Added Damping For Tall Buildings & Structures

Services:

Building Acoustics

Wind and Snow Loading

Environmental Noise

Air Quality Studies

Structural Wind Loading

Wind Tunnel Testing

Cladding Pressures

Long Span Roofs

Control of Mechanical Vibrations

Computational Fluid Dynamics

Microclimate Engineering

Design of Mass Dampers

Telephone:
(613) 836-0934

Facsimile:
(613) 836-8183

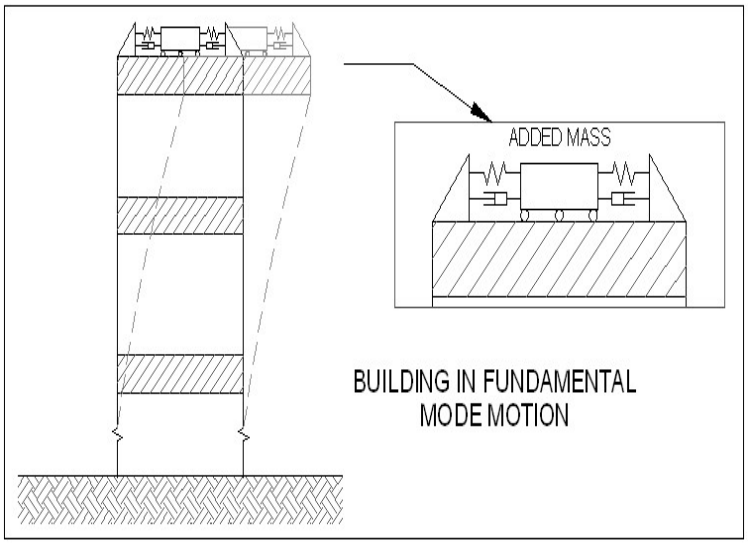
GmE is involved in the design of mass damping devices for tall buildings.

Added damping involves the addition of mass in solid or liquid form to the top of a building which counteracts the mass of the building as it moves back and forth under the influence of wind. The building and the added mass are treated as a two-degree-of-freedom system where the added mass, and its own internal damping, is tuned to counteract and reduce the building motion. The key elements of a damping system include: a mass block (liquid or solid), internal damping, and tuneable springs (mechanical, hydraulic or pneumatic). The most effective place to add the mass is at the top of the building. Placing it further down along the height reduces its effectiveness as the square of the ratio of mass height to building height. The figure below illustrates the two-degree-of-freedom system to represent a tall building with a mass damping device.

The building's fundamental modes in each principal direction are reduced to a single-degree-of-freedom system by converting the mass to generalized mass, and the stiffness to the generalized stiffness, so that the natural frequency of the building and the single-degree-of-freedom system are both represented by

$$f \equiv {}^{1}\!/_{(2\pi)}\sqrt{\frac{K*}{M*}}$$

where M* is the generalized mass (= mass per floor x mode shape squared), and K* is the generalized stiffness.



Added damping is often used on slender structures including bridge deck and towers

Types of Mass Damping

(i) Liquid Sloshing Damper

LSD generally use water in a container with internal baffles to generate the damping forces from building motion. The design parameters are the dimensions of the vessel, the depth of water and the obstructions placed within the water to generate friction. The frequency of the damper is tuned to that of the building by selecting the appropriate dimensions and water height. The mass of the water is controlled also by the dimensions of the vessel and depth.

(ii) Liquid Column Damper

The LCD also uses water contained in a 'U' tube column with one or more orifices along the horizontal length of the tube. The frequency of the column is tuned to that of the building by controlling the cross sectional area of the column and the height of the tube. Internal damping is obtained by sizing the orifices.

(iii) Pendulum Damper, Active & Semi-Active Devices

A pendulum damper is a form of mass damper which can be oriented with a solid mass hanging in a pendulum mode. The frequency of the damper is controlled by selected the length of the pendulum. The mass of the pendulum is focused at the end of the pendulum as is selected as a small fraction of the building (usually 1 to 4%). Internal damping of the pendulum is obtained from hydraulic or pneumatic pistons fixed between the moving mass and the structure. The pendulum damper cables are usually 3 m to 12 m in length to provide typical frequencies of tall buildings.

AMD and SMD are similar to the pendulum type except that the mass slides horizontally on a bed of oil or low friction material. The mass is selected in the same way as for other dampers, as a calculated small fraction of the building mass, whereas the frequency is controlled by computer using pneumatic or hydraulic actuators. Damping is also obtained by means of pistons attached between the mass and the building. The difference between active and semi-active devices depends on whether the system has feedback control from sensors placed around the building to sense the motion independently of the damper itself. In both cases, a computer tunes the frequency of the mass to that of the building. While these devices provide the best performance for the least floor space, they are also the most expensive with respect to both initial and operating costs. They also have the greatest down time for maintenance and repair.