

## Top Ten Sustainability Benefits of Shotcrete

The United States Green Concrete Council's (USGCC) *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 following advantages. Previous discussion of advantages from past issues can be viewed on the ASA Web site at [www.shotcrete.org/sustainability](http://www.shotcrete.org/sustainability).

1. Formwork savings of 50 to 100% over conventional cast-in-place construction.
2. **Formwork does not have to be designed for internal pressures** (see below).

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%.
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.



## Formwork Does Not Have To Be Designed for Internal Pressures

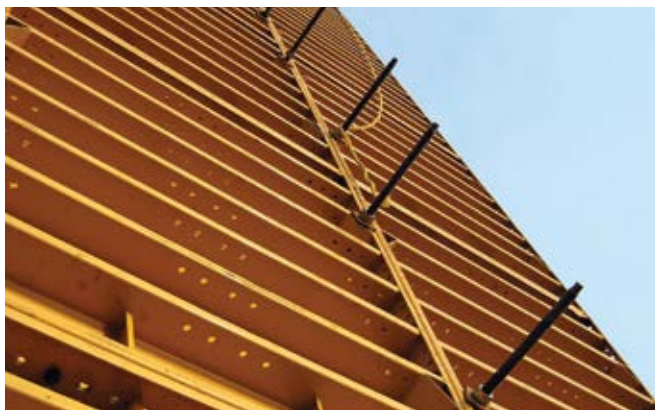
One of the most expensive and labor-intensive parts of traditional cast-in-place concrete construction is the design, fabrication, erection, removal, and transport of forms used to support fresh concrete until it reaches a strength to be self-supporting. Fresh concrete in its liquid state before set exerts a substantial lateral pressure on the formwork trying to contain it. ACI 347, "Guide to Formwork for Concrete," provides formulas to estimate the lateral pressure considering the temperature, casting rate, and type of concrete with a minimum of 4.16 psi (0.03 MPa). Common casting rates and weather conditions can easily double the pressure. If one considers the outward pressure on a 4 x 8 ft (1.2 x 2.4 m) sheet of plywood using just the minimum lateral pressure, nearly 10 tons (9.1 tonnes) of pressure needs to be contained to hold the concrete in place. To put this magnitude of pressure into perspective, think about a parking garage where the design live load is 0.35 psi (0.002 MPa) for car, truck, or bus traffic. The minimum concrete pressure inside a cast-in-place form is well over 10 times greater than cars, trucks, and buses driving in a garage structure.

For formwork to physically hold together in the desired shape during the casting operation and to withstand these

massive lateral pressures requires substantial structural strength and rigidity in the forming system. Thus, you will find that properly designed formwork uses a substantial amount of lumber, steel, or aluminum, depending on the form system. Additionally, the formwork needs to be transported to the site, erected, braced, removed, and then trucked off site either for reuse or disposal. This equates to substantial CO<sub>2</sub> emissions from transport, as well as labor and cost for a product that isn't even incorporated in the final structure.

With the shotcrete process, the concrete is shot in place, so the weight of concrete is carried by the concrete itself. There is little or no lateral pressure because the shotcrete is essentially self-supporting and doesn't "flow" like fresh concrete does. Forming is reduced by at least 50% of the surface area with the use of one-sided forms. In many cases, no formwork is required at all. In addition to the many benefits of one-sided forms that were discussed in the last issue of this column, when one-sided forms are required, the structural strength requirements of the formwork are substantially reduced because there is no need to design for internal pressure from fluid concrete within the form.

A copy of the USGCC's *The Sustainable Concrete Guide—Applications* can be obtained by visiting the American Concrete Institute's online bookstore at [www.concrete.org](http://www.concrete.org).



Bay of St. Louis bridge



Finishing touches are made to a freshly placed shotcrete wall