SUPPLEMENTARY DAMPING SYSTEMS

Improving occupant comfort by enhancing a structure's dynamic response to externally induced motion

When a structure is subjected to external forces—wind, pedestrian movement or seismic activity, for example—it vibrates or sways. In tall buildings and on large bridges, such movement can make people uncomfortable. In other structures, it can hasten material fatigue or other failures.

There are ways to reduce this motion. For example, designers can add stiffness, add mass or change the shape of the structure. Unfortunately, such methods of reducing vibration are costly and may not work as well as needed.

An alternative method is to install a supplementary damping system. This device adds mass, as in a traditional solution—but here the mass moves. This movement is passive, requiring no electricity or computer system to control it. The device simply responds to the structure's movement according to basic physical principles and helps reduce it. Thus the moving mass supplements the damping already inherent in the structure.

A properly designed damping system can easily double or triple the inherent damping capacity of a traditionally designed structure. The result is far superior response.

Supplemental damping is usually less expensive and less restrictive than other solutions. Sometimes this strategy even makes an otherwise impossible structure possible.

Our service

We work in partnership with the entire project team—from lead architect to structural engineer to general contractor to crane operator—to provide practical, functional and reliable control of structural motion. The architect defines the shape; the structural engineer determines how to make that shape stable; we enhance the structure's ability to dissipate the energy absorbed from the external conditions it will experience; the general contractor makes it real.

SUPPLEMENTARY DAMPING SYSTEMS

This approach has a lot in common with designing an engineered suspension for automobiles. Our goal is to smooth out the bumps without changing the look.

Our solution will be unique to your design, local conditions, budget and construction schedule. We understand the priorities and pressures of every stage in the process, and we have consistently met them for more than 20 years.

We combine three evaluations—external energy source, building response and damper dynamics—into one coherent (though complex) analysis. These analyses draw on our decades of experience worldwide with weather data and wind forces, seismic forces or pedestrian-induced loads, as the application requires. We use the resulting computational models to demonstrate structural performance both with and without various damping systems.

There are many options to consider. We have an in-house design for placing a large damping mass in a small space, especially in very tall, thin buildings. But if that solution isn't right for your project, we'll use another strategy. And our design process ensures that the device will fit in the designated space without incident. For every project there is an ideal solution that meets all requirements; we find it.

Before fabrication starts, we demonstrate how the device will perform, in detail. And we participate in its fabrication, installation, testing and commissioning, so you can be assured that the final system will perform as specified.

We have designed 59 mass damping systems that are installed or in progress in 15 countries. They are found in towers, bridges, air traffic control towers, architectural features and other tall structures, including bridge supports, an oil rig, a pinnacle and a spire.

RWDI is a valuable partner to clients seeking to...

Explore Innovations

- Push structural boundaries for height or flexibility while keeping occupants comfortable

Create Opportunities

- Optimize the profitable space in a "lively" structure by choosing a compact damping design
- Optimize use of structural mass, eliminating unnecessary material and construction costs

Meet Challenges

- Manage motion (even post-construction) with a customizable, cost-effective solution based on proven designs
- Fit a damping solution into a challenging space

Fulfill Expectations

- Satisfy expectations for budget, schedule and performance simultaneously, with a damping solution that takes fabrication and installation costs and concerns into account

SUPPLEMENTARY DAMPING SYSTEMS

How we work

Contractual Arrangements

We can work in various roles within a project. For example, we might work under contract with the developer as designer and owner's representative. In other cases, we might be a member of the design-build team along with the fabricator and installer, reporting to the general contractor.

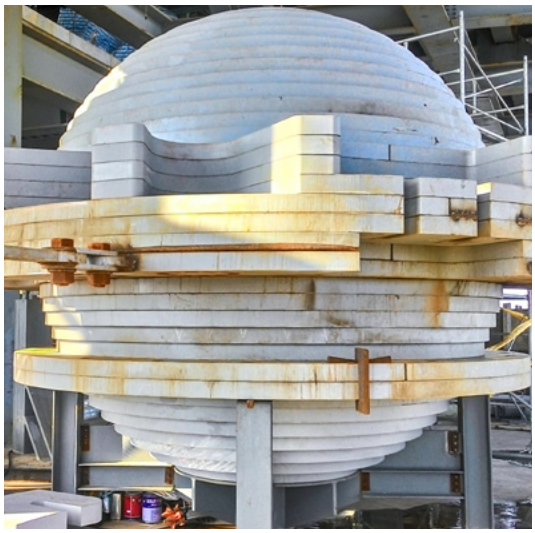
Design Process

A supplementary damping system is, in effect, a very large machine designed to perform to demanding specifications. It is also designed to withstand ultimate events and a large number of dynamic load cycles. Thus, our design process is extremely rigorous. However, it is structured so that even complex designs can be installed on schedule and within budget.

Implementation assessment (IA)

This assessment is analogous to a concept design and is completed relatively early in the design process. At this stage we determine the most appropriate system for your application.

The implementation assessment begins with the external loads—typically from wind—and the building's response. For wind loads, our exceptionally experienced meteorologists determine the nature and frequency of expected wind conditions (the "wind climate"), using a statistical analysis customized to your site. Starting from those conditions, our wind engineering team uses wind tunnel tests of



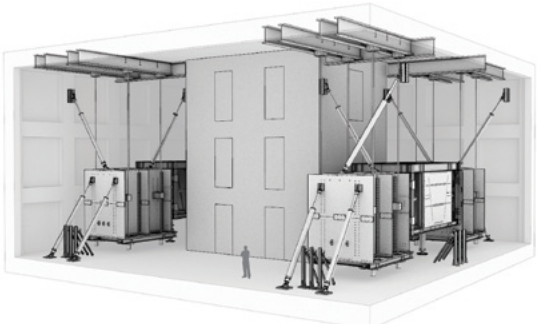
How we work

physical models (and computational models, if needed) to find the loads those winds will place on the structure. In these studies we use proprietary time-domain techniques to obtain highly specific results. For pedestrian or seismic loads, our scientists model likely scenarios and responses.

Once the expected conditions are determined, we propose a damping system to respond to them and tell you how much mass and space it will require. (We work with several supplemental damping strategies; for convenience here, the system is simply called a damping device.) Throughout this activity we will dialog with the client, structural engineer and architect to understand the constraints and needs around space.

Performance analysis

Here we develop the concept further and run a series of dynamic analyses on the overall damping device. We determine three things in much greater detail: the amount of relative movement of the damper within the available room (to identify any interferences in the space), the forces imparted to the structure and the overall performance of the entire building¬–damping system. In this step we also consider how various larger components of the damping device fit together. We look at constraints of the site, the size of room and so on; this analysis has a strong basis in experience from past projects. In addition, we begin specifying components that have a long lead time, so they will be ready for the build schedule.

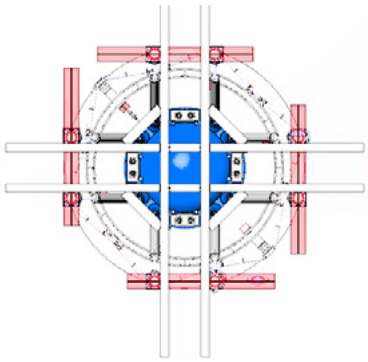


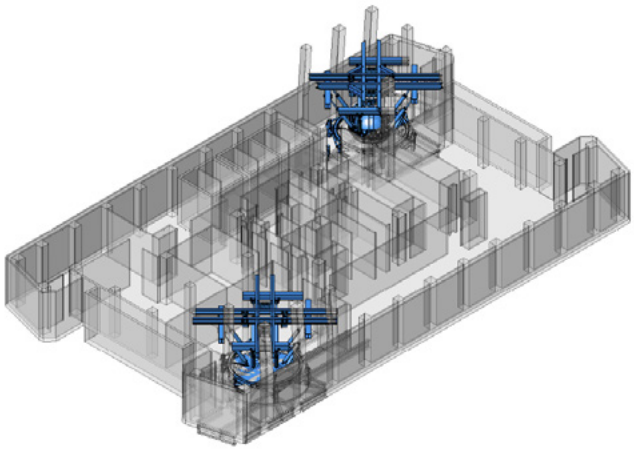
In the performance analysis, we make sure the device can handle everything that might be asked of it. The deliverable here is a specification of all the loads that the structure and the damping device itself will experience for the predicted conditions.

Detailed design

When designing a damping device, we next carry out the detailed design of device components, subject them to the loads determined in the performance analysis and produce fabrication drawings of the design. The detailed design step is critical and very complex because the damping device is in essence a large machine. This phase includes designing components, welds and bolted connections, as well as conducting stress analyses. Also, we anticipate and design to avoid possible issues with fabrication and installation. Construction concerns, such as crane capacity and transportation limitations, are integral to the design. By analogy, the detailed design step includes both the engineering design intent (as would traditionally be determined by the structural engineer) and the myriad small details traditionally handled by the detailer, such as all bolted and welded connection details.

SUPPLEMENTARY DAMPING SYSTEMS





How we work

Tender assist

Members of our design team are available during the selection of components and fabricators. They may review bids and participate in supplier interviews to ensure that bids are consistent with the requirements of the project.

Fabrication and acceptance testing review

We visit fabricator facilities periodically during fabrication and also review factory acceptance testing reports; these steps ensure conformance to the specifications for the damping device.

Frequency measurements

We measure building frequencies when the superstructure is approximately 90% complete. We use these results to compare as-built building properties to the predicted frequencies and tuning range we used to design the damping device.

Installation review

We review the installer's installation procedure, visit the build site periodically and make ourselves available for build-related queries.

Tuning and commissioning

We measure the frequencies of the completed building; then the installer makes adjustments under our on-site supervision. Working with the installer, we perform a series of tests to demonstrate the performance of the device. Finally, we deliver training and a manual to building maintenance staff.