Newly Proven Seismic Connections Impact Designers And Owners

Creative precast concrete seismic connections tested in the PRESSS program now proven to offer better options as codes tighten across the country

Designers across the country soon will be impacted by tighter seismic controls being incorporated into the new unified-model building code being adopted by many states. Recent re-evaluations and adaptations to precast concrete connections will allow designers to continue using materials they've grown accustomed to, while saving money and producing structures better able to withstand seismic forces. But to take full advantage of these systems, engineers say, they must be aware of the options and think outside the box.

"Systems that designers currently are using will not meet the new code, because the code is tightening seismic requirements in many parts of the country," explains S.K. Ghosh, principal in S.K. Ghosh Associates Inc. in Northbrook, Ill. "It is doing away with the specific zones that designers are used to and taking a new approach. That means they will have to find new solutions in order to build their structures."

The changes result from the implementation of the new International Building Code (IBC), Ghosh explains. Designed to replace the three differing model codes used in varying localities around the country, it will be adopted by many states in the coming months, with perhaps 25 states relying on it by the end of 2001, he estimates. A key change in its provisions affects how many cities, especially those in the Southeast, will have to build structures to meet tighter seismic requirements.

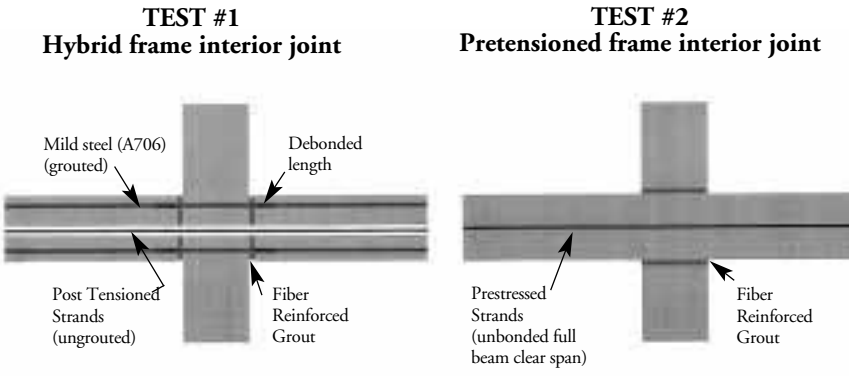
Zone Concept Eliminated

IBC does away with the existing four seismic zones and relies instead on interpolating between ground motions as delineated on a seismic map and taking account of local soil conditions for that specific location. That means many cities' ratings will vary from site to site, with many being upgraded beyond the systems that now can be used in these areas, Ghosh notes. Among cities that will face several levels of stricter standards will be Charlotte, N.C., Charleston, S.C., Atlanta and Little Rock, Ark.

To offset these restrictions and offer more effective and less expensive options, a team of engineers and precast concrete experts has been testing precast concrete solutions for the past nine years. Known as the Precast Seismic Structural Systems (PRESSS) research program, the experiments tested four frame systems and one shearwall system to determine their capability for creating new seismic designs. PRESSS represents a coordinated effort from the academic, scientific and business communities in Japan and the United States and is sponsored by the National Science Foundation (NSF), the Precast/Prestressed Concrete Institute (PCI) and the Precast/Prestressed Concrete Manufacturers Association of California (PCMAC).

All five systems produced satisfactory results in testing that was completed last September, according to participants. The designs were installed and verified in a 60-percent scale five-story building. Although all offer new ideas, two key benefits are provided by the hybrid frame and pretensioned frame systems. These advantages will save owners and designers money both in the design phase and in recovering from a seismic event, says Suzanne Dow Nakaki, principal in The Nakaki Bashaw Group Inc. in Irvine, Calif.

"The more money saved upfront in the structural design, the more that's available for making the building look



Two different connection systems tested in the PRESSS program are shown above.

Rigorous tests performed last year on an experimental structure proved the success of the PRESSS program's connection techniques.

great," she points out. "And owners certainly will be interested in structural systems brought to them that not only help their structures withstand a seismic event, but make them available for reoccupancy right away without any adjustments to be made."

Self-Righting Is Key To Design

These designs bring one key idea to structural design that has not existed in any form before: the ability to self-right a building after a seismic event. The designs create a "rubber band" effect that allows the building to flex with the earthquake force but then pulls it back to its original position, she explains. This was a critical problem found after the 1994 Northridge, Calif., earthquake, where some steel-frame buildings resisted the seismic forces, but wound up about 1 percent off plumb.

"The displacement was just enough to make things not work well — doors wouldn't shut and nothing was level," Nakaki says. "And they couldn't be straightened because the required force was simply too great." She also notes that the new precast systems eliminate concern over weld fractures, another key factor with steel structures in the Northridge earthquake, and one that is difficult to ascertain because of the large number of joints and the inability to access them for inspection.

The other key advantage offered by these two systems is their ability to "tune" the structural systems to absorb less energy and lower forces, thereby saving money, she points out. Tuning in the structural design allows the designer to separate stiffness and strength to provide both without overdoing one or the other, she explains. For instance, stiffness is the determining factor in designing for steel-frame structures — in other words, by the time the designer has achieved sufficient stiffness to meet seismic codes, strength needs already have been exceeded. On the other hand, strength governs most concrete designs, meaning by the time the designer has added enough strength to meet codes, the stiffness requirement has been met.

With most of these new designs, designers can adjust both stiffness and strength together to meet individual requirements. "This makes them more economical, because you aren't providing too much stiffness in the precast frame as a byproduct of achieving the proper strength," Nakaki explains. "You can minimize both requirements and shift that additional budget to a better use."

These systems allow designers to adjust for both stiffness and strength individually.

Which system designers find most advantageous will depend on the situation and a variety of factors, Nakaki estimates. "The key factor probably will be how the contractor wants to build it and which approach offers the best constructability," she says. "These systems can be built with similar characteristics to satisfy the desired criteria, so the choice probably will come down to local conditions and constructability factors."

Choices Will Be Narrowed

The systems are more than simply new cost-saving options, she stresses. "As the IBC 2000 gains acceptance, it will limit designers from doing what they've been doing in many places," Nakaki says. "These new options not only will allow them to continue to use precast concrete structural frames, but they offer better solutions than the existing options because of their added advantages and potentially lower costs."

Convincing designers, owners and contractors of these advantages will require a significant educational effort, she admits. "Too few designers are willing to think outside of the box and consider new options, even when the ideas offer better alternatives. They grow comfortable with what has worked in the past, especially with seismic design."

On the West Coast, she notes, designers ultimately adjusted to the tightened code restrictions they faced many years ago by virtually eliminating precast concrete structural frames from their repertoire. With the new code, designers in other parts of the country now will have to find new alternatives. These precast systems not only re-open the door for West Coast designers to expand their existing options but will give designers in lower seismic areas the ability to continue to use materials they're already designing with regularly.

"Precasters and structural engineers who have seen these systems have to get the word out and explain them to owners and designers who are unfamiliar with them," she says. "These designs are more economical for owners and provide better solutions. But no one is going to force their use, especially if they aren't aware of the advantages. But I have a lot of hope for the systems. They're better and cheaper, and I don't see how anyone can walk away from that." ■

— Craig A. Shutt

For More Details

For more technical information on the test building and the PRESSS research program, contact PCI Publications at 312/786-0300 or info@pci.org. Order the 1999 March/April, September/October and November/December issues of the PCI JOURNAL.