Special Session on Experience Sharing around the French Practical Approach of Seismic Security Engineering and Risk Management

Two Examples of Overall Seismic Security Engineering

Strategic Elements for Crisis Management in Seismic Situation: Choice of the Needed Public Buildings & Connections in-between (Emergency Itineraries); Seismic Base-Isolated Buildings & Bridges as an example of Seismic Designed Structures & Equipment for Strategic Buildings & Infrastructure of Transport

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ABSTRACT: After 1989 Loma Prieta quake (San Francisco), the concept of "Strategic Elements" was born in France and Europe, with an additional safety factor γ_I = 1.4. The 20 years feed-back of application of such regulations, together with additional requirements for the equipment and facilities, lead, more and more, to an economically justified quasi-elastic conceptual design, for both bridges and buildings. Base-isolation concept is already applied to long bridges for thermal considerations. The association of special powerful dampers with elastic bearings is used in order to reduce the seismic loads in a quasi-elastic manner.

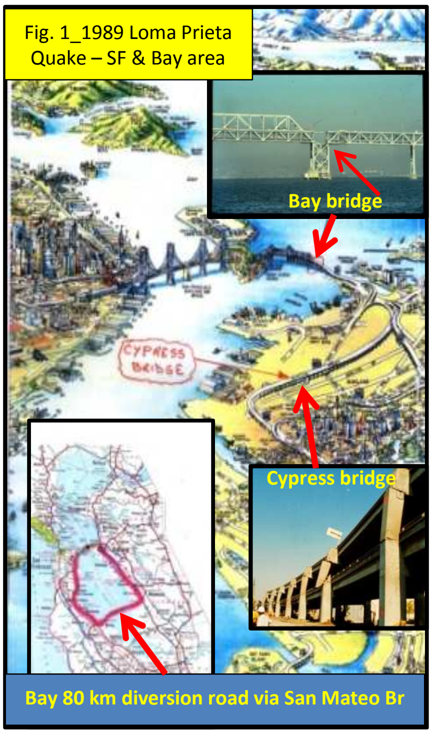
The application of the same concept to strategic buildings might also offer many advantages for sensitive equipment and facilities, such as: higher mastering of the seismic effect; possibility of prototype-design; sensitive reducing of cost: advantages which largely compensate an eventual higher civil works cost of about 4 to 9%.

The concept is already applied in high risk industrial plants in France as well as in many cases in Japan and USA.

1. INTRODUCTION

Bridges have always been supposed to be correctly designed for gravity loads and considered as not sensitive to earthquake, according to the feedback. In France, in seismic areas, they usually were calculated for a horizontal static acceleration of 0.1g. The 1989 Loma Prieta quake (San Francisco area) did not contradict such a supposition but showed the hyper socio-economic incidence on the whole Bay Area of a very limited damage to the Bay Bridge (Fig. 1) and the collapse of the Cypress bridge, over 2 km (≈50% of its total length). That was the beginning of a new reflection on bridges in France and Europe (but not only): 'important" bridges have to be designed for a much higher safety factor than ordinary constructions. The 1994 Northridge quake (San Fernando & Los Angeles) and the 1995 quake (Japan) confirmed such a view shortly after.

Fig. 1_1989 Loma Prieta Quake – SF & Bay area



The concept of Strategic Elements (not only bridges, but itineraries, hospitals, Elements of Crisis Management, etc.) was then born, followed by the differentiation of other structures, by the use of an "importance factor γ_I" depending on the number of its frequent users and its operative and social function. The current values of γ_I are 0.8 – 1 - 1.2 (for current structures) and 1.4 (for strategic elements).

Such an approach gives enough indication for the design of Strategic Elements. The 20 years feed-back of application of such regulations, together with additional requirements for the equipment and facilities, lead, more and more, to an economically justified quasi-elastic conceptual design, for both bridges and buildings. A brief description of the concept follows.

2. CHOICE OF NEEDED PUBLIC BUILDINGS AND CONNECTIONS IN-BETWEEN (EMERGENCY ITINERARIES)

The list of needed strategic services in seismic situation can easily be dressed. Such services include those providing the preliminary supplies such as water, electricity and information net; those necessary for crisis management such as public security services (fire-brigades or emergency-brigades, etc.), or forces, hospitals and their access roads from damaged areas (itineraries), etc., and those in connection with the commandment and decision making process.

For the new strategic structures, the seismic extra-cost can be less than 3-5% thanks to a proper seismic design. All structures in connection with such services might be designed as strategic element.

The question is quite different when thinking about the existing such buildings to be upgraded. Should the upgrading concern all existing hospitals and roads network, or only a few one considered as strategic structures or equipment? The optimized answer is surely the second one, but in this case, which roads and which hospitals to be selected, and by whom? The optimized reply must be elaborated through a technical multi-discipline Scenario-Study, prior to designation of Strategic Buildings.

Such a study consists on supposing that the event just arrived and then imagine what must work (control-command process and center, radio and television for public information, etc.) in order to dress a hierarchy of what must be done. The questions to answer are the following:
i) Positioning of main concentrated risk-centers (number of hyper-vulnerable buildings times concerned population /m2) according to seismic feedback (Fig. 2)
ii) Positioning of nearest hospital to each (either existing to be upgraded, or new one to be built) to be qualified as Emergency-Hospital and of the nearest Emergency-Brigade (Fig. 3)
iii) Definition of the strategic itineraries as linking the emergency-brigades to the damaged areas and then to the emergency-hospitals (Fig. 3)
iiii) All that, with consideration of the problem of contiguous-risk-creating buildings, which is not correctly answered yet.

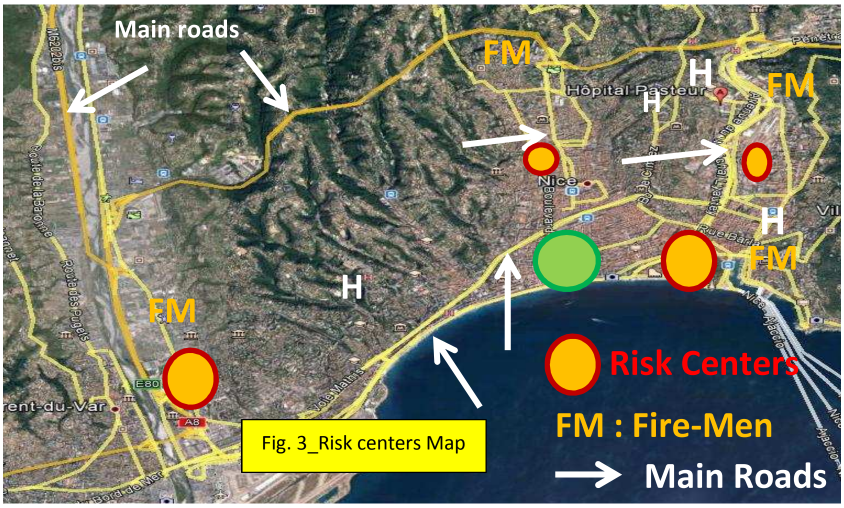
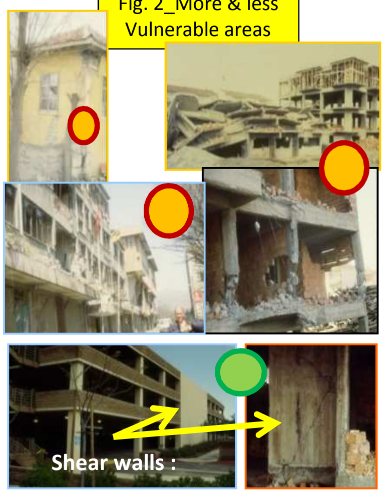


Fig. 3_Risk centers Map

Fig. 2_More & less Vulnerable areas


Today, there is no structural problem for building or upgrading very high-safety structures. In Los Angeles, both seismic-isolated Crisis Commandment new building (Fig. 4) and San Fernando reinforced masonry upgraded Emergency Hospital (Fig. 5) withstood perfectly the quake.

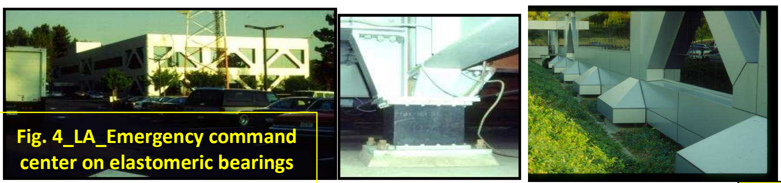


Fig. 4_LA_Emergency command center on elastomeric bearings


Fig. 5_LA_Masonry upgraded emergency hospital

3. CONCEPTUAL DESIGN FOR STRATEGIC BRIDGES

The cultural design of bridges in France corresponds to very long continuous bridges for new freeways and high-speed rail-roads. For such bridges, elastic or sliding special bearings are necessary for thermal displacements, while the plastic-hinge seismic approach is based on the concept of deck-piers continuity. The irregularity in transvers direction, due to the necessary variation of length of different piers, is another complication in the way of using the classical plastic-hinge seismic approach.

The concept of special devices has then been developed first by association of elastic neoprene-rubbers with external powerful dampers, then by elaborating real special devices for seismic design.

The principle of such a device by using a “perforated piston-silicone gum box” device is shown (Fig. 6). For long-slow displacements (thermal), the silicone gum acts as a fluid going from one side of the piston to the other through holes. For shock-type actions (earthquake), the gum acts as an elastic solid. The continuity between piers (support of the gum box, let say) and the deck (support of the piston) is then guaranteed. Both elasticity and damping ratio of the gum can be adjusted. A damping ratio of 20% can easily be obtained. The concept is already used in France for high-speed train rail-road and unusual FW bridges (Fig. 7).

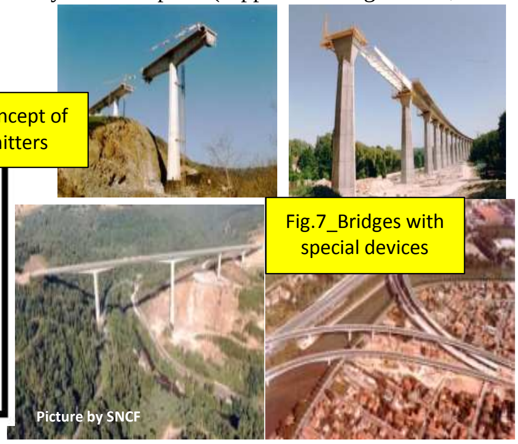


Fig.7_Bridges with special devices

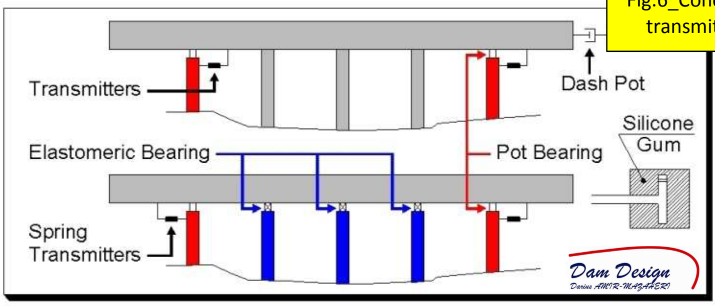


Fig.6_Concept of transmitters

There can be significant energy dissipation by high damping. The system has a quasi-elastic behavior, with the very advantage of reversibility; the transmitters can easily be changed.

4. EXTRAPOLATION TO CONCEPTUAL DESIGN FOR STRATEGIC BUILDING

Elastomeric bearings have already been successfully used in France for nuclear reactor buildings since 1960ties, either for thermal and pressure displacement gap (graphite-gas reactors, Chinon, St Laurent, Bugey) or seismic isolation (Cruas, 1980ties).

With the recent evolution of the information and communication technology, the use of such concept on strategic buildings became more and more appropriate, mainly because of its incidence on equipment and facilities: the old communication net, essentially wire-cable components (Fig. 8, San Francisco Telephone center in 1989), was proved not very sensitive to earthquake as well as other classical equipment. But the new system, essentially wireless, is based on computers and other high-technology machinery for which new requirements on matter of frequency and seismic displacement govern.

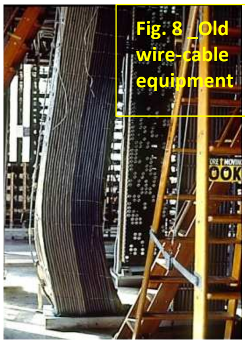


Fig. 8_Old wire-cable equipment

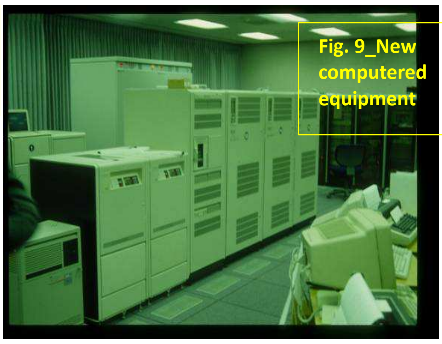


Fig. 9_New computered equipment

With elastomeric bearings, the building has a quasi-perfect mono-modal translational seismic behavior, without any rotation on its basis (Fig. 10). As a result, its response-spectrum has a quasi-harmonic shape (Fig. 11) and is almost the same for all floors.

The only “dangerous” frequency of the structure f_0 is governed by bearings characteristics and can easily be adjusted once forever. f_0 is the only value to avoid for the equipment which can be designed, in a prototype logic (if useful), for a very reasonable acceleration value. As an elastic concept, the system is perfectly reversible with a very low degree of damage in seismic situation.

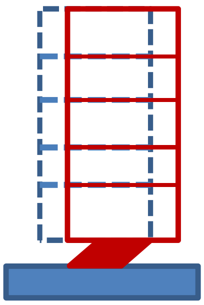
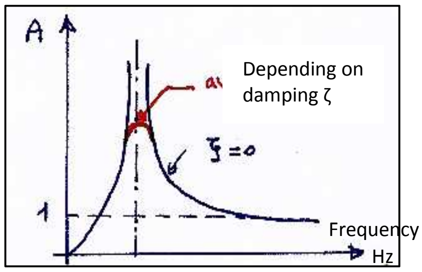


Fig. 10_Mode Shape & Seismic displacements & Accelerations



$f_0 = (K_{bearings}/M_{building})$ /

Fig. 11_Quasi-Harmonic type Response Spectrum - all floors

5. CONCLUSION

For bridges, base-isolation system seems an almost natural way for seismic protection. For strategic buildings, it offers also advantages for sensitive equipment, such as higher mastering of behavior in seismic situation; possibility of prototype design; sensitive reducing of cost. Advantages which largely compensate an eventual higher civil works cost of about 4 to 9%.