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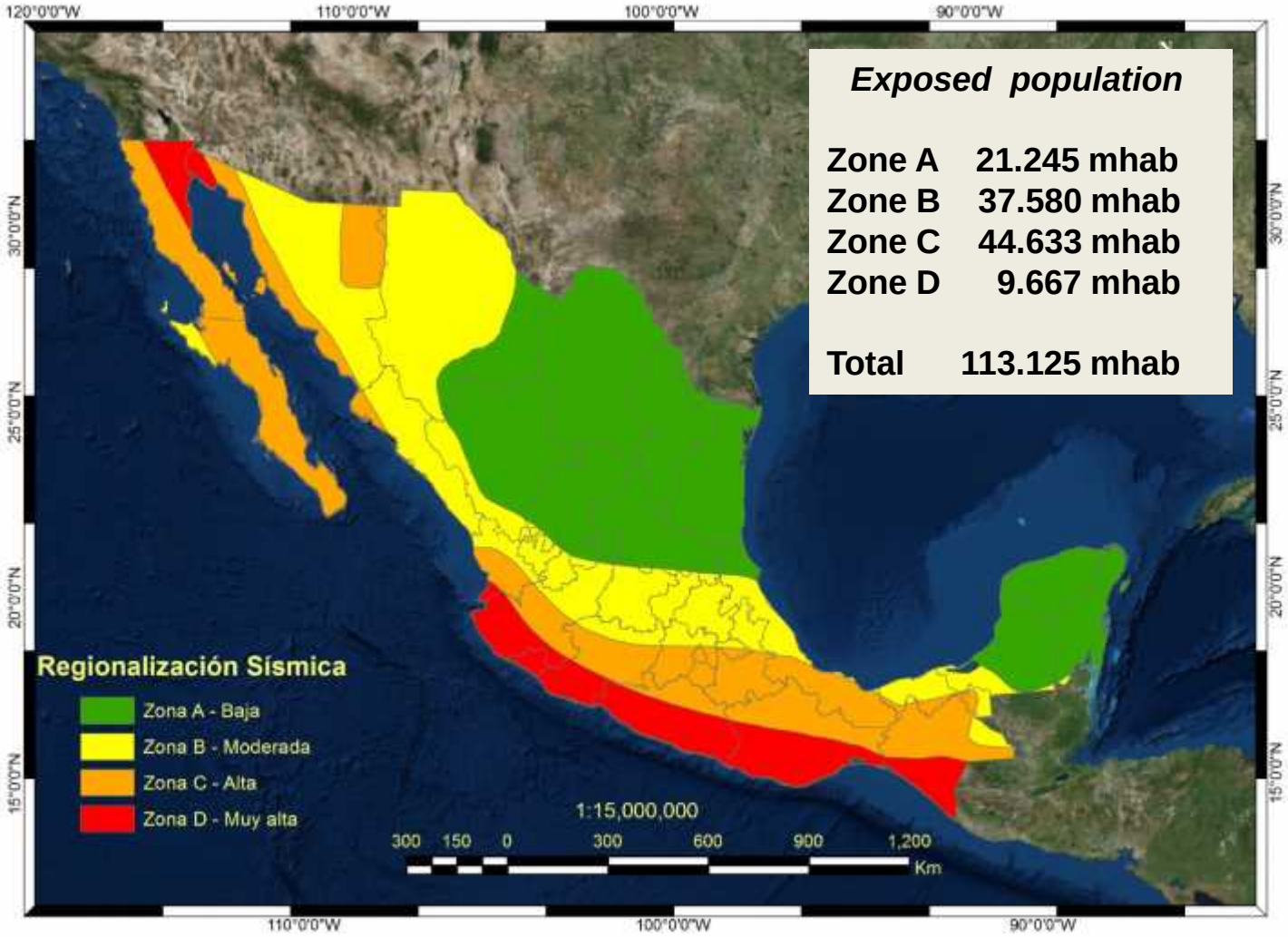
Development of a building-design code for hospitals in Mexico

October 2017

Seismic regionalization by Federal Commission of Electricity

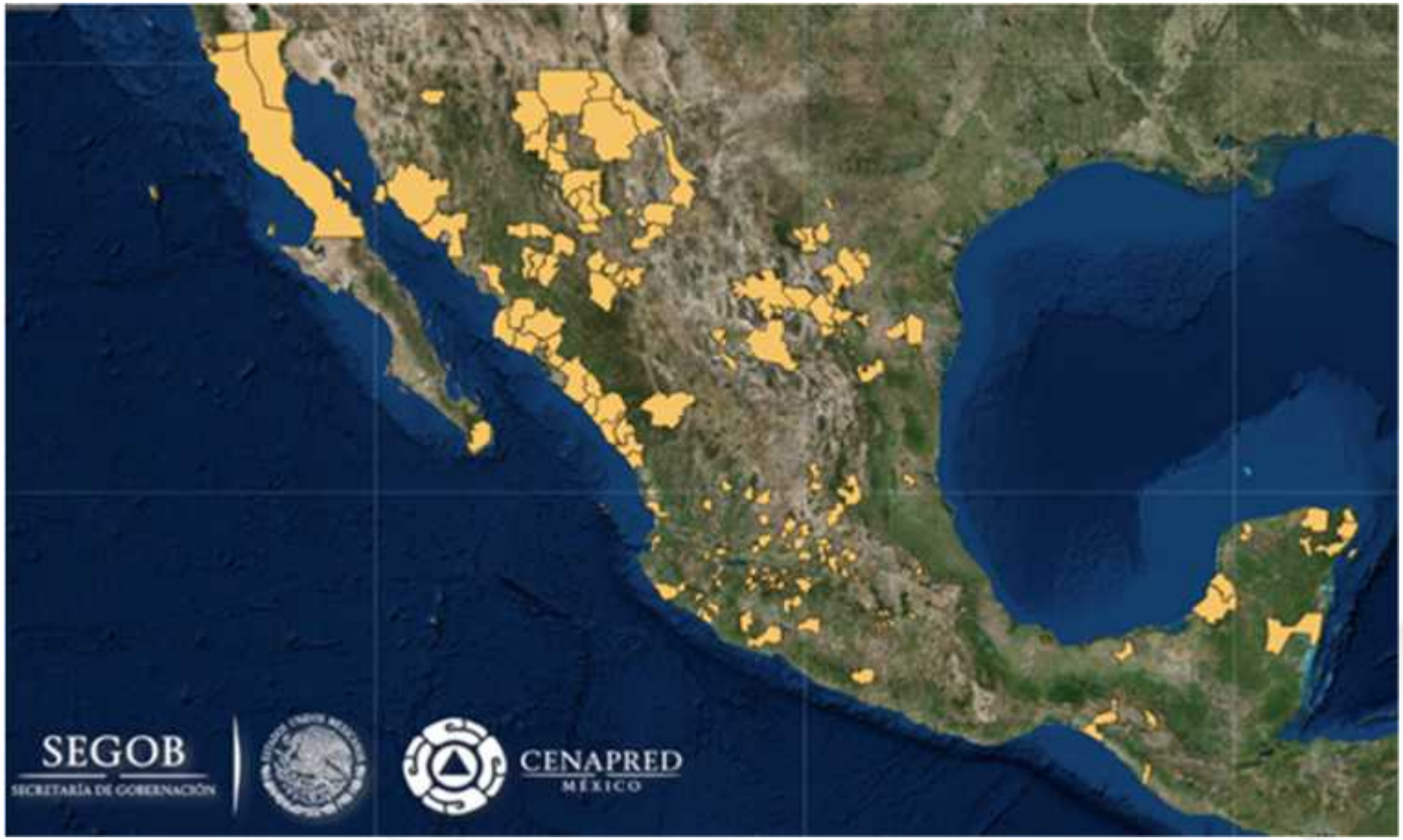


Exposed population

Zone A	**21.245 mhab**
Zone B	**37.580 mhab**
Zone C	**44.633 mhab**
Zone D	**9.667 mhab**
Total	**113.125 mhab**

States with building code. 54% of territory has no building code

Municipalities with building code. 13 % of total (326 of 2457)



Legal context

In a different way to the rest of the Latin American countries, Mexico lacks a national building code.

The interpretation of the Article 115 of the National Constitution gives the municipal governments

attribution of designing and applying their own rules, among them the building codes

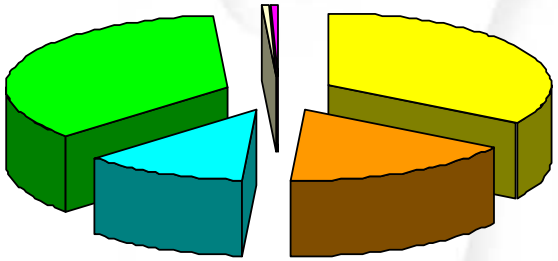
However, for public buildings, mainly those of the federal government, there is a legal possibility of issuing an Official Mexican Standard, for national and mandatory application

Safe Hospital program , does it imply structural safety?

Collapse of Juárez Hospital**. -** 536 lost beds and 561 casualties. 1985 EQ

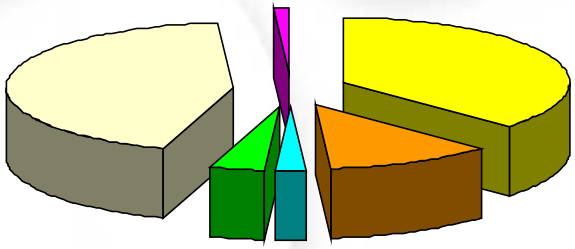
Economical losses due to 1999 earthquakes

Tehuacán, M_w = 7
Total = 150 M USD



Housing
Schools
Hospitals
Historical monuments
Roads

Oaxaca, M_w = 7.5
Total = 150 M USD



Although *low* or *small* damage could be thought to be acceptable in hospitals, the damage in such buildings should not exist. Any damage will cause evacuation and let the bulding out of operation, producing a major social impact

Damage in hospital due to Tehuacán 1999 M 7.0

Damage in non-structural elements, repairable. Occurred with a moderate EQ

Six months out of operation

Damage in hospital due to Tehuacán M 7.0

Continuity of operation and good performance of both critical equipmentand facilities is of paramount importance once a strong earthquake has occured

Building code for hospitals

In Mexico the most up-to-date building code is the one of Mexico City.

→ taken as a *model* to other states' codes.

It has been pointed out that if this code is applied without a proper adequation procedure, taking into account local seismic hazard studies, it could generate high vulnerability, *ab origine*, to new buildings.

An alternative is offered by the Design Manual for Earhquake-resistant buildings, issued by the Federal Comission of Electricity.

↓

Although not mandatory,
is useful for hospital with national coverage

Traditional philosophy for seismic resistant hospital design

The structure should be thought, designed and built, in order to:

- To resist without damage at all, moderate intensity earthquakes (< 150 gal)
- To resist with minor and easily repairable non-structural damage, *medium intensity* earthquakes (> 150 gal)

How to guarantee a proper and continuous function?

- Resist with repairable structural damage and to guarantee uninterrupted service under very severe earthquakes (≥ 400 gal in soft soil; ≥ 500 hard soil)

How to achieve it?

Philosophy for seismic-resistant design for hospitals

- Clinics
- Local hospitals

- To resist without damage at all, moderate intensity earthquakes.
- To resist with minor and easily repairable non-structural damage, medium intensity earthquakes.
- To resist with repairable structural damage + warranty of continuous service during severe earthquakes

Design based on resistance and displacement control.

The content cost is not significantly high

- General hospitals
- Specialties hospitals

- Under any earthquake, no service is interrupted
- The specialized equipment maintains its callibration condition

Design based on displacement and acceleration control

(Energy dissipation or base isolation)

Energy dissipation device

Experimental study: Testing model at Large Structures Lab - CENAPRED

Shear panel type energy dissipation device, easy to design, build, place and change once damaged. In addition, it does not have a national or international patent.
Introduced by Dr. Katsumata H., from Obayashi Corporation, Japan.

Reinforcement at hospital with energy dissipation devices

Use of an ADAS (Added Damping and Stiffness) device in the Cardiology Hospital of *Centro Médico Siglo XXI*. Device with international patent.

Viscous-rheological reinforcement device

Installed in stiffing elements at Torre Mayor. Downtown Mexico City

Source: E Martínez S.A.

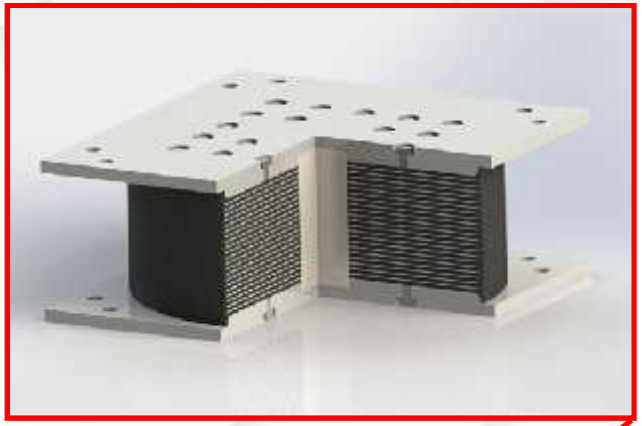
Use of Taylor type device in the *Torre Mayor* building at MexCity.
Damper type energy dissipating device.

Example of building with base isolation
Hotel Vía Vallejo, MexCity

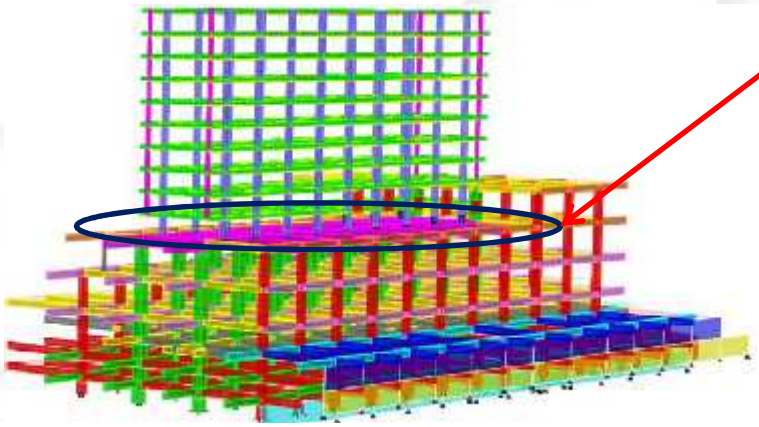
Project

Real

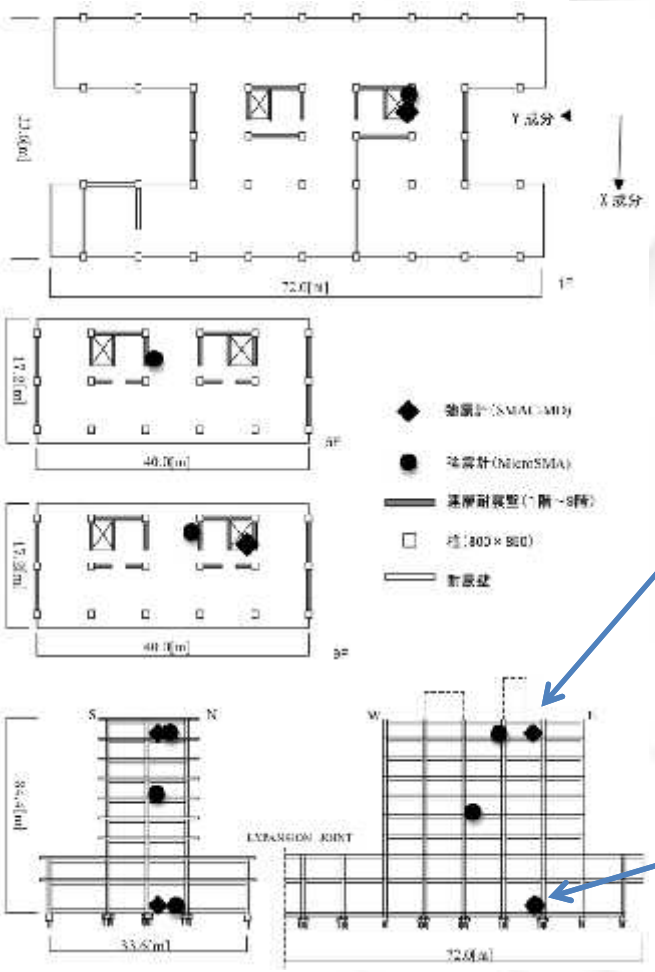
Base isolation device installed in foundation of hotel



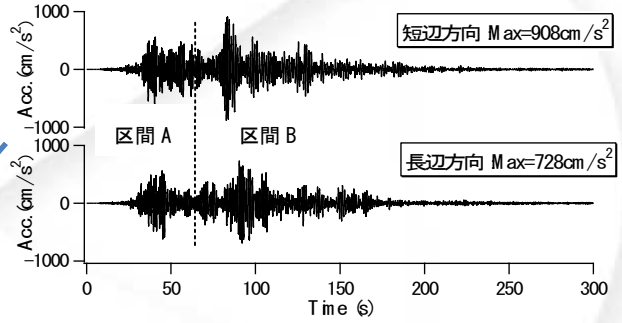
Mageba México



New technologies for risk mitigation

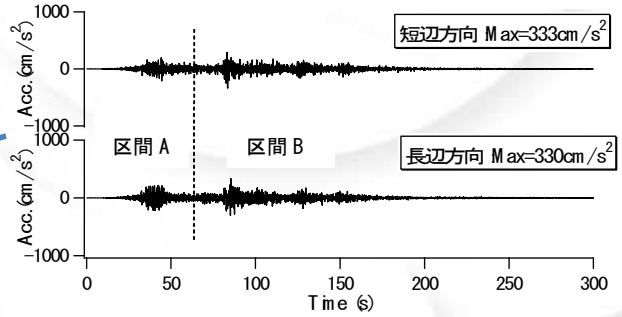


Instrumented building, traditional design
Faculty of Engineering
University of Tohoku, Sendai, Miyagi



(a) 9階における観測記録（本震）

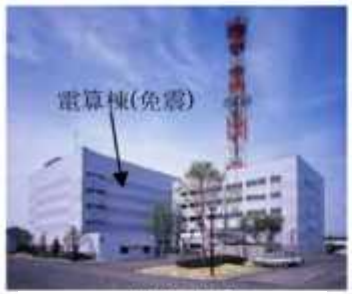
Acceleration at roof
908 cm/s²



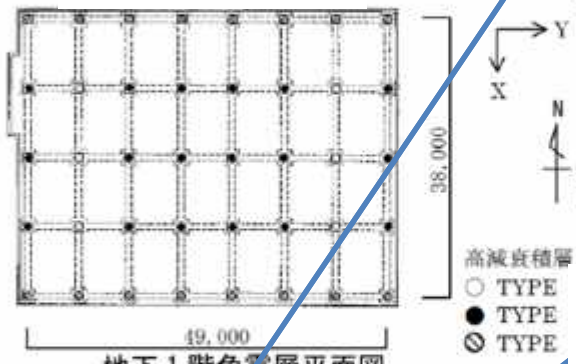
(b) 1階における観測記録（本震）

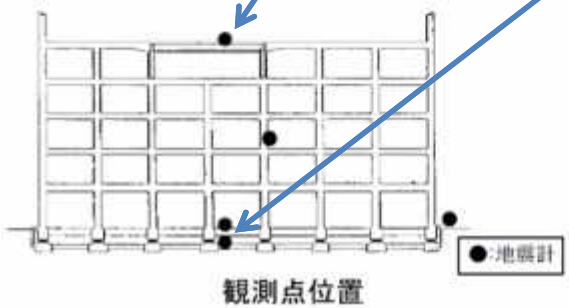
Acceleration at base
333 cm/s²

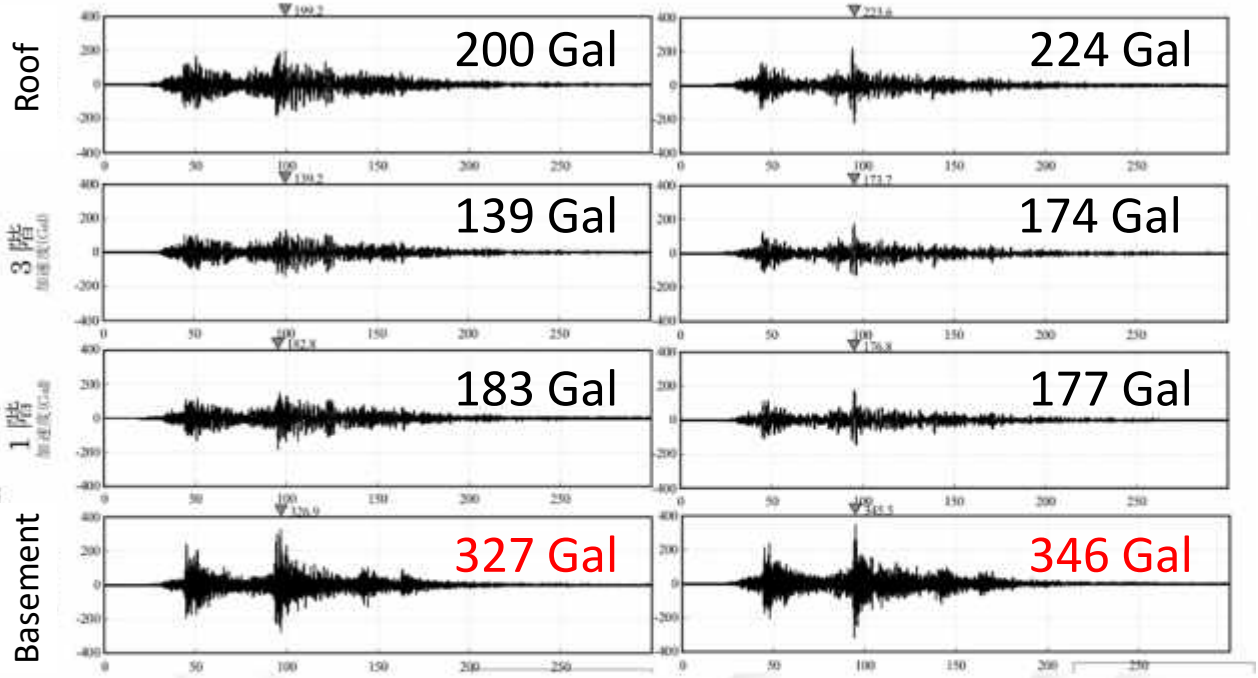
New technologies for risk mitigation



General overview





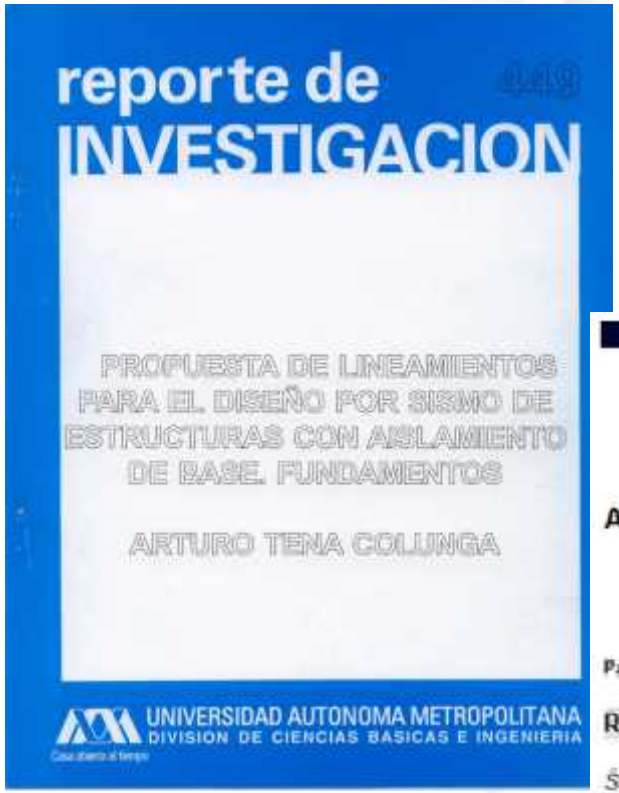


Instrumented building, base isolated
NDG building
Sendai, Miyagi

BASE ISOLATION DESIGN AND ENERGY DISSIPATION DEVICES

ENERGY DISSIPATION AND BASE ISOLATION STUDIES

Recent studies in Mexico present generic procedures of analysis and design considering different types of devices, providing basic information to define limits of structural behavior for design or retrofitting, independently or jointly, applicable to any product



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Algunas Recomendaciones para el Refuerzo Sísmico de Edificios, empleando Disipadores de Energía

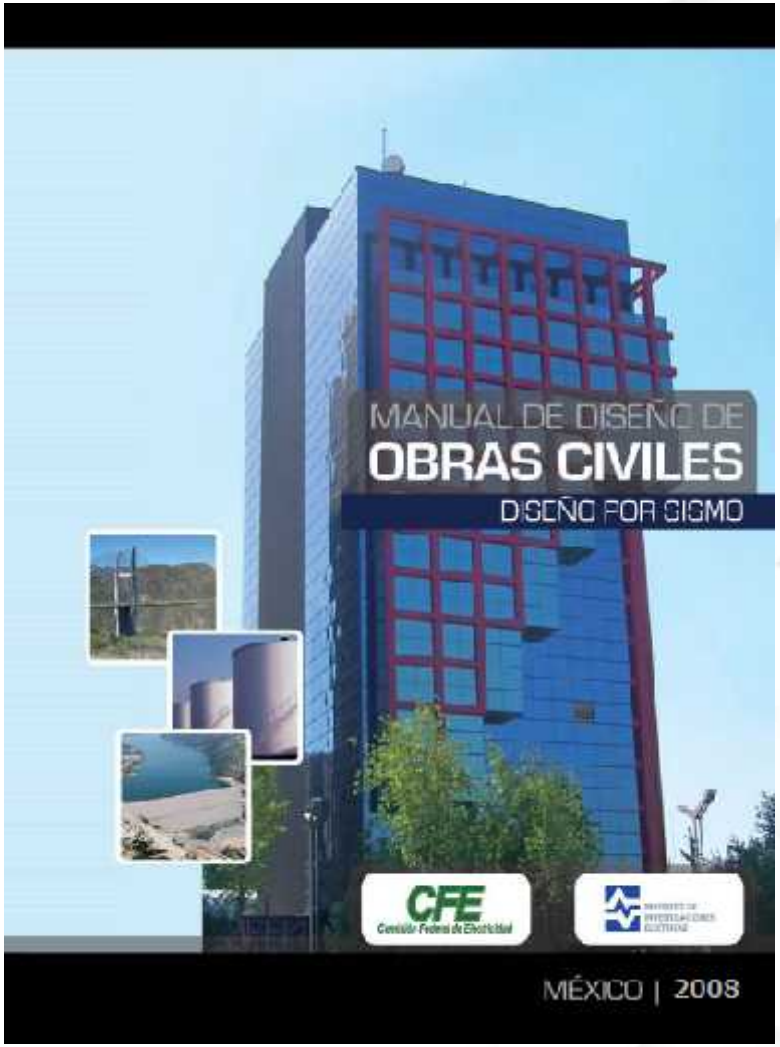
Sonia E. Ruiz Gómez

Palabras Clave: Disipadores de energía sísmica, disipación pasiva de energía.

Resumen

Se dan algunas recomendaciones sobre el diseño sísmico para el refuerzo de edificios con disipadores de energía, y se identifican estudios que es necesario realizar sobre este tema. El artículo es congruente con las especificaciones del Apéndice A de las Normas Técnicas Complementarias para Diseño por Sismo, del Reglamento de Construcciones del Distrito Federal propuesto. El escrito se refiere a disipadores de control pasivo, cuyas relaciones carga-deformación

DESIGN OF SEISMIC BASE ISOLATION AND ENERGY DISSIPATION DEVICES



ÍNDICE GENERAL

Key issues for optimum achievement of the code

Special attention has been put in the professional level and supervision during the whole building process, as well as the personel involved.

Chapters 7 and 8 of the code project, related to **Local Authority Advisors** (Senior Engineers, endorsed by authorities or hired by private individuals) and **Procedure for Conformity Assesment** represent the key elements to achieve that health buildings and infrastructure comply thoroughly with minimum requirements established in the code

The *Evaluación de la Conformidad* (conformity assessment): Procedure to verify compliance with the standard, from the architectural project, through the process of structural design and construction, to the delivery of the building to the owner.

Avoiding overregulation (states and municipalities codes).

Concluding remarks

- **Hospitals designed in Mexico under tradicional philosophy usually suffer <u>at least</u> non-structural damage – causing interruption of activities**

- **The proposed Safe Hospital Code is ready, and on its final stage towards approval and application.**

- **For optimum achievement the following elements are considered of paramount importance:**

  - **Use of new technologies – base isolation and energy dissipation**
  - **Permanent upgrade of structural engineering professionals**
  - **To define supervision procedures to improve efficiency through a project manager**

- **The above mentioned items altogether will allow to comply with the purpose of a SafeHospital, not only on the funtional aspect but, very important, on the structural aspect.**

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