# Sheet Pile Supported Bridge Abutments for Accelerated Bridge Construction

*By Joshua M. Wight, P.E.*

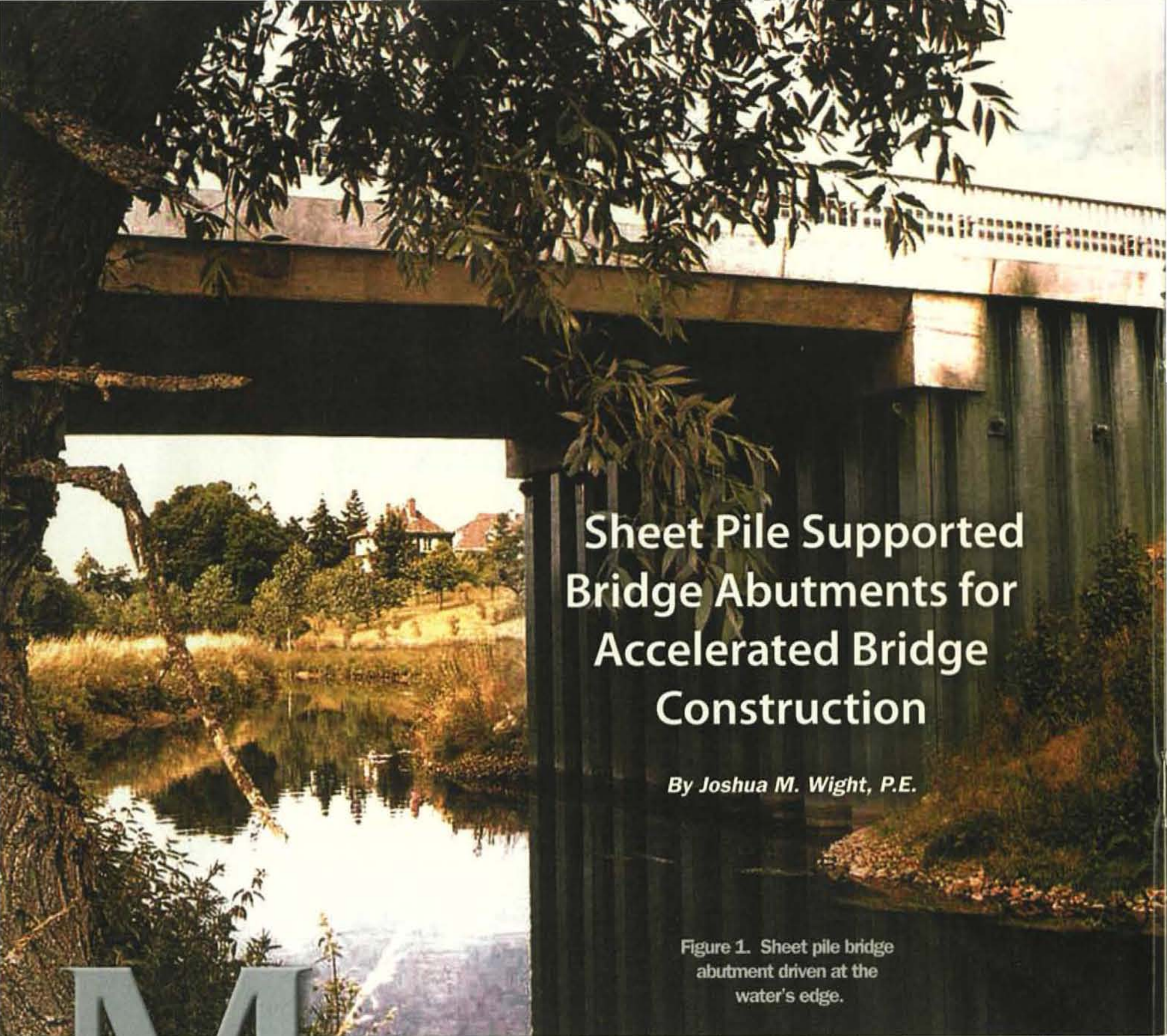

Figure 1. Sheet pile bridge abutment driven at the water's edge.

Many of today's top corporations do not begin a meeting without first addressing safety; it's the way of the corporate world. Not only do executives genuinely care about the well-being of their employees, but the bottom line usually benefits from exemplary safety performance as well, creating a win-win situation for all. Some companies even provide incentives for health and fitness practices at home. In the same vein, any discussion about innovation in construction must first address the environment.

## Construction and the Environment: A Precursor

The implementation of a point system to quantify levels of environmental responsibility within the built world has been a huge advancement for the construction industry, with one exception: the ultimate objective can be easily misconstrued. Many times these projects acquire points in a fractured sequence, one at a time, and often well beyond the design phase. They may even be tacked on as an afterthought. Damage is not necessarily done when this occurs; upgrading to low-emissivity windows, installing automatic light switches, or adding insulation will probably help in the long run, but a myriad of opportunities to perform even better will be missed with this approach.

Gaining points on paper is not the end goal. Instead, the aim is a profitable completed project with minimal negative implications to the environment. True optimization of both cost and ecological impact is achieved when the entire project is considered as one system of integrated parts. Using steel sheet piling as the permanent shoring and bearing element of bridge abutments can positively impact every aspect of the project, including longevity, sustainability, short-term and long-term ecological impact, superstructure design, cost, schedule, and safety, among others.

## Longevity and Sustainability

The durability of steel, which refers to its resistance to corrosion, has been analyzed for decades and is well documented. For instance, the Eurocode, which is the European Standard for design of steel structures, includes tabulated corrosion rates for bare steel sheet piling in various soil, fresh water, and sea water conditions. The values given for five and 25 years are based on actual measurements, which are then extrapolated for 50-, 75-, and 100-year estimated performance.

With regard to sheet pile bridge abutments, steel piles in fresh water lose less than 1/16 in. of thickness due to corrosion in the zone of high attack after 100 years of life, without any surface coating or maintenance required. This small amount of sacrificial material can be designed into each face of the sheet pile if need be, but is typically inherent to the structure because the zone of high attack and the location of controlling design loads do not often coincide. Galvanizing or coating the steel can extend the life of the structure another 15-25 years on average while providing an alternate aesthetic at the same time.

The sustainability of steel is even better documented. As a viable material for significant structures, steel is truly a sustainable option – structural steel today can be made from 100 percent recycled steel and is 100 percent recyclable over and over again. Other properties of steel sheet pile, such as elasticity under extreme loading, ductility, and weldability, aid the longevity and sustainability of the bridge itself. As a result, boat or car collisions that may happen over the life of a bridge can be repaired. (Figure 1)

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## Short-term and Long-term Ecological Impact

In southeastern Minnesota, the Department of Natural Resources is extremely careful about the effect of bridge construction on the trout streams native to the area. The fish are sensitive to disruptions, so the bridge abutments are usually constructed away from the shoreline to allow room for temporary shoring, excavation, and abutment placement. Sheet pile abutment walls, on the other hand, can be installed right along the water's edge. There is no space required for temporary shoring, because the sheet pile serves as the temporary and permanent shoring of the stream bank and bridge approach. As no excavation is required with this system, there is very little soil displacement and disposal.

Additional bearing piles, poured footings, and concrete abutment walls can all be eliminated by utilizing the axial capacity of the sheets to take the vertical loads from the bridge. The loads are typically transferred from the superstructure into the sheets through a small concrete cap beam at the girder bearing elevation. After the sheets are installed and leveled off, a preformed wire cage is placed over the top of the sheets, and then the concrete cap beam is poured. This cap beam also ties the sheets together and helps to prevent differential settlement. (Figure 2)

Figure 2. Preformed wire cage reinforcement for concrete cap beam.

Another benefit of using driven sheet piles in a sensitive eco-system is that they can be extracted at any time in the future. Sheet piles can be removed without substantially disturbing the natural landscape. In a recent design of a two-lane bridge located on wetlands, the original design consisting of mechanically-stabilized earth abutments would have impacted more than a quarter acre. By switching to steel sheet pile abutments and wing walls, the project impacted less than a quarter acre of the wetlands, allowing for simpler permitting and cutting months out of the schedule while reducing the environmental impact.

## So What Does It Cost?

For many, the idea of a "green" project means additional costs. This mindset stems back to the last-minute-add-on mentality that is sometimes associated with "green" or LEED projects. However, integrative design of the entire system for any project, and for sheet pile bridge abutments in particular, will result in overall cost savings as well as dramatic reductions in project schedules. By using steel sheet piles as the permanent abutment, the contrac-

**Figure 3. A view of the Sprout Brook Bridge showing three phases of construction.**

tor can eliminate temporary cofferdam construction, bracing, deep excavation, formwork, reinforcement, de-watering, and the foundation curing period from the project.

*Case 1: Otter Creek and Big Cow Creek Bridges, TX.* The original designs included temporary cofferdams with space to pour concrete footings and abutment stems. By using a cantilevered PZ27 sheet pile design, the abutment setback was eliminated. This reduced the bridge span significantly, thereby reducing the mass of the superstructure required. The Otter Creek Bridge shrunk from a 77-ft span down to a 59-ft span, a 66 percent reduction in moment of inertia required. The Big Cow Creek Bridge shrunk from a 102-ft span to an 86-ft

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span, a 49 percent reduction in moment of inertia required.

*Case 2: Sprout Brook Bridge, Paramus, NJ.* This bridge (Figure 3) was part of a much larger interchange development project at the intersection of Routes 4 & 17. The new bridge would expand from four lanes to 13 lanes and span 48 ft. The contractor was offered a $7 million bonus if they could finish the entire 30-month project in 13 months. This aggressive schedule meant a large number of people working long hours during six- or seven-day weeks. Redesigning the bridge saved 10 weeks and $280,000. The original abutment design used temporary sheet pile cofferdams, 860 H-piles for bearing, and included six lane change phases. The new design utilized AZ36 sheet piles driven right at the water's edge and had only two lane change phases.

*Case 3: Hog Branch Creek Bridge, Coles County, IL.* The original design of this 42-ft span, two-lane bridge included traditional concrete abutments with channel protection and H-piles for bearing. The project was redesigned using PZ22 sheet pile abutments with integral H-piles for bearing. Nothing else was changed in design, yet the total project cost was reduced by $144,000, which equated to a nearly one-third overall savings.



## What Lies Ahead?

These projects just begin to scratch the surface regarding the capabilities of structural steel sheet pile in permanent load bearing applications. The possibility of using high-modulus combination walls for long span bridges or bridges adjacent to deeper canyons is only one area of interest for future development. Also, many firms have already had tremendous success designing steel sheet piles as the permanent foundation walls for below-grade parking structures and basements. With proven durability, sustainability, and profitability in the arsenal, this is an innovation the industry can embrace with confidence.

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