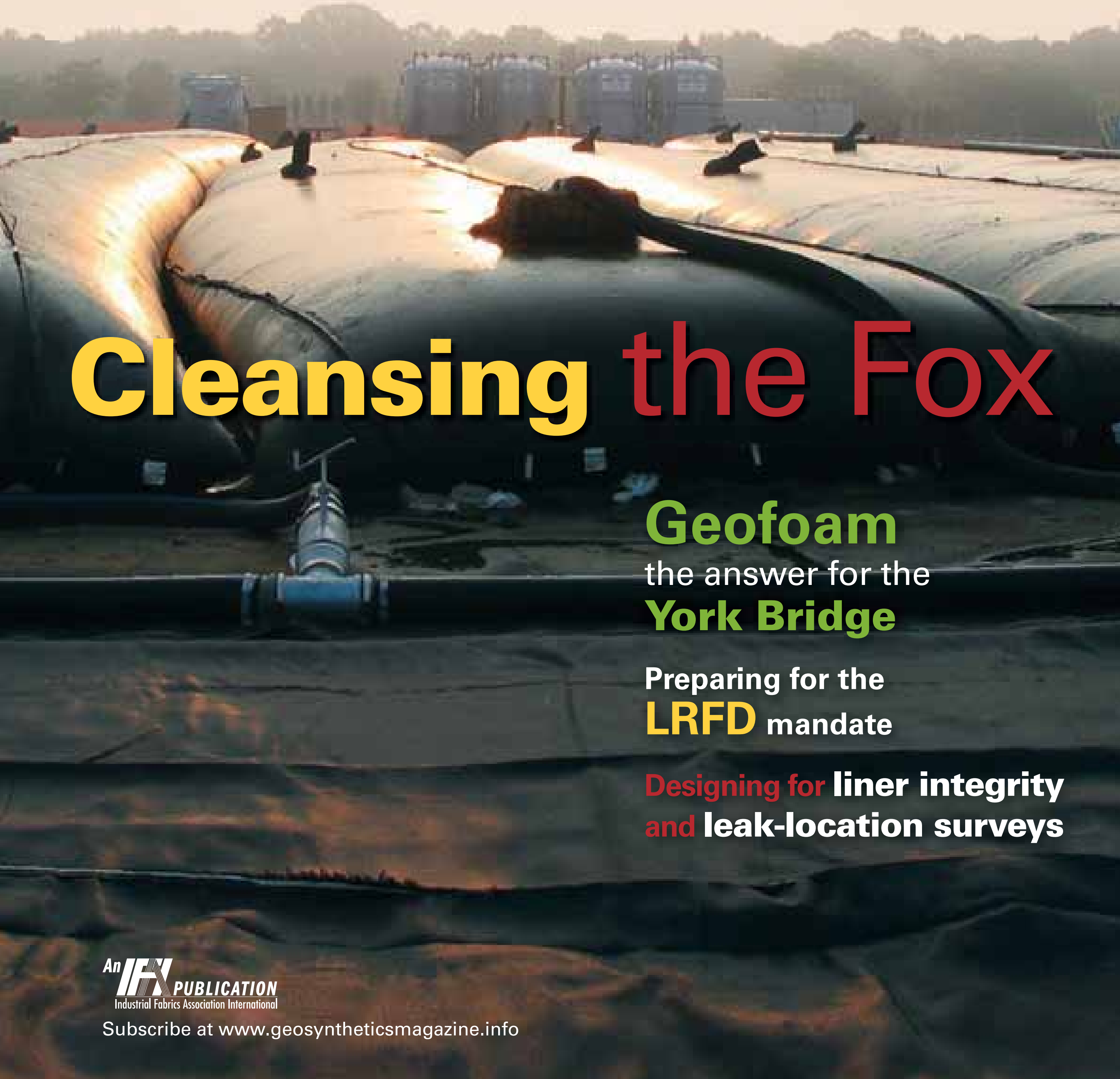
August September 2006
Volume 24 Number 4

Geosynthetics

formerly GFR



Cleansing the Fox

Geofoam the answer for the York Bridge

Preparing for the LRFD mandate

Designing for liner integrity and leak-location surveys

An IFAI PUBLICATION
Industrial Fabrics Association International

Geofoam provides lightweight fill for York Bridge in Washington

| A King County DOT bridge project illustrates the use of geofoam fill


All photos courtesy of King County DOT (Photographer: Ned Ahrens)

| At this stage, the geofoam placement is complete and preparations are now made to pour the load distribution slab on top of the geofoam and to set precast concrete fascia walls. The black lines on the geofoam are utility trenches that are backfilled with foam packing peanuts around the utilities and enclosed by a filter fabric.

Abstract

An interesting project under way in the Seattle area is the reconstruction of the York Bridge on Northeast 116th Street north of Redmond, Wash. After the supports for the new bridge were completed, crews worked on the deck and approach roadways using some innovative materials this summer.

Because the bridge over the Sammamish River is surrounded by deep, compressible peat and clay soils, the King County Road Services Division needed to find a lightweight fill for the approach road on the west side.

Engineers on the project turned to geofoam blocks. The blocks were placed between precast concrete panel walls. On top of the foam is a concrete slab—a "load distribution slab"—that secures the geofoam blocks to keep them in place and to distribute the traffic loads. Next is a layer of soil, then the asphalt layers.

Using this technique made it possible to raise the road elevation. In fact, to raise it enough so that the Sammamish River Trail now runs under the new bridge—instead of on the road as it was before the bridge reconstruction—improving safety for trail users as well as motorists.

The new bridge is scheduled to open in September.

Engineering and design details

The King County Department of Transportation and the City of Redmond own the York Bridge. The jurisdictional boundary is at the middle of the structure. The bridge crosses the Sammamish River at Northeast 116th Street in Redmond. The agencies entered into an agreement to replace the bridge with King County DOT as the lead.

The project includes a new 220-ft. bridge over the Sammamish River and two river trails, access to the river trails from Northeast 116th St., 1,400 ft. of new approach roadways, structural earth retaining walls, wetlands mitigation, river enhancement, a three-legged precast concrete box culvert supported on geopiers, and a major geofoam embankment.

DMJM Harris was the prime consultant for the project and was involved in all stages of the design, from preliminary studies through construction. For the design report, the environmental team assessed biological and cultural resources, completed the wetlands delineation, conducted

| Kevin Dusenberry, associate vice president at DMJM Harris, and Ron Bygness, editor of *Geosynthetics* (formerly *GFR*), contributed to this article.

Geofoam near west York Bridge abutment: Near the west abutment, the geofoam is deeper near the outsides of the fill. This accounts for the added weight of barriers, sidewalks, and fascia panels. On the left is the leveling pad for the full-height concrete fascia panels.

a special stream study, and prepared a habitat mitigation plan. The final design entailed preparation of the plans specifications and estimate (PS&E) documents for the preferred alternative.

Project features include: the new bridge, ADA-compliant access to the Sammamish River Trail, geofoam embankment construction, artistic bridge railings, a concrete finish using custom-designed form liners, and kayak access to the river.

Challenges

The project is located near a high-use recreational area within a rural setting. Several wetlands, sensitive farmland, and riparian habitat are adjacent to the existing roadway. The old bridge was 117-ft. long with a single lane and a narrow shoulder in each direction and was structurally deficient and functionally obsolete. Poor vertical site distances, combined with at-grade trail crossings, made it necessary to place stop signs at the trail crossings. A deep 72-in. sanitary sewer runs along the west bank of the Sammamish River, a fiber-optic network facility crosses the river on the north side of the roadway and a City of Redmond sanitary sewer runs along the south side of the roadway.

The replacement bridge has a number of unusual features that required extensive analysis and design. The selected bridge type is a 4-span precast, prestressed, concrete girder bridge with cast-in-place arches and inclined columns supporting the intermediate pier. Due to the presence of a very thick layer of soft compressible soils, the entire bridge is founded on driven piles. The bridge deck is curved with overhangs of up to 8 ft. The complexities required innovative analysis methods to accurately model the structure.

Explorations of the soil conditions at the site revealed that the proposed bridge and approaches are underlain by loose sand and gravel, soft clay, silt and peat soils to depths up to 195 ft. The depths of the loose soils varied greatly with the deepest soft soils located on the western end of the project. The new bridge is supported on deep pipe piles that penetrate the soft soils and bear within a dense glacial till that underlies the entire site.

Geofoam cut around utilities: Blocks of geofoam sit on a sand drainage and leveling blanket. The sand layer is placed above geotextile reinforcement, over existing ground. The geofoam is cut to fit around the utilities.

The eastern approach was located over somewhat shallower loose materials and was proposed to be a lightweight fill composed of bottom ash constructed after a pre-load surcharge and 8-week settlement period.

During construction, the contractor requested that the pre-load and lightweight fill be eliminated since it appeared

| Embankment getting higher: Temporary timber supports provide fall protection and are not required to hold the geofoam in place.

| Embankment looking farther west: The geofoam steps down to follow grade as the fill is placed from east to west.

Embankment continuing to the west: The leveling pad for the precast fascia wall panels is clearly seen in front of the fill.

that much of the loose material could be overexcavated or densified in place. After additional analysis, the lightweight fill on the east approach was eliminated and replaced with a conventional fill with structural earth walls. Additional pile driving efforts had to be incorporated at the east abutment to account for down-drag forces caused by consolidation of deep loose-soil layers.

Enter geofoam

The west approach overlies deep unconsolidated peats, clays, and silty sands that cannot be overexcavated and would exhibit long-term excessive settlements, a problem for the city sewer that runs underneath the road. To resolve this potentially expensive and long-term challenge, a geofoam embankment was selected as the preferred alternative. (See sidebar articles on pages 40 and 42.)

To eliminate potential settlements, the embankment was designed such that zero new dead load will be added to the bridge roadway approach. The height of the geofoam varies from 1-ft. minimum to about 9-ft.-high at the face of the bridge abutment.

The entire geofoam mass is underlain by a layer of geogrid soil reinforcement and a 6-in.-thick sand drainage and leveling blanket. The geofoam was placed in alternating layers up to within 3 ft. of finished grade.

An additional sand drainage blanket was placed on top of the geofoam and a 6-in.-thick, reinforced concrete, structural load distribution slab is constructed on top of that. The structural slab serves more than one purpose: it distributes live loads evenly to the geofoam, protects the geofoam from solvents that could cause damage, and provides lateral support for the concrete facing panels at the outsides of the roadway embankment. The roadway subgrade and pavement section are then constructed above the structural load distribution slab.

Mowat Construction Co. worked with King County and the designer to refine the final design and improve constructability. The geofoam embankment is concealed by architectural concrete fascia panels that rest on a concrete leveling pad below ground surface and are attached at their tops to the load distribution slab. To offset the weight of the concrete panels, soil below the panels was removed and replaced with a 2-ft.-deep x 6-ft.-wide layer of geofoam. This layer of geofoam is covered with 2 ft. of granular fill and the fascia wall leveling pad is constructed on top of that. From all appearances, there will be no indications that the roadway approach is different than any other earthen embankment. The use of geofoam eliminated the potential for long-term settlement and maintenance of the roadway approach. By not having deep overexcavation, and the placement and removal of a preload surcharge, impacts to the sewer and adjacent wetlands were minimized and the construction of the bridge could be completed independent of the embankment construction.

Expanded polystyrene (EPS) geofoam

Using geofoam in road and bridge projects

Problem: Highway capacity is insufficient to meet growing demand

Traffic congestion on highways in the United States continues to be an area of concern to the traveling public, and to roadway managers. Every year, congestion continues to grow as vehicle travel increases and the nation's bridges and roads deteriorate.

To help alleviate this growing congestion, capacity on U.S. highways and major roads must be expanded. In many circumstances, however, roadway embankment widening or new alignments may require construction over soft or loose soils that are incapable of supporting increased loads. Embankment construction projects must identify innovative materials and construction techniques to accelerate project schedules by reducing vertical stress on the underlying soil.

Solution: Get in, get out, and stay out with geofoam

Putting it in perspective:

• 1 in every 5 highway projects is considered "traffic sensitive."

• 2 out of every 5 urban interstate miles are considered congested.

• Traffic delays have more than tripled in the past 20 years.

• By 2020, the U.S. population is expected to grow by 16% and vehicle travel is expected to increase by 42%.

Geofoam benefits:

• Accelerates foundation construction, reduces project time line

• Saves money

• Requires limited labor for construction

• Exerts little to no lateral load on retaining structures

• Can be constructed easily in limited right-of-way areas and in adverse weather conditions

Successful applications: Results demonstrate geofoam advantages

Many states have used EPS geofoam in both large and small highway projects. By using geofoam as a lightweight fill, engineers at the Minnesota Department of Transportation (MnDOT) have realized significant time and cost savings for a number of small and moderate sized roadway embankment projects over deep, soft, organic soil deposits prevalent in the state.

After years of searching for a permanent solution to a failing slope problem on State Route 23A, New York State DOT turned to EPS geofoam. By replacing upper sections of the slide area, the state significantly reduced the driving forces that were causing the slide and successfully rehabilitated the roadway section.

Two large, high-profile jobs—the Big Dig in Massachusetts and Interstate-15 in Utah—turned to EPS geofoam to construct large embankment sections. Geofoam helped maintain the tight construction schedules that would not have allowed enough time for conventional embankment construction. Both projects illustrated the ease and speed with which EPS geofoam can be constructed for highway embankments.

Deployment Statement

This technology is a lightweight, rigid foam plastic that is approximately 100 times lighter than most soil, and at least 20 to 30 times lighter than other lightweight fill alternatives. This extreme difference in unit weight, compared to other materials, makes EPS geofoam an attractive fill material to significantly accelerate construction schedules.

Deployment Goal

By October 2008, EPS geofoam will be a routinely used lightweight fill alternative for state DOTs on projects where the construction schedule is of concern.

Deployment Status

EPS geofoam has been used on roadway projects in more than 20 states. The FHWA Resource Center has developed a half-day seminar on geofoam and has presented the seminar in 10 states. A guideline specification for state DOTs is being revised and updated to reflect trends in the industry and fluctuations in the cost of materials.

In addition, an innovations and advancements report is being prepared to highlight state-of-the-art developments in the use of geofoam as a lightweight fill material.

Source:
U.S. Department of Transportation—Federal Highway Administration Resource Center

What is "geofoam?"

EPS geofoam is a lightweight, rigid, foam plastic that has been used around the world as a fill for more than 30 years. Geofoam is approximately 100 times lighter than most soil and at least 20 to 30 times lighter than other lightweight fill alternatives. This extreme difference in unit weight compared to other materials makes geofoam an attractive fill material. Because it is a soil alternative, geofoam embankments can be covered to look like normal sloped embankments or finished to look like a wall.

What are the advantages of geofoam for highway construction?

EPS geofoam can be used as an embankment fill to reduce loads on underlying soils, or to build highways quickly without staged construction. Geofoam has been used to repair slope failures, reduce lateral load behind retaining structures, accelerate construction on fill for approach embankments, and minimize differential settlement at bridge abutments.

Because geofoam weighs only 16 to 32 kg/m^3 (1-2 lbs./$ft.^3$), large earthmoving equipment is not required for construction. After the material is delivered to the site, blocks are easily trimmed to size and placed by hand. In areas where right-of-way is limited, geofoam is constructed vertically and faced, unlike most other lightweight fill alternatives. It also can be used in construction during adverse weather conditions.

Source:
U.S. Department of Transportation—Federal Highway Administration Resource Center

Project Highlights

Project: York Bridge replacement
Location: Redmond, Wash.
Owners: King County and City of Redmond
Design team:
DMJM Harris—Bridge and walls, roadway, trail, right-of-way, environmental impacts and permits, wetland impacts, hydraulics and scour, utilities design
HWA GeoSciences—Geotechnical investigation
Aquatic Resources—Stream special study
NW Archaeological Associates—Cultural resources
General contractor: Mowat Construction Co.
Artist: Cliff Garten
Total project construction cost: $9.5 million
Project start (construction): June 2005
Project completion: September 2006
Key materials/suppliers:
Geofoam—ACH Foam Technologies
Structural earth walls—SSL, LLC
Precast/prestressed concrete girders—Concrete Technology Corp.
Precast concrete box culvert—Granite Precasting and Concrete Inc.
Reinforcing steel—Harris Rebar of Seattle Inc. G

Placement of reinforcing steel for the load distribution slab: The load distribution slab provides protection for the geofoam, distributes live loads and the roadway pavement dead loads, and is used for the top lateral connection for the fascia walls.