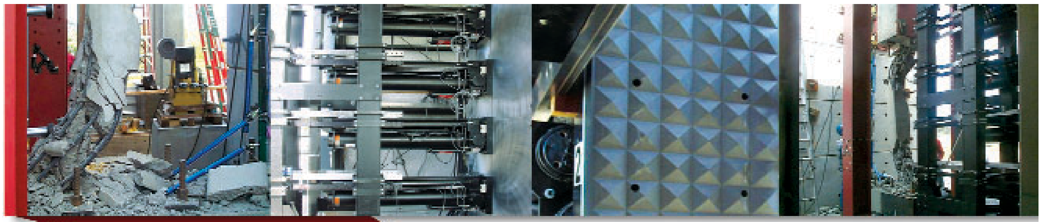
MTS BLAST SIMULATION SOLUTIONS



be certain.

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Lab-Based Blast Simulation

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Engineers worldwide turn to MTS for the testing solutions they need to effectively and efficiently determine the strength and durability of structural elements under dynamic loading conditions.

The latest in MTS civil structural testing technology and expertise is the UCSD Blast Simulator. Developed in close partnership with the University of California San Diego (UCSD), this system offers an economical and safe laboratory-based alternative to conventional field blast testing with explosives, delivering more reliable and repeatable test results.

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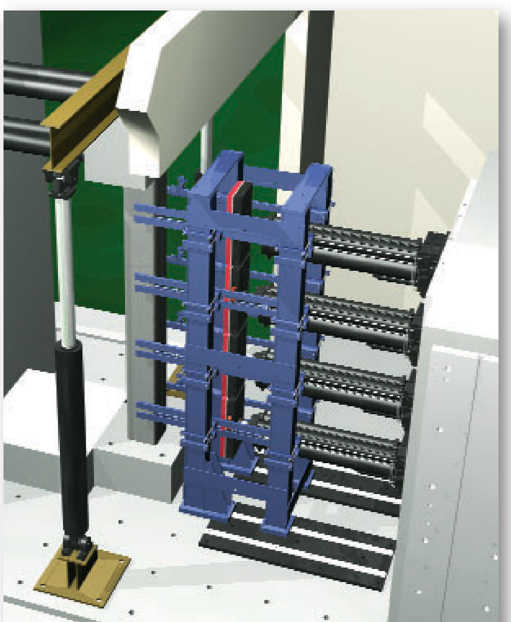
Laboratory-Based Blast Simulation



Developing and validating blast resistant design methodologies for structures requires high fidelity data that are repeatable and available in sufficient quantities. Obtaining such data through field testing with explosives, however, is limited by constraints on cost and time. Furthermore, reliable real-time data is very difficult to acquire under these conditions as the test blast renders visual and high speed video viewing of failure processes virtually impossible.

To improve the quality and affordability of blast experimentation, UCSD and MTS set out to build the world's first hydraulically driven system capable of simulating blast loads on structural components in a laboratory setting – without the use of explosives.

Completed in 2005 at UCSD, the system has been used to test reinforced concrete columns 355 mm square by 3 m high, and reinforced concrete block walls 200 mm thick by 3 m high. It uses impact loading to produce a 2 ms pulse with a typical peak pressure loading of 35 MPa and an impulse of 14 kPa-s over the surface of the specimen. By delivering such energy to the specimen without the ensuing fireball typical of field blast tests, the system better facilitates the gathering of data via direct observation, high speed video and instrumentation of the specimen.

Figure 1 illustrates how simulation post-test data correlates with field post-test data, demonstrating how accurately the laboratory-based system simulates live explosive loads.

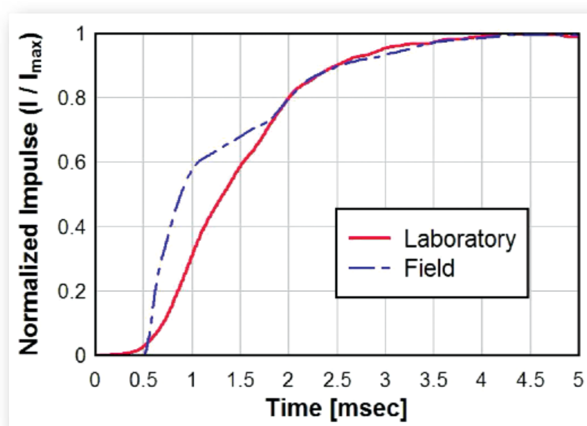
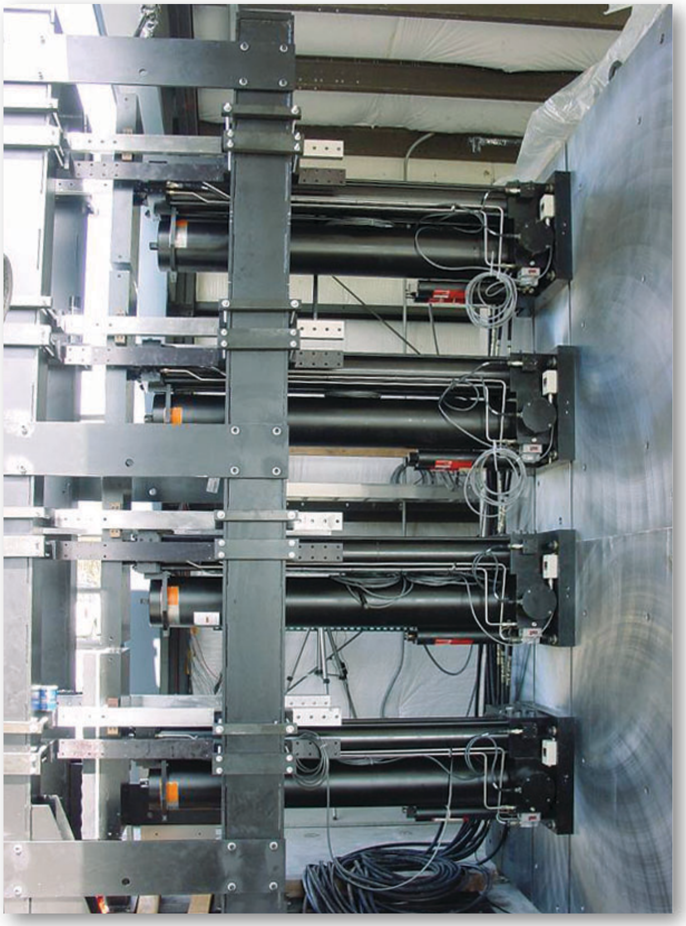


Figure 1

High Force Blast Generators



To develop the energy required for effective blast simulation the system employs high-force Blast Generators (BGs). Comprising a hydraulic actuator, control valves, accumulators and transducers, each BG can accelerate an impacting mass to 30 m/s (1200 in/s) within a stroke of about 1 m (40 in).

A BG's actuator can produce a maximum force of about 250 kN (56000 lbf) to accelerate the impacting mass. A close-coupled, pressure-line accumulator provides the fast flow response required to supply the energy needed to accelerate the impacting mass to a velocity of 40 m/s. A close-coupled, return line accumulator accommodates the flow from the retract valve.

The two high-flow valves are servo controlled, using LVDT feedback on the valve position. During setup they are operated together to provide position control for the actuator. Pressure transducers provide readings of all actuator pressures to facilitate precise setup and measurement of actuator forces during impact. A differential stroke transducer is used to position the actuator precisely during setup and will output an accurate measurement of the impact velocity.

Figure 2 shows how the simultaneity of impacts among four BGs can be achieved in a range of 0.3 ms to 2 ms depending on test settings and conditions.

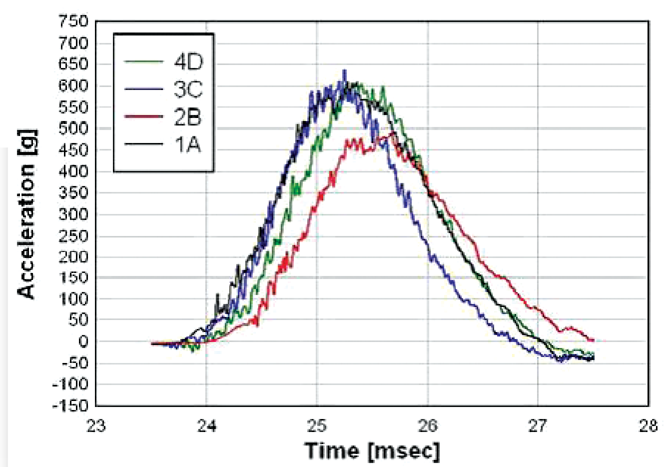
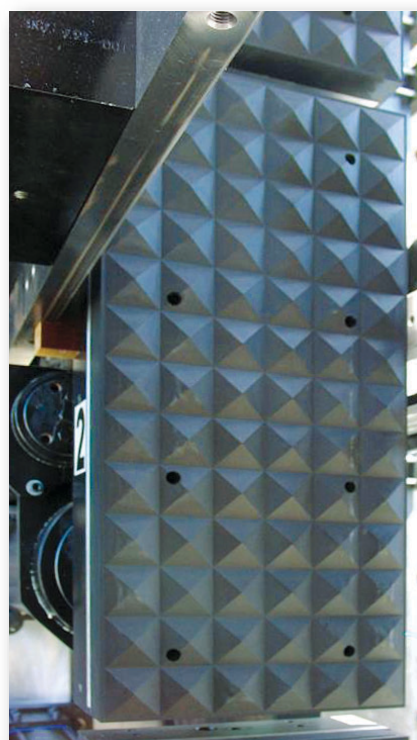


Figure 2

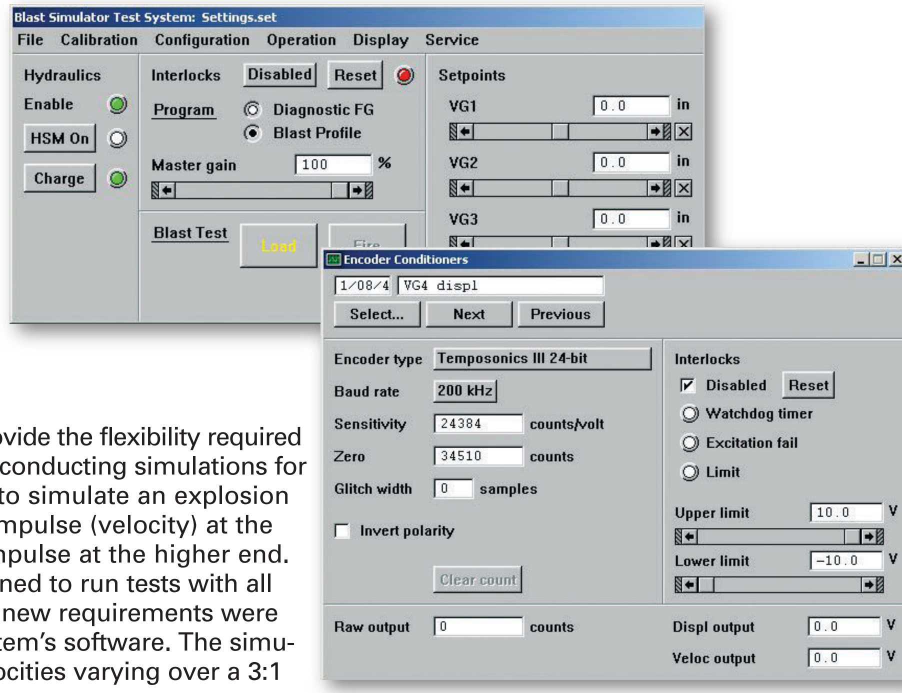
Impact Mass & Elastomer Spring



The impacting mass used to deliver energy to the specimen consists of a steel plate with an elastomer spring. The impacting face of the elastomer spring is contoured to provide an initially low contact spring rate that progressively increases. This contouring reduces excitation of high frequency vibrations in the impacting mass and the specimen.

Real-time Control System & Software

A computer based control system determines BG positions during test setup. During the simulation, it provides the valve commands to generate the desired impact velocity and timing on the four BGs. After the simulation, it retracts the BGs and returns them to a safe state. For each simulation, a computer model of the BG is used to determine the setup values for oil and nitrogen pressures, initial position, and valve command profile to achieve the required impact velocity.



The control system software is designed to provide the flexibility required to adapt to changing test requirements. After conducting simulations for several months, UCSD researchers decided to simulate an explosion close to a column specimen with a greater impulse (velocity) at the lower end of the specimen and a reduced impulse at the higher end. Even though the simulator was initially designed to run tests with all actuators impacting at the same velocity, the new requirements were easily met through minor changes to the system's software. The simulator is now able to run tests with impact velocities varying over a 3:1 range while still maintaining simultaneous impact.

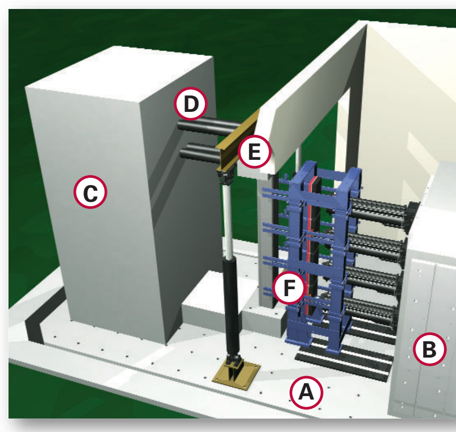
Instrumentation & Data Acquisition

Control and setup transducers include three pressure transducers on each BG, LVDT stroke transducers on the control valves, and a Tempsonics® stroke transducer used to control actuator position and measure velocity at impact. Accelerometers mounted on the impacting mass record impact data for calculating force and impulse. Output from all BG control system transducers is digitally recorded at 4 kHz for each test; accelerometer output is recorded at 800 kHz.

The specimen instrumentation system features a variety of transducers that can vary to suit test requirements; these include accelerometers, stroke transducers and strain gages. High speed data acquisition, triggered by the control system, can record 52 channels of 14-bit data at 1 MHz. This system can also record data from any of the control transducers if necessary.

Two Phantom version 7.1 high speed video cameras, capturing 5000 frames per second, are used to capture specimen failure and also provide velocity and deflection measurements of the specimen.

Configurable Foundation and Frame



The blast simulator's foundation is adaptable by design to accommodate a wide variety of test specimens. It consists of an isolated test floor (A) supporting both fixed and moveable reinforced concrete reaction walls.

The fixed reaction wall (B) features a steel plate for mounting the BGs. For tests to date, the BGs have been mounted in vertical columns, utilizing t-slots in the reaction wall to provide adjustment. The mounting plate allows other BG mounting locations as required.

The moveable reaction wall (C) is constructed of large reinforced concrete blocks that are stacked and post-tensioned to the foundation. It is designed to be configurable and features an adjustable link (D) for supporting the upper end of specimens. Fixtures (E) have been built to simulate end conditions on specimens that match those in actual structures.

Guide rails are employed to support the weight of impacting masses and keep them aligned with the specimen. The guide rails are attached to an adjustable guide frame (F) that allows the reconfiguration of spacing between BGs. The guide frame is also adjustable to accommodate several sizes of impacting masses.

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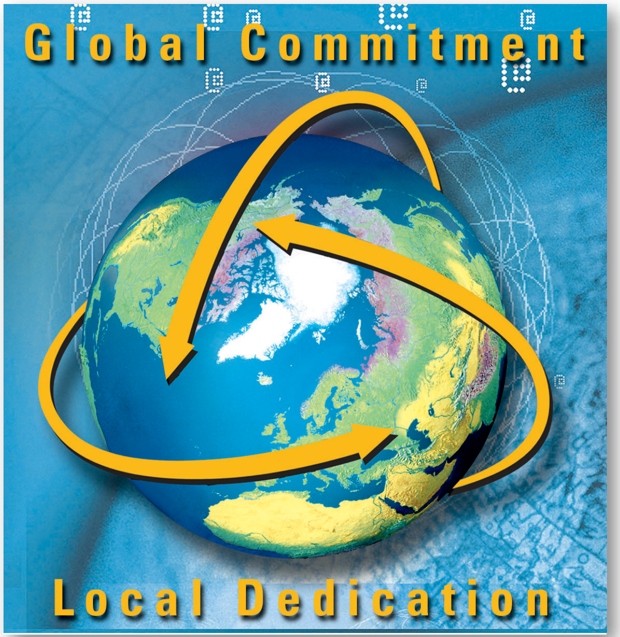

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