Blast Overpressure Test Description and Results

CeraTech Armor Panel Design Incorporating M2 Structural EPS Panel

Test Dates: September 17/18, 2009

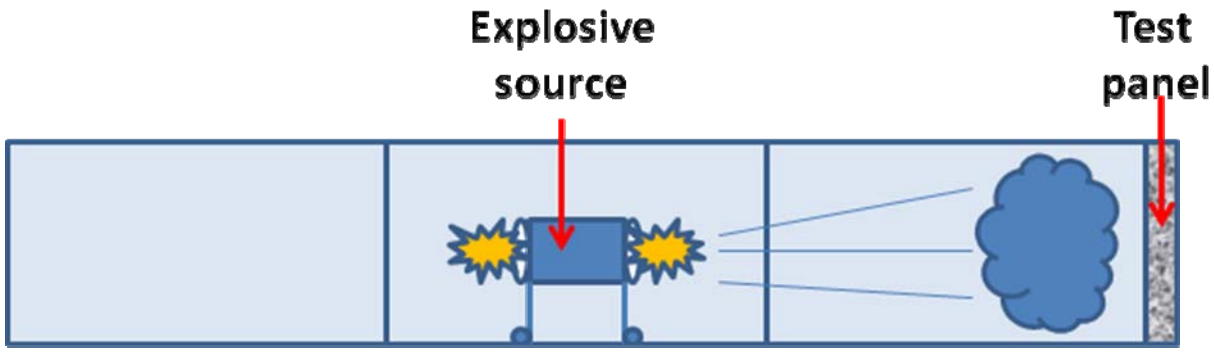
Test Location: University of Kentucky, Lexington, KY

Test Layout:

5 x 5 ft. panels of different combinations of CeraTech high strength cement together with different styles of M2 steel reinforced EPS building panels were evaluated for blast resistance. The panels were tested against a commercial high explosive in a test chamber optimized to produce a uniform blast wave at the face of the panels.

The test chamber design is shown in the Figure below. Essentially, it consists of a long shock tube comprised of multiple ISO containers with steel reinforced/welded external support beams. The tube is 100 ft. long. At one end of the tube, the test panel is securely fastened by angle iron on both the inner and outer faces of the panel. In the center of the tube, a steel cylinder ~ 5 ft in length and 2 ft diameter is centered with the open ends directed at each end of the test chamber. A known quantity of explosive is detonated from the center of this tube. The explosive quantity, together with the distance at which the explosive is placed in relation to the test panel determines the blast overpressure applied at the face of the test panel. The quantity of the explosive also controls the duration of the blast event.

Test Chamber Set-up



The following specific tests were performed:

Test 1.

M2 panel design – thin steel mesh, single layer on both sides (modified from the as supplied double layer mesh on both sides). CeraTech high strength concrete, unreinforced, was applied at a thickness of ~ 1 inch to both sides of the panel. The cement was cured for at least 28 days. The compressive strength of the cement was ~ 12,000psi.

The blast overpressure achieved in this test was 15 psi.

The rear face of the panel incurred minor cracking, while the front face (side facing the blast wave) had no visible cracks.

Test 2.

M2 panel design – thin steel mesh, single layer on both sides (modified from the as supplied double layer mesh on both sides). CeraTech high strength concrete, unreinforced, was applied at a thickness of ~ 1 inch to both sides of the panel. The cement was cured for at least 28 days. The compressive strength of the cement was ~ 12,000psi.

The blast overpressure achieved in this test was 30 psi. Note: The panel tested was the very same panel used in test 1 that had already survived a 15 psi blast overpressure event.

The rear face of the panel incurred additional cracking, while the front face (side facing the blast wave) generated minor cracking.

Test 3.

M2 panel design – thin steel mesh, single layer on the concrete side, double layer on the rear side CeraTech high strength concrete, unreinforced, was applied at a thickness of ~ 1 inches to one side only of the panel (side facing the blast pressure pulse). The cement was cured for at least 28 days. The compressive strength of the cement was ~ 12,000psi.

The blast overpressure achieved in this test was 15 psi. The panel incurred minor cracking on the front face. The rear panel steel mesh deformed around the frame holding the panel.

Test 4.

M2 panel design – thin steel mesh, double layer on the concrete side, double layer on the rear side CeraTech high strength concrete, unreinforced, was applied at a thickness of ~ 2 inches to one side only of the panel (side facing the blast pressure pulse). The cement was cured for at least 28 days. The compressive strength of the cement was ~ 12,000psi.

The blast overpressure achieved in this test was 30 psi. The panel incurred minor cracking on the front face. There was a single crack across the entire panel where a full-length seam existed in the foam panels. The rear panel steel mesh deformed around the frame holding the panel.

Test 5.

M2 panel design – thin steel mesh, double layer on the concrete side, double layer on the rear side CeraTech high strength concrete, unreinforced, was applied at a thickness of ~ 2 inches to one side only of the panel (side facing the blast pressure pulse). The cement was cured for at least 28 days. The compressive strength of the cement was ~ 12,000psi.

The blast overpressure achieved in this test was 32 psi. The panel incurred additional cracking on the front face. There was a single crack across the entire panel where a full-length seam existed in the foam panels. The rear panel steel mesh deformed around the frame holding the panel. During the explosive event, sufficient flexing occurred that caused some of the foam to extrude through the rebar, as can be seen in the video.

Test 6.

M2 panel design – ¼ inch steel rebar, single layer, welded through both sides of the panel. CeraTech high strength concrete, unreinforced, was applied at a thickness of 1,5 inches to one side only of the panel (side facing the blast pressure pulse). The cement was cured for at least 28 days. The compressive strength of the cement was ~ 12,000psi.

The blast overpressure achieved in this test was 37 psi. The panel incurred minor cracking on the front face. There was a single crack across the entire panel where a full-length seam existed in the foam panels. The rear panel steel mesh deformed around the frame holding the panel.

Test 9.

M2 panel design – ¼ inch steel rebar, single layer, welded through both sides of the panel. CeraTech high strength concrete, unreinforced, was applied at a thickness of 1,5 inches to both of the panel. The cement was cured for at least 28 days. The compressive strength of the cement was ~ 12,000psi.

The blast overpressure achieved in this test was 42 psi. The panel incurred minor cracking on the back side. There were no visible cracks on the front side of the panel.

Test Panel Configurations

Test	Panel type	Concrete thickness	sides	test pressure (Psi/MPa)
Test 1.	TPSM100, 3mm wire	3cm	2	15 /0.103
Test 2.	same as test 1	3cm	2	30 /0.206*
Test 3.	TPSM100, 3mm wire	3cm	1	15 /0.103
Test 4.	TPSM100HP, 3mm wire	5cm	1	30 /0.206
Test 5.	same as test 5	5cm	1	32 /0.220*
Test 6.	TPSM100, 5mm wire	4cm	1	37 /0.255
Test 9.	TPSM100, 5mm wire	4cm	2	42 /0.289
Test 10.	same as test 9	4cm	2	47 /0.324*

* *Panel tested was the same panel from the previous test, demonstrating blast overpressure from a second pressure pulse.*