Water and Waste Water Treatment
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Lecture -13
Waste Water Treatment Plant: Preliminary Treatment

Hello everyone, welcome back to the latest lecture session. Quick recap of what we have been up to, we talked about material balances or mass balance, in the context that of wastewater treatment. In environmental engineering; our environmental engineer is going to apply mass balance and has everyday life too. We discussed that in some detail we looked at the kinetics too because we have to look at the rates of formation and rates of loss when looking at mass balance.

Then, we started looking at various aspects in terms of quality and quantity of the water that is going to be coming into the wastewater treatment plant. In that context, we looked at four or five major parameters. What were they?

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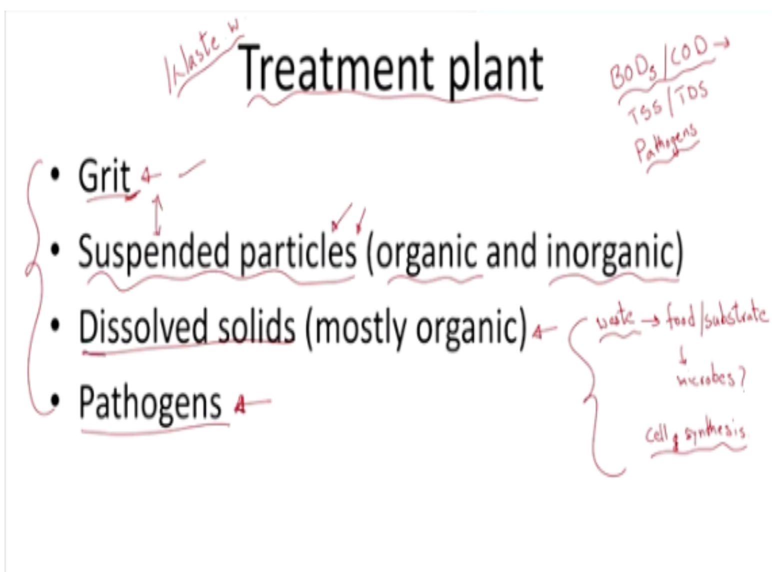

Let us just have a quick recap BOD and COD, which more or less look at the organics. We are trying to measure the organics that exert an oxygen demand. Then, we looked at suspended solids and total dissolved solids. We also looked at pathogens, those that can or microorganisms that can lead to formation of disease. These were the major categories that we looked at.

In the treatment plant, I am trying to treat my waste water, what is it that we are trying to remove? I am just trying to, classify them, because the kind of process that you choose will depend upon the kind of what we say not parameter, material that you are trying to remove here. We have grit and other heavier particles grit.

Think of your coffee beans, sand or such that comes in along with the rains or coffee beans or roasted coffee beans that you use and sometimes dispose into the grains such we have grit. Then we have some relatively finer suspended particles. Grit, how do we differentiate that from the suspended particles? We can differentiate by the fact that grit or the particles which we classify as grit are relatively heavier.

Thus are going to settle that an order of magnitude greater than that of the suspended particles. Suspended particles we are going to have both organic and inorganic the fraction will vary. Then we would like to also remove the dissolved solids, which is mostly the organic compounds are mostly organic content; and where is this organic common content coming from its my feces or urine and that we are going to call as the waste or our waste and this waste is the food or substrate for the microbes.

Why do microbes want to use this? Because they; want to use it for their own cell synthesis, and for energy needs and growth. You are going to want to multiply same case with microbes they want to thrive and multiply, so from this redox reaction where the organic compounds are oxidized in the presence of oxygen they are going to gain the relevant energy here.

We want to look at pathogens or we want to take care of them, so that the treated wastewater does not have a lot of pathogens. And one aspect to notice note is that the conditions we create in this particular process or during this process typically leads to decrease in pathogens. The pathogens cannot survive the kind of complex microbial environment that we have out here other than that we are still going to look at removal of pathogens by disinfection.

What are we going to look at in general, heavier particles which are typically suspended and relatively smaller. But suspended particles and then dissolved particles and then pathogens.

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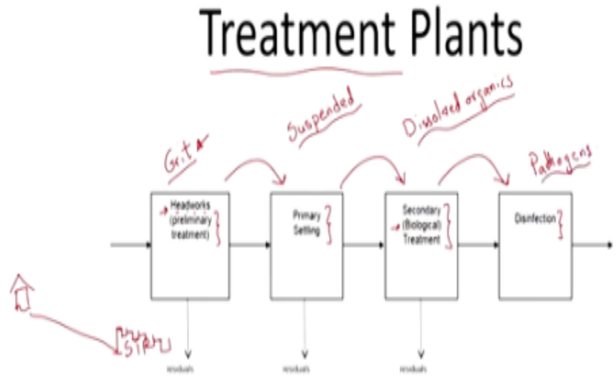

Let’s see, which of the unit process in our treatment plants correspond to each of these relevant, particles or parameters we just discussed. Here we have, four major classifications or unit process; one is the head works or the preliminary treatment preliminary, the other one is primary treatment or primary settling primary treatment. The second one is called secondary treatment or the biological treatment and the last one is disinfection.

Here we are trying to do or remove grit, the coarser particles sometimes finer suspended particles but typically you do not do that. But, why do we also say head works? We call that; headworks because how is it that sewage is flowing from your home to the relevant wastewater treatment plant. If it is a very hilly area or if there are great undulations in the terrain that is a different aspect.

But in general, in India that is not the usual case that is encountered. Here, you are out here and typically the wastewater treatment plant is considered constructed at a lower elevation. By gravity, your sewage is going to flow from your particular home to the STP now, to the sewage treatment plant. For this flow to occur from the flow or the wastewater to go from headworks to primary settling then to secondary treatment and then to disinfection.

You want to have a particular flow or you need the flow from one unit process to another and that you typically want to achieve by gravity. What you need to do? Here you are going to pump it up to a certain head or height and there from each unit process to the other you are going to have flown by gravity. That is why we call it headworks because you are going to have the relevant pumping.

You are going to have removal of the grit and coarser particles and those particles that can mess up your mechanical instrument the machinery and such. In primary settling, we are going to remove the relatively finer but suspended particles. Here we are going to remove the suspended particles, preliminary treatment not preliminary primary treatment.

In secondary which we refer to as biological treatment we are going to remove the dissolved organics, mostly the focus is on dissolved organics. Here in disinfection what is it that we are trying to take care of? The pathogen that is what we have, more or less most waste water treatment plants are going to look at variations of what we just discussed.

Sometimes, you will have tertiary treatment when we are looking at removal of nitrogenous or phosphorus the nutrients or when you are trying to look at further treatment of your effluent from the secondary treatment. That something to keep in mind let us just have a quick look at the relevant unit process in greater detail.

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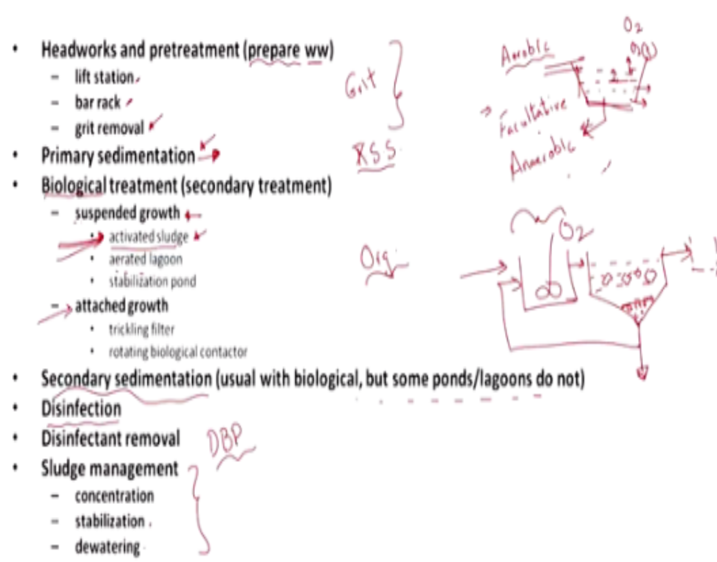

Head works and pretreatment, so what are we trying to do? We are trying to prepare the waste water. Such that it is fit to be treated by the relevant unit process downstream of the head works. You are going to remove the bigger particles; people throw plastics rags what not comes into the relevant drains or through the drains and you do not want them to clog or what we say cause abrasion on your mechanical or moving parts and lead to wear and tear.

You want to prepare the waste water and also increase the head available so that the flow can go by gravity so you are going to have pumping stations or lift stations as I mentioned we just discussed this. Bar racks to remove the relevant rags sometimes, tooth paste tubes. Coarser particle removal sometimes then grit removal, grit removal is also going to take place we are going to look at that today.

Then you will have primary sedimentation or primary removal primary treatment. Here suspended particles are going to be removed, so how are they going to be removed? We will look at that in greater detail, but stokes law more or less we are still relying on gravity to do the job. But we might add coagulant, so that the particles flocculate, form flocks and then settle down.

Depends on whether or not you want to use that in your wastewater treatment, we will discuss why later. Then biological treatment in biological treatment as the name indicates you need to have microbes. The microbes can be suspended in the water, yes and there are different types of process which depend upon suspended microbes in the relevant wastewater. One is the activated sludge which is relatively more engineered system and the other is an aerated lagoon.

You see that you see the lagoons out here yes and you see the aerators out here aerated lagoons. The air being supplied but we are not really adding microbes or such we let them typically, or people typically let them develop there. Though we are calling or classifying aerated lagoons under suspended growth, you will also have attached growth, along the slopes and the bottom microbes will develop along the slope and the bottom.

Then stabilization point, you can have aerobic similar to what you say aerated lagoon you can have different types of stabilization points. But the issue is that they are requiring large area treatment efficiency is relatively less. Earlier people used to use them, when land was plentiful or availability of land was not an issue. When the concentration of wastewater was not very high and the flows were less.

But with increasing initialization and what do we see changing lifestyles, you have what we say different or higher quality and quantities of wastewater being discharged and these stabilization points do not really do the job anymore. You can have aerobic facultative and anaerobic, so they can be in series or depending upon the depth of your pond you can have aerobic faculty two and anaerobic. If, the depth is relatively higher.

Let us see, so the top layer where you have more oxygen available because of transfer of oxygen from the gaseous phase to the relevant top layer of the water, it is going to be aerobic. In between out here it is going to be facultative and at the bottom where there is no oxygen it is going to be anaerobic. Enough of that let us move on. Attached growth that sometimes you see the microbes growing on the walls of poorly cleaned restrooms or maybe near the canals or such let us see.

The outlet of wastewater or such that is more or less attached to growth you have microbes developing on a media let us see or a surface attached growth. Here we have trickling filter and rotating biological contactor and then we move on to secondary sedimentation. But in general, people mostly go for activated sludge process and sometimes a combination of activated sludge and attached growth, but we will discuss this later.

We are just looking at an overview. Here, we are removing the grit, here we are removing the suspended solids let me say just suspended solids knowing to say suspended solids. Here we are removing the organic content which is mostly dissolved. After your particular activated sludge process depending upon the kind of process that you use, for example if it is actuated sludge you will need to have a secondary sedimentation tank.

Because the kind of microbes that are going to be formed, they form flocks and they are going to settle down we will have a video and we will look at that soon. As is mentioned here usual with biological but some ponds and lagoons do not have that. Secondary sedimentation, and all those sludge meaning microbes that have degrade the organics what will they do they are form flocks if we maintain it well and because they are heavier, they will settle down.

This settled sludge or the microbes what do we do we bring it back to your activated sludge process, where oxygen is pumped in. Why is it? As the name indicates, its activated sludge. That is what you see the microbes or the sludge that has settled down will be recycled back because the wastewater coming in will not have enough microbes, so you need a source of microbes in your aeration tank for the redox process to go through at a faster rate.

That is why you have this particular what we say microbes being recycled. That is the activated sludge process. Let us see activated sludge process, then disinfection. Because out here, even though most of the pathogens will be killed in this particular, what do you say aeration tank you will still have some pathogens and that is what you want to take care of by disinfection.

Depending on the kind of disinfection that you are using you either have to look at bringing down the, what do you say disinfectant that you as added or need to minimize the disinfection by products. Which I am going to label as DBPs which are typically carcinogenic and then, sludge management not all the sludge is going to be recycled. Mass balance everything is about mass balance, we look at that later.

Depending on the mass balance, we will have to waste some sludge and that sludge needs to be managed. Why is that? Microbes' sludge, considerable organic content if you leave it out there, anaerobic conditions it is going to smell, decompose and septic conditions and such. You have to look at it, what do, you need to do, as we looked at it in the video earlier, we have to what we say dewatered and then stabilization and such.

We are not going to go into that in detail now, but you have to also look at sludge depending upon the kind of plant people can try to look at energy recovery from this particular decomposition or stabilization of the sludge? Let us move on.

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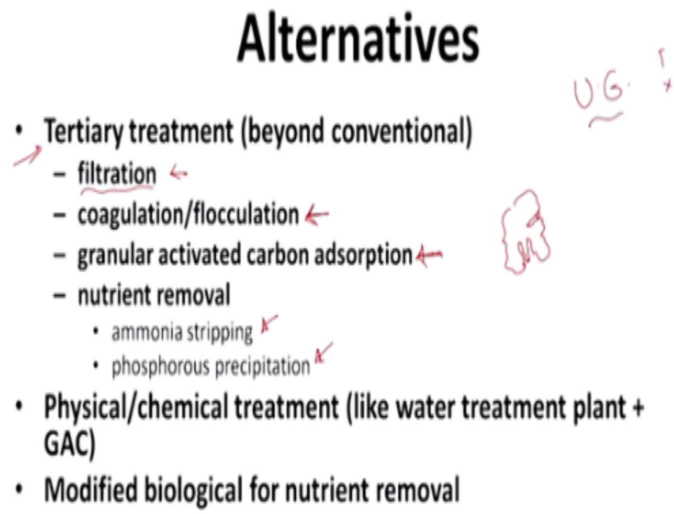

Sometimes as I mentioned, we will look at tertiary treatment for example I might need an additional level of filtration or removal of suspended particles. I can have an additional removal of filtration or coagulation and flocculation step after the secondary treatment or before to depends and granular activated carbon I have activated carbon media that has a lot of pores and such.

It provides good sites for adsorption of the relevant organic content so that you can decrease the organic content of your effluent further, so that is one way to do that. Then, nutrient removal either by ammonia stripping nitrification and denitrification or then ammonia stripping or phosphorous precipitation. You are going to look at that, we will look at that later then physical treatment but in wastewater not really done.

But sometimes depending upon the quality of the waste water or you can modify your particular secondary biological process such that you can achieve nitrogen and phosphorous or end or nitrogen phosphorus removal. These are minor modifications. Let us see, this is a UG course, we will not go into the design steps in detail. We would not go into the design steps in detail, we want to see to it that, we spread awareness certainly, but then we want to give out the principle and give you the fundamental building blocks such as mass balance.

Let us see what are the relevant unit process and such, so that you can use them as and when required.

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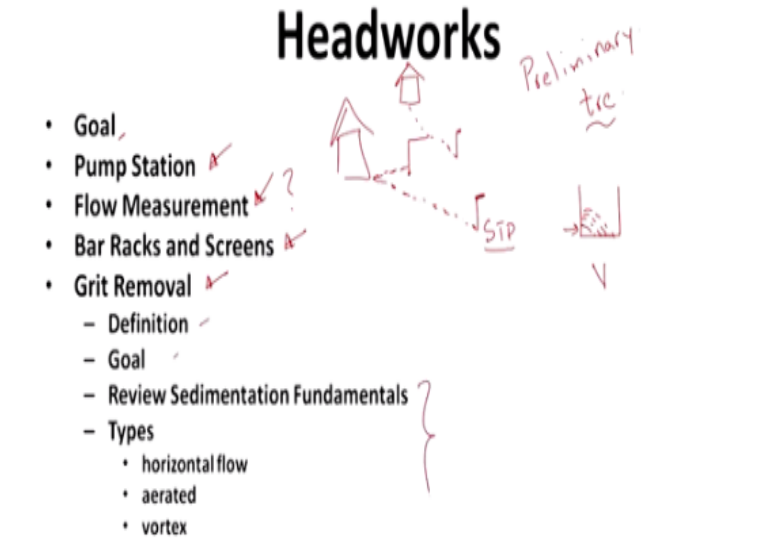

Head works in today's class I will try to cover these aspects: head works or preliminary treatment. We will today try to cover preliminary treatment or head works. Well, we will have to understand the goal what is it that I need to do now, the organic content a lot of suspended waste that is junk plastics. A lot of it comes in, sand and silt come in because we have open drains or even if there is a combined storm water and what is this sewerage network you will have lot of silt coming in.

You do not want this choking up your relevant plant settling down in your preliminary or primary treatment or secondary treatment process. That will choke up your plant , you do not want that. If I have a particular design for a particular volume but I do not remove the sand out here during pulmonary treatment but in my primary treatment I need a volume of V. But what happens is that all the sand can end up what we say choking, not choking taking up valuable space or taking up the valuable volume by settling at the bottom.

Then you are going to be left with a relatively smaller effective volume and that is going to affect the time that your compound or the water is going to spend in that particular tank so that is an issue. Then pumping station, we discussed this here is my house and in general we do not use pumping stations for the sewerage network. But we let the sewerage network situate that it flows by gravity to the STP.

It is at a low point now but for all the succeeding unit process I want the flow to occur by gravity. Here I am going to pump up the water to a certain head or height. Another aspect which we are not going to discuss in detail is that, for example STP is already out here and some homes are here. This is where , holistic planning with respect to sewerage treatment comes into play.

You can either try to have pumping stations so that this sewage joins here and ends up at my STP and such. But pumping stations for wastewater treatment I would say as not a sustainable solution in the long term pumping stations. For bringing up the sewerage from one network to the other let see that is at higher height flow measurement.

Why do I need to look at flow measurement, we will look at that, I need to know how much flow is coming because I need to be able to design the system. We will look at that as I mentioned we will have bar racks and screens coarse screens to remove the coarser particles. Each step we are going to remove first the bigger particles then the slightly bigger particles and then the suspended but finer particles.

The dissolved particles you can see the steps and then, grit removal which we discussed, what is grit? What are we trying to do? And then some sedimentation fundamentals because, grit remove is can be done by what we say or with the aid of gravity. Let us get this started now.

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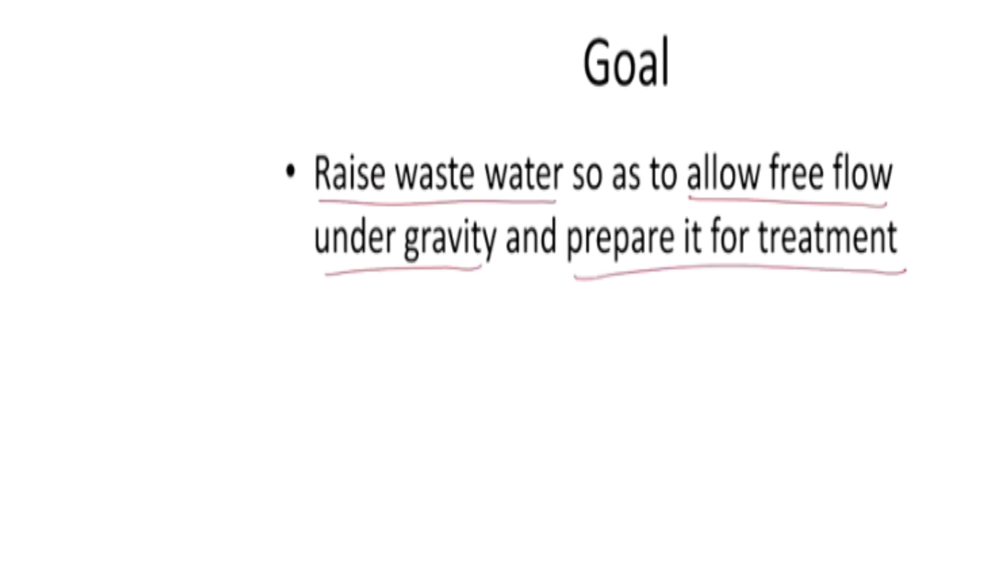

Goal of this head works and preliminary treatment; primary goal is to raise waste water, so as to allow free flow under gravity and also prepare it for treatment by removing the grit or the particles, that can what you say mess up my machinery. I do not want it to go into the stream that is the river it meaning: the plastic waste other than that I also do not want to have high maintenance in my particular plant. I need to look at preparing the waste water for treatment, so that is my primary goal.

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- Dr. A.A. Kazmi
  - IIT Roorkee

Some of the figures for which I might not give reference, some of the figures at least from with an Indian background, I took them from Dr Kazmi my colleague in IIT Roorkee. Thanks to him for that.

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Pump station

Pumping station, underground sewer is coming in and this is the screens that we see coarse screens typically before the pumping station. Then the sump well, where the wastewater is being collected, I think you saw this in the video also, for IIT Roorkee sewage treatment plant. Then, you have the may probably the submersible pumps maybe probably the submersible pumps, pumping the water up from the sump well into this particular pumping mains or rising main slits.

That is what, we have pumping station, but here we are not really talking about some of the; what we say aspects we are going to discuss. But let us move on.

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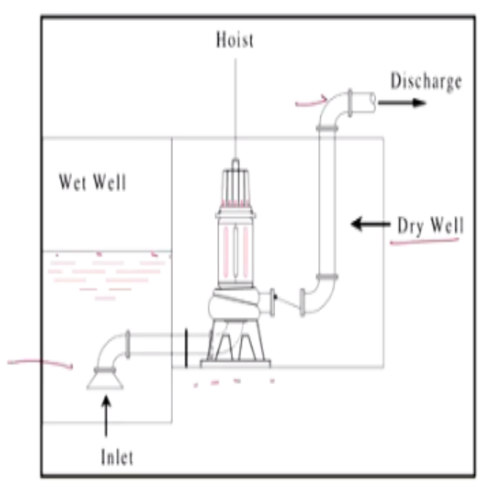
DRY-WELL PUMP



When we are talking about pumps, there are two types of configurations: one is the dry well pump and the other is the one with just the wet well, but with the submersible pump. What is the difference here? You have two sections one is the dry section dry well, which contains your relevant pump and such. It has access to the pump so easier to maintain whenever there is a breakdown.

The other one is the wet well or drywall pump will dry wells, will also have a wet well section . But we typically only look at the term driver, when trying to describe this particular system. Wet well from there, this particular water is sucked in and brought up to the required head let us see. This is the head that we are trying to increase.

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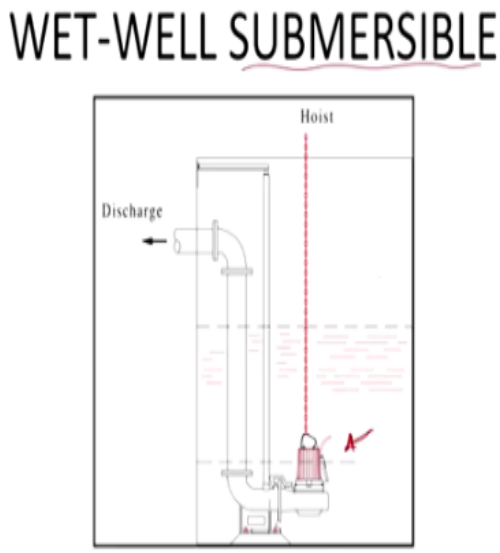

The other one is wet well here you, see that we do not have a separate driver system and the relevant pump is more or less a submersible pump that is what you see out here. Whenever required it is hoisted up . Here typically maintenance seems to be low, but whenever maintenance is required then that is going to be a concern. But one aspect is the costs are relatively less or seems to be relatively less with wet well submersible pump systems.

That is what at least we see in India, most of the time now. That something to keep in mind let us move on.

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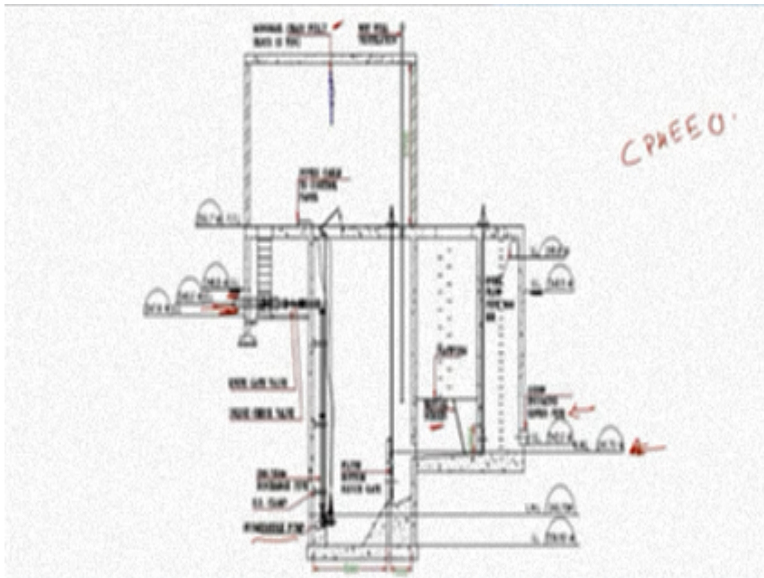

Submersible pump system and what we say greater detail. Submersible pump out here flush bottom for the relevant flushing as and when required you have the relevant what is this now? Heights that are given but you can look at the CPHEEO manual for such figures now. I will not go into this in great detail, so here is the ground level as you can see. Let me see, where it is that? This is the chain pulley.

That is one aspect to keep in mind, overflow pipe fine manual screen and that is the relevance. Here is the incoming sewer pipe and I have the manual screen out here, and then this pump is going to lift it up to the relevant level out here. Here is the inlet and here seems to be the outlet. Let us see , so that is something for you to keep in mind.

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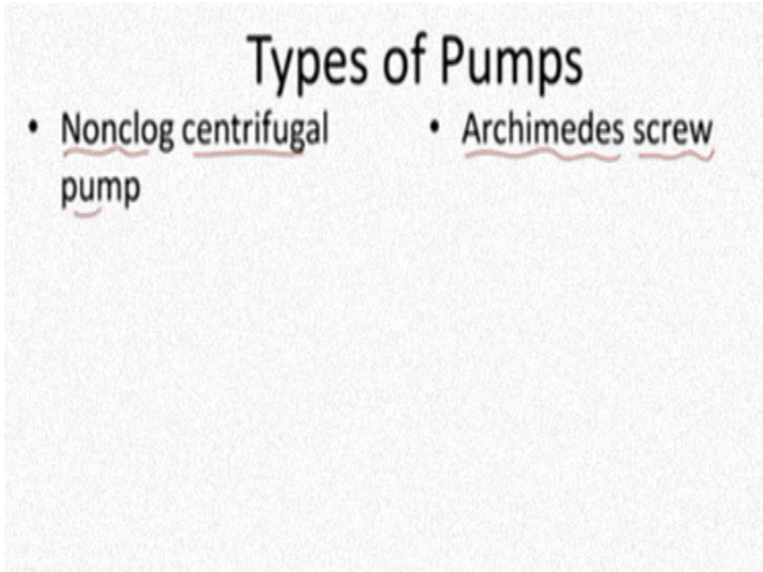

What are the types of pump? Typical one; Archimedes screw, pretty simple setup relatively less moving parts remarkably easy to maintain and then non clog centrifugal pumps. Let us look at what they are.

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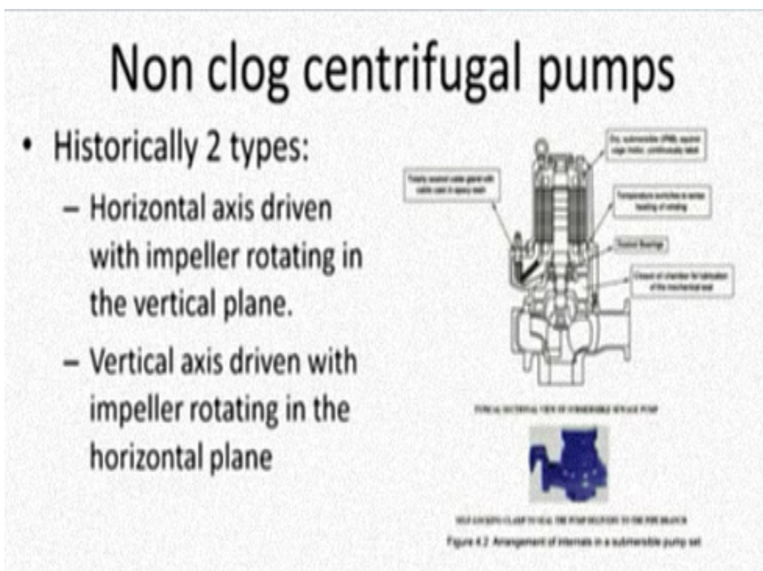

Non clog centrifugal pumps; one is the horizontal axis driven with the impeller rotating in the vertical plane, impeller rotates in the vertical plane. The other one for which we have the figure here is seems to be the one at least if I am not wrong; the vertical axis driven with the impeller rotating in the horizontal plane, impeller rotates in the horizontal plane. We are not going to go into details pardon me.

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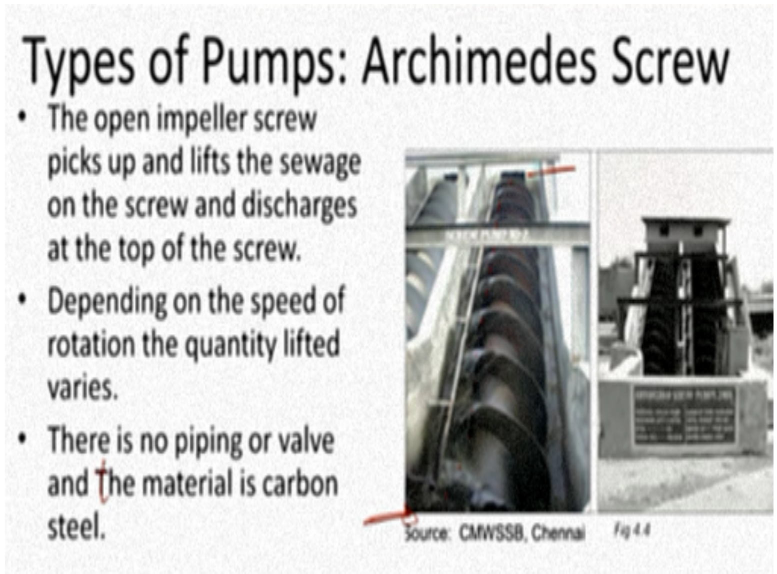

Other one is, as I mentioned the Archimedes screw pump. As you can see, as this Archimedes pump rotates from around this height, the water is being brought up to this side. Depending on the speed or velocity of rotation your water will be taken up to this particular head and that is what you see, Archimedes screw pumps. The open impeller screw picks up and lift the sewage depending on the speed the quantity lifted varies.

There is as you can see there is no piping or walls and the material is carbon steel and relatively less maintenance but always pros and cons with respect to the flows.

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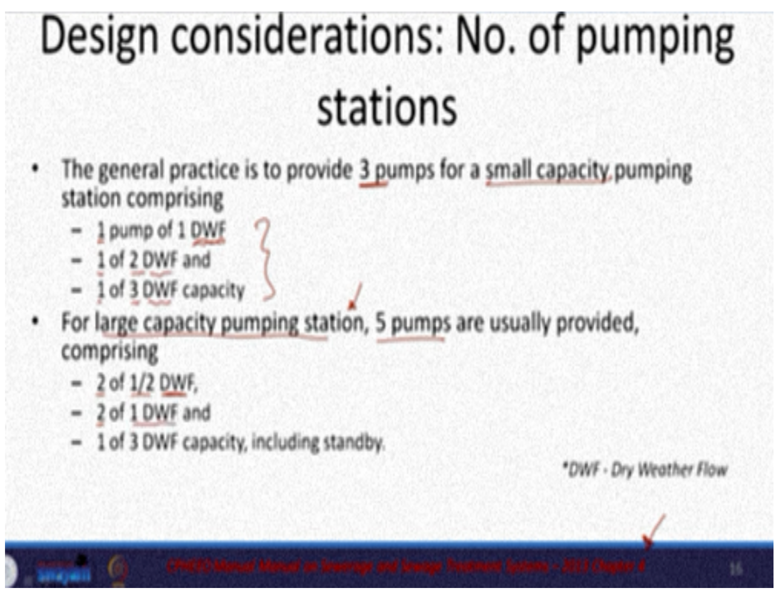

Next aspect is how many pumps do; I need to put up. Here note that we were talking about 30 year design period and we were also talking about peak factor 2 hourly maximum 2 hour maximum flow or one hour one month maximum flow and such. If I just have the pump, designed for just the average flow rate during the peak flows the system is going to fail. How do I take that into account?

We take it into account by seeing to it that even with the largest pumping station what we say disabled, offline, disabled, under repair the system can still handle the peak flow. That something to keep in mind there is always going to be a fallback option. We are going to look at two aspects this is the reverse CPH EO and we are looking for small capacity here and then for large capacity pumping stations.

We have three pumps here and DWF stands for the dry weather flow, that something that we looked at in the earlier session. One pump will be of capacity that can handle the average dry weather flow and one of a capacity that can handle two times the dry weather flow and one pump that can handle three times the dry weather flow. Overall three pumps with increasing capacities and here we have five pumps for the larger pumping station.

What do we have here; the two will be of half I mean such that they can handle half the dry weather flow and two will be such that they can handle the dry weather flow capacity by themselves. Each one will have will be able to pump up the drive, other flow capacity or has the capacity to pump up the dry weather flow by itself and one will be of three times the drive weather flow capacity.

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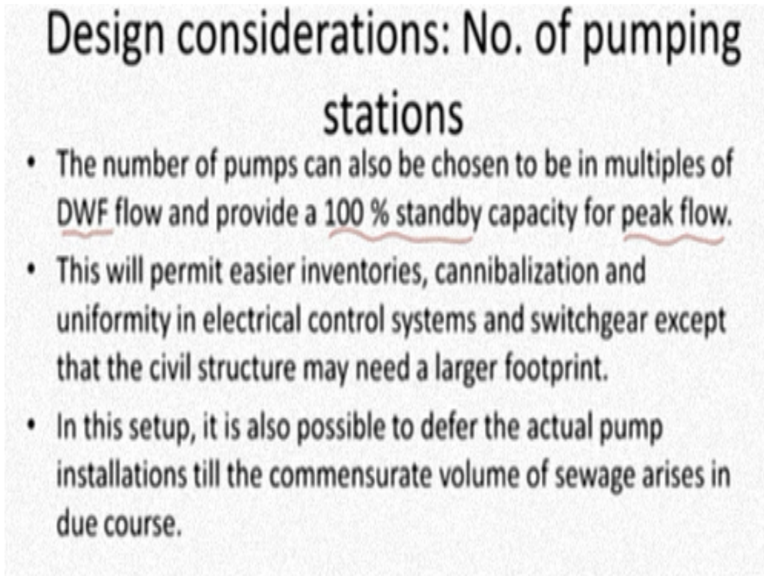

Here you see that we are trying to choose it in terms of DW flow or dry weather flow and then 100% standby we are providing for the peak flow as I mentioned earlier and then it is going to lead to easier inventories and such. Then this setup it is possible such that we do not need to put in the pump insulation till the volume increases. I am what we say building my or designing my sewage treatment plant for what is it 30 year period.

But now, the population is less but that does not mean I should not start the sewage treatment. In this setup, as you see you can keep increasing the capacity as and when the flow increases or is estimated to increase rather than having all the capital being spent away and thus incurring costs. That is one aspect to keep in mind.

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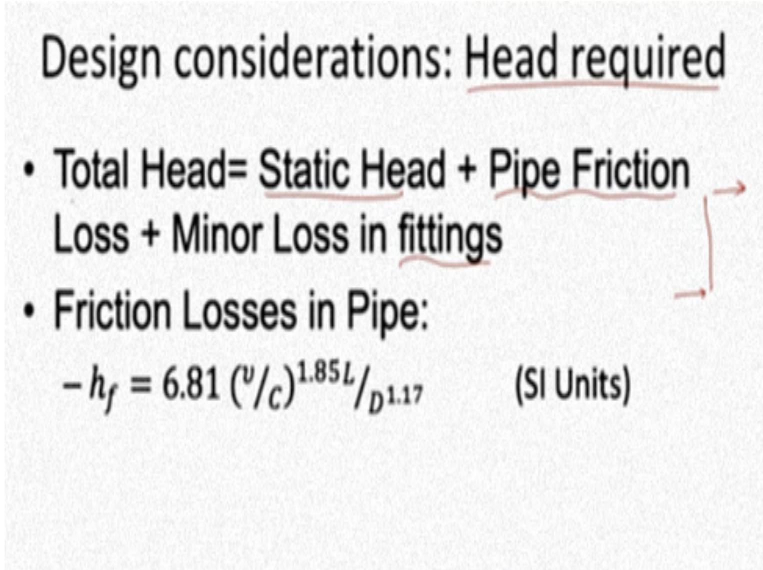

What is the head required that you need to pump up the water too? Total head is the static head , for example inlet is coming here outlet is going here. That is say static head the other one is there will be losses due to pipe friction and also losses in the fittings. These are the aspects that you need to take care of when you are trying to look at the total head. The total head will have to take care of the static head and also the losses due to the pipe friction.

We see losses in the fittings, pipe friction loss but we are not going to go into that in detail now.

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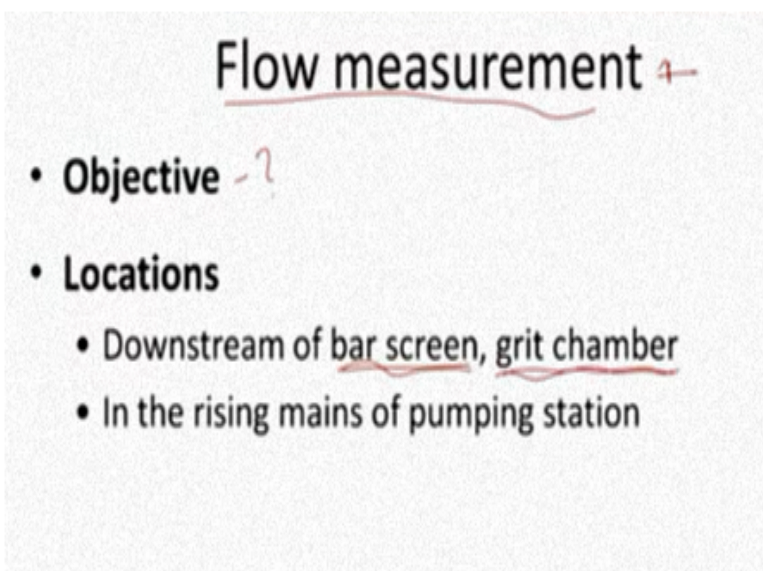

Flow measurement; firstly why do I need to measure the flow? Why is that? Because if I do not know how much flow is coming in, how do I know how much microbes to be maintained in the system. How do I know, how much oxygen to pump into the system? Because if I keep pumping oxygen at the same rate even if the flow is less, I am wasting money because pumping costs of oxygen are remarkably high or most probably the they lead to the or they take up almost 50 or 45 % of the total operation cost of a sewage treatment plant.

They pump oxygen into the waste water and if I keep it constant when the flow is high I am not providing enough oxygen. The process efficiency is going to decrease and I am talking about disinfection. If I do not know the flow, I do not know how much to pump him or how much disinfectant to add and such. I need to know the flow so that is one aspect to understand.

We have it downstream of the bar screen sometimes downstream of the grit chamber too, it depends. Certainly, you are going to remove the bigger or coarser, what we say particles, certainly the much bigger particles, plastics so that they do not choke your pump sets. Let us see this with respect to flow measurement.

I got that slightly wrong, so we will have that downstream of the bar screen and the grit chamber party typically. When I spoke about having it after bar screen, but before grit chamber I was talking about the pumping station. You can have this flow measurement, in the rising mains of the pumping station but that is possible due to the magnetic flow meters. We will just discuss that now.

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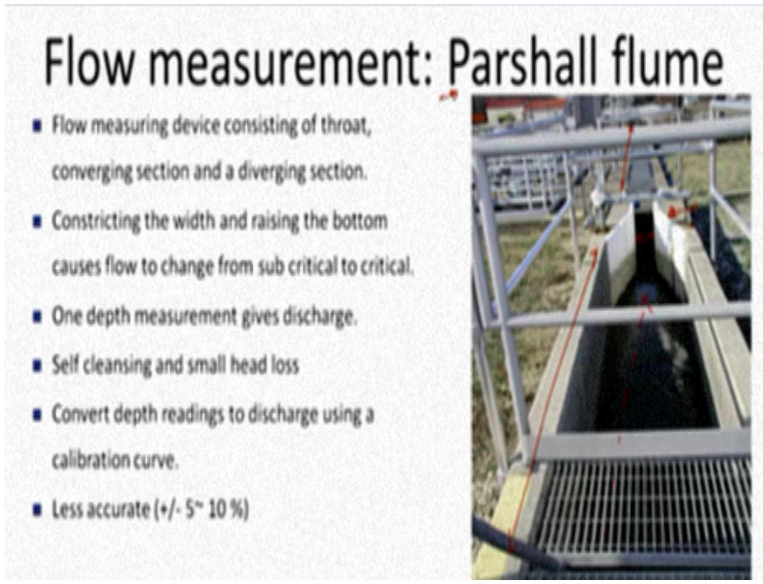

Flow measurement, Mr. Parshall wrote his particular theory which is working remarkably well. We construct what is called a Parshall flume that is what you see out here. For this , you need to have relatively longer distance or considerable distance depending upon the width of this particular flume. For the creating, the relevant flow conditions out here and also downstream also depending on the width.

You need to maintain some conditions so that, the back flow conditions do not affect your flow conditions through the flume. You need to have considerable lengths, that you can provide. What is this consist of?

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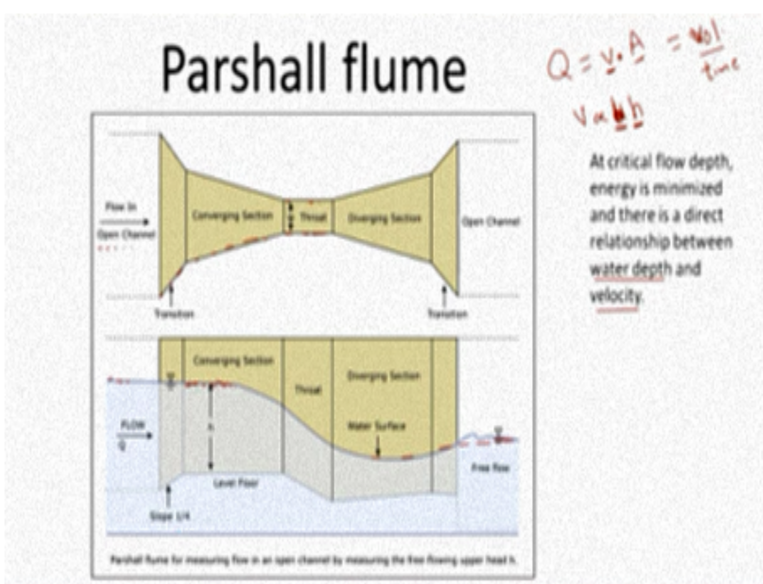

Let me look at the figure; this consists of a converging section this is the water coming in, this is the top view and then transition, so converging section and then throat and then diverging section. What is the need here? Why am I trying to vary the flow because here I am trying to measure the flow rate Q; Q is v times a velocity times the cross sectional area. Then I will get the volume per time that is what I am trying to get.

$$Q = v \times A$$

At sub critical or such flow, the velocity is not really proportional to the height of your particular flow. At critical flow depth, the energy is minimized and there is a direct relationship between the depth of the water and velocity that is why I want to construct this partial flume. That I can achieve critical flow conditions or super critical conditions out here, here it is sub critical here critical or super critical and then sub critical out here.

I want to be able to come up with a way such that the flow at that particular point is proportional to my particular what you say the depth of that particular flow is proportional to the velocity of flow. That is why we are constructing the Parshall flow. What do we have consisted of a throat converging and diverging section. Constricting the width that is what we saw this is the width is decreasing and raising the bottom.

Raising the bottom, I think that is not clear from here. Causes flow to change from sub critical to critical or super critical. One depth measurement gives the discharge and more importantly it is supposed to see to it that itself cleansing and there is little head loss and we are going to convert the depth readings to discharge using a calibration curves. It is not greatly accurate but it typically does the job within this level of accuracy.

That is something we just discussed or looked at flow is coming in and here is where we at have the critical flow conditions and you are going to measure the head here, and then you are going to measure the head relate that to the velocity and get the flow rate.

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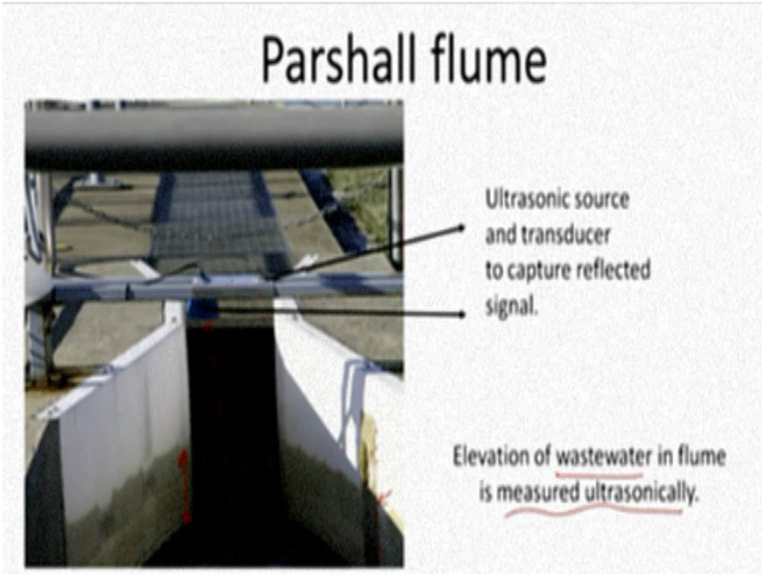

Here, how are people measuring the head or the depth. They have an ultrasonic source and transducer to capture the reflected signal. Ultrasonic source and transducer to what we say capture the depth you can see the varying depth out here. Salvation of waste water in a flume is measured ultrasonically here, some earlier or here you see a standby, where you see the manual scale if I may say so, where you have to manually record the readings.

But that is not going to be instantaneous, you have errors and people you have to depend upon the relevant person out there.

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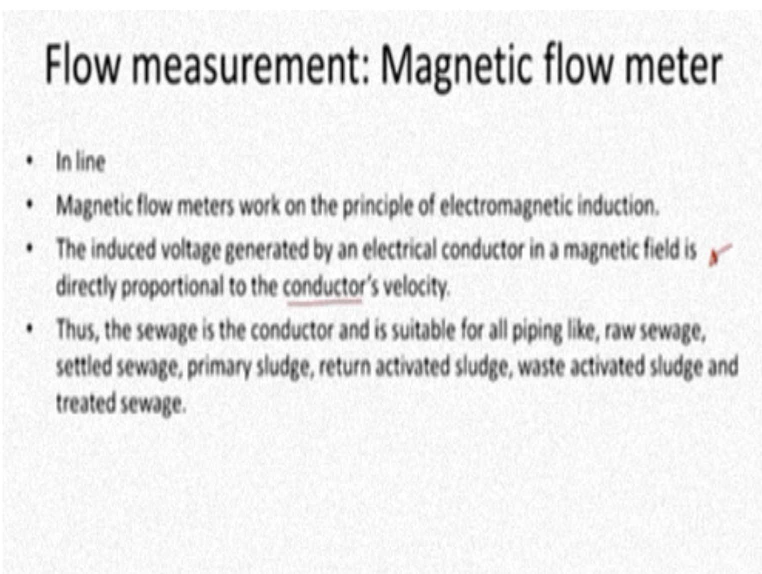

Flow measurement another aspect that we have is a magnetic flow meter. Let me just look at the relevant video here with you.

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We do not want to chat with anybody, so magnetic flow meters typically do not require as much distances before and after certainly not after. They can be done in line, in pipes that is why, we saw earlier that in the rising mains 2 looks like you can have this magnetic flow meters. Let us see what this is about? What do we have? We have a transmitter and a sensor, but what is it that we are transmitting and what is the principle?

Let me see, if I can keep up with the video, so we have this magnetic. What do we have? We have a transmitter, and we are trying to create a magnetic field. This particular principle is depending upon or uses the Faraday's principle. Let me just try to go through and here we are trying to create the magnetic field out here and then you have the relevant electrodes at the side. Once you are creating the magnetic field what is going to happen?

The charged particles in the water are now going to be I should not say used to the go to the opposite ends. Negatively charged and positively charged they are separated. You have a potential difference or here or difference and this voltage you can measure. With the magnetic field you can now create conditions such that you can measure this difference or the voltage.

Let us just look at that Faraday's law, velocity and what is it proportional to as you see it is proportional to the velocity of the process fluid and what is the conductor? The conductor is the sewage itself and we know the magnetic field strength that we are maintaining. That is how we can go through that distance between the electrodes depends upon the kind of system that you have the induced voltage is what you are measuring out here.

Induced voltage due to the magnetic field that is what you are measuring and that you can relate to the velocity of the process fluid. That something, that we have the others are constant for a particular system. That is more or less, the case for your magnetic flow meter.

(Video Ends: 37:03)

Enough of that, Faraday's law, so let us move on. Inline magnetic flow meters work on the principle of electromagnetic induction, induced voltage, we already discussed this but you can look at that as and when required and what is the conductor? The conductor here is nothing but the sewage itself.

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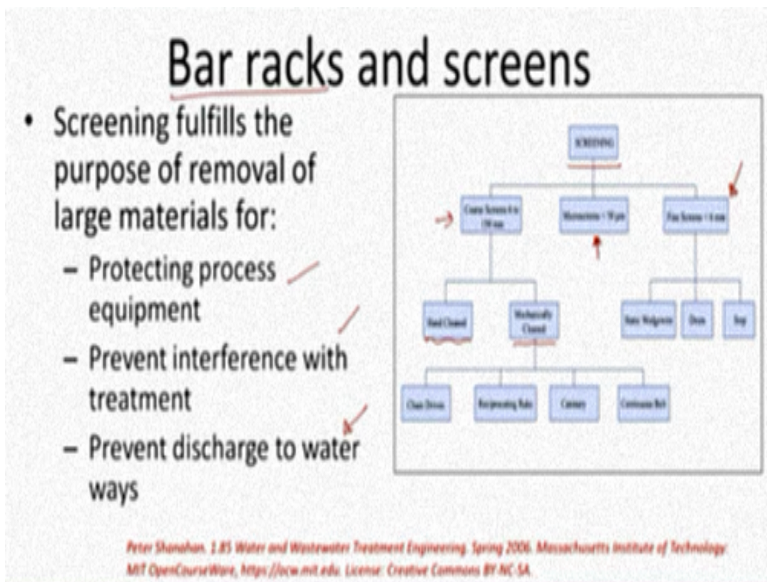

We looked at pumping the water up, we looked at measuring the flow of water and now we will also look at how to measure, not measure, to remove the bigger particles and junk that comes into the waste water? They do not mess up my downstream unit process, let us see, what we have out here? We bar racks and screens. We are going to look at the screening out here.

What is it? It is trying to protect the process equipment, that is downstream and it prevents interference with treatment and also we do not want it to be discharged into the streams or the rivers. Screens have different kinds, coarse screens which are always employed. Fine screens which are not really employed in wastewater treatment, at least not in India because the maintenance is high and micro screens too in India, we do not really or people do not really go for them, certainly not micro screens.

Coarse screens earlier they used to have manual or hand cleaned and now most of them are mechanically cleaned chain driven, reciprocating continuous belts but will just look at the pictures and move forth.

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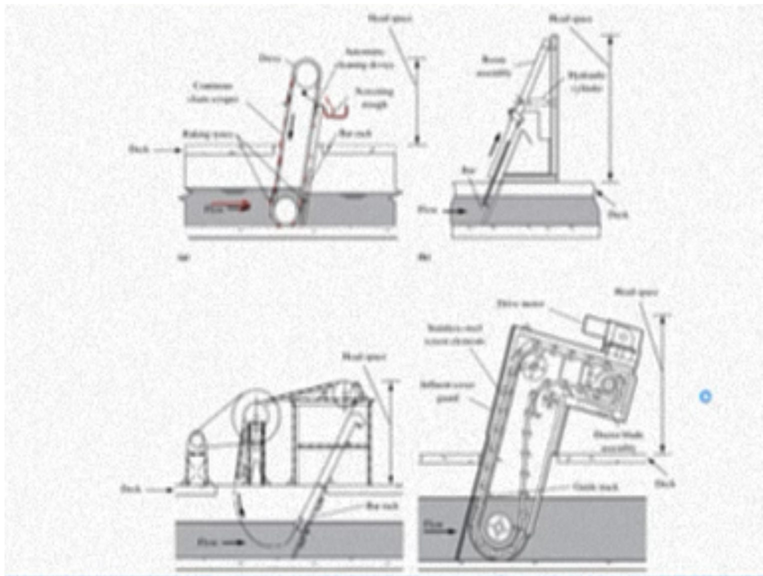

I have front and chain driven, you have this coming in and going forth and the flow going through in this process and you have racks or such which we are going to look at. You have the bar racks out here and here is the collection truck where the relevant particles or material that screened out is, collected and then we have this reciprocating rake and that is what you have out here.

Different such mechanisms as do we have catenary and continuous belt, catenary and continuous belt that is what we have out here general operation.

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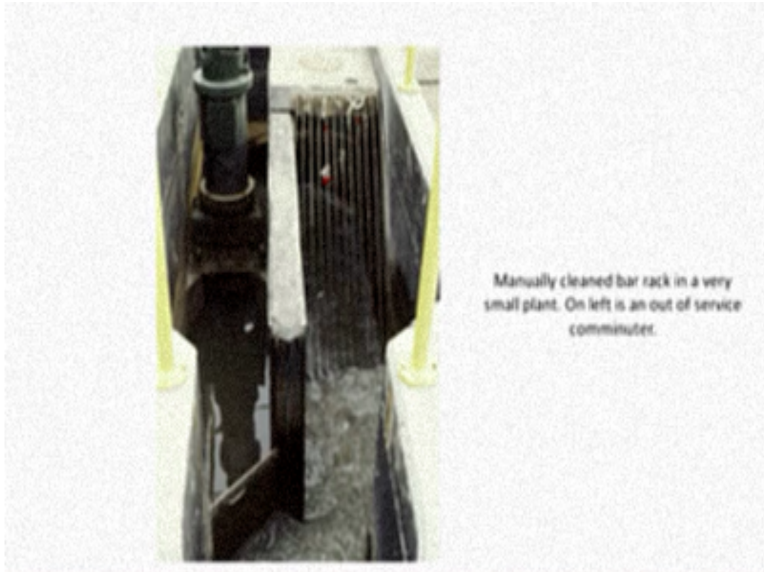

Let us see this is the manual screen, manually cleaning the bar rack in a very small plant, easy to maintain so that you guys can see the kind of particles that they were trying to capture. A commuter which used to be used to polarize but it is now not functioning , so that is something to keep in mind.

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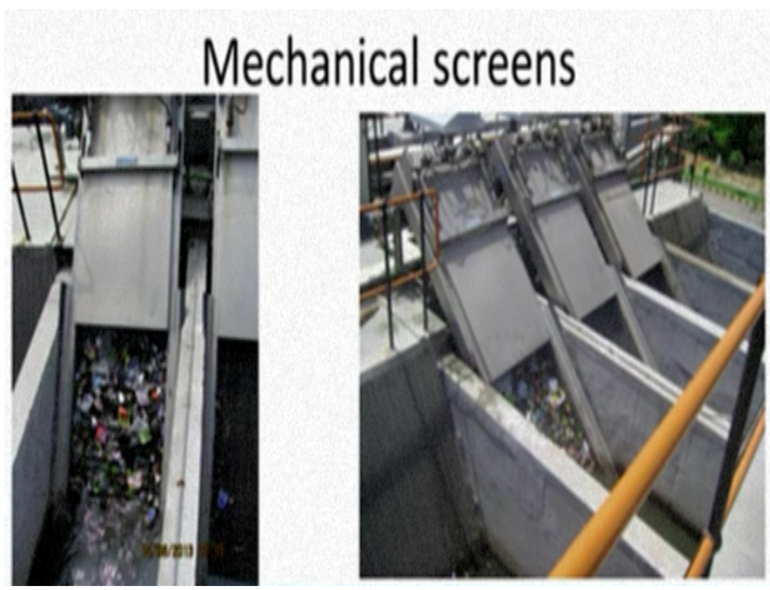

But mechanical screens and now this is a picture from India which I got from Dr Kazmi you can see what kind of junk comes up. The other picture was from the US and this is what you see on mechanical screens now, you see the kind of junk that we are trying to remove out here. That is something to keep in mind, so I think they have some combination of manual and mechanical screens out here.

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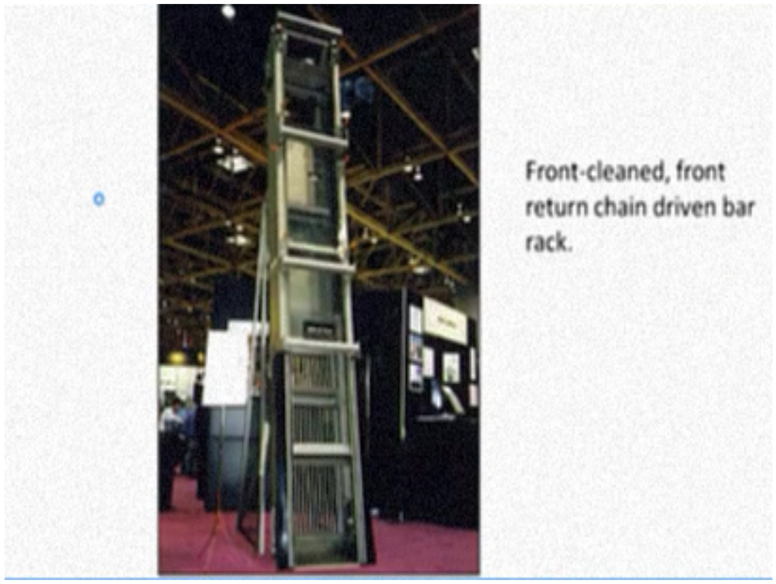

Front cleaned front return chain driven rack, so that some that in the picture that we saw out here, this one this kind of one. Also, variations of it used widely in India this is what you have.

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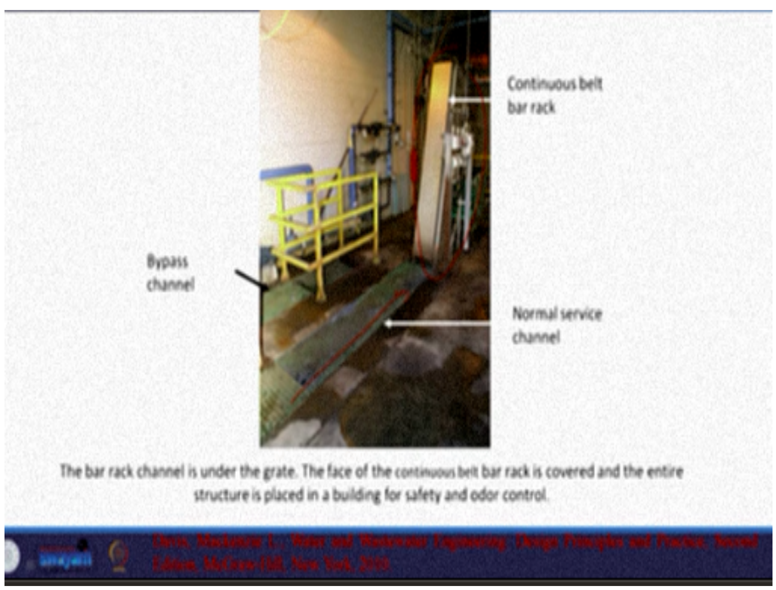

Now it is installed out here as you can see the continuous belt bar rack and the water is coming in this direction and you can see the continuous belt operating its all covered now and it is covered or the waste is being collected out here let us see.

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You can see the kind of waste that is been collected in this from the back of the bar rack and in India we see much more different kinds of waste but this was from a relatively more developed country where the sewerage network and the kind of waste that comes in are relatively more controlled that something to keep in mind.

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Mechanical and in mechanical screening we also have drum screens this is where we are looking at relatively finer particles depending on the size of this particular pores in this screen. As I mentioned in wastewater plant people typically do not go for that depending on the waste or your design you might want to, the issue is because the maintenance is high but mechanical screens front end and manual out here, front end and manual.

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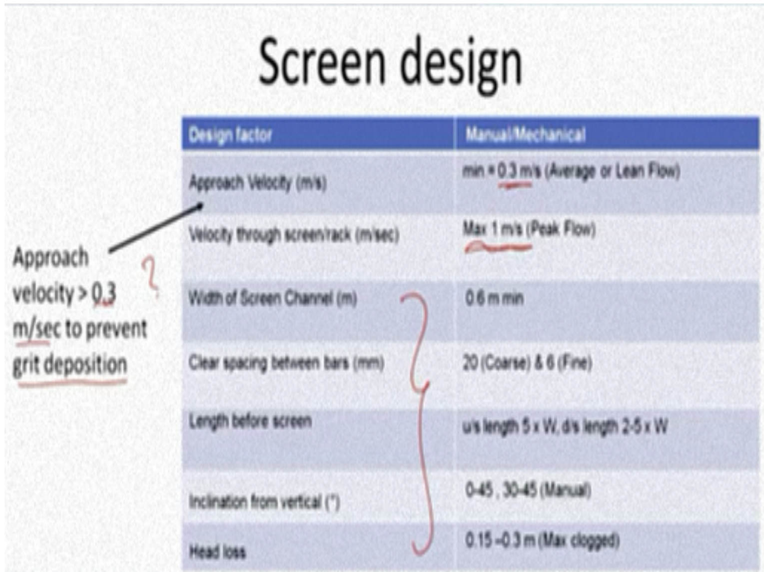

Screen design one aspect is the velocity should be above a particular threshold why is that? Because in this particular location you do not want the grit to deposit, so you need to have relatively high velocity but the velocity should not be so high such that these particles or the probability of these particular materials being captured on the bar racks is less. It is a balance between a particular velocity so that the grit does not deposit.

Higher threshold so that these particles do not escape and then when you are going to have to design you have to look at these parameters but we are not going to look at that in detail now though not in an UG class anyway.

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Grit removal when I say grit, what is it that the term talking about? We have sand coming into the picture, dust, bone chips, coffee grounds, seeds, egg shells which are usually heavier than or much heavier than organic matter but which are relatively inert. What do I have out here so this is typical grit removal or grit you see the outlet here.

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Let us move ahead and this is from a relatively more developed country where they looked at grit and then screenings later.

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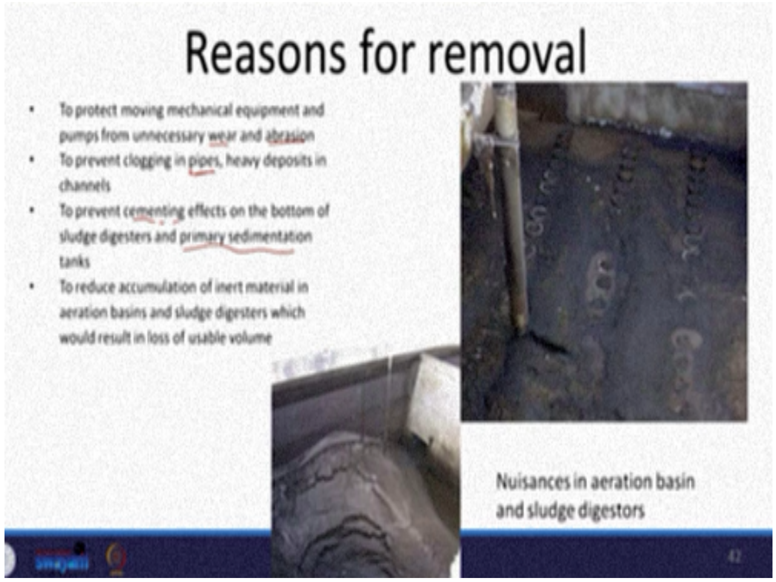

Reasons for removal, why do I need to remove it? We look at the pictures to protect the moving equipment and pumps from unnecessary wear and tear because that will lead to high maintenance. You do not want your pipes to be clogged up, recently we had an MTech student who was trying to divert the flow from what we say the resident outside IIT Roorkee, there was a particular colony and he wanted to use that for a particular pilot scale waste water treatment plant.

MTech typically the thesis here at least is done over one or one half years and in that period he spent around nine months trying to unclog the relevant pipes and such, why is that, because lot of plastic, rags always comes into the issue. Not just plastics and then grit and that leads to relevant issues and maintenance that is what I am trying to I was trying to stress upon when I was giving the example.

You have a lot of issues with respect to maintenance and downtime and you want to prevent that, so that is what you see and preventing cementing effects on bottom of sludge digesters, bottom of digesters you can remove the sludge but if these kinds of particles which end up almost forming a solid layer, your effective volume will decrease and that is what we looked at inert material deposition you want to prevent that in aeration basins.

We see the new sensors in aeration basin and sludge digesters all this is because they did not have good grit removal systems upstream in the aeration tanks and sludge digesters now have all this grit that has accumulated, so that is the reason.

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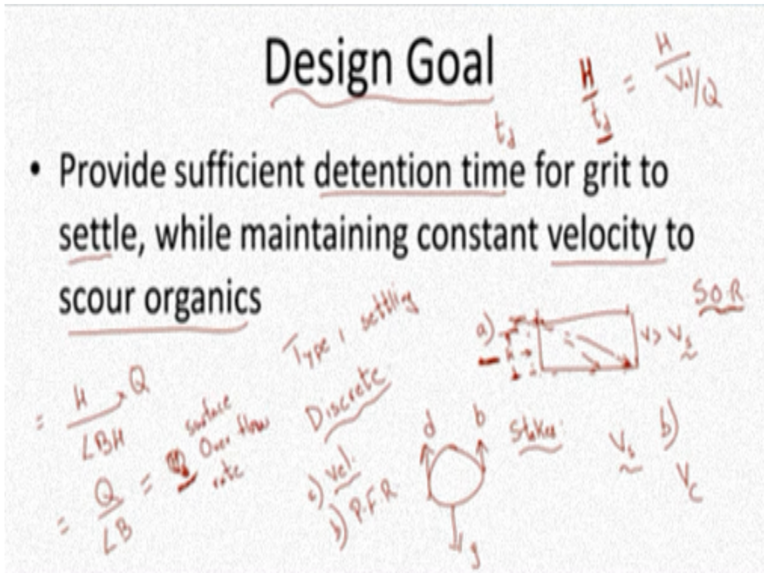

Design goals are what we are trying to do not what, how are we trying to do that. We want to provide sufficient time which I am going to call as detention time for the grit to sit up, here gravity or different separation processes while maintaining constant velocity to scour the organics. The issue here is that I need to see to it that the particle that comes in settles down before it goes out that has to be achieved.

For that I need to maintain a particular velocity which is greater than settling velocity. If the settling velocity is this if v is greater than v s the particles will be removed if not a fraction but we look at this type 1 settling later, type 1 settling which is discrete settling this kind of settling we are not concerned with interactions of one particle with the other within that particular system.

That is something to keep in mind, but the assumptions are that the velocity is constant in this system and we assume that it is a plug flow reactor that something that we mentioned and discussed earlier. There are some assumptions that we have to make at least in this case, type 1 settling we know the Stoke's law and that will let you get an idea about the settling velocity how can we get that we know that due to gravity it is going to be pulled down gravity but there will be drag resisting this and also buoyancy.

If you balance these out and look at the relevant calculations you will get the settling velocity but we will look at this in greater detail soon when we look at sedimentation but for now when we are trying to look at the removal of grit why are settling these are the principles let us see, what is it that we are providing sufficient time for grit to settle while maintaining constant velocities to score organics.

One is maintaining sufficient time but A, the B part is that I do not want my organic content some of which is suspended, I do not want that to be removed now because this grit is inert sand if I dump it out there not really a lot of issues. But if I have organic content that is dumped out there I need to look at it is disposal and it is treatment. I do not want to club these two together and remove them, why? Because what I do later also depends upon the kind of particles that I am removing in that unit process.

The velocity has to be such that it is low enough for the particles to be, these heavier particles to be removed but high enough such that you have a scouring what we say velocity. Even if the organic settle down the velocity is high enough such that they can be scoured up and they can be taken out, so that is something to keep in mind. Two aspects out here and here we need to calculate the surface overflow velocity or surface overflow rate.

How do we do that let us just look at that surface overflow rate or such, here I am just trying to calculate the h or height required or height. If I am trying to look at that time by detention time what will this give me, it will give me the velocity in this particular direction if I may say. Here I have this h or let me use the term capital H, H by time. But this time is governed by how much flow is coming in and what is the volume of this tank H by.

I am going to look at the velocity here and this is height H and now I have this detention time but what is this time depend upon or what is this going to give me, it is going to give me the time that this particle or water to is going to stay in that particular tank, so it is going to be depend upon the volume v, this is volume by the flow rate. Let me just write that out here so that is going to be the height, volume is length into breadth into height by the flow rate.

I will take this Q up, so let us try to simplify this further H, H cancel out the Q and length into breadth, H is the particular depth. This is called the overflow rate and this is something that I need to consider when looking at which particles will be removed or let me not use this term overflow velocity or surface overflow rate, surface overflow rate, so that is something to keep in mind.

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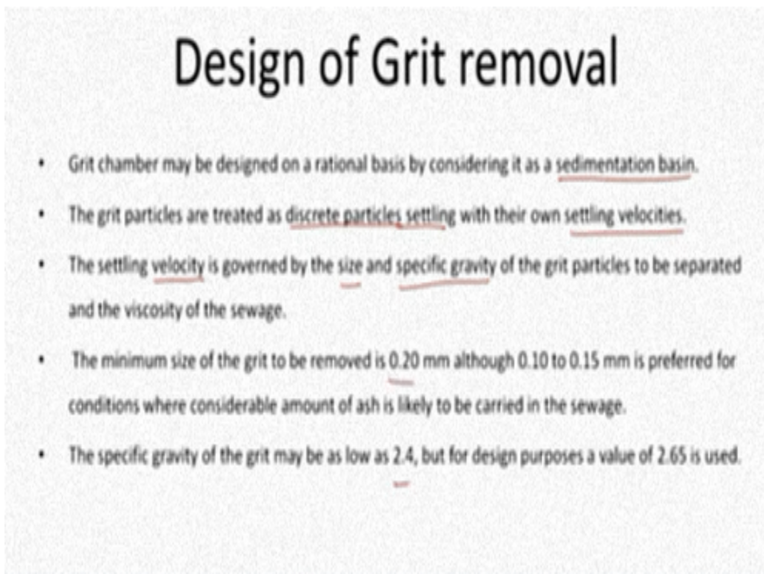

let us move on we will discuss this in detail later, so design of grit removal, grit chamber may be designed assuming that it is a sedimentation basin, so particles are treated as discrete particles that is why we said discrete settling or type one settling with their own settling velocities and the velocity of settling of each particle will be depend by the size and gravity of the particles and minimum size we discuss this out here but we can move on.

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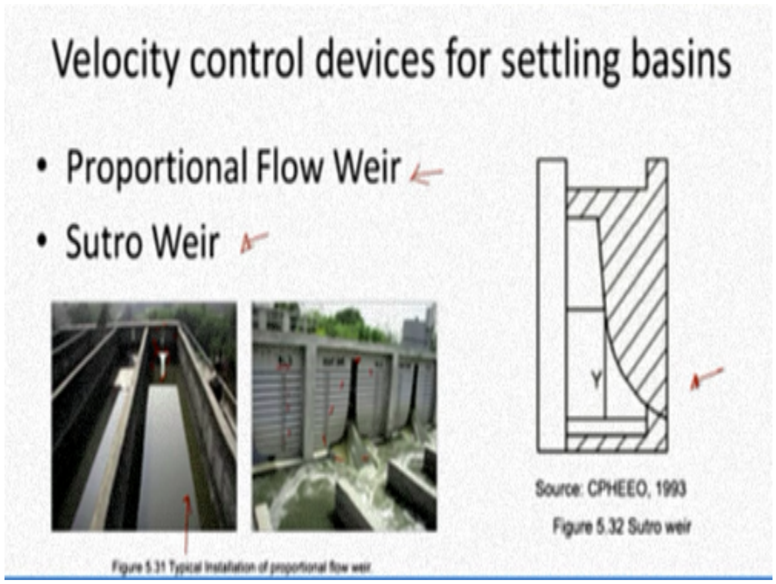

We have this long I mean the flow is in this direction as I mentioned constant flow velocities have to be maintained and how they do that, they use do that by using either the proportional flow where as you can see out here the reflection is seen in here and the exit is seen or from the other direction this is what you can see or the Sutro weir. That is what you see out here the point is to maintain constant velocities even at different flow rates, what do we have here is the flow rate here million liters per day at different heights.

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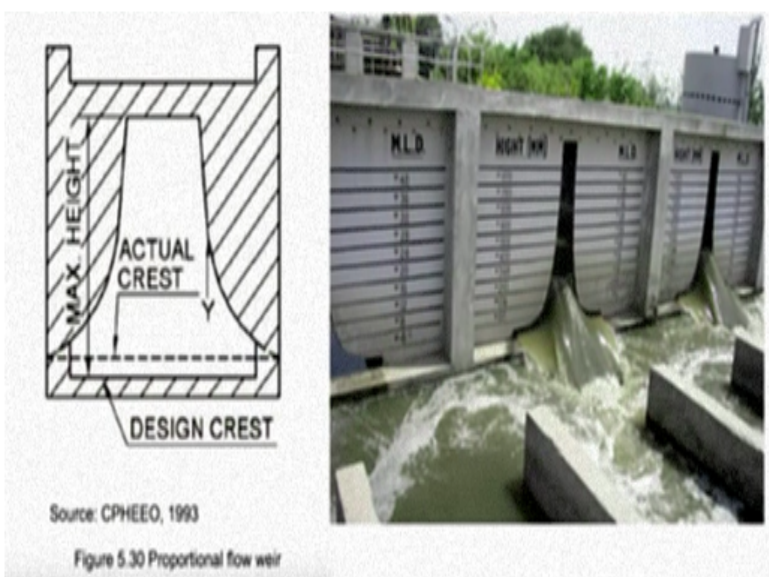

Proportional weir, we have we have a close up out here different velocities and such.

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Without water this is what it looks like. What is it? As the particle travels in this direction, the H for different flow rates and then you if your velocity of settling is greater than v s then the particle will be removed , so that something to keep in mind.

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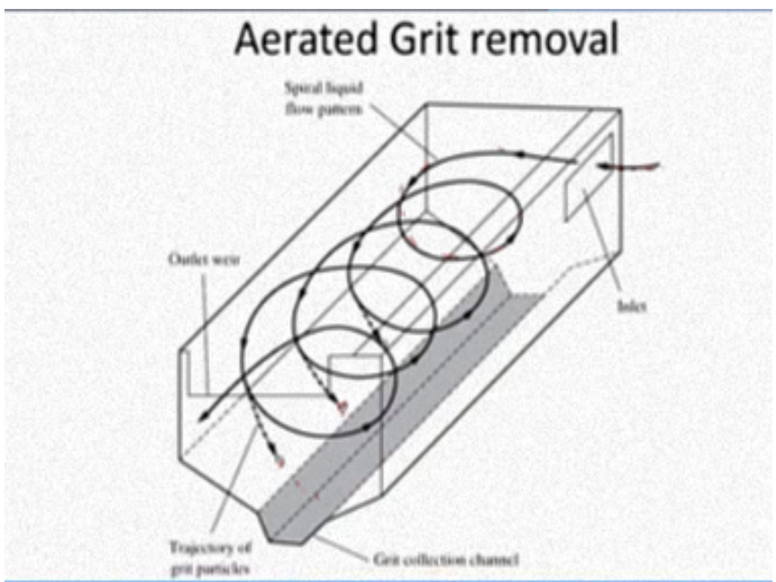

If you want to look at more compact systems or you want to also look at better removal in a way. Where it is not depending upon the flow rate coming in, you will look at this aerated grit removal where by pumping air in, you are going to pump air in to create this spiral flow path for the relevant particles and because of that your particles heavier particles will be settled out or removed at the bottom, the trajectory of the grit particles, so they will be removed at the bottom.

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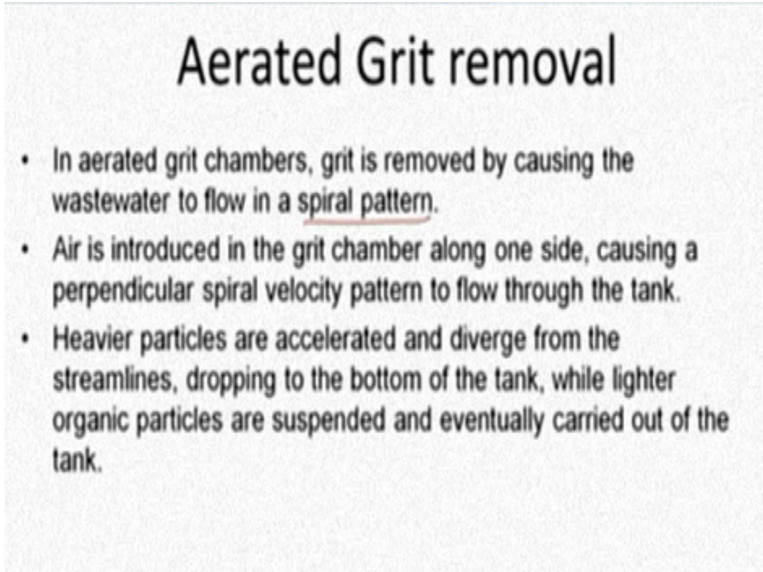

Let us see, if we have a relevant picture out here, in aerated grit chambers we are letting the water waste water flow in a spiral pattern and how are we inducing this spiral pattern by introducing air along one side, heavier particles are accelerated and diverge from the streamlines that are pretty much straight forward.

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Let me see what I have, so diffusion header air is coming in here and you are trying to create this condition and the heavier particles they settle down out here let us see, separation zones here and this is how air is being let up, that is something to keep in mind and the grit or the heavier particles will be collected out here, air is coming in and it will create that spiral motion.

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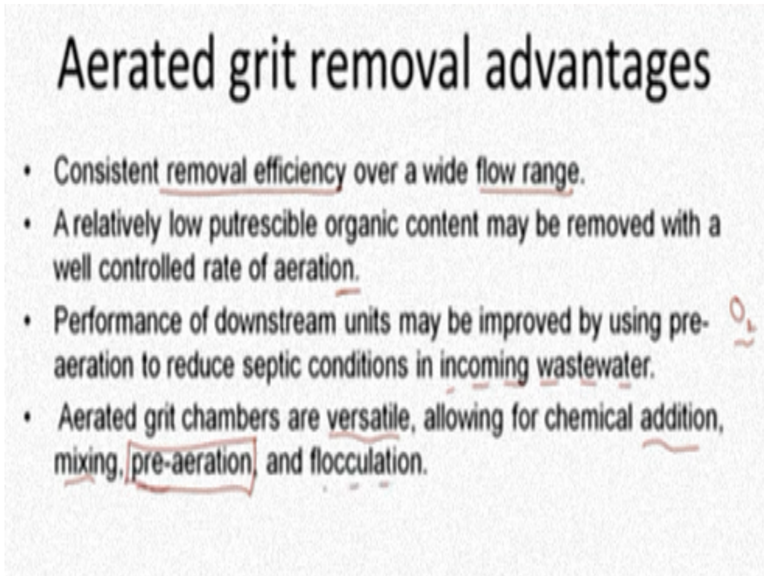

So, what are the advantages let us just look at that, over a wide flow range you will have consistent removal efficiency because it mostly depends upon the spiral action or the air that you are pumping in. Some organic content may be removed with a well-controlled rate of aeration. You can start organic or degradation earlier but microbe concentration is less, performance down of downstream units is improved or can be improved to reduce septic conditions in incoming wastewater.

Why is that? Because here we are pumping in air containing oxygen, so that is one aspect. Aerated grit chambers are versatile allowing for chemical addition or mixing pre aeration which is the key and sometimes it allows for flocculation that is one aspect to keep in mind but the area is relatively higher but higher compared to .

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This is the relevant spiral or aerated grit chamber these should be the air diffusers.

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Aerated grit removal design

- A typical minimum hydraulic detention time at maximum instantaneous flow is 3-5 min.
- Typical length-to-width ratio is greater than 5:1.
- Depth to width Ratio – 1.5:1 to 2:1.
- Air rates typically range from 0.3 to 0.4m^3/min.m of tank length.
- Typical Depth 2-3 m.
- Tank inlet and outlet are positioned so the flow is perpendicular to the spiral roll pattern.

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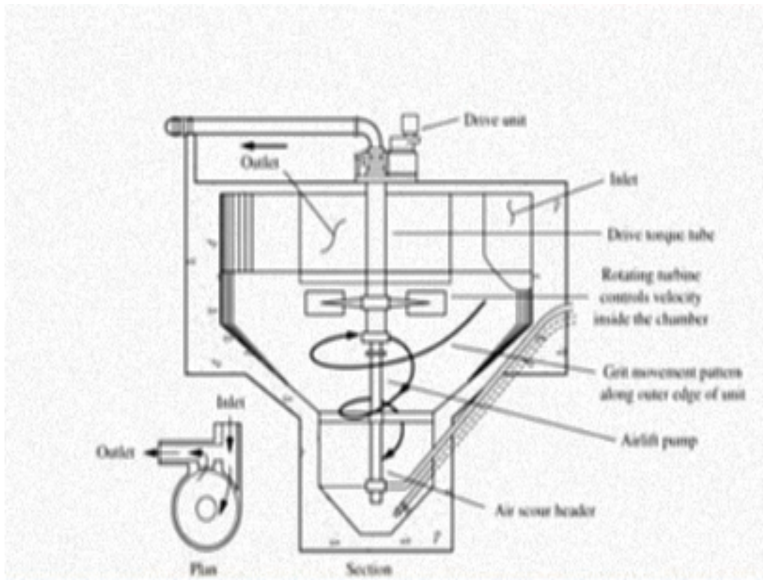

Compared to the vortex flow grit remover but we will just look at that, I am almost at the end of my session. Here what is the HRT that we are trying to maintain its 3 to 5 minutes and the relevant dimensions are the design parameters are given being a UG course we are not going to go into that, but retention time as you see is not high. Hydraulic retention time how much time is my water hydraulic detention time or retention time is it spending in the relevant system.

It is not high 3 to 5 minutes and another aspect or way but with a much lesser footprint is the vortex grit removal chamber.

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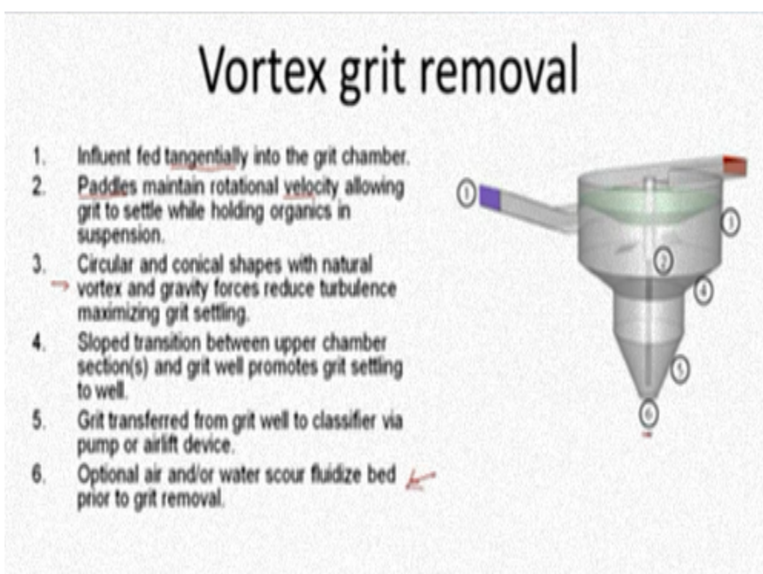

What do we see out here its water is fed tangentially and you have these rotating turbines that create this spiral flow and then grit movement pattern along the outer edge of the unit, so grit will be collected and then it can be removed in this way and then the outlet is out here and the outlet chamber typically is going to be at a relatively or almost twice the area of the inlet, why is that? Because you want to have low velocities at the outlet such that the grit is not carried through, so that is something to keep in mind.

Let us just look at the main points influent fed tangentially, you want to have the vortex. Paddles are used to maintain the rotational velocity, circular and conical shapes to reduce turbulence and maximize grit settling. Let me move on to the relevant pictures, so inlet and outlet I think I have a better picture but here we see the relevant shapes corresponding to the relevant what we say location in the vortex unit, optional air is water scour fluidized bed prior to grit removal.

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Here we see the inlet coming in tangentially and as I mentioned the area of your outlet is typically twice that of the relevant inlet.

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From a different angle, so here is the inlet coming in and this is the vortex chamber here is the impeller if I may say so, this is still under construction and here you will grit will be collected out here and your outlet is out here.

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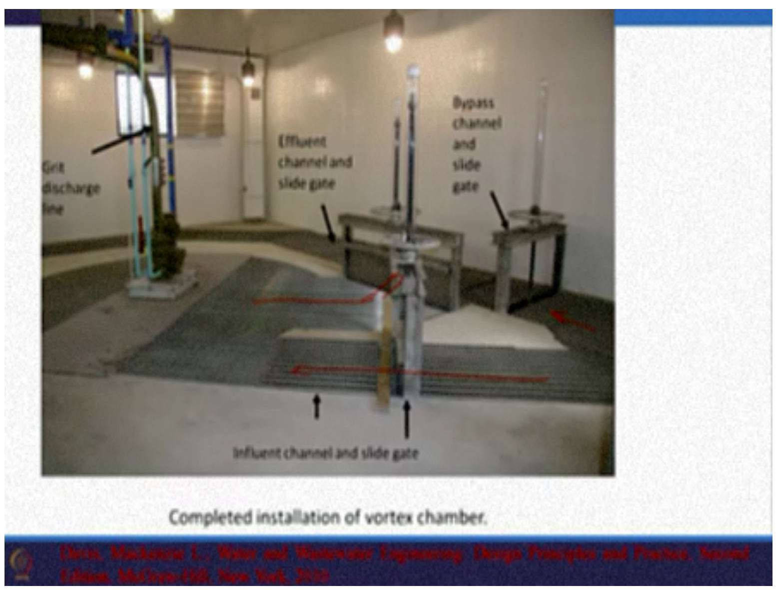

That is the same picture that we looked at earlier, once it is fully constructed coming in grit discharge line from the center, an effluent channel is going out this way. As required if the flow conditions require the bypass that is something that you see.

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Typically there are also compact units but the issue with this vortex is that grit removals are that, unlike the aerated ones or such here they are relatively what we say not relatively, they are proprietary you need to typically buy them from a company and such. Costs are going to be an issue and if you buy it from a company the maintenance is dependent upon the relevant person and such.

But here with respect to the vortex one the costs of maintenance are less because you are not really aerating it, in the aerated one you need to pump in a lot of air but here you have your own disadvantages. You need to look at which one to choose. With that thanking you for your patience for a marathon session, I will end my session for today.