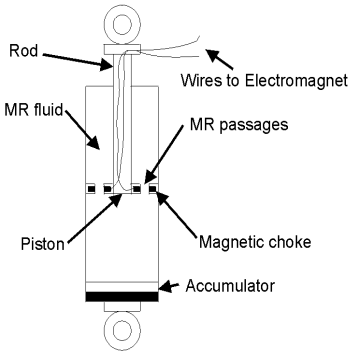
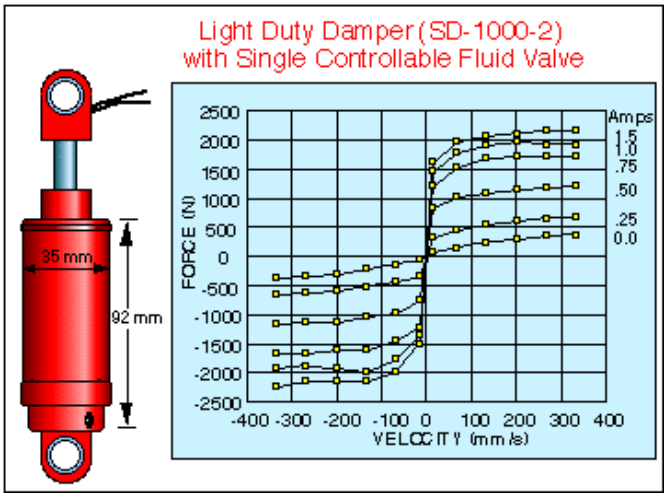
MR Fluid Damper

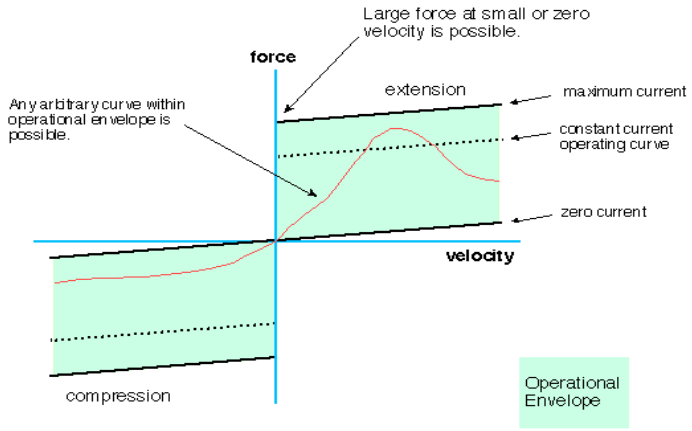
- MR passage
  - Flow rate controlled by magnetic choke
- Accumulator
  - Bladder with nitrogen pressurized at 300 psi
  - Account for volume of fluid displaced by piston





MR Fluid Damper

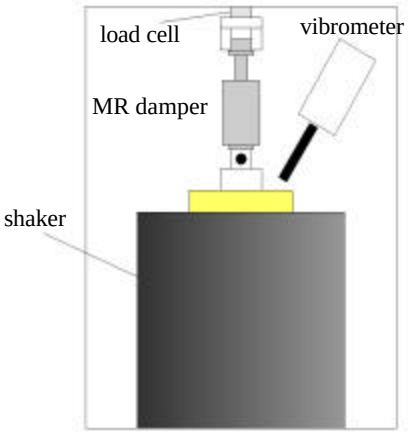
Force versus Velocity Envelope for MR Fluid Damper



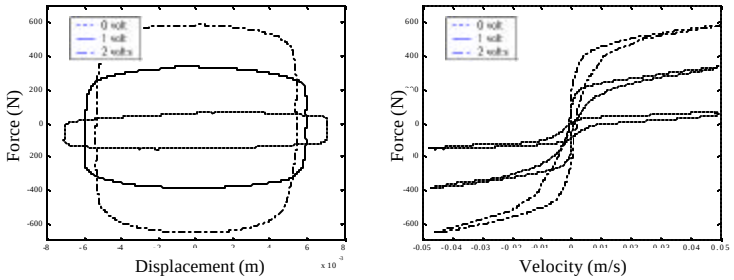
Damper may be controlled to produce a force that is any arbitrary function of displacement, velocity or acceleration.

Experimental Setup

- Obtain MR damper characteristics
- Shaker: produce excitation
- Load cell: measure damping force
- Laser vibrometer: measure displacement and velocity

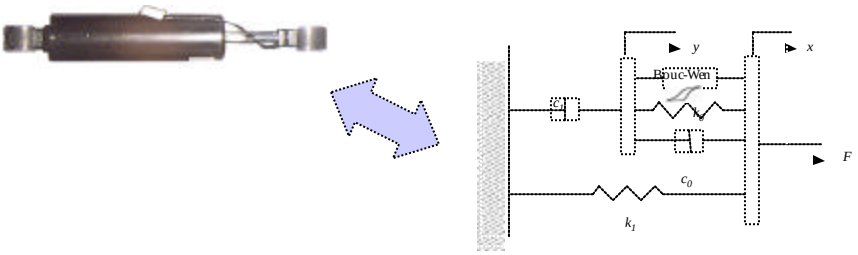


MR Damper Characteristics



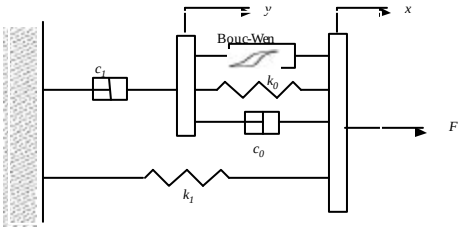
- Force vs. velocity & displacement for different voltages
- Offset in the damping force due to the accumulator
- Hysteretic looping

MR Damper Model



- Relation between force and other parameters (displacement, velocity, voltage input)
- Bouc-Wen model: hysteretic modeling

MR Damper Model



$$F = c_1\dot{y} + k_1(x - x_0)$$

$$c_1\dot{y} = az + k_0(x - y) + c_0(\dot{x} - \dot{y})$$

Bouc-Wen model:

$$\dot{z} = -g\left|\dot{x} - \dot{y}\right|\left|z\right|^{n-1} z - m(\dot{x} - \dot{y})\left|z\right|^n + A(\dot{x} - \dot{y})$$

$$a = a(u) = a_a + a_b u$$
$$c_1 = c_1(u) = c_{1a} + c_{1b} u$$
$$c_0 = c_0(u) = c_{0a} + c_{0b} u$$

Rheological equilibrium

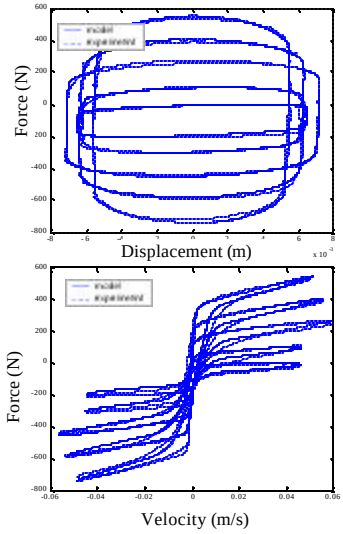
$$\dot{u} = -h(u - v)$$

Model Parameters

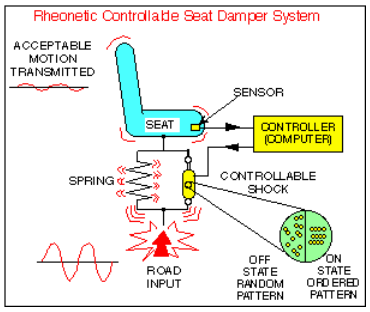
- Minimizing the error

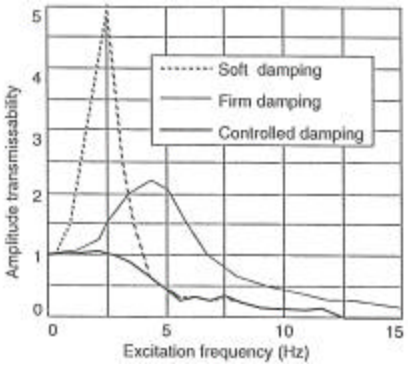
$$J = \sum \left(f_{\text{experiment}} - f_{\text{model}}\right)^2$$

- Accurately predicts the behavior of the damper



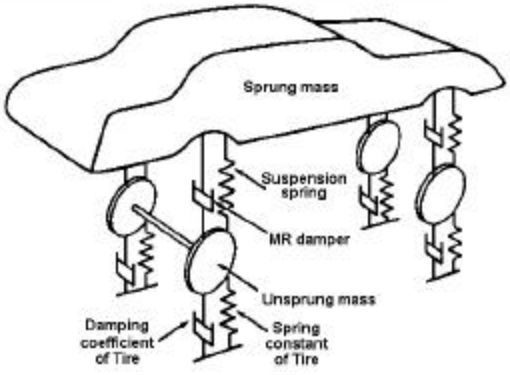
MR Suspended Seat

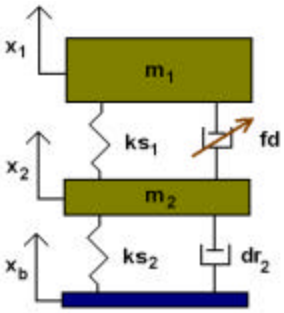


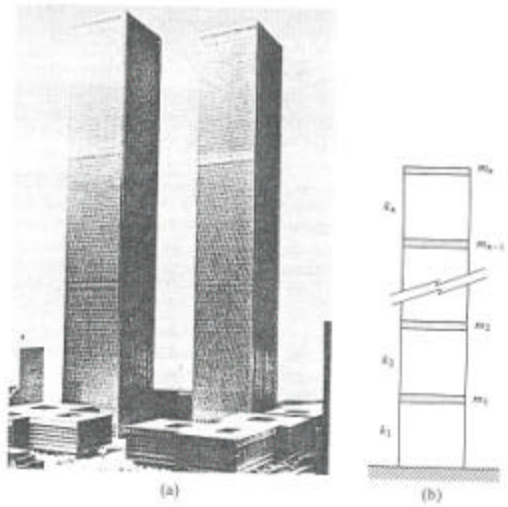


Performance for an MR semi -active controlled suspended seat

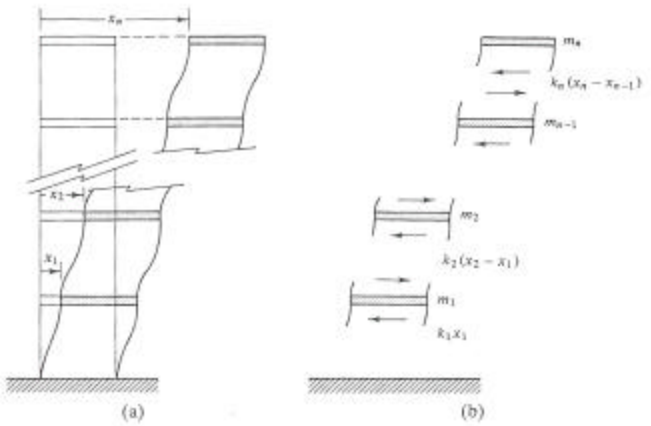
Car Suspension System



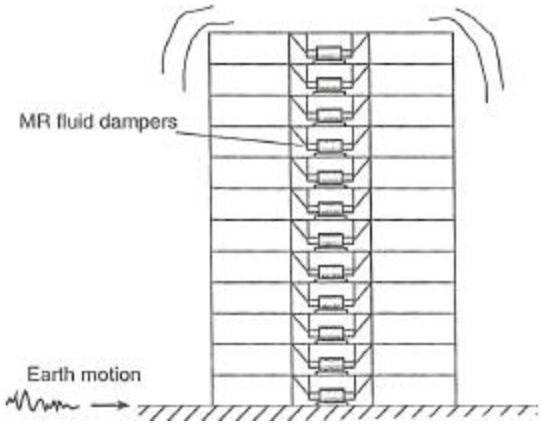




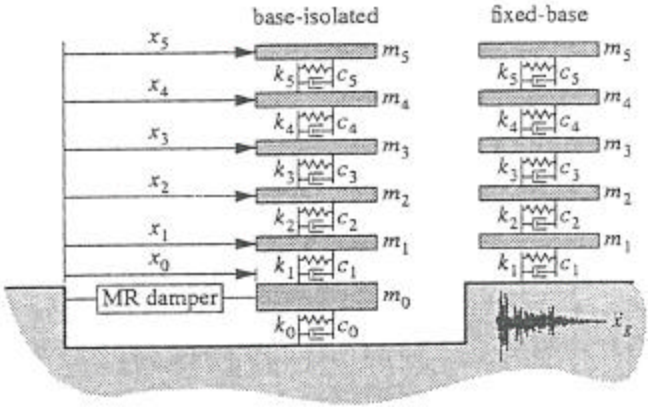
(a) Twin buildings of New York World Trade Center
(b) Model of a multistory building



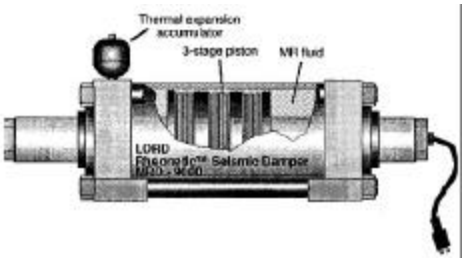
Free-body diagram for multistory building dynamics



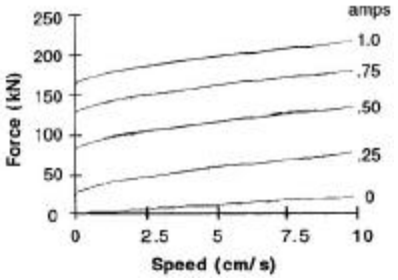
Distributed array of MR dampers as part of a civil engineering structure. Seismic motion causes one floor to shear relative to next floor



Linear, lumped-parameter model of the structure

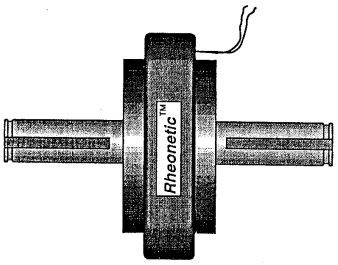


Schematic of MR fluid seismic damper

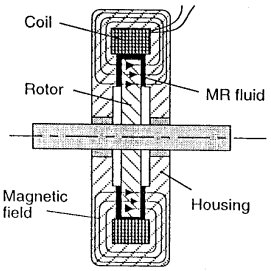


Performance for 20-ton MR damper

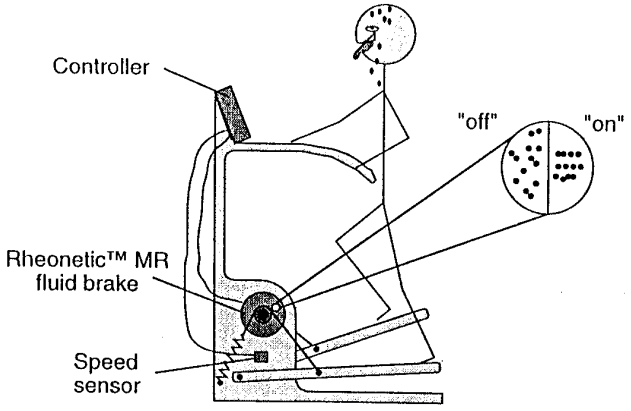
Completed 20-ton MR fluid damper



Commercial MR fluid rotary brake



Schematic of MR fluid rotary brake



Exercise machine with MR brake