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# **PRESSS Program Offers Exciting Seismic Potential**

Innovative uses for existing technologies show dramatic, cost-effective options for extending precast concrete seismic designs, as proven by test structure

Engineers of Record Civil Engineering Department University of Washington Seattle

The Nakaki Bashaw Group Inc. Irvine, Calif.

#### **Project Sponsors**

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TCY Frame

he use of precast concrete systems in structural design has been limited in some high-seismic areas as designers grapple with ways to meet design requirements in a cost-effective manner. Now, research featuring five connection systems that were evaluated in a test building indicate that designing with precast concrete not only is possible but it may offer a better and less expensive approach than current steel or cast-in-place concrete designs.

The tests, conducted by the Precast Seismic Structural Systems (PRESSS) Research Program, are part of an evaluation underway since 1991. They represent a coordinated effort involving members of the academic, scientific and business communities in Japan and the United States. The engineers of record on the test structure were John F. Stanton of the Civil Engineering Department at the University of Washington in Seattle and Suzanne Dow Nakaki of The Nakaki Bashaw Group Inc. in Irvine, Calif.

The test building consisted of a five-story structure at a 60percent scale that was used to evaluate five key seismic loadresisting systems, four ductile frames and one shearwall. The key to the systems tested is that, unlike in past designs, the techniques generally don't attempt to strengthen connection points between the precast concrete components. Rather than view the connections as a negative aspect of the structures, these systems approach connections as a controllable focus for absorbing seismic energy and flexing with it.

### **FIVE SYSTEMS TESTED**

The five systems comprised:

A Hybrid Frame connection in which the beams were connected to multistory columns by unbonded post-tensioned strands that run through a duct in the center of the beam and through the columns. Mild steel passes from the beams through the columns and dissipates energy in large earthquakes.

A **Pre-Tensioned Frame** in which the most economical connection method features one-story columns with multi-span beams. The multi-span beams are cast with partially debonded pretensioning strand set on one-story columns. As the frame displaces laterally, the debonded strand remains elastic and re-centers the structure after a major seismic event. The hybrid frame also has this characteristic.



Post-tensioned Shearwall



"The self-righting characteristic makes these systems stand apart not only as a precast solution but as the only solution, as no other competing seismic system possesses this characteristic."

—Prof. John F. Stanton, Civil Engineering Department, University of Washington



"Total precast systems now can be expected to provide the highest quality solution for major commercial, institutional and industrial buildings in all seismic zones."

—Suzanne Dow Nakaki, principal, The Nakaki Bashaw Group Inc.



Prestressed Frame Elevation

A Tension-Compression Yielding (TCY) Gap Frame, in which the beams are erected between columns, leaving a small gap between the end of the beam and the face of the column. Only the bottom portion of this gap is grouted to provide contact between the beam and column. The reinforcing steel is debonded for a specified length at the gap so it can yield alternately in tension and compression without fracture.

A TCY Frame, which features a traditional tension/compression-yielding connection similar to that used in cast-in-place concrete construction. The yielding is concentrated at the connection, rather than creating distributed yielding over the finite length of a plastic hinge.

A **Shearwall System**, which is post-tensioned vertically to re-center the system after an earthquake. Special devices located in the joints between panels dissipate seismic energy.

"The goal of this test program was to develop new precast framing systems that would meet or even exceed the existing Special Moment Resisting Frame (SMRF) requirements as defined in the 1997 UBC," explains Stanton. "The tests were extremely successful in meeting this goal."

## **UNIQUE CHARACTERISTICS**

Among the findings of the test building were:

- The structural systems provided seismic performance as good as or better than that of cast-in-place concrete systems.
- The systems are suitable for low-, moderateand high-seismic regions.
- They typically will sustain less seismic damage than conventional cast-in-place systems.
- Response, especially drift, can be accurately predicted.
- All hardware is conventional and widely available.
- Design is simple.

"The self-righting characteristic in the Hybrid Frame, Pretensioned Frame and Shearwall is not available using any other seismic system currently on the market," says Nakaki. "This property, along with the minimal damage these systems experience, allows immediate reoccupancy of the affected building after a major seismic event."



Yielding Frame Elevation

Adds Stanton, "The self-righting characteristic of some of the systems tested in this building makes them stand apart not only as a precast solution but as the only solution, as no other competing seismic systems possess this characteristic. This will make them the solution of choice for building applications in markets that have previously been closed to precast construction."

All of the materials used in the tests are readily available, including A706 reinforcing steel, prestressing strand, prestressing bar and fiber-reinforced grout. "Posttensioning steel, a material historically banned for use in seismic systems, was shown to provide exceptional performance for several systems," Stanton says.

"Total precast systems now can be expected to provide the highest quality solution for major commercial, institutional and industrial buildings in all seismic zones," says Nakaki. "While this high quality is already expected by designers specifying architectural precast, it can now be supplied for building the seismic system as well."

- Craig A. Shutt

## THE JUDGES SAID...

"This work will advance the precast, prestressed concrete industry by opening new markets in moderate- and high-seismic areas. A key point is that the performance standards not only met but also exceeded all expectations. The benefits of this successful test are only beginning to be seen, with more undoubtedly to come. Showing the world that precast concrete behaves well in a high seismic area will create more widespread use of the product and better, more cost-effective structures overall."