Figures 18 and 19 show the sectional view of retrofitted buildings and the close-up sketch at a base isolated foundation.

The expected seismic performance was calculated through three dimensional earthquake response analyses and it was confirmed that the maximum response of the superstructure remained within the elastic range

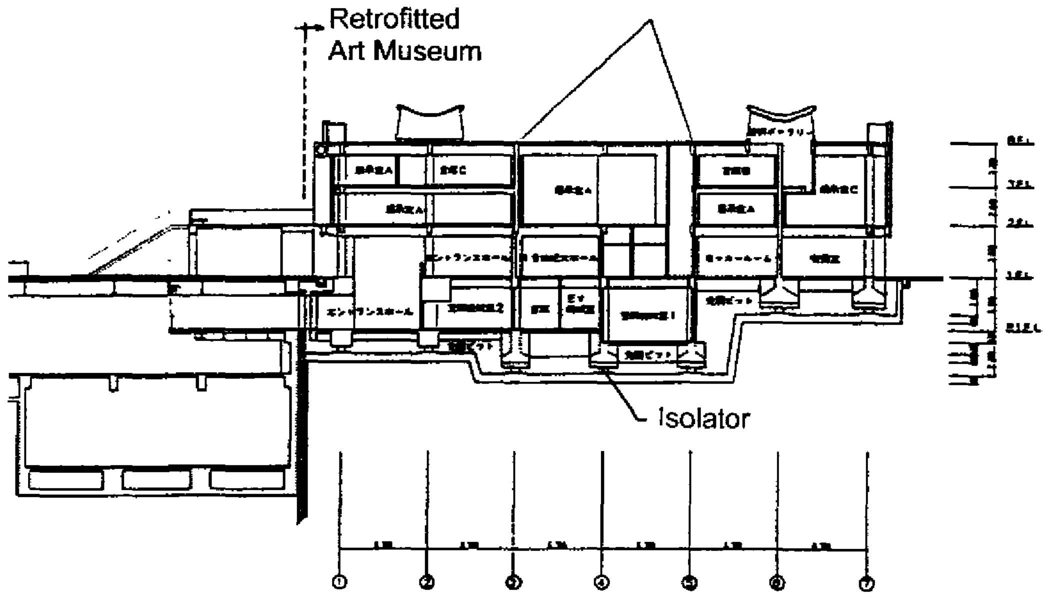


Figure 18. Sectional view of base isolated building[4)]

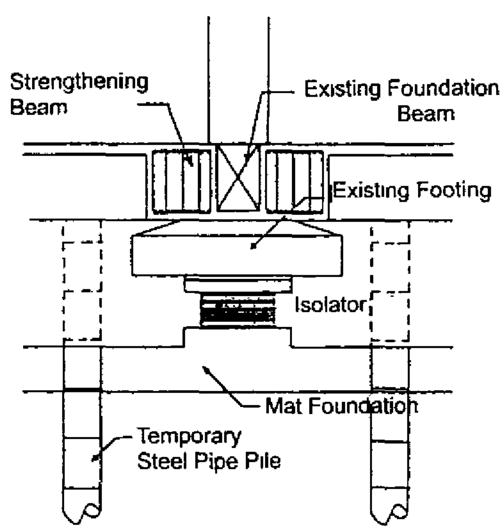


Figure 19. Close-up view of isolator[4)]

Figure 20 shows another example which was retrofitted with seismic isolators installed in columns of mid-story. This building consisted of two wings: the main building with 16 stories and the east wing with 7 stories. The main building was retrofitted with seismic isolation technique at mid-story as shown in Figure 21 while the other was retrofitted with base isolation technique. Figure 22 shows the retrofit procedure of mid-story isolation.

Earthquake responses to artificial earthquakes simulating expected near-field earthquakes in addition to famous earthquake records which have been often used in the seismic design in Japan were calculated and it was confirmed that the expected maximum responses were below the capacity.

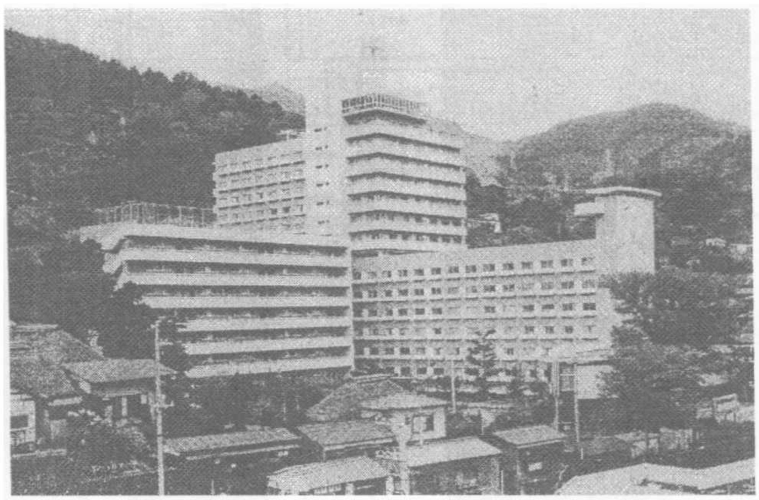


Figure 20. General view of retrofitted building with seismic isolator at mid-story[4)]

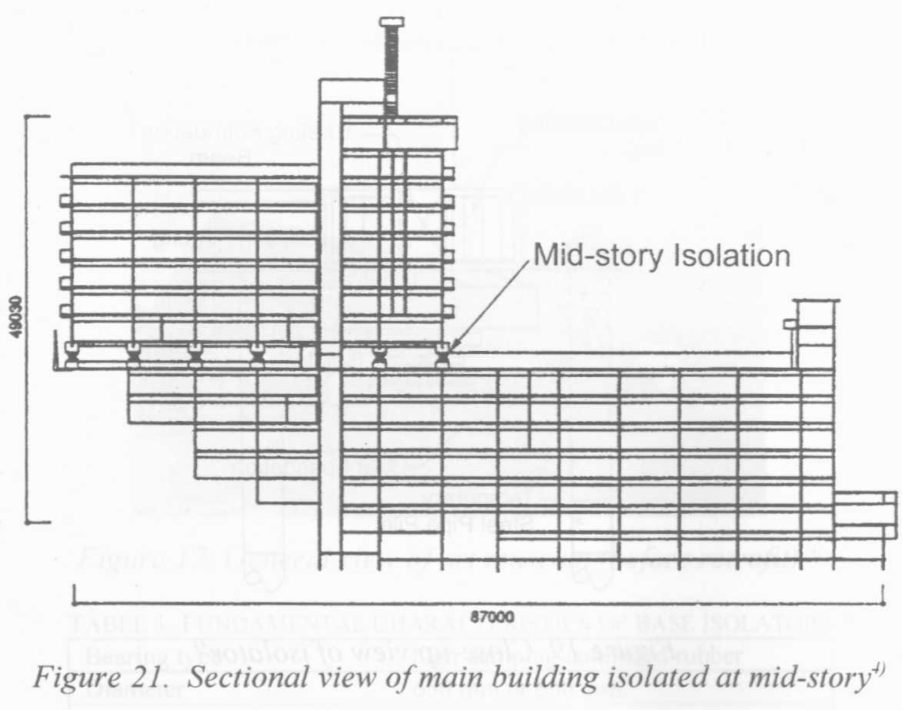
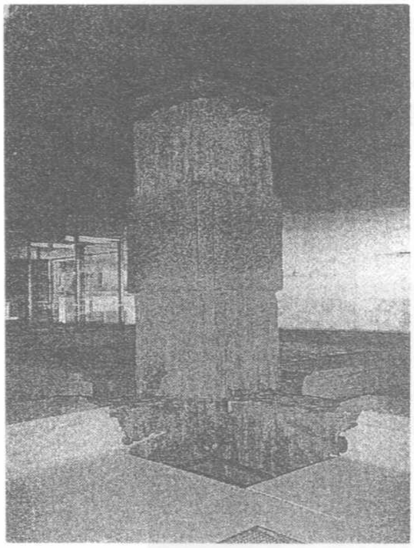
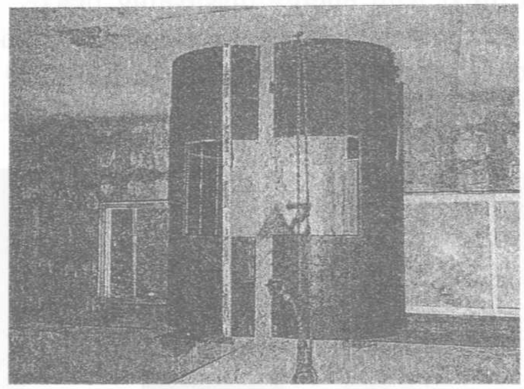


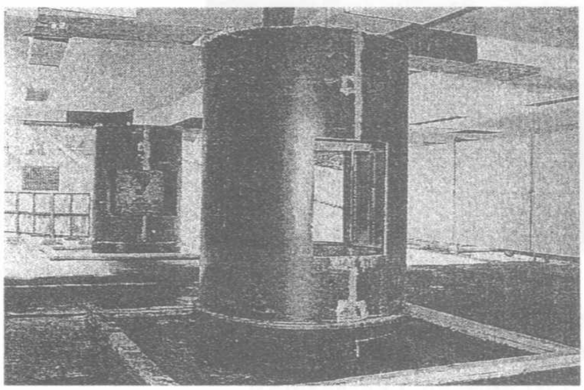
Figure 21. Sectional view of main building isolated at mid-story[4)]



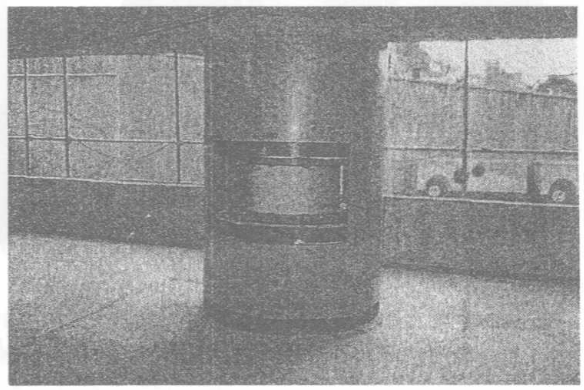
(1) removal of finishing



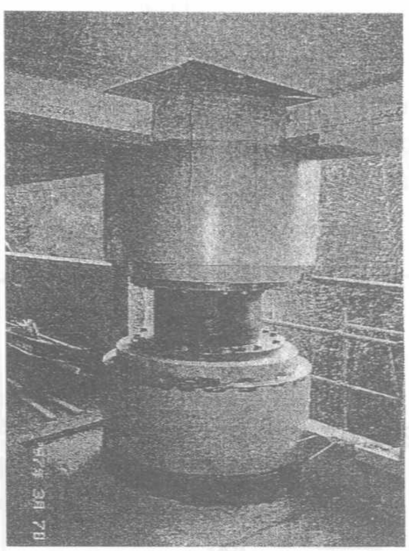
(2) installation of temporarily supporting steel pipe



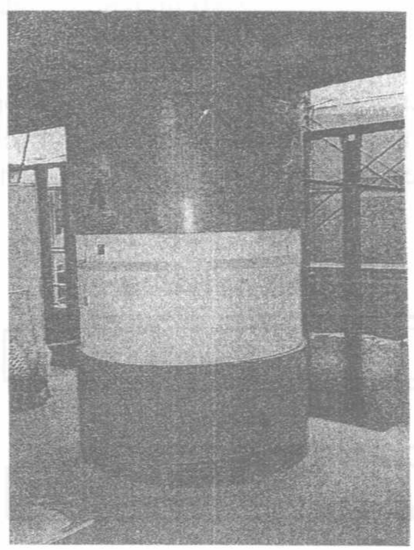
(3) cut-off of exiting column at mid-height



(4) installation of isolator



(5) cut-off of steel pipe



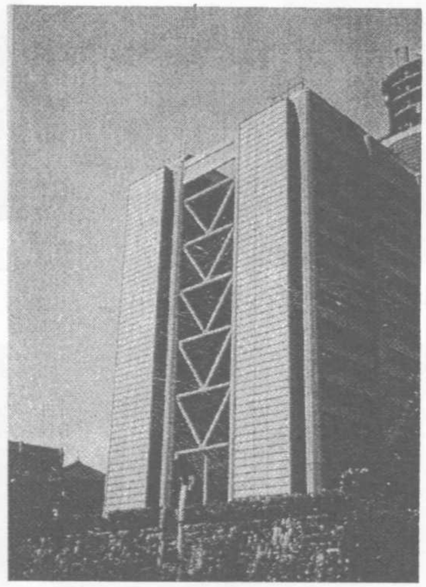
(6) providing fire protection

Figure 22. Retrofit procedure of mid-story isolation[4)]

Energy dissipating braces

Figure 23 shows a local governmental office which is planned to be retrofitted with energy dissipating braces. The bracing system consists of low strength mild steel and buckling restrainer. The mechanical properties of low strength steel are shown in Table 2.

(before retrofit)



(retrofit plan)

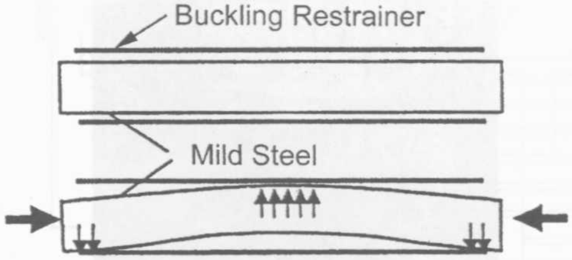
Figure 23. Retrofit plan of a local governmental building[4)]

TABLE 2. MECHANICAL PROPERTIES OF LOW STRENGTH STEEL

Strength (N/mm^2)*	70 to 120
Elongation (%)	More than 50

* 0.2 % off-set strength

Figure 24 shows the load-deflection relationship of the bracing system. Since the outer restrainer prevents buckling of inner steel, stable hysteretic characteristics and large energy dissipation can be achieved.



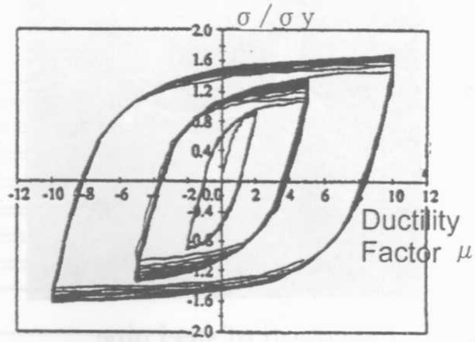


Figure 24. Load resistive mechanism and load-deflection relationship of bracing system[4)]

4. CONCLUDING REMARKS

Seismic retrofit techniques recently developed or applied in Japan were presented. What governs the seismic performance of retrofitted structure is smooth transfer of actions from retrofit element to existing members. In conclusions, the author strongly wishes to point out the importance of structurally rational design of connection details and construction works through appropriate workmanship for sound seismic performance during real earthquakes.

ACKNOWLEDGMENTS

The author gratefully acknowledges Dr. K. Kusunoki, research associate of the Institute of Industrial Science, University of Tokyo, for his great assistance in preparing this report.

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