# CTB3365x – Introduction to Water Treatment

## D5c – Sedimentation

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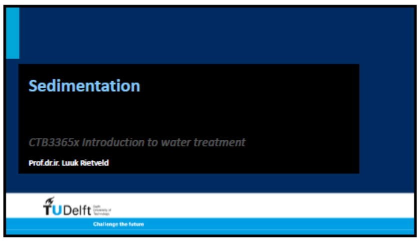
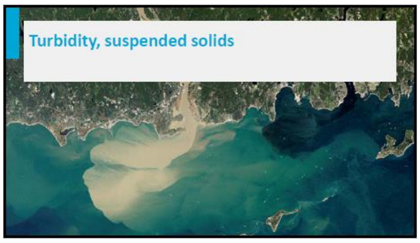
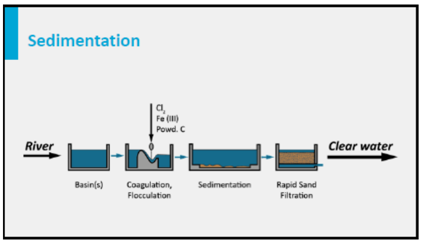


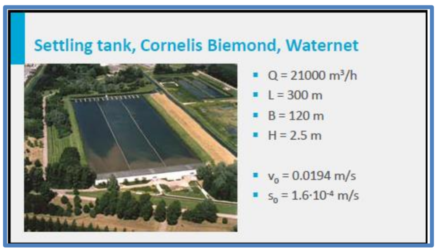

Welcome! Today we will discuss the treatment step sedimentation.



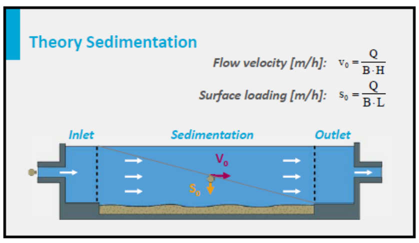

Surface water contains large amounts of suspended solids, measured as turbidity.



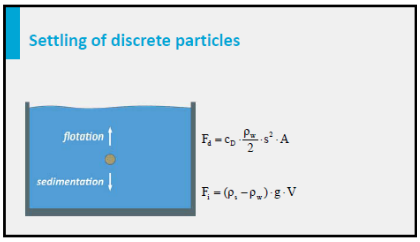

These solids can rapidly clog the rapid sand filters and should therefore, as much as possible, be removed by prior sedimentation.



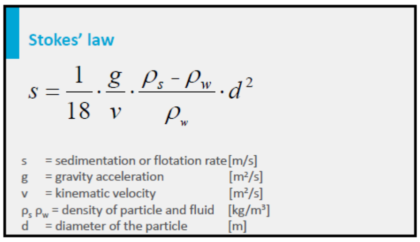

Conventional sedimentation tanks are large in size to be able to remove even small flocs and particles.
This conventional system is called horizontal sedimentation, characterized by two basic parameters:
the flow velocity, defined as the flow over the cross section of the tank; and the surface loading, defined as the flow over the surface area of the tank.



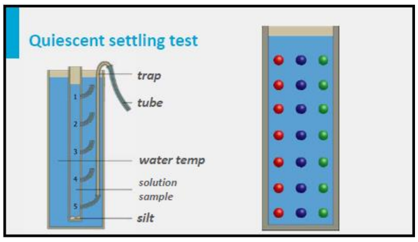

The surface loading is expressed as a velocity, equal to the settling velocity of a particle that enters the tank at the top and settles exactly at the end of the sedimentation area. Apart from the characteristics of the solids to be removed, this surface loading is the most important design parameter to calculate the efficiency of discrete sedimentation.



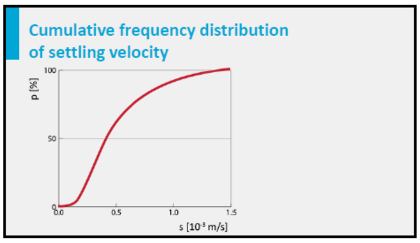

To characterize the settling velocity of a particle, several settling tests were performed in the past.
The settling velocity depends on gravity and the friction forces, that in its turn depends on the settling velocity, surface area and friction coefficient.
From these equations a general equation for the settling velocity can be derived.



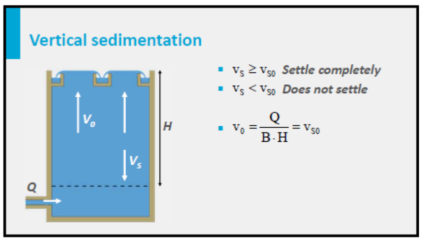

For laminar settling this is reduced to the famous Stokes' law.
From this equation is concluded that laminar settling depends on the viscosity of the water, and the size and the density of the particle.



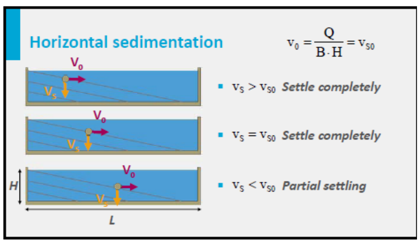

In practice, water consists of many different particles with various sizes and densities that are difficult to measure.
Therefore, settling tests are performed to determine the distribution of the settling velocities of the particles.
The principle of these tests is that heavier particles settle quicker resulting in less turbid water.



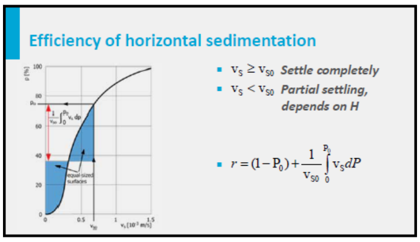

From these results a cumulative frequency distribution of the settling velocities is made, wherein a representation is given of the percentage of particles with a settling velocity equal or lower than the corresponding point on the curve.
For discrete settling this curve is independent of the height of the tank.



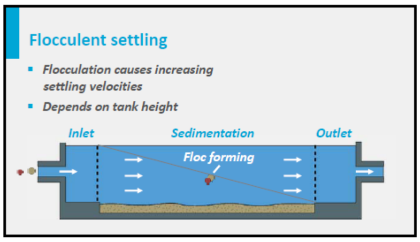

When a vertical sedimentation tank is applied only the particles with a settling velocity higher than the surface loading are removed.



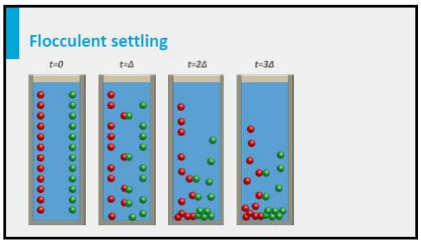

In an horizontal sedimentation tank also part of the particles with a settling velocity lower than the surface loading can be removed, since not all particles enter in the top of the sedimentation tank.
For example, only 50% of the particles with a settling velocity equal to half of the surface loading will settle.



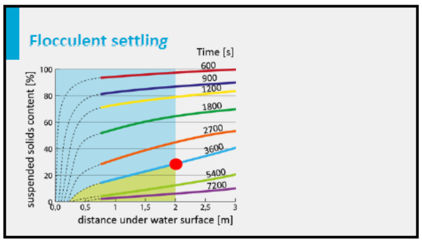

Because many classes of particles exist, integration is needed. The total removal of particles is then the sum of the percentage of particles with a settling velocity higher than the surface loading and the percentage of part of the particles with a settling velocity lower than the surface loading.



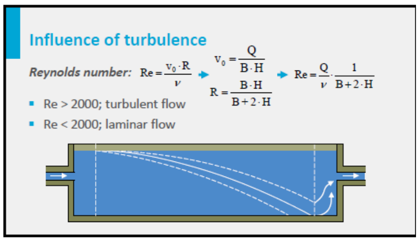

Discrete settling only occurs when removing sand grains, but most of the particles will flocculate, form aggregates that are larger than the original ones and settle faster.
Therefore, unlike discrete settling, flocculent settling is dependent on tank height.



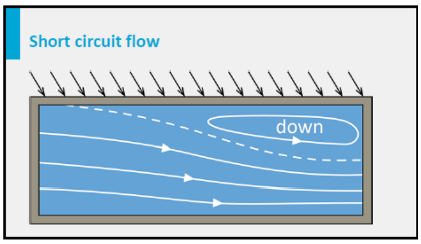

To determine the efficiency in a flocculent tank, pilot test can be performed and the suspended solid content is expressed as a function of height and time.



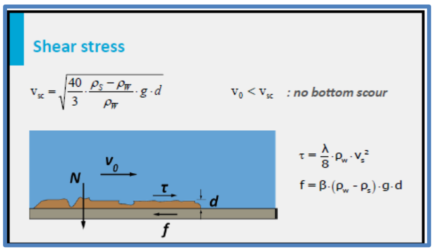

To determine the removal percentage of a tank with a certain height, say 2 meters, and a certain retention time, say 3600 seconds , the amount of removed solids are divided by the total, initial amount of solids.



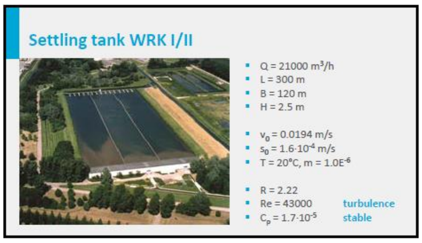

We basically discussed the removal of particles in an ideal sedimentation tank.
In practice this is not the case.
First of all turbulence will interfere.
The higher the turbulence, the lower the removal.
Therefore, sedimentation tanks must be designed with a low Reynolds number, indicating laminar flow conditions.




Second, the flow must be stable to avoid short circuiting in the tank and the formation of eddies that diminish the actual sedimentation area.
For stability, water velocities must be relatively high.

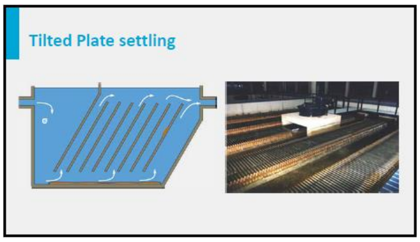



Finally, re-suspension of the settled solids must be avoided, keeping the flow velocity in the tank below the critical scouring velocity of the settled solids.



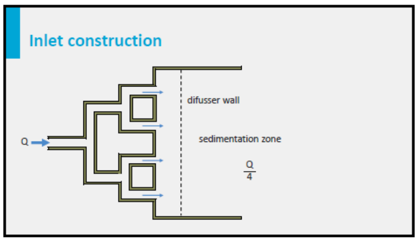

When all these criteria are met, strange designs are obtained that cannot be realized.
Therefore, in practice, vertical baffles are used to increase stability of the flow, without increasing turbulence and risk of re-suspension.


When placing horizontal baffles, also the removal efficiency is improved, since the sedimentation area is doubled and the surface loading is halved.
This especially affects discrete settling, where tank height is not important.

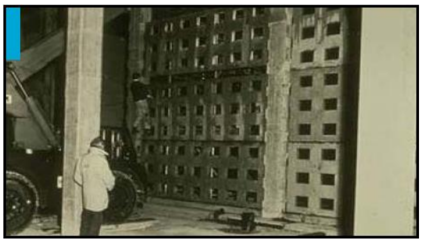



With titled plates the sedimentation area is increased even more.
Surface loading of one twentieths of the original surface loading can be reached.
As a consequence more water can be treated by the same surface area, resulting in less building costs and a more efficient use of the available space.

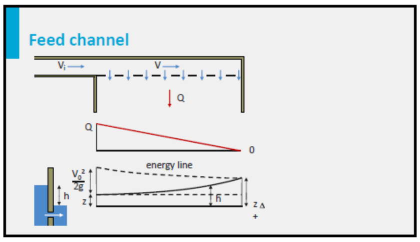

A special design of a sedimentation tank, is the sludge blanket clarifier.
In fact it is a conical, vertical sedimentation tank, where flocculation is stimulated, settling velocity increases during the residence time and flow velocities decrease with the height of the conical tank.
The consequence is that a sludge blanket is formed that can even act as a filter for particles with a low settling velocity.
Although the efficiencies of sludge blanket clarifiers are relatively high, they are rather sensitive to changes in flow and operation.



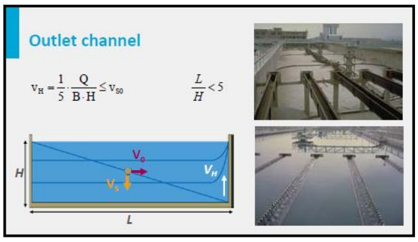

As was discussed earlier, short circuiting must be avoided in sedimentation tanks.
Therefore the water must be evenly divided over the width of the tanks.



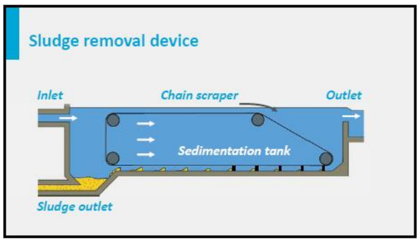
Therefore, special inlet constructions and diffuser walls are developed.



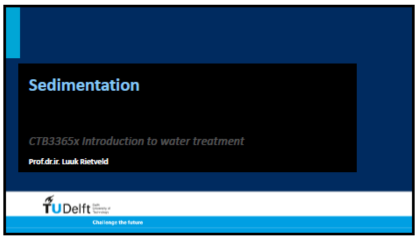

The feed channel should also be designed such that flow velocities are not too high, resulting in a high velocity head and thus low water levels at the entrance of the channel, resulting of a lower influx of water in the sedimentation tank.




Outlet constructions must be designed such that re-suspension is avoided.
As a rule of thumb, the overflow rate at the outlet must be smaller than five times the height of the tank times the surface loading.
This means that the length of the outlet gutters must be longer than the width of the tank and special construction must be made.




The settled sludge must also be removed.
This can be done intermittently and continuously, depending on the amount of sludge that is accumulated in time.
Special scraper and belts are designed to remove the sludge and to transport it to the sludge treatment system.




Now you know the basics of sedimentation.
Thank you for your attention!