Sound Barrier Walls Incorporate Architectural Features

City and county officials in North Dakota wanted their sound barrier walls to be more than lifeless concrete walls; they wanted aesthetics.

By Dain Miller and Brian Long

The new Interstate 94 sound barrier walls in Fargo, ND, are a first for the Peace Garden state. Because this is the highest-traffic gateway into North Dakota and its largest city, Fargo city officials and the North Dakota Department of Transportation (NDDOT) wanted some type of architectural feature incorporated into the wall design to give it aesthetic appeal.

As the project's design firm, Ulteig Engineers, Inc., (www.ulteig.com) worked with David Hetland, an artist hired by the city, to give the sound walls that appeal. Today, as travelers enter the state from Minnesota, they don't see a drab, gray concrete wall. Instead, they see a textured, colored surface and eye-catching designs. In fact, the project won an award for aesthetic merit from the North Dakota Ready Mix and Concrete Products Association.

To have some influence on what the final wall designs looked like, the city not only hired an artist and helped pay for the additional costs, Fargo officials also established a committee to approve the chosen designs—a combination of raised sunflowers, wheat stalks, and trees. It was cost-prohibitive to create the design form liners for the entire wall. Instead, nine interchangeable form liners were cast and used to create the combination of designs that appears on the walls. Other efforts were made to improve the appearance of the walls, including decorative caps on each supporting column.

Form meets function on Interstate 94 sound barrier walls in Fargo. Decorative walls feature raised sunflowers, wheat stalks, and trees.

Project Challenges

The design team from Ulteig took on many other project challenges as well, including issues presented by the flat terrain of the Red River Valley. The design team needed to ensure that water did not pond on the residential side of the walls. Homeowners adjacent to the interstate were already experiencing drainage problems and expressed concerns during public hearings that the barrier would exacerbate the problem. The design of the walls incorporated a 5-in. by 16-in. weep hole at the bottom of each wall panel—a solution unique for a sound wall. To facilitate drainage, the project also incorporated a subsurface drain tile system that runs alongside and under the panels for the entire length of the walls and additional stormsewer inlets to collect runoff.

Existing utilities also presented challenges in both the design and construction phases of the wall. Throughout the planning and preliminary design process, the alignment of the wall was a moving target. Overhead power lines on both sides of the interstate were a major part of the decision process. On the north side a 115-kV transmission line posed a challenge for crane operators during construction. On the south side a distribution line had to be moved and tilted to allow for construction of the wall. Water and sanitary sewer lines also had to be avoided. On the south side a 30-in. emergency water diversion pipe running near the right-of-way dictated a majority of that wall's alignment.

The consultant's design team devised a traffic control plan for the construction phase of the project. Because the sound walls were being built along the busiest sections of freeway in North Dakota, traffic control and contractor access to the construction area also posed challenges. The walls were located close to the on- and off-ramps for University Drive, so merging traffic had to be controlled. All the wall panels were delivered to the construction site by semi trucks. Cranes were used to lift the panels off the trucks and also to erect them. The NDDOT did not want to close down an entire lane because the work was off of the freeway. However, limited options were available to the contractor for accessing the site. For safety reasons, the NDDOT agreed that one lane could be closed during the day to allow construction vehicles to enter and exit the work area. At the end of each workday, the lane had to be reopened.

As with every transportation project, right-of-way and easement negotiations are necessary for construction. The consultant's engineers were responsible for the right-of-way acquisition. Even though the wall was built 2 ft from the property line, contractors still needed to access the private property side of the wall during construction. Access would also be required for ongoing maintenance. Each of the 40 property owners along the project had a different situation. There were homeowners with landscaping that would be destroyed. A few homeowners had trees they wanted removed, but most homeowners had trees they wanted unharmed. Storage sheds and fences of all different types also factored into the negotiations.

Innovative Design

The consultant came up with an innovative design to support the wall while dealing with tight right-of-way issues. They wanted to place the walls on the right-of-way line or close to it so the walls were as far from the roadway as possible. They also wanted to limit the amount of construction activity on private property. The engineers designed a pre-cast concrete wall panel system supported by pre-cast concrete posts on drilled concrete pier foundations. The foundations, cast on site, were 3 1/2 ft in diameter and varied in depth from 15 to 25 ft. Spread footing foundations can range up to 15 ft and require excavation in excess of 20 to 30 ft.

The idea of using drilled concrete piers to support the walls was a new concept. For the past 60 years, Ulteig has done a significant amount of work for electric utilities in the Upper Midwest. The consultant's engineers used their experience in designing electric transmission towers to design the foundations for the sound barrier walls.

The pre-cast concrete wall system lends itself to an efficient method of construction. Once the contractor, Industrial Builders, Inc., Fargo, developed their in-field construction process, the erection of the wall system went fairly quickly. It was anticipated that the erection of the walls would not be completed until December 2003. However, the walls were actually completed by the middle of October 2003.

The project moved from concept to construction over a seven-year period beginning in 1997. Ulteig Engineers had more than 1,000 man hours into the project, including approximately 700 hours for the design. The other hours were accrued during the study phase of the project.

In 1997 the city of Fargo initiated the sound wall study using local resources. That was followed by the NDDOT selecting Ulteig as the consultant to work with a committee to study both the feasibility and reasonableness of constructing sound barriers. The group, consisting of people from the NDDOT and Fargo, looked at the possibility of sound barriers on both sides of I-94 from the intersection of I-94 and I-29 to

Summary by the Numbers

Project Cost:

Engineer's estimate	$2,994,000
Contractor's bid	$2,459,693

Project Milestones

Final plans submitted to NDDOT	Jan. 31, 2003
Project bid date	April 11, 2003
Begin construction	May 24, 2003
Substantially complete	Oct. 15, 2003
Original completion date	Dec. 20, 2003

The Numbers:

North wall length	1/2 mile
South wall length	1/2 mile
Pier foundations	3.5 ft. diameter x 15-25 ft. depth (depending on wall height)
Pre-cast wall	6 in. thick (pre-stressed); wall height varies from 10 ft to 24 ft
Wind loading	80 mph wind or 27 psf
Total length of wall	4,751 lf
Total length of pre-cast concrete columns	6,669 lf
Total sq ft of pre-cast concrete wall panels	103,442
Cu yd of concrete (pier foundations)	1,500
Concrete columns	range in length from 19 to 40 ft
Total sq ft of wall	86,100
Number of column caps	204
Steel for drilled piers	90,700 lb
Steel for concrete columns	232,100 lb
Steel for wall panels	1,093,850 lb

Typical Costs for Major Items:

Item Description	Unit	Quantity	Unit Cost	Total Cost
Pre-cast concrete wall panel	SF	85,770	$8.75	$750,487.50
Pre-cast concrete column	LF	6,669	$86.20	$574,867.80
Pre-cast concrete column cap	EA	204	$230.00	$46,920.00
Class AAE-3 concrete	CY	1,453	$255.00	$370,515.00
Architectural treatments	SF	17,672	$4.50	$79,524.00
Special surface finish	SF	96,286	$1.00	$96,286.00

the Red River bridge at the border with Minnesota. The two-mile stretch from University Avenue to I-29 was not included in the final project.

The consultant provided the committee with different design options, including earth berm, concrete, wood, and steel as well as construction and maintenance costs for each option. They studied how many properties would benefit from noise abatement based on the height of the wall. North Dakota's winter weather also became a factor. The study looked at whether the sound walls would create snow drifts on the interstate and if the height of the walls would interfere with the sun melting snow and ice off of the roadway. The study determined the right-of-way needs each type of wall would require in terms of easements. The consultant also facilitated a number of public input meetings at the time to educate people on what walls could and could not do. Of course, the study also included a cost-benefit analysis. From that the committee determined that it was only reasonable to install walls between 5th Street and University Drive.

A preliminary design study in 1998 focused only on the area between 5th Street and University Drive. That study focused on cost estimates, where the barriers would be placed, the height of the walls, and some preliminary design decisions, including the choice to construct a five-decibel concrete post and panel wall. The consultant had teamed with one of the leading noise modeling experts in the United States, Louis Cohn of The Technology Group, (Louisville, KY). Their detailed modeling of various sound barrier locations and heights helped the consultant recommend where the walls should be placed.

For the public meetings, Ulteig prepared three-dimensional images of the barriers so the public could better visualize what the walls would look like. At the public meetings, people were also given the opportunity to actually hear highway noise with and without the walls. They could literally hear the difference a sound barrier wall would make.

Only a few property owners did not want the walls built at the time construction started. Even so, once the project was completed, they admitted that the wall now in their backyard turned out better than they anticipated. Getting adjacent property owners and the public involved early in the process through participation on committees and public input meetings contributed to gaining excellent support for the project.

The sound barrier wall, unique in both design and appearance, has successfully reduced traffic noise levels for homeowners along North Dakota's busiest stretch of freeway. The quieter neighborhood has already improved the quality of life for homeowners and will help protect the value of their property. GE

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