September 2013

CE NEWS

business and technology for civil engineers

A park with a basement

Creating green space in an urban environment

NOW INCLUDING RAI

ROADS | BRIDGES | RAILWAYS

WWW.CENEWS.COM

zweigwhite

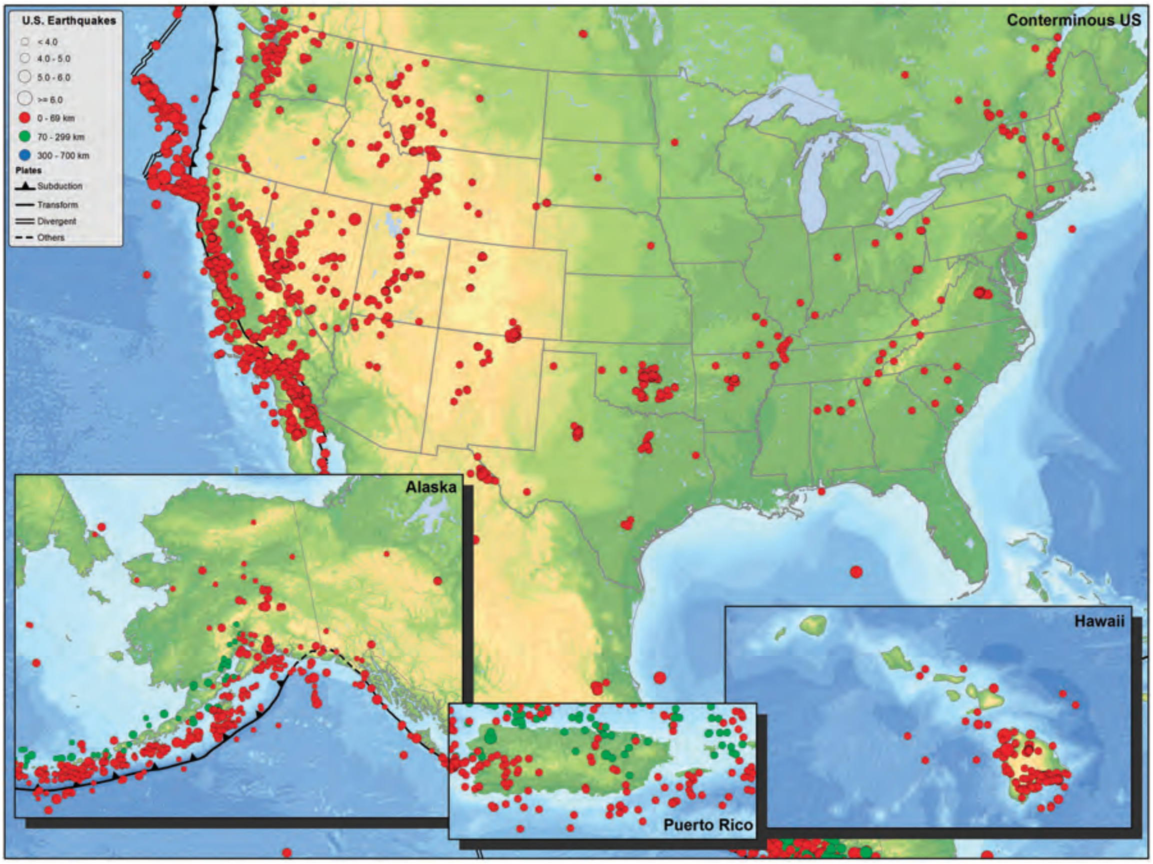

Figure 1: Seismicity of the United States from 1900-2001. *Image: U.S. Geological Survey*

Protecting pipelines from catastrophic effects of earthquakes

An expanded polystyrene geofoam cover system can reduce impacts of seismic forces on buried pipelines.

By Terry Meier

According to the U.S. Geological Survey, 14,000 earthquakes with a magnitude of 4 or greater occur worldwide each year; 700 of those occur in the continental United States and Alaska (see Figure 1). “If an earthquake occurs, high-pressure gas lines are one of the most important items to protect,” said Steven Bartlett, associate professor of civil engineering at the University of Utah. “If they rupture and ignite, you essentially have a large blowtorch, which can be catastrophic.”

There are several methods for mitigating the effects of seismic activity on infrastructure, including the use of expanded polystyrene (EPS) geofoam as a seismic buffer for buried structures and rigid retaining walls. Six years ago, Canadian engineers Richard Bathurst, Saman Zarnani, and Andrew Gaskin showed with shaking table testing and numerical modeling that geofoam could reduce the seismic forces on rigid retaining walls (Bathhurst, et al., 2007). The lightweight EPS blocks used with highway embankments, green roofs, and landscape fill are growing in popularity for seismic and other buried applications.

Since 2007, Bartlett and his team have been examining geofoam’s mitigating effects on pipeline damage due to seismic faulting. “During the summer of 2007, Questar Gas Company requested that the University of Utah evaluate a conceptual EPS geofoam cover system for a steel, natural gas pipeline crossing the Wasatch fault in the Salt Lake City valley,” explained Bartlett. “The fault rupture is expected to produce an earthquake with a potential magnitude of 7.5 and several feet of potential fault offset at the pipeline crossing.”

If a major earthquake were to strike the Wasatch fault zone in the Salt Lake Valley, fault displacement and the subsequent weight of shifting and compacted soil on buried pipelines is likely to cause them to rupture. Many buried pipelines lie under six to eight feet of soil. Bartlett and his students at the University of Utah showed that a pipeline protected with a lightweight geofoam cover could withstand the fault offset and reduce the force on the pipe by as much as four times compared with a pipeline covered with conventional soil backfill (Bartlett, 2012). Geofoam weighs roughly 1/100 of the weight of soil.

When a 37-mile-long section of natural gas pipeline between Coleville and Ogden, Utah, had to be replaced, approximately 20,000 cubic feet of EPS geofoam was specified to reduce movement, shears, axial forces, and strains imposed on the pipeline. EPS types 22 and 15 were shipped from ACH Foam Technologies' local plant in Murray, Utah.

The goal of a geofoam cover system on top of a buried pipeline is to reduce the lateral, longitudinal, and vertical forces induced on the pipe as the surrounding ground undergoes deformation (see Figure 2). Geofoam has two main advantages compared with traditional earth cover materials. First is geofoam's low mass density, which reduces the vertical and horizontal stresses on buried utilities and compressive soils. This reduction in loading and deformation likely will improve pipeline performance during and after a major seismic event along the fault area.

The second advantage of geofoam is its use as a compressible inclusion for systems undergoing static, monotonic, and dynamic loadings. Geofoam is somewhat compressible, and controlled compression can be used to reduce earth pressure against buried structures as well as deformation induced by structural loadings. Bartlett's team confirmed that the loadings that cause compression may include static and dynamic lateral earth pressure swells, frost heave pressures, settlements of support soils, faulting, liquefaction, landslides, and traffic loads.

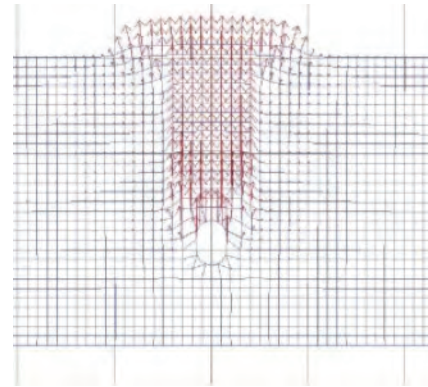

Figure 2: Pipeline displacement vectors during failure.
Drawing: Bret Nills Lingwall, University of Utah

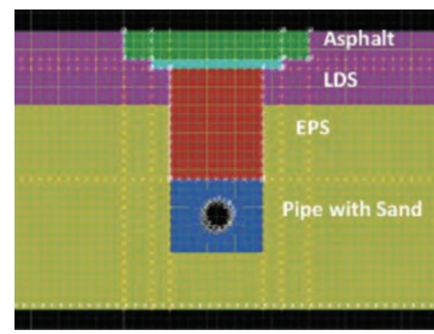

Figure 3: Lightweight geofoam cover system for pipelines.
Drawing: Bret Nills Lingwall, University of Utah

Using a "slot trench" design, a block of geofoam is placed in a narrow trench between a pipeline and the pavement above.

In some cases, geofoam blocks are covered with a geomembrane. This membrane helps reduce the vertical uplift stress by reducing the friction force between the geofoam and the trench sidewall. In addition, placing a geomembrane around the geofoam block provides added protection against a potential petroleum spill.

EPS geofoam has been used for a number of large transportation projects in Utah. Geofoam proved to be a time- and cost-saving material for the embankments along I-15 in Utah. After realizing the benefits of using geofoam for I-15, Utah Transit Authority specified it for its TRAX light rail projects. At the same time it was used in the Weber Canyon and 3300 South pipeline replacement projects.

According to Bartlett, a new approach was taken to protect the 3300 South pipeline. "Questar Gas had to put the pipeline right down the center of the roadway. When we looked at what other countries did, they built a trapezoidal geometry above the pipe — basically just a wedge," explained Bartlett.

Such a wedge would require many blocks of foam and would disrupt a large section of road. "This would have been a major problem in an urban area, as you

The reduction in loading and deformation due to geofoam's compressibility likely will improve the performance of this Weber Canyon pipeline during and after a major seismic event along the fault area.

might have to tear up 20 feet of lateral roadway. Try to do that for 3300 South — you'd have to shut the whole road down," Bartlett said.

Rather than gut a major thoroughfare, Bartlett proposed a "slot trench" design in which a block of geofoam is placed in a narrow trench between a pipeline and the pavement above (see Figure 3). In this design, if the pipeline begins to lift up, it will displace the geofoam block and compress it. Although geofoam is solid, it contains tiny air pockets that can compress without sacrificing the material's overall integrity. As the geofoam is compressed further, it will slide upward along the trench sidewalls and could eventually damage the pavement above. "However, the pipeline will remain intact and essentially undamaged," Bartlett explained. Since the 3300 South project, Questar has been installing geofoam to protect other natural gas pipelines in the valley and elsewhere.

New research is being conducted to measure the effectiveness of geofoam to help new buildings withstand earthquakes (Bartlett, et al., 2011). The use of geofoam backfilling against a vertical structure significantly reduces or completely eliminates lateral pressure on that structure, whether it is a bridge abutment, retaining wall, or foundation wall. For example, with a foundation wall going 30 feet below grade, the compacted soil will create 3,750 pounds of vertical pressure at the wall base and 1,250 pounds of lateral pressure at the base of the foundation wall. The use of geofoam greatly reduces lateral and vertical pressure.

Geofoam's light weight and compressive resistance makes it an ideal fill material for pipeline protection as well as highway embankments, landscape fill, and green roofs. New information is pointing to its value as a potential seismic buffer for structural and infrastructure applications.

Terry Meier is ACH Foam Technologies' EPS representative, specializing in geofoam. He was a participant in the Geofoam Task Force for the I-15 project (the largest such project in the world) and helped introduce the material to Taiwan and the Philippines during the last decade. Meier has been a guest speaker at the Geofoam Research Center at Syracuse University, the North American Geosynthetics Society Seminar, and EPS EXPO Conventions. He can be contacted at tmeier@achfoam.com.

References

- Bathurst, Richard J., Saman Zarnani, and Andrew Gaskin, 2007, "Shaking Table Testing of Geofoam Seismic Buffers," Soil Dynamics and Earthquake Engineering, volume 27, April, pages 324–332.
- Bartlett, Steven F., 2012, "Protecting Pipelines from Earthquakes," University of Utah, Oct. 2, http://unews.utah.edu.
- Bartlett, Steven F., Evert C. Lawton, Aurelian C. Trandafir, and Bret N. Lingwall, 2011, "Applications of EPS Geofoam in Design and Construction of Earthquake Resilient Infrastructure," Department of Civil and Environmental Engineering and Department of Geology and Geophysics, University of Utah, April.

Geofoam Manufacturers Come in Two Sizes.

There's us…

*ACH Foam is the **#1 PROVIDER** in the U.S. for Geofoam, based on volume and number of projects.*

www.ACHFoam.com
1.800.525.8697
info@achfoam.com

ACH
FOAM TECHNOLOGIES