The capabilities for using precast concrete structural systems on the West Coast are being highlighted this summer by the construction of an $87-million, 39-story apartment building in San Francisco. The project is one of several undertaken recently on both coasts by the general contractor using newly proven techniques for developing precast concrete seismic load-resisting systems.

When finished in October 2001, 680 Mission Apartments on Mission Street will be the tallest concrete structure erected on the West Coast in a high seismic zone. The building, standing 425 feet tall, will contain two floors of retail, one floor of commercial office space and 36 stories of apartments. To achieve this height with the restrictive code requirements for seismic design in San Francisco, the general contractor took advantage of the newly developed precast concrete system that features a hybrid moment-resistant frame. The frame provides seismic resistance in both the longitudinal and transverse directions and brings the structure back into alignment after the deformation energy of an earthquake is dissipated in the beam-to-beam connection region.

“This format definitely offers superior seismic performance, and that’s why it was developed and is being used on this project,” says Joe Sanders, project manager for Charles Pankow Builders Ltd. of Altadena, Calif. “The hybrid frame’s ability to control damage is a major improvement over previous seismic design approaches and will have

The 680 Mission Apartments building, a 39-story skyscraper in San Francisco, currently is under construction using a precast concrete hybrid moment-resistant frame for structural resistance. The structural components also serve as architectural cladding. Rendering: Elkus/Manfredi
a dramatic impact on the construction industry worldwide.

**PRESSS Research Was Catalyst**

The structural system results from the culmination of research undertaken with Pankow’s development work at NIST (the National Institute of Standards & Technology) in conjunction with the PRESSS (Precast Seismic Structural Systems) Research Program. The research began in 1990 at various universities and research institutions around the country. It represents a coordinated effort involving members of the academic, scientific and business communities in the United States and Japan.

‘This format definitely offers superior seismic performance.’

The program is sponsored by the National Science Foundation (NSF), the Precast/Prestressed Concrete Institute (PCI) and the Precast/Prestressed Concrete Manufacturers Association of California (PCMAC). Professor M.J. Nigel Priestley of the University of California at San Diego coordinated the research. Pankow also worked with John Stanton of the University of Washing-
	on, who was one of the key researchers in the PRESSS program.

The research and development phases of the PRESSS program culminated in September 1999 with the construction and testing of a five-story building at a 60-percent scale that included five key seismic load-resisting systems (four ductile frames and one jointed shearwall). The key to their success comes from using the joints as a controllable focus for absorbing force and flexing with it, providing an easily inspected and repaired location after a seismic event. In other types of structures, that deformation can occur randomly and at an unknown point, producing time-consuming and expensive inspection and repair processes.

“In recent years, structural solutions that minimize the damage or destruction of the structure itself during a major seismic event have been focused on,” explains Sanders. “But these solutions have been expensive and very complex technologically, making them difficult to build in all but the world’s most sophisticated construction markets.”

The system Pankow adapted for the Mission Apartments consists of a precast concrete moment-resistant frame that absorbs seismic energy in a manner independent of the integrity of the structural members. The post-elastic performance is concentrated in the connection region rather than a structural member. By combining both inelastic and elastic responses, the moment frame shows minimal damage, typically consisting of minor spalling even when tested to a rotation equivalent story drift of 6 percent.

**Reusing Existing Technology**

“Many structures in the past have used the technology of post-tensioning and prestressing strands; they have a long history,” Sanders says. “All we’re doing is marrying the two systems together to create something new and more efficient.” The Mission Apartments are the company’s sixth project using these new design techniques but the first of this substantial size in a high seismic zone. “This project is a quantum leap of the application of the hybrid frame from the structures we’ve previously built with this system.”

Numerous benefits accrue from this hybrid frame. Foremost, in addition to its life safety features, it was more economical. “There are great benefits in general to building a residential building from concrete,” Sanders notes. “It allows the building to be built with lower floor-to-floor heights because of the shallower cross-section. So we achieve the same headroom on each floor with a shorter...
Five Other Projects Use System

Charles Pankow Builders Ltd. has constructed five other projects using the precast concrete hybrid frame being installed in the Mission Apartments building. They comprise:

A three-story New York City parking structure completed in 1995. “That was the first time the components were put together using this principle,” explains Joe Sanders, project manager for Pankow. “It gave us the opportunity to review the details and economics of the system in a low-seismic zone.”

A four-story, 264-car parking structure in Eugene, Ore., completed in November 1996.

A three-story, 1,504-car parking structure at Stanford University in Palo Alto, Calif. “That was our first use in a high-seismic zone using the hybrid moment-resisting frame.”

The West Side Media Center in Los Angeles, a four-story office building under construction. Structural work is finished but architectural interior work is still underway.

An 8-story office building in Daly City, Calif., which currently is under construction with foundation work completed. “The significance of this project is that Daly City sits directly on the San Andreas fault line,” Sanders says. “This project is as close to ground zero in an earthquake as one can get. That will be a real test for how well the system performs—and it definitely will have to perform someday.”

Beams cast for the project are being stored in the precaster’s yard in Corcoran, Calif., until needed to ensure erection moves smoothly and rapidly once the site is ready.

‘Precast concrete is a very city-friendly material and a good approach overall.’

The cost savings becomes greater once the post-earthquake costs are added in, Sanders says. “In steel systems, the deformations can destroy any part of the system, which requires an in-depth inspection following a significant seismic event. This precast concrete system also offers a self-righting force due to the post-tensioning strand. That allows the building to undergo deformation or seismic drift and then restore itself. So the long-term benefits after a seismic event add more savings — and we know there will be a seismic event in this area.”

Several Connection Systems Used

Because of its unique shape and combined functions, the Mission Apartments project actually uses several connection systems. Its shape features a wide base that rises to the 34th floor before narrowing on each side for five more floors, creating what the architect terms “shoulders” on the lower floors. The façade also includes a curving face that added more architectural interest.

The project, which is owned by The Related Companies of California, Irvine, Calif., was designed by Elkus/Manfredi Inc. in Boston with Kwan Henmi Architecture/Planning Inc. in San Francisco serving as executive architect.

To express the unique architectural design on the exterior, the precast concrete structural load-resisting members were designed to serve as the façade cladding as well. This meant that the structural components were cast and finished as architectural precast concrete pieces, killing two birds with
one stone but creating more challenges
in the casting process.

“We have always tried to achieve dual
use of concrete structural components for
façade design as well,” he says. “This
project has a significant architectural
element to it that adds interest and
distinction.” Two finish colors were used
on the precast components, with the
“shoulders” using a darker color than the
rest. All of it features a sandblasted finish,
with components produced by Pankow’s
precasting division.

The building was conceived using a
tubular post-tensioning frame with a
hybrid moment-resistant frame around
the perimeter. But because the building
is not rectangular, several connection
systems were used. The hybrid frame
gains efficiency when frames are long
and join a number of bays, Sanders
explains. In some areas that offered
only one bay, the Dywidag brand
ductile-connection system was used.
In these sections, making up less than
one-quarter of the entire frame, the
components are bolted together rather
than post-tensioned. The first eight
floors, including one level of under-
ground parking, were supported with
cast-in-place shearwalls and moment
frames.

Sleeve System Used

A unique aspect of the post-
tensioning system comes in the way
Pankow handles corners. Rather than
post-tensioning each side separately,
creating two sides that must stressed in
the same space, the company devised
90-degree angled tubes that let the
strands turn the corner and continue
along the adjoining side. This allows
post-tensioning to occur in only two
locations per floor, directly opposite to
each other.

This application will be the first time
the sleeve system has been used in the
field, although Pankow has tested it
past design needs at the University of
Washington, Sanders says. “Stressing
two sides in the same space would have
created an engineering complication,”
he explains. “One of the features that
allows the building to attain the height
it does is that the tube frame remains
uninterrupted around the perimeter of
the building. This tube system allows
us to deal with the corners.”

Mission Apartments also will see the
first application of the frames using grout-
filled columns with splices, he adds. The
other projects the company has created
could use one-piece precast columns from
footing to roof. In a 39-story building,
that was impossible. Instead, the columns
are being cast in two-story lengths and are
locked together with NBM Splice Sleeve
brand connections.

“This system requires a more technical
approach to concrete construction than a
cast-in-place approach would need,”
Sanders says. “But our efforts were
designed to ensure the system was not
too technically daunting so ordinary
craftsmen could accomplish it. Some
technical application is needed in casting
and putting together the elements, but it
is not a technologically complex design.”

That approach, combined with the
significant benefits offered by the
system, gives Pankow great optimism
for the future use of these techniques.
“We see this system potentially
becoming the dominant approach in
many areas,” he says. “We see great
advantages from it. We’ve always
recognized the benefits that precast
concrete provides to the economics of a
project. You can control the cost of the
components much better than with
others that are more volatile; you can
achieve higher quality with factory-cast
components and you can produce a
system that is more economical in first
cost and in the long term. When you add
in the superior seismic performance, it
offers a strong option — especially since
it simply uses existing ideas and
components and connects them in an
innovative way.”

— Craig A. Shutt

For more information on PRESSS
research program, see the Winter
and Spring 2000 issues of Ascent.