ATC-15-2

3rd U.S.–Japan Workshop on the Improvement of Building Structural Design and Construction Practices

by

APPLIED TECHNOLOGY COUNCIL
3 Twin Dolphin Drive, Suite 275
Redwood City, California 94065

Conducted by

Japan Structural Consultants Association

PROJECT STEERING COMMITTEE

United States	*Japan*
Robert Burkett	Shigeru AOKI
Christopher Rojahn	Hiroyuki AOYAMA
Roland L. Sharpe	Toshiharu HISATOKU
	Hiroshi INOUE
	Yuji ISHIYAMA
	Toshihiko KIMURA
	Yoshio MURATA
	Kenji NAKAGAWA
	Toshio OHKOSHI
	Yukihiro OMIKA
	Masakazu OZAKI
	Kazuo SAIDA
	Tokuyuki TAHARA
	Takayuki TERAMOTO
	Akira WADA
	Shoichi YAMAGUCHI
	Akira YAMAKI

PUBLICATIONS CONSULTANT
Rdd Consultants, Inc.

1989

design program developed by the Beijing Institute of Architectural Design. Twelve drawings show typical design of frames and shear walls. Table 1 compares three designs: Ohbayashi (Japan), Brandow & Johnston (United States), Beijing Institute of Architectural Design (People's Republic of China).

Detailed information is given on: design parameters, including vertical load (dead and live), horizontal earthquake action, vertical earthquake action, and criteria for seismic design; seismic analysis, including story load and story drift, earthquake force (directions X-X and Y-Y), typical design of frame, and typical design of shear wall (flexural design of shear wall, shear resisting design of wall at strengthened portion, amount of longitudinal reinforcement in the boundary column).

Current Construction Practice of Base-Isolated Buildings in Japan

Shoichi Yamaguchi and Akira Wada

The authors outline the history of the concept of base-isolated structures.

about 1889	Kozo Kawai
about 1909	Calantarient (Britain)
1920s	Kenzaburo Kito (patent for an aseismatic device for buildings such that the building foundation and column bases have concave pan-type disks set at opposed positions, a ball bearing being fitted between the disks to support the building)
1920s	Okiie Yamashita (patent providing for structure foundation and column bases to slide to lessen earthquake force transmitted to superstructure)
1927	Taro Nakamura (proposal of method to support building with long piles with a pump-type damper mechanism on the 1st floor)
after 1928	Ryuichi Oka (repeated proposals of base-isolated foundation comprised of floating-type vibration-free column, spherical base planes with a large radius being erected on the foundation slab, and joint on top of columns being located at a height lower than the center of the spherical surface)
1934	Kanzaburo Majima (patent on vibration-free construction—said two-story building could be independently separated and second story supported with low-rigidity columns)
1951	Toshio Otsuki (proposal of device to limit transmitted earthquake force—rollers operable to intersect at right angles are provided in the foundation, which is supported at four sides)
1965	Masatetsu Izumi (paper at 3rd World Conference on Earthquake Engineering, on dynamic structural analysis to isolate the foundation from the superstructure by locking balls)
1964	Senri Katsuta, Tokyo Institute of Technology (study on a vibration-free device utilizing electrical-hydraulic automatic control system)
1982	Hideyuki Tada and Shoichi Yamaguchi designed base-isolated building utilizing rubber bearings
1987	Beginning of application of base-isolated construction to high-rise apartment buildings, office buildings, national laboratories, etc.

The authors believe the recent spurt in base-isolated building design in Japan reflects the wish of architects and structural designers to practice design with greater freedom by avoiding aseismatic issues. Rubber bearings have made this possible: their vertical bearing capacity is high, they have low lateral rigidity and high deformability, and buildings mounted on them oscillate slowly no matter how severely they yield.

Japanese codes regard buildings over 60 m high as high-rise buildings; their dynamic response analysis must be considered during structural design. Although no legal criteria governing the design methods for base-isolated buildings are in force as of the writing of this paper, conventional input levels and criteria equivalent to those for high-rise buildings are used: isolators and dampers are designed to fall within the ultimate deformability based on experimental results.

In January 1987 the Subcommittee of Base-Isolated Structure was established in the Committee of Structure of the Architectural Institute of Japan; five working groups are preparing recommendations for base-isolated buildings:

Working Group 1: Evaluation of Input Earthquake Motion

Working Group 2: Dynamic Response and Structural Design

Working Group 3: General Design Problems

Working Group 4: Example Design

Working Group 5: Mechanical Properties of Isolator and Damper

The 40-member subcommittee is drawn from universities, national research institutes, architects' offices, and contractors. Recommendations were scheduled for March 1989 publication.

Current Practice of Energy Dissipation Techniques Including Base Isolation

Roland L. Sharpe

The use of energy dissipation devices or techniques to reduce the deformations and stresses induced in structures by earthquakes has been extensively studied in the United States over the past decade or more. Passive energy dissipation and base isolation techniques are slowly being accepted by owners and engineers as feasible methods of reducing and controlling building and structure response during earthquakes.

For superstructure energy dissipation, systems are currently under study for: mechanical damping with viscoelastic materials, friction dampers, and flexible metal plates.

A variety of base isolation concepts are being studied: high damping rubber bearings, rubber bearings with lead core, rubber with Teflon and steel plates, high damping rubber with uplift control, earthquake barrier system (friction surfaces, flexural hysteritic control beams, hydraulic dampers, Neoprene limit stops), elastomeric bearing with displacement control, friction pendulum system.

After outlining design requirements drawn up by the Structural Engineers Association of Northern California (SEAONC) for seismic isolation, Sharpe comments that many innovative systems are under development, and several appear feasible, although no one system now has all the optimum characteristics. Sharpe provides 16 figures, and 14 references (all United States).

Current Modeling and Analysis Methods by Computer: High-rise Case Study

Navin R. Amin, Hamed Fatehi, and Peter Lee

Using San Francisco's 42-story Five Fremont Center Project as a case study, the authors compare the dynamic analysis of this building with three other San Francisco projects: 388 Market St. (triangular project site), California Center (stiffness in long, but not short direction), 333 Bush St. (several setbacks in upper portion of building). The authors state that for complex structures, the use of computer software and hardware capabilities has proven invaluable in the dynamic analysis and design of these structures. The stated purpose of this paper is to highlight those methods that aid the engineer in achieving such analysis and design.

In Computer Modeling, the authors discuss scope, programs, and structure idealization.

The Analysis Methods explain the following as performed on the tubular frame for the Five Fremont Project: Linear Elastic Static Analysis; Linear Elastic Design Response Spectrum (LEDRS) Analysis; Inelastic Design Response Spectrum (IDRS) Analysis; and Static and Dynamic P-Δ Analysis.

Analysis and Design Criteria are presented in Figure 8 and in a short discussion. The Discussion of Results is briefly discussed and graphically presented in Figures 9–15.

Comparative Study Results describe the 4 buildings and graphically display the analysis in Figure 16.

Thirteen U.S. references are cited in the bibliography.