Innovative Blast Resistance System

Recent Advances In The US Department of State's Blast Resistant Steel Stud Curtain Wall Technique

By Russ Norris and Don Moffett

The Department's Bureau of Diplomatic Security (DS) has developed an innovative blast resistant system for the construction of new US diplomatic facilities overseas. Development of this construction system has resulted in a number of refinements and advances in the past 16 months.

This technique leverages the design, fabrication and erection benefits of traditional curtain walls by employing commercially available, cold formed steel studs to fabricate blast resistant building envelopes for moment resisting structural frames. Conventional blast resistant construction typically involves thick, heavily reinforced, poured in place concrete walls. The blast resistant curtain wall system employs back-to-back 54 mil (16 gauge), cold formed studs spaced at 16-inch centers with a stone cladding to achieve comparable performance.

For the specific system described above, DS has conducted three full-scale blast tests. Two were component level tests conducted at Eglin AFB undertaken in conjunction with the US Army Corps of Engineers (USACE), Engineer Research and Development Center (ERDC) as part of the DS/ERDC, Embassy Wall Retrofit Program (EWRP) test series.These tests took place in April and December of 2005. A full-scale validation test was conducted in August 2005 at Kirtland AFB with the support of the Defense Threat Reduction Agency (DTRA). A 30-foot wide by 60-foot tall three-story replica of the Department's new class of Standard Embassy Design (SED) embassy buildings, incorporating the steel stud curtain wall system, was tested in the new DS blast test reaction structure.

The result of these test and development efforts is a proven construction system that closely mirrors conventional curtain wall approaches to cladding a concrete or steel framed structure while providing blast protection to building occupants. As such, it's amenable to either new construction or re-cladding of an existing building.

Ground Floor Connections Have Been Simplified

Early variants of this technique required numerous bolted connections of stud pairs to the ground floor slab to realize the structural capacity of the steel studs. Recent developments have eliminated these mechanical connections, and the only attachment now required between this system and the structure are driven by gravity and wind loads. This is accomplished by providing a "brick ledge", stepped down six inches from the unfinished floor slab height, into the design of the ground floor slab. Retrofit applications can achieve this same condition by casting a new stepped down horizontal ledge, or attaching a steel angle or "T" section to the vertical edge of the existing ground floor slab.

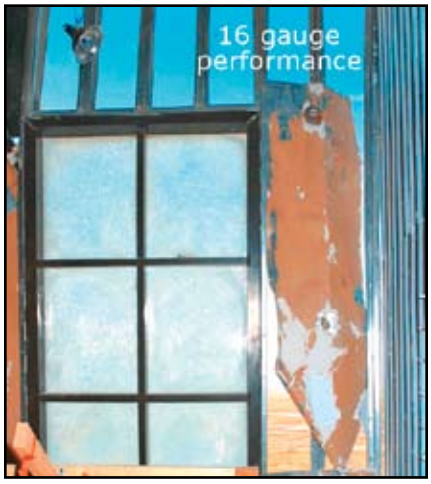
Exterior Metal Sheathing Revised

A significant advancement to this system is the selection of a thicker steel cladding material applied to the exterior side of the stud pairs above the first level. Replacing the 16-gauge (.06-inch or 1.5 mm) sheet steel material utilized in initial system development with 10-gauge material (.1345-inch or 3.4 mm) has resulted in a number of advantages. These include an overall increase in reserve capacity and protection against secondary debris, simplified window rough openings, flexibility of the vertical stack joint locations and easier welded fabrication.

Reserve Capacity Increase

Previous iterations of this construction system, when clad with the 16 gauge sheet steel and tested, would at times have the exterior cladding pulled off the studs by the negative pressure phase of an explosion or rebound of the wall. Despite the fact that measured internal pressures were very safe, this cladding failure could expose the occupants of the structure to injury from secondary debris created by an explosive event.

The 10-gauge material allows for better connection to the studs and a post-event response that does not exhibit the cladding failure noted above.

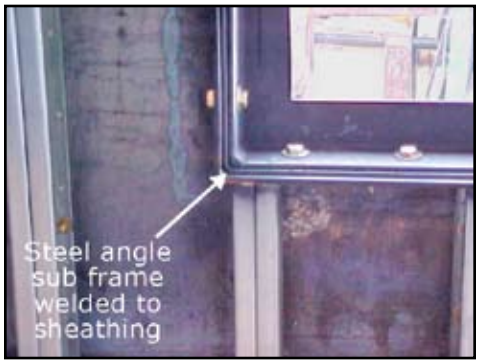


Window Rough Openings

Increasing the thickness of the exterior cladding, from 16 to 10 gauge, results in window rough openings being much easier to construct. Earlier system variants utilized a complicated arrangement of 6 mm (½ inch) angle brackets to attach windows to stud pairs at head and sill. Welding a steel angle sub frame to the outer face of the steel sheathing can now produce these rough openings. The window is then attached to this sub-frame. The exterior steel sheathing will be 6 mm (¼ inch) thick at the ground floor and 3 mm (10-gauge or ⅛ inch) thick above the ground floor. This approach removes traditional blast window embeds from the project critical path.

Construction Stacking Joints

The substitution of 10-gauge sheet steel as an exterior cladding allows for more flexibility in the location of vertical assembly or "stacking" joints. Previously, stacking joints were located between floors so they did not interfere with the dynamic reactions of the studs post blast. The new system allows for the stacking joints to be located just above floor level, in accordance with typical curtain wall designs that facilitate fabrication and erection of the wall system.



Welded Fabrication

From its inception, the DS blast resistant steel stud curtain wall system was developed to allow general contractors and their curtain wall fabricators the flexibility of fabricating by either welding or mechanically fastening with ELCO DrilFlex self drilling, self tapping screws. While this approach is still viable, increasing the thickness of the exterior steel cladding from 16 to 10 gauge facilitates rapid fabrication and panelization of this construction system by making it more amenable to wire feed welding of the exterior steel sheathing to the steel studs.

Interior Partition System

To complement the blast resistant steel stud curtain wall system, a 60 minute FE/BR interior partition system has been developed and successfully tested to DS' proprietary test specification. This interior partition was developed to provide the requisite levels of protection in embassy core areas, yet not become load bearing structural walls. This partition system employs steel plate on either side of a 16-gauge steel stud core secured at floor and ceiling by steel angles that allow for slab creep.▪

Refinements to the blast resistant steel stud curtain wall system described above will be presented to prospective bidders on the Department's Overseas Building Operations (OBO) 2006 SED drawing package as an alternative structural design approach. To allow use of this construction technique for different conditions such as charge size, range, floor height, stud size/spacing and exterior cladding materials, additional testing and data collection has been accomplished and will be incorporated into future development of this system. For additional information contact the following Bureau of Diplomatic Security staff, Russ Norris, *norrisrj@state.gov* or Don Moffett, *moffettdl2@state.gov*.

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