Defense Threat Reduction Agency
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TECHNICAL REPORT

Research Program Tests for the U.S. Defense Special Weapons Agency (DSWA) for Breaching of Concrete Panels Set Against a Sandstone Rock Wall

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14. ABSTRACT
The New Mexico Institute of Mining and Technology's Energetic Materials Research and Testing Center (EMRTC) performed a test that investigated breaching methods against a single wall design. This experiment investigated breaching methods for reinforced concrete walls. Each test was conducted with different quantities of composition C4 and PETN sheet explosive. The objectives of the test were: 1) Through construction of test panels, explore different methods of breaching 2) Determine the difficulties and nuances of drilling behind wall test panels 3) Test different blast hole sizes, blast hole locations, and blasting sequences in an effort to identify the advantages and disadvantages of different breaching approaches. Accelerometer and high-speed camera data were collected, and the charges were initiated sequentially.

15. SUBJECT TERMS
Wall vulnerability, breaching methods

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CONVERSION TABLE

Conversion Factors for U.S. Customary to metric (SI) units of measurement.

MULTIPLY ——→ BY ——→ TO GET
TO GET ←—— BY ←—— DIVIDE

angstrom	1.000 000 x E -10	meters (m)
atmosphere (normal)	1.013 25 x E +2	kilo pascal (kPa)
bar	1.000 000 x E +2	kilo pascal (kPa)
barn	1.000 000 x E -28	meter^2 (m^2)
British thermal unit (thermochemical)	1.054 350 x E +3	joule (J)
calorie (thermochemical)	4.184 000	joule (J)
cal (thermochemical/cm^2)	4.184 000 x E -2	mega joule/m^2 (MJ/m^2)
curie	3.700 000 x E +1	*giga bacquerel (GBq)
degree (angle)	1.745 329 x E -2	radian (rad)
degree Fahrenheit	$t_k = (t^o f + 459.67)/1.8$	degree kelvin (K)
electron volt	1.602 19 x E -19	joule (J)
erg	1.000 000 x E -7	joule (J)
erg/second	1.000 000 x E -7	watt (W)
foot	3.048 000 x E -1	meter (m)
foot-pound-force	1.355 818	joule (J)
gallon (U.S. liquid)	3.785 412 x E -3	meter^3 (m^3)
inch	2.540 000 x E -2	meter (m)
jerk	1.000 000 x E +9	joule (J)
joule/kilogram (J/kg) radiation dose absorbed	1.000 000	Gray (Gy)
kilotons	4.183	terajoules
kip (1000 lbf)	4.448 222 x E +3	newton (N)
kip/inch^2 (ksi)	6.894 757 x E +3	kilo pascal (kPa)
ktap	1.000 000 x E +2	newton-second/m^2 (N-s/m^2)
micron	1.000 000 x E -6	meter (m)
mil	2.540 000 x E -5	meter (m)
mile (international)	1.609 344 x E +3	meter (m)
ounce	2.834 952 x E -2	kilogram (kg)
pound-force (lbs avoirdupois)	4.448 222	newton (N)
pound-force inch	1.129 848 x E -1	newton-meter (N-m)
pound-force/inch	1.751 268 x E +2	newton/meter (N/m)
pound-force/foot^2	4.788 026 x E -2	kilo pascal (kPa)
pound-force/inch^2 (psi)	6.894 757	kilo pascal (kPa)
pound-mass (lbm avoirdupois)	4.535 924 x E -1	kilogram (kg)
pound-mass-foot^2 (moment of inertia)	4.214 011 x E -2	kilogram-meter^2 (kg-m^2)
pound-mass/foot^3	1.601 846 x E +1	kilogram-meter^3 (kg/m^3)
rad (radiation dose absorbed)	1.000 000 x E -2	**Gray (Gy)
roentgen	2.579 760 x E -4	coulomb/kilogram (C/kg)
shake	1.000 000 x E -8	second (s)
slug	1.459 390 x E +1	kilogram (kg)
torr (mm Hg, 0^0 C)	1.333 22 x E -1	kilo pascal (kPa)

*The bacquerel (Bq) is the SI unit of radioactivity; 1 Bq = 1 event/s.
**The Gray (GY) is the SI unit of absorbed radiation.

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Research Program Tests for the U. S. Defense Special Weapons Agency (DSWA) for Breaching of Concrete Panels Set Against a Sandstone Rock Wall

1.0 INTRODUCTION

EMRTC was tasked by the Defense Special Weapons Agency (DSWA) to conduct a research program involving the breaching of concrete panels set against a sandstone rock wall. The program was completed in three phases: construction, training, and testing.

2.0 CONSTRUCTION PHASE

The tests panels, four total, were fabricated according to the drawings supplied by DSWA in the Statement of Work (SOW). Figures 1 and 2 show the reenforcement bar placement prior to the concrete placement. The sandstone wall behind the panels was shaped into a vertical face using rock drilling and blasting techniques.

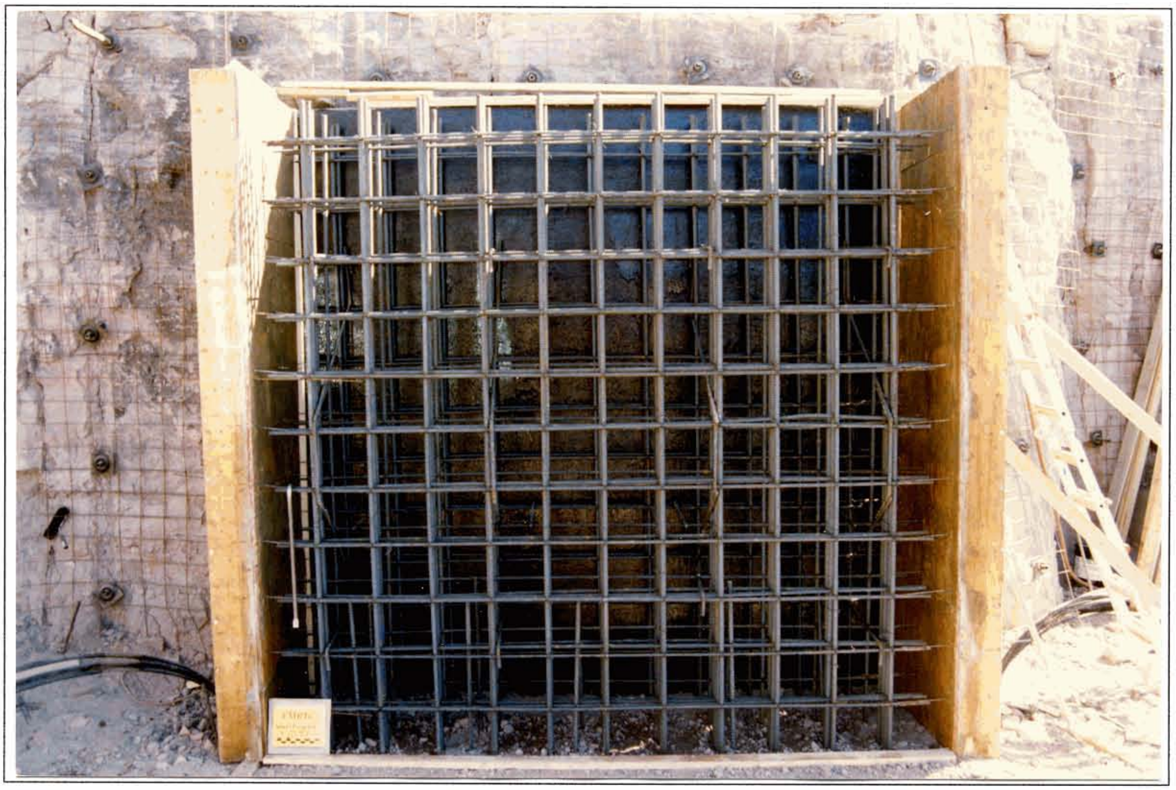

Figure 1. Reenforcement bar placement prior to concrete placement.

Figure 2. Reenforcement bar placement prior to concrete placement.

The first three panels were fabricated on footings, whereas the fourth wall was fabricated on the bedrock. The panels were fabricated using 5000 psi compressive strength concrete. The first three test panels were fabricated as one monolithic unit.

The fourth panel was fabricated in two vertical sections with the rear section being 10 inches thick from the sandstone wall. The joint between the two units was coated with roofing tar. The fourth panel included a steel whale beam at the top of the wall to anchor the wall to the sandstone wall using anchor bolts imbedded into the sandstone wall. The wall also used a load beam on the top of the wall to preload the wall with a simulated overburden stress prior to testing.

Accelerometers were installed in each panel according to guidance from onsite DSWA representatives. Stress gauges were installed on the fourth panel in order to determine the load being applied to the panel from the load beam.

3.0 TRAINING PHASE

The training phase involved contractor personnel using a remote operated articulating drilling machine mounted on a mobile tractor platform. The training involved the drilling of 2- and 4-

inch diameter holes into the concrete and the sandstone. The hole placement was determined by the onsite contractor personnel. The holes were drilled in a variety of configurations:

1) straight into the concrete face (perpendicular to the concrete face) of the panel into the sandstone wall behind the panel;
2) into the concrete through the side of the panel (parallel to the concrete face); and
3) into the sandstone from the side of the panel (parallel to the front concrete face). The Composition C4 explosive charges were packed and loaded into the holes by EMRTC personnel with guidance from the onsite DSWA personnel.

4.0 TESTING PHASE

4.1 Panel No. 1

The panel was drilled from the front face with four equally spaced 2-inch holes four feet above the bottom of the panel (Figures 3,4, and A). The explosive charges, composition C4 high explosives, were packed into thin wall acetate plastic tubing. Each charge was 2800 g with a loading density of 1.57 g/cc and was loaded into each hole in two pieces with a piece of PETN sheet explosive (C6 Detasheet) at the interface between the two pieces. A wooden dowel was used to stem each hole. A Nonel detonator was used to initiate each charge. A four-channel fire control system was used to initiate the Nonel detonators. Polyurethane foam was used on the side-wall of the panel closest to the last hole to be initiated in order to minimize the spall damage to the side of the panel. The front face and sides of the panel were photographed with high-speed cameras to document crack propagation through the panel.

The explosive charges were to be initiated 8 msec apart. The first two holes initiated at the correct times (0 and 8 msec), while the second two holes initiated at the same time of the second hole (8 msec). The accelerometer data was collected and turned over to DSWA personnel. Figures 5 through 7 show the resulting damage to the panel.

4.2 Panel No. 2

The sandstone wall behind the panel was drilled from the side with a single 4-inch hole parallel to the front concrete face (Figures 8 and B). The composition C4 explosive charge, 49.8 pounds with a loading density of 1.63 g/cc, was loaded into an acetate tube and stemmed with wood. Polyurethane foam was used on the side-wall and top of the panel to minimize the spall damage to the panel. The front face and sides of the panel were photographed with high-speed cameras to document crack propagation through the panel. Figures 9 through 11 show the resulting damage to the panel.

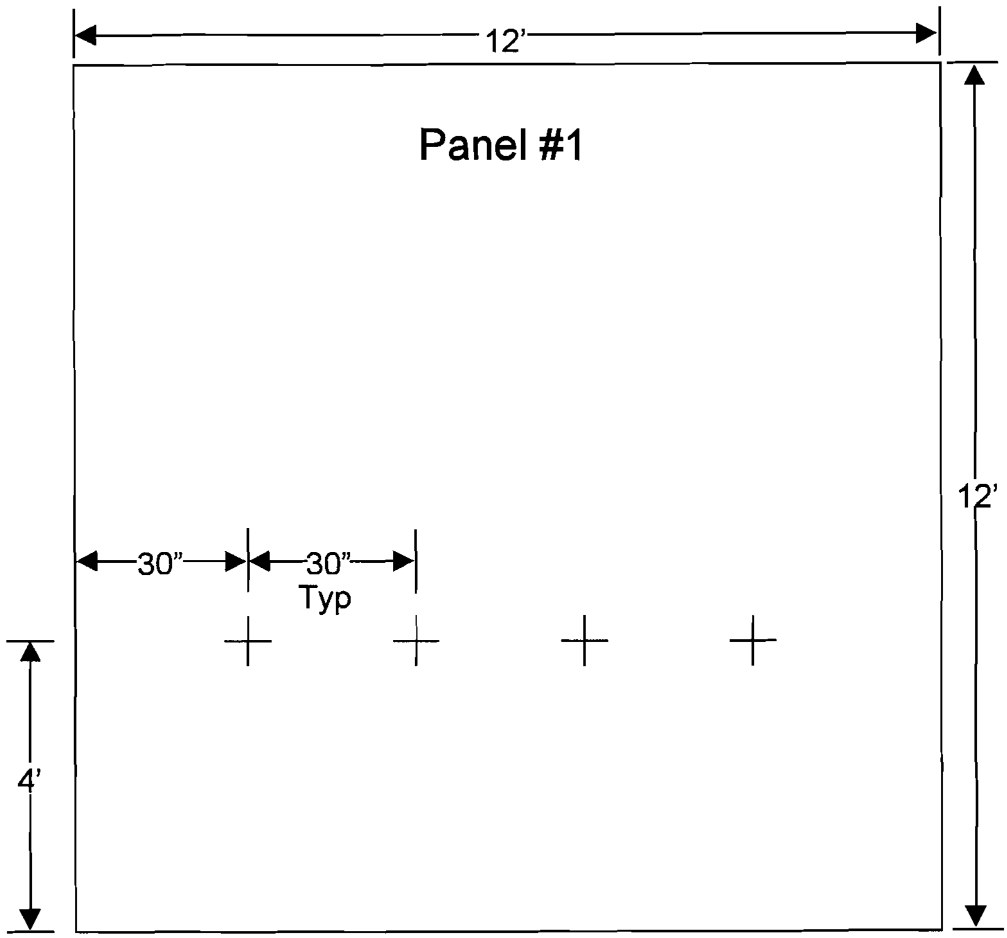

Figure A. Explosives placement, Test 1, perpendicular to front face.

Figure 3. Panel 1 explosive charge placement.

Figure 4. Panel 1 explosive charge placement.

Figure 5. Test 1, resulting damage to Panel 1.

Figure 6. Test 1, resulting damage to Panel 1.

Figure 7. Test 1, resulting damage to Panel 1.

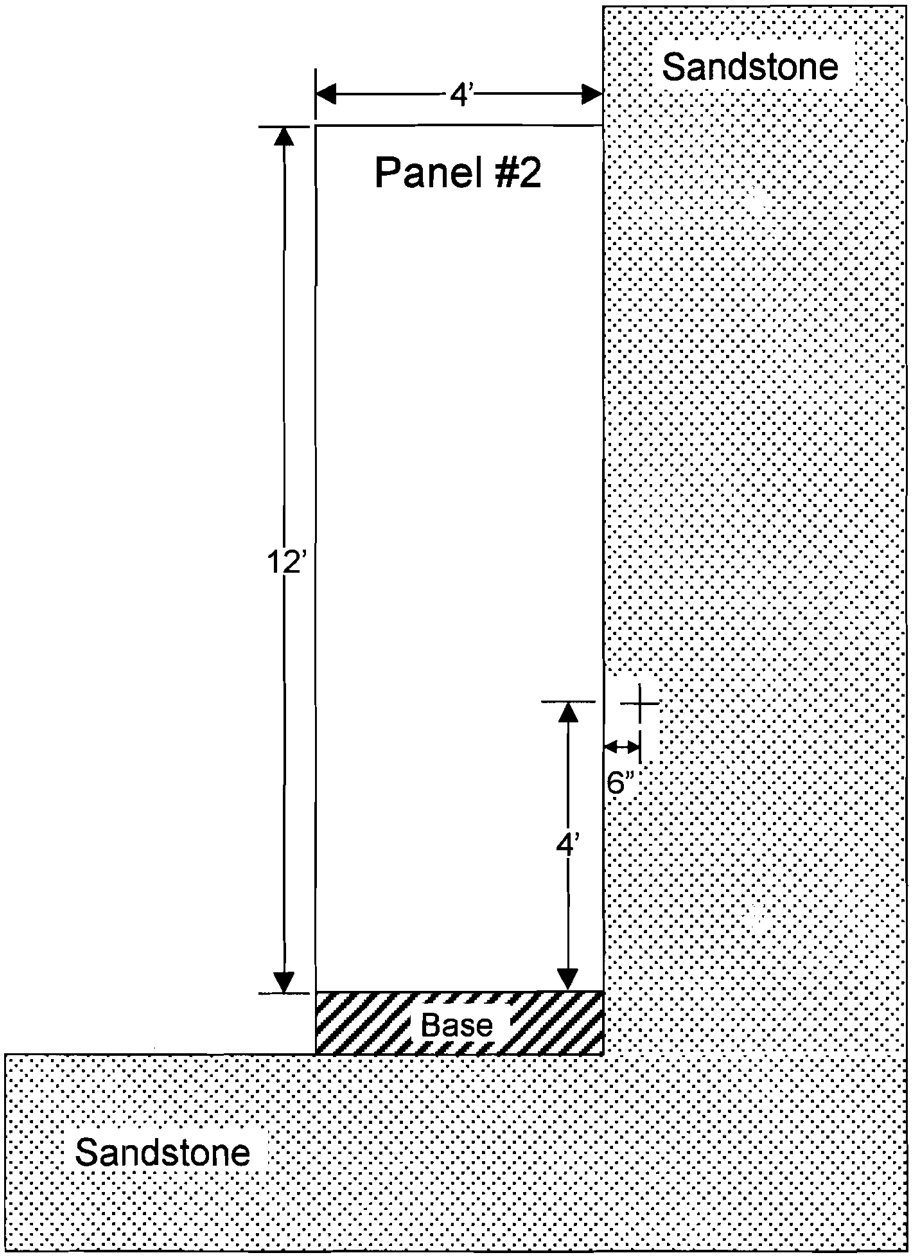

Figure B. Explosives placement, Test 2, parallel to front face.

Figure 8. Panel 2 charge placement (indicated by white bar on panel face).

Figure 9. Resulting damage to Panel 2.

Figure 10. Resulting damage to Panel 2.

Figure 11. Resulting damage to Panel 2.

4.3 Panel No. 3

The panel was drilled from the side (parallel to the front face) with a single two-inch hole two feet back from the front face of the panel and 4 feet above the bottom of the panel (Figures 12 and C). The composition C4 explosive charge was 20.33 pounds with a loading density of 1.59 g/cc. The hole was stemmed with wood. Polyurethane foam was used on the side-wall and top to minimize the spall damage to the side and top of the panel. The front face and sides of the panel were photographed with high-speed cameras to document crack propagation through the panel. Figures 13 and 14 show the resulting damage to the panel.

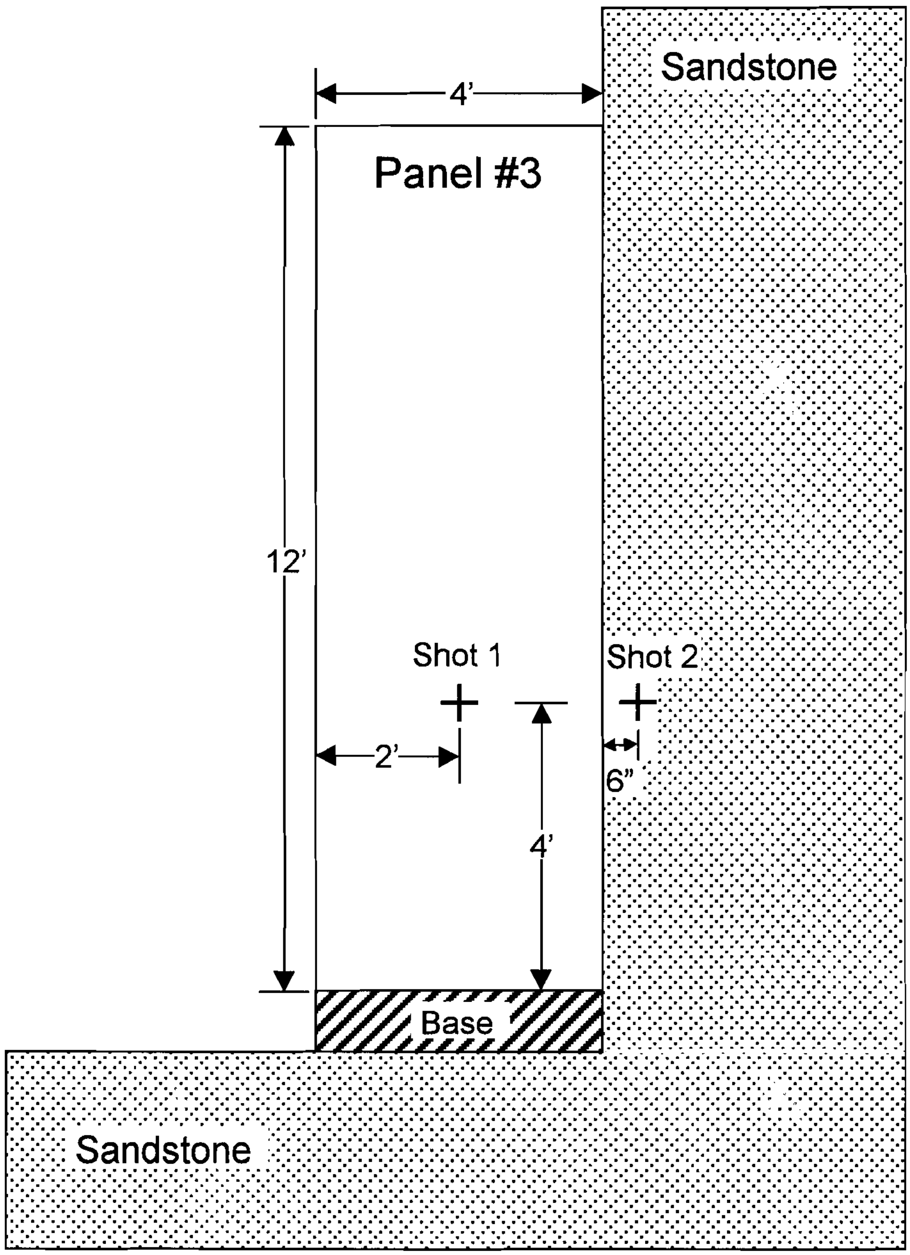

Figure C. Explosives placement for test 3. Shot 1 and shot 2 parallel to front face.

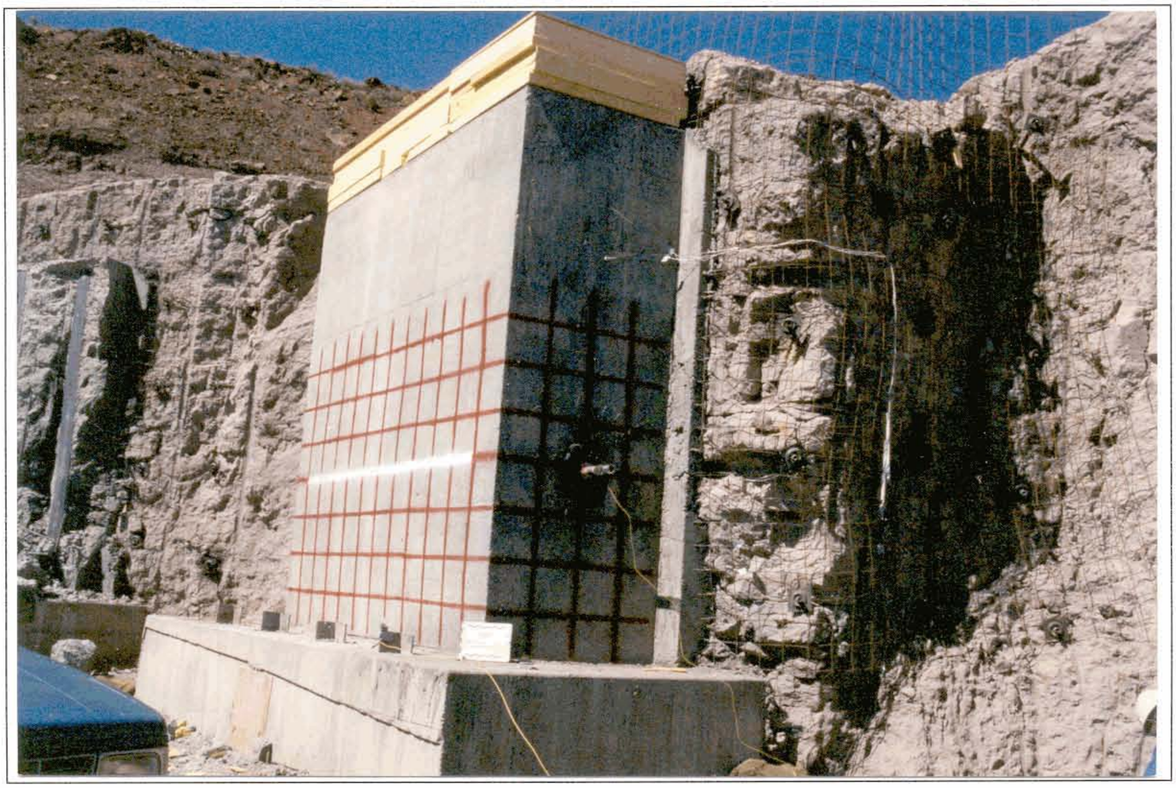

Figure 12. Test 3, Shot 1, Panel 3 charge placement.

Figure 13. Test 3, Shot 1, resulting damage to Panel 3.

Figure 14. Test 3, Shot 1, resulting damage to Panel 3.

A second test was performed on the panel. A single 4-inch hole was drilled into the sandstone wall parallel to the hole drilled into the panel. The composition C4 explosive charge was 76.2 pounds with a loading density of 1.59 g/cc. The hole was stemmed with wood. The front face and sides of the panel were photographed with high-speed cameras to document crack propagation through the panel. Figures 15 and 16 show the resulting damage to the panel and sandstone wall.

Figure 15. Test 3, Shot 2, resulting damage to Panel 3.

Figure 16. Test 3, Shot 2, resulting damage to Panel 3.

4.4 Panel No. 4

The panel was drilled with a 2-inch hole and the sandstone wall was drilled with a 4-inch hole in the same locations as the Panel No. 3 tests. The explosive charges were the same as those in the Panel No. 3 tests. The panel was pre-stressed to 70 psi using the load beam on the top of the panel (Figure 17). The charges were initiated with a 10-msec delay between the charge in the panel and the charge in the sandstone. The delay was obtained using 65.5 feet of shock tube on the sandstone charge. The holes were stemmed with wood. The front face and sides of the panel were photographed with high-speed cameras to document crack propagation through the panel. Figures 18 through 20 show the resulting damage to the panel.

Figure 17. Test 4, explosive charge placement.

Figure 18. Test 4, resulting damage to Panel 4.

Figure 19. Test 4, resulting damage to Panel 4.

Figure 20. Test 4, resulting damage to Panel 4.

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