Tech Note

SHEAR STRESS

Key to Channel Erosion Protection

The design of hydraulically stable storm water drainage channels is a key element of most civil engineering projects. The ability to collect, contain, and convey storm water until it leaves the job site, without creating significant erosion, requires a thorough engineering analysis.

Hydraulically stable channels are vital to assure that adjacent capital improvements on the site are not damaged by erosion. They are also needed to ensure that the regulatory requirements regarding water Quality and construction site storm water discharge are being met.

Generally accepted engineering practice uses shear stress as the key parameter for determining the hydraulic stability of a storm water drainage channel.

DEFINITION

Shear stress is the force applied by flowing liquid to its boundary. In this case, the liquid is storm water and the boundary is the channel surface. Shear stress is also occasionally referred to as the "tractive force."
Put simply, shear stress describes the force of water that is trying to drag the channel surface downstream with it.

THEORY

Shear stress is calculated based on the principle of conservation of momentum.

MATHMATICS

For non-uniform flow conditions, the shear stress equation is complex to account for the changes in the depth over a given length; however, for the uniform flow conditions found on many storm water drainage channels, the complex equation can be simplified to the following formula:

$$\tau = \gamma \text{ X } d \text{ X } S$$

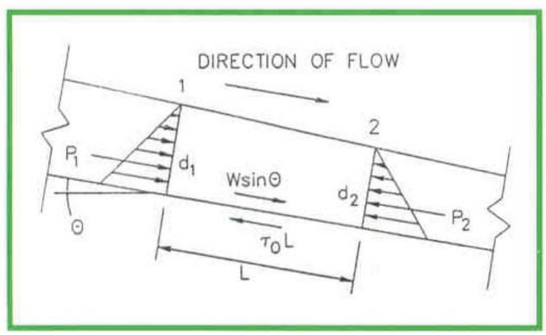
Where,

τ = shear stress, Pa (lb/ft^2

γ = unit weight of water, N/m^3 (lb/ft)^3

d = depth of flow. m (ft)

S = energy gradient, m/m (ft/ft)



For most open channel flow conditions, the energy gradient is Parallel to the channel bottom. Therefore, the bed slope of the channel can be substituted for the energy gradient.

If non-uniform flow conditions are present (i.e. accelerating or decelerating flow) or if channel cross section changes are encountered, a more sophisticated analysis will be required. Special attention needs to be given to hydraulic structures, such as bridges and culverts. For most cases, the above equation is applicable.

APPLICATION

When calculating shear stress, the standard unit weight of the water is generally used 9,806 N/m^3 (62.4 lb/ft^3). This unit weight is for clear water in standard atmospheric conditions. In reality, most storm water discharges have a slightly higher unit weight due to the mass of suspended solids. The unit weight should be increased accordingly if significant suspended solids are likely.

The shear stress equation can be used to calculate the value at any given depth. For most applications though, the critical (i.e. maximum) stress is the key criteria. Therefore, the maximum depth of flow should be used.