

UTC Project Information	
Project Title	MPC-422 – Highway Structures Supported on Expanded Polystyrene (EPS) Embankment without Deep Foundation
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Project Duration	1 Year
Brief Description of Research Project	<p>In 1972, the Norwegian Public Roads Administration (NPRA) adopted the use of Expanded Polystyrene (EPS) geofoam as a super light-weight fill material in road embankments. The first project involved the successful reconstruction of road embankment adjacent to a bridge founded on piles to firm ground. Prior to reconstruction, the pre-existing embankments, resting on a 3 m thick layer of peat above 10 m of soft marine clay, experienced a settlement rate of more than 200 mm per year. However, by replacing 1 m of ordinary embankment material with two layers of EPS blocks, each 0.5-m thick, the settlement was successfully halted. The EPS blocks deployed had a density of 20 kg/m³, which is nearly 100 times lighter than the replaced materials (Aabøe R. and Frydenlund, T. E., 2011).</p> <p>Subsequently, EPS geofoam technology has been successfully used elsewhere in Europe, Japan and the United States as a super light-weight material which is placed around highway bridges supported on deep foundations. (Frydenlund and Aabøe, 2001; Miki, 1996; Bartlett et al., 2000) (Figure 1). The American Association of State Highway and Transportation Officials (AASHTO), in cooperation with the Federal Highway Administration (FHWA), funded National Cooperative Highway Research Program (NCHRP) Project 24-11(01) titled “Guidelines for Geofoam Applications in Embankment Projects” and Project 24-11(02) titled “Guidelines for Geofoam Applications in Slope Stability Projects.” The results of these projects are available in the following reports: NCHRP Report 529, NCHRP Web Document 65,</p>

NCHRP 24-11(02) Final Report. The results of both NCHRP Project 24-11 studies demonstrate that EPS-block geofoam is a unique lightweight fill material that can provide a safe and economical solution to construction of stand-alone embankments and bridge approaches over soft ground, as well as an effective and economical alternative to slope stabilization and repair. Benefits of utilizing EPS-block geofoam as a lightweight fill material include: (1) ease of construction, (2) can contribute to accelerated construction, (3) ability to easily implement phased construction, (4) entire slide surface does not have to be removed because of the low driving stresses, (5) can be readily stored for use in emergency slope stabilization repairs, (6) ability to reuse EPS blocks utilized in temporary fills, (7) ability to be placed in adverse weather conditions, (8) possible elimination of the need for surcharging and staged construction, (9) decreased maintenance costs as a result of less settlement from the low density of EPS-block geofoam, (10) alleviation of the need to acquire additional right-of-way for traditional slope stabilization methods due to the ease with which EPS-block geofoam can be used to construct vertical-sided fills, (11) reduction of lateral stress on bridge approach abutments, (12) excellent durability, (13) potential construction without utility relocation, and (14) excellent seismic behavior.

DOTs are particularly interested in the benefit of accelerated construction that EPS-block geofoam can provide when constructing embankments over soft foundation soils. In June 2002, the FHWA, in a joint effort with AASHTO, organized a geotechnical engineering scanning tour of Europe (AASHTO and FHWA, 2002). The purpose of the European scanning tour was to identify and evaluate innovative European technology for accelerated construction and rehabilitation of bridge and embankment foundations. Lightweight fills is one of the technologies that was evaluated. One of the preliminary findings of the scanning project is that lightweight fills such as geofoam are an attractive alternative to surcharging soft soil foundations because the requirement of preloading the foundation soil can possibly be eliminated and therefore, construction can be accelerated. The benefit of accelerated construction that use of EPS-block geofoam can provide was a key factor in the decision to use EPS-block geofoam in projects such as the I-15 reconstruction project in Salt Lake City, UT; the Central Artery/Tunnel Project (CA/T) in Boston, MA; and the I-95/Route 1 Interchange (Woodrow Wilson Bridge Replacement) in Alexandria, VA. The extremely lightweight nature of EPS allows for rapid embankment construction atop soft ground conditions without causing damaging settlement to the deep foundations, bridge structure and approach pavements. The EPS embankment technology is well-developed for such applications, but except for a few cases in Norway, it has not been used for the direct support of the bridge structures (i.e., placing the bridge foundation support directly on the EPS without the installation of deep foundations (e.g., piles, shafts, caissons or piers) in

the U.S.

However in Norway, bridges have been directly supported by EPS geofoam without deep foundations. The NPRA has pioneered this application for a few bridges underlain by soft, clayey deposits where the bridge structure rest solely on EPS blocks. These sites are: (1) the Lokkeberg Bridge, which is a single-span, temporary, Acrow steel bridge; (2) the Gimsøyvegen bridge, which is similar in construction and size to the Lokkeberg Bridge, (3) the Hjelmungen bridge, which is a multi-span, continuous concrete slab bridge with one abutment founded on EPS-blocks and the other founded on piles; and (4) three pedestrian bridges in the City of Fredrikstad, which consisted of EPS block supports clad with protective panels. The NPRA reports that an EPS bridge support system has provided considerable cost and time savings when compared with traditional bridge support systems (Aabøe R. and Frydenlund, T. E., 2011).

The best documented and studied case is that of the Lokkeberg Bridge which is located in Norway near the border with Sweden (Frydenlund and Aabøe, 2001, Aabøe and Frydenlund, 2011). This is a 36.8-m long, single span truss structure that is founded on EPS block resting atop quick clay (Figure 2). This temporary structure remained in service for about 17 years and considerable data were obtained regarding its performance. During that period, no signs of cracks or uneven deformation were observed even though the underlying sensitive clay settled about 25 cm and the geofoam compressed internally about 5 cm (Figure 3) (Aabøe and Frydenlund, 2011).

In 2006, the bridge was removed and reused and the EPS blocks were also reused at another embankment site. (It should be noted that the amount of consolidation settlement that occurs under an EPS system can be reduced to smaller amounts than was experienced at the Lokkeberg Bridge by using a fully compensated foundation system. In this approach, subexcavation of some native soil is required in an amount equal to the weight of the EPS and proposed pavement system. When done in this manner a “zero net load,” case is obtained, which reduces the settlement of the foundation soils.)

Creep and stress distribution measurements were also made within the EPS and foundation soils at the Lokkeberg Bridge. Most of the deformation occurred during the construction period and only minor creep affects were measured after this period (Figure 3) (Aabøe and Frydenlund, 2011). For a 17-year period, the average creep in the total embankment was about 1 percent; however the lowest layer of EPS underwent about 6 percent creep strain. Except for the side of the embankment where the pressure reached 80 kPa, pressure cell data show that the internal pressure in the EPS embankment from the dead load is about 50 to 60 kPa. These values corresponded well with those

	<p>estimated from theoretical studies (Aabøe and Frydenlund, 2011).</p> <p>Research Objectives: This proposal focus on objectives and tasks required to evaluate potential use of EPS as a bridge support system for temporary and permanent bridges and pedestrian overpasses. The objectives of the proposed research are: (1) evaluate an EPS support system for single span structures and pedestrian overpass supported on EPS using the knowledge and data gained from the Norwegian case studies, (2) evaluate the expected performance of this system(s) under static and dynamic loading using material testing and numerical modeling of prototypes and full-scale systems previously used and installed in Norway, and (3) develop recommendations for future research/testing/development required for implementation of this technology in the U.S.</p>
<p>Describe Implementation of Research Outcomes (or why not implemented)</p> <p>Place Any Photos Here</p>	
<p>Impacts/Benefits of Implementation (actual, not anticipated)</p>	<p>The report findings show that EPS bridge support systems are possible for simple overpass and pedestrian bridge structures, most likely constructed of steel or other light-weight materials. This allows accelerated bridge construction (ABC) on soft ground conditions without the need of deep foundation systems; thus, saving the cost and time associated with such systems.</p>
<p>Web Links</p> <ul style="list-style-type: none"> • Reports • Project Website 	<p>https://www.ugpti.org/resources/reports/details.php?id=900</p>