Seismic Technology

Poised to Shake Up Residential Design?

BY EMI STIELSTRA + JANUARY RUCK

Advanced technology is all around us, touching many aspects of our lives. New structural systems are just one of the many technologies that can make our homes more comfortable, efficient, healthy and resilient to natural disasters. Yet few people in Northern California know resilient seismic systems — common for mitigating the impact of earthquakes in commercial buildings — are available as a sensible and attractive upgrade for single-family residences.


Portola Valley Residence. All renderings and images courtesy of 2M Architecture.

Matarozzi Pelsinger Builders, a design-build firm based in San Francisco, aims to change that with an innovative Portola Valley, CA, home located just over one mile from the San Andreas fault.

According to Billy Lee, a business development manager with Matarozzi Pelsinger, the homeowner's primary goal was to ensure the family's safety during a large quake, but they also wanted to avoid the trauma of experiencing a post-quake relocation or seeing their most significant financial investment damaged or destroyed. To that end, the house is the first single-family residence to use a fluid viscous damper frame system to absorb the energy of an earthquake.

When the ground starts shaking, dampers absorb the shock instead of transmitting it up into the building. This means that the rest of the structure can be designed for reduced seismic forces, as the dampers take the bulk of the impact, just like shock absorbers in a car. The damper frames result in lower seismic design forces (compared to conventional solutions with the same performance targets) by reducing the size of the lateral force resisting system, from foundation to roof.

The fluid viscous damper frame technology could be employed in any residence seeking to accomplish a seismic performance target greater than code minimum, "life safety" (see definitions). For a relatively flat site, a "base isolation" system could be considered, but on a hillside site, the damper system is the only practical method.

At the Portola Valley home, the owner, an engineer, recognized an opportunity to help advance the state of building science by implementing the dramatic solution. By sharing the cost of instrumenting and monitoring for the home with the California Strong Motion Instrumentation Program (CSMIP), this project offers an opportunity to track the new technology's performance and provide data to help improve the resiliency of future buildings.

Project architect and principal of 2M Architecture, Marc Lindsell, LEED AP, explains the main architectural changes made to accommodate the damper frames included "thickening" the walls to enclose the frames inside the finishes. Generally, the braced frames sit in the same locations as the traditional structures, requiring some changes in the original schematic design. Lindsell emphasizes that seismic systems in buildings may be considered equivalent to airbags and crumple zones in a car. "Yes, they add some weight and expense, but when an accident occurs, your health and safety will depend on it."

People who are commissioning new large custom homes will likely be the earliest adopters of this technology. In such cases, the additional cost of installing the damper frames is relatively modest (a few percent of the total construction cost). Given the expense and difficulty of building in the Bay Area, the comparative costs to repair or replace a structure when the "Big One" hits could make this system a reasonable investment for many homeowners.

The damper frames can be used in retrofit situations undergoing a complete seismic upgrade in a similar way to how moment frames are used today. As the design progresses, the construction methods become standardized, and building codes evolve, this technology will likely become more mainstream, just like other structural members such as prefabricated trusses and engineered shear panels.

In Japan, where large earthquakes are frequent and society values life-safe buildings that allow people to return home and work immediately after a large earthquake, this technology is already the preferred seismic system. The long-term domestic goal is to bring this design approach to more American homeowners at a lower cost.

Even if employing the fluid viscous damper frame technology isn't immediately realistic for every homeowner, Lee advises simply hiring highly qualified architecture and engineering professionals can make all the difference … even on a small project. Soliciting design services and choosing the lowest-fee solution is not necessarily the best long-term investment. It's important to know that current building codes do not require site-specific analysis, but rather make fairly generic assumptions about the ground motions that could occur. In contrast, hiring professionals to prepare a performance based design requires understanding the vulnerabilities of a particular site and then designing a structure to manage them.

The Structural Engineers Association of Northern California (SEAONC) is launching a program under the name US Resiliency Council (usrc.org) that it hopes will allow customers to better understand what they are building, buying or renting. The program intends to help insurance companies to assign risk more accurately and motivate owners to increase the resiliency of the building stock. Increased resiliency will help reduce damage in the event of strong earthquakes, minimizing associated cost and improving public safety. ■

In this house, the damper frames were enclosed inside of the wall material of the building. Some of the frames are expressed "visually" as structural fins supporting the tall roof. It would also be possible to expose the frames completely and express the steel and dampers. If the damper system is included early in the design, the architect can seamlessly integrate them into the fabric of the building as they would with any other structural system.

PERFORMANCE BASED DESIGN DEFINITIONS

- **Collapse Prevention** — Substantial structural and non-structural damage. Little margin against collapse. Some falling debris hazards may have occurred.
- **Life Safety** (equivalent building code standard for new buildings) — Significant damage to structural elements; however, a margin remains against collapse. Non-structural elements are secure but may not function. Occupancy may be prevented until repairs can be instituted (it may be possible to repair the structure, but for economic reasons may not be practical).
- **Immediate Occupancy** — No significant damage has occurred to the structure. Non-structural components are secure and most would function if utilities are available. Building may be used for its intended purpose.
- **Operational Level** — No significant damage has occurred to structural or non-structural components. Building is suitable for normal intended occupancy and use.