Top Ten Sustainability Benefits of Shotcrete

The United States Green Concrete Council's (USGCC) book, *The Sustainable Concrete Guide—Applications*, includes a list of the top 10 sustainability benefits of shotcrete in its chapter on shotcrete. Over the next 10 issues of *Shotcrete* magazine, this Sustainability column will elaborate on each one of the listed advantages. Previous discussion of advantages from past issues can be viewed on the ASA Web site at **www.shotcrete.org/sustainability**.

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1. Formwork savings of 50 to 100% over conventional cast-in-place construction.
2. Formwork does not have to be designed for internal pressures.
3. Complex shapes require very little—if any—formwork.
4. Crane and other equipment savings or elimination.
5. Labor savings of at least 50% in repair applications.
6. **New construction speed savings of 33 to 50%** (see below).
7. Speed of repair reduces or eliminates downtime.
8. Better bonding to the substrate, which enhances durability.
9. Adaptability to repair surfaces that are not cost-effective with other processes.
10. Ability to access restricted space and difficult-to-reach areas, including overhead and underground.

New Construction Speed Savings of 33 to 50%

Both cars looked the same. When asked why one was more expensive, the salesman had no explanation. "They are the same, one just costs more," he replied. When we buy automobiles, we expect to pay more for a superior product. We hunt out value by purchasing certain brands that possess attributes such as quality or durability. To the car buyer, two identical cars should cost the same amount.

In the construction industry, costs may vary based on intangibles that may be difficult to initially understand. Obviously, most would be unhappy to realize that they have paid substantially more for an identical product, but this is a common scenario. Concrete is the most common construction material on the planet, but its installed cost will never be the same. The speed and efficiency with which concrete can be placed will determine its installed cost.

The Magic of Shotcrete Efficiency

Since the first use of concrete, it has been cast into forms. Even today, almost all concrete produced is ultimately cast in place. Currently, shotcrete placement methods are capable of creating virtually the same in-place product as traditional cast-in-place concrete construction, but in many applications, shotcrete construction methods are much more efficient than conventional cast-in-place concrete construction. If asked, however, many construction professionals may not be able to clearly explain why.

The "magic" that explains this unique placement method's efficiency is the nearly nonexistent fluid pressures applied to vertical forming materials during shotcrete placement. Shotcrete is not cast in a fluid state. Therefore, vertical forming materials need only be sufficiently rigid to initially stop the impact of nozzle flow at the receiving surface.

Shotcrete Methods That Save Time

For decades, tunneling, earth retention, and concrete repair contractors have used shotcrete placement methods to speed production. Today, more conventional concrete projects are switching to shotcrete placement methods to save time. A good example is the remodeling of commercial and industrial concrete structures. Window and door infills are regularly formed, placed, and completed on a single overnight shift. Structural improvements, seismic retrofitting, and shear elements commonly use shotcrete to save time. A very common method for seismic upgrading of existing structures is the addition of concrete shear walls. The lack of form pressure from fluid concrete liquid head allows the shotcrete method to often use existing structures as the back form. Many unreinforced masonry buildings can be restored by adding shear walls to the existing structure with very little, if any, added forming. In this same way—that is, using existing surfaces—sea walls, water canals, and erosion control construction are also expedited by the use of shotcrete. On average, shotcrete

placement techniques can yield 33 to 50% time savings over traditional cast-in-place methods.

Alternative Shotcrete Form Materials Speed Production

Many shotcrete contractors speed production by using alternative forming materials. Light-grade steel studs, commonly used for commercial and industrial wall framing, provide adequate rigidity as form framing, and standard interior-grade gypsum drywall or expanded metal lath sheets work well as an alternative to plywood or dimensional lumber panels (Fig. 1). Unacceptable to withstand internal casting pressure, as traditional forming materials must, alternative shotcrete forming materials provide unparalleled construction speed. They are tougher than they look! Lightly framed vertical walls higher than 20 ft (6.1 m) can be placed without special precautions. Alternative form materials are proven to dramatically speed production with no compromise in product quality.

There are also times when traditional forming materials cannot be used because of the configuration. The Experienced Music Project (Fig. 2) built in 2000 in downtown Seattle, WA, is an example where forming and cast-in-place methods simply would not work. Using shotcrete placement and a stay-in-place forming system allowed for the construction of an irregular-shaped, 5.5 in. (140 mm) structural concrete shell over 100,000 ft^2 (9300 m^2) in size.

A Closer Look Reveals More Time Savings

Are low material costs and ultra-fast construction not enough? Alternative shotcrete forming techniques are enormous time savers when compared to conventional retaining wall methods. Traditionally designed as a cast-in-place application, concrete walls constructed against earth embankments require substantial over-excavation to allow safe access to both sides of the wall for construction and removal of forming materials. Although some walls may be shot directly against earth surfaces, common construction details typically require the installation of drainage and waterproofing membranes. Taller walls constructed near excavated earth can become dangerous, creating confined space hazards to workers who can become trapped behind walls in the event of earth movement. Current construction standards mandate that tall concrete walls within close proximity to unsecured earth embankments cannot safely and legally be conventionally constructed without extensively over-excavating the slope or using temporary earth-shoring methods.

Alternative wall-forming techniques can allow shotcrete walls to be safely erected near most earth embankments because the forming system is designed to stay in place. After placement, the wall is simply backfilled with a drainage material. This eliminates the need to place workmen at risk

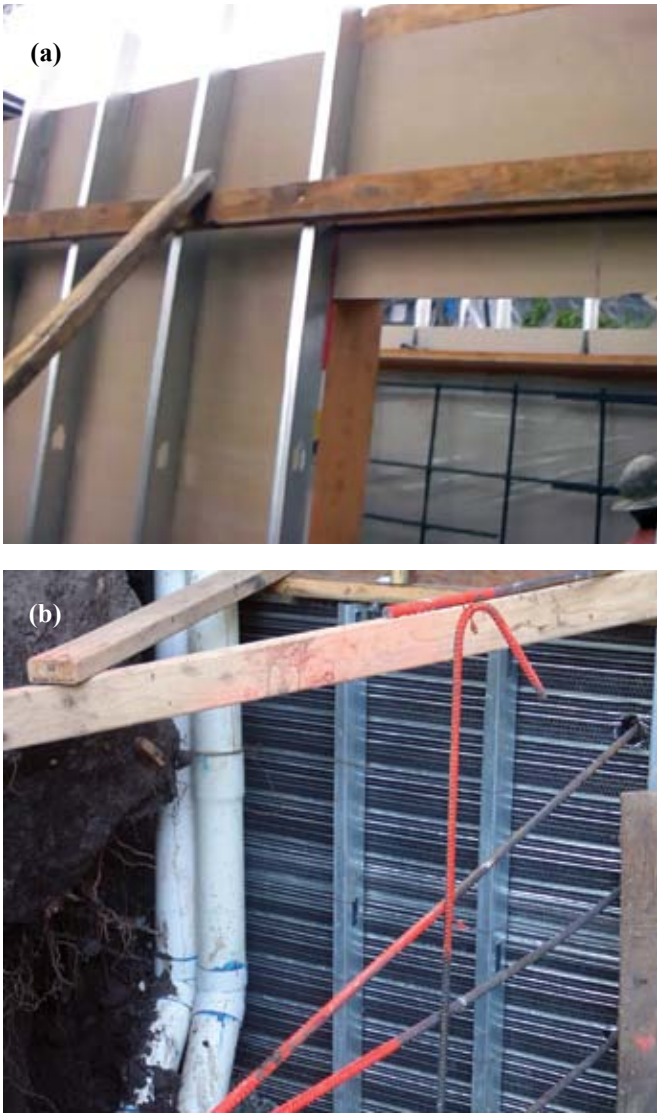

Fig. 1(a) and (b): Forming techniques that use alternative materials

Fig. 2: Experienced Music Project, Seattle, WA, 2000

Fig. 3: Nine-foot (2.7 m) tall wall constructed near excavated earth bank. Note drainage and waterproofing membranes applied to face side of form

Fig. 4(a) and (b): Back side view reveals minimal over-excavation. Alternative form materials will remain in place

when working between the embankment and the completed wall. All required drainage or waterproofing membranes are incorporated into the face side of the formwork, prior to placement, and will remain in place, undisturbed, and protected by the form materials during backfilling (Fig. 3 through 5).

The use of stay-in-place forming techniques nearly eliminates costly over-excavation, haul-off, and recompaction, while providing identical performance to traditionally constructed concrete. Innovative shotcrete techniques consistently generate speed savings of 33 to 50% over conventionally cast-in-place concrete. Speed and efficiency directly influence the concrete's final cost. Less formwork, labor, and time also significantly enhance the project's sustainability. Like the two cars, similar products can have vastly different final prices.

Fig. 5(a) and (b): Completed wall after backfilling with drainage material