

Expanded Metal Sheet Forming

by Edward Hart

When the Port Authority of Allegheny County decided to build a busway from the Pittsburgh International Airport to downtown Pittsburgh, PA, part of the project incorporated rehabilitating an existing 2900 ft (884 m) tunnel. Part of the project included extending the tunnel portals up to 740 ft (225 m) in length as well as adding retaining walls.

The original project was designed by ICF Kaiser Engineers, Inc., Pittsburgh, PA, and Michael Baker Jr., Inc., Coraopolis, PA. The general contractor on the job was Mosites Construction

Company, Pittsburgh, PA. They hired the tunnel consulting engineering firm Dr. G. Sauer Design and Consulting Company, Herndon, VA. The tunnel and tunnel portals were redesigned using the New Austrian Tunneling Method (NATM) method of construction. A value-engineered proposal was made to the owner, PA Transit, Port Authority of Allegheny County, by the Dr. G. Sauer Corporation and Mosites Construction, resulting in a savings of \$2 million compared with the original design.

The shotcrete canopy support system consisted of lattice girders, reinforcing bar, two layers of welded wire fabric, and Stay-form (expanded metal sheet) acting as a backstop. After a minimum of 10 in. (250 mm) of steel fiber-reinforced shotcrete was applied to the entire tunnel cross section (horseshoe-shaped profile), a waterproofing membrane was then applied. A jumbo form was then used to help place 12 in. (305 mm) of cast-in-place concrete against the 10 in. (250 mm) of shotcrete for a 22 in. (560 mm) overall tunnel lining.

Alabama Metals Industry Corporation (AMICO), a Gibraltar Industries Company, manufactures Stay-form at its Birmingham, AL, facility.



Figure 1: Tunnel portal and retaining walls

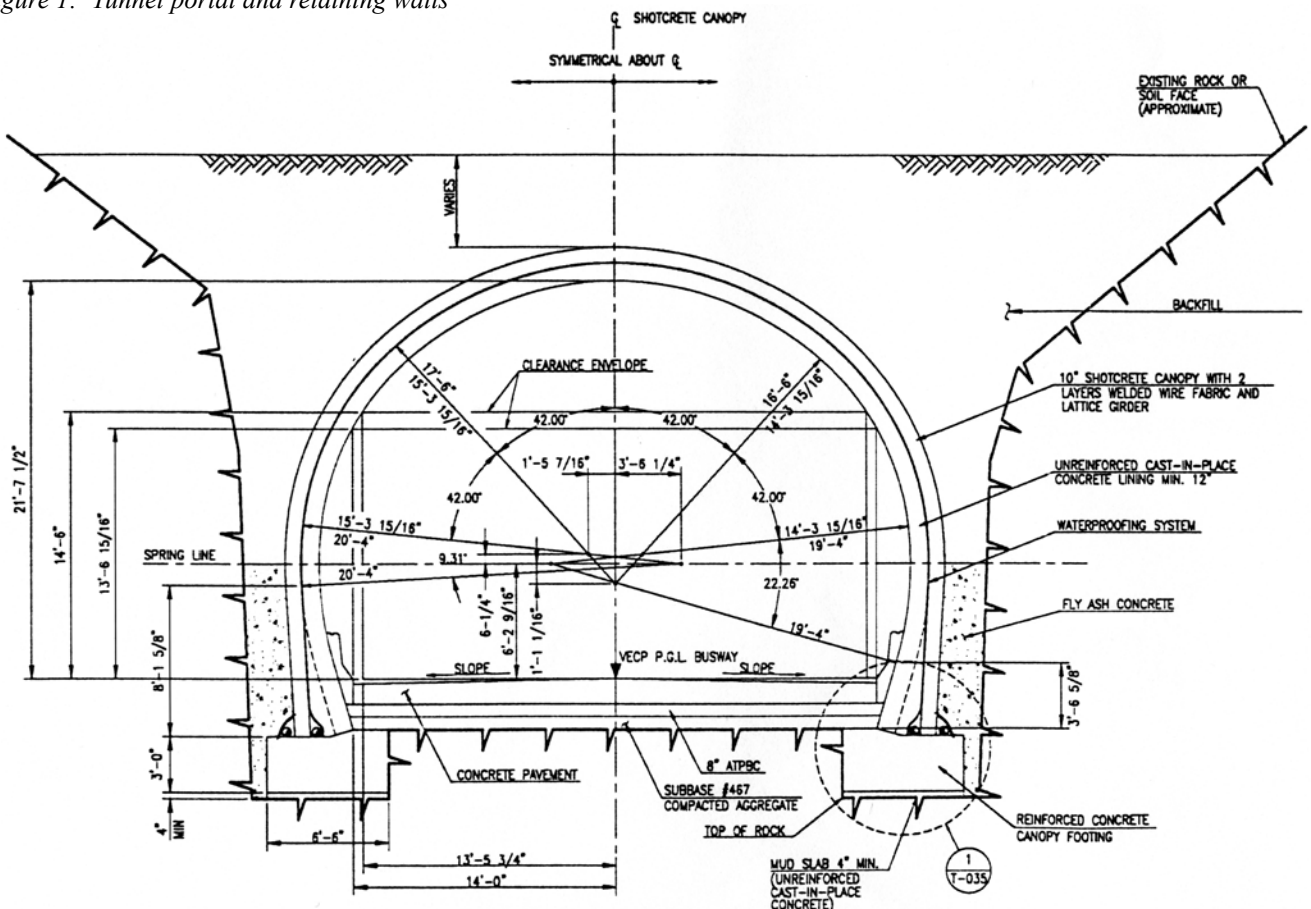


Figure 2: Typical canopy cross-section



Figure 3: Men working on wire tying Stay-form to lattice girders and reinforcing bars



Figure 5: Backside of retaining wall using Stay-form and modular forms



Figure 4: Shotcrete being applied to the canopy support structure

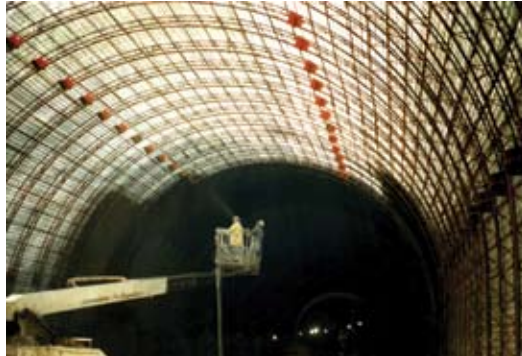


Figure 6: Shotcrete being applied to the tunnel portal

Stay-form is made from 26 gauge galvanized sheet steel with overall dimensions of 27 x 97 in. (685 x 2464 mm). A series of 3/4 in. (20 mm) deep V-ribs are spaced 3-7/8 in. (98 mm) on center, which gives the steel sheet its rigidity. Stay-form, however, can be used to form a radius if it is curved in its longitudinal axis. Cutting Stay-form to conform to various geometric configurations is accomplished with tin snips, a grinder, or a cut-off saw with an abrasive blade. When contractors install Stay-form to a reinforcing bar cage, lattice girder, or wire mesh, they typically use 16 gauge tie wire. The ability to work from both sides of the backstop is also advantageous because one can see through the open herringbone mesh. The herringbone mesh and V-ribs create an excellent surface for retaining shotcrete with minimal rebound. It is also simple to make penetrations for reinforcing bar, conduit, and dowels.

The following companies had a significant impact on the success of this project:

- Master Builders Technologies, Inc., Cleveland, OH—
admixtures and shotcrete mixture design
- American Commercial Inc., Louisville, KY—
lattice girders
- Elfin Manufacturing Company, Indiana, PA—
shotcrete mixture plant

This project is an excellent example of how a value-engineered proposal by Mosites Construction

and the Dr. G. Sauer Corporation benefitted both the contractor team as well as the owner.

Some other projects that have incorporated Stay-form as a backstop for shotcrete are:

- Whistler Sliding Centre 2010 Winter Olympics Bobsleigh/Luge Track, Whistler, BC, Canada
- Lake Placid Olympic Facility, Lake Placid, NY
- Park City Olympic Facility, Park City, UT
- Big Savage Tunnel, Frostburg, MD
- Weehawken Tunnel, Weehawken, NJ
- Six Flags Over Kentucky Water Flume Ride, Lexington, KY
- Grain elevator repair, Wichita, KS



Edward Hart is the Product Specialist for the Stay-Form product for AMICO at its corporate office in Birmingham, AL. He has a Bachelor of Science degree in civil engineering from Rensselaer Polytechnic Institute, Troy, NY. He has over 30 years of experience in the shotcrete/concrete construction industry. He is presently a member of the American Shotcrete Association, the American Concrete Institute, and the American Society of Civil Engineers.