that, this line of collimation is making an angle of 45 with this line which is joining the station point, then I know this station point and this station point, they have they are already being located. So, you can use a theodolite and make an angle which is predefined, let us say here in this case as it is showing in this figure is 45, so you can have a line of collimation at 45 degree from this station point as well as from this station point.

So, wherever they will intersect, this will give you one point for laying out the bridge centre line, likewise you can get various points on this particular line.

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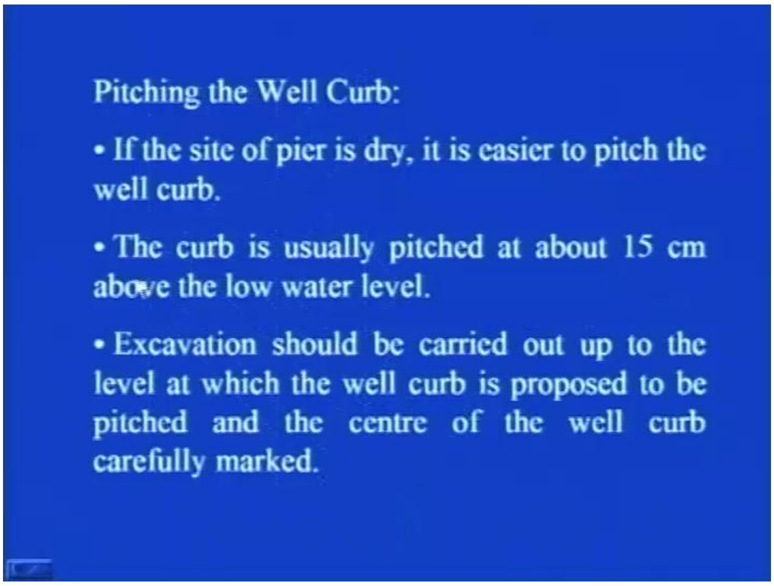

Now, the second thing is that, how you can pitch the well curb, well curb is the lower most part of the well foundation, so it has to be constructed first, so that thing is pitching the well curb. In this one there are few salient points, which you need to keep in mind is that, if the site of pier is dry, it is easier to pitch the well curb. In case if it is dry then it becomes easy; however, if the site of the pier is not dry that is under wet condition then it becomes little difficult to pitch the well curb.

So, the well curb is usually pitched at about 15 centimetre above the low water level, then excavation should be carried out up to the level at which the well curb is proposed to be pitched and the centre of the well curb should be carefully marked. So, all these points when you go for the construction and sinking of the well, this is the first thing that you need to do that is pitching of the well curb and all these points you need to keep in mind.

Then, the well curb should then be assemble on wooden blocks or sand bags placed at suitable intervals.

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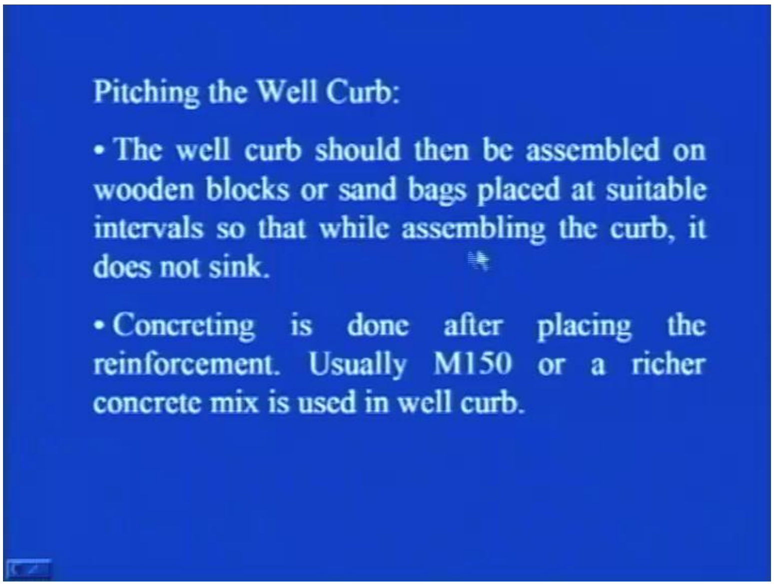

So, that while assembling the curb it does not sink, concreting is done after placing the reinforcement, usually M 150 or a richer concrete mix is used in well curb, so when you go for pitching the well curb one has to use either one M 150 or a richer concrete mix.

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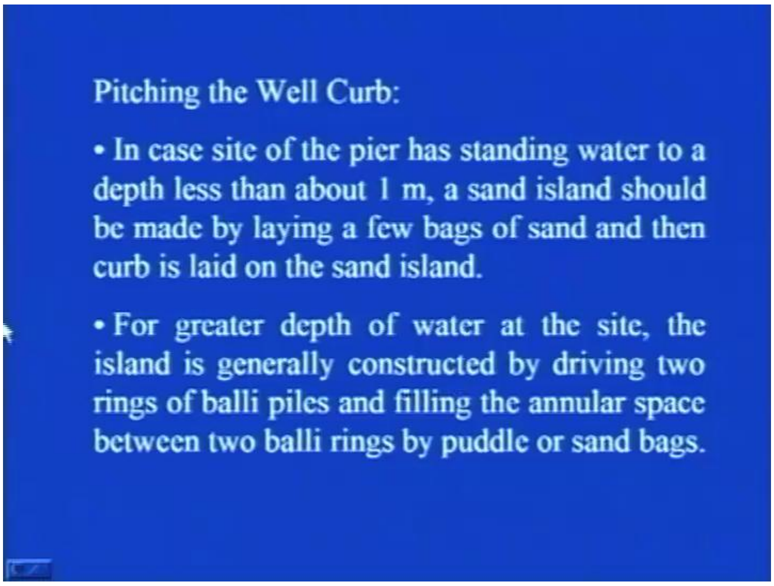

Now, the we were talking of, in case the site of the pier is dry, now what happens if it is having a standing water, so in case if the site of pier has standing water to a depth less than about 1 meter, a sand island should be made by laying a few bags of sand and then the curb is laid on the sand island. Because it need some base to rest on, So, that is why in case if the water is there, which is having depth of less than 1 meter then those sand bags can be used.

For greater depth of water at the site that is, let us say if it is more than 1 meter the island is generally constructed by driving two rings of balli piles and filling the annular space between two balli rings by puddle or sand bags. In case if the height of the standing water is more then, only sand bags will not serve the purpose and in that case you have to drive two rings of balli piles and the space, annular space which is in between these two rings, that you have to fill with the sand bags or puddle.

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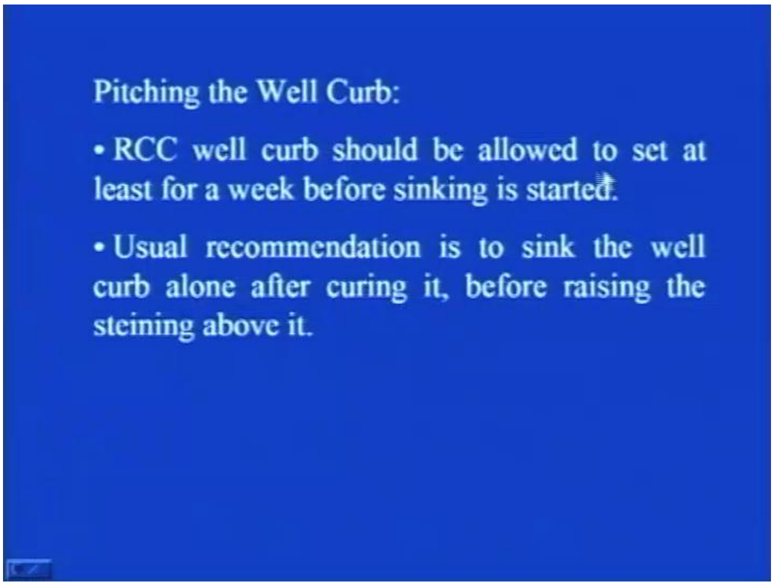

Then, RCC well curb should be allowed to set at least for a week before sinking is started, so one week time you have to give, usual recommendation is to sink the well curb alone after curing it before raising the steining about it You know that the well curb is the lower most part of the well foundation and on top of that it is connected to the well steining So, first the pitching of well curb is take takes place and then you it is recommended, that the well should be sink only after you have cured the curve alone and then only you should go for the raising of steining above that well curb.

Now, after the pitching of well curb is over there comes well steining.

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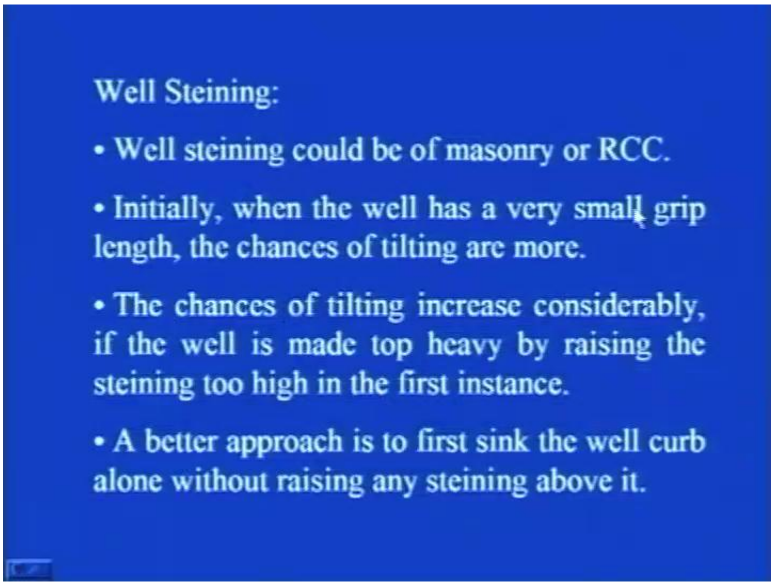

So, let us see that what are the various points, that we need to keep in mind while the going for construction and sinking of a well foundation. so well steining could be of masonry or RCC. Initially, when the well has very small grip length the chances of tilting are more, I told you that when you have to sink the well the tilting and the shifting should be as least as possible and they should be within permissible limit

So, when the well has very small grip length, the chances of getting the well tilted or getting the well steining tilted is quiet high. The chances of tilting increased considerably, if the well is made top heavy by raising the steining too high in the first instance, so you have to keep in mind, that in one go you do not raise the well steining quiet high. So, a better approach is to sink the well curb alone without raising any steining above it; that means, once the sinking of the well curb is over, then only you should start going for well steining.

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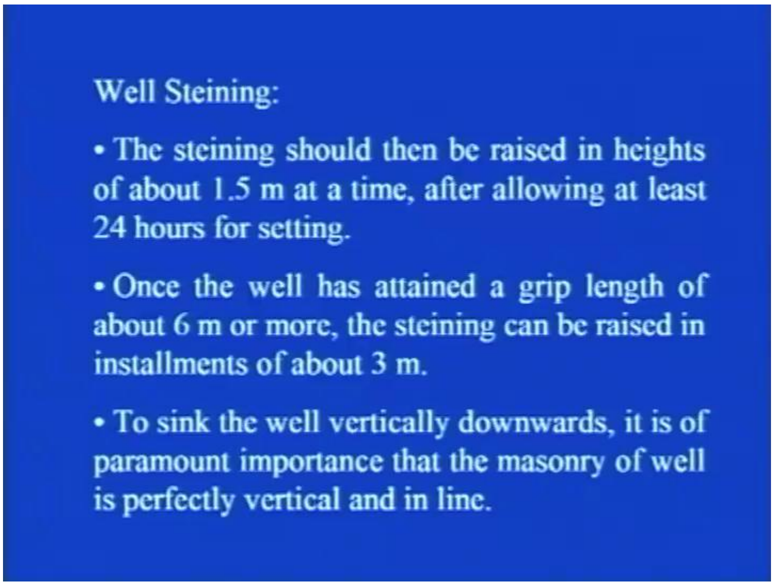

The steining once the well curb has been sunk to that particular desired depth, then only the steining should then be raised in heights of about 1.5 meter at a time after allowing at least 24 hours for setting, so in one go you should raise till 1.5 meters. Once the well has attained a grip length of about 6 meter or more, the steining can be raised in instalments of about 3 meters, which was earlier as 1.5 meters.

Now, when the grip length is more, that is 6 meter or more, then this instalment can be higher like of the order of say 3 meter. Now, to sink the well vertically downwards, it is of paramount importance that the masonry of well is perfectly vertical and in line. So, we need to keep a check, that when you go for the construction of well steining, first thing is that it should not be too high at first instance, when the grip length is less and when the grip length is more than 6 meter or so, then you can go in the instalments of 3 meter height of well is steining.

Then, we have to keep in mind that it should be the masonry or the concreting, which are being laid in well steining, that has to be perfectly vertical and in line.

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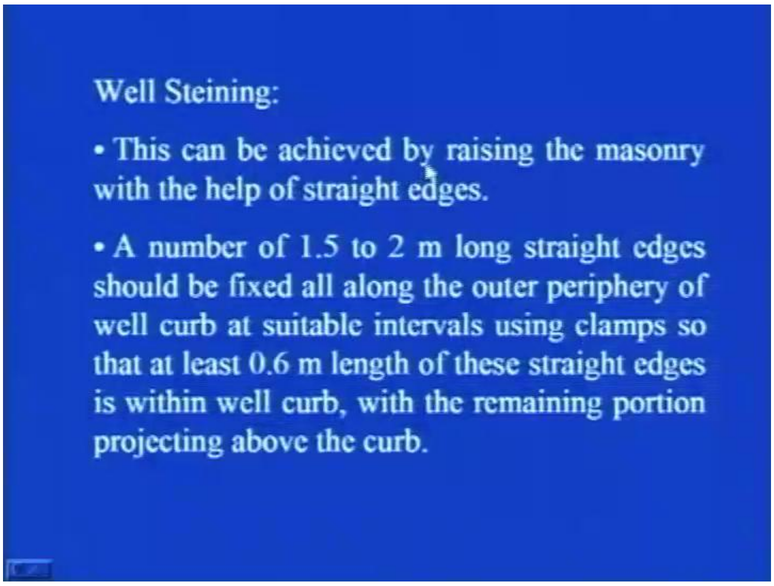

This can be achieved by raising the masonry with the help of a straight edges, so when you raise the steining with the help of a strait edges, the verticality of well steining can be taken into account. A number of 1.5 to 2 meter long straight edges should be fixed all along the outer periphery of well curb at suitable intervals using clamps. So, that at least 0.6 meters length of these straight edges is within the well curb, with the remaining portion projecting above the well curb.

See well curb will be having a plan, let us see if you are going for circular well, then it will be having a circular shape in plan. So, you have to provide or you have to fix around 1.5 meter to 2 meter strait edges all along the periphery of the well curb and you have to keep in mind that around 0.6 meter of these strait edges remain inside the well curb and rest all projecting outside.

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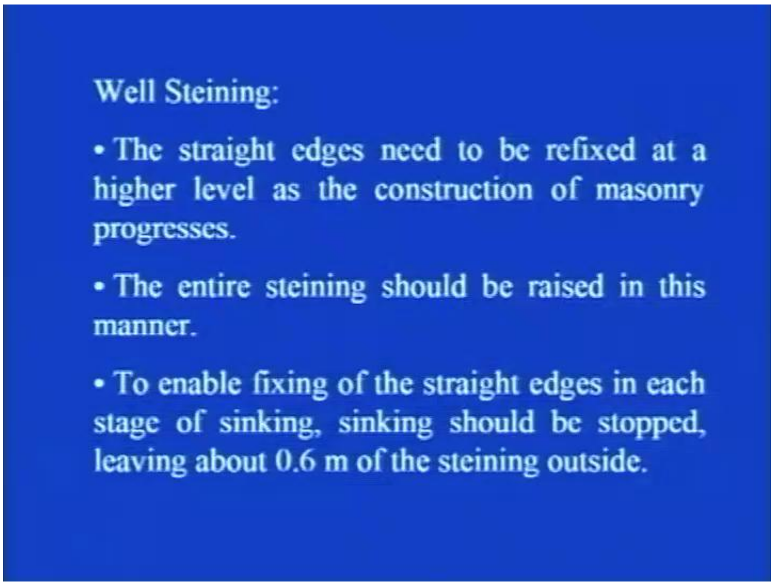

The straight edges need to be refixed at a higher level as the construction of masonry progresses. Let us say that in first go, you have fixed 1.5 to 2 meter long strait edges, now once the concreting of the well steining or the masonry construction till that particular height is over, then you have to shift those straight edges. So, that, the construction of well steining above that height can progress. So, the entire steining should be raised in this particular manner.

To enable fixing of a straight edges in each stage of sinking, sinking should be stopped, leaving about 0.6 meter of the steining outside. So, this thing you need to keep in mind because it is not only the construction as is the sinking also which is taking place simultaneously.

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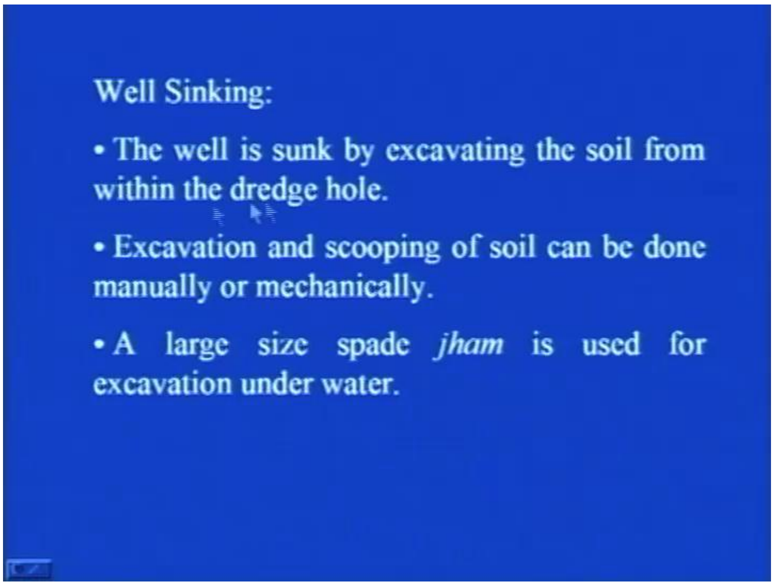

The well is sunk by excavating the soil from within the dredge hole, that is as you process in the ground what happens is a dredge hole is created and the soil inside the dredge hole is excavated and then as a consequence the well is sunk So, excavation and scooping of soil can be done manually or mechanically. A large size spade jham is used for excavation under water, so it is the matter that how you are taking out the soil from the dredge hole, either manually or mechanically.

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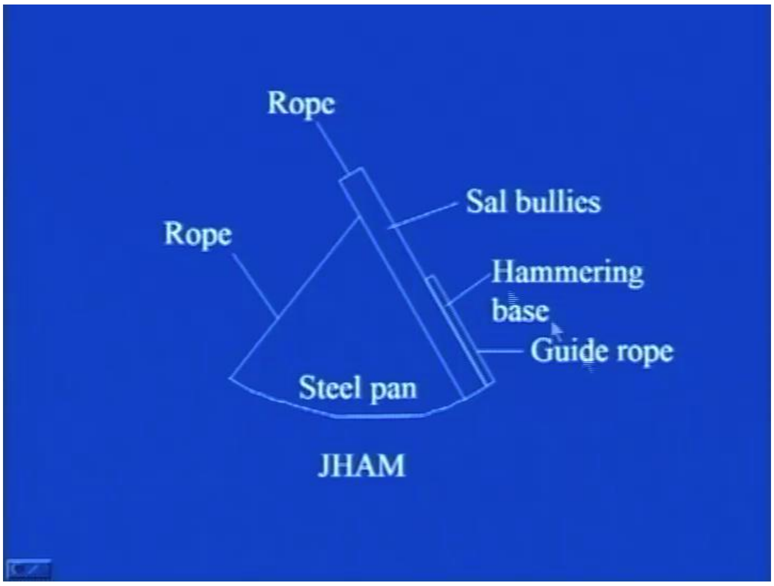

So, you can see here this gives pictorial view of a typical jham, here you have the steel pan, it is connected to a rope, a rope is here also it is Sal bullies. Then, you have a hammering base and here you have this guide rope.

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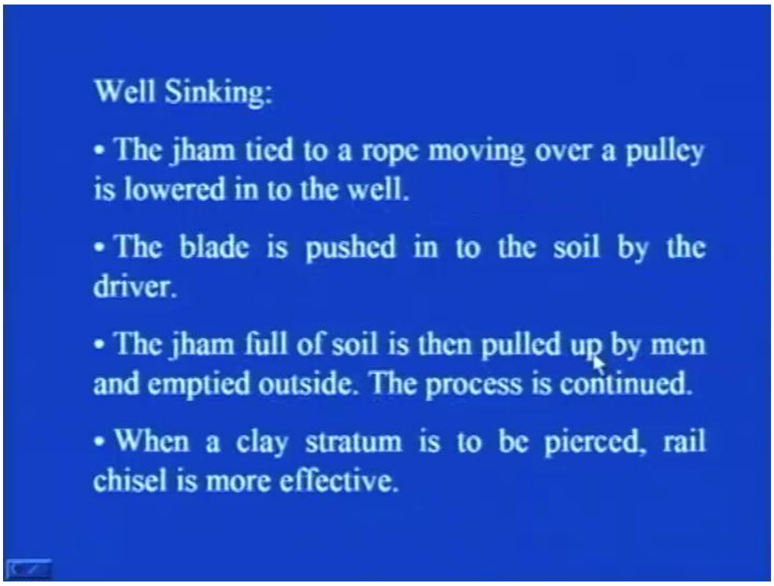

How it works, let us try to see in this particular slide, that the jham tied to a rope moving over a pulley is lowered in to the well, so the blade is pushed in to the soil by the driver, when it is lowered to the pulley, it is the blade of that particular jham is pushed into the soil. Then the jham gets full of soil and which is taken out, so the jham which is full of soil is then pulled out by men and emptied outside. Likewise the process is continued till the total excavation has been taken place.

So, when a clay stratum is to be pierced, rail chisel they are more effective, what are they.

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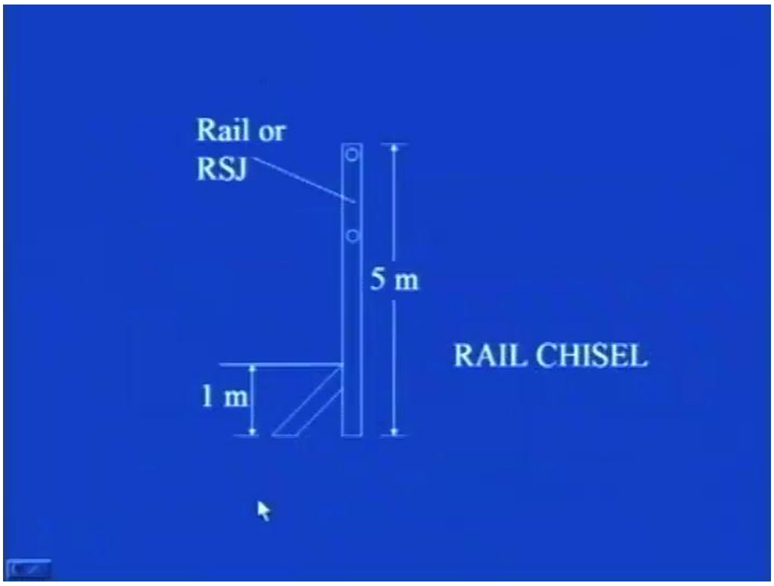

Here is one typical. this figure for rail chisel, it is a rail here and then a 1 meter of 1 meter thickness this particular part is there, so it is lowered and when it is taken out it is filled with the soil, you can empty it on the ground surface and then again lower this.

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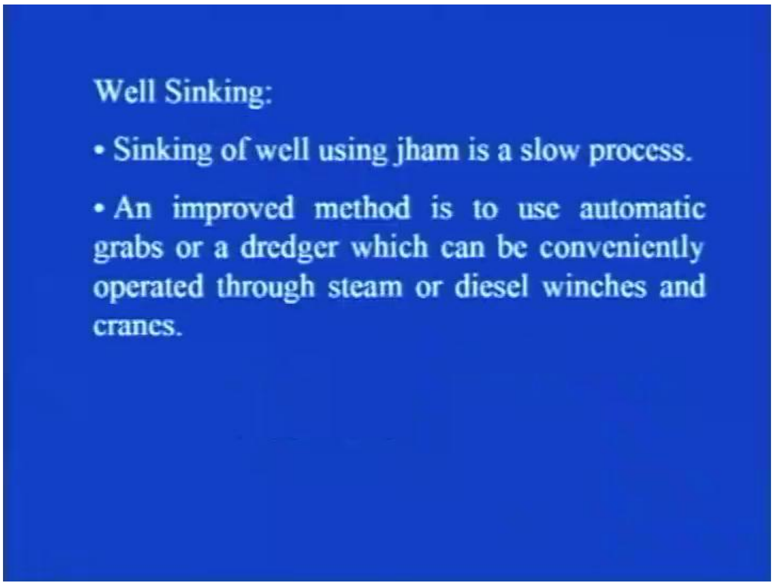

Sinking of a well is using jham is a slow process, so when you use the jham you know that every time you have to lower it, then it will get filled with the soil and then you have to take it out empty it and then again lower it, so that makes it a very slow process. An improved method is to use automatic grabs or a dredger which can be conveniently operated through steam or diesel winches and cranes. So, these are all I mean, the less of manual effort and more of mechanical in nature, so these enhances the process of sinking of well.

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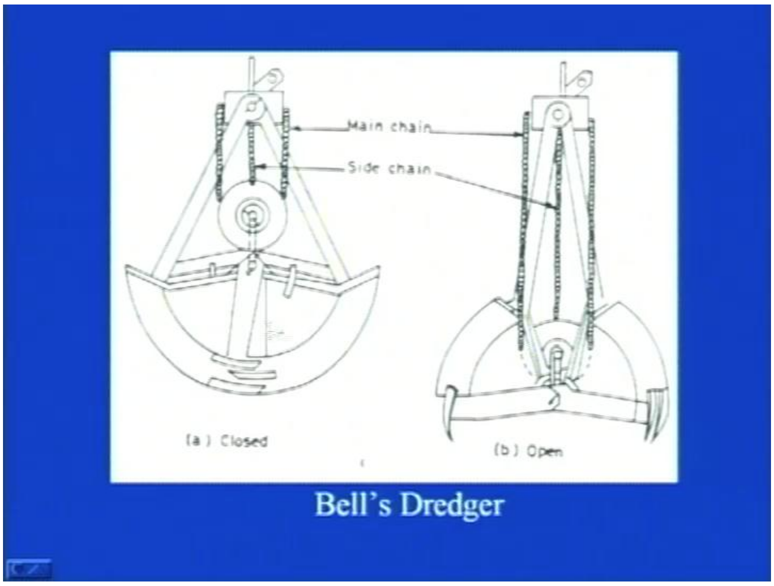

You can see here a typical view of bells' dredger, here it is closed position and here it is in open position, main chain and side chain they are being shown in this particular figure. So, this is just a schematic diagram of this bell's dredger.

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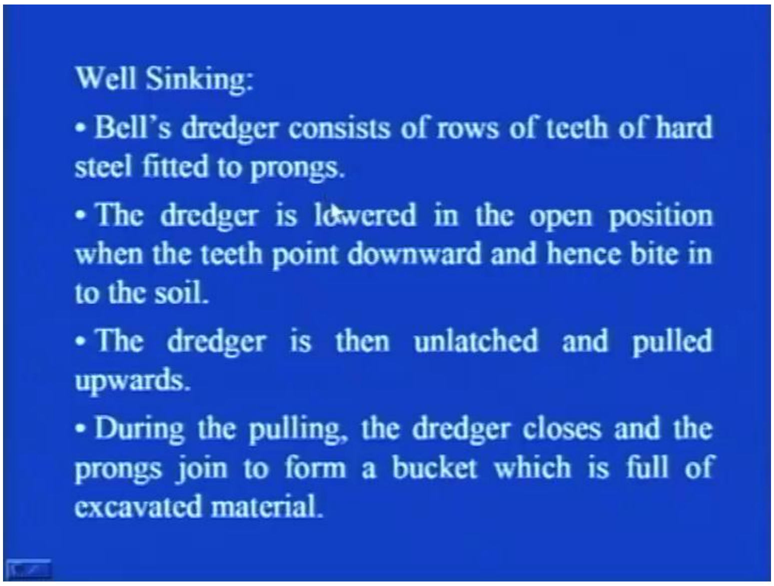

How it works we see in this particular points, that bell's dredger it consists of rows of teeth of hard steel fitted to prongs. The dredger is lowered in the open position when the teeth point downward and hence bite in to the soil, you can see, this is being lowered in open position you can see the teeth over here, so it just goes in to the soil, it bites in the soil. The dredger is then unlatched and pulled upwards.

What happens during the pulling the dredger gets closes and the prongs join to form a bucket which is full of excavated material. You can see here when you are lowering it down it is in open position, when you take this out it becomes in closed position and it takes a form of this bucket and in this one you have or it is filled with the excavated material. So, you can take this out and empty this and then again you can lower this in open position.

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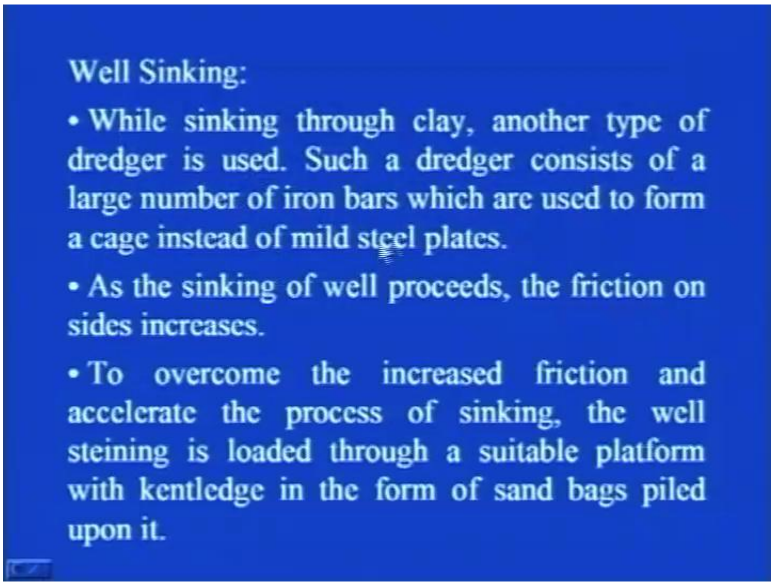

While sinking through clay, another type of dredger is used, such a dredger consists of a large number of iron bars which are used to form a cage instead of mild steel plates, In bell’s dredger we saw that you were having mild steel plates and the teeth were there, but in this case it has large number of iron bars which make a kind of cage. As the sinking of well proceeds, the friction on the side of the well it increases, now it is not good for the sinking procedure.

So, how you can overcome this increased friction is that you have to overcome this increased friction as well as you have to accelerate this process of sinking, for this purpose the well steining is loaded through a suitable platform with kentledge in the form of sand bags piled upon it, so you we increased the load on the well steining with the help of suitable platform with kentledge.

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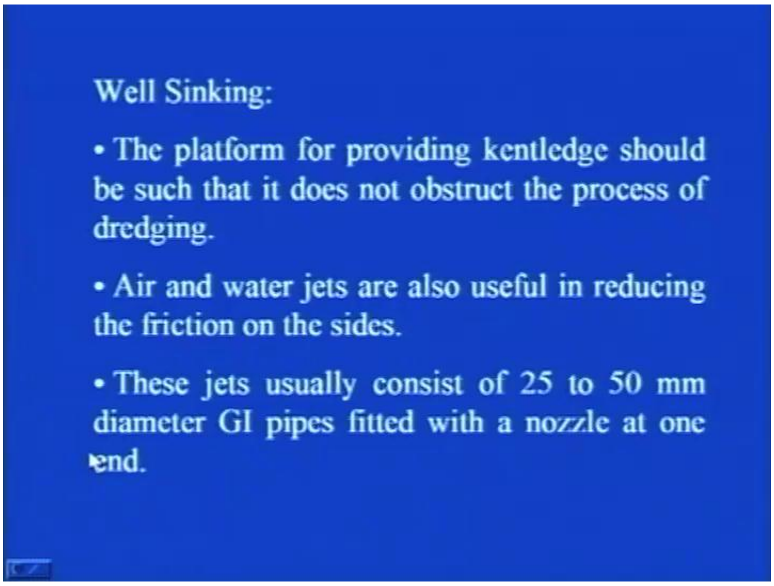

The platform for providing kentledge should be such, that it does not obstruct the process of dredging, so the suitable arrangement has to be made, so that the dredging as well as sinking it all goes simultaneously. Air and water jets are also useful in reducing the friction on the sides. These jets usually consist of 25 to 50 millimeter diameter GI pipes fitted with a nozzle at one end, so air and water jets they are also useful, when if you have to reduce the friction at the sides and usually the diameter of GI pipes of 25 to 50 meter, they are used for this particular purpose.

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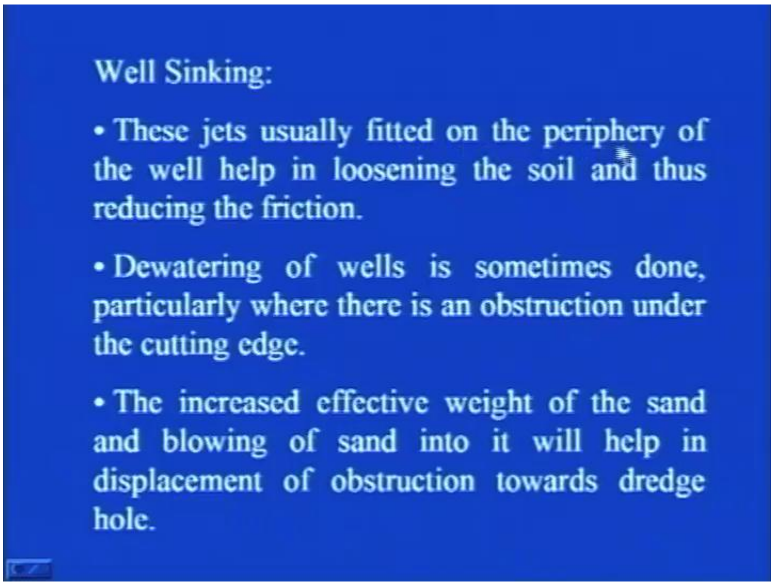

Then, these jets they usually fitted on the periphery of the well they help in loosening the soil and thus reducing the friction, so the water or air jets they are there, they lose the soil around the well and subsequently reduce the friction. Then, dewatering of wells is sometimes done, particularly when there is an obstruction under the cutting edge, so de watering also helps the process of sinking, the increased effective weight of the sand and blowing of sand in to it will help in displacement of obstruction towards dredge hole.

So, in case if the dewatering of the well is done, it happens that the effective weight of the sand gets increased and the blowing of sand into it, it helps in the displacement of obstruction near the dredge hole.

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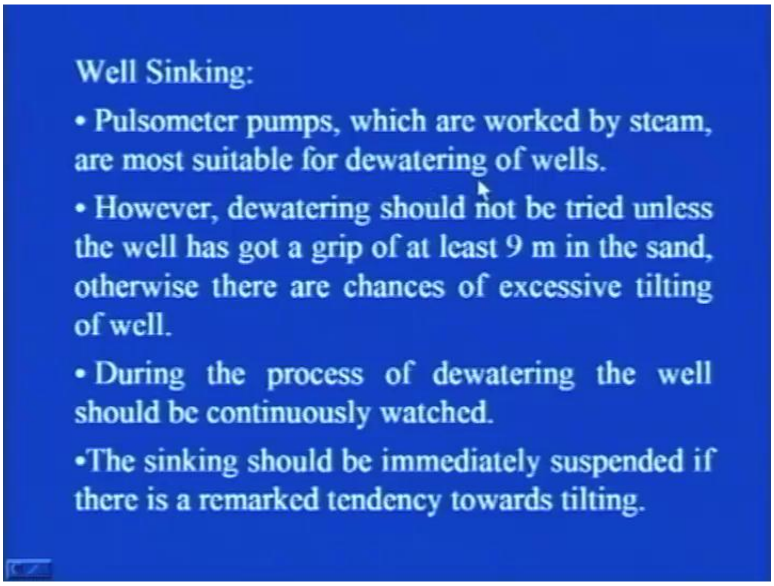

Now, this pulsometer pumps, which are worked by steam they are most suitable for dewatering of wells. However, dewatering should not be tried unless the well has got a grip of at least 9 meter in the sand, otherwise there are chances of excessive tilting of well, then during the process of dewatering the well should be continuously watched, so that if the excessive tilts or shifts are being done over there or if they are occurring, so it can be taken into account or some corrective measure can be taken right at that particular stage.

The sinking should be immediately suspended, if there is a remarked tendency towards tilting, so in sinking it is an important thing, that the tilting should not be more than permissible limit, so where ever if you see, that the tilting is becoming more, you have to stop the sinking, first you have to rectify that tilt and then only proceed for further sinking of well.

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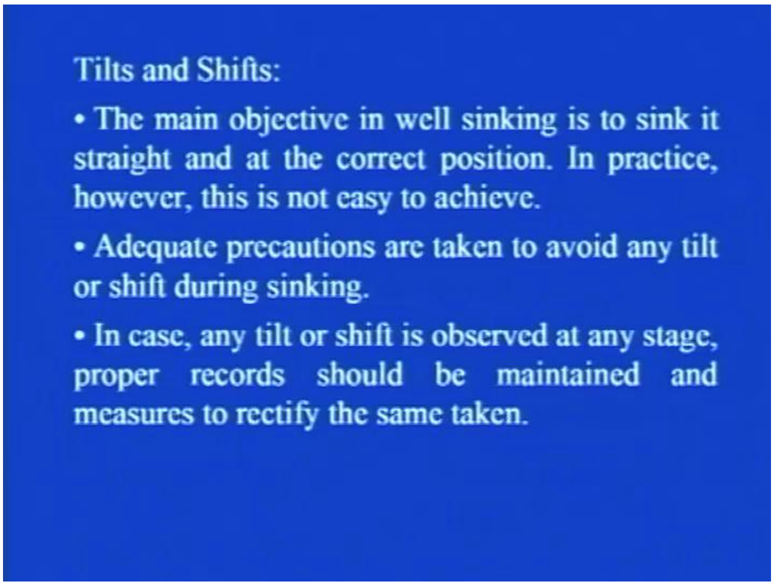

Then tilts and shifts, now coming to the tilts and shifts some of the aspects related to these. The main objective in well sinking is to sink it straight and at the correct position; however, in practice it is not easy to achieve, so adequate precautions are taken to avoid any tilt or shift during sinking, In case, any tilt or shift is observed at any stage proper record should be maintained and measures to rectify the same is taken at that particular instance only.

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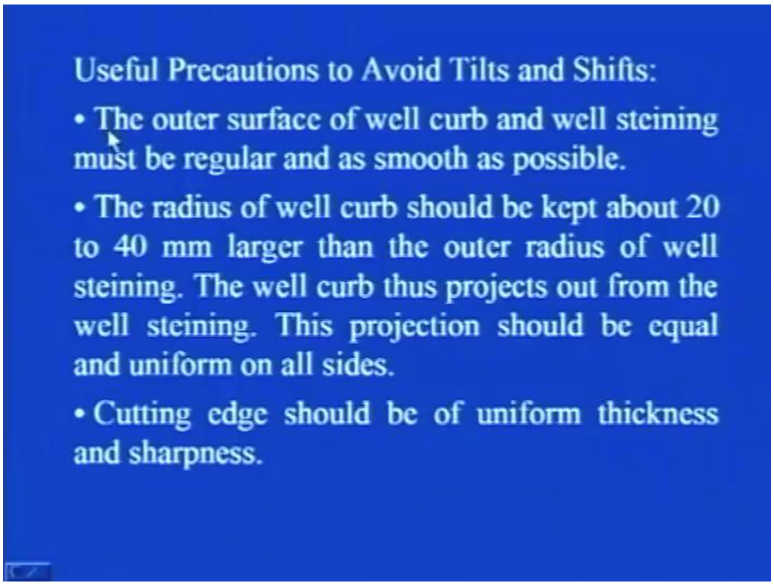

The various useful precautions, which are to be taken to avoid tilts and shifts are, that the outer surface of well curb and well steining must be regular and as smooth as possible, So, if it is quite smooth the tilts and shifts are relatively less. The radius of well curb should be kept about 20 to 40 millimeter larger than the outer radius of well steining. The well curb thus projects out from the well steining and this projection should be equal and uniform all on all the sides.

Because, it is a monolithic and very rigid structure, so we need to take care of these small things at every stage of construction and sinking cutting edge should be of uniform thickness and sharpness, cutting edges is the lower most edge or the part of your well curb.

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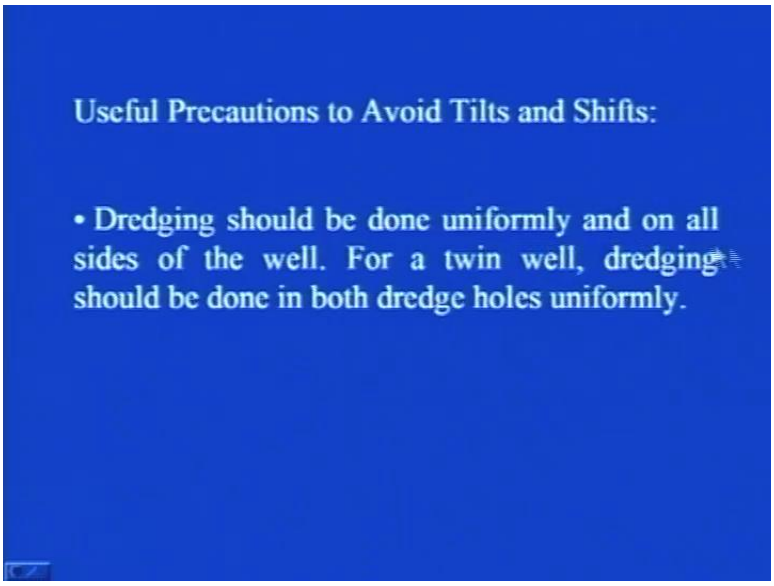

Then, dredging should be done uniformly and on all sides of well, for a twin well dredging should be done in both dredge holes uniformly. You have seen that in twin well two dredge holes are form formed, so the excavation or the sinking for both the dredge hole should be done uniformly.

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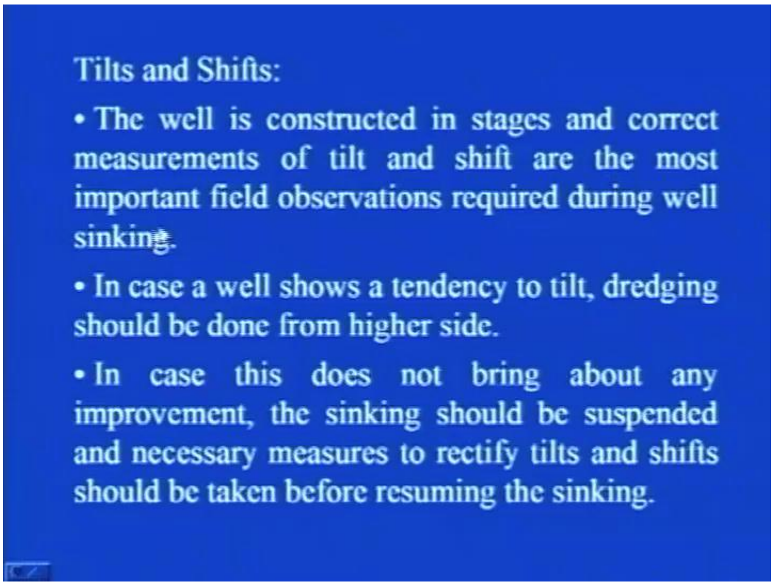

The well is constructed in stages and correct measurements of tilt and shift are the most important field observations required during the sinking of well, because without the correct measurement of tilt and shift you really will not be able to get to know, that whether it is going beyond the permissible limit or whether it is within that,

If it is within that, then there is no problem, but then it should not be more than the permissible limit.

In case, a well shows a tendency to tilt dredging should be done from higher side, higher side means the since it is going below the ground surface, so if you see, if you see the cross section in the vertical direction, then you will see that the two well steining, you can see. So, while you go for dredging it can happen that one side, if the tilting and shifting is taking place, so when the tilting shifts place one side can move more in the vertical direction and one can move lesser.

So, which moves in the which the side which moves more in the vertical direction, that is called as a lower side and which moves lesser is known as the higher side. In case, this does not bring about any improvement, that is dredging more dredging towards higher side, in case if does not bring any improvement, the sinking should be suspended and necessary measures to rectify tilts and shifts should be taken before resuming the sinking.

So, at any stage, when you are seeing that the sinking, during the sinking process that the tilts and shifts are becoming more, then you should stop sinking right at that particular stage and first you should try to rectify that tilt and shift and then only go for further sinking of well. Different methods are available to rectify tilts and shifts, one is controlled dredging.

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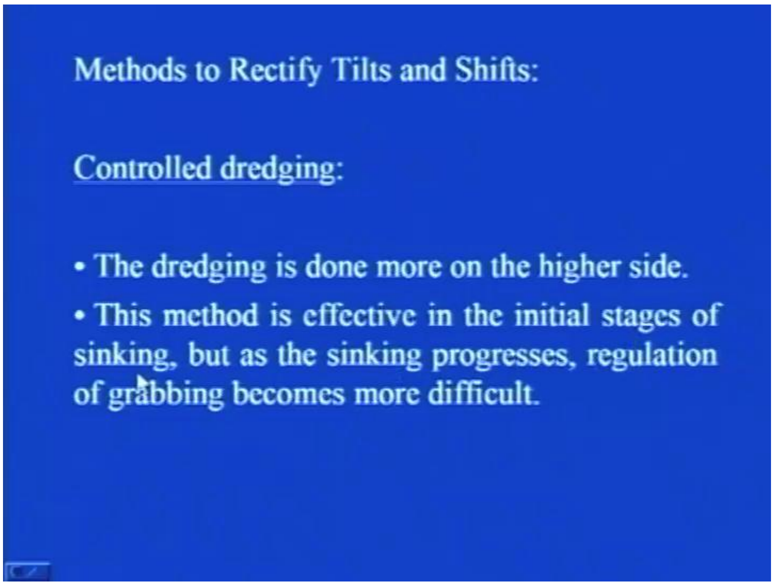

In this one, the dredging is done more on the higher side. This method is effective if the initial stages of sinking, but as the sinking progresses, regulation of grabbing becomes more difficult, so if in the initial stage of sinking only, you are observing the tilts then you can adopt this particular method that is controlled dredging to rectify tilts and shifts. But if you are as the sinking process is progressing, that is if the in the later stage of the sinking if you are observing this becomes it is not more useful or it becomes difficult to use this kind of this method to rectify tilts and shifts.

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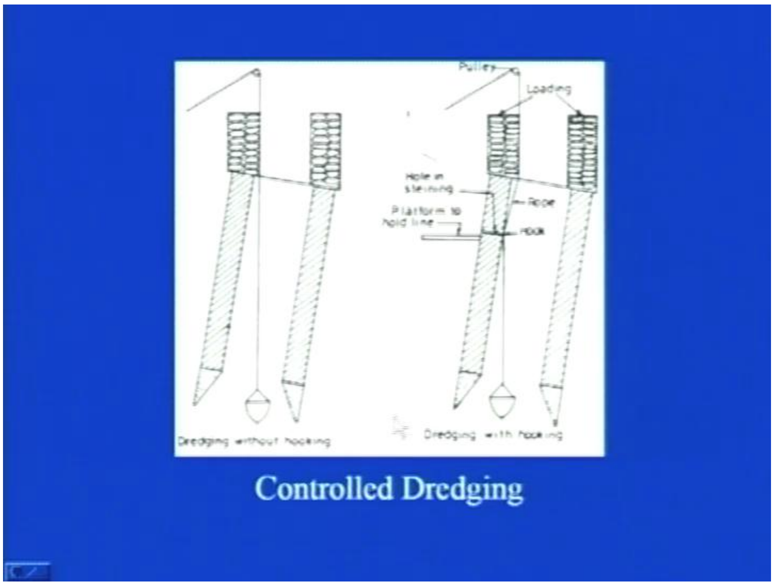

You can see here in this particular figure, that here the dredging without hooking is going on, wherever here in this case the dredging with hooking is going on, so you can see here that platform to hold this particular line is there, there is a hook and a rope has been tied to it and it is the loading. So, this helps in, this is a sort of controlled dredging which at the initial stage of sinking is quite useful.

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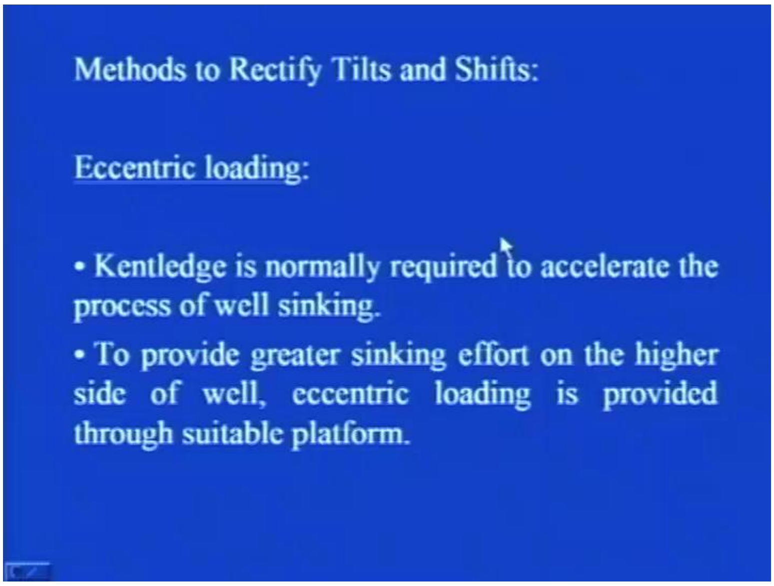

Then, the second method is eccentric loading, Kentledge is normally required to accelerate the process of well sinking. To provide greater sinking effort on the higher side of well eccentric loading is provided through suitable platform.

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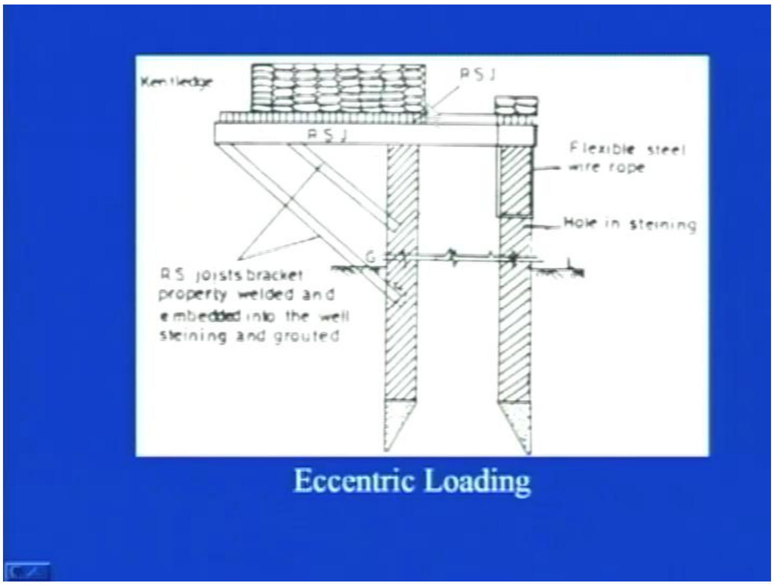

So, you will see here, that if this is the higher side, so more of the kentledge is put here right, so that the sinking becomes uniform or the tilts and shifts they can be rectified, here it is these are the two RS joists bracket, which are properly welded at and embedded into the well steining and grouted. Here is the, this is the hole in steining and a flexible steel wire rope has is coming in this particular hole, here you can see that the kentledge is being provided.

Kentledge is provided over here also, but towards a higher side, if you are observing any tilt and shifts at any stage, so towards a higher side kentledge is provided, so this what is your eccentric loading.

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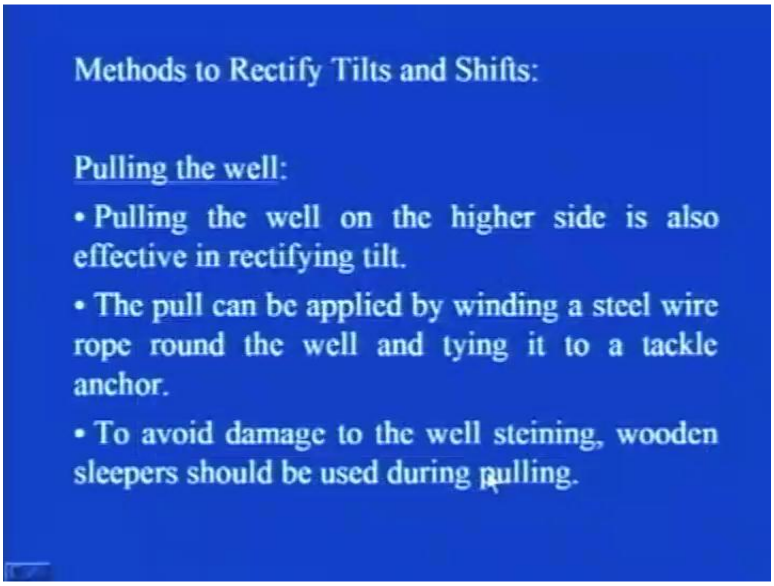

Then, the third one is pulling the well, so pulling the well on the higher side is also effective in rectifying tilt. The pull can be applied by winding a steel wire rope round the well and typing it to a tackle anchor. To avoid damage to the well steining, wooden sleepers should be used during pulling.

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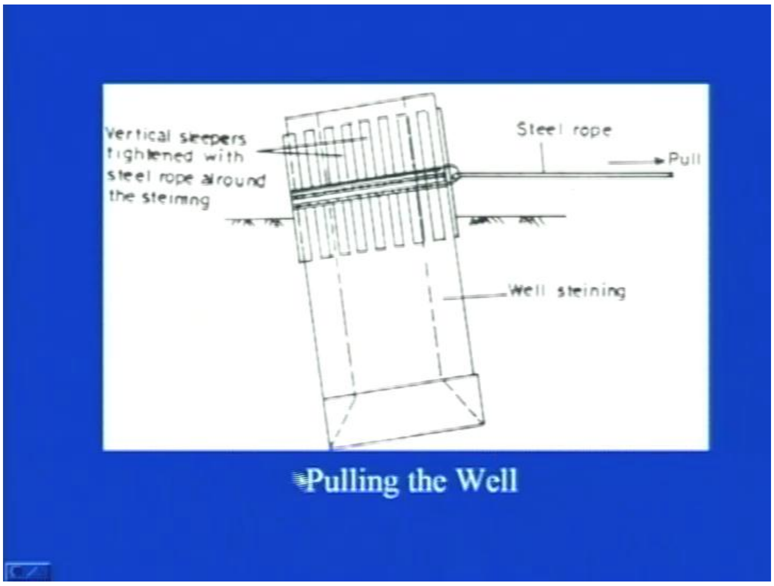

You can see here in this figure that it is the higher side and this is the lower side, so as I told you, that pulling of the well on the higher side, so here if you, start pulling it from this particular, at the this particular side that this is higher side this helps in rectifying tilting and shifting. You can see here, that various vertical sleepers, they are tightened with a steel rope which is all around the steining and this is the steel rope and a pull is applied, you can see here this is the higher side and the pull is applied on the higher side.

So, once the pull is applied it this particular well steining will have the tendency to move in this particular direction and which will have the tendency to rectify this tilt which has been occurred in this particular direction, it should have gone vertically in this direction, so you have to provide a pull here in this directions, so that it can resume this vertical position; that means, that it can rectify the tilt and the shift if it has occurred at any stage.

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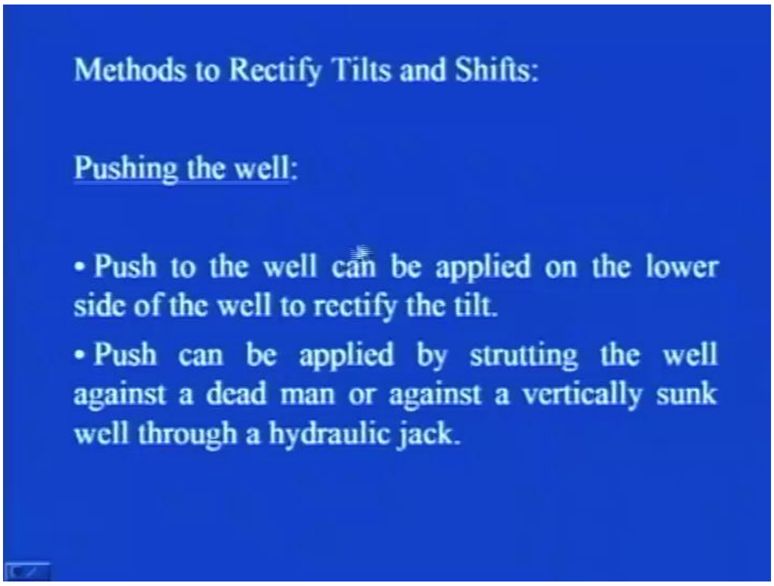

The fourth one is pushing the well, push to the well can be applied on the lower side of the well to rectify the tilt, this push can be applied by strutting the well against a dead man or against a vertically sunk well through a hydraulic jack.

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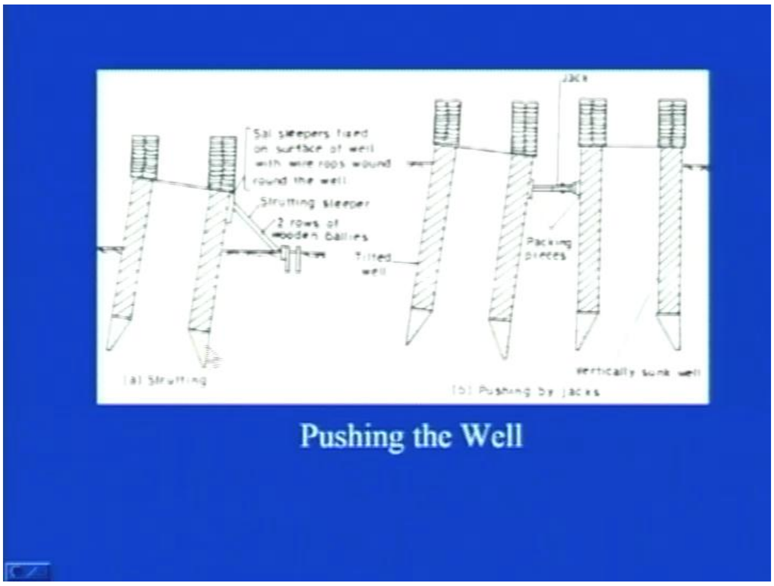

Let us see with the help of this particular figure, you can see this is the lower side and this is higher side, it is two rows of wooden bullies they are being installed here, this is strutting sleeper this one and this is sal sleepers fixed on surface of well with wire ropes round the well. So, this pulling is applied on the lower side, so when the pull is applied, it will have the tendency to rectify the tilt and the shift if it has occurred at that particular stage.

Here, it has been shown that with the help of wooden bullies this pull is being applied; however, if you have any vertically sunk well in the near by area, then with the help of this jack, you can apply that pull to the tilted one. So, you can see here two wells are there one is vertically sunk well and another one is tilted well, so with the help of a jack over here, the pull can be provided, so two ways are there.

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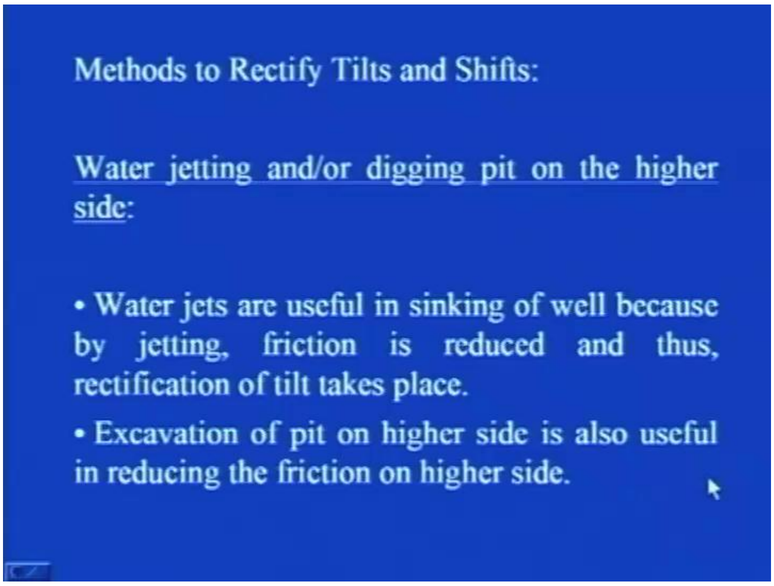

Then, water jetting and or digging pit on the higher side, so water jets are useful in sinking of well because of jetting, friction is reduced and thus rectification of tilt takes place. Excavation of pit on higher side is also useful in reducing the friction on higher side.

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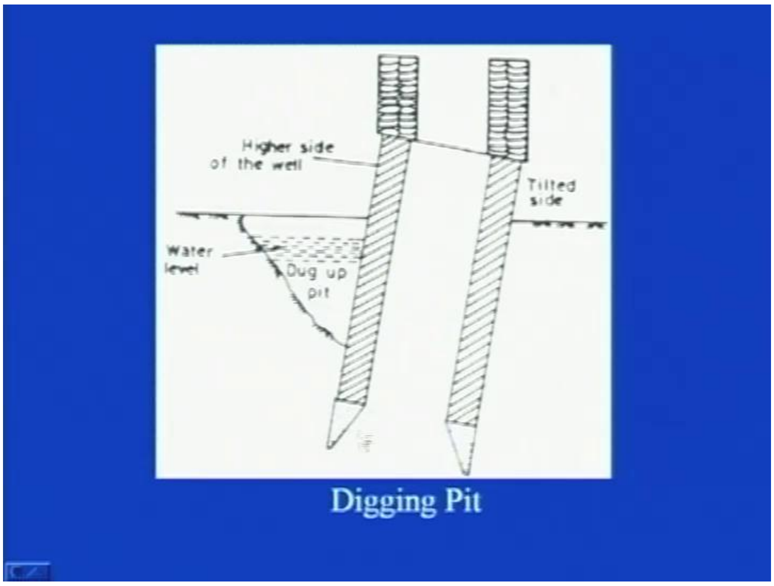

We will see with the help of this particular figure, that here it is the lower side, this is the higher side, you can see it is written here that the higher side of the well, this has got tilted and this is what is your tilted side. So, here you can dug a pit and fill it with water, this will reduce the friction over here and will try to rectify the tilt, so we have seen different measures to rectify the tilt and shift if it comes during the process of sinking.

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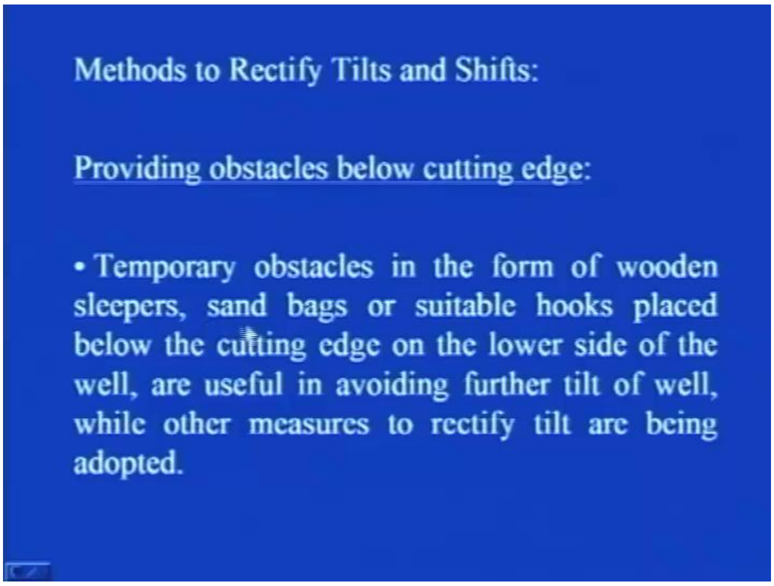

Now, another one is that providing obstacles below cutting edge. Temporary obstacles in the form of wooden sleepers, sand bags or suitable hooks placed below the cutting edge on the lower side of well, they are useful in avoiding further tilt of well, while other measures to rectify tilt are being adopted. So, previously we discussed the methods to rectify the tilt, but this particular method that is providing obstacles below cutting edge will reduce the or will stop the further occurrence of tilt and shift.

How it is done and you can see here with the help of this particular figure.

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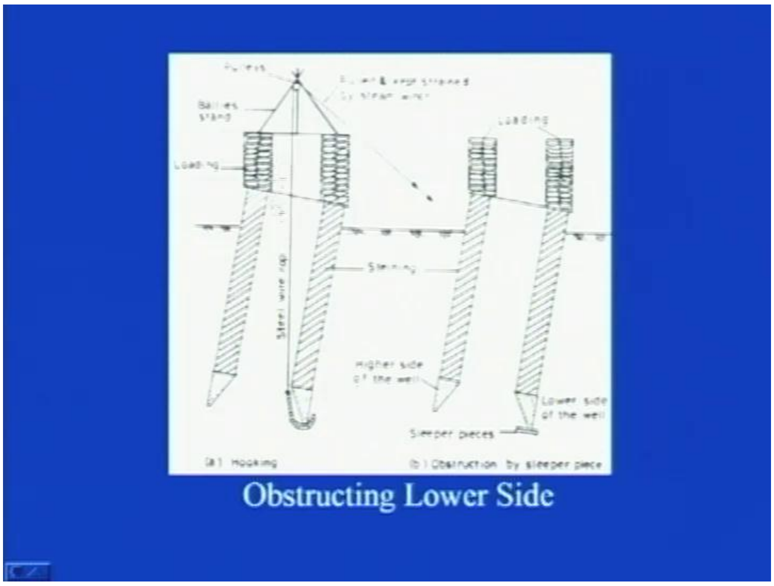

Here, the hooking has been done, hook has been formed and over a pulley with the help of a steel wire rope, the this once this, although you are using the different methods which we have just now discussed regarding rectifying the tilts and shift, but additionally this obstacle below the lower side. You can see here that this is lower side, this is higher side, so here a hook has been found and it is providing obstacle.

So, likewise here and then if you are using sleeper pieces, so if you just provide the sleeper piece at the lower side of the well and put a obstacle, this will also help in further tilting and shifting of the well. So, we have seen various methods related to the rectification of tilt and shift, before that we took the various steps to be followed while you go for the elastic theory method as per IS IRC recommendations.

And then we saw that with the help of an example that how different conditions which are recommended by IRC and IS codes can be satisfied when you do any numerical problem or when you deal with any practical problem, related to the stability analysis of well foundation. So, in this chapter of well foundation, we saw various aspects related to well foundation that it is a type of de-foundation and then circular oblong different shapes it can be provided.

We have seen various advantages and disadvantages of different shapes, then we saw that how you can find out allowable bearing pressure of well foundation and then we saw that what all are the various forces which act on well foundation, what are the combination of these forces to be considered while going for stability analysis. Then I have discussed with you that the Terzaghi's analysis to see the stability of well foundation.

Further, we discuss the elastic theory method of IRC with the help of example of these two and then we saw various aspects related to construction and sinking of well foundation and in that one we saw, that the most important thing is that the tilting and the shifting of the well foundation should not be there during the construction and sinking process of well foundation and we saw, different methods to rectify the tilt and shift and then we saw that providing the obstacle at lower side, it reduces the further tilting and shifting of well.

However, the other methods of rectifying tilting and shifting are to be adopted simultaneously.

Thank you.