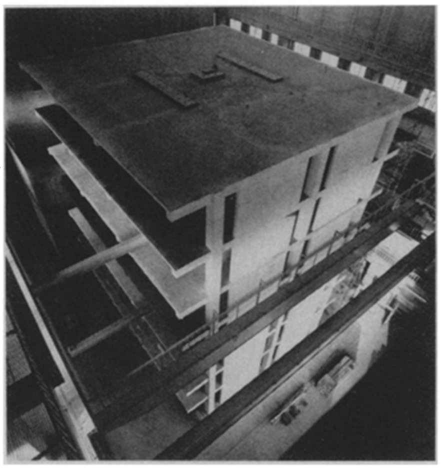
# Big 'shakes' test good quake design

When the *big* quake hits San Francisco, Tokyo or another seismically active locale, how well will the skyline hold up? Working toward answering that question, the United States and Japan set up a cooperative program in 1979 for validating the integrity of structures designed for earthquake-prone regions. Now data are available from the first major full-scale project within that program, the testing of a seven-story reinforced-concrete structure. Taken together with the results of a number of related, smaller-scale tests, these data affirm the quality of current earthquake-engineering designs used in both the United States and Japan, says Robert D. Hanson, a University of Michigan (in Ann Arbor) civil engineer and a coordinator of the U.S.-Japan technical committee overseeing these tests.

The full-scale experiments were carried out at the Building Research Institute in Tsukuba, Japan, beginning with four tests simulating the lateral displacement — or shaking — that might occur with ground-acceleration motions similar to those measured in four actual quakes. Lateral (horizontal) movement, usually greatest in the topmost floor, was achieved by pushing against the test structure with hydraulic jacks attached to a rigid adjacent wall. The tests took a week or two to simulate the inertial forces experienced in a 15-second quake.

Building Research Inst., Japan



*Left: Seven-story building tested for earthquake soundness. Above: After the initial experiments, larger test-induced cracks are patched, as shown. Tests were then rerun to check the integrity of repairs.*

Overall, damage was fairly minimal to a building that had been challenged by a sideways acceleration of 350 centimeters per square second. That's equal to what occurred in the 1940 El Centro, Calif., quake and higher than the acceleration buildings are now designed to withstand. Signs of damage were not very evident until the most severe test, in which 439 tons of lateral force yielded a maximum first-story sway of more than 13 inches. This caused major cracking of lateral-load-bearing walls on the first floor, in addition to concrete crushing and spalling (expelling of chips).

The worst damage was repaired by injecting epoxy resin into cracks and by buttressing or replacing damaged steel bars in the concrete. When the tests were repeated, repairs appeared to have restored much, though not all, of the building's initial stiffness and strength.

"We found a number of things that did not behave as predicted," Hanson notes, emphasizing the need for redundant measures. For instance, researchers learned that when the shear walls designed to bear horizontal stresses started to give, the vertical-load-bearing beams and columns picked up some of that load, showing that the latter must be designed to survive such a burden. —*J. Raloff*

# Nemesis: Searching for the sun's deadly companion star

If the sun is not a member of a binary or multiple star system, it is among the minority of stars. Yet if the sun has a companion, no one in thousands of years of observing has found it. It must be both distant and dim. A search for such a solar companion is now under way in Berkeley, Calif. Richard Muller, Jordin Kare and Carl Pennypacker of the Lawrence Berkeley Laboratory are using a telescope at the University of California's Leuschner Observatory in the Berkeley hills, and are just completing their first series of observations.

They call the putative companion star Nemesis, after the Greek goddess of doom. The impulse to search for such a star now and the rationale for the name come from paleontology. Evidence recently put together seems to show mass extinctions of biological species at intervals of 26 million years. Why would this happen? One theory suggests that changes in living conditions are triggered by comets striking the earth after their motion was changed by an impulse due to the passage of Nemesis (SN: 4/21/84, p. 250).

Nemesis is supposed to cause comet showers by perturbing the Oort cloud, a collection of solar system debris orbiting the sun at about 100,000 times the earth's distance. Muller says an important recent determination shows such showers might last as long as 1 million years — a finding consistent with the ideas of some paleontologists that the extinctions were not all that abrupt.

From Kepler's law, calculation shows that for an orbit of 26 million years, the semimajor axis of Nemesis's orbit has to be 88,000 times that of the earth. Doubled, this gives 2.8 light-years for the major axis or longest dimension of the star's orbit. That puts it closer than any known star to the sun, so Nemesis should show a larger parallax than any now known. (Parallax is the apparent shift in the positions of nearby stars against the background of more distant ones as the earth goes around its orbit. It results from the change in the angle of view as the earth moves. Knowing the parallax and the size of the earth's orbit, astronomers can calculate the distance of a star.)

All the brightest stars, those visible to the naked eye, as well as others that show large motions across the sky, have had their parallaxes measured, and none fits. Arguments combining the distance with the criterion that the apparent magnitude of the star must be dimmer than 7 led Muller and his group to search among red dwarf stars of spectral classes M3 to M8. With the equipment at Leuschner they are searching through a catalog of 5,000 such stars in the northern hemisphere. The apparatus is highly automated — it was designed for a similar systematic search of the sky for supernovas (SN: 1/15/83, p. 33), but has for the moment been diverted to look for Nemesis. It photographs 75 star fields per hour, a speed "unheard of in any astronomy I've ever heard about," Muller says, and records the images on tape.

The first survey completed, they will now wait a few months — during which they intend to go back to the supernova search — and then do it again. Comparing the two sets of images, they will look for a star with the appropriate parallax. If they don't find it in the north, they will have to look in the southern sky. Pennypacker designed the system for searching the north, and it would be hard to take the automation to the southern hemisphere. Furthermore, there is no catalog of red dwarfs for the southern sky. So if they have to go south they will follow Kare's suggestion of doing a full-sky survey and reverting to the older technique of photographic plates rather than videotape.

If they find a candidate, then things become much easier, Muller says. Anybody with field glasses will probably be able to see the star, he continues, and multitudes of astronomers can follow it and calculate its orbit. Once the needle is found in the haystack, it will be easy to prove that it is in fact the needle. —*D. E. Thomsen*