CHAPTER

9

EARTHQUAKES AND EDUCATIONAL INFRASTRUCTURE POLICY IN MEXICO

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Abstract: Mexico is located in a high seismic risk zone, and today's industrial and commercial development has elevated the existing threat. This paper describes the measures that are being taken to improve the response of Mexico's educational sector to earthquakes. Federal, state and municipal governments are acting to increase awareness in communities through civil protection; to support public infrastructure in case of disaster with the Natural Disaster Fund, Natural Preventive Disaster Fund and a seismic alarm system; and to provide updated and regional building codes.

Introduction

Approximately 105 million Mexicans live in an area of 1 958 201 km^2 on a 10 142 km coastline; 70% of the population reside in urban areas. Mexico is located in a high seismic risk zone, and other natural phenomena such as hurricanes, tropical depressions and unpredictable storms can also have a devastating effect. Today's industrial and commercial development has elevated the existing threat. It is clear that communities must be prepared for catastrophic events, or risk the momentary shutdown of social, economical and political systems.

In Mexico, the Civil Protection Agency and the National Disaster Prevention Centre – both bureaus are within the jurisprudence of the State Department – have implemented several disaster relief mechanisms for aiding the country's federal and state governments. These bodies have mapped risk zones, emphasising geological, hydro-meteorological and chemical environment vulnerability hazards.

Site effects

The site effect is the soil's reaction to the duration and frequency of the seismic wave. Although the geological characteristics of the site location are a significant factor, this unique element responds differently according to the released seismic energy. In the 1985 earthquakes, the assessed damage of buildings in Mexico City was related to the soil properties in the valley. The dynamic wave experienced on the surface was provoked by the site effects, whereby intensity increased for ground water deposits with widths ranging from 25 m to 45 m. Seismic intensities diminished for deposits of less thickness, becoming insignificant to surface effects.

As a result of these findings, several secretariats devised a number of preventative measures in the following four fields.

Investigation

- Greater knowledge about natural phenomena.
- Identification and evaluation of risk zones.
- Research and education.
- Special training, updating and development of programmes for relevant professionals.
- Increased coverage of the accelerogram network.

Civil protection

- Elaborate training and contingency plans for disaster events.
- Population training and awareness.
- Seismic alert system.

Construction techniques

- Damage assessment.
- Educational buildings security diagnostics.
- Structural reinforcement.

Guidelines and regulation codes

- Urban development plans.
- Periodic checking and updating.
- Distribution and application of guidelines and regulation codes in all risk zones.

Seismic classification

Mexico has been classified into four seismic zones – A, B, C and D – according to the level of risk – low to high.

- Zone A is located in the northern part of the country and the Yucatan peninsula.
- Zone B is located in the mid-region states.
- Zone C is situated in the Baja California peninsula in the south-east of the country.
- Zone D, significantly, is located in the Guerrero seismic gap.

Conurbations in under-developed regions, which are located in high seismic risk zones, increase the risk. Death tolls and material damage resulting from natural disasters are also much higher in these areas compared to more developed regions.

Seismic alert system

The Guerrero Gap is a well-known source of large earthquakes in the area surrounding Mexico City and Acapulco. The existence and dangers of the Guerrero Gap have been confirmed by accelerograms obtained in this region over a time period of six years. To prevent the disastrous effects of another major earthquake in Mexico City, funding was obtained from the city government to design, operate and build a seismic alert system. The Centre for Instrumentation and Seismic Registry is responsible for the system's operation. The seismic alert has 12 seismic sensor stations on the coast of Guerrero that can anticipate and track a major event. Mexico City is located approximately 300 km from the epicentres, and information can reach the city quickly.

The alert system is activated when two or more sensor stations located between Ixtapa and Acapulco sense a major earthquake above 6.0 on the Richter scale. Accelerograms linked to personal computers relay the signal to Mexico City Valley, where every broadcasting station – television and radio – alerts the population an estimated 60 seconds before the event occurs. However, the alarm is not activated by minor earthquakes or by events located outside the Guerrero Gap. Since 1993, the Ministry of Education has strongly encouraged all schools in the metropolitan area to listen to school emergency broadcasts on the radio. Seismic alerts, with evacuation drills for prevention and protection of the population, can save lives.

Guidelines and regulations

The evolving process of creating, implementing and monitoring social and construction guidelines and regulations has been driven by past destructive events. In many cases, structures did not adhere to existing structural codes and standards.

The regulations established by the Secretariat of Education through its technical advisor CAPFCE in the structural engineering and construction disciplines concerning seismic activity have been developing steadily. Further modifications have been made to the Mexico City Construction Code; more results have been obtained in the field; and building performance has been observed during seismic events. New codes extend beyond structural parameters and seismic-resistant factors to consider:

- Design policy criteria.
- Design methodology.
- Innovative structural systems.
- Material quality.
- Relation to structural behaviour.
- Professional responsibility.

President Fox delivered specific instructions to the Secretariats of Social Development, Education and Health on the last anniversary of the 1985 earthquakes. He prioritised the civil protection programmes within each sector, thus supporting a preventive culture for inhabitants in high and low risk areas. In addition, in 2003-04, the Secretariat of Education issued a strong statement endorsing the civil protection culture. As a result, 3 220 emergency drills were held in public buildings, schools – including pre-schools – and museums; 66 000 leaflets on prevention were distributed in the native language (Spanish), and in the Nahuatl, Tzotil, Mixteco and Purepecha dialects; and more than

70 seminars, courses and workshops in the area of civil protection were held in Mexico in 2003. Today, there are approximately 2 900 certified state and municipal officials in Mexico.

Stability design

The construction code bases its seismically resistant structural design on the following performance criteria:

- *Low intensity seismic activity*. The structure and its secondary elements remain unharmed.
- *Moderate seismic activity*. The structure remains undamaged.
- *High intensity seismic activity*. The structure does not collapse and the occupants of the building are unharmed.

Concerning educational spaces, it is important that the structure complies with additional criteria, such as:

- *Displacement limitation*. The design is structurally unyielding, avoiding excessive lateral deformation produced by cross momentums.
- *Damage confinement*. Limiting displacement reduces structural damage, thus helping to achieve:
  - Greater safety of occupants.
  - Less panic among occupants.
  - Better structure.
  - Fewer costs and reparation expenses.

Educational infrastructure

Education authorities initiated a major reconstruction programme in the capital following the 1985 earthquake in Mexico City, which included structural reinforcement and rebuilding of units located in high-risk zones, in compliance with construction codes and regulations imposed after the events of September 1985. Between 1986 and 1991, 2 400 facilities were rehabilitated. This programme is continuing in 2004.

In 1999, an earthquake shook 870 school buildings in the state of Puebla and another 486 buildings in the state of Oaxaca; 2 000 classrooms and 56 000 students were affected. 451 schools reported minor damage, and 17 schools reported major damage.

A summary of the damage to schools in Oaxaca is provided below:

- 7% of schools required structural refurbishing.
- 5% of schools were demolished.

- 21% of schools were repaired.
- 67% of schools reported minor damage.

The majority of damage (93%) occurred in pre-school, primary and secondary education buildings. Oaxaca alone required EUR 13.9 million to repair schools. The estimated cost for both states was EUR 17.8 million.

In early 2003, the earthquake in Colima damaged an estimated 387 schools and 94 university buildings in the Autonomous University of Colima. 84 000 students were affected. Two major schools located in downtown Colima – three-storey buildings that offered basic education – were demolished. New single-storey buildings were constructed. The distribution of damaged buildings by type of facility is provided below:

- 27% state-owned basic education facilities.
- 5% higher education facilities.
- 68% federal-owned basic education facilities.

The cost of repairing federal and state basic education facilities was EUR 4.1 million; and the cost of repairs to the University of Colima was EUR 5.8 million.

Site selection

Destruction caused by natural phenomena can be significantly reduced given correct information. Scientific research has produced a vast amount of information and knowledge, and it is the responsibility of this specialised community to use and publicise these resources to generate awareness among the rest of the community. To this end, CAPFCE has recently created the Mexican Construction of Educational Buildings code.

However, there are events that are attributable to or aggravated by human factors, such as ignorance, negligence, lack of prevision, and allowing sites to be located in high-risk zones. Each year, there is a substantial loss of life and infrastructure damage due to urbanisation in high-risk zones, such as riverfronts, hills, faulty landfills, susceptible flood areas and unreliable terrain. In response to these problems, Mexican authorities are planning a mandatory regulation of urban sites, including school construction sites.

Natural Disaster Fund and the Natural Disaster Preventive Fund

The Natural Disaster Fund is a fund supported by the federal, state and municipal governments to provide public domain infrastructure in case of a disaster. The purpose of the fund is to aid non-protected sectors.

In the case of the educational sector, the fund provides a temporary resource until the insurance premium is collected. The objective is to restore the damaged property to pre-event conditions and to implement preventative measures. Since 2001, approximately 30%

of FONDEN disaster subsidies have been allocated to emergency earthquake situations.

The main task of the Natural Disaster Preventive Fund (FOPREDEN) is to devise preventative measures – including identifying possible risk situations and developing training and awareness material – for buildings that are located in high-risk zones or that have been damaged or repaired as a result of a natural disaster.

Future work

In 2004, the National Subcommittee for Damage Assessment will be formed, and every state will have its own local chapter. This will allow the establishment of permanent programmes and actions – with an emphasis on social participation – in such areas as improvement of local construction codes, national building diagnostics, and civil protection strategies and/or guidelines.

Summary

Mexico has reached a milestone, yet there is still much to be done. This paper has described some of the measures that have been implemented in Mexico to prepare its citizens for a seismic event:

- Better awareness in the communities through civil protection.
- Natural Disaster Fund.
- Natural Disaster Preventive Fund.
- Seismic alarm system.
- Updated and regionalised building codes.

While these measures are working effectively, civil protection must also become a way of life and not only a reminder of a life-threatening experience in an emergency situation.