ISOLATED PROBLEM

A new research center at Missouri's Botanical Garden in St. Louis utilizes base isolation for earthquake protection

The design utilized 41 base isolators to help reduce the building's seismic period from 0.05 to 3 seconds.

THE MISSOURI BOTANICAL GARDEN'S HERBARIUM/RESEARCH CENTER houses the Garden's world-renowned library and about half of its priceless herbarium collection of nearly five million plant specimens. It provides office space for research botanists and associates, graduate students, and the hundreds of visiting scientists from the United States and abroad who do research at the Garden each year.

The unique collections of the Missouri Botanical Garden's Research Center resulted in establishment of the primary objective: creation of a secure repository which would permit as little damage as possible to the dried plant specimens and rare books under a wide range of reasonably anticipated conditions, including earthquakes.

The challenge of David Mason & Associates was to create a design to isolate the building from earthquake induced ground movement and to provide superior protection for the Research Center and its contents during an earthquake. The design was required to reduce seismic damage to the building, to minimize disruption caused by an earthquake, and ensure the preservation of the irreplaceable plant and library collections.

Until the late 1980s, St. Louis building codes included little, if any, recognition of earthquake hazards, despite the presence of the nearby New Madrid fault, source of largest recorded earthquake in North America. Both national and local codes have improved significantly in the last decade.

The 78,000-sq. ft. structure required a design for a maximum probable earthquake in St. Louis with an average intensity of 0.27g. Since conventional design would not protect the building and the collections, the designers considered and eventually chose to utilize elastomeric, high damping rubber base isolators. The isolators were designed to increase the building's seismic period from0.05 to 3 seconds. The four-story building's floor design live load varies from 260 psf for collection storage to 80 psf in research areas.

Foundations are drilled piers

to shale bedrock. The piers support pile caps and grade beams which provide support for the base isolators. The structural steel building frame is a moment resisting frame in the north-south direction and a braced frame in the east-west direction. Combinations of welded and bolted connections are utilized. The floors and the roof are designed as diaphragms to resist and distribute the lateral forces uniformly to the base isolators.

The first floor girders are designed to permit column load transfer to jacks for removal and replacement of base isolators. The pier has a flat surface for placement of hydraulic jacks in pairs for each column.

Base Isolators

Structural design creativity was required to accommodate 41 base isolators and the maximum 10" lateral movement. All entrances, elevator pits, building frame, and masonry facade were designed for 13" of potential movement. A 3D-computer model of the structural frame was required for design of the base isolators and the maximum 13" lateral movement. A non-lineal, dynamic structural analysis was used to determine maximum stresses and displacements and to check the building performance during varying earthquake intensities. The foundation and first floor girders were designed for the jacking loads required for removal and testing of the base isolators. This is the first use of base isolators in the St. Louis area and only the second in the Midwest. The use of seismic base isolation systems provides the protection to the building and collections. Conventional design would have been made strong enough to save the building frame in the maximum probably seismic event, but would not protect the building contents.

The structural steel building frame is a moment resisting frame in the north-south direction and a braced frame in the east-west direction. A combination of welded and bolted connections was utilized. The floors and the roof are designed as diaphragms to resist and distribute lateral wind and seismic loads to the moment frames and bracing systems. Stud shear connectors are detailed at critical locations and where shear transfer loads exceed allowable weld capacities of the metal deck diaphragms. The first floor diaphragm and moment frames distribute the lateral forces uniformly to the base isolators. Magnetic particle testing of all critical fillet welds in moment connections was performed on both shop and field welds. Ultrasonic testing of all full penetration shop and field butt welds was also performed.

Complete detachment of the building above the isolators from the foundations and surrounding ground was required to accommodate the 13" movement. The foundation and first floor girders were designed for the jacking loads required for removal and testing of the base isolators.

By isolating the building form earthquake induced ground movement, base isolation will provide superior protection for the Research Center and its contents during an earthquake. It will reduce seismic damage to the building to a small fraction of that which would occur in an average or conventionally strengthened building. This project will be the first in Missouri

to employ base isolation technology and only the second such building in the Midwest. In addition to the obvious benefits to the mission of the Garden, it represents an opportunity to further increase public awareness of this important safety issue.

As a symbol of the Missouri Botanical Garden's dedication to environmental leadership, the Herbarium/Research Center is a model of sustainable design and construction techniques popularly known as "green architecture." The structural steel frame was preferred because of future recycle scrap value. The structure conserves resources with energy-efficient heating, cooling, and lighting systems. The Center is a showcase of innovative design that makes extensive use of recyclable, sustainable materials, and furnishings. It is the first building in the St. Louis region to be protected from earthquake damage by state-of-the-art base isolators. Structural design was by David Mason & Associates. From floor to ceiling, the Research Center utilizes sustainable materials. Promoting sustainable resources helps to reduce the exploitation of natural areas all over the world. The result is a building as beautiful as it is friendly to the environment-easy to maintain, comfortable to inhabit, and setting a standard for others to emulate.

The Missouri Botanical Garden's Herbarium/Research Center symbolizes a shared dedication to sustainable development, which is ultimately based on the mastery of the plant sciences. The building will have a profound impact on research and conservation activities around the world, especially in Latin America, Africa, China, and North America. It also stands as a symbol of commitment to the city of St. Louis.

Vance Lischer, Jr., P.E., of David Mason & Associates, Inc. in St. Louis, MO, was the project engineer on this project.