A System for Multi-axial Subassemblage Testing (MAST): Design Concepts and Capabilities


MAST Laboratory, Department of Civil Engineering
University of Minnesota, Minneapolis, Minnesota

Sponsors: National Science Foundation
University of Minnesota

Seventh U.S. National Conference on Earthquake Engineering
July 22, 2002
MAST – Basic Specifications

- Lat. (Long.) Force: ± 880 kips (± 3900 kN) in two actuators
- Lat. (Long.) Disp: ± 16 in. (± 406 mm)
- Vertical Force: ± 1,320 kips (± 5,900 kN) in four actuators
- Vertical Disp: ± 20 in. (± 508 mm)
- Ancillary Actuators: 4 with ± 220 kips (± 980 kN) and ± 16 in. (± 440 mm) each
- Specimen Lat. (Long.) Clearance: 20 ft (6.1 m)
- Specimen Vertical Clearance: 16-25 ft (7.6 m)
Features of MAST

- MAST enables multi-axial cyclic quasi-static or pseudo-dynamic tests of large-scale structural subassemblages including portions of beam-column frame systems, walls, and bridge piers.
- MAST employs sophisticated six-degree-of-freedom control to apply deformations and loading.
- All DOFs, including four ancillary actuators, are controlled with high precision coordinated motion in three-dimensions, each achieving their end-of-ramp value simultaneously (i.e., clover-leaf 3D patterns are not required).
- Permits control of a plane in space rather than a point in space.
Sample of MAST Control
Features of MAST

• Any of the six DOFs may be programmed in stroke- or load-control

• Any DOF may be a linear function of the other DOFs

• Mode switching may be done during a hold

• Load resolution: ± 0.2 kips (0.9 kN)

• Hydraulic lock-up circuits to protect the specimen
Wall Subassemblage  Beam-to-Column Connection Subassemblage

Mixed-mode control can be used to impose desired M:V ratio at boundaries.

2D or 3D Frame Subassemblages

*Illustrates potential applications for ancillary actuators
MAST Laboratory Strong Floor

- 7-ft (2.1-m) thick solid concrete slab on piles with 5-in. (127-mm) thick steel plates forming the tie-down surface

- Regular grid of holes at 18 in. (457 mm) c/c
  - Each hole has a capacity of approximately 125 kips tension or compression plus shear through friction

- Post-tensioned to minimize deflection
  - Maximum vertical deflection limited to ± 0.1 in. (± 3 mm)
MAST Laboratory Strong Wall

• L-shaped plan, post-tensioned horizontally and vertically
• Each leg is 35 ft (10.7 m) tall and wide, and 7 ft (2.1 m) thick
• Regular grid of thru-holes at 18 in. (457 mm) c/c
• Capacities at the base of the wall are
  – Out-of-plane (horizontal) shear: 1760 kips (7800 kN)
  – Out-of-plane moment: 43,600 kip-ft (59,100 kN-m)
  – Vertical torsion: 38,000 kip-ft (52,600 kN-m)
• Maximum horizontal deflection limited to ± 0.5 in. (± 12 mm)
MAST Laboratory: Telepresence Equipment Layout

• On Laboratory Floor:
  • Sensors and transducers
  • Eight or more video cameras with audio
  • Eight still image cameras (including wireless)

• In Control Room:
  • MTS controller
  • All servers and monitors
  • VTC equipment

• At Remote Sites:
  • NEES Client machine:
    • Teleobservation / teleoperation
MAST Data Collection and Telepresence Infrastructure
Model-Based Simulation and a Common Framework for Control, Archiving, Replay, and Simulation

Example for structural tests—geometric framework
- Graphically associate dimensions, instrument locations, (metadata file) with structure
- Use as framework for computational model or simulation
- “Click on framework” to guide control of teleobservation equipment, to display sensor data, etc.
**MAST Laboratory Conclusions**

- MAST Laboratory is a national facility funded as part of the NEES initiative.
- The MAST System provides large-scale three-dimensional cyclic quasi-static or pseudo-dynamic testing with six-DOF control.
- Complex combinations of stroke- and load-control are feasible.
- Ancillary actuators can be used to simulate gravity loads or additional boundary conditions.
- Telepresence system will permit remote observation and limited control of experiment and simulations.
- Integration of experimental testing with computational simulation and model-based simulation will continue to be developed.
- The NEES Collaboratory will be operational in October 2004.

For more info: [http://www.ce.umn.edu/mast](http://www.ce.umn.edu/mast)