Water and Wastewater Engineering
Prof. C. Venkobacher
Department of Civil Engineering
Indian Institute of Technology, Madras
Lecture-17

In the last class we were discussing about the wastewater treatment and the various processes that are employed for the treating the wastewater. Number one we said about the primary treatment and we have seen the various units that are put in place to remove the suspended solids, after that we discussed about the secondary treatment wherein we aimed at removing the dissolved organic matter. Today we will discuss about what is called a tertiary treatment third degree type of treatment to the wastewater to remove special components present in the wastewater.

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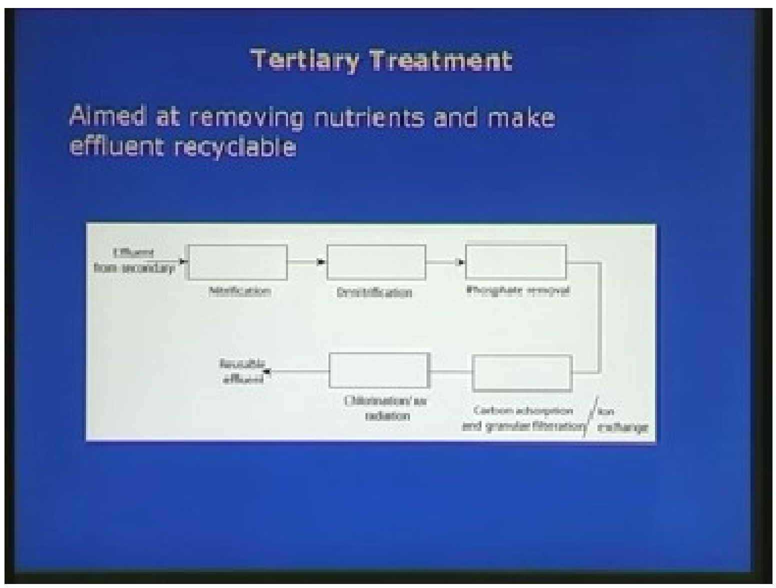

If you look at the wastewater it contains several components. For example, the wastewater contains what is called solids, the solids could be divided into two types; one is the suspended solids and then dissolved solids. The suspended solids could be again of two different types; one is inorganic suspended solids inorganic in nature and another is organic in nature. So we have got both inorganic and organic suspended solids. Similarly for dissolved solids also we have got inorganic solids and organic solids. Hence, as far as the solids are concerned these are the things which are present.

Now in the primary treatment, just to recapitulate, what we tried to do was we tried to remove mainly inorganic solids and to some extent we also removed organic solids suspended so I am trying to remove inorganic solids suspended in this so to some extent inorganic I should say here suspended solids. In the primary treatment this is the objective. In the secondary treatment we try to remove the solids again basically organic in nature. Organic dissolved solids are removed in the case of secondary treatment. That means as far as the secondary and primary treatments are concerned we are trying to remove the inorganic solids and to a great extent organic.

Now, if you see the composition of wastewater, wastewater consists of various components like carbohydrates, undigested carbohydrate which we take and composition of wastewater and it consists of proteins, undigested proteins and it consists of lipids. These are the three major components which are coming out in the wastewater. All these things are organic solids organic in nature and they are also biodegradable. In other words I would say biodegradable organic components or compounds.

Now, if you take proteins, the proteins are of special importance for tertiary treatment which we are going to discuss now. The proteins contain carbon, hydrogen, oxygen and nitrogen. They contain nitrogen compounds which are of importance. The nitrogen compound which is important here, this is the nitrogen compound (Refer Slide Time: 6:28) which is important that is going to be causing some problems. Now what will happen is the nitrogen which is present in the proteins is in the form of ammonia that is fresh wastewater that is not septic**.** Fresh wastewater contains undigested proteins and these undigested proteins are converted into amino acids, protein is the polymer of amino acid that is AA, this is converted into amino acids by microbial action and these amino acids is further degraded by deamination reaction. The deamination reaction is removal of ammonia deamination reaction which is mediated by microorganisms, microbes where all these reactions are mediated by microorganisms converted into ammonia and this ammonia is present in the wastewater.

The ammonia which is present in the wastewater is converted into what is called nitrite and then goes to nitrate. That is, ammonia is oxidized to nitrate and to nitrate. So this step is known as nitrification and nitrification is carried out by microorganisms. This is an oxidation process and during the oxidation process oxygen is required and this has oxygen demand. Ammonia exerts oxygen demand for conversion of nitrite and nitrate so this is called nitrification, this is again microbial reaction.

There are two types of microorganisms which bring about this reaction. After that suppose the nitrate is present in the effluent suppose this oxidation takes place and nitrate is present in the effluent and if the nitrate containing effluent is discharged into the water they cause some problems. The problems that are caused are eutrophication of rivers. eutrophication is nothing but the growth of algae or toliphic growth of algae. Excess growth of algae takes place if nitrate is present in the effluent and that nitrate containing effluent is discharged into the rivers so nitrification will take place.

The second thing is that if the river water is used for the water supply containing high content of nitrate you know what is going to happen. Methemoglobinemia is a disease that affects children that is called blue baby syndrome which we have discussed already. So the nitrate as such cannot be discharged into the environment I cannot discharge nitrate containing effluent into the river water and for that what I have to do is I have to convert this nitrate into some other compound which does not create a problem. So what I do is this nitrate is converted into, nitrate is sort of reduced into nitrogen gas so this is the reduction again there is a microbial reduction and this is called denitrification. Denitrification is a process by which the nitrate in the effluent is converted into nitrogen gas which goes to the atmosphere. This is the effluent here (Refer Slide Time: 11:27).

So what all I have done is that ammonia which is present in the wastewater is converted into nitrate and that nitrate is reduced to nitrogen gas by denitrification process. So this process is carried out by denitrifying bacteria, they are the ones which cause this reduction so finally I am producing nitrogen gas. I have taken care of ammonia and am producing the nitrogen. Nitrogen gas is not a pollutant that is what we know.

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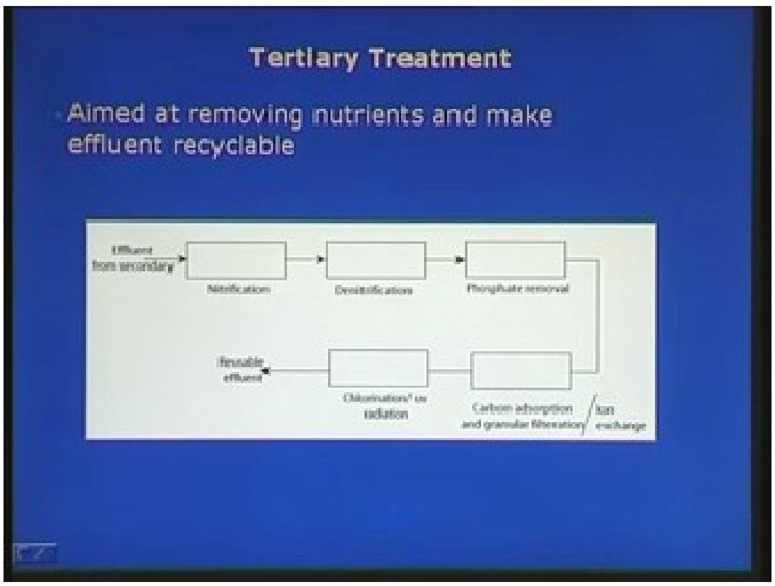

Now, coming back to the slide here we can say that the tertiary treatment is aimed at removing nutrients that is nutrients are nitrate and also phosphorous and make the effluent recyclable, I would like to make the effluent recyclable so that I can use the water. Then if you see the flow diagram; effluent from the secondary treatment plant comes to what is called nitrification tank. What happens in the nitrification tank is ammonia is converted to nitrate and the effluent goes into a denitrification tank. In the denitrification tank the nitrate that has been produced by the oxidation of ammonia to nitrate is reduced to nitrogen gas. So in this particular thing we are producing the nitrogen gas in the denitrification tank. Now this effluent from the secondary is allowed to go the unit called phosphate removal.

The phosphate removal plant could be biological in nature or it could be chemical in nature. So the biological phosphorous removal is normally employed. After removing the phosphorus, phosphorus also causes excess algal growth, algal growth is caused by the phosphorus also so I am removing the nitrate, nitrate has nitrogen gas and phosphate is also removed by the microorganisms after that I will pass the water or this particular thing to what is called carbon absorption columns, carbon absorption columns and granular filtration or granular filtration.

The purpose of doing so is to remove any trace organics that are present. I would like to remove trace organics that are present that means I want make this effluent reusable, recyclable. That means either I can use carbon absorption or an exchange or granular filtration. One of the options can be used. After that we use the chlorination. The effluent is chlorinated either using the conventional chlorine or it could be UV radiation because chlorine is causing some problems nowadays and hence we go for UV radiation.

After this particular thing we have got a recyclable effluent. The effluent they can be recycled, we can use it for various other purposes; recyclable is present here. This can be reused for gardening or flushing or particularly for some other problems. So this is the tertiary treatment which is very specific which is not mandatory at this moment of time to use the tertiary treatment.

But primary treatment and secondary treatment we should have it. primary treatment and secondary treatment removes number one the suspended solids, number two the organic present in the wastewater and we also disinfect it to kill the microorganisms that is the primary and secondary treatment while tertiary is optional. So if you want to recover the water from the effluent we can use the tertiary treatment for that you have to spend money that is nitrification, denitrification, phosphorus removal, carbon absorption and chlorination should be there for this particular thing. So with this particular thing there are three different types of treatment systems. Now we will look into more specifically about each one of these systems. Of course I will be aiming at looking more into the details of primary treatment and secondary treatment. So let us get into more details of primary treatment now.

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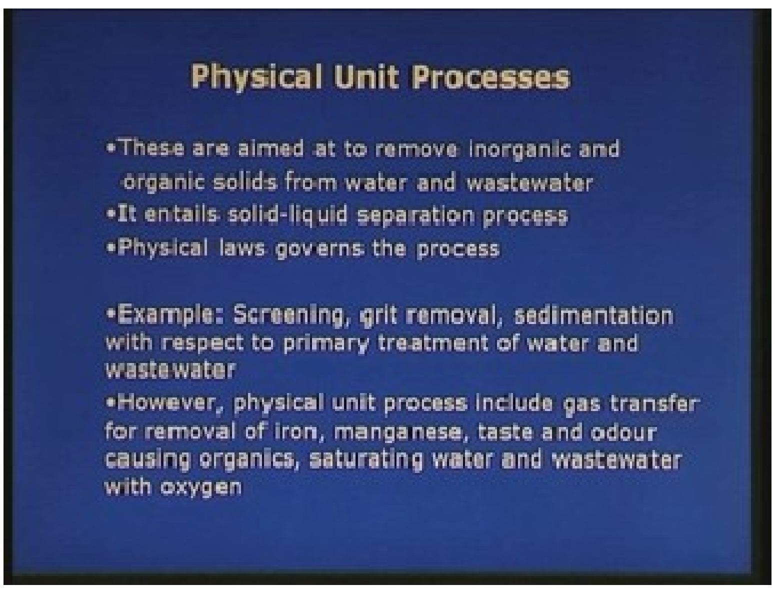

Primary treatment is the physical chemical process so I would like to go into the primary treatment of physical chemical unit. So here this is the physical unit process and these are aimed at removing inorganic solids mostly and organic solids to some extent from wastewater. In fact it entails what is called a solid liquid separation process that is the sedimentation. We use the gravity sedimentation for the solid liquid separation process. Since it is a gravitational process the physical laws governs the process so we can use the physical laws. That is classical mechanics can be used for design of system to remove the solids from the liquids like sedimentation tank and so on and so forth.

Some of the examples of the primary treatment systems we have seen in the last class so I am elaborating on that. I have got the screening, screens are there, we have got grit removal, grit is removed, third one is the sedimentation tank with respect to the primary treatment of water and wastewater. That means we have got mainly the screens then grit removal grit chamber and then sedimentation tank. However, what we could do is a physical unit process can also include gas transfer so gas transfer is also an important physical unit process that we employ for the removal of iron.

How do we remove iron?
Iron is oxidized that is ferrous iron is oxidized to ferric iron and ferric iron is removed as ferric hydroxide. So this particular thing I have already discussed as an example. For removal of iron we use the aeration or the gas transfer. Removal of manganese, manganese should also be removed by the aeration and precipitation sedimentation and then we can also use aeration for the taste and odour causing organics. To remove the taste and causing organics we can use gas transfer.

Taste and odour causing are generally volatile in nature. Whenever the volatile organics are present in water and wastewater by putting the oxygen in it, by forcing the oxygen with turbulence into the water and wastewater we can drive out the taste and odour causing organics. Also, we try to saturate the water and wastewater with oxygen because if oxygen is present in water it is very pleasant. The wastewater also is saturated with oxygen by gas transfer. This oxygen when it enters into the wastewater then water then it supplies the oxygen to microorganisms and the microorganisms utilizes the organic matter and then produce carbon dioxide and the water pollution is removed. That is what we normally do with this particular thing.

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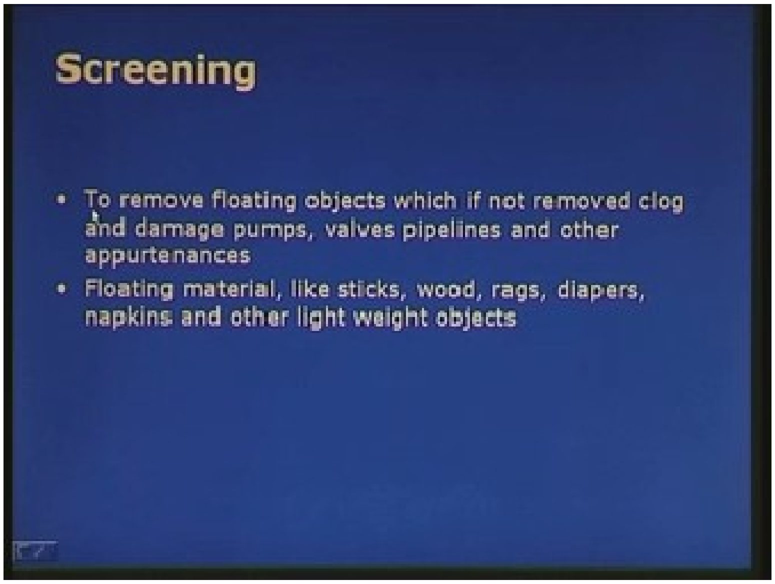

Now let us look at the screening. the objective of the screening is to remove floating objects present in the wastewater which if they are not removed they clog the pumps they damage the pumps, valves, pipelines and other appurtenances that are present in the wastewater collection system. So the wastewater collection system is hampered is damaged because of the floating objects that are present in the wastewater.

So the screening are aimed at removing particular thing. Next, the floating materials like sticks, wood, rags - rags is nothing but a cloth that people use, diapers for babies, now it is a prevalent usage of diapers, sanitary napkins etc and other light weight objects are found in the wastewater and all these things if they are present in the wastewater they are going to damage the pumps, they clog the pumps, they damage the pumps, valves and so on and so forth. That is why they need to be removed.

Some of the design aspects of screens:
There are two types of screens; one is fine screen and another is the coarse screen. Fine screen is characterized by the diameter of the opening, the opening size is less than 15 mm that is the fine screen and coarse screen or bar screen as it is called has a bigger opening so that is greater than 15 millimeter which is the opening size of the screen. Then these screens are usually made up of bars, rods or wire grating or wire mesh or perforated plates. These are the materials that are used and these are various shapes. It could be bars, it could be rods, it could be wire grating and mesh type of thing. And the shape of the opening is circular or rectangular. That means between the two bars it could be a circular opening or it could be a rectangular opening. That is what we have said.

Then once you have these screens in the direction of flow the flow passes through these screens and other things and the material gets deposited on the screens so that material which gets deposited on the screen should be removed that is done by cleaning. There are two types of cleaning; one is cleaning can be manual manually we can clean it, remove the screenings that deposit we can remove or there is mechanical cleaning, there are mechanical cleaning devices also available for this. then the bar screens or the coarse screens the file screens, these bar screens are made up of vertical bars so there is not much difference between the fine screens and coarse screens in terms of the design but the only thing is that the coarse screens remove a bigger material and fine screens will remove a finer material so that is what it is.

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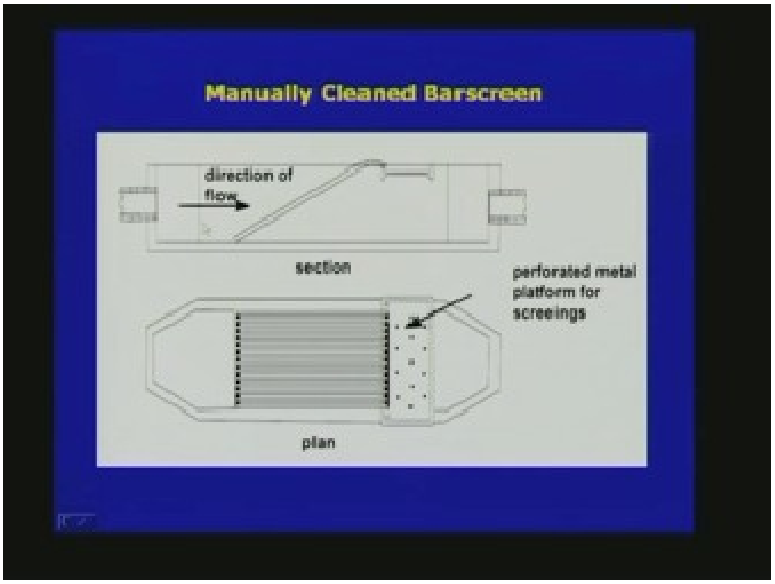

This is the design aspect of screen if you take, this is the plan view and this is the section, the top one is the section of the screens. So, the wastewater is coming in here (Refer Slide Time: 23:40) this is the direction of flow of wastewater and there is an inclined bar screen, the screen is there and if you see in the plant this is the screen what we have and then these screens have got the openings between these two things we can see openings and the materials are sort of deposited and this particular thing is moving up and then this is going up and then this is the place where the perforated metal platform for the screenings. Screenings are deposited here and those screenings are removed manually and then we have the wastewater going out.

This is a very simple arrangement of the screens that is possible for removing the floating material from the wastewater.

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Now, this is another picture of the screen. This can automatically operate and then you can remove the screening. Now the third one is some of the design aspects of these screenings are indicated here in this table.

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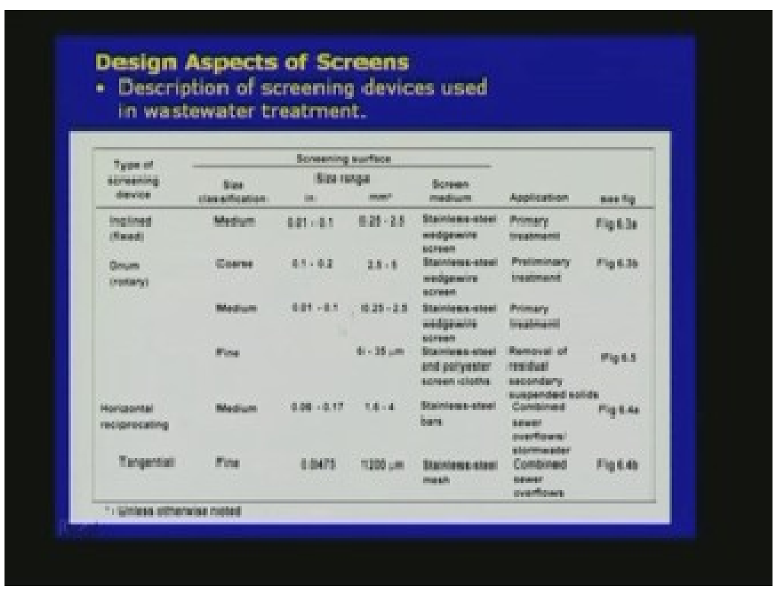

Type of screening device	Screening surface: Size classification	Size range: in	Size range: mm*	Screen medium	Application	see fig
Inclined (fixed)	Medium	0.01 - 0.1	0.25 - 2.5	Stainless-steel wedgewire screen	Primary treatment	Fig 6.3a
Drum (rotary)	Coarse	0.1 - 0.2	2.5 - 5	Stainless-steel wedgewire screen	Preliminary treatment	Fig 6.3b
	Medium	0.01 - 0.1	0.25 - 2.5	Stainless-steel wedgewire screen	Primary treatment	
	Fine		6 - 35 μm	Stainless-steel and polyester screen cloths	Removal of residual secondary suspended solids	Fig 6.5
Horizontal reciprocating	Medium	0.06 - 0.17	1.6 - 4	Stainless-steel bars	Combined sewer overflows/ stormwater	Fig 6.4a
Tangential	Fine	0.0475	1200 μm	Stainless-steel mesh	Combined sewer overflows	Fig 6.4b

*: Unless otherwise noted

This table tells some of the design aspects. For example, type of screening device, what type of screening device we have and then here is the size and classification, third is the size range in millimeters and then screen media, what type of media which it is made and then applications of these screens and also the figures which I am going to present afterwards.

Now let us see the types of screening devices. One is inclined, I like to suggest one thing. this is a fixed type of screen then you have got a medium size characterization and it has got a size of 0.25 to 2.5 millimeters is the size of opening between the screens and then this is made up of stainless steel and also the stainless steel which were screens. So the purpose this is a primary treatment. It can be used for primary treatment. In the figure I will show it later on.

The second thing is a drum. A drum is a rotating type of screen where the flow is there, flow passes through it and then the material is screened. So this is normally coarse and the size is 2.5 to 5 millimeters. Here we say 0.25 to 2.5 millimeters is fine but here it is 2.5 to 5 millimeters in size and then this is also stainless and here we have the figure for the primary treatment or preliminary treatment as some people call it. There are coarse, medium and fine types of things and we have got the reciprocating type of thing and another thing is the sort of tangential type of thing.

Now we like to discuss the various types of screens. We can see here in the pictures.

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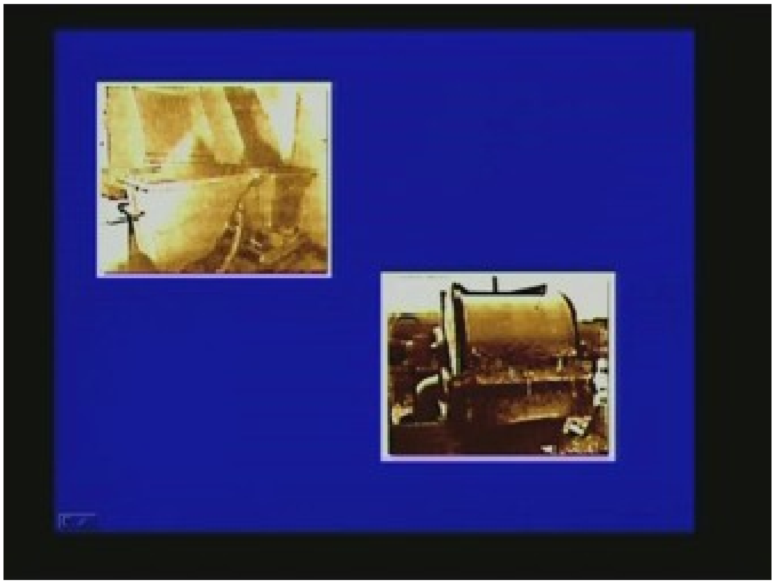

This is one type of screen which I have indicated as 6.3 and this is the rotating drum type of screen and this is also again another type of screen for a very big wastewater treatment plant that is in operation.

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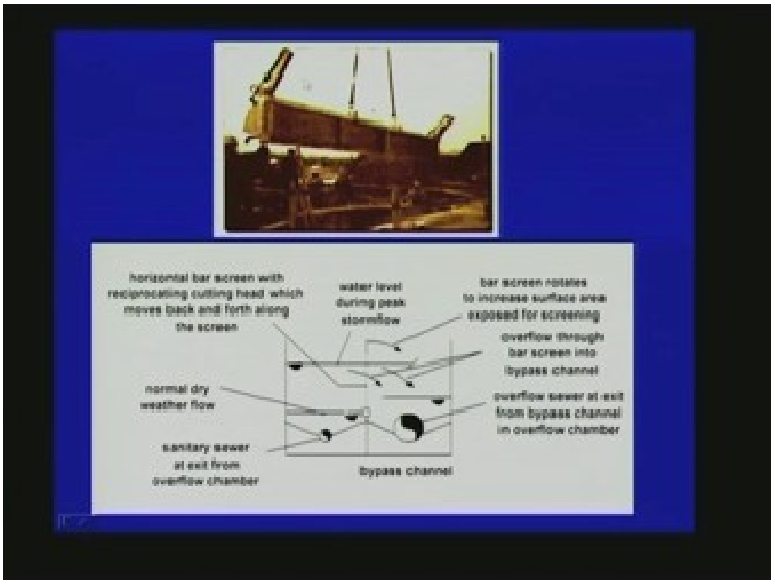

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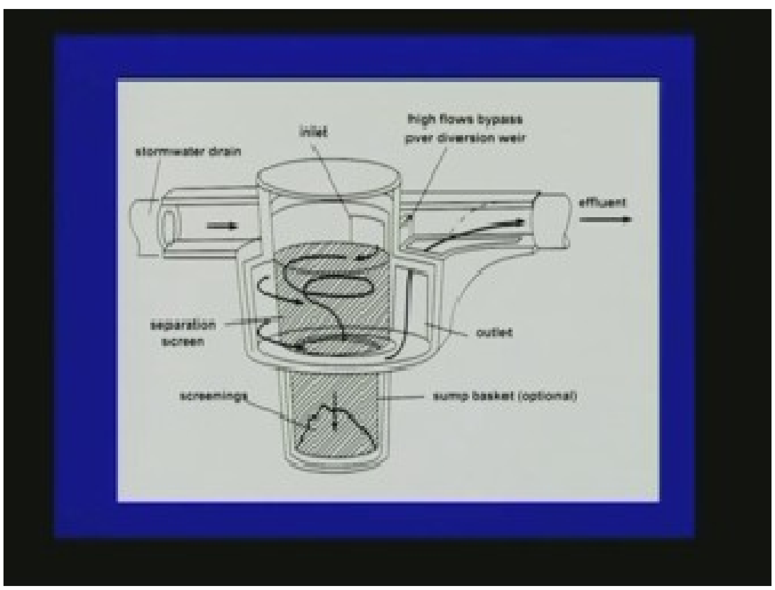

This is another type of screen where the material comes in here, the liquid comes in and flows through this and gets screened. The effluent after screening will go out like this. This (Refer Slide Time: 27:25) is the direction by which it goes, this is the influent and this gets screened and goes out in this effluent and the screenings are collected at the bottom.

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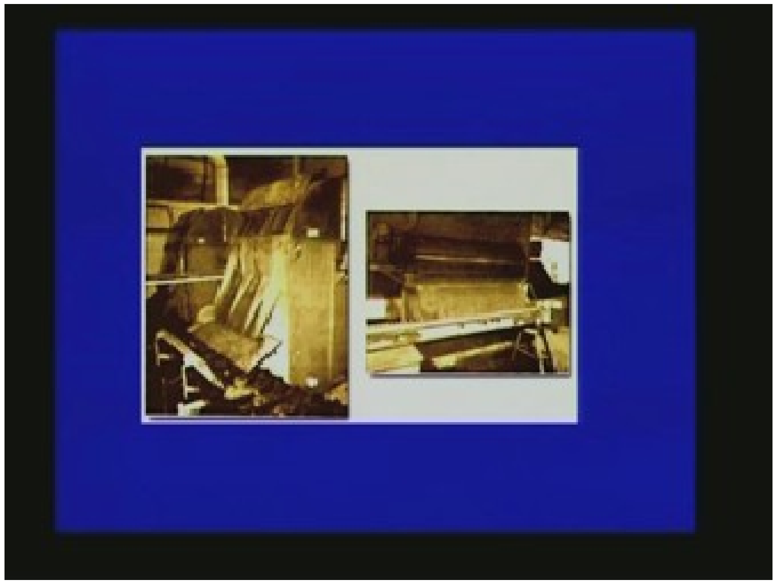

This is another thing the scraper blade where the screenings are removed from this thing. Here again there is another modification of that particular thing. Now if you look at the design aspect how do we design these screens? Screens I am talking about is a very simple type of screen. The screens are designed based on the approach velocity and also the channel in which the screen is placed the channel should be straight forward, straight section of the channel should be there, about 10 to 15 meters straight channel should be there.

So, for design approach the minimum velocity is one meter per second to avoid settling of solids. This is the biggest problem. The problem is that if you do not maintain a velocity which is sufficient for the particles to remain in suspension then what would happen to the particle is that the particles will settle down in the channel. And once the particle settles down in the channel the carrying capacity of the channel is reduced and the solids tend to settle down and then they biodegrade and cause lots of nuisance. That is why a minimum of one meter per second velocity should be maintained to avoid settling.

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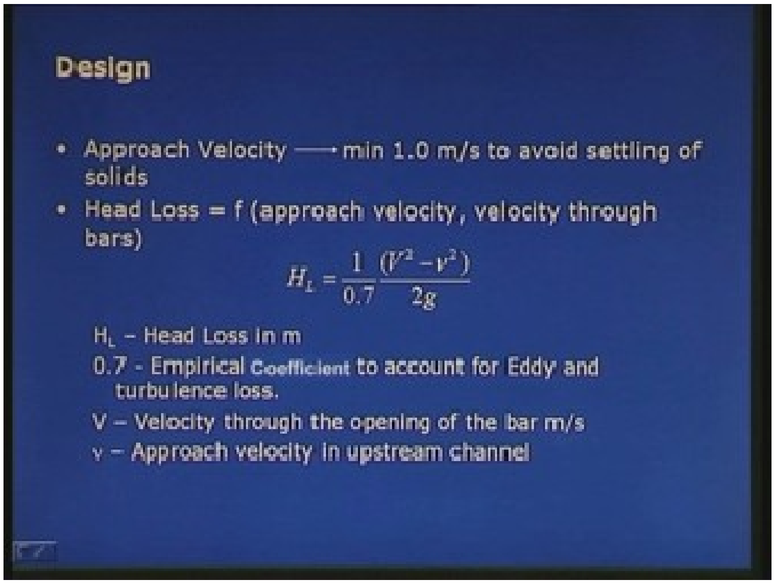

Head loss:
Whenever the flow is taking place through the screens and when the particles get deposited on the screens there is going to be a pressure drop or head loss. That head loss, loss of head is a function approach velocity, velocity with which the liquid is coming and velocity through the bars. That means the approach velocity; velocity with which water is coming, wastewater is coming and also the velocity through the screens. That is given by HL, HL equal to V square minus v square over 0.7 into 2g where hl is the head loss in meters, 0.7 is empirical discharge coefficient or value to account for eddies and turbulences, V is the velocity through the opening of the bar, v is the approach velocity in the upstream channel, this is also in meters per second.

You can see very clearly that the approach velocity is smaller than the velocity through the screens. Why? The velocity through the screen will be higher because area of cross section is going to decrease that is the reason why the velocity will be higher. That means V is the velocity through the opening that is the higher value and v is the approach velocity of the channel.

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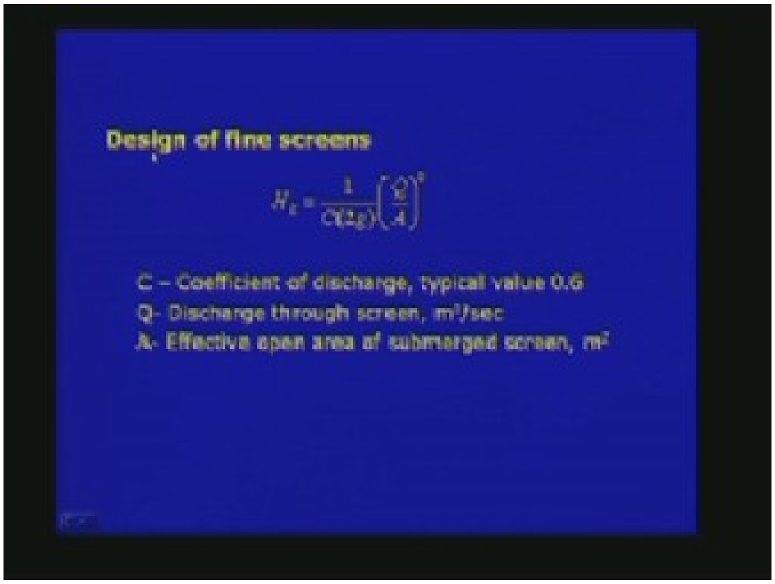

Now, if you take the fine screens then the head loss equation is given by 1 by that is loss of head is given by 2 into 1 by c into 2g multiplied by Q by A square so this is equation that is there where c is the coefficient of discharge, typical value is taken as 0.6 and Q is the discharge through the screen and cubic meter per second, A is the effective open area submerged screen. That means how much area of the screen is submerged in the liquid that is given by effective open area of submerged screen that is the square meters. So initial head loss if you see here at the bottom, it is 0.1 meter. That means if the wastewater is flowing through the screens there is a head loss, that head loss is 0.1 and then permissible head loss is point three meters.

Permissible head loss means when the particles get deposited on the screen the head loss is going to increase, that increased head loss, and permissible head loss is going to be about 0.3. Here is the graph which shows a relationship between the opening between the bars that is opening between the two bars the screens and also the amount of screenings that is cubic meters of screenings per million cubic meters of wastewater. If I pass one million cubic meters of wastewater how much of the screenings will be deposited on my screens. That particular relationship is given by this.

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This is taken from Metcalf eddy wastewater treatment so the maximum value is given by this particular curve. This is the maximum value, maximum amount of screenings and this gives the average value, average value is this value.

What you mean by maximum value and average value?
Maximum value is when the flow rate is maximum and for average it is average flow rate. What is the cubic meters of screenings that have been deposited on the screens per million cubic meter of wastewater is what it is. And as you see here the opening between the bars are increasing and the amount of screening is going to decrease.

Why it is going to decrease?
The reason it is going to decrease is because some of the material will escape out of the screening, they will be going in the effluent that is the reason why at one centimeter width the screening removed is so much and if you have three centimeters as the bar spacing the screening will be very less. Thus, screening is going to be less if you increase the space between the screens.

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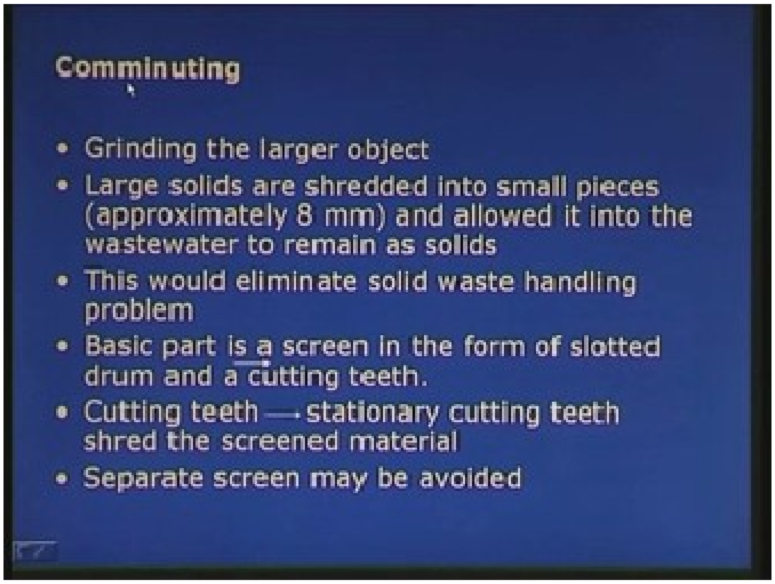

Next important unit operation in the physical treatment plant is communiting. Communiting means grinding larger objects that are found in the wastewater. Large solids are shredded that means cut into small pieces, shredded means cut into small pieces approximately of the size of 8 mm and these small pieces are allowed into the wastewater to remain as solids. So we would like to allow these solids to be present in the wastewater. So these large solids are cut into pieces and then they are allowed to go into the wastewater.

Therefore, many of the sinks in the kitchens have got these grinders at the bottom. The purpose of the grinder is that when you put some of the material that is the food particles and the residue of vegetables and so on and so forth bigger than the size what they will do is that they will grind it, this grinder is placed underneath the sink in most of the developed countries so that will cut these into small pieces and those will go into the wastewater. This would eliminate solid waste handling problem. So, from the kitchen waste etc we can eliminate the solid waste handling problems.

A basic part of a screen is in the form of a slotted drum and cutting teeth. The cutting teeth are the one which shreds the large solids into small particles. Cutting teeth is the stationary cutting teeth that shred the screened materials. The material is screened and then it is shred by the stationary cutting tool. By having this type of thing that is the shredder, cutter or cutting teeth and also a slotted drum which is acting as a screen we can avoid having separate screens. We need not have to separate screens. Comminuting itself can do shedding and as well as the screening.

Design aspect of the shredder is similar to the screens. I will not go into the details because it is similar to that particular thing. Now let us take the third important unit in the primary treatment which is the grit or grit chamber.

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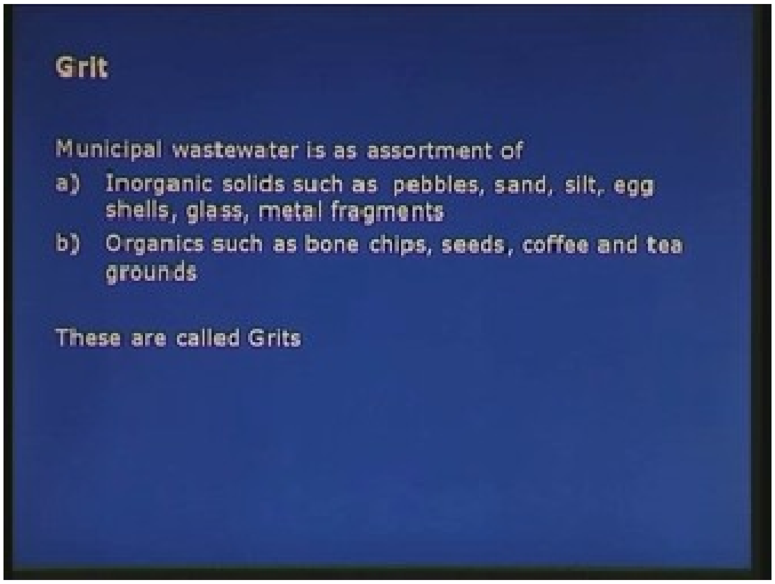

Grit has to be handled. If you consider the municipal wastewater it is an assortment that means it is a combination of various things. It is an assortment of things like inorganic solids such as pebbles, sand, silt, and egg shells, glass, metal fragments so all these things are present in the municipal wastewater. And then they also have organic such as bone chips, seeds, then coffee and tea grounds. All these things are present in the wastewater so these are all termed as grit. We term these as grit. Grit is not just sand, grit is pebbles, sand, silt, egg shells, glass, metal fragments and all these. You know, we have a habit of throwing everything into the sink or everything into the water closet, so that the water closet takes it away from our sight the unwanted materials. So, organics such as bone chips, seeds, coffee and tea and so on and so forth are all called grits.

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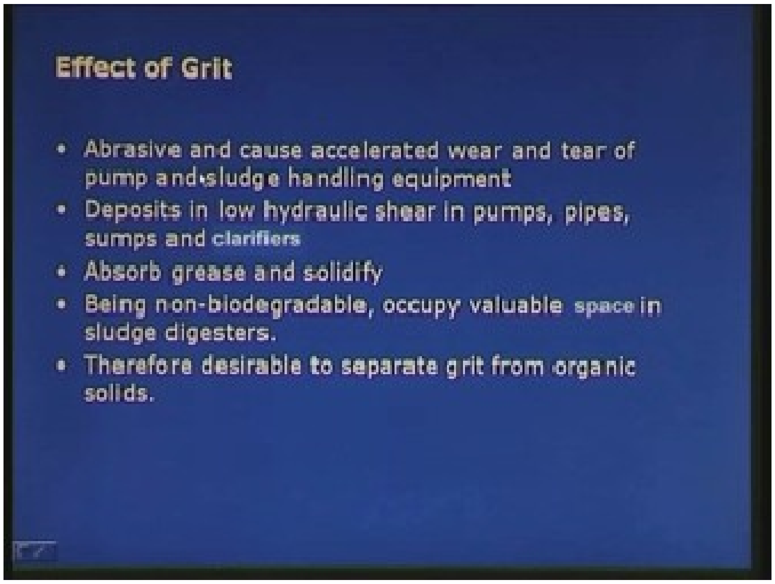

Suppose if the grit is present in the wastewater and if I do not remove it then what is going to happen. So this grit is abrasive and cause accelerated wear and tear of pumps and sludge handling equipment this is very important. It erodes, sometimes it may not corrode but it erodes. It speeds up the wear and tear of the pumps and sludge handling equipment. So we have several sludge handling equipments which go out of order because of this wear and tear. Then these grits deposit wherever it is possible. Where it is going to deposit? It is going to deposit most likely in places where low hydraulic shear is there, where low flow conditions are there in pumps, in pipes, sumps and clarifiers. Clarifiers are the sedimentation tanks which we are going to use so all these grits are going to settle down there whenever there is a low hydraulic shear. Low hydraulic shear means when we do not have much of the velocity.

They absorb grease. these grits have another property because it offers lot of surface area and because they offer surface area the oil and grease which is present in the wastewater get absorbed onto the grit as a result of which the absorbed grease solidify and as a result there are what is called grease balls that are produced. This grease is absorbed on the grit. And the grit definitely are non biodegradable organics they cannot be degraded because bone chips is non biodegradable, egg shells is non biodegradable, grit is non biodegradable, pebble is non biodegradable so being non biodegradable they just sit in the sludge digesters. That means they occupy the space in the reactors which we design for the treatment of organic matter. They occupy a valuable space in the sludge digesters, they just go and sit there, they cannot be removed, they cannot be degraded, they are conservative chemicals so they keep on accumulating as a function of time. Therefore it is very essential desirable to separate grit from the organic solids.

We have to separate the organic solids from the grids because organic solids are biodegradable, organic solids undergo a change, they are non conservative, while the grit is a conservative chemical it cannot change so it occupies the space that is why we should remove the grit from the wastewater before it goes to the secondary treatment. We have grit removal facilities.

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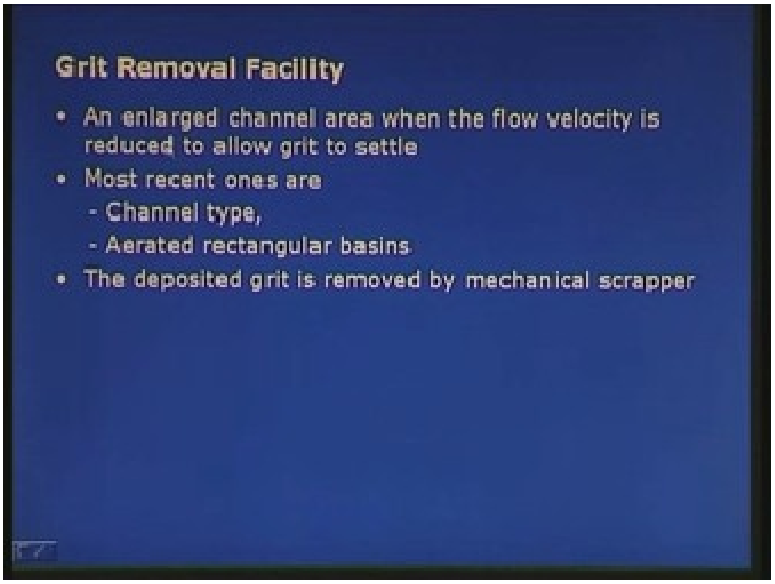

Many grit removal facilities are there. One of the easiest, one of the most common grit removal facility is; have an enlarged channel area, that means the channel is there carrying the wastewater, I suddenly increase the channel area, I make the channel with bigger thus increasing the channel area and when I increased the channel area what would happen is the velocity would not remain the same because the channel velocity is there and as soon as I increase the area the velocity reduces. When the channel area is increased the velocity is reduced and this reduced velocity allows the particles that are the grid to settle down by gravity that means it allows gravity settling, gravity settling of the grit will take place.

The most recent ones are; this is enlarged area, channel type is whatever we discussed, enlarging the channel area, decreasing the velocity will sort of enhance the settling of the particles. Second thing is aerated rectangular basins. We have got rectangular basins specially designed as the grit chambers wherein the rectangular basins again the same principle is followed, I am going to decrease the velocity of the flow and when the velocity of flow is decreased the particles will settle down in the basin, in the grit chamber and they are also aerated.

The purpose of aeration is that I do not want to make the whole sewage septic that is one thing, I will aerate it and also this aeration will keep supplying the oxygen for the microorganisms that may be present in the wastewater. So aerator rectangular basins are generally used in the western countries. However, in India mostly we have got the channel type of grit removal facilities. And then at the bottom of the tank the grits are deposited, the deposited grit is removed by mechanical scrapper that means there is an endless chain moving up and then the grit is removed. Let us see some of the aspects of grit removal facilities.

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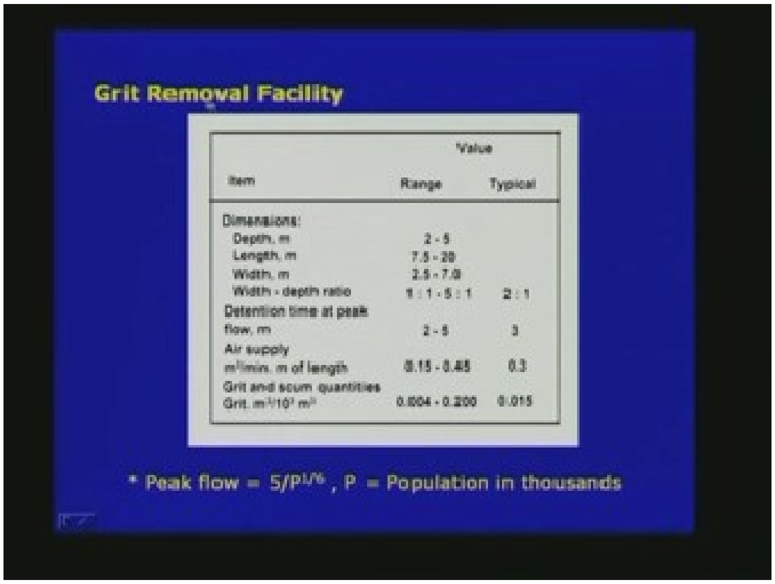

Here are various design parameters for the aerated grit chambers. Again I am taking the source from the book Metcalf and Eddy and we have got these dimensions. The depth of the grit chamber is 2 to 5 meters, the length of grit chamber could be varying between 7.5 and 20 meters and the width is varying between 2.5 and 7 meters and width to depth ratio is 1 to 1.5, 1 is to 1 these are the values and the typical is 2 is to 1, the width is 1 and depth is 1 so I have the length and so on. And the detention time at peak flow in minutes is 2 to 5 minutes. The detention time is the time for which the flow is staying or remaining in the grit chamber. That is at the peak flow the maximum flow and not at the average flow. It will remain for 2 to 5 minutes in the grit chamber and then the typical value is three minutes. So normally if you want to design a grit chamber the grit chamber should be designed based on this three minutes detention time.

Now if it is an aerated grit chamber we need to supply the air. Air is supplied using a compressor. We use a compressor or a blower to supply air. That means the cubic meters of air per minute; the meter length of the grit chamber is 0.15 to 0.45 so this is the air that is to be supplied. next is, the grit and scum quantities that is coming out of the grit chamber, like screenings the materials are deposited, here also the grit is deposited at the bottom and that is being removed by endless scraper to the top and then grit removal is cubic meters of grit per one thousand cubic meters of this thing (Refer Slide Time: 46:05) is equal to 0.004 to 0.2. The typical value 0.015 is the amount of grit that is collected in this.

Now there is a one formula which I would like to stress in order to find out the peak flow. Peak flow is the flow or this is the peaking factor. Peaking factor is given by a formula 5 divided by p to the power of 1/6 where p is the population in thousands. That means if I know the average flow then I can find out the peak flow very easily. Let us workout an example here at this point of time so as to show this particular, thing how we use this peak flow and also by using the design parameters we can try to workout.

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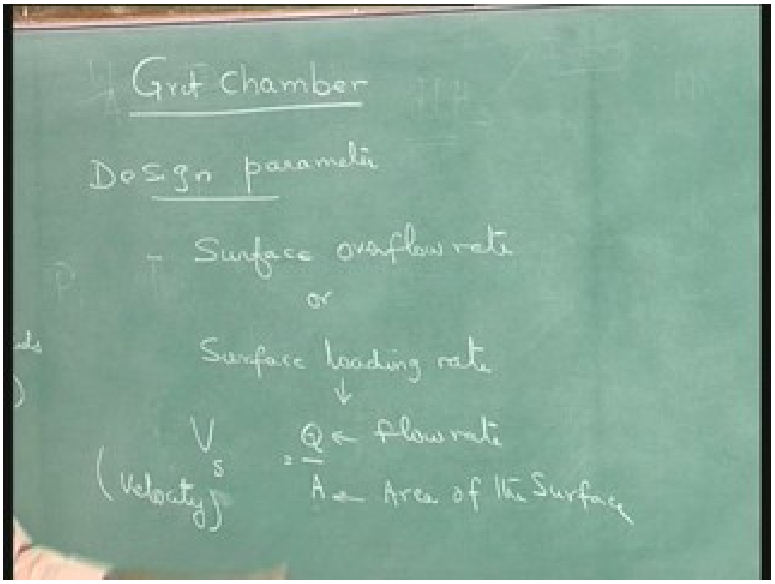

Now we will try to look at the grit chamber, the design considerations or design parameters. One of the important parameter for this is what is called a surface overflow rate which we will discuss in the sedimentation tank, surface overflow rate or this is also called surface loading. Surface loading rate is nothing but the rate at which the surface area of the grit chamber is loaded with the flow. That means surface load is nothing but the flow rate over area that is the rate of flow of water discharged and then this is the area of the surface. So this is nothing but velocity Vs. So this Vs is a velocity and velocity is equal to Q by A, Q is the flow rate and A is the area of the surface of the tank, that is what it is about Vs and now this Vs is nothing but the settling velocity of a designed particle, of a critical particle.

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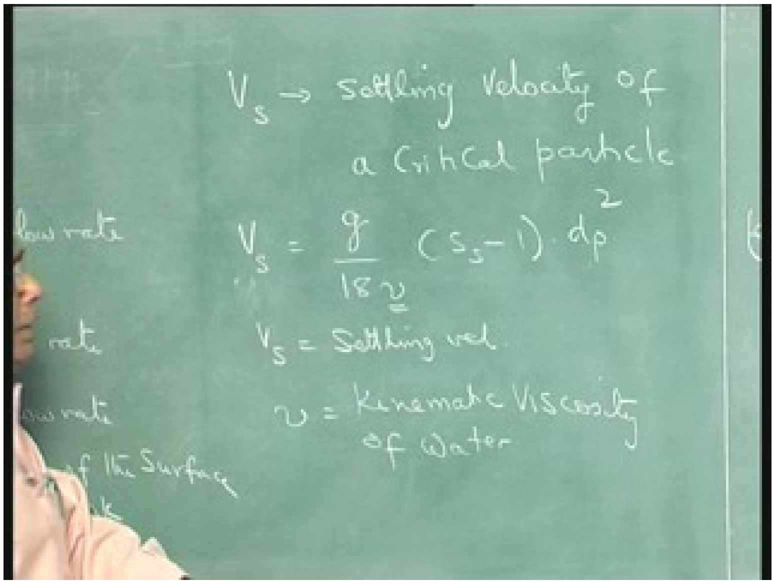

So, the Vs is given by stokes law g by 18 nu S_s minus 1 into dp square this is the settling velocity where V_s is the settling velocity and g is acceleration due to gravity and nu is the kinematics viscosity of water, S_S is the specific gravity of the particle and dp is the diameter of critical particle.

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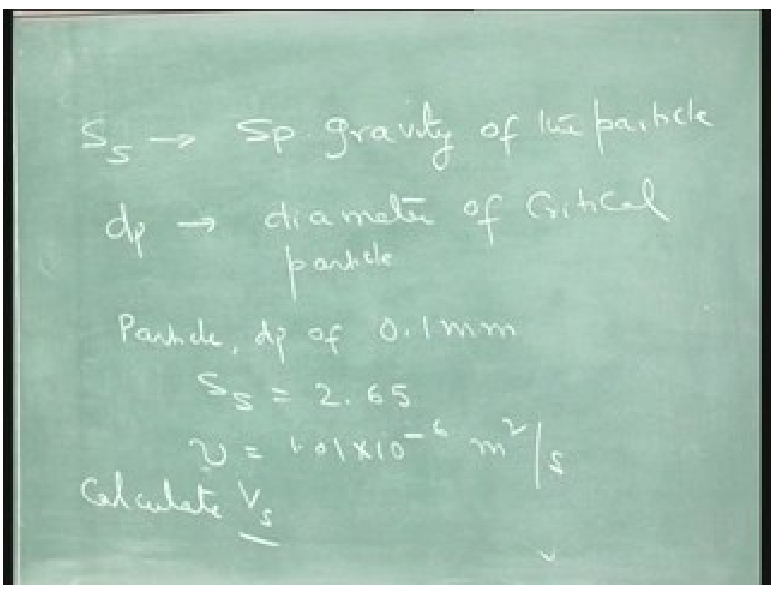

Suppose if I want to remove a particle with diameter dp of 0.1 millimeters; 0.1 millimeters is the diameter of the grit and then Ss is equal to 2.65 specific gravity is 2.65 and then nu the kinematic viscosity is 1.01 into 10 to the power of minus 6 meter per second which is this then I can calculate V_s. Now V_s can be computed, Vs is nothing but the settling velocity. Once I compute the V_s next what I will do is I will try to find out, using this equation V_s is known that is computed now and Q by A_s I will put it surface area so the Q is the flow rate.

Suppose I say Q is equal to 1 million liter per day 1 MLD then 1 MLD 10 to the power 6 L by D which is equal to 10 to the power of 3 cubic meter per day; Q is this much it is known then V_s is known now you calculate A_s; A_s is the surface area is nothing but the plan area; this is nothing but plan area.

Therefore, once I get the surface area, then surface area is multiplied by volume of the grit chamber is nothing but surface area of the grit chamber A_s multiplied by the depth. So the depth is given to us so I can calculate the volume of the grit chamber that is nothing but V and once I find out the volume of the grit chamber then I can find out the detention time which is equal to theta V by Q; V is the volume, Q is the flow rate, theta is the detention time, the detention can be calculated. So all these things are done for Q and Q is the average flow, for average flow I can calculate it. Then once I calculate the detention time and also the volume of tank further average flow then I have to find out whether this particular system is going to work for peak flow because you know very well that the flow is not always average, the flow can be less than average or flow can be more than average. Hence, if the flow is less than average I do not have to worry and if the flow is more than average I need to worry so for that matter I need to find out whether my grit chamber is going to work or not at peak flow, whether the system works at peak flow or not I have to find out.

In order to find out the peak flow what we have is the peaking factor. Peaking factor is given by the equation 5 over p to the power of 1/6 and p is the population in thousands. For, example if the population is the ten thousand population is 10000 p will become 10 so 10 I have to substitute here and take it raised to the power of 1/6 and this particular 5 over this one and find out the peaking factor.

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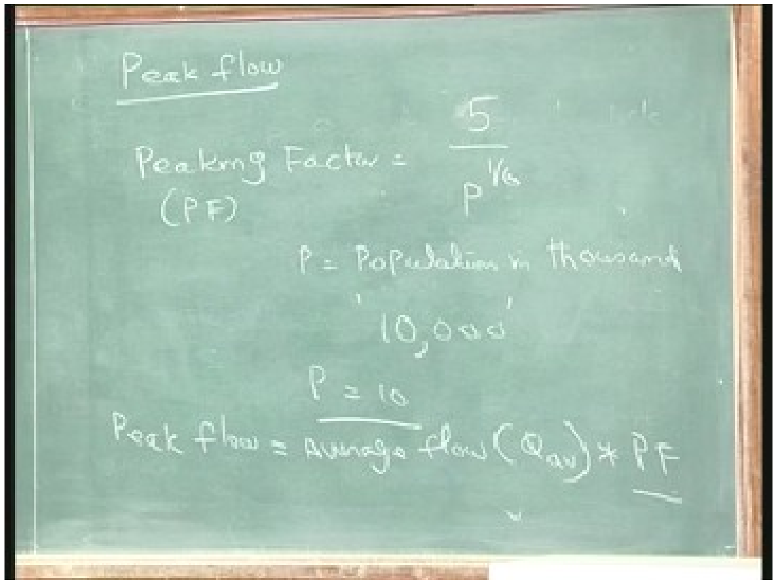

Now, the peak flow is nothing but average flow Q average this is the Q average multiplied by peak factor so this is peak factor PF so I can calculate the peak factors like that. Now what I have to do that I have designed system for the average flow then I have to check whether it is going to work for the peak flow or not. that is peak flow is more than the average flow and then I check it and if it works the design is fine, that is what we are going to do now.