

# Successful Testing of PRESSS Five-Story Precast Building Leads to Innovative Seismic Solutions

Reported by

L. S. (Paul) Johal and George D. Nasser\*

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*Preliminary test results indicate that the PRESSS (Precast Seismic Structural Systems) five-story precast, prestressed concrete building has performed very well as predicted.*

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**O**n August 9, 1999, a special PCI/PRESSS Day was held at the University of California, San Diego (UCSD), to view the seismic testing of a five-story precast, prestressed concrete frame and shear wall building. The event was witnessed by over 60 professional, producer and associate members including several industry representatives from around the United States (see Fig. 1).

The testing was carried out at the Charles Lee Powell Structural Laboratory of UCSD, one of the largest structural testing laboratories in North America. The precast, prestressed con-

crete test building measured 30 x 30 ft (9.14 x 9.14 m) in plan and was 40 ft (12.2 m) in height. This size represented 60 percent of a full-scale building in order for the test structure to be properly constructed and tested in the laboratory.

The test building included four different ductile frame systems in the longitudinal direction and a jointed shear wall system in the transverse direction to resist lateral loads. The floor system used in the first three levels was pretopped double tees while the top two levels consisted of topped hollow-core slabs. Several innovative dry connections developed and tested during the first two phases of the PRESSS research program were used to interconnect the various structural

precast components. Even though the test program was designed to test the building under very severe seismic conditions, the results also apply to precast, prestressed concrete structures in all seismic zones.

The morning program comprised presentations on the design, erection and instrumentation details of the test building as follows:

- **Professor Nigel Priestley**, principal coordinator of the PRESSS research program, gave an overview of the PRESSS program from its inception to the present (see Fig. 2). He stated that this project utilizes the Displacement Based Design (DBD) approach, which incorporates more efficiently the unique properties of well-designed jointed precast con-

\* Research Director and Editor-in-Chief, PCI JOURNAL, respectively, Precast/Prestressed Concrete Institute, Chicago, Illinois.





Fig. 1. Over 60 people witnessed the seismic testing of a five-story precast, prestressed concrete building at the University of California, San Diego.

crete construction. Dr. Priestley emphasized that it was necessary to test the super-assemblage for verification of the design and analysis procedures developed in PRESSS Phases I and II. The test would provide valuable confirmation of the excellent seismic performance and low damage possible with properly designed precast systems.

- **Suzanne Nakaki**, one of the primary researchers and designers in the PRESSS program, explained the structural economic benefits derived from using the DBD approach. One major advantage is that the design base shear is reduced considerably as compared to using the currently allowed Force Design Method. The engineer can have better control of the design of the

structure by incorporating both strength and stiffness requirements, thereby obtaining the most economical solution.

- **Sri Sritharan**, assistant project scientist, University of California at San Diego, described the instrumentation, loading and monitoring of the test program. On the day of the test, the loading was being applied in the direction of the shear wall (stiff side) whereas when the frame building was to be tested later, the loading would be shifted orthogonally along the frames in the longitudinal direction. Because the DBD method was being used, displacements at each level of the structure had to be applied delicately so that they would work in unison. Also, because of differential

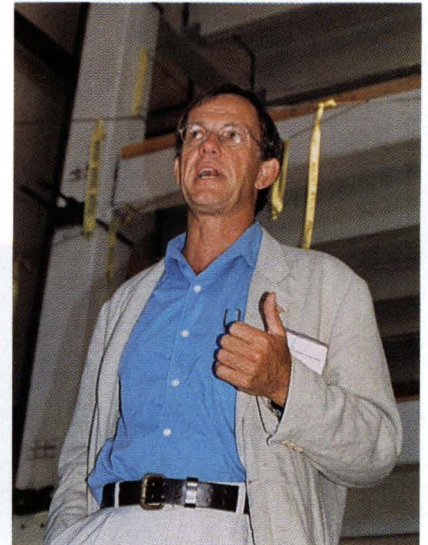


Fig. 2. Professor Nigel Priestley presented an overview of the PRESSS research program as well as the highlights of the building test.

thermal displacements between night and day temperatures, much of the testing was started in the evenings. A sophisticated computer program was used to automatically monitor the displacements, loads and strain measurements.

- **Randy Clark**, Clark Pacific's manager for the construction of the test building, explained the logistics of hauling, handling and erecting the various components of the test building. One major consideration was in ensuring the stability of the structure in a very tight enclosure. For the benefit of the viewing audience, a video tape showed the carefully coordinated steps in the erection process.

The afternoon session included interviews with various PRESSS participants, followed by an industry advisory committee meeting to discuss future plans and programs to maximize the test results and knowledge gained from the test program. The group felt unanimously that during the next couple of years it was imperative for PCI to develop design recommendations, bring about changes in the building codes, and follow this up with the development of design examples and seminars for the engineering profession.

The PRESSS test building was designed to examine questions of design, constructability and performance of





Fig. 3. Hybrid frame under construction.



Fig. 4. TCY frame and wall panels under construction.

five different seismic load resisting systems — four ductile frames and one shear wall system. All five systems had been previously developed in the first two phases of this program and experimentally validated through component tests.

The five seismic building systems tested were:

- Hybrid Frame
- Pretensioned Frame
- TCY Gap Frame
- TCY Frame
- Shear Wall System

Detailed descriptions and cross sections of each of these systems are given in Ref. 1.

The testing of the five-story building was carried out from July to September 1999. Figs. 3 through 8 show various details of the test building.



Fig. 5. Test building is 30 ft wide and 40 ft high (9.1 x 12.2 m).

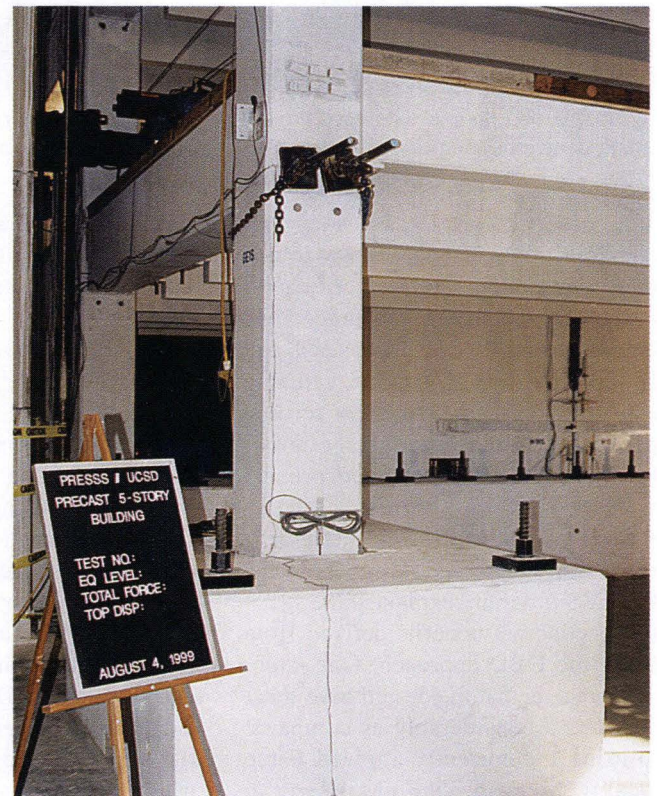


Fig. 6. Anchorage of TCY frame.



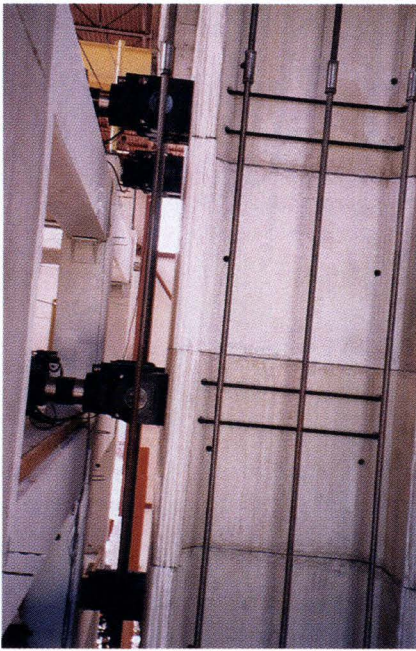


Fig. 7. Loading arrangement for test structure.

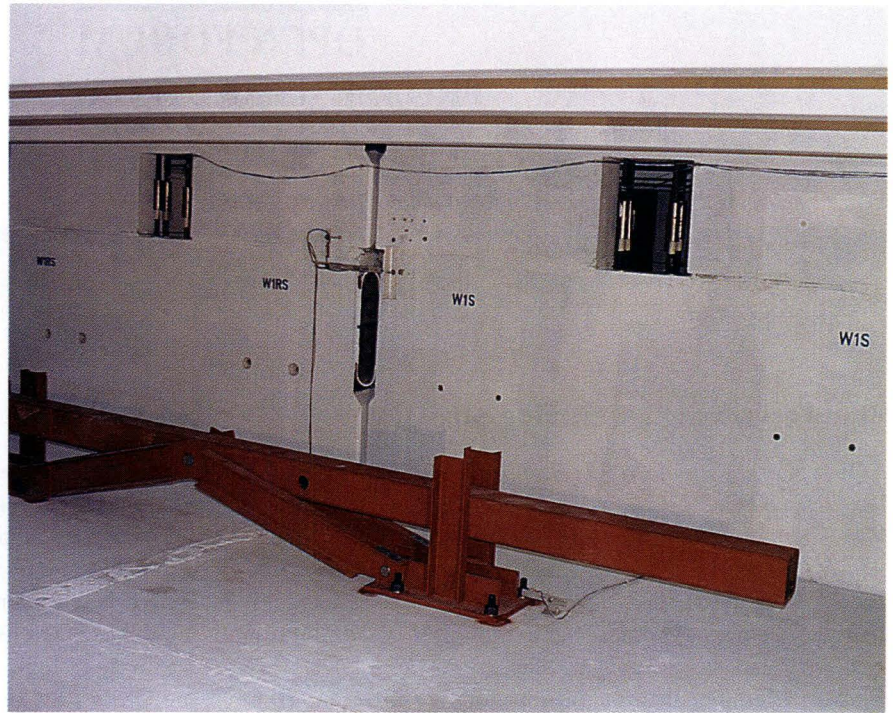


Fig. 8. Jointed shear wall showing U-shaped flexural plate.

The following are some of the preliminary results from the testing program:\*

- The shear wall structure withstood a drift of 2.7 percent, which is substantially greater than code drift limitations.
- The residual displacement at the end of the test was less than 0.3 in. (7.6 mm) with hardly any damage to the building.
- The frame structure was subjected to a maximum inter-story drift of 4.5 percent, with only minor damage at a drift of 3 percent.
- In general, the seismic frames performed very well with the base shear continuing to increase even at the maximum drift. Performance of the prestressed frame was particularly good. Damage to beam-column connections was minimal in all frames.

This research program has validated the use of precast shear wall and frame systems in high seismic regions, and has revealed potential areas susceptible to localized damage. The results obtained from this research will be used to develop design guidelines that emphasize the inherent advantages of precast, prestressed concrete systems in various seismic zones. These guide-

lines can then be incorporated into the various building codes.

A comprehensive report on the design of this five-story test building was published in the March-April 1999 issue of the PCI JOURNAL.<sup>1</sup> A special program has been scheduled on the results of this research for Wednesday, October 20, during the Membership Luncheon at the PCI Convention in Palm Springs, California. It is expected that a detailed report from the primary

researchers documenting the various aspects of the building including test results will be published in a forthcoming issue of the PCI JOURNAL.

## REFERENCE

1. Nakaki, Suzanne Dow, Stanton, John F., and Sritharan, S. (Sri), "An Overview of the PRESS Five-Story Precast Test Building," PCI JOURNAL, V. 44, No. 2, March-April 1999, pp. 26-39.

## MAJOR CONTRIBUTORS TO PRESS RESEARCH PROGRAM

The Precast/Prestressed Concrete Institute (PCI), the Precast/Prestressed Concrete Manufacturers Association of California (PCMAC) and the National Science Foundation (NSF) are the primary sponsors of this research program.

In addition, contributors to the testing program include A.T. Curd Structures, Inc., BauMesh, Co., California Field Iron Workers Administrative Trust, Charles Pankow Builders, Ltd., Clark Pacific, Coreslab Structures, L.A., Dayton Superior, Dywidag Systems International, ERICO, Florida Wire & Cable, Inc., Fontana Steel, Gillies Trucking, Headed Reinforcement Corporation, Horizon High Reach, JVI, Inc., LG Design, Master Builders, Inc., NMB Splice Sleeve, Pomeroy Corporation, Precision Imagery, Spancrete of California, Sumiden Wire and White Cap.

Professor Nigel Priestley, UCSD, the principal coordinator of the PRESS research program, played a key role in providing leadership through all phases of this research. The PCI Ad Hoc Committee on ATLSS (Advanced Technology for Large Structural Systems) and PRESS, chaired by Mario J. Bertolini, the Industry Advisory Group and PRESS researchers provided invaluable guidance throughout the PRESS research program.

\* Personal communication from Dr. Nigel Priestley.