

## SUMMARY OF THE SEMINAR

### INTRODUCTION

According to the seminar purposes, presented at Capri were overviews on the activities in progress and future programmes, the state-of-the-art of applications and designs, codes and standards, research and development and observations of behaviours of structures under actual dynamic loads. An exhibition concerning innovative antiseismic devices developed and applied in Italy was held in parallel to the seminar; it was organized by ACEDIS and lasted the whole duration of the seminar.

The countries and international organizations which participated in the seminar were Brazil, Bulgaria, Canada, Chile, China, France, Germany, Greece, India, Italy, Japan, Mexico, New Zealand, Portugal, Republic of Korea, Russian Federation, South Africa, USA, and the International Atomic Energy Agency and Commission of the European Communities. 138 participants took part in the seminar.

### SEMINAR SESSIONS

The seminar consisted of six Technical Sessions (TS), four Panel Sessions (PS) and one Video Presentation Session. Two Technical Sessions (TS 1 and TS 2) and the following Panel Session (PS 1) mainly dealt with isolation of industrial buildings and bridges from seismic and non-seismic vibrations; one Technical Session (TS 3) was devoted to seismic isolation of nuclear facilities and one (TS 4) to seismic isolation of non-nuclear industrial structures, together with one Panel Session (PS 2) regarding both items; two Technical Sessions (TS 5 and TS 6) dealt with passive energy dissipation and active/hybrid control; finally, one Panel Session (PS 3) was devoted to design guidelines and one (PS 4) to general conclusions.

### DISCUSSIONS AND CONCLUSIONS

**Seismic isolation of civil structures:** The full maturity of seismic isolation for applications to both new and existing civil constructions (bridges, viaducts and buildings) was confirmed. Most experts agreed that the studies performed and large number of ascertained applications existing in several countries (more than 150 to bridges and viaducts and more than 380 to buildings) have already provided all the necessary information on isolators and isolation systems, thus, that it is now necessary to proceed to an extensive application, to bridges, viaducts and important buildings at least.

In particular, there are no more doubts about the sufficient durability of rubber isolators, which was a major concern until recently. Indeed, both accelerated aging tests performed in various countries and tests on naturally aged bearings confirmed that rubber bearing lifetime of at least 60 to 80 years may be assured, which is not shorter than the usual lifetime of structures (Japanese accelerated aging tests showed that bearings should maintain acceptable characteristics even for more than 100 years). According to this result, replacement feasibility of bearings has been judged no more necessary in New Zealand, where a long experience of use of rubber bearings exists (although in the other countries such a feasibility has still to be ensured).

An extensive application of seismic isolation to residential houses also, might be restrained by usually higher construction costs, with respect to those of conventionally founded structures. However, a complete economic balance (taking into account costs related

to possible uninhabitableness periods and the necessary repair of the structural and non-structural elements) might be frequently favourable to seismic isolation in this case also; furthermore, the higher construction costs might be easily recovered, in the case of rental buildings, by somewhat higher but still acceptable rents, and advantage could be taken in the future from lower insurance costs. Finally, low-cost seismic isolation systems, similar to those in use in China and in the former USSR, might be adequate for such applications.

Among others, it was mentioned by Japanese experts during the seminar that seismic isolators, if adequately designed, were proven to be in some cases effective to reduce the effects of non-seismic vibrations also (for instance, those due to traffic).

Most experts agreed that the only problems to take care of in the application of seismic isolation are those related to seismic input, the quality of isolators, the effects on the design of inner equipment and the exact definition of roles, especially as far as maintenance is concerned.

The importance of providing isolated structures (as well as structures using other innovative antiseismic techniques) with adequate seismic monitoring systems was stressed, because increasing information on the actual behaviour of such structures in earthquakes is essential to support development and extension of the new techniques, to high risk plants also.

Finally, the need for an alignment of codes for fixed-base and isolated structures was judged feasible and urgent, 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.

**Seismic isolation of nuclear plants and other industrial facilities:** Seismic isolation seems now mature enough for a wider use in the industrial field as well, like for high risk facilities (in particular, but not only, nuclear structures), electric equipment, other sophisticated strategic or valuable components, and tanks. However, great care must be paid to issues mentioned above, and some more applications are needed, with respect to the few already existing, in order to fully confirm the aforesaid conclusion: the ascertained numbers of such existing applications are only 14 for non-nuclear facilities (in addition to some buildings which may be regarded as industrial structures), and 14 for nuclear structures. Anyway, there was a general consensus of opinion at the seminar that a large number of applications will be soon available.

With regard to nuclear structures, confirmed was the great interest in an extended use of seismic isolation not only in reactors, but also in other nuclear facilities (like spent fuel element pools, reprocessing plants, etc.); in spite of the only few nuclear applications existing to date, important projects or researches have been developed in several countries. The reasons for the aforesaid interest are both the increased safety and overall reliability achievable, and economical reasons, including the possibility of keeping standard designs for construction in highly seismic countries also.

In addition, stressed at Capri were the advantages of a possible wide application of seismic isolation to other high risk plants, for instance to allow for a correct antiseismic construction or retrofit of some chemical facilities, for which only very few, but very encouraging, applications already exist.

Finally, all agreed on the need for solid international cooperation, especially for the nuclear applications.

**Passive energy dissipation and provisional restraint of civil and industrial structures:** Particularly for passive energy dissipation, recognized at Capri was the need for and the interest in further R&D, before undertaking an extensive use of this technique in structures other than bridges and viaducts. Indeed, while in the latter the ascertained number of applications was already significant (more than 90, although mostly in Italy), for buildings only 18 applications were reported, and for industrial plants none.

The aforesaid conclusion was reached according to the very promising features of passive energy dissipation systems, but also taking into account that some doubts still remain, especially on design methodologies.

A similar conclusion applied to oleodynamic systems, for which even lesser applications were reported at the seminar (about 40 for bridges and viaducts, 10 for buildings and only 1 for large industrial components).

**Active/hybrid control of structures:** Active/hybrid control of vibrations — for which 9 important applications already existed in Japan — was judged to be quite an interesting technique, but it was recognized that its purpose must be limited — at the time being, at least — to ensure comfort in moderate earthquakes and especially protection from wind loads, more than seismic safety, for which the technique is still too costly and not reliable enough (also due to the use of complicated equipment and need for quite a large power).