Basic Environmental Engineering and Pollution Abatement
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Lecture 28
Primary Treatment Equipment

Hello, everyone. Now, we will discuss on the topic primary treatment equipment. In the previous class, we have discussed on the schemes for the treatment of domestic and wastewater. Now, in this class we will discuss on different types of equipment used in primary treatment.

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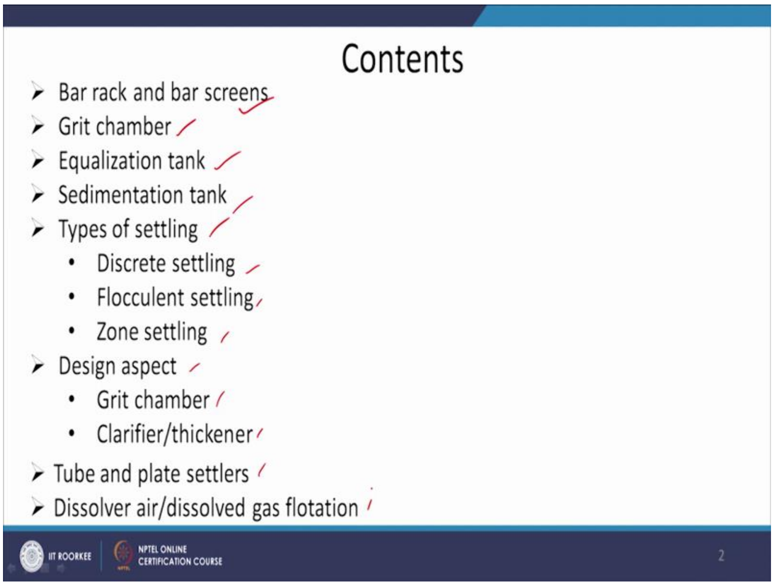

And the contents are bar rack and bar screens, grit chamber, equalization tank, sedimentation tank, then types of settling that is discrete settling, flocculent settling, zone settling and design aspect of grit chamber and clarifier and thickener and then tube and plate settlers and dissolved air or dissolved gas flotation. So, these are the primary treatment equipment which are normally used in different types of effluent treatment plant or sewage treatment plant.

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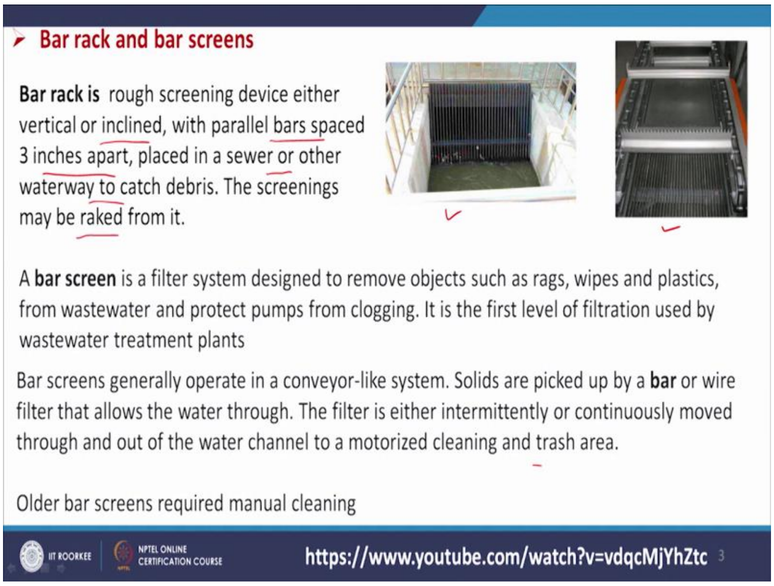

So, you see here this is bar rack and this is bar screen. Bar rack is rough screen device either vertical or inclined with parallel bars spaced 3 inches apart, placed in a sewer or other waterway to catch debris. The screening maybe raked from it. So, the materials will be stuck here and it will be collected. But bar screen is like this. So, a bar screen is a filter system designed to remove objects such as rags, wipes and plastics from wastewater and protect pumps from clogging. It is the first level of filtration used by wastewater treatment plants.

And bar screens generally operate in a conveyor like system as shown here. Solids are picked up by a bar or wire filter that allows the water through. The filter is either intermittently or continuously moved through and out of the water channel to a motorized cleaning and trash area. And older bar screens required manual cleaning, now it is motorized.

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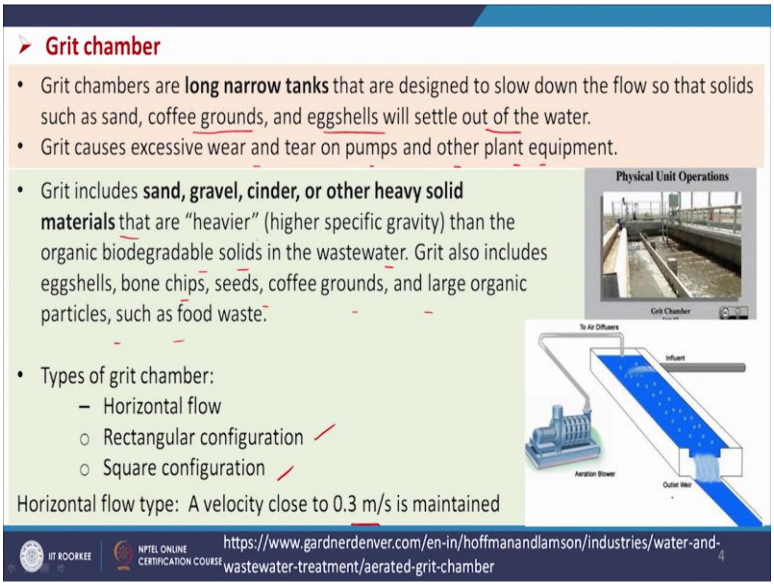

And now we will see the grit chamber. So, as you have seen the grit chambers are basically used to separate the heavier particles. So for that grit chambers are long narrow tanks that are designed to slow down the flow so, that solids such as sand, coffee grounds, and egg shells will settle out of the water.

And grit causes excessive wear and tear on pumps and other plant equipment that is why the grits need to be removed. And this is the physical unit operation you see, a very long narrow tank. So, water will flow and its speed will reduce and particle will fall. So, this is the mechanism for the separation here. So, certainly the settling will play a role.

And grit includes sand, gravel, cinder or other heavy solid materials that are heavier than the organic biodegradable solids in the wastewater. Grit also includes egg shells, bone chips, seeds, coffee grounds and large organic particles such as food waste. So, our objective is to remove these but not to remove the dissolved organic compound.

And these types maybe horizontal flow or maybe rectangular configurations or square configuration, so as shown here. And horizontal flow type, the velocity close to 0.3 m/s is maintained, this is some typical velocity of water. And here we see in some cases, air is also supplied, so effluent is getting entry we are providing air so that will be giving us more separation.

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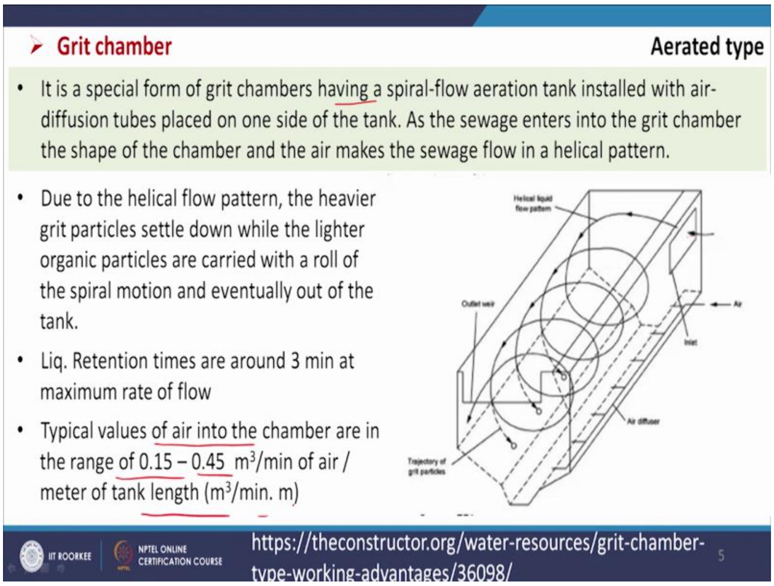

So, this type of situation will be arising, you see this is our inlet of the water and from the bottom we are giving the air. So, it is a special form of grit chambers having a spiral flow aeration tank installed with air diffusion tubes placed on one side of the tank. As the sewage enters into the grit chamber, the shape of the chamber and air mixed the sewage flow in a helical pattern, like this, it will be moving like this. So, this is a helical pattern.

Due to the helical flow pattern the heavier grit particle settle down while the lighter organic particles are carried with a roll of the spiral motion and eventually out of the tank. So, our objective is to separate the heavier particles only not the lighter one. And then, liquid retention times are around 3 minutes at maximum rate of flow and the typical values of air into the chamber are in the range of 0.15 to 0.45 m^3/min for air per meter of tank length that is m^3/min-m.

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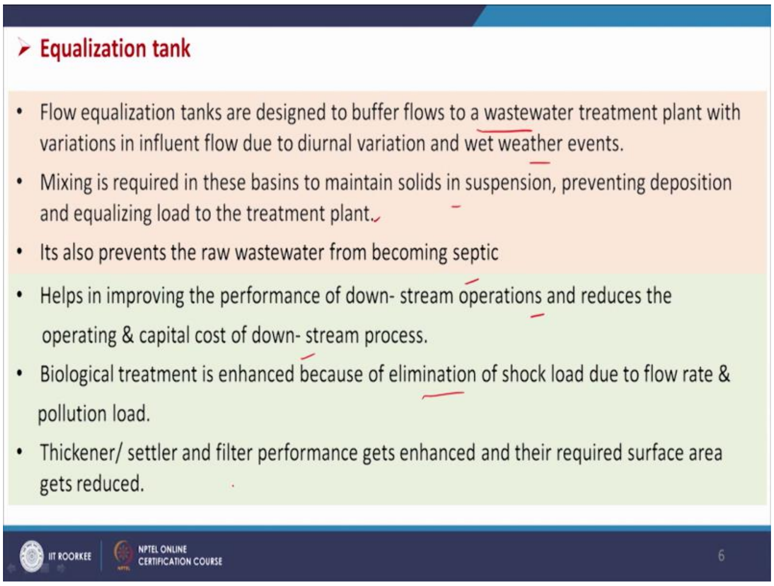

Then we will see the equalization tank and flow equalization tanks are designed to buffer flows to a wastewater treatment plant with variations in the influent flow due to diurnal variations and wet weather events. That means, this ensures the constant flow of effluent to the primary treatment unit. Like say, coagulation flocculation unit. So, whatever variations in the waste generation is taking place in the premise or in the industry that will be accommodated in the equalization tank that is the basic objective of it.

And then, mixing is required in these basins to maintain solids in suspension, preventing depositions and equalizing load to the treatment plant. That means uniform concentrations will be available that is a main objective and there will be no settling or solids will be in suspension form. It is also prevents the raw wastewater from becoming septic.

It helps in improving the performance of downstream operations and reduces the operating and capital cost of downstream processes and biological treatment is enhanced because of elimination of shock load due to flow rate and pollution load. And the thickener and settler and filter performance gets enhanced and they are required surface area gets reduced. That means continuous flow, we are able to provide into the ETP devices downstream of this equalization tank.

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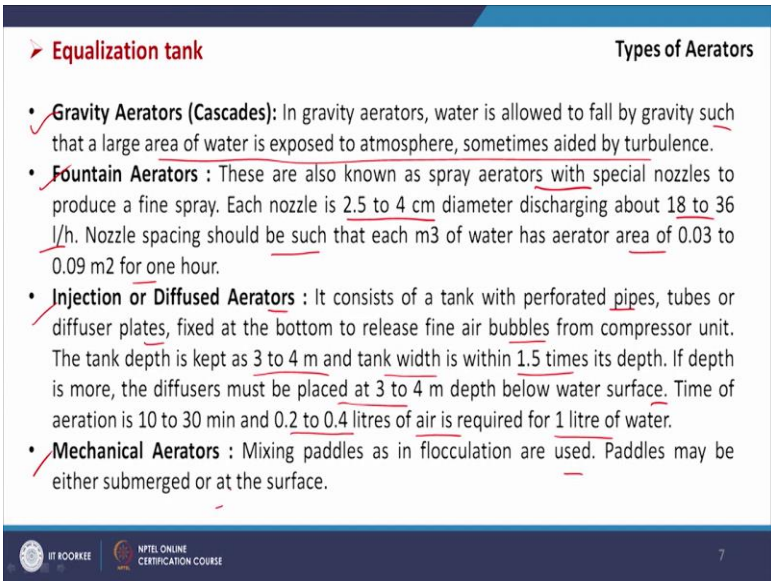

And then aerators, there are some aeration systems are available that is gravity aerators, fountain aerators, injections or diffused aerators, and mechanical aerators. So, in gravity aerators water is allowed to fall by gravity such that a large area of water is exposed to atmosphere sometimes aided by turbulence. So, water is falling under gravity and is coming in contact with the air or oxygen. So, that is the principle of the aeration.

And fountain aerators, these are also known as spray aerators with special nozzles to produce a fine spray. So, each nozzle is 2.4 to 4-cm diameter discharging about 18 to 36 L/h and nozzle spacing should be such that each meter cube of water has aerated area of 0.03 to 0.9-m^2 for 1 hour. So, this is one typical consideration for fountain aerators. And most effective and mostly used in industry is your injections or diffused aerators.

So, it consists of a tank with perforated pipes, tubes or diffused plates fixed at the bottom to release fine air bubbles from compressor unit. The tank depth is kept as 3 to 4 m and tank width is within 1.5 times its depth. If depth is more, the diffusers must be placed at 3 to 4-m depth below water surface.

Time of aeration is 10 to 30-minute. And 0.2 to 0.4 liters of air is required for one liter of water. These are some typical values provided here. Mechanical aerators that mixing paddles, as in flocculation are used paddles may be either submerged or at the surface, we have already discussed about it.

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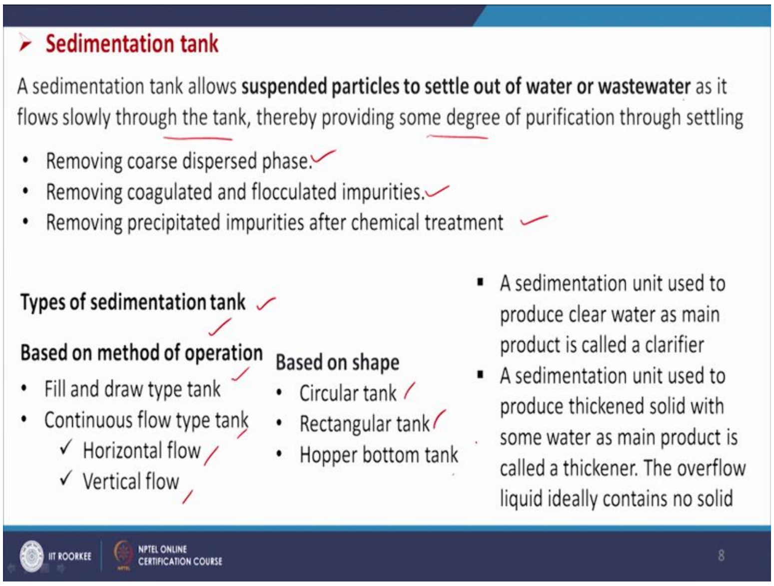

Then sedimentation tank. So, a sedimentation tank allows suspended particles to settle out of water or wastewater as it flows slowly through the tank thereby providing some degree of purification through the settling. And it helps to remove coarse dispersed phase, it helps to remove coagulated and flocculated impurities and removing precipitated impurities after chemical treatment. BOD can also be removed and TDS can also be removed.

So, types of sedimentation tanks, if we classify these so, based on the method of operation, we can have fill and draw type tank that is batch type operation and continuous flow type tank that is horizontal flow and vertical flow. And based on the shape, it may be circular tank, it may be rectangular tank, it may be hopper bottom tank.

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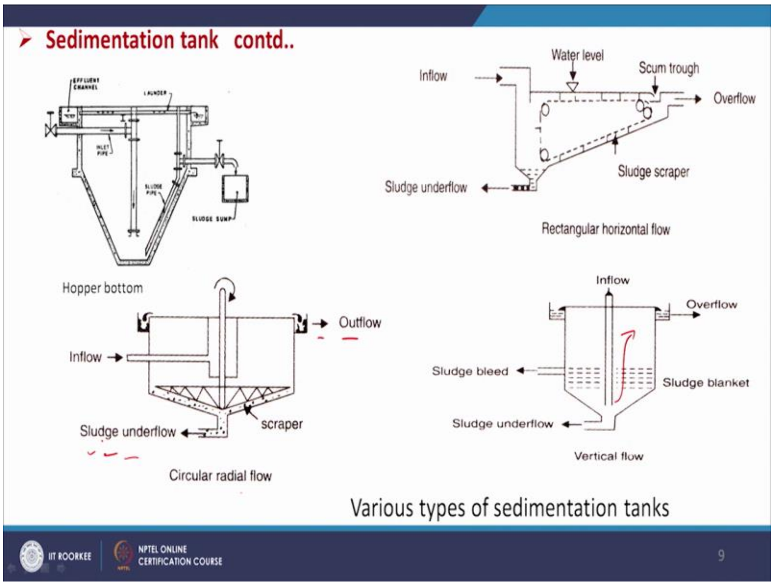

So, this is a hopper bottom tank, this is a rectangular horizontal flow tank, this is circular radial flow tank, this is vertical flow tank. So, what do we see, for this case, so what are, this is our entry and the sludge is generated here and sludge is collected here. So, this is hopper like structure the bottom part, so hopper bottom arrangement or tank.

And rectangular this is rectangular but here in flow, so there is some belt arrangement and so water level is maintained and scum is separated. And sludge is collected from the under flow. And here circular radial flow in flow from the middle and then it is settled sludge is collected from the bottom and from the top we are getting the clear water. And here we are getting in flow from the bottom that is called vertical flow.

So, the water will flow like this from this and it will be collected here and overflow and this is sludge will be bleeded from this part and sludge under flow here. So, this is the vertical flow. So, different types of tank can be used for the sedimentation purpose. And we see there are two objective basically, we want to get clear liquid here and we also need to get the sludge.

So, when our objective will be to get the clear liquid because this is our primary product then these systems can be called as clarifier and where our primary product will be sludge then that may be termed as thickener. So, thickener and clarifier both perform the similar job for the separation of solids materials from the water with a small particle size. And in one case, our main product is liquid or water that is clarifier and for other case, our main product is sludge and in that case the device is called as the thickener.

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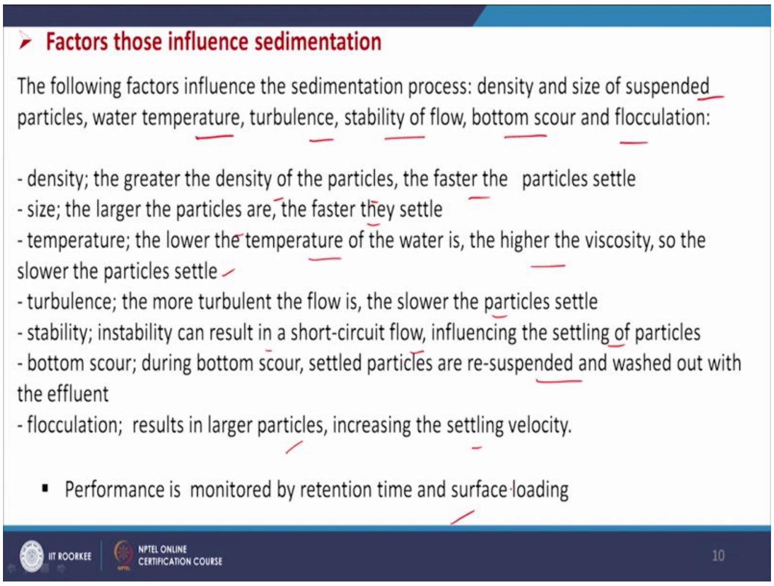

Now, there are some factors which influence the sedimentation like say density and size of the suspended particles, water temperature, turbulence, stability of flow, bottom scour and flocculation. So, the higher, the greater the density of the particles the faster the particles settle, the larger the particle size the faster they settle, the lower the temperature of the water the higher the viscosity. So, the slower the particle settle, the more turbulent the flow, the slower the particle settle, and instability can result in a short circuit flow influencing the settling of the particles.

And bottom scour hampers the settling basically, during bottom scour settled particles are resuspended and washed out with the effluent. And flocculation results in larger particles increasing the settling velocity, so more sedimentation is possible. Performance is monitored by retention time and surface loading. So, if we want to ensure the performance of the sedimentation unit, we need to consider two parameters one is your what is the retention time and what is the surface loading rate.

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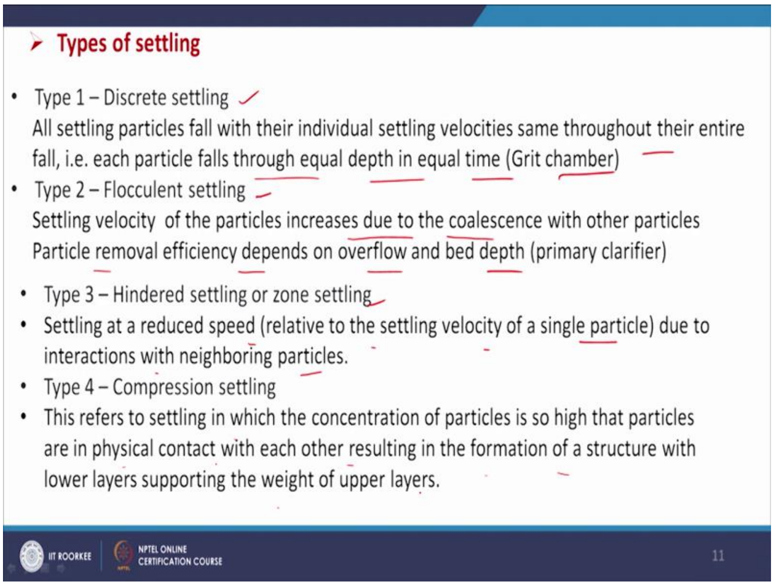

Now, we will see what are the different types of settling available in a sedimentation unit. So, one type is discrete settling that means all settling particles fall with their individual settling velocities same throughout their entire fall that is each particle falls through equal depth in equal time. So, other particles are not interfering in this case. And here good example is grit chamber where discrete settling takes place.

And flocculant settling, here settling velocity of the particles increases due to the collisions with other particles. So, particle removal efficiency depends on overflow and bed depth.

Good example is primary clarifier. And third type, hindered settling or zone settling. So, settling at a reduced speed relative to the settling velocity of a single particle due to interactions with neighboring particles. So, this settles at a reduced speed because of the interfering of the other particles. So, that is why the individual settling rate is reduced, it is hindered or zone settling.

And compression settling, this refers to settling in which the concentration of particles is so high that particles are in physical contact with each other resulting in formation of a structure with lower layers supporting the weight of upper layers. So, this is a compression settling. So, these different types of settling phenomena we can observe in sedimentation tank.

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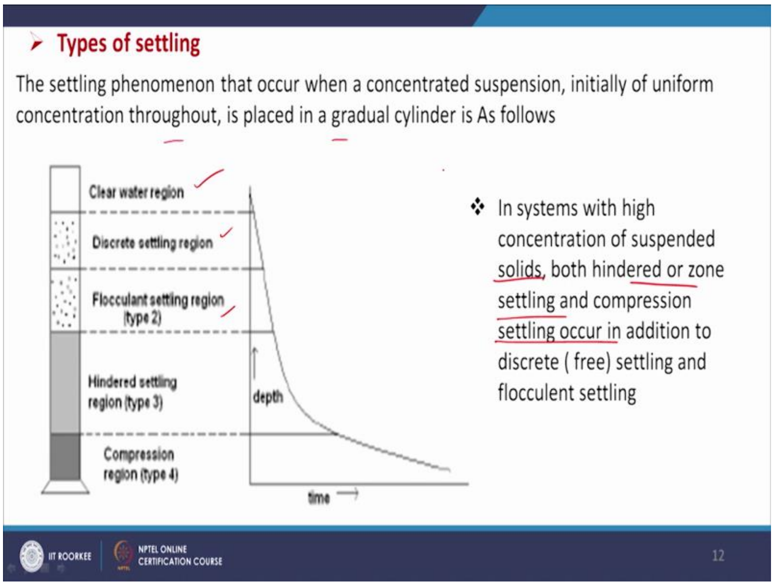

And for the more understanding of these phenomena, we can perform a simple jar test, we can take some slurry here, some solids in liquid and properly mixed. And then after a certain time we allow it to settle, we will see with time gradually the top layer will becoming to clear and the density of the layers will be varying. Initially we will be having the same but gradually it will be varying, so it will be more denser then like this.

So, these types of, so this is clear, water region will get then this will be getting discrete settling region and less number of particles are there. And then, flocculent settling region when the particles will be influenced where there will be some collisions will be taking place and then flocculation will take place that is type two.

And here hindered settling that particles will affect the settling of others and this is the compressions as you have discussed. So, in any system, we can say in systems with the high concentration of suspended solids if we have very high concentration of suspended solids, both hindered or zone settling and compression settling occur in addition to discrete settling and flocculant settling.

So, what you see that discrete and flocculent settling can be happening with every concentration of the solids, but if the concentration of solid is higher, so then the hindered settling or zone settling and compression settling will also take place. The settling phenomena that occur when a concentrated suspension initially of uniform concentration throughout is placed in a regular cylinder is as follows.

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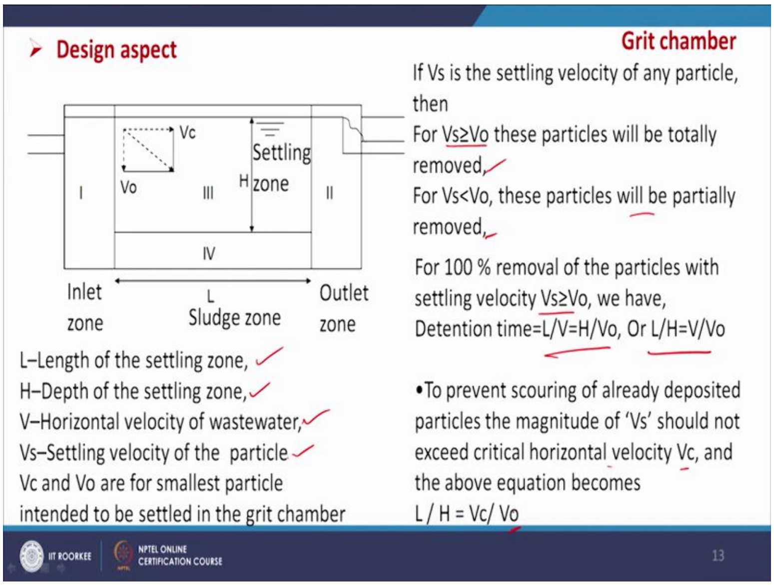

Now, we will discuss on the design aspect of grit chamber. So, grit chamber as we have discussed that the main objective is to remove the heavier particles. So, if this is a grid chamber, it has say length L and this is inlet zone, this is outlet zone. So, a particle is there, it is having two types of velocity one vertical direction velocity and other horizontal direction velocity.

So, L is the length of the settling zone, H is the height of the settling zone as shown here and V is the horizontal velocity of the wastewater and V_s is the settling velocity of the particle. Now, V_c and V_o are for smallest particle intended to be settled in the grit chamber. So, this for the smallest particle which you want to settle.

Now, this V_s that is the settling velocity of any particle. Then V_s greater than V_o this particle will settle, will be totally removed. And V_s less than Vo these particles will be partially removed. For 100 % removal of these particles with settling velocity Vs greater than Vo we have detention time $L/V = H/V_o$ that means, the time taken to travel the cell distance that is L/V that will be time taken to travel the H distance with a Vo. So, L/V is equal to H/V_o, already we have discussed in a previous class. So, L/H equal to V/V_o. But we see that what can be the V?

V the critical velocity, horizontal critical velocity we have to determine and V_o that is which you have considered for the smallest particle that can be separated. The V_o value should not be higher than that. So, V_s should not exceed critical horizontal velocity that is V_c and the above equation becomes $L/H = V_c/V_o$. So, to prevent scouring of already deposited particles, the magnitude of V_s should not exceed critical original velocity V_c and the above equation becomes $L/H = V_c/V_o$.

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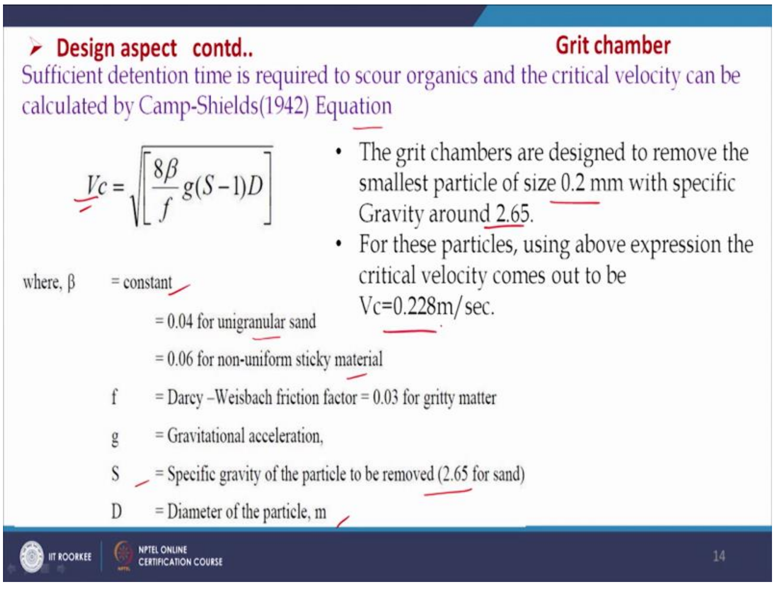

So, this is the design expression one way that we can determine the critical velocity, horizontal velocity that can be applicable for that particular grit chamber. And we can also calculate this V_c by some empirical relationship that is sufficient detention time is required to scour organics and critical velocity can be calculated by Camp-Shields Equation.

$$V_c = \sqrt{\frac{8\beta}{f} g(S-1)D}$$

where this beta is a constant that is equal to 0.04 for unigranular sand and 0.06 for non-uniform sticky material. And f Darcy-Weisbach friction factor that is 0.03 for gritty matter. And g gravitational acceleration. S is specific gravity of the particle to be removed that is

2.65 for sand. And D diameter of the particle. So, these are the different parameters which is defined here.

If we know the values of these we can calculate the value of V_c also. So, the grit chambers are designed to remove the smallest particle of size 0.2 mm with specific gravity around 2.65. And for these cases, if we want these values here, the V_c value comes as 0.228 m/s. So, this is for the grit chamber.

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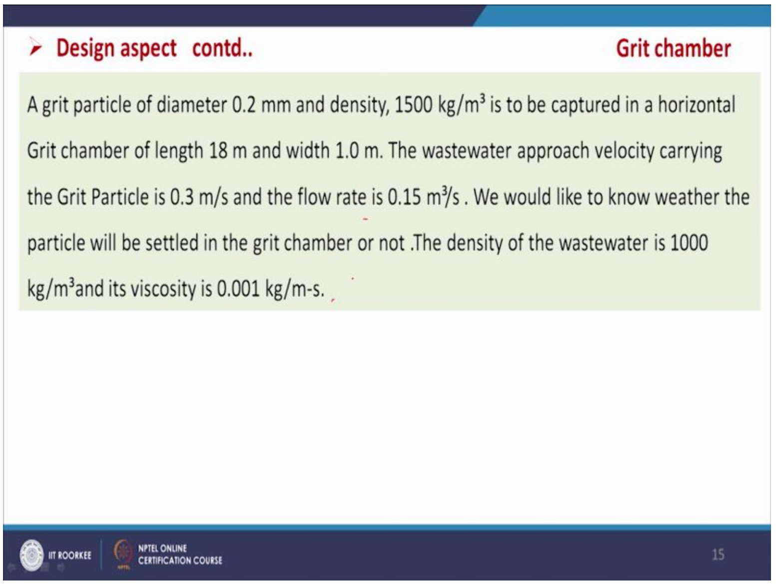

Now, one numerical problem we will see. So, a grid particle of diameter 0.2 mm and density 1500 kg/m^3 is to be captured in a horizontal grit chamber of length 18 m and width 1 m. The wastewater approach velocity carrying the grit particle is 0.3 m/s and the flow rate is 0.15 m^3/s. We would like to know whether the particle will be settled in the grit chamber or not. The density of the wastewater is 1000 kg/$m^3$and its viscosity 0.001 kg/m-s.

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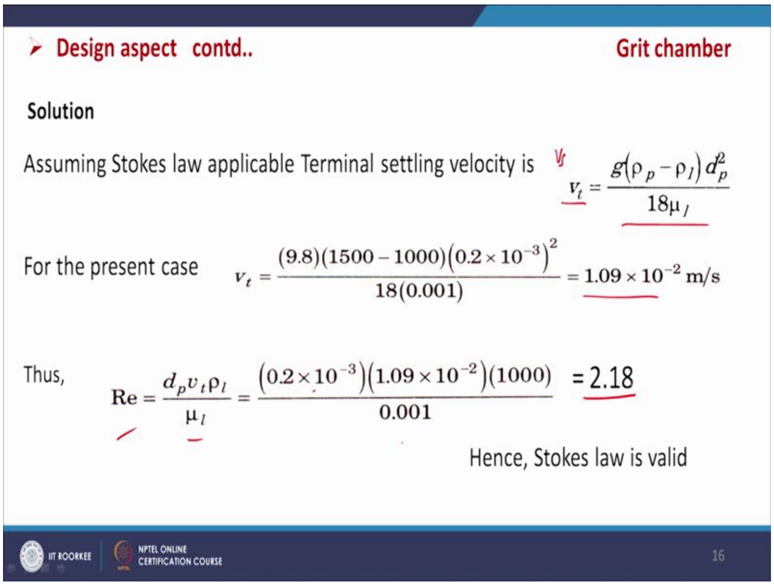

So, in this case, we can assume that the laminar flow regime is there. So, Stokes law can be applicable. So, if we apply the Stokes law we can determine the Vt terminal settling velocities that is Vs which mentioned in the previous slide that is equal to Vs, Vs, Vt same. So, g into dp minus dl into dp square by 18 mul. These expressions already we have discussed in our previous classes.

$$v_t = \frac{g\,(\rho_p - \rho_l)d_p^2}{18\mu_l}$$

$$v_t = \frac{9.8\,(1500 - 1000)(0.2 * 10^{-3})^2}{18(0.001)} = 1.09 * 10^{-2}\ m/s$$

So, what will be the Reynolds number? The particular Reynolds number

$$Re = \frac{d_p v_t \rho_l}{\mu_l} = \frac{(0.2 * 10^{-3})(1.09 * 10^{-2})(1000)}{0.001}$$

Re = 2.18 So, Stokes law is valid.

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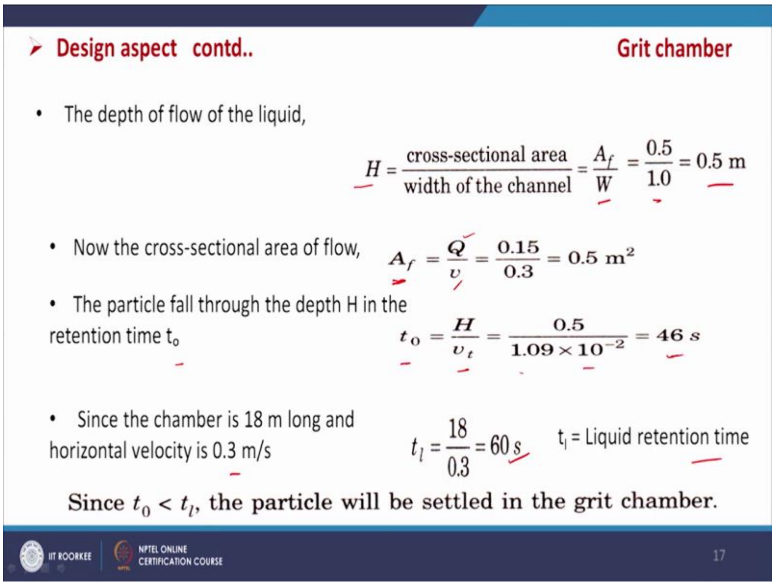

Now, the depth of flow of the liquid we have to calculate. So, if it is H and if we multiply the width of the channel then we will get the cross-sectional area. So, cross sectional area is the height * width of the channel.

$H = A_f/W = 0.5/1.0 = 0.5$ m

Now, A_f we can calculate the cross-sectional area if we know the volumetric flow rate divided by linear velocity then also we can get the A_f.

$A_f = Q/v = 0.15/0.3 = 0.5\ m^2$

The particle falls through the depth H in the retention time to, if it is the retention time is t_o

$t_o = H/v_t = 0.5/(1.09*10^{-2}) = 46$ s

And since the chamber is 18 m long and the horizontal velocity is 0.3 m/s. So, time taken to travel the chamber horizontally,

$t_l = 18/0.3 = 60$ s

So, since the t_o is less than t_l the particle will be settled in the grit chamber.

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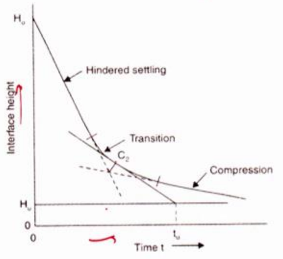
➢ Design aspect contd.. Zone settling — Sedimentation tank

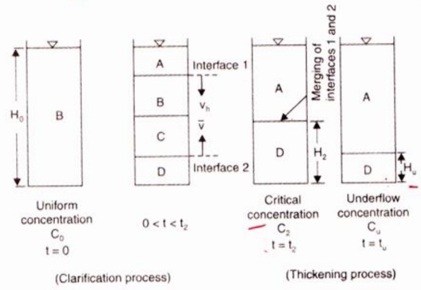
Suspension is dense and the particles are so closely spaced that the velocity field of the fluid is displaced by the adjacent particles during settling overlap

Upward movement of fluid reduces settling velocities of particles (hindered settling)

Example - Secondary clarifier



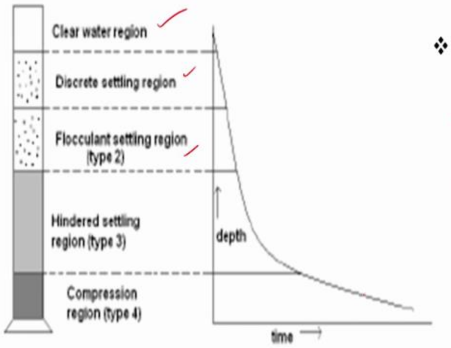
Characteristic settling curve



Zone-settling at different time intervals

➢ Types of settling

The settling phenomenon that occur when a concentrated suspension, initially of uniform concentration throughout, is placed in a gradual cylinder is As follows



- In systems with high concentration of suspended solids, both hindered or zone settling and compression settling occur in addition to discrete (free) settling and flocculent settling

➢ Design aspect contd.. Determination clarifier/thickener area

The area required for clarification is given by:

$$A_c = \frac{Q}{v_h}$$

A_c = clarification area,

Q = overflow rate,

v_h = Subsidence velocity in the zone of hindered settling

v_h can be obtained from the hindered settling portion of the curve

Now, we will discuss on the zone settling. So, zone settling if you have when the suspension is dense and the particles are so closely spaced that the velocity field of the fluid is displaced by the adjacent particles during settling overlap, upward movement of fluid reduces settling velocities of particles and that is why the settling velocity reduces because of the upward thrust and this is called hindered settling.

An example is a secondary clarifier. So, in secondary clarifier we experienced the hindered settling and which actually happens in case of industrial sedimentation unit for getting more understanding on it we can do some jar test and in jar test we have seen, if we allow it initially mix some solids and water in slurry and then make uniform concentration and allow it to settle then initially it will be HO, but gradually we will get four different layers.

That is we have just discussed that it is clear layer, then discrete settling, then your flocculant settling, then hindered settling and then compression. So, these four A, B, C, D basically we will get and if we allow more time, then we will see that these four zones are basically converted to two zones A and D. B, C in between these are overlapped and it is vanished only two layer we get.

And after certain, this time is called critical concentration, when we get two layer. And if we provide more time, then this will be condensed that is compression settling. So, then this height will be reduced and finally, this Hu we will get that is this D volume. This Hu will not reduce further, there is ultimate height we are getting. And here we are assuming all the solids which are present initially, now it is concentrated here.

Now, if we want to collect it in your real plant, if we want to get the underflow with certain concentration, that concentration may be similar to here in our lab experiment. So, zone settling at different time intervals, we can see this type of settling will be there, and this settling data we can get and that can be plotted in this graph, that is interface height, and this is our time.

So, this is our experimental setup initially. So, these layers will be finally merged and we will get two layers and this compression zone will also further reduce, and we will get this with time versus height. So, initially height will reduce, reduce, reduce, reduce and time will increase. So, this type of graph we will get. So, here we see this is our compression zone, this is yours hindered settling.

So, if we can extend, so, they will meet somewhere and then from this we will make a tangent here. So, this C_2 point, this C_2 corresponding C_2 is called the transition concentration and the time we will get that is the $t = t_2$ or that is called critical concentration we can get.

Now, if we are interested to get the dimension of the sedimentation tank or the diameter of the sedimentation tank which is required for a particular application. So, we can calculate it by two way. You see here what happens in case of real practice we are getting two zones so from the top we will be getting clear liquid from the bottom we will be getting concentrated sludge.

So, this will be called as thickening zone and this will be called as clarification zone. So, the two zones may have different surface area and what surface area will be more that will be considered for the design purpose. So, now the area required for clarification we can determine by this approach.

$A_c = Q/V_h$

So, here you see. So, V_h that is in case of hindered settling, what is the V_h we are getting that V_h into cross sectional area that will be the liquid which is going out through the clarifier zone. So, what slurry is getting entry some part is going out and some part is going up. So, which is going up that will be free from the solids and that will be clear liquid and that is the consideration here.

So, we need to get the value of V_h. So, V_h can be determined from this part that is $\Delta H/\Delta t$, this is our ΔH and this is our Δt. So, any point if we take from this point to this point. So, here ΔH and this is our Δt, so $\Delta H/\Delta t$ will be our V_h, so that way we can calculate. So, then we can calculate V_h from that and this is subsidence velocity in the zone of hindered settling and can be obtained from the hindered settling portions of the curve.

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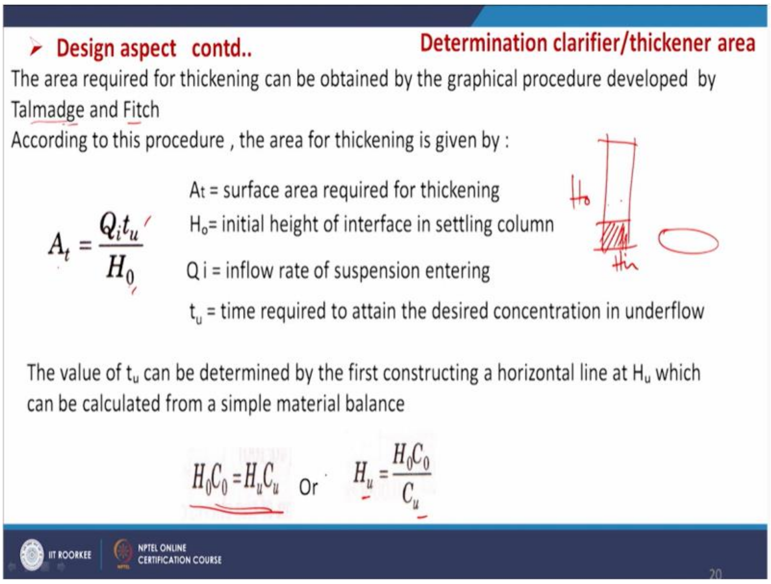

And in the thickener zone if I want to get the area requirement, then we will be doing some mass balance. So, what here we are considering that A_t is the surface area required for thickening so

$$A_t = \frac{Q_i t_u}{H_o}$$

H_o is the initial height of the interface in settling column. So, if we had a settling column, so then we had initial height, so this is equal to H_o. So, this H_o*A_t, we are considering one cross-sectional area in the real settler or thickener. What is Qi? In flow rate of suspension entering into the column and t_u is the time required to attend the desired concentration in the underflow.

Say if we are interested to concentrate the slurry to a particular concentration so say some ppm to some percentage in the sludge and from the top we will be getting solid free liquid. So, here H_o, the height of it into Ai that is into volume of this the total volume which was present here in our lab case we are talking about. So, this into this into concentration that is equal to how much liquid is passing through the sedimentation unit that is your Q_i*t_u, because t_u time required to attain the desired concentration in underflow.

So, to get all the solids here, so, some time is required, so that is t_u. So, within these t_u how much liquid has come into the real sedimentation unit in the industrial sector, so that we are comparing with this our lab scale data. So, that

$H_o*A_t*C = Q_i*t_u*C$,

$A_t*H_o = Q_i*t_u$.

So, that we are getting. And what will be the value of H_o we know and t_u value we have to calculate. So, for t_u value calculation, there are some method. So, they have proposed that

$H_oC_o = H_uC_u$.

So, what is H_uC_u? So, this will be the H_u. And C_u will be the concentration of the slurry here after concentration. So, that we can, H_u value can be determined by this mass balance, H_u into total solids which are present here. Now, we are assuming all the solids are coming in concentrated in the lower part. So, upper part is completely free from the solids. So,

$Hu = H_oC_o/C_u$.

H_oC_o we know and C_u we can calculate, here we can get the value of C_u by experimentation. So, H_u value we will get. So, knowing the H_u value will be getting the value of t_u. How this can be possible?

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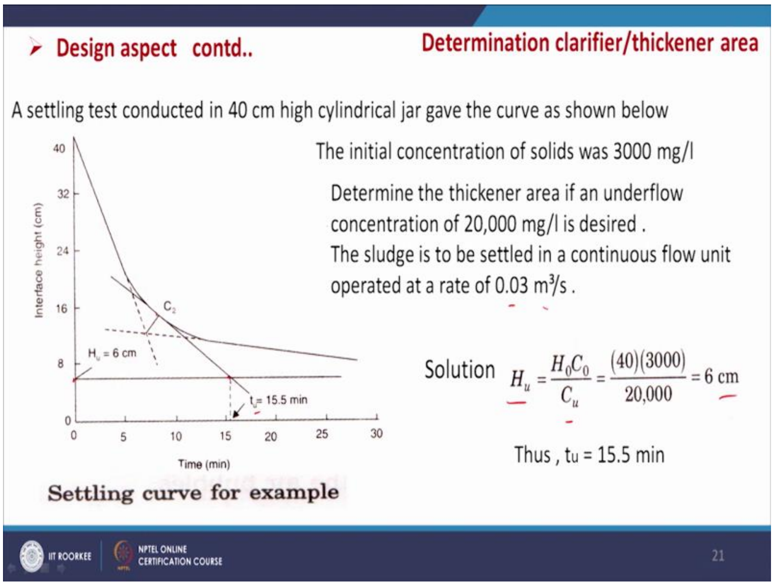

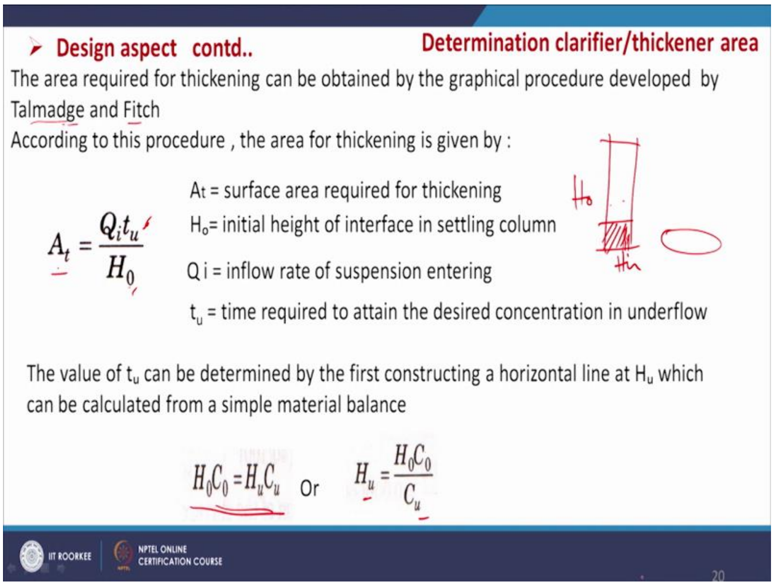

You see here we have our settling curve. So, this is our hindered zone and settling zone, compression zone, so we will extend it crossing this we will make a tangent here the C_2 and then H_u value we have got we will mark that H_u value in this case, then we will make a horizontal line here. So, that will make a cross section with this line. So, that corresponding t is our t_u. So, this t_u will be using in our previous expression here to get the value of A_t. So, this is the process which is used to determine the area requirement for the thickening part.

One example is given here, a settling test conducted in 40-cm-high cylindrical jar gave the curve as shown below. So, this is a curve, it is shown. The initial concentration of the solid was 3000 mg/L. Determine the thickener area if an underflow concentration of 20,000 mg/L is desired the sludge is to be settled in a continuous flow unit operated at a rate of 0.03-m^3/s. So, this is a industrial problem. We are considering that our jar test will be performed with the same initial concentration of the slurry.

And the concentrated C_u which we will be getting that also be same one. So, now in this case, we have discussed

$H_u = H_oC_o/C_u = (40)(3000)/(20000) = 6$ cm

So, here in this we will go up upto 6 centimeter, make a horizontal line and that will cross intersect this point and the corresponding t_u is our 15.5 minute in this case we are getting.

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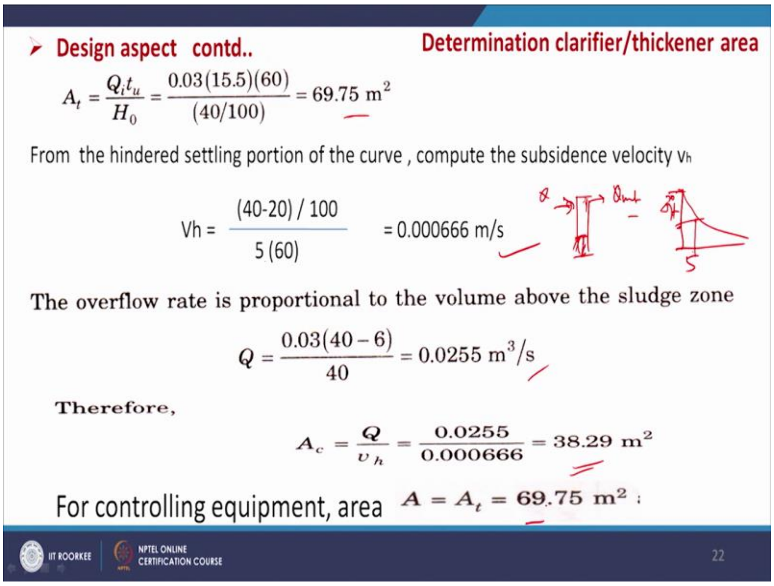

At = Qi*tu/ Ho = 0.03*(15.5)(60)/(40/100) = 69.75 m^2.

This is what thickener zone area requirement. And from the hindered settling portions of the curve, we can compute the subsidence velocity V_h,

$V_h = ((40 – 20)/100)/(5*60) = 0.000666$ m/s

So, overflow rate is proportional to the volume above the sludge zone that means, now we are getting two zones, so, this will be sludge and this will be free from the sludge that clear water will go.

So, if the inlet flow is our Q, then what will be the Q out.

Q = 0.03(40 – 6)/40 = 0.0255 m^3/s

So, we will put this Q as a output and S is equal to that will be going as a overflow.

Ac = Q/v_h = 0.0255/0.000666 = 38.29 m^2

So, here we see in a clarification zone area requirement is 38.29, for thickening zone 69.75 m^2. So, for design purpose we will consider the area requirement as 69.75 m^2.

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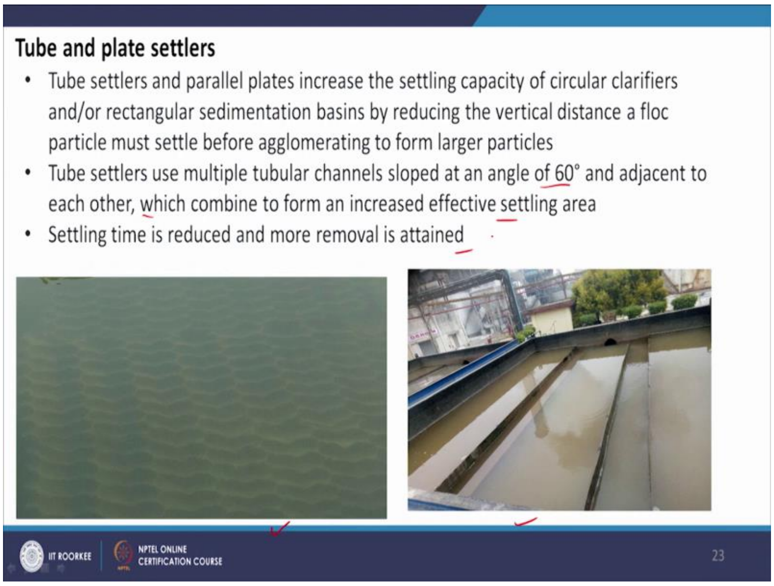

So, now, another important type of sedimentation unit which is used that is tube and plate settlers, these are some improved versions, the efficiency is more than the conventional sedimentation unit in this case. So, here this is our tube settlers and this is our parallel plates in our rectangular sedimentation unit. So, this installation of these plates reduces the requirement of height for the separation.

So, tube settlers and parallel plates increase the settling capacity of circular clarifiers and rectangular sedimentation basins by reducing the vertical distance, a floc particle must settle before agglomerating to form larger particles. And tube settlers use multiple tubular channels sloped at an angle of 60 degree and adjacent to each other which combined to form an increased effective settling area and settling time is reduced and more removal is attained. So, by this way more settling is possible and the efficiency of the settler is increased, residence time requirement is reduced as a result, the capacity of the ETP is increased.

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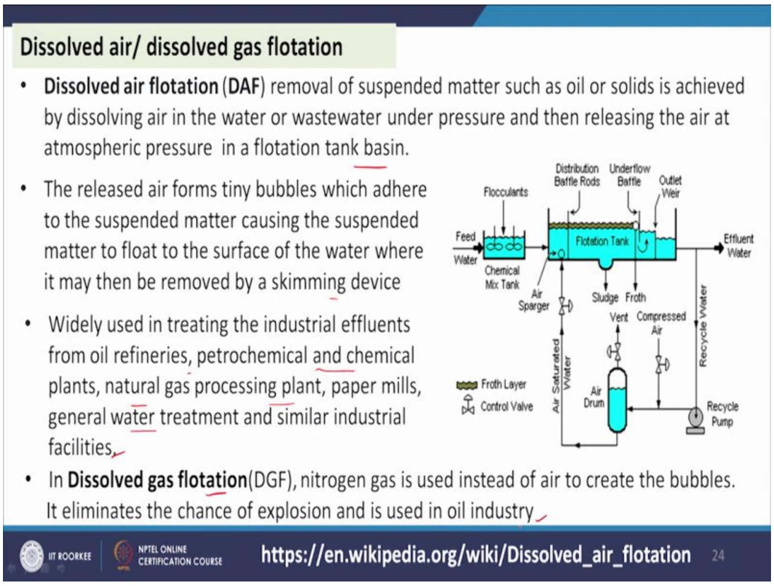

And then dissolved air flotation or dissolved gas flotation. So, we have another type of when we have say oil and grease like these type of materials which are, having lower density. So, that can be separated and to increase the efficiency of this flotation unit air is sent. So, air will be sent here. And also, this is our wastewater is coming. So, flocculant is added, so air will help and it will make the hydrophobicity, air will increase hydrophobicity and separation from the water and it will go up and it will be collected here.

So, dissolved air flotation removal of suspended matters such as oil or solid is achieved by dissolving air in the water or wastewater under pressure and then releasing the air at atmospheric pressure in a floatation tank basin. And the released air forms tiny bubbles which adhere to the suspended matter causing the suspended matter to float to the surface of the water where it may then be removed by skimming device.

And widely used in treating the industrial effluents from oil refineries, petrochemical and chemical plants, natural gas processing plant, paper mills, general water treatment and similar industrial facilities and dissolved gas floatation is also used in some cases when say explosive materials are present to reduce or to eliminate the chance of explosion nitrogen is used in place of air so that is called dissolved gas flotation and the mechanism is similar. So, these are the different types of equipment which are used in primary treatment processes. So, up to this in this class. Thank you very much for your patience.