

**USA.** There was only 1 application of passive energy dissipation to US buildings at the time of the seminar [51], namely to a two-story r.c. structure in downtown San Francisco. However, a second retrofit project of this kind was also underway for a 13-story building in San Jose, and a third was being considered for the seven-story Travelers Hotel in Sacramento.

Examples of applications of oleodynamic systems (which provide provisional restraints during of strong earthquake motions) to structures other than bridges and viaducts were reported at the Capri Seminar only for Italy [13, 19], the first was in 1985, to the second Fire Station Building at Naples (which, in Table I, has been included among seismically isolated building, because it is also supported by neoprene bearings), and three further applications were the retrofit to the Collegiate of S. Giovanni Battista in Carife, construction of an industrial building of FIAT at Melfi, and use in the new ENEL Directional Center at Naples (where the main system is formed by energy dissipation devices).

However, the actual number of buildings provided with oleodynamic systems in Italy — even excluding the first and last cited above — is somewhat larger (10) than that reported at Capri: in fact, such systems were also used in a second FIAT Industrial building at Prato La Serra (Molise), the Sport Hall at Rimini, the Faculty of Engineering at Brescia, hangars at Bologna and Torino Caselle airports, and the Turbine and Thermal Cycle Buildings of Montalto di Castro Power Station [13].

### **2.5.2. Industrial structures**

Similar to seismic isolation, among the civil buildings provided with energy dissipation or oleodynamic systems which were mentioned in the previous sections, some may also be regarded as applications to non-nuclear industrial structures. In addition to these, however, only 1 more application, related to oleodynamic systems, is known [13]: this is to a large water supply pipe at S. Giacomo (Abruzzo) in Italy.

Active control of vibrations aims at suitably modifying the dynamic response of the structure by means of controlled input of artificially generated energy. Practical applications are hybrid, because there is a simultaneous combination of tuned mass dampers and actuators which provide external forces. The only structures using active/hybrid control systems which were reported at the seminar are located in Japan. There, starting in 1992, active/hybrid mass damper systems had already been applied to 9 buildings, which include 5 high-rise buildings (more than 100 m high) in Osaka, Tokyo and Yokohama; further 7 or 8 buildings were under construction or design [52, 53]. Because the main purpose of the aforesaid applications was control of wind-induced vibrations, their number has not been included in Table I.

## **3. REMARKS ON DESIGN GUIDELINES, CODES AND STANDARDS**

As clarified in PS 3 and by previous contributions, the first recommendations for design and construction of isolated structures were published in New Zealand in 1979.

Afterwards, considerable design guidelines development activities were performed in the USA. In 1989 SEAOC published specific codes for buildings as an appendix of Recommended Lateral Design Requirements and Commentary (Blue Book), which were later implemented in the 1991 version of Uniform Building Code (UBC). With regard to bridges, in 1990 AASHTO adopted as standards its 1983 Guide Specifications. For nuclear reactors, design guidelines covering the case of horizontal isolation systems using HDRBs were jointly developed by GE Nuclear Energy and ENEA (Italy) and were published in a tentative form

in 1990; work is continuing in the framework of both cooperation with Italy and activities of the American Society of Civil Engineers (ASCE).

In Japan — where applications of seismic isolation to buildings began relatively late — design guides for such structures were only recently published; however, guidelines have also already been drafted for isolated nuclear reactors. All seismic isolation applications are still regarded as "innovative methods", thus they still require a special procedure for approval by the Ministry of Constructions.

In France, a recommendation for guidelines for isolated structures was published by AFPS in 1990.

In Italy, existing codes for bridges and buildings do not cover seismic isolation nor other innovative systems, yet. As to bridges, however, "Società Autostrade" published specific recommendations in 1991. For buildings, two guidelines documents have been tentatively proposed to allow for a broad review from experts: the first, prepared by the National Seismic Survey in 1992 to 1993 with the co-operation of ENEA, ENEL and ISMES, concerns isolated building; the second, prepared by a specific Working Group of the National Standards Authority (UNI) focusses on the design, use and control of innovative antiseismic devices. Finally, the ENEA/GE proposal for isolated nuclear reactors was updated and is being extended to isolators other than the HDRBs in the framework of a CEC funded project.

Most above-mentioned guidelines, recommendations and standards require the use of two seismic design levels. A lower level characterized by relatively short return period (OBE for nuclear reactors), for which structural elements shall remain elastic, and a higher level characterized by long return period (SSE for nuclear reactors), for which non-linear response is permitted. Requirements are given as to the evaluation of low frequency energy content of design earthquakes, which is an essential topic for an adequate design of isolated structures.

For buildings having a limited height and for which specific rather stringent requirements are satisfied, the tendency is to permit the use of simplified calculation procedures in the design. Anyway, in all guides the use of dynamic analysis based on floor-response spectra or step-by-step direct integration methods is encouraged. For modal analysis, approximated methods, based on modification of design spectral values, are proposed to evaluate the effects of larger dissipative effects caused by isolation and energy dissipation devices.

At the time being, recommendations and guides for structures using innovative antiseismic devices are frequently much more severe (e.g. in the USA ) than design rules applicable to conventionally founded constructions. This feature is certainly understandable when technology is still in an early development stage; however, according to the already achieved demonstration of reliability of seismic isolation, the confidence was expressed by most experts at Capri that about an alignment of codes for fixed-base and isolated structures will be soon possible, so as to reduce the unnecessary degree of conservatism that is currently present in the design of isolated structures, and to allow the economic use of this technology.