EARTHQUAKE ENGINEERING

Seismic Engineer Develops 'Showcase' for Isolators

COLUMN MOUNTED A system of triple-pendulum bearings spliced into columns cost less than base isolators because there is no excavation required for a basement level.

Steven Tipping is developing and engineering what is likely the world's smallest seismically isolated structure. The 7,500-sq-ft building in Berkeley about a half-mile from California's Hayward fault is an investment property as well as an office expansion.

Complete with column-mounted triple-pendulum isolation bearings, 1908 Shattuck Avenue is also the seismic engineer's pet project. "We tell clients they should do this," says Tipping, who is paying a $200,000 premium to isolate the $3.8-million building. "I wanted to put my money where my mouth is."

By exposing the isolators in the first-floor restaurant, Tipping will be showing off the "wares" of Tipping Structural Engineers. But he also wants to learn more about performance-based seismic design.

So does the California Geological Survey of the state's Dept. of Conservation. Early this month, the group accepted the three-story row building, scheduled for completion by year-end, into its California Strong Motion Instrumentation Program. CSMIP, mostly funded by an assessment on building permits, plans to install sensor equipment on both Tipping's new building and his office building next door—to compare the earthquake behavior of an isolated building to a building designed 20 years ago to meet, not exceed, the seismic code.

"Our purpose is to measure strong shaking, building response" and to verify performance-based seismic designs, says Tony Shakal, manager of CSMIP, which has 235 buildings instrumented. "Use of isolation in a wood frame is quite new and we want to confirm the anticipated behavior in an earthquake," he adds.

Only the upper two wood-framed levels, which enclose 5,000 sq ft, are isolated. In the maximum credible quake on the Hayward fault, which would measure about magnitude-7.4, there would be no structural damage and minimal architectural damage in the upper two floors, says Tipping. The ground floor would have "normal" cosmetic damage.

Lateral loads are taken by six 2-ft-dia interior columns—all isolated. Each concrete-filled steel-pipe column has a 1-ft-tall triple-pendulum isolation bearing spliced in 10 ft above the ground floor and 4 ft under the second-floor post-tensioned slab.

The six isolators, which cost about $10,000, will reduce lateral seismic shear by 70% or 80% by attenuating column shaking, says Victor Zayas, president of isolator supplier Earthquake Protection Systems Inc. Shaking in the upper levels will be similar to ground-level shaking, not three times as much, he adds.

The ground floor has a concrete structure, plus the pipe columns. Fifty shear studs lock each pipe column into the second-floor slab. The second floor and partial third floor have load-bearing wooden shear walls, except for wide-flange-steel column extensions of the pipe columns to carry the roof.

The bearings allow 2 ft of building displacement in any direction, for a total of 4 ft of movement. To accommodate that and keep the building from colliding with its neighbors, the width of the building above the first floor is only 32 ft, not 36 ft.

The isolated columns take loads to a grid of post-tensioned-concrete grade beams, set up as the yielding mechanism in the lateral system. If movement exceeds 2 ft in any di-

LATERAL SYSTEM Ground-floor pipe columns, with isolators, span vertically between grade beams and the second-floor slab of the three-story building.

THREE-GEAR SLIDER Triple-pendulum bearing (top) is shown in upper and lower sections to reveal the three pendulums. Four cross-section sketches (above) show the isolator's static position (top left) and three positions during increasingly higher-magnitude earthquakes.

PHOTOS (TOP AND BOTTOM LEFT) COURTESY OF TIPPING STRUCTURAL ENGINEERS; PHOTO AND SKETCHES (BOTTOM RIGHT) COURTESY OF EARTHQUAKE PROTECTION SYSTEMS

rection, the isolators lock up and lateral loads go into the columns—as a jolt—and down into the grade beams, says Tipping.

Grade beams are designed to initially bend and yield but the post tensioning would re-center them, forcing the columns to go back to plumb, he adds.

Each isolator is a sandwich consisting of a 3-ft-square steel plates, each 2 in. thick, with two shallow "bowls," one inverted and set atop the other, between the plates. Each 3-ft-dia covered bowl contains three sliders or pendulums.

The bearing operates like a transmission with three speeds, says Zayas. Each slider has a different displacement period and damping level, depending on the force of the quake.

Column-mounted bearings rather than base isolators minimize the cost of the system because no site excavation is required. All building systems that go through the 25 holes in the second-floor slab, including piping, sprinklers, plumbing and domestic water, have to be flexible to accommodate the movement. Even the upper-level gangway between Tipping's current office and the new building is detailed to handle the maximum displacement, says Richard Fernau, of project architect Fernau&Hartman.

SIDE BY SIDE State will compare quake behavior of isolated building under construction (at left, in photo and rendering) and its conventional neighbor.

There also have to be gaps between any first-floor concrete walls and the second-floor slab. "There are 'trick' details" throughout, says Steve Cetrone, project manager for contractor Oliver & Co. "The structural issues made trade coordination difficult, especially for the dynamic slab," he adds.

After workers from Jos. J. Albanese Inc. completed the grade beams, crews from steel contractor Ogletree's Inc. installed the pipe columns. First, workers set the 10-ft-tall section below the isolator. Next, crews placed the concrete filling, the isolator and the 4-ft-tall section above it. The second-floor slab followed.

Cetrone calls the job "unique," but not just because of the isolators. With Tipping's office next door, "our super, Tim Miller, has 20 engineers looking over his shoulder," he says. But on the positive side, Cetrone says, "Tim can whistle and an engineer comes out and immediately solves any conflict." ■

By Nadine M. Post

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