# Building damage in Mexico City earthquake

*from Adrian M. Chandler*

*One lesson to be learned from the recent Mexico City earthquake is that the Mexican earthquake-code torsional design recommendations for asymmetric buildings do not include a sufficient safety margin.*

To engineers, the most disturbing aspect of the recent earthquake disaster in Mexico was the type and extent of the buildings which failed. Many were modern, engineered structures designed and built to withstand just such an occurrence. In the central area of Mexico City, 177 buildings collapsed completely and 85 suffered partial collapse as a result of the magnitude ($M$) 8.1 earthquake of 19 September 1985 and its aftershocks[1], while virtually every building in the city suffered some form of foundation failure. The nature and severity of this devastating earthquake has already forced a major reappraisal of engineering and architectural practices in earthquake-prone areas of the world.

Mexico itself has one of the most advanced building codes for earthquake-resistant design[2], but the extent of its enforcement and possible corruption in construction practices has come under sharp attack in the wake of the disaster[3]. The unprecedented severity of the earthquake, however, was chiefly responsible for the extent of the damage caused.

A joint venture by the US National Science Foundation and the Instituto de Ingenieria of the Universidad Nacional Autonoma de Mexico funded the installation only weeks before the earthquake of an array of 20 state-of-the-art accelerographs spread along the west coast of Mexico north of Acapulco. The accelerograph project was set up to record the strong-motion earthquakes predicted for the Guerrero seismic gap in the Mid-American trench. Major ground movements were expected in the area because there had been a 75-year lull following a decade (1900–1911) in which 24 large earthquakes had occurred. In addition, a network of accelerographs had been set up over the past 30 years in and around the capital city. Thus the documentation collected from the Mexico City earthquake and aftershocks constitutes the most detailed and extensive ever recorded, and full analysis of the mass of information generated will take several months or even years. Work so far has concentrated on the initial earthquake. Careful analysis is being made of the source of the shocks beneath the Pacific near Playa Azul. The first evidence from the coastal arrays is that the earthquake contained a significant proportion of its energy at frequencies of ~0.5 Hz. Examination of data from the arrays established farther inland will show how the initial spectrum of vibrations was attenuated or amplified as it spread out across the country. Of interest to engineers is the local amplification of ground motion imparted by Mexico City's soft lake-bed subsoil which resulted in a series of 0.5-Hz shockwaves at ~400 km from the earthquake epicentre.

Resonance of Mexico City's subsoil at a period of ~2 s was observed during the earthquake on 28 July 1957 (ref. 4), but its significance was not fully appreciated at that time. Far less damage occurred in the city than during the latest earthquake, but the event prompted the establishment of a building code for seismic design[5] (one of the first of its kind), together with the foundation of the engineering institute. Engineers in Japan and the United States in particular are awaiting the results of seismological surveys which will analyse to what extent the apparent local amplification of the 2-s ground waves is peculiar to the sedimentary basin of Lake Texcoco on which Mexico City is founded (Fig 1*a*); there may well be important implications for places such as Oakland in California and the many Japanese cities that are built on soft alluvial coastal plains[6]. Both the Californian Earthquake Engineering Research Institute (EERI) and Britain's Earthquake Engineering Field Investigation Team (EEFIT) have sent groups of engineers to study the damaged areas and to report on why some buildings survived while others were completely destroyed. Visits of this nature are now commonplace following major earthquakes. EEFIT, for example, is a UK-based group of engineers and scientists with considerable experience in post-earthquake reconnaissance in Italy, Turkey, Chile, North Yemen, Belgium and Pakistan. A preliminary report on the Chilean earthquake ($M$ = 7.4) of 3 March 1985[7] cited topographical effects similar to those in the region of Mexico City as a likely cause of the concentration of earthquake energy into the particular part of the alluvial plain on which the damaged towns are situated.

## Comparison with Europe

Long-period amplification of ground motions has also been observed and extensively reported in eastern European earthquakes[8–11]. The Vrancea region of

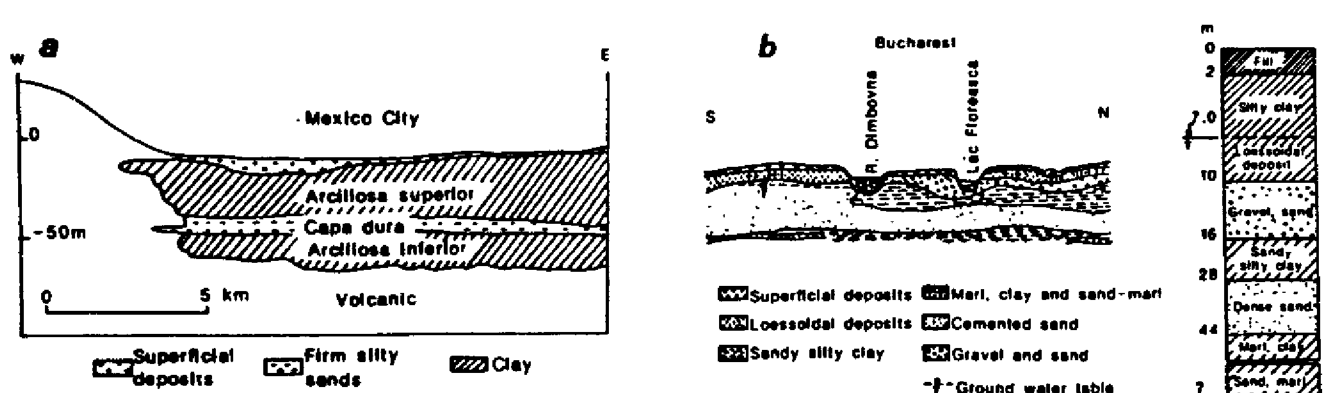


**Fig. 1** An east–west section through Mexico City subsoil[1] (*a*), and a typical cross-section and soil profile in Bucharest[8] (*b*).