# Seismic Testing Wall Needs No Vibration

**By Douglas E. Benedict, Marketing Manager**
**Commercial & Industrial Segments**
**W.R. Grace, Cambridge, MA**

The University of Illinois, Urbana-Champaign (UIUC) is home to one of the nation's leading civil engineering programs. It is also headquarters for the Mid-America Earthquake Center, and a driving force behind the George E. Brown Network for Earthquake Engineering Simulation (NEES), a national earthquake engineering resource that enables world-class laboratories around the country to collaborate remotely on experiments, computational modeling and education.

**An "Immovable Object"**
As part of the NEES program, UIUC's Department of Civil and Environmental Engineering received funding to construct a Multi-Axial Full Scale Sub-structure Testing and Simulation (MUST-SIM) facility including a "strong wall" within its Newmark Civil Engineering Laboratory in Champaign. Designed for state-of-the-art seismic testing, the specially constructed concrete strong wall will serve as an "immovable object" against which forces can be reacted.

An imposing edifice, the strong wall is 80 feet long, 28 feet high and 5 feet thick, built in an L-shaped plan with 50 foot and 30 foot long legs. Made of high strength, densely reinforced concrete, it is designed to withstand testing that simulates the forces on structures caused by earthquakes of different magnitudes. "The strong wall was designed to support the forces from three very large loading units that can be attached to any point on the wall. Each of these loading units has a self-weight of 34 tons and can be used to exert forces of up to a million pounds to test specimens such as bridge piers and other structures," noted Daniel A. Kuchma, Assistant Professor at the Department of Civil and Environmental Engineering at the University of Illinois, Urbana-Champaign.

**Designed for Extreme Forces**
To prevent the wall from lifting off of the Newmark strong floor when exposed to these extreme forces, the strong wall was post-tensioned to the floor using eighty-one 2.5 inch diameter high-strength post-tension bars in sleeves.

A heavy grid of reinforcing bars was used on the front and back faces of the wall to resist the loadings imposed on the wall by the use of the loading units. This grid consisted of a #9 and #11 bars on 4.5 inch centers in the more heavily reinforced regions.

In addition, more than 800 large tubes on 18-inch centers were placed through the thickness of the wall to support the connection of the loading units to the strong wall. These tubes were required to be within 1/8 inch from the specified location in the horizontal, vertical and out-of-plane positions. This precise arrangement was achieved through the use of vertical stands that held in position the horizontal reinforcement to which the tubes were anchored.
Unique Engineering Challenges

The design and engineering requirements of the strong wall presented a special set of challenges to concrete supplier Champaign Builders Supply. Specifications called for high performance concrete with a minimum of 8000 psi. In addition, the unique design of the wall dictated the use of a highly flowable mix that would place easily around the highly congested steel reinforcement within the structure.
Another consideration was the need to place the concrete without disturbing the precise positioning of tubes during concrete placement. This requirement, coupled with the sheer height of the wall, made the use of vibration equipment in the placement process problematic. In addition, there was concern about the high noise level from vibration equipment, because the wall is located indoors.

"The need to achieve a very high break, use a highly flowable mix that didn't affect the concrete's strength, and yet place it without vibration posed a significant challenge," said Bernie Hinkle, General Manager of Champaign Builders Supply. "We needed a mix that would satisfy all these criteria," he added.

Complicating matters further was the need to place the concrete in a single day. "Speed of placement was important so there would be no cold joints. Finishing the job in one day was critical, and a continuous pour was mandatory. To do this, we required a consistent supply of concrete that met all the design parameters," said David A. Lange, P.E., Associate Head of the Department of Civil and Environmental Engineering at the University of Illinois, Urbana-Champaign.

**Self-Consolidating Concrete Provides Solution**

The Champaign Builders team worked with Grace Construction Products to design a Self-Consolidating Concrete (SCC) mix to meet these challenges. Grace's proprietary SCC technology produces highly flowable, self-consolidating concrete that can be placed without vibration equipment and without aggregate segregation. On the day of the pour, Grace's team worked with Champaign Builders Supply personnel at their plant and at the job site to ensure that everything went as planned.

With a continuous line of concrete trucks ready to back into position, the pour was completed in approximately seven hours.

The concrete was pumped to a tremie hose that was lowered into the form from a single location on top of the wall. As the concrete level rose, the hose was pulled up, a section cut off, and once again lowered into the form. In all, the job took more than 50 truckloads of concrete totaling 320 cubic yards.

Ready to Help Save Lives

According to Lange, the SCC concrete mix met all of their expectations. "When we initially made plans for the wall, there was some concern about making sure we could place the concrete in a 28 foot tall structure without vibration. SCC was the only solution to that problem. People were impressed with the truck-to-truck consistency of the delivered mix, the fluidity of the SCC and the way the concrete moved through the forms, flowing smoothly around the rebar and tubes," he added.

An additional bonus was that the pour was relatively quiet. With the SCC mix, the only noise inside the building was from the pump and the trucks - not from vibration equipment.

In October 2004, NEES transitioned from a developmental to operational state. Today, UIUC's strong wall is being put to the test by some of the best minds in earthquake research - work that will be used to make structures better able to withstand the effects of earthquakes and ultimately, save lives.