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American **Concrete Pipe** Association

Concrete Pipe Information

# Insignificance Of A 0.01-Inch Crack

*"Some engineers insist that a crack in a concrete pipe in excess of 0.01-inch represents a failure or partial failure situation. Such a conclusion is utterly ridiculous and represents a disservice, not only to the concrete pipe industry, but taxpayers as well."*[9]

This quote from Professor M.G. Spangler, a well respected authority and early pioneer in the design of concrete pipe, should be taken into consideration when designing, installing, inspecting, or funding a project using reinforced concrete pipe, (RCP). All parties involved should be aware of the **insignificance** of a 0.01-inch crack.

Reinforced concrete pipe, like other reinforced concrete structures, is designed to crack. It is well known that while concrete is very strong in compression, its tensile strength is so low that it is considered negligible in design. Therefore, RCP design accommodates the high compressive strength of concrete and the high tensile strength of steel. As load on the pipe increases, and the tensile strength of the concrete is exceeded, micro-cracks will form first at the invert and occasionally at the crown as the tensile load is transferred to the steel. This is known as the modulus of rupture. Because of the excellent distribution of the tensile stresses in RCP, the cracks are very small. Typically, the cracks form a V-shape with the largest part of the crack at the surface. The crack most often terminates before reaching the concrete reinforcement. The presence of a 0.01-inch crack does not represent failure, but rather an indication that the concrete and reinforcement are working together, as intended.

The 0.01-inch crack criteria has been used as a service load design criteria for RCP for nearly 70 years. This criterion has served the industry well through the clear designation of a plant test protocol. It has also served the public well by conservatively ensuring that a strong and durable product is used in their buried infrastructure. Most RCP is designed to have a crack width of 0.01-inch or less after the fully installed loading condition is applied. While a crack width greater than 0.01-inch is an indication that the performance of the soil-pipe structure is not entirely consistent with its original design, it is not necessarily an indication that the specifier should be too concerned with the performance of the installed pipe.

For example, both Caltrans, and more specifically the AAS-

***0.01-Inch Crack Measured in a 36-Inch, Class IV Pipe.***

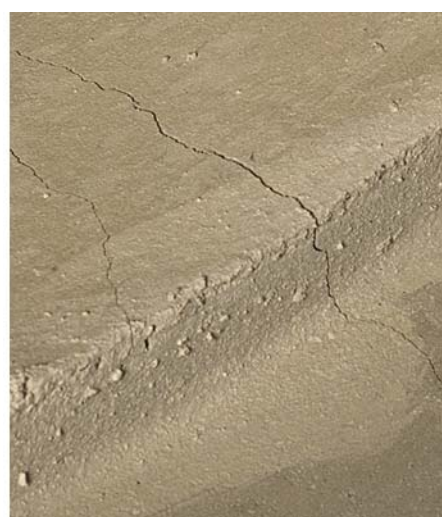
HTO LRFD specification in section C27.6.4 states, "Generally in noncorrosive environments (pH ≥ 5.5) cracks 0.10-inch or less in width are considered acceptable."[1] This allows for 10 times greater width than the design crack without repair. In other environments, "Cracks having widths equal to or greater than 0.01-inch and determined to be detrimental shall be sealed by a method approved by the engineer."[1] This means that it must first be determined that the crack will have a damaging or harmful effect. Even then, it only requires a repair seal, not replacement. For destructive reactions to continue within a crack located in a corrosive or highly alkaline environment, there must be a continuous replenishment of the aggressive solution and/or oxygen.

Many sources agree, the 0.01-inch crack was never intended to determine the failure of installed RCP. This crack width was established by Professor W.J. Schlick of Iowa State University to establish the strength of RCP, in a three-edge-bearing test by using a simple 0.01-inch thick leaf gauge to determine a measurable and definitive size crack. The three-edge-bearing test is a plant test that applies a bearing strip along the top of the pipe, and two closely spaced bearing strips along the bottom. This test creates a much more severe load than installed conditions. Specifications for RCP require an ultimate load resistance that exceeds the required 0.01-inch crack strength, giving the designed pipe a significant factor of safety above the required service load. The 0.01-inch crack width has absolutely no relation to the size of a crack that should be considered a structural failure of an installed concrete pipe. In fact, ASTM C76-06 states in section 11.3.1, "Pipe that have been tested only to the formation of a 0.01-inch crack and meet the 0.01-inch load requirement shall be accepted for use."[2]

The critical crack width of installed RCP should be determined by the size of the crack that would allow moisture to cause detrimental corrosion of the reinforcing steel. Professor Spangler even noted his opinion on the durability of RCP as, "Cracks up to approximately 1/16-inch in width will not permit corrosion except under the most adverse conditions"[8]. In the CP Info - Effects of Cracks in Reinforced Concrete Culvert Pipe[4], a study performed on the Diamond Bar Culvert installed with 80 feet of fill in California, found that even with cracks 0.2-inch wide, structural integrity was maintained. These results should be reasonably representative of what would be expected in similar environments. This projection was based on observed corrosion, a ratio of ultimate working stress of reinforcing steel of 2.0, and essentially unchanged environmental conditions.

***Autogenous healing in concrete pipe.***

Furthermore, a phenomenon, known as autogenous healing often occurs between two surfaces of narrow cracks in buried pipe. Autogenous healing is the ability of concrete to heal itself in the presence of moisture and air. This explains why the healing occurs in concrete pipe where moist conditions are higher than



***The 0.04-inch crack shown is less than half the crack width of 0.10-inch accepted by Caltrans and AASHTO.***

those of other concrete structures. During this process, calcium carbonate, (a hard white substance), forms when moisture reacts with unhydrated cement powder and regenerates the curing process. This self-healing process creates a monolithic structure, as if the crack had never occurred. In Ohio, the Department of Transportation has developed a post construction inspection standard for installed pipe, where there is evidence of cracking, that requires nothing be done to a pipe with a crack width up to 0.06-inch, due to the autogenous healing that is expected to occur.[7]

During a post installation inspection of a sanitary sewer for the Brazos River Authority, a hairline crack was revealed in both 30-inch and 42-inch diameter pipe.[5] Cores, centered on the cracks, were cut from both sizes. The samples were then tested for autogenous healing by either submersion in water, exposure to water vapor, or exposure to 5% sulfuric acid solution. The results showed that autogenous healing occurred in all the samples, although at a decreased rate for the sample subjected to acid vapor. The samples that were exposed to the acid vapor showed no detrimental effects on the inside surfaces of the cracks, or the reinforcement. Not only is deterioration of the reinforcement due to a crack a low probability, autogenous healing has a high probability of occurring where moisture and air are present.

With recent developments in video imagery technology, OSHA confined space rules, and GASB 34 rules, video inspections are often employed to inventory existing systems and acceptance of new installations. During these inspections, cracks and the presence of autogenous healing may be evident. BEWARE! All too often an untrained inspector views a small crack in a post installation video inspection of a RCP to be a failure. This occurs most often because many of the cameras currently available for video inspections produce some distortion and unavoidably magnify hairline and shrinkage cracks. This causes the cracks to appear as though they are much larger, resulting in unnecessary repairs or replacements. Recent technology has produced a calibration device that clearly indicates the actual size of the crack, resulting in an accurate inspection. Hairline cracks are expected to occur in concrete pipe so that reinforcing steel will function as designed. It is important to know the intensity of magnification and how the magnified image appears in a video inspection. Engineers, contractors and owners of pipelines should contact a professional who is familiar with the procedures involved in the inspection of RCP to ensure an accurate inspection.

## References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