CONCRETE PRESSURE PIPE IN EARTHQUAKE ZONES

The performance of concrete pressure pipe during seismic events has been excellent. The inherent safety factors included in the pipe design procedures presented in AWWA Manual M9 for AWWA C300 reinforced concrete cylinder pipe, AWWA C302 reinforced concrete noncylinder pipe, and AWWA C303 bar-wrapped cylinder pipe, and in the AWWA C304 design procedure for AWWA C301 prestressed concrete cylinder pipe, have proven sufficient in pipelines buried proximate to fault movements from earthquakes of magnitudes up to 7.2 (Richter scale).

Three case studies of concrete pressure pipelines inspected after large earthquakes in California and northwestern Mexico demonstrate the excellent performance of concrete pressure pipe with ordinary gasket joints. These studies were presented in the paper, "Review of Performance of Gasketed Joints of Buried Concrete and Steel Pipelines in California After Recent Seismic Events," at the ASCE Pipelines 2011 Conference.[1] As an example, a 60" PCCP line immediately adjacent to the fault which caused the damage shown in Figure 1 was examined after the earthquake and found to be undamaged.

Figure 1. Extensive damage (right picture) to the Mexicali-to-Tijuana Highway at kilometer 20 at the Laguna Salada Fault Crossing. The fault line can be observed in the left picture. A 60" PCCP line with gasketed joints is installed parallel to this highway. The PCCP was inspected by potholing several locations and found to be undamaged.

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Damage to concrete pressure pipelines from seismic events is generally associated with changes in the pipeline structure where the pipe cannot move with the energy waves in the surrounding soil which occur during an earthquake. These locations may include bends, outlets, concrete encasements or cradles, and locations where joints are welded or restrained in a manner that does not allow sufficient joint movement during an earthquake. It should be noted that in most cases, the concrete pressure pipeline has sufficient ductility to remain undamaged at these various locations of stress risers unless the pipeline is proximate to the earthquake fault, where the movement is of sufficient intensity to exceed the strength of the pipe and appurtenance.

SOME RECOMMENDATIONS TO AVOID DAMAGE ON CONCRETE PRESSURE PIPELINES FROM SEISMIC EVENTS INCLUDE:

- Avoid concrete encasement, if possible, or provide transition to flexibility at the ends of the encasement using one or two flexible couplings/joints to allow pipe movement or pipeline rotation.
- Use "ethafoam" closed cell polyethylene grout bands, which will bridge joint mortar cracks up to ½" that may result from tensile stress in the pipeline from seismic force.
- Orient the pipeline route to cross faults so that movement puts flexible joints in tension.
- Have design analysis at faults performed by a qualified consultant to evaluate expected seismic stresses and deformations in the pipe wall and joints.

[1]Henry Bardakjian, P.E., Michael McReynolds, S.E., P.E., Mehdi Zarghamee, Ph.D., S.E., P.E., "Review of Performance of Gasketed Joints of Buried Concrete and Steel Pipelines in California After Recent Seismic Events," *Proceedings — ASCE Pipelines 2011, A Sound Conduit for Sharing Solutions*, (Reston, Virginia, American Society of Civil Engineers), pp. 872–881.

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For more information on using Concrete Pressure Pipe in seismic zones, speak with your Concrete Pressure Pipe supplier, or contact the American Concrete Pressure Pipe Association at **714.801.0298** or **www.accpa.org**.

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