International Material Inc.
Sure-Board® Series 200B Blast Products
Blast Test, Kirtland, New Mexico
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The world has changed dramatically for designers since 9/11. No longer are dead, wind and seismic loads the only forces needed to be considered when engineering structures. Domestic threats are real and must be considered when designing high profile or high risk buildings such as courthouses, federal and local government buildings, transportation hubs such as airports and train stations. Much attention has been given to increasing the resistance of building support systems to preclude progressive collapse, and rightfully so. As always, the engineer's primary goal is the protection and life safety of the building's occupants and visitors. More recently, however, blast resistant exterior walls have drawn the focus of professionals, owners, and government agencies who want to provide additional security to those working in a potentially dangerous surrounding. With increased security at entry points to buildings, the exterior wall is typically the first line of defense for any outside attack, whether it be via explosives or gun fire. In this article, we explore one such wall system that provides benefits to both types of assault, yet utilizes many commonly available building materials.

With regards to blast resistance, the US Department of State (DOS) has established a 40psi pressure as it's design level event for U.S. Embassies. Exterior walls and windows are expected to protect interior occupants from debris, while maintaining some form of structural integrity. The U.S. General Services Administration (GSA) has established somewhat lower pressures for domestic structures. GSA Level D requires 10psi pressure, and Level C requires 4psi peak design pressure. The Army Corps of Engineers has followed the GSA requirements with a 10psi and 4psi tiered standard.

International Materials, Inc. of Newport Beach, CA (Intermat) has developed a wall system utilizing standard metal stud framing and their patented metal sheet laminate wallboard product called Sure-Board® Series 200B. This product developed for shear resistance to lateral loads such as wind and seismic, naturally lends itself to resist explosive, ballistic and impact forces. The key to any blast resistant system is it's ability to absorb the energy of the blast wave while remaining ductile. Much like the crumple zone technology used in modern automobile design. The Sure-Board® product, which is applied to both interior and exterior faces, contains a continuous thin sheet of steel which provides a large surface area of energy absorbing material. The metal studs are configured back-to-back in an I-section shape and captured in standard metal track runners at the top and bottom connections. The framing components are designed to yield locally during the peak pressures, but are fastened to the building in such a way as to prevent disengagement. Further resistance to airborne debris is provided by a simple stone veneer adhered to the exterior cement board based Sure-Board® via Laticrete thinset epoxy mortar. The Laticrete system not only provides excellent bond strength, but also provides the necessary weather barrier behind the veneer. (ref Figure 1)

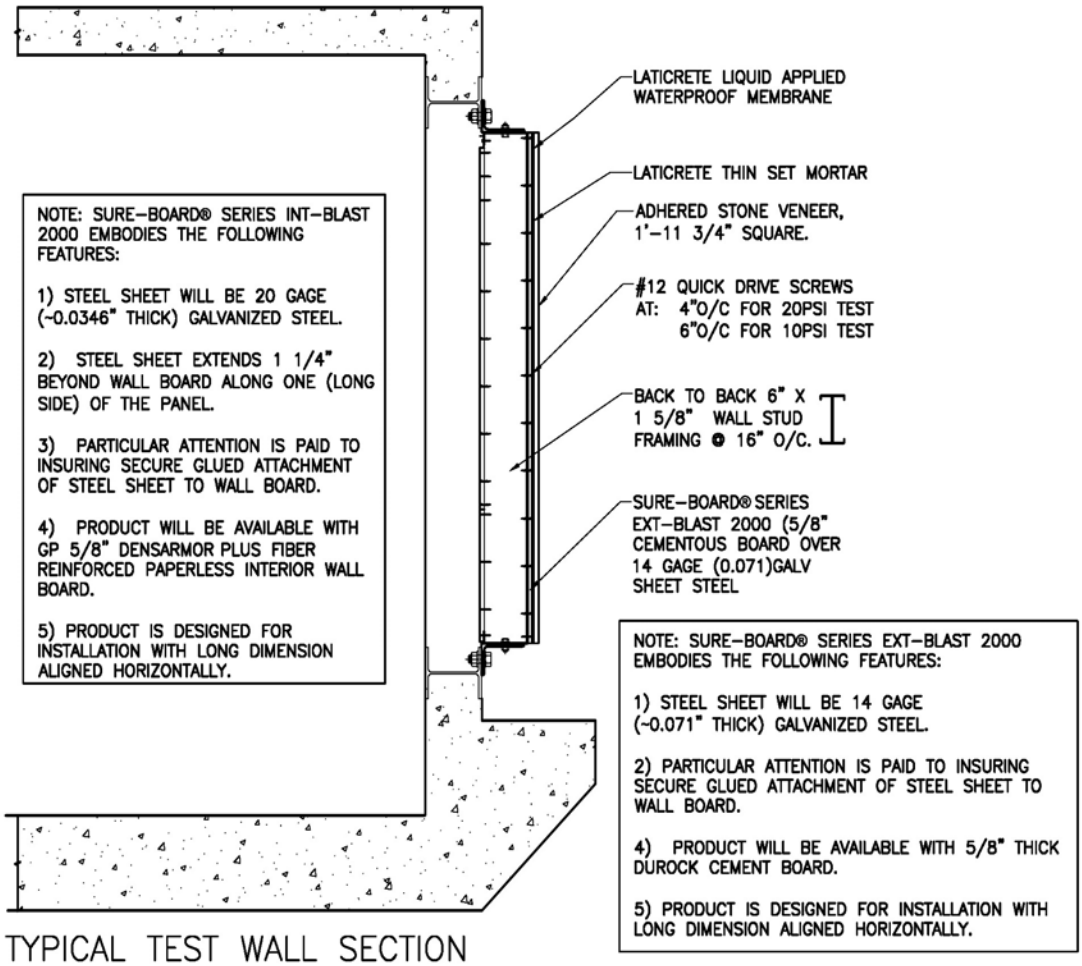

FIGURE 1

Testing performed at Kirtland AFB (near Albuquerque, NM) on August 23, 2007, demonstrated the excellent performance of the Intermat system. Three sample walls were constructed and positioned at various distances from the explosive charge (ref Figure 2).

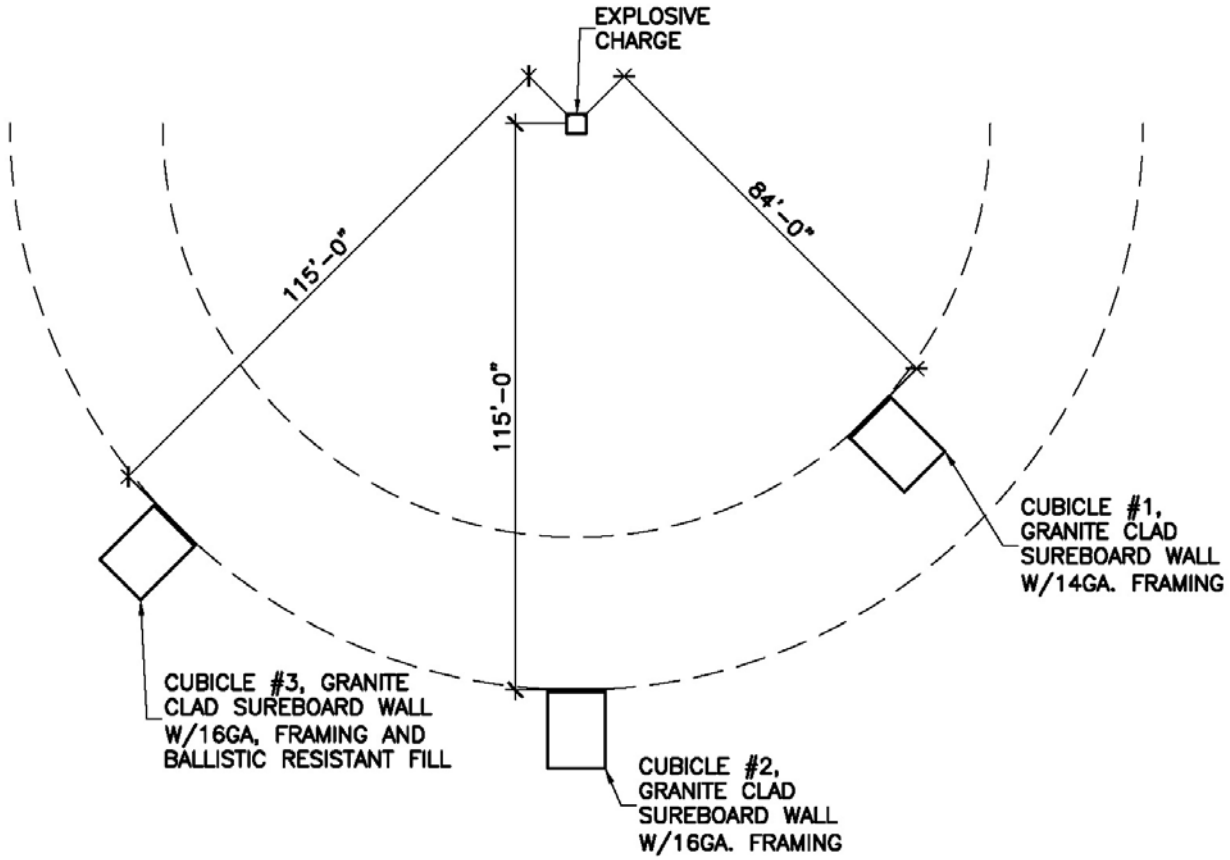

FIGURE 2

One wall was located 84 feet from the 375 lb C4 shot. Our calculations predicted a pressure of 21 psi. The actual measured pressure was 23.6 psi. This is more than double (236% higher than) the pressure of the highest GSA standard currently used. Two other walls were positioned 115 feet from the charge. The calculated pressure using A.T. Blast predicted a pressure of 11 psi. The actual measured pressure was 13.7 psi (136% higher than the highest current GSA standard). One of the walls at 115 feet was constructed with ballistic resistant materials as well. Blast pressures were calculated using A.T. Blast© V2.2 developed by Applied Research Associates, Inc. (ref Figure 3), and measured using sensors made by PCB Piezotronics, Inc.

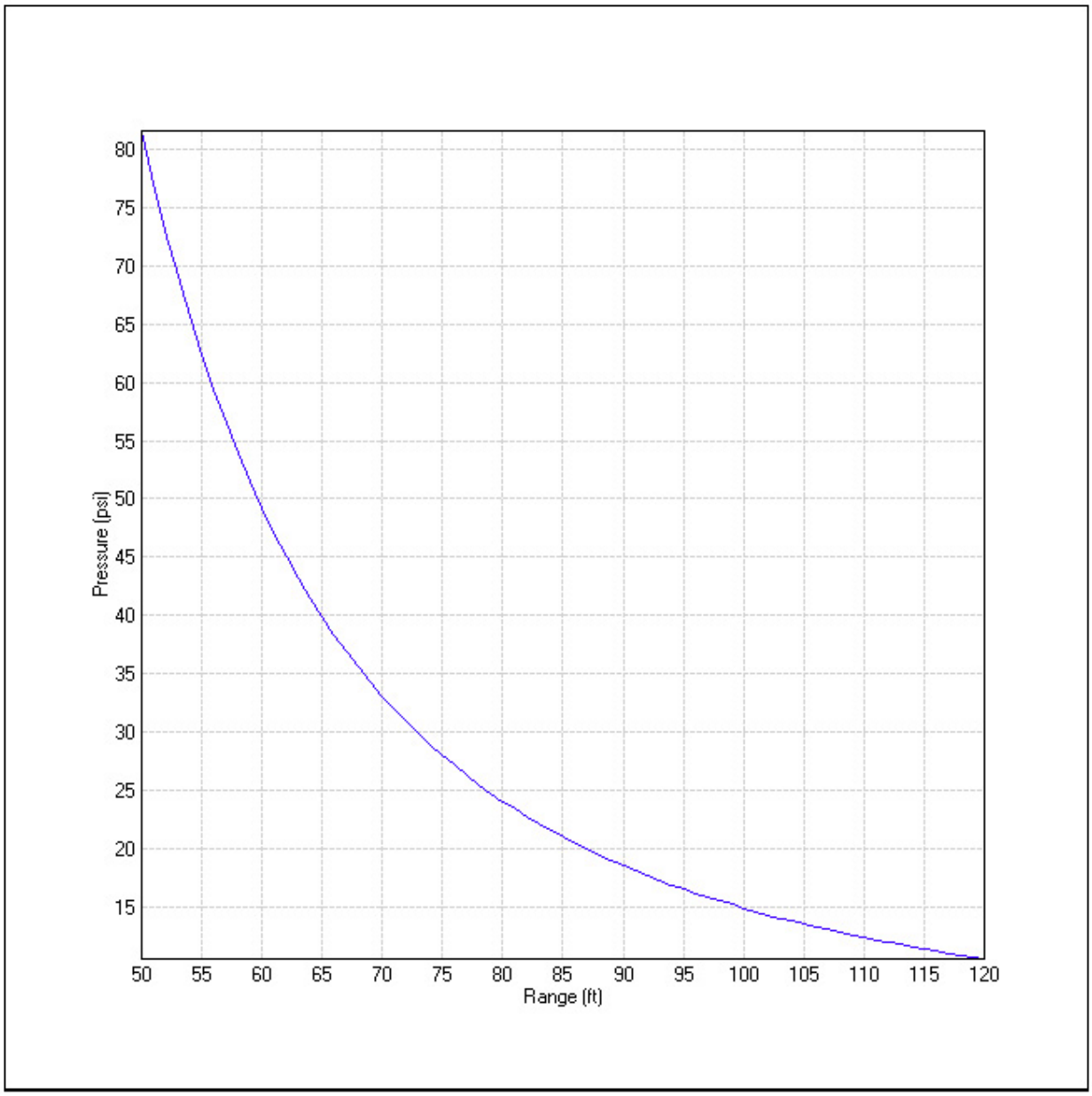

FIGURE 3

The results of the testing were surprising in that the performance of the wall system (at 84 feet) exceeded our most optimistic expectations. The test wall located at 84 feet from the charge suffered only minor damage. A horizontal hairline crack appeared in the exterior stone veneer at two locations; at approximately 8" below the top and 6" above the bottom of the wall. Four vertical hairline cracks appeared in the stone at approximately mid-height on the panel. The vertical cracks were not visible to the eye until we rubbed the stone units down with gypsum board dust. The dust lodged in the cracks making them easier to see (ref Figure 4). In addition, to the hair line cracks, the stone veneer showed some minor signs of rock strikes in the form of small (approximately 1/8" deep) chips missing from a few locations on the stones surface. The interior Sure-Board® wall surface appeared completely undamaged. Disassembly of the wall, by removing the interior Sure-Board®, revealed deformation in the interior flange of the top and bottom tracks. We believe this deformation helped absorb some of

the blast energy (ref Figure 5). The vertical studs themselves exhibited no measurable permanent deformation. There was no evidence of any damage or disturbance, of any kind, to the interior space.

FIGURE 4

FIGURE 5

Test Specimens located 115 feet from the charge suffered no visible damage to either the interior or exterior finished surfaces other than some missing chips due to rock strikes on the exterior surface. The ballistic resistant wall maintained its full integrity. The performance of both wall assemblies was exemplary. In this case, disassembly of the wall, revealed very slight deformation in the interior flange of the top and bottom tracks and one small tear in the 16 gage top track. The deformations and the small tear were located directly opposite the back to back webs of the double studs. As with the 84' test, the interior space was undamaged with no signs of any disturbance.

The test results demonstrated the viability of the wall board and exterior finish system. The attachment of the stone veneer to the exterior Sure-Board® Series 200B with the Laticrete system resulted in a composite structure that acted as a single unit instead of a series of separate components. This assembly enabled us to take advantage of the combined strength and blast resistant characteristics of all the components. The resultant composite action, and mass retention, limited the magnitude of the deflection. The lower deflection translated into less damage to the interior and exterior components.

The entire system was constructed from components that are readily obtainable. Installation of the system involved no special techniques or unusual skill requirements. The resultant wall system is water proof, highly corrosion resistant, virtually air tight, and compatible with most standard blast resistant door and window assemblies.

The choice of exterior finishes would include any type of stone veneer that can be adhered. We believe that similar test results can also be achieved using ceramic, porcelain or glass tile. We will be verifying this assumption in future testing.

The ballistic resistant characteristics of the filled wall have been repeatedly tested by International Materials. To date, we have not found any fired projectile capable of penetrating the full thickness of the wall with the exception of the 50 BMG. Calibers tested include 9mm, 357 magnum, 44 magnum, 243 Winchester, 25-06, 30-06 Springfield, 7mm Remington Magnum and 338 Winchester Magnum. The advantages of having a wall assembly that is both blast and ballistic resistant are obvious.

More testing is in the planning stages. Additional energy absorbing components will be added to the wall system in an attempt to achieve even higher levels of blast resistance. Future testes will be expanded to cover load bearing walls in addition the curtain wall assemblies currently being tested.

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