## SCIENCE NEWS of the week

# Mexico City's Earthquake: Lessons in the Ruins

Last September's disastrous earthquake should have leveled practically every building in Mexico City's downtown core, say Mexican engineers. Instead, only a relatively small number of buildings suffered severe damage.

"The earthquake was very selective," says Enrique del Valle, who studied the earthquake's aftermath for the ICA Group, a Mexico City civil engineering firm. "I'm astonished that so few buildings collapsed," he said last week at the Second Century of the Skyscraper meeting in Chicago.

At the time of the quake, Mexico City had one of the world's most stringent building codes, based on experience gained from severe quakes in 1957 and 1979. Nevertheless, "the earthquake intensity in particular areas of Mexico City was much larger than what the buildings were designed for," says Roberto Meli of the National Autonomous University of Mexico in Mexico City.

The problem was the unexpected way in which the downtown's underlying layers of soft clay soil behaved during the 1985 earthquake (SN: 9/28/85, p. 196). This "weak" soil transmitted much more ground movement than engineers and planners had ever expected for such a distant earthquake.

"We thought that the type of soil was such that ground movement of very high acceleration could not occur," says Meli. On top of that, the shaking lasted longer than many buildings could withstand (SN: 1/11/86, p. 25).

What isn't clear is whether this type of shaking is an exceptional event or whether it may occur again within a few decades. How this question is answered will decide future building regulations, says Meli.

Earthquake engineer Mete Sozen of the University of Illinois at Urbana-Champaign emphasizes that one of the lessons of the Mexico City quake is that even with the best available knowledge, earthquake effects may still be unpredictable. Before the earthquake, he says, no one was in a position to criticize with any degree of authority Mexican estimates of probable ground motions.

There are also lessons to be learned from both damaged and undamaged structures. The most vulnerable buildings, all located within the small fraction of Mexico City that lies on an ancient lake bed, were those between 6 and 15 stories tall. Buildings in this height range tended to sway with a natural motion that was close to the 2-second period of the seismic waves as transmitted by the clay soil (taller buildings have longer periods). About 15 percent of these structures were severely damaged.

It's easy to define this group of vulnerable buildings, says architect Christopher Arnold of Building Systems Development, Inc. in San Mateo, Calif. "It becomes much more difficult within this group to decide why a particular building should suffer devastating collapse and why one adjoining it should not," he says. "You can't make simple judgments."

Detailed damage surveys, however, provide some clues. In many damaged buildings, just one floor had collapsed. In some cases, the damage was caused by the top of a lower, adjacent building banging against the walls and the supporting columns of its neighbor. Eventually, the columns gave way. In other cases, the first few floors of buildings were designed as parking garages, open lobbies or large shopping areas. These "soft" stories were particularly flexible and tended to collapse after a prolonged shaking.

Some types of foundations, particularly those involving piles driven into clay and held in place by friction, turned out to be weak. One 9-story building, for example, overturned. Its piles were pulled entirely out of the ground.

Although most modern buildings in Mexico City are constructed from reinforced concrete, a few are built around a steel framework. One of these buildings also collapsed. "Until the Mexico event, we had never seen the total collapse of a structural steel building designed under a modern code," says Sozen. "It demonstrates that if one doesn't take care, any material is vulnerable in an earthquake."

Mexico City now has a new emergency building code. This may be premature, says Sozen. "There are always two disasters," he says, "the earthquake itself and then the reaction . . . of people who make decisions about construction."

The thing to do would be to analyze the data, filter them through what is known and then make recommendations, Sozen suggests. "It is within our means to reduce the size of the second disaster."

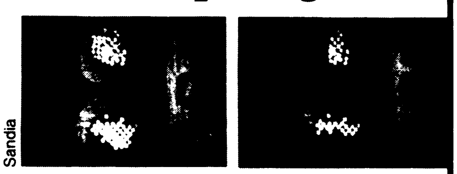
*— I. Peterson*

## Optical seals record nuclear tampering

The International Atomic Energy Agency (IAEA) has begun field tests of a fiber-optic seal for use at nuclear facilities and on equipment the agency inspects. This seal permits on-the-spot identification of tampering — a capability not previously available to inspectors of the Vienna, Austria-based agency. One of IAEA's major responsibilities is detection of efforts to steal nuclear material for use in weapons.

The new seals, developed jointly by Sandia National Laboratories in Albuquerque, N.M., and the Alexandria, Va.-based Atlantic Research Corp., would replace the metal-and-wire seals IAEA now uses, which are removed for analysis of tampering, then discarded. Because the new seals can be analyzed in place, they should last indefinitely, says Dennis Mangan, Sandia's international safeguards supervisor.

To picture how the seals work, imagine the type of shackle lock used to secure a gym locker. The U-shaped arm that would be passed through the locker door is, in this device, a tiny cable containing 64 randomly twisted optical fibers. After being fed through openings on the device that will be secured, the cable's two free ends are threaded through holes in a plastic housing. Insertion of a serrated horseshoe-shaped blade through a slit in the housing's body manacles the cable ends in place.



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*Signature of a new seal (left) was altered (right) by tampering.*

In securing the cable, some of the blade's teeth will sever 40 to 60 percent of the optical fibers, making them unable to transmit light. Later, when light is shined into one cable end, a pattern of lighted dots will appear at the other end, identifying intact fibers. This pattern, the cable's signature, is unique to each secured seal.

The seal's sensitivity to tampering comes from the special blade used to secure the cable. Its teeth are angled in several directions. Upon entering the cable, only some cutting teeth are active. Others slide harmlessly through optical fibers in the downstroke, but actively cut additional fibers if an attempt is made to withdraw the blade.

IAEA inspectors would periodically query each seal with a device that shines light into one end of a seal's cable and takes a Polaroid snapshot of the signature emitted by the other end. It would be compared against the seal's initial signature. *— J. Raloff*