Water Table Concerns for Storm Drains and Culverts

American Concrete Pipe Association
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An educational document from the American Concrete Pipe Association for users and specifiers

Storm drain and culvert pipe installations can be sensitive to the presence of a water table in the backfill and surrounding soil. Soils placed and compacted in the pipe envelope need to be stable in the presence of water. **The soil-pipe interaction analysis needs to account for the buoyant effect and impact on the passive soil pressure that a water table has on the soils used in the installation**. For a rigid pipe installation these factors are somewhat insignificant, since the majority of the strength is resident within the structure of the rigid pipe material. But, for a flexible pipe, the majority of the strength is built into the soil envelope which is impacted directly and extensively by the presence of a water table.

Concerns and Precautions:

One of the assumptions included in a flexible pipe system is the soil prism pressure (Psp) which is directly impacted by water table fluctuations. As the water table elevation rises above a pipe, the vertical load on the pipe increases. This is accompanied by a reduction in the passive lateral soil pressure because of a reduction in the internal friction in the soil columns on either side of the pipe, thereby reducing the horizontal pressure available to resist lateral deflection of the flexible pipe.

Fluctuations in the water table have a limited effect on rigid concrete pipe since the active lateral earth pressure pushing on the sides of the pipe actually increases when the internal friction in the soil is reduced. Because of this, **engineers have become accustomed to using fill height tables without regard to the elevation of the water table**. The impact of water table elevation is vastly different for the flexible pipe system depending on the type of soil installed in the pipe envelope (granular or soil containing fines), as well as how well it is installed. Although consideration of the effects of the water table on soil-structure is negligible with rigid pipe, the combined system impact is rarely, if ever, addressed in fill height tables for flexible pipe, where it is critical. (Note: The loss of side soil support due to migration caused by water table fluctuations can be critical to the structural capacity of flexible pipe and must be considered by the design engineer.) **Designers who default to using manufacturer tables, without taking into consideration all of the design caveats, greatly increase their risk and liability.**

When a pipe system is installed below the water table, an uplift force caused by buoyancy is introduced to the system. The current AASHTO LRFD design for flexible pipe indicates that hydrostatic loading should be calculated in all cases. **Hydrostatic forces are assumed to act normal to the pipe surface, and thus have no effect on the bending deflection of a flexible pipe. This is not true when you consider the buoyant effects of a water table, which is in addition to the hydrostatic forces.** The buoyant force on a flexible pipe can add between 5% and 20% to the vertical load assumed in the design, thereby increasing the Vertical Arching Factor that is calculated per the current AASHTO LRFD code. This same impact for a rigid pipe is negligible given the relative weight of the pipe material included as dead load in the design analysis.

Needed Steps:

The engineering community must design their projects with the actual water table impact considered. A very large component of the structural capacity of the soil-pipe system is dependent on the design of the backfill envelope for plastic pipe. That can be possible only by mandating a high quality installation with a thorough understanding of the project variables, such as water table height. The engineering community will help reduce their liability when specifying a plastic pipe system by following the steps outlined above for every project.

Reference: Flotation (Buoyancy) Comparison Brochure Resource #07-125