

The Legacy of Northridge Lives On

By Larry Kahanar

The January 17, 1994 Northridge, California earthquake dramatically affected how structural engineers conduct the art and practice of building design, probably more so than any other earthquake in recent history. Certainly changes resulted from the 1933 Long Beach earthquake and the 1971 San Fernando earthquake; but it was the Northridge earthquake that led to widespread and sweeping changes in regulation, standards, design and products that have become well-accepted and employed throughout the world.

The growth of performance-based design is probably the most significant change that resulted from Northridge. Although it has been used for decades in the manufacture of cars, airplanes and other mass produced products, performance-based design is difficult to employ in structures because each structure is unique, exists in a different environment, and is built on varying ground conditions.

“Our LA office does a lot of hospital projects, mainly performance-based design, for existing and new buildings,” says Aaron Reynolds, Principal of consulting engineers KPFF, Inc., and based in their Los Angeles office (www.kpff.com). “The state of the art on seismic design for buildings that need a higher degree of seismic performance is performance-based design, base isolation, or use of modern technology like BRBs.” He says: “We are doing a lot of retrofit performance-based design on steel moment frame buildings built in the 70s or concrete shear walls from the 50s.”

Adds Reynolds: “There’s a number of FEMA and ASCE guidelines for how to model, and we’ve really gone and tested that to get more performance out of buildings. That’s why we’re doing complicated, non-linear analyses of buildings. Performance-based retrofitting, with component testing, is the cutting edge in learning about the behavior of buildings and building components... It’s the most interesting seismic design we’re doing right now.”

“We definitely have noticed, in the past few years, an increase in structural engineering firms using performance-based design,” says Henry Gallart, President of SidePlate Systems, Inc., based in Laguna Hills, California (www.sideplate.com). “Non-linear dynamic analysis is definitely increasing among firms that do this kind of work.”

SidePlate offers a suite of high-performance steel frame connection technologies that have successfully been tested to provide protection against blasts, progressive collapse, and earthquakes. The technology was originally developed in response to the devastation caused by the 1994 Northridge earthquake in California, but it has been proven to provide protection for other hazards as well, says Gallart.

Upcoming projects using SidePlate products include the Oakland (CA) Air Traffic Control tower, which begins construction in the fall, and the Scripps Cardiovascular Institute in La Jolla, California.

“Another trend we’re seeing,” says Gallart, “is that patented construction systems like SidePlate seem to have reached a level of maturity, where more engineers are accepting them and willing to use them... When they’ve proven to be cost effective, fabricators also have accepted them; and that’s also been a factor in engineers’ decisions.”

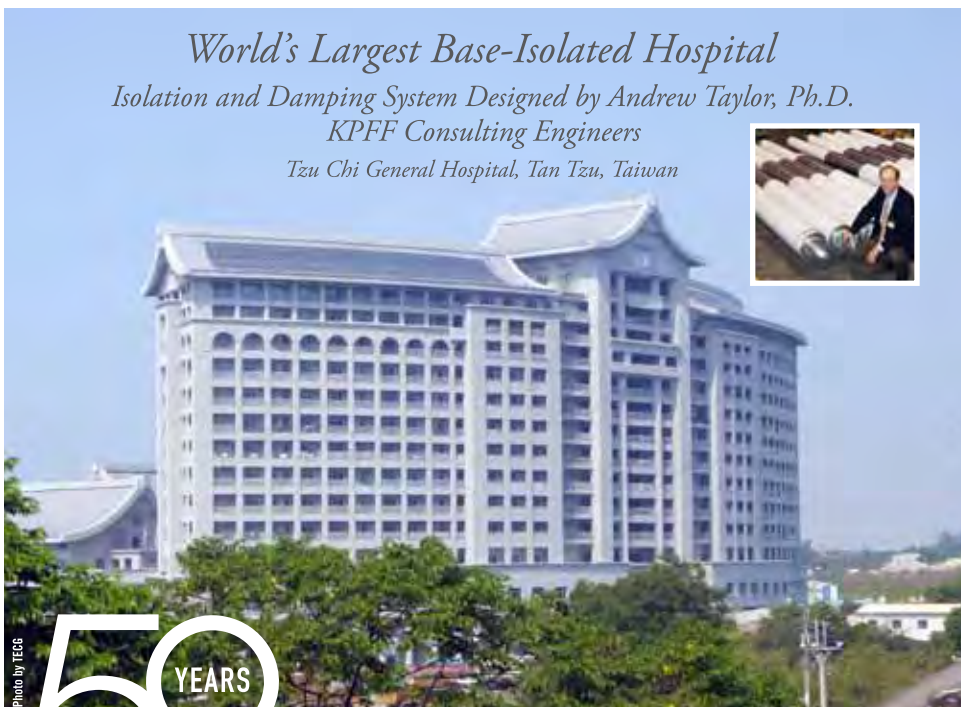
Another proprietary system that grew out of the aftermath of Northridge is that of The Spectrus Group’s Special Truss Moment Frame (STMF) called *Tru-Frame*, which evolved from an extensive, multi-year study at the University of Michigan.

“We took the study’s results and produced a STMF,” says John Mayo, President and CEO of The Spectrus Group, Inc. in Auburn, California (www.thespectrusgroup.com), a division of JD Squared, Inc. “We added a special segment in the middle of the truss. It yields. We want them to chew up energy, to elongate and not return... After Northridge, lots of buildings had to be closed and redone,” he says.

Mayo says that his company has been involved in the construction of about 60 buildings, mainly on the West Coast, including warehouses and military office buildings. “In warehouses, we are able to eliminate chevron bracing, which opens up the interior space... We get rid of the heavy moment connection at the column which requires a lot of welding and inspection. This reduces the weight 25-30 percent and

continued on page 18

World’s Largest Base-Isolated Hospital
Isolation and Damping System Designed by Andrew Taylor, Ph.D.
KPFF Consulting Engineers
Tzu Chi General Hospital, Tan Tzu, Taiwan



50 YEARS
kpff

Consulting Engineers

www.kpff.com

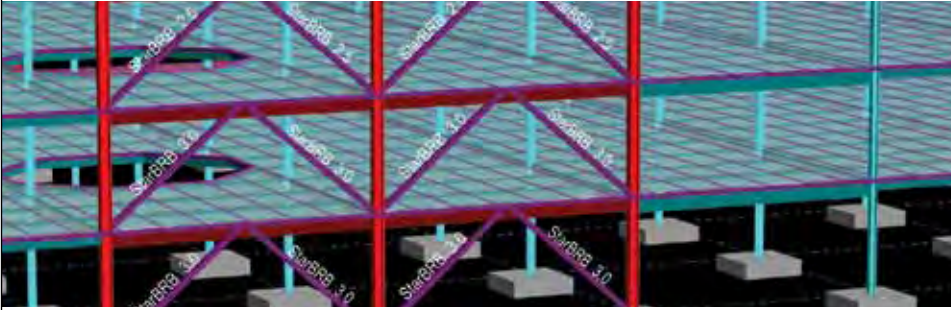
Seattle	Portland	Walnut Creek	Irvine	St. Louis
Everett	Eugene	Los Angeles	San Diego	New York
Tacoma	Sacramento	Long Beach	Boise	Amman, Jordan
Lacey	San Francisco	Pasadena	Phoenix	Abu Dhabi, UAE



BUCKLING RESTRAINED BRACES

SIMPLIFIED MODELING TOOLS

For fast and easy project modeling, Star Seismic BRB data is included with RAM and available for ETABS, RISA and REVIT.



We can help! Star Seismic provides design guidance for BRB frame analysis.

brb@starseismic.net 435-940-9222 www.starseismic.net



decreases foundation requirements. The speed of the project goes quicker, too,” says Mayo.

Another offering, by Seismic Structural Design Associates (SSDA) (www.slottedweb.com), is SlottedWeb, a proprietary design developed in response to the failure of moment frame connections during the 1994 Northridge earthquakes, according to company officials. The International Code Council approves it for general use as a pre-qualified connection in Special Moment Frames.

The SlottedWeb design works by separating the beam web from the beam flanges in the connection region, thus eliminating lateral-torsional buckling and reducing large stress and strain gradients across the beam flanges by permitting them to flex out of plane. Vertical beam shear in the flange/welds are reduced from typically 50 percent in the pre-Northridge Welded-Flange/Bolted-Web connections to approximately 3 percent with the SlottedWeb design. Essentially, all of the vertical shear is transferred to the column through the beam web and shear plate, thus reducing complex multi-axial stress and strain in the column flanges which can lead to reduced material ductility. Residual stresses in the welding processes are also significantly reduced. (See ad on page 15.)

continued on page 20

ADVERTISEMENT - For Advertiser Information, visit www.STRUCTUREmag.org



Nationally Manufactured and Approved using the most conservative ASTM E2126-07a (reverse) Cyclic Test Protocol. Our patented panel has been approved using all nationally accepted building codes for over a decade.



THE NEXT GENERATION OF SHEAR PANELS

SURE-BOARD® . . . for Shear

Today, designers of both WOOD and CFS framed structures in seismic and hurricane affected areas in our vast nation are now beginning to realize that **Sure-Board®** can also be used to resist terrorist blast and ballistic attack. **Sure-Board®** is the best choice for superior strength, fire resistance as well as all weather protection from infestation and mold. Our shear panels are installed to resist nature's toughest challenges including a resilient steel sheet to resist flying debris. **Sure-Board®** is fast becoming the first choice for shear walls for many of the nation's largest designers and contractors in commercial, institutional, residential and GSA "hardened" facilities.

SURE-BOARD®
is proven the strongest and longest-lasting cyclic tested shear panel available.

TESTED APPROVALS: ICC, IAPMO, Los Angeles City (LARR), DSA, Miami Dade, E119 Standard 1 and 2 Hour Load Bearing fire test approvals, Sound tested to STC 60, Blast tested by the United States Department of State.



Sure-Board® is manufactured by CEMCO, a leader in steel technology for construction. Call CEMCO at (866) 469-7432 to make **Sure-Board®** your shear-wall product of choice today! Or visit: www.cemcosteel.com or www.sureboard.com

Many engineers are exploiting the growing popularity of Buckling Restrained Braces or BRB because they are not only replaceable after a quake, but they can be adjusted to a structure's specific requirements. "One of the nice things about BRB's is that you can fine tune the buckling for a specific application. We can fine tune for stiffness and strength," says Steve Powell, a Principal of Star Seismic, Park City, Utah (www.star seismic.net), which holds patents on BRB products. (See ad on page 18.)

Powell notes that many of the buildings in Chile use structural steel frames, and the question raised after the giant quake this year was whether to repair the damaged buildings or tear them down. "This is a huge issue because of the non-ductile shear walls there. Not very many buildings failed, but now they're damaged buildings. There were not many deaths, but many people had to move out. Minimal compliance is a safety matter. People got out; but now what do you do with the buildings?"

Carleton Elliott, CFO of International Materials, Inc., parent company of Sure-Board (www.sureboard.com), says that his company's patented, proprietary product, which laminates steel sheet to many different substrates, can increase the load-resisting capacity of steel up to 35 percent. "The typical method of controlling lateral movement is with products such as X-bracing, plywood or OSB [oriented strand board]. X-brace is for the uplift side, but not compression. Sure-Board and plywood come from the same family of control, but we're non-combustible." He adds: "We can butt a standard piece of drywall to Sure-Board without furring."

Elliott notes that Sure-Board is used on the East Coast to prevent damage from hurricane-force high winds in buildings such as military facilities and housing projects. It is also used for earthquake protection on West Coast buildings such as those at Cal Poly, San Luis Obispo, and Los Angeles schools. "They chose steel to eliminate off-gassing

from lumber... In the Tallahassee Supreme Court building, it is used for its blast resistance." (See ad on page 18.)

Sure-Board has been in business for ten years. Their products are approved by the GSA using ASTM E2126-07 reverse cycling testing.

A company that offers a unique product for seismic protection is Fibrwrap Construction, Inc. (www.fibrwrapconstruction.com) of Ontario, California. "We are a specialized contractor that supplies and installs fiber-reinforced polymer products, or Fiber Wrap, manufactured by the Fyfe Company," says CEO Heath Carr. "We also perform other structural strengthening applications, including concrete repair, epoxy crack injection, and specialty coatings."

"When the Fiber Wrap is applied to columns, for instance, for seismic strengthening," says Carr, "it reinforces the structure so that, during an earthquake, catastrophic events do not occur, such as building collapse." The company recently finished work on the Downtown Women's Center in Los Angeles where it retrofitted 140 columns, as part of the building's renovation and conversion to housing for homeless women. "The key benefit of the Tyfo® Fibrwrap® is that you can add structural value to columns, beams, walls, and even piping with a lightweight, low-profile, advanced composite material. The foundation is not impacted, even though you're adding significantly to the robustness of the structure; and, at the same time, when the material is applied, the overall profile of the structural member is typically only increased one quarter to one-half an inch," says Carr.

Taylor Devices (www.taylordevices.com) of North Tonawanda, New York, takes another approach to seismic protection with its line of seismic dampers and seismic isolation components. "For tall buildings, we have been doing well with our toggle brace. We pioneered its use on 111 Huntington in Boston, a 38-story high rise," says CEO Doug Taylor. "Toggle braces lower building deflections by a factor of four, so you can use smaller dampers; and this makes dampers easier to package.

continued on page 22

ADVERTISEMENT - For Advertiser Information, visit www.STRUCTUREmag.org



Over 20 years ago we created an industry.

Today we set the standard as the premier installer of the Fyfe Company, Tyfo® Fibrwrap® Carbon Fiber Reinforced Polymer (FRP) system.

Fyfe pioneered the invention of the Tyfo® structural strengthening products, and to date has over 6,000 installations and a worldwide organization dedicated to excellent service.

Fibrwrap Construction offers innovative, turn-key solutions for structural strengthening, pipeline repair & renewal, and concrete restoration projects.

Call today for a no-obligation consultation.

FIBWRAP CONSTRUCTION, INC.

The Future of Construction Technology

909.390.4363

www.fibrwrapconstruction.com

Atlanta | Baltimore | Chicago | Halifax | Los Angeles | San Diego | San Francisco | Vancouver

We sell it along with dampers; there is a cost savings of 20 to 30 percent over conventional dampers. It cuts damper diameter by half, which saves space.”

Taylor notes that there is some potentially game-changing seismic testing now being conducted at the State University of New York at Buffalo. The research, funded by the National Science Foundation, is studying a Negative Stiffness Device. “It’s an odd name,” admits Taylor. The device works in conjunction with dampers and makes the building fairly stiff under smaller wind gusts. Under larger inputs, such as 5.5 earthquakes, the building becomes ‘softer’ once it moves past a certain point. “I know it sounds weird,” Taylor says of the device, which uses technology borrowed from NASA. “It is inactive under small pushes, but under larger pushes it tries to push the building further, which

sounds weird; but in the world of earthquakes, that’s good.” One of the unique facets is that the device uses machined spring technology which, in large sizes, is pretty new, Taylor notes. “You can make it from steel that you cannot ordinarily make springs from, because it’s machined from a hunk of metal.” The first paper describing the study is expected to be published in July.

Still another approach to seismic protection is soil improvement and mitigation of liquefaction, specialties of Hayward Baker, Inc., headquartered in Odenton, Maryland (www.haywardbaker.com). “People hear seismic and they think California; but we do a lot of work outside of California, such as in the Northeast and the Caribbean. They also have seismic issues,” says Director Jim Hussin. “There are few parts of the country that don’t have to deal with these issues.” (See ad on page 21.)

One trend that Hussin is seeing is that increasing numbers of jurisdictions are adopting the International Building Code (IBC). “It’s becoming more and more the standard; and, the IBC is pretty specific about how foundations should be designed.”

Hussin notes that the company’s first job was the Santa Barbara waste water treatment plant in 1974. A more recent project is the Cancer Center in Ventura, California, where they did soil mixing. The company also performed seismic upgrading for the San Pablo Dam in Richmond, California. “People don’t think of earthquakes in New York City, but they have faults. We just did Harlem Hospital, which is in an area with loose sands that can liquefy during an earthquake.”

Although innovative engineering designs are key to seismic protection, proper fabrication procedures also must be addressed. To this end, ESAB North America (www.esabna.com), a subsidiary of Anderson Group, Inc., has been working for about three years on electrodes that are certified for seismic use. “We have quite a few certified, and they’re being used now,” says Roger Bushey, Product Compliance Manager. “The most famous project where these are being used is the Freedom Tower in New York.” Founded more than 100 years ago, ESAB Cutting & Welding is involved in welding and cutting equipment, welding consumables, welding automation, and cutting systems.

Bushey notes that electrodes must adhere to American Welding Society (AWS) D1.8 for seismic service. “We have had inquiries from Mexico (about certified electrodes) as well as interest from Asia, even though they don’t always follow AWS or FEMA standards.”

To help inexperienced welders and make experienced welders more productive, ESAB has come out with its *Dual Shield X-Series* of flux-cored wires. The new wires are much more forgiving than traditional flux-cored wires. “We have seismic certified electrodes, and we’re coming out with more. They have a wider operating range, so it doesn’t have to be dialed in exactly. The wires are forgiving because of how they’re made,” says Bushey. ■

YOU BUILD IT.
WE’LL PROTECT IT.

SEISMIC PROTECTION FROM TAYLOR DEVICES

Stand firm. Don’t settle for less than the seismic protection of Taylor Fluid Viscous Dampers. As a world leader in the science of shock isolation, we are the team you want between your structure and the undeniable forces of nature. Others agree. Taylor Fluid Viscous Dampers are currently providing earthquake, wind, and motion protection on more than 240 buildings and bridges. From the historic Los Angeles City Hall to Mexico’s Torre Mayor and the new Shin-Yokohama High-speed Train Station in Japan, owners, architects, engineers, and contractors trust the proven technology of Taylor Devices’ Fluid Viscous Dampers.



Taylor Devices’ Fluid Viscous Dampers give you the seismic protection you need and the architectural freedom you want.



www.taylordevices.com

taylor devices inc.

North Tonawanda, NY 14120-0748
Phone: 716.694.0800 • Fax: 716.695.6015

ADVERTISEMENT - For Advertiser Information, visit www.STRUCTUREmag.org