Drinking Water Treatment Technology Adapted for Stormwater Treatment

Hans de Bruijn
Terre Hill Stormwater Systems
A Division of Terre Hill Concrete Products
Terre Hill, Pennsylvania

Water is the most common liquid on the earth. Potable drinking water is necessary for human survival. The water supply for potable drinking water is either ground water or surface water. The water from each source contains sediment and other solids. Part of the treatment process requires removal of the sediment and other solids. Many different processes are used to obtain the finished product of potable drinking water.

The world's drinking water industry applies the most efficient, proven technology to clean the water of sediment and solids prior to additional filtration and purification processes. This sediment and solids removal process is necessary to reduce the turbidity of the water. Turbidity interferes with the additional treatment processes, so the removal of sediment and solids is critical to the overall treatment process.

Sedimentation technology works more efficiently when favorable hydraulic conditions exist to allow for solids separation from water by gravity. While many natural forces are present in the sedimentation process, the force of gravity is, by far, the single most important factor influencing the removal of solids from water in the sedimentation process.

Water turbulence is a condition which affects the behavior of the water flow and also influences the settling characteristics of particles in the flow. Generally, the greater the water turbulence, the more difficult it is to remove sediment from a stream of water.

One way to improve hydraulic conditions and to decrease turbulence is by developing multi- sectional shallow sedimentation basins which divide the water flow,

The sedimentation removal technology most often used in the drinking water industry is the stacked inclined plate settler system, also known as the lamella plate system. Separation of suspended solids from a liquid by gravity is primarily a function of the size of the available sedimentation area. Thus, stacked inclined plates, inclined to the horizontal, increase sedimentation area within a given structure footprint. As gravity affects the suspended particles, they settle onto the inclined plates and slide down and are captured in a sump area below the plates.

Plate settling technology has been in existence for over 120 years. An English patent was issued in 1886 and a French design was developed in 1887. A. Hazen published an article regarding plate settlers in 1904. T.R. Camp did the same in 1946. In the late 1930's plate settlers were used in the mining and mineral industries to settle out heavy particles from water flow. In the 1950's Chalmers University in Stockholm, Sweden engaged in a long term study of plate sedimentation technology, resulting in the development of the "GEWE Lamella Sedimentation System.

This system was used primarily to remove hydroxide flocs in the treatment of surface water for potable water supplies and industrial water discharges.

Some of the benefits of a stacked inclined plate design are the compact space in which each system of stacked plates can be used and the fact that there are no moving parts in the design.

The stacked inclined plate system has many unique design features:

1. Flow distribution channels to ensure an even split flow to each individual plate;

2. Counter current or up-flow pattern, in which the suspension and water flow directions are opposite to the removed sediment flow;

3. 55º inclination to the horizontal.

Stacked inclined plate settlers are an application of shallow depth sedimentation technology. The stacked inclined plates promote laminar and stable water flow conditions, which produce favorable conditions for solids removal by gravity. In this design the Reynolds number is significantly reduced.

The efficiency of the stacked inclined plate sedimentation system is dependent upon control of the hydraulic conditions so that the influent flow does not interfere with the settling process of the removed solids and, also, that any water flow does not scour or resuspend the previously captured and stored solids.

The stacked inclined plate system distributes water flow evenly to each inclined plate surface. This produces an equal hydraulic load on each inclined plate cell. This is accomplished by several design features :

1. Placing the inlet location at the lower part of the inlet channel in such a way that the flow does not interfere with the settled sediment downward flow on the inclined plates;
2. Treated water is directed to the outlet section by a weir.
3. The inclined plates extend above the surface of the water

After entering the inclined plate cell the water flows upward between the lamella plates. The plates extend above the water surface, thereby separating the inclined plate cells completely from each other, equalizing water flow. After traveling up the inclined plate the treated water exits the area over a v-notch weir.

The stacked inclined plate system thereby provides an even hydraulic load on each separate inclined plate cell. The low side entry point of water onto each inclined plate ensures maximum utilization of the sedimentation area. The sediment settles onto each inclined plate; slides down the plate and is captured in a sump area.

In order to properly size the stacked inclined plate sedimentation area, the water flow entering the device must be calculated. With this information the surface loading rate can be established. Surface load is the water flow over the horizontally projected area of the stacked inclined plates.

The surface loading rate is a function of the settling velocity of the solid and the ratio of the length of the plates to the spacing between the plates.

The stacked inclined plate system requires no energy source and provides maximum sedimentation through a design that takes advantage of the following laws of nature:

1. **Gravity** : the downward force drawing the particle vertically down

2. **Shear Stress** : Gravity force on the particle, parallel to the sedimentation surface

3. **Normal Stress** : Gravity force on the particle, perpendicular to the sedimentation surface

4. **Friction** : coefficient of friction is determined by the surface texture of the particle

5. **Particle Density** : sedimentation of a particle requires a particle density greater than the density of the water flow

6. **Kinematic Viscosity** : measure of a liquids inability to flow (water has unusually high viscosity)

7. **Particle size** : measure of degree that affects the sinking velocity exponentially.

8. **Temperature** : inversely related to viscosity

9. **Polarity** : can cause flocculation, which aids

The above physical natural laws are constants; they apply uniformly in all water flow analyses. They provide the parameters which control the calculation of sediment and solids removal from water flow by sedimentation. As will be discussed later, the effect of gravity controls and the amount of sedimentation area is critical to the calculation.

In addition to the laws of nature important variable water characteristics need to be identified, before design of a stacked inclined plate system can be completed:

Influent Characteristics

Mean Influent Sediment Concentration of the sediment in the water flow is important to quantify;

Mean Particle Size Distribution needs to be identified or reasonably estimated;

Flow Rate and Volume of the significantly affects the sediment and solids removal. A lower flow rate results in greater sediment and solids removal rate.

The drinking water industry has successfully used this technology for decades. Clearly no better method exists for the removal of sediment and solids from water prior to the filtration process. Water, whether water to be processed for potable drinking water purposes or stormwater runoff, have the same physical properties. It stands to reason that the time tested and proven technology of stacked inclined plate technology should be equally effective in the treatment of stormwater for the purpose of removal of sediment and other solids.

NPDES Phase II requires that stormwater pollution be removed to the “maximum extent practicable”. While not further defined or clarified, this standard is well served by utilizing technology that removes sediment from stormwater runoff with the highest degree of efficiency and at the lowest cost, both of operation and long term maintenance.

No other technology in the stormwater treatment industry can compare to the stacked inclined plate sedimentation technology .It has been used for the removal of solids from liquid since 1886. Two of the most respected engineers in the United States, A. Hazen, over 100 years ago, and T.R. Camp, in the 1940’s endorsed the stacked inclined plate technology.

Under proper design a stacked incline plate hydrodynamic separator provides the greatest sedimentation area per total area of a structure. This results in a low cost per square foot of sedimentation area.

Significant long term data on the removal rates and efficiencies of stacked inclined plates exists in the drinking water industry; industrial waste water treatment and in he mining and mineral industries. There exists no reason why such data can not be reviewed to provide reasonable assurance that the same technology will perform similarly in the stormwater treatment industry.

The EPA estimates that 94% of the population lives within 10 miles of an impaired body of water. This sobering statistic highlights the enormity of the NPDES Phase II goal to preserve, protect and improve the nation’s water resources. The removal of sediment from stormwater runoff is a high priority objective.

The EPA should “stack the deck” for stormwater sediment removal by promoting the use of the only time tested and proven technology for removal of sediment from water. Stacked inclined plate sedimentation technology is the most efficient cost effective sediment removal technology.

Other stormwater treatment technologies are being promoted in the marketplace.The stormwater treatment industry is in its beginning stages. New technologies do not have the historical data that exists for the stacked inclined plate technology. To date the data shows that gravity and sedimentation area are the dominant factors that influence the removal efficiency rate of a hydrodynamic separator.

A close examination of the various stormwater hydrodynamic separators, shows that underlying all of the purported new technology is the fact that gravity and sedimentation area remain the only factors that influence particle settling in any of these devices.

Only a hydrodynamic separator having a stacked inclined plate design can fully take advantage of the gravitational force and maximize its effect on sediment by concentrating the sedimentation area in a compact design.