conference preview

EMBRACE YOUR BRACES!

BY TERRI MEYER BOAKE

Exposing seismic bracing not only provides new architectural possibilities, but also makes structural framing inspection easier in the event of an earthquake.

ON FEBRUARY 22, 2011, Christchurch, New Zealand, experienced a magnitude 6.3 earthquake. One of the deadliest and most destructive in the country's history, it claimed nearly 200 lives.

The examination of the massive amount of destruction served as a lesson on the ability of contemporary structures to resist seismic loads and allow for post-event repair. Of the close to 1,600 buildings in Christchurch's central business district that have either been demolished or are in line for demolition, it was evident that the failure of reinforced concrete structures exceeded the failure of steel structures. Not only were the structures incapable of resisting the forces, but the type of damage suffered was impossible to repair, making reuse of the structures impossible. The structural problems were hidden within the frames, slabs, columns and walls. The only safe and economic solution was to demolish and build anew.

Many of the larger commercial buildings that survived the Christchurch earthquake used steel as their framing and bracing system. Structural repairs to Pacific Tower—an eccentrically braced frame structure that opened in 2012 and is the tallest tower in Christchurch at 23 stories—were completed last May, with the steel braced frame being repaired and the hotel portion reopening; the repairs took more than two years. All braces had to be inspected before the building could be given permission for occupancy; only one active link showed failure.

This was the case with other examined steel buildings as well, prompting a major push for more steel framing throughout New Zealand.

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Exposed Bracing

Besides demonstrating steel's favorable performance in an earthquake, the examination resulted in another revelation as well: It is more effective to design seismic bracing systems to be exposed to view in regions of high seismic activity, as walls and finishes wouldn't need to be removed for framing inspection in the event of an earthquake. Engineers are not likely to object to this practice but architects normally choose to conceal such systems. This need not be the case.

Exposed bracing systems, including those employing architecturally exposed structural steel (AESS), can very easily be adapted to include seismic functionality and a transparency of purpose in their design intent. They can effectively create a new seismic vernacular that could be applied equally well to new or retrofitted structures. It is not difficult to imagine simple modifications to current AESS bracing that would make it effective as a seismic system—or vice versa.

Replaceable Link Bracing Systems

There are new systems in development that can allow for the quick repair of seismic damage. The replaceable link bracing system was studied in 2010 research by Nabil Mansour at the University of Toronto in his Ph.D. thesis "Development of the Design of Eccentrically Braced Frames with Replaceable Shear Links," and the work has been continued by Professors Constantin Christopoulos of the University of Toronto and Robert Tremblay at Polytechnique Montréal.

The simple version of the replaceable link bracing idea is to create well controlled weak spots in the eccentrically braced frame (EBF) that will fail during a seismic event and absorb the energy of the quake in the process. In failing, the energy of the event is absorbed by the link in a sacrificial move, and the balance of the frame remains intact.

If this link remains exposed, then inspection and replacement become quite straightforward. What is unique about this approach is the way that the link is bolted into the frame. Up to this point the link in an EBF system was integral to the spanning member. If the link failed, it would have to be cut out and a new section welded into place. By using a short

➤ A braced frame in Christchurch's Three35 project using a "replaceable link" in post-earthquake construction.

wide-flange section, with plates welded to the ends, bolted to the frame, the failed link need only be detached and a new link bolted into place (after realignment of the brace elements).

The system has already been used in the recently constructed Three35 project in Christchurch, designed by Jasmax Architects. SCNZ (Steel Construction New Zealand), in conjunction with HERA (Heavy Engineering Research Association) and Associate Professor Charles Clifton from the University of Auckland, is currently updating HERA report R4-76 "Seismic Design of Steel Structures" to include replaceable links, partially based on experience with this project.

Currently, the biggest drawback to including this kind of seismic functionality in AESS systems is that the types of sections they commonly employ, such as round and square HSS as well as custom profiles fabricated from plate, have to date not been subjected to adequate testing. (Wide-flange shapes, on the other hand, have had the benefit of field testing in actual seismic events, which has proven their suitability and success.) That is not to say that shapes typical to AESS systems would not be able to pass performance tests, only that research funding and initiatives have not focused on these member types.

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Bracing as Style

The growth of AESS systems is setting the stage for the creation of a vital language of exposed steel seismic bracing systems. These systems are using the aesthetic of diagonal steel bracing to create their architectural statement, and their increasingly widespread adoption indicates that there is potential for shifting the traditional concealment of seismic bracing systems to an exposed condition. This provides an architectural opportunity in terms of the aesthetic expression of the steel systems as well as a way to provide for quick inspection and repair in the post-quake scenario. Exposure of the systems eliminates much of the required removal of finishes in order to carry out the inspections, saving time and money. Architectural design sensibilities change with time, and systems that were once considered unacceptable in time come to be considered as acceptable and even preferred. This holds promise for seismic reinforcing systems. ■

This article serves as a preview of Session N43, "Embrace the Brace" at NASCC: The Steel Conference, taking place March 26-28 in Toronto. Learn more about the conference at ***www.aisc.org/nascc****.*

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The Manukau Institute of Technology in Auckland, New Zealand, designed by Warren and Mahoney Architects, uses a perimeter diagrid on its exterior to purposefully express the structure. Note the absence of vertical columns. EBFs are used on the building interior to assist with seismic resistance. These are left exposed.