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THE MEXICAN EARTHQUAKE OF SEPTEMBER 1985 - DAMAGE STATISTICS AND IMPLICATIONS FOR RISK ASSESSMENT

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SUMMARY

The results of a statistical evaluation of insured losses caused by the Mexican earthquake are presented and discussed with respect to their universal validity. First, the most heavily affected risk categories are identified. Then, the multiple factors of seismological, geotechnical and risk-specific nature which generated the damage pattern of the Mexican earthquake are isolated. Finally, the experience of the Mexican earthquake and other recent earthquakes is combined to enter into a general discussion on loss ratios and on implications for the assessment of catastrophe potential. In particular the problem of regionally representative MMI degrees is addressed in view of the relatively low loss ratios observed.

THE MEXICAN EARTHQUAKE - LOSS ANALYSIS

Introduction The data supplied by the Mexican earthquake of 1985 provided for the first time the opportunity to evaluate in detail a significant number of losses broken down into various risk dategories. Although derived from insured losses most of the results have universal implications, and the conclusions drawn go beyond the field of purely insurance-related issues.

Data basis Loss figures: The information was gleaned from 2943 separate losses, representing almost 75% of the aggregate loss amount under extensions to fire policies. According to the final figures of the Mexican Insurance Association, the aggregate loss was $ 105,000 mio (US$ 270 mio), which was accounted for by a total of 8964 reported losses.

Total values exposed: To calculate average loss ratios, data on total exposed values is necessary. This data was obtained from the accumulation reports of insurance companies which compile their total liabilities on a quarterly basis. Loss ratio is defined here as (gross) loss divided by total values-at-risk in % of the replacement cost.

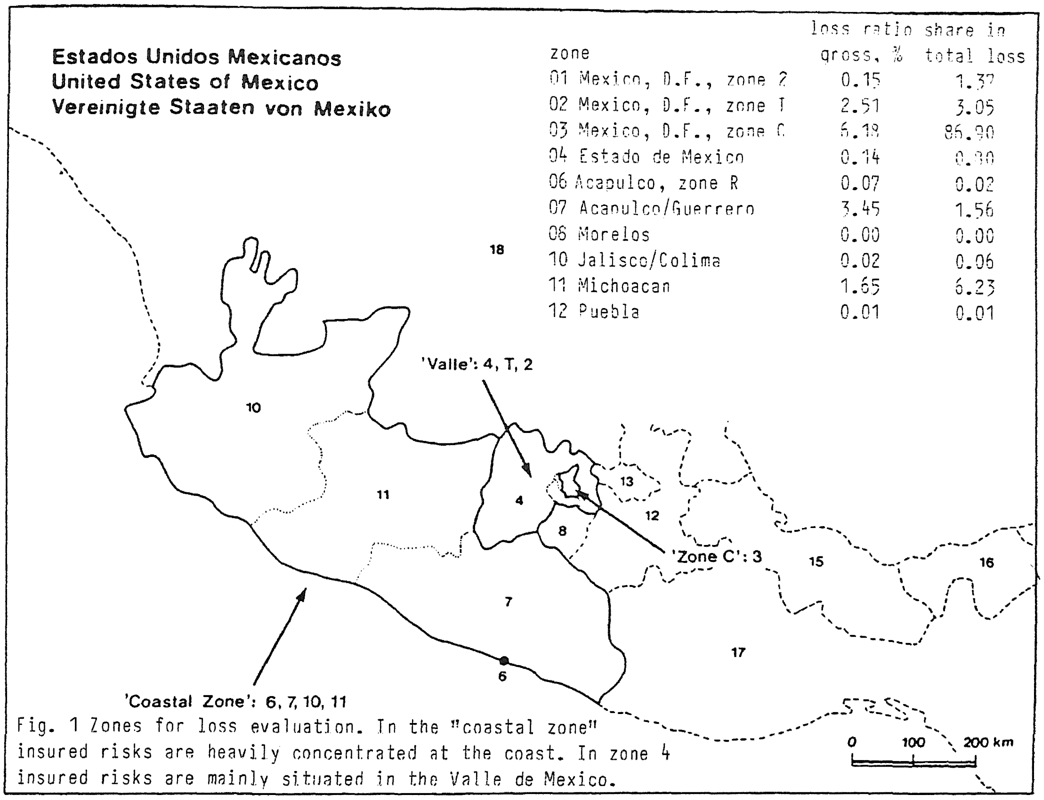
Results: Types of risk The results are summarized in table 1. It presents the results for Zone C, the rest of the Valle de Mexico and the coastal zone (see fig.1) according to the following risk categories:

a) Buildings, 3 classes of height
b) Buildings general - contents - business interruption
c) Residential - commercial - industrial

Two interesting aspects cannot be considered because there is no information on total values available: The construction type and the age of buildings. As the four largest losses account for no less than 43% of the data base, separate analyses were carried out, one including these large losses and another one excluding them (cf.table 1, columns 2 & 3). The main conclusions to be drawn are:

- Height of buildings: The high loss percentage for medium and high-rise buildings is undoubtedly the most prominent feature of the loss profile. Although the figures shown for this zone are too high due to inadequacies in the accumulation reports they demonstrate the importance of this problem at least in a qualitative manner. To judge the role resonance can play within the total loss picture it must be remembered that the average loss ratio for all risks in the most heavily affected area, Zone C, did not surpass 10%.
- Buildings/contents: The Mexican earthquake is the first quake which supplied valid data for losses to contents. It provided conclusive proof that on the whole the loss ratios for contents are lower than those for buildings. As regards different types of risk the general tendency is seen most clearly in the case of residential and commercial risks. The heavy losses suffered by the Mexican telephone company demonstrated that damage to contents depends heavily on the existence or non-existence of easily applicable damage control features such as fixing sensitive items to their supporting structure.
- Residential/commercial/industrial risks: The Mexican earthquake confirmed past experience that commercial risks are very vulnerable as compared to industrial and residential risks. State housing (Tlatelolco) constitutes an exception. Although buildings of medium height are strongly represented in the class of commercial risks, an above-average loss ratio was also observed for lower buildings. To explain the high vulnerability of commercial risks it may be remarked that this risk class represents a miscellany of poor risks, ranging from small businesses often located in old buildings that have been built, refurbished, and extended without engineering advice, to spectacular modern constructions (hotels, shopping precincts). The low average losses connected with heavy industry may be traced to the robustness of the installations themselves (Ref.1).

Results: Regional distribution From fig. 1 it can be seen that almost 90% of the aggregate loss amount was in zone C, where with a gross loss of 6% the highest loss ratio was also recorded. Otherwise a loss ratio of 1% was exceeded only in Zone T (2,5%) and in the coastal zones of Acapulco/Guerrero (3,5%) and Michoacan (2%). Disregarding for the moment the special circumstances in Zone C, the most conspicuous feature of the earthquake in Mexico was the low average loss ratio, even in the areas near to the coast and thus closest to the epicentre.



zone	loss ratio gross, %	share in total loss
01 Mexico, D.F., zone 2	0.15	1.37
02 Mexico, D.F., zone T	2.51	3.05
03 Mexico, D.F., zone C	6.18	86.90
04 Estado de Mexico	0.14	0.30
06 Acapulco, zone R	0.07	0.02
07 Acapulco/Guerrero	3.45	1.56
08 Morelos	0.00	0.00
10 Jalisco/Colima	0.02	0.06
11 Michoacan	1.65	6.23
12 Puebla	0.01	0.01

Fig. 1 Zones for loss evaluation. In the "coastal zone" insured risks are heavily concentrated at the coast. In zone 4 insured risks are mainly situated in the Valle de Mexico.

Type of risk / Zone	Zone C	Zone C, without largest losses	Valle de Mexico without zone C	Coastal zone
Buildings total	9.4	7.0	1.0	1.75
1-6 st	4.3	2.3	0.16	1.6
7-11 st	51.0	52.5	2.7	10.4
12 st	44.0	34.6	6.9	3.9
Contents	3.6	1.6	0.11	0.05
Residential	8.9	2.4	0.25	0.65
Buildings total	10.9	3.0	0.4	0.95
" 1-6 st	4.1	1.4	0.2	0.95
Contents	0.2	0.2	0.03	0.01
Commercial	7.25	4.5	0.55	1.15
Buildings total	15.6	12.75	1.9	2.2
" 1-6 st	8.4	4.4	0.15	1.4
Contents	3.8	1.0	0.08	0.13
Industry	2.5		0.14	1.3
Buildings total	1.9		0.16	1.7
" 1-6 st	0.75	see	0.14	1.7
Contents	3.3.	left	0.14	0.02
average	6.2		3.3	1.1

Table 1: Loss ratios of the Mexico earthquake of September 1985, summarized

THE MEXICAN EARTHQUAKE - EVENT CHARACTERISTICS

The loss pattern of the Mexican earthquake was characterized by an unexpectedly heavy predominance of long-period effects far from the focus in the Valle de Mexico and relatively little damage in the epicentral region. On the other hand, most aspects of the risk-related loss distribution can be claimed to be valid in a more general sense.

Now we can try to identify the event-specific factors which generated the loss pattern and to interpret them in a worldwide context. These factors may be allocated to three groups:

1. source-specific factors,
2. regional and site-specific factors,
3. risk-related factors, specific to the property affected.

ad 1) The 1985 earthquake is typical for the class of offshore events with a high magnitude in a subduction zone. The event was characterized by two main shocks 27 seconds apart, which accounted for the long duration of strong ground motion. As regards the source spectrum the Mexican event was not anomalously energetic in the two second period band that played such a prominent role in the spectra obtained from recordings in the Valle de Mexico (Refs.2,3). On the other hand, there are signs that energy radiation towards Mexico City was particularly high (Ref.4).

ad 2) Over 85% of the overall loss amount generated by the Mexican earthquake was recorded in a region of young, hardly compacted, and oversaturated lake deposits (Zone C) in the Valle de Mexico. At least three factors were involved simultaneously:

- the distance from the focus
- the characteristics of the propagation medium seismic between the focus and Mexico City, and, most important
- the above-mentioned subsoil conditions themselves.

The interplay of factors 1 and 2 - together with the rupture process - determines the frequency spectrum of the seismic waves arriving at a site and the duration of extreme ground motion. The large proportion of long waves and the extended duration are clearly recognized in the acceleration records for firm and soft subsoil in Mexico City (Refs.2,4). There is no reliable information as yet on factor 2. It is speculated that energy focusing towards the Valle de Mexico may have taken place due to path effects. Factor 3, the subsoil conditions, results in a local transformation of the arriving seismic waves. In zone C, this transformation took the form of pronounced amplification of the waves in the 2s range as a result of resonance. It is even probable that "standing waves" arose within the basin of the old lake (5). Amplification like that in Mexico has hardly been observed anywhere since the recording of accelerations first began in 1933, but there is no guarantee that it will not happen again, either in Mexico or anywhere else, even if on the strength of present knowledge the subsoil conditions in Mexico City are considered unique (6).

The effects of the regional conditions, which were so disastrous in Mexico City, were more favourable in the rest of the affected area. The intensities observed locally were nothing out of the ordinary either in the zone of soft sediments in Acapulco or in the coastal strip closest to the epicentre with the industrial complex of Lazaro Cardenas, which is also situated on soft subsoil.

ad 3) Even such an unfavourable combination of subsoil and other conditions as that encountered in Mexico City 1985 is of far less significance without a correspondingly "receptive" set of buildings: About 45% of the loss in Zone C affected buildings with more than 6 storeys. Two aspects of Mexican construction practice may be added here: High-rise buildings differ from those in other countries on account of their very flexible construction. Thus even lower buildings exhibited the fatal 1 - 2s periods. The other aspect is the widespread use of structures with flat or waffle slabs, which were particularly hard hit by the earthquake. However, other aspects as insufficient spacing are quite found commonly.

CONCLUSIONS

The Mexico City effect and the exposure of other cities The discussion in the previous sections may be summed up as follows: The incidence of the "Mexico City" effect depends on numerous variables. Certainly the unique subsoil conditions play a decisive role in Mexico City, but the very small size of the severely affected area within the much larger area covered by lake sediments is a clear sign that even the lack of just one of the various source-, site- and risk-specific preconditions will prevent the phenomenon of resonance occurring to such a significant degree as it did in the centre of Mexico City in 1985. Nevertheless, the existence of numerous major cities whose subsoil conditions are known to be problematical, but have not been examined specifically in terms of resonance coupling would make such investigations a worthwhile undertaking even if a "Mexico City effect" will remain a rare event. Without claiming for completeness, we might mention here San Juan (Puerto Rico), Kingston, Panama City, Port-of-Spain, Vancouver, Lisbon, Manila and Djakarta.

Implications for catastrophe potential It has been observed repeatedly that the pattern of damage caused by large offshore subduction earthquakes is rather irregular. Damage can be recorded even at distances of several hundred kilometres whereas the intensities near the epicentre are often surprisingly low. The reasons for this are at present not fully understood. Whereas the long-distance effects can be explained by the relatively large proportion of long period waves in high magnitude earthquakes, the relatively low levels of intensity in more proximate regions are usually attributed to a particular radiation pattern typical of subduction quakes.

But here the question has to be raised if this short-distance effect is not merely an artefact created by a lack of data as regards earthquakes of comparable size on the mainland. Obviously heavy destruction was observed in cases where the epicenter was near or within a major city (eg Tangshan 1976). But this very short distance - which can never happen in an offshore quake - may constitute the only difference. San Francisco 1906 could be an example to show that the shaking damage caused by mainland earthquakes need not be higher in the near field than that caused by offshore subduction events. Unfortunately the ensuing conflagration masked the shaking damage to such an extent that quantitative proof is difficult.

Coming back to the cases of Chile and Mexico 1985, the loss ratios of the regions closest to the epicentre were considerably lower than expected on the basis of commonly used intensity-damage relations (eg Ref.7). It is suggested here that the explanation for these apparently low ratios may lie above all in the fact that taking an average intensity of IX, for instance, is too cautious even in the immediate coastal area. This applies in like manner to Zone C in Mexico City: Only a small part of Zone C was severely affected and an average intensity of VIII - IX is too high, in view of a loss ratio of well below 10%.

To summarize both the Chilean and Mexican earthquakes give support to the argument that local peak intensities have often been wrongly interpreted to be average intensities with regional validity. This interpretation does not properly consider how isoseismal maps are usually prepared in practice, that is by connecting the farthest points of the different intensity degrees and disregarding points of lower intensity within the isoseismal zones thus defined.

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