North American Pipe Corporation™

Burial Depths for PVC Pipe

Questions are often asked regarding the maximum depth of bury for PVC pipe, especially PVC sewer pipe. The short answer to the question of how deep can you bury PVC pipe is “really deep” because the pipe is not the limiting factor; it is the quality and installation of the embedment material.

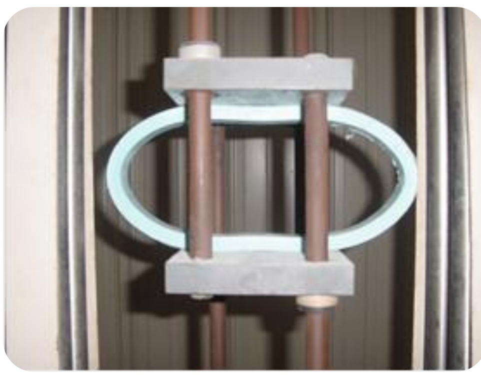
FLEXIBLE AND RIGID CONDUIT THEORY

PVC pipe is classified as a flexible conduit. Ductile iron pipe is also considered to be a flexible conduit. Concrete and clay pipe are classified as rigid conduits. The difference between the two classifications is this: flexible conduits bend without breaking in response to soil and traffic loads. As these loads come to bear, the flexible conduit deflects in the vertical direction and extends in the horizontal direction and becomes slightly elliptical in shape. In this way the vertical soil and traffic loads are transferred horizontally to the embedment material at the sides of the pipe. Rigid conduits rely on their structural strength to resist the same loading. Once a maximum load is reached the conduit will fail. This has led to the use of terms such as “crush strength” or “crush rating” for those materials. Because flexible and rigid conduits react differently under load, the terms crush strength and crush rating do not apply to flexible conduits such as PVC pipe.

PVC pipe in and of itself will not support very much load without deflecting. As such it is reliant upon the quality of the embedment material and the compaction of that material to control the amount the pipe deflects. The “stiffer” the embedment the more support provided for the pipe. The amount that a buried flexible pipe will deflect can be calculated with the Modified Iowa Equation. This empirical equation and the soil values that are used with it were derived through extensive testing and evaluation. More information about flexible conduit theory, the Modified Iowa Equation, and soil and embedment values and their use with PVC pipeline design can be found in the Uni-Bell PVC Pipe Association technical report UNI-TR-1-97 entitled “Deflection: The Pipe/Soil Mechanism”.

MAXIMUM DEFLECTION

The maximum recommended vertical deflection for PVC pressure pipe (AWWA C900, AWWA C905, ASTM D2241…) is 5% and for solid wall sewer/drain pipe (ASTM D3034, ASTM F679, ASTM D2729…) it is 7 ½%. Please note that deflections in excess of these amounts will not cause the pipe to fail. These values were determined by applying a safety factor of 4:1 to in-soil deflection test results. The tests indicated that PVC pipe becomes and remains elliptical in shape at in-soil deflections of up to 30%. Deflections of more than 30% result in inverse curvature of the pipe but no structural failure. In fact the standards to which PVC pipe is made require that deflection tests to 40% of the inside diameter (or a deflection of 60%) be run on a routine basis to confirm the quality and integrity of the produced material. The following photographs show the testing of a piece of eight inch, DR18 AWWA C900 PVC pipe before testing and at the required 40% deflection.



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The requirements of the different standards are that, after the test, "There is no evidence of splitting, cracking, or breaking" of the sample. (AWWA C900-97, Section 4.3.3.4)

CALCULATING PIPE DEFLECTION

It is possible to obtain a computer program based on the Modified Iowa Equation free of charge from The Uni-Bell PVC Pipe Association (http://www.uni-bell.org/unidown.html). This program can be used to calculate pipe deflections for a variety of installation conditions and pipe stiffness values. It was used to perform the following calculations for ASTM D3034 and ASTM F679 pipe bedded in a class II material as defined by ASTM D2321 and compacted to 95% Proctor density.

Thickness Class	Pipe Stiffness, lb/in^2	Bury Depth-20ft, % Deflection	Bury Depth-40ft, % Deflection	Bury Depth-60ft, % Deflection
SDR35	46	0.88	1.76	2.63
SDR26	115	0.83	1.67	2.50
E'=3000 lb/in^2				

The calculated values are independent of the pipe size because the pipe stiffness value is the same for all. Notice that with quality embedment and compaction the calculated deflections of the SDR35 and SDR26 pipes are nearly identical and are approximately one-third of the recommended maximum value at a depth of sixty feet. These values can be compared to the same pipe and bedding material but with a compaction of 85% Proctor density.

Thickness Class	Pipe Stiffness, lb/in^2	Bury Depth-20ft, % Deflection	Bury Depth-40ft, % Deflection	Bury Depth-60ft, % Deflection
SDR35	46	2.46	4.91	7.37
SDR26	115	2.13	4.27	6.40
E'=1000 lb/in^2				

It can be seen from these comparisons that the quality of the embedment plays a much greater role in the deflection of the pipe than does the stiffness value. Even with a looser compaction on the backfill the calculated deflection at sixty feet is within the recommended maximum value of 7.5%.

TRAFFIC LOADS

Traffic loads can be incorporated into these calculations and they are much more of an issue with shallow depths of bury than deep. What's more, at depths of 10 feet or more an H20 traffic load can be considered to have a negligible affect on the pipe. The minimum depth of bury for PVC pipe with traffic loading is twelve inches from the top of the pipe to the bottom of the flexible road surface. For light to medium aircraft loadings of up to 320,000 pounds gross weight the minimum depth of bury is two feet. These depths assume a minimum 95% Proctor density with grade I or grade II embedment. Special attention should be given to the selection, placement, and compaction of shallow bury flexible pipes underneath rigid road surfaces to prevent excessive cracking of the road surface.

SUMMARY

The combination of the pipe stiffness and the soil stiffness enables PVC pipe of all sizes to be utilized at significant depths of bury in a very efficient and economical manner through the use of common, attentive installation techniques.