PIPE ON AERIAL SPANS AND PIER SUPPORTS

Concrete Pressure Pipe river crossing.

Installations of concrete pressure pipe can be designed for a wide variety of site-specific conditions. Aerial installations may be required to cross over an obstacle such as a roadway or streambed. Pipeline alignment may require installation in unstable or low-strength soils, such as swamp or river bottom silts. These are among the most difficult local conditions for pipeline design, and it is in such applications that concrete pressure pipe most clearly exhibits its superior beam strength.

PIER-SUPPORTED SOLUTIONS

There are basically two types of pier-supported systems. The supports can be placed under the joints of the pipe, forming a simply supported beam, or they can be placed within the span of the pipe, to form a continuous beam-type structure. The latter is usually preferred since it can provide the advantage of reducing stresses in the steel cylinder to approximately one-half of those created in a simply supported system. The support location that results in equal positive and negative longitudinal bending moments can be located by deriving the equations for the maximum positive longitudinal bending moments between the supports and the maximum negative longitudinal bending moments at the supports, and then equating them to each other.

Pipe can be placed on piers either with restrained or unrestrained joints, as required for each situation. Unrestrained joints and mechanically restrained joints will transfer shear forces, but will not transfer bending moments. Mechanically restrained joints include harnessed clamps, Snap Ring® joints, Victaulic®-style couplings, etc. Joints restrained by welding will transfer full bending moments. Unrestrained and mechanically restrained joints can be used for continuous beam-supported pipe and will cause a point of zero bending

AMERICAN
Concrete Pressure Pipe
ASSOCIATION

Multiple lengths of Concrete Pressure Pipe can be welded together to extend span length and reduce the number of piers.

moment at the joint location. It can be shown that, when the spans on both sides of a support are equal in length "L" and the pipe length is equal to the span length "L", placing the unrestrained or mechanically restrained joint a distance of 0.146L from the support will equalize the maximum positive and negative bending moments, thereby minimizing the maximum design bending moment stress in the pipe.

The standard O-ring joint provides joint flexibility to allow for movement resulting from expansion and contraction. The forces created by expansion and contraction, plus any other forces that may exist, can be resisted by design and installation of pipe support anchorage systems. If the pipe joints are unrestrained, the support anchorages must restrain the pipe from moving across the support and disengaging a joint. Supplemental anchorage should be provided at intermediate points in long, multiple-joint, aerial spans.

Design of pipe on piers, whether the joint support system or continuous beam system is used, must consider all of the live and dead loads typically included in normally buried pipe. Design must also accommodate expansion and contraction of the pipe and any resulting forces at the joints. Additionally, aerial installations must include applicable wind loads. However, the design calculation must address that, between the piers, there is no support for the pipe. (Design of concrete pressure pipe for support on piers is detailed in the AWWA M9 Manual, Chapter 10.)

UNSTABLE SOILS

When a pipe project must pass through low-strength soils, the design engineer must first determine if the soil can be stabilized by removing a portion and replacing it with higher-strength stabilizing materials. If such an approach is insufficient and more traditional foundation designs are also not practicable, the best design solution may be to reinforce the foundation by using piles. Bearing piles are the most common, extending below the weak soil layer to a stronger strata such as firm soil or bed rock below. Bearing piles are particularly useful when there is a risk of the upper soil strata being eroded by fast moving water currents.

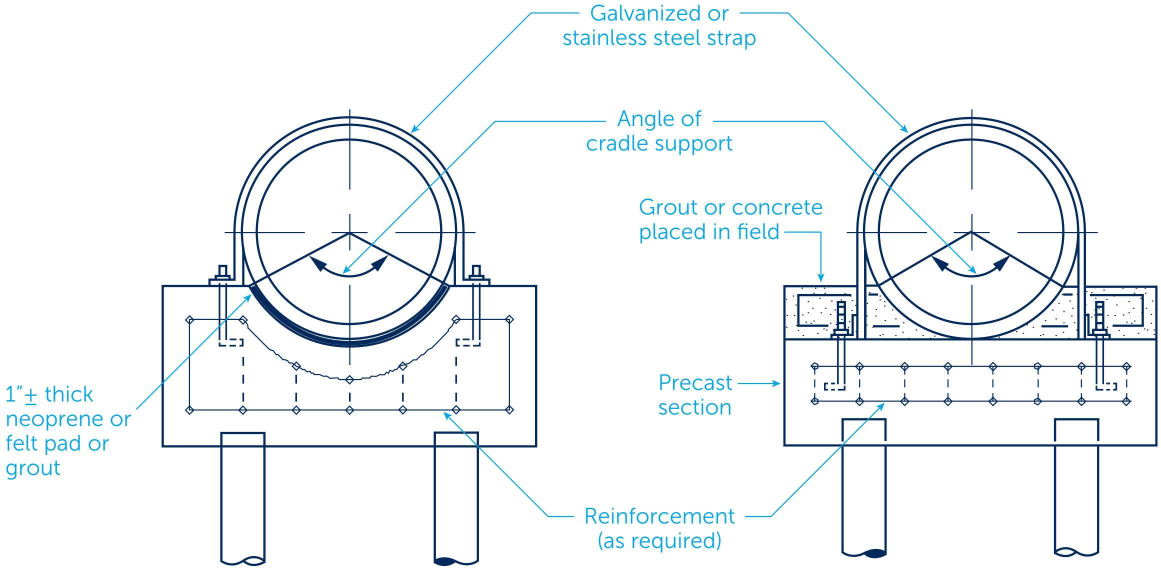
Another commonly used type of pile is the friction pile, so named because its resistance to load derives from frictional resistance between the pile surface and the surrounding soil. Batter piles are designed to carry lateral loading and may be of either bearing or friction pile type. The best type of pier support for a given location often is a compromise between engineering preferences, cost, and availability. Supports can range from shaped concrete support saddles to pile-driven timber, concrete, or steel supported systems.

Design of pile foundations must rely upon careful foundation investigation. Considerations are: the depth of firm soil or rock; characteristics of the upper soil strata; actual vertical load to be carried; and application of any lateral loading to the foundation. Such information provides data to determine the required pile depth, spacing and type of pipe support required. While pile foundations may be costly, they may also offer the only solution for constructing a project in the desired location.

OTHER FACTORS

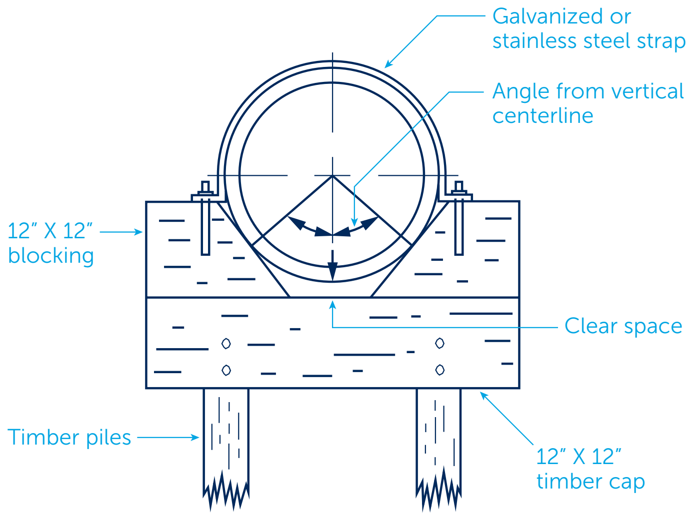
There are other design parameters that may need consideration. If the pipeline is to be buried under heavy loads, the shear strength of the joint must be investigated during the design phase. Also, in above-ground and aerial installations, consideration must be given to environmental conditions. Exposed pipelines may have a seal coat of light-colored paint applied to protect the pipe from environmental deterioration. Alternatively, since exposed mortar often lasts longer and is less expensive to repair than exposed paint, it can be left bare and maintained through scheduled inspections and occasional mortar/crack repair.

The amount of total differential settlement at the piers should be held to less than ½" in order to minimize secondary stresses in the pipe, especially in continuous beam-supported pier installations. If settlement does occur in a continuous beam-supported pipeline, gaps may occur between the pipe



Precast Pipe Support

Partially Precast Pipe Support



Two Point Support
(Not Recommended for C303 Pipe)

Piers assure Concrete Pressure Pipe laid in unstable soil will maintain the required elevation after soil settlement.

and the support, which will increase the bending moments in the pipe.

The pipe supports at the top of the pier or pile bent can range from a simple two-point support (wood chocks) on each side of the pipe, to a reinforced concrete saddle. The type of support and its area of contact with the pipe have a large influence on the circumferential moments in the pipe wall and therefore upon the load-carrying capacity of the pipe. Wide cradles with large support angles provide the best support.

The pipe span length is also a major cost factor. The fewer the number of supports, the lower the overall project cost and the greater the horizontal clearances for objects such as highways, rivers, etc. Many aerial installations have utilized multiple pipe lengths that have been welded together in order to form long rigid spans up to 60 feet in length.

Timber piles are the simplest type, but are often limited in load capacity and are generally less than 50 feet in length. In low, swampy areas, they are advantageous since they may be used without preservative treatment if they will always be wet.

THE POWER OF CONCRETE

Precast and prestressed concrete piles can be custom designed and engineered for a project for both length and load-bearing capacity, and thus offer many advantages. The main disadvantage of concrete piles is their weight, but this can be overcome where long piles are required by splicing shorter sections together.

H-piles are also widely used, since they too can be designed to carry a wide range of loads and can be joined to form almost any length. They are very rugged and can penetrate difficult soil materials by simple reinforcement of the end tip.

Pier-supported concrete pressure pipe installations have ranged from buried structures passing through unstable soils and subaqueous installations to aerial crossings over highways, canals, rivers, and existing structures. Concrete pressure pipe is available in nominal lengths ranging from 16 to 40 feet and can be welded together to form longer spans where required.

LEARN MORE

For more information on using concrete pressure pipe for aerial spans and pier supports, speak with your Concrete Pressure Pipe supplier, or contact the American Concrete Pressure Pipe Association at **714.801.0298** or **www.accpa.org**.

References

AWWA Manual M-9, Concrete Pressure Pipe, 2008.

Hunt, Hal W., "Piles – Tips On Their Use Under Water Supply Structure," Water and Sewage Works, October, 1974.

Sowers, George B. and George F., "Introductory Soil Mechanics and Foundations," Macmillan Publishing Company, 1970.

AMERICAN Concrete Pressure Pipe ASSOCIATION

ACPPA Headquarters
T 714.801.0298
email: support@acppa.org
www.acppa.org