LETTER FROM TOKYO (6)

Waiting for the "Great Tokai Quake"

Despite dramatic signs of an impending major earthquake, preparations remain slow and confused

BY JOHN H. DOUGLAS

A barely perceived motion suddenly stopped lunchtime conversation in the Foreign Correspondent's Club atop a 20-story building in downtown Tokyo. "Is that a quake?" someone asked nervously. It took a moment to be sure. "Yeh," someone else answered finally; then he added, "They've been having foreshocks down on the Izu Peninsula all morning." By now the motion was all too apparent. As the building began to sway more and more, people's deepest instincts started to come out: A Japanese waitress ran and hid under the bar; the journalists — ever curious — ran to the window to see what was happening.

Outside, television towers began a steady swaying, their tops clearly whipping back and forth. Despite a growing sense of fear and helplessness, I became fascinated with the slow, steady swinging of some heavy pictures hanging from a molding. The more I stared, the more their hypnotic sway soothed my fright, and, with what is left of my training as a physicist, I tried to analyze their motion: Are we really moving *that* much?

The time was 12:24 p.m. on January 14. About 75 miles southwest of Tokyo, along the Izu Peninsula and on nearby Oshima Island, an earthquake measuring 7.0 on the Richter scale was shaking loose severe landslides throughout the rugged resort area. A total of 110 landslides accounted for most of the quake's destruction, sweeping a bus off the road, crushing houses and burying several people alive. Eventually the death toll rose to 25 and about $20 million in damage was reported, but the little group around me — and the rest of the 14.5 million people in the Tokyo-Yokohama area — breathed a sigh of relief: This wasn't "The Big One."

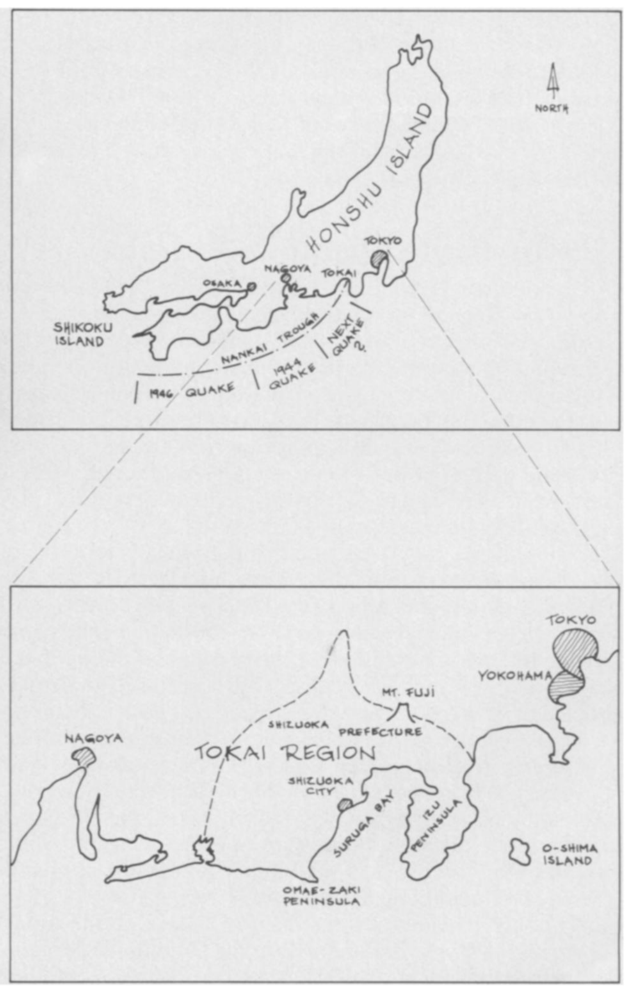
Although it hasn't happened yet, the impending major quake in central Japan already has a name — The Great Tokai Earthquake. Japanese officials shy away from saying such a quake has actually been "predicted"; after all, to predict a quake one needs to be able to specify with some precision when it will occur, how large it will be and where it is likely to be centered. Instead, the Tokai region of Shizuoka Prefecture, about 100 miles southwest of Tokyo, has been rather ambiguously labeled "an area of intensified observation." What this euphemism implies, however, remains starkly ominous: Within the limits of present scientific understanding, a major earthquake (with a magnitude of perhaps 8.0 on the Richter scale) is likely to occur within a few years, with the most likely center being in Suruga Bay, offshore from Shizuoka city. Such a quake could devastate the Tokai district and cause major damage as far away as Tokyo.

At the very least, the intensified observation taking place in the Tokai region is likely to produce data that will advance the art of earthquake prediction worldwide. At best, geological precursors may be detected in time to issue a formal warning to residents one or two days prior to the quake. The current investigations were summarized for SCIENCE NEWS by Kazuo Hamada and Masakazu Ohtake of Japan's National Research Center for Disaster Prevention.

Generally, long-term quake prediction involves study of past earthquakes in a region and measurement of deformation of the earth's crust as stress builds up. The fundamental reason why central Japan is one of the world's worst earthquake areas is that under the ocean floor, near Tokyo, three continental plates are slowly grinding together. As the Pacific and Philippine plates push against each other and slide below the Asian plate, the east coast of the main Japanese island of Honshu is pulled downward, building up stress. This stress can be measured by seeing how much the coastal land has subsided over a period of years, and how much compression has taken place between points whose distance is precisely known. Slight volume changes in underground tanks of liquid also indicate stress in surrounding rocks directly.

In the Tokai region, the land facing Suruga Bay has subsided by 30 centimeters

John H. Douglas



Exceptionally tall (50-story) skyscraper of Tokyo's Shinjuku district (above). A product of Japanese engineering, it has been built to withstand earthquakes such as those already experienced and those predicted for the Tokai region (right).

Another in a series of articles on Japanese science and technology by contributing editor John H. Douglas, a Fulbright Research Journalist in Tokyo.

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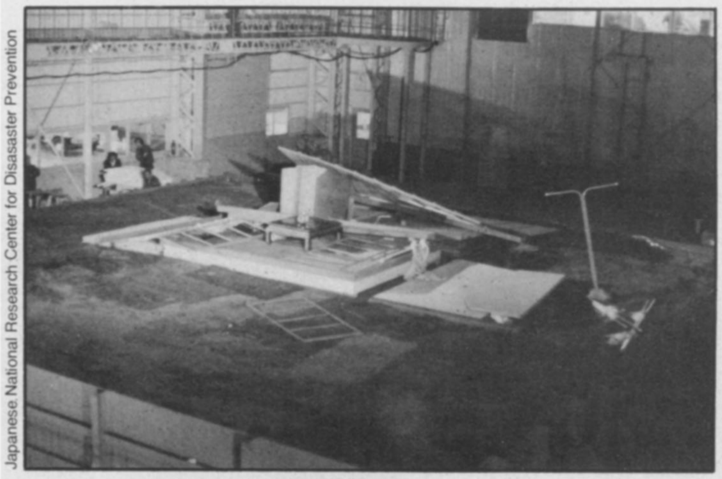
Japanese National Research Center for Disaster Prevention

Quake damage on Izu Peninsula.

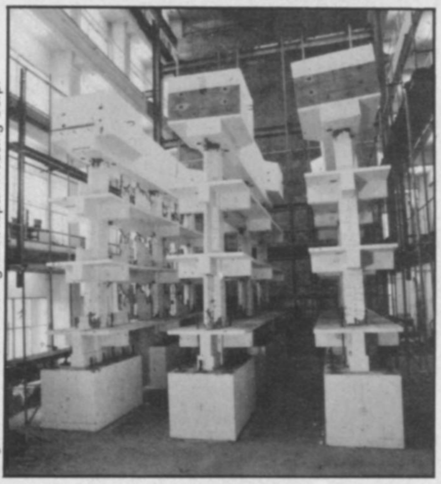
John H. Douglas

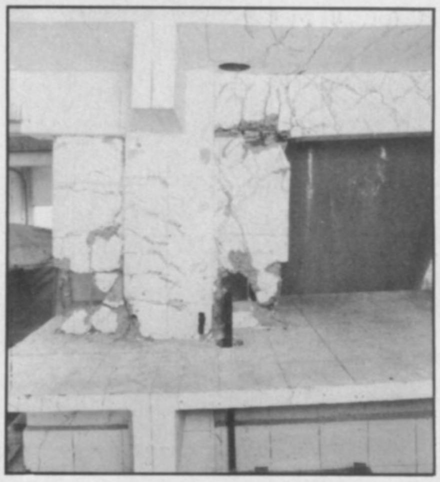
Intricately carved beam ends are still used in typical Japanese wooden houses to give joints that are strong and flexible.



Japanese National Research Center for Disasaster Prevention

Simple prototype of Japanese house after shaking on earthquake simulator.





Large Size Structures Testing Lab./Japan Housing Corp.

Model of ferro-concrete building elements undergoing static pressure (left). Detail of structural damage (right).

over the last 85 years, and considerable stress and compression of the crust have been measured. The implication is that when stress reaches some critical value, the earth's surface will spring back upward, causing an earthquake. This mechanism of earthquakes caused by plates pushing under one another ("subducting") is fundamentally different from that involved when the plates are pushing past one another, as in the San Andreas fault of California. Of particular importance, the origin of a major quake along a subduction zone is often deeper and more spread out than one along a "strike-slip" fault, so that its effects can be felt over a larger area. A general lack of small quakes beneath the ocean off the Tokai area serves as further evidence that the plates are "stuck" there and will release their energy soon with a sharp jolt.

Just when this release may occur can be judged by examining the history of past quakes along the southern coast of Honshu. About every hundred years or so, a series of quakes takes place along this part of the Nankai trough that marks the boundary between the Asian and Philippine plates. In 1854, the tension was released in two great quakes, one along the northern half of the trough and another along the southern half. In 1944 and 1946 two quakes eased the stress along the southern three-quarters of the trough, leaving only the Tokai region, at the extreme northern end, still building up pressure. Now, 30 years later, stress has built up so much that Ohtake says there is roughly an 80 percent probability of a major quake in the area in the next decade.

Short-term prediction — a warning just before the quake occurs — will depend on measurements that indicate a weakening of the connection between the opposing plates and the imminence of slippage. As in the case of the Izu Peninsula quake, there may be a series of foreshocks, but these do not always occur and they are not always distinguishable from the numerous small tremors that normally occur in this seismically active country. (As many as 10,000 temblors of Richter magnitude 3.0 or greater occur annually in and around Japan.) To minimize interference from sources close to the surface of the ground, sensitive seismographs and tiltmeters have been installed in a 200-meter-deep well on the Omaezaki Peninsula, beside Suruga Bay, and other instruments are being attached to the nearby ocean bottom. Changes in the relative velocity of various seismic waves associated with possible foreshocks are being particularly scrutinized.

Other possible immediate precursors include changes in ground water, acceleration of land movement and the actions of animals. Data from research into the possibility that animals may sense an impending earthquake are particularly difficult to interpret, although the Chinese have apparently made good use of such indications. After the recent Izu quake, for example, one Tokyo newspaper carried the headline "Fish predicted quake," while another carried the headline "Catfish didn't predict the recent quake." In fact, one observer thought he saw signs of unusual activity in his fish, while another said that his "remained motionless, keeping a dejected look."

Just what damage might be caused by a massive quake in Suruga Bay remains uncertain, but the possibilities are disturbing. Two members of the Tokyo Metropolitan Government's Disaster Prevention Council said that if the Izu quake had been centered closer to Tokyo, the city would have been decimated. And, according to another researcher, a major quake in the Tokai region could produce the same amount of shaking in Tokyo as that recently felt on the Izu Peninsula (that is, an intensity of about five on the seven-point Japanese scale). The intensity would, of course, be much higher closer to the Tokai area and, although Shizuoka Prefecture is largely agricultural, it does have about 3 million inhabitants. The threat of

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damage to a nuclear reactor on the Omaezaki Peninsula is also causing some concern.

To assess the possible damage such a quake might cause in Tokyo, one need only consider what happened during the last great quake there, in 1923, and what changes have taken place since. By far the greatest damage caused by that earthquake came as a result of fires, often set by the tipping over of charcoal stoves. The fires took two days to burn themselves out and left 60 percent of Tokyo and 80 percent of Yokohama in ashes. About 140,000 of the 3 million people in the two cities died. Charcoal pots have now been replaced by oil and gas stoves, and houses are generally better constructed, but the spilling of oil and bursting of gas mains could still lead to serious fires in closely packed residential neighborhoods of the adjoining cities. And, since 1923, the population of the metropolitan area has roughly quintupled.

(According to a more controversial theory—one based on statistics alone and with no geological corroboration—Tokyo itself may soon be hit by a major quake. Historical records show that the area has experienced major quakes on the average of once every 69 years for a millennium. Two-thirds of these quakes occurred during the last 13 years of each cycle, which would now correspond to the period from 1979 to 1992. Direct measurements of stress in the crustal region that snapped during Tokyo's last great quake, however, indicate that tension has not yet mounted close to the breaking point.)

A dramatic, although somewhat imprecise, warning has thus been sounded, and in one respect the Japanese response has been exemplary — they have become perhaps the world leaders in the field of earthquake engineering. A tour of the two major laboratories devoted to this work reveals the extent of this commitment.

The world's largest earthquake simulator is located at the National Research Center for Disaster Prevention in the "science city" of Tsukuba, north of Tokyo. A steel table, 45 feet on a side, is driven by hydraulic pistons in either the horizontal or vertical directions to produce earthquake-like motions for testing structures weighing up to 500 tons. The drive mechanism can even reproduce the vibrations of an actual earthquake by amplifying waves recorded on tape during the quake. Among models tested so far are those of an underground tunnel (which was imbedded in a huge tray of gelatin), the casing of a nuclear power plant and various kinds of household equipment.

The world's largest facility for static testing of architectural models is located at the Large Size Structures Testing Laboratory in Tokyo, operated by the Japan Housing Corporation for the Ministry of Construction. Here, five-story apartment buildings and other large structures can be built inside the laboratory and subjected to static pressure by a movable wall. In one important test, it was found that apartment buildings constructed from prefabricated concrete components could withstand lateral force greater than that likely to occur during an earthquake, and are thus supposedly safe to use in Tokyo. The test also revealed seven points of the structure that needed improvement.

As a result of the work at these and other laboratories, new building codes are being drawn up for various types of buildings in Japan, a process described for SCIENCE NEWS by Utaka Matsushima, an engineer at the Building Research Institute of the Ministry of Construction.

The problem, he says, is to design buildings that can withstand sideways acceleration of 1,000 gals (about equal to the pull of gravity; 1 gal = 1 cm/sec^2). Current building codes demand resistance to acceleration of only about 200 gals, assuming that the structure would then spring back into place elastically. To make a building perfectly elastic up to 1,000 gals would be prohibitively expensive, so the philosophy of design to be used in the revised codes will be to have buildings suffer some permanent deformation—but not collapse.

To achieve this inelastic absorption of energy, Matsushima says, will require the use of more steel in ferroconcrete structures (thus making the elements more ductile) and designing steel columns to be slimmer than before, so that they will not be so rigid. He also confirmed my conclusion from watching the swinging pictures: Tall buildings must indeed be able to bend considerably to withstand the shock of a quake.

Contrary to some popular opinion, the greatest danger of collapse during an earthquake is apparently not from very tall (well-built) skyscrapers or simple wooden houses, but rather from buildings of about five-story height. Every building has a natural frequency at which it tends to vibrate; the period of the swaying rises by 0.1 seconds for each story of height. (Thus, as expected, the pictures at the top of my 20-story building were swinging back and forth in about 2 seconds.) Since the waves of an earthquake tend to concentrate around periodicities of 0.5 second, the most violent shaking occurs in buildings of five stories. It is in these buildings that efforts need to be concentrated to increase the "give" of the structure.

Matsushima concludes that the direct damage of a foreseeable earthquake to buildings in Tokyo should not be too great. Traditional wooden Japanese homes are still constructed with elaborate, hand-carved joints between the beams, which can yield quite a bit before breaking. The new crop of skyscrapers also seems to be well planned and constructed. Some five-story apartment houses could be dangerous, he says, but the greatest damage is likely to come from "secondary effects" of a quake — fires, floods and landslides. "I cannot predict these," he admits, "but I'm afraid."

Such fears seem well founded, for despite significant strides in earthquake prediction and engineering, Japan has not fully utilized the lessons learned from these pursuits to prepare for the impending major quake. A survey of existing buildings has been started, to determine probable damage during a quake, but only a relatively few government buildings are so far involved. The earthquake prediction program is wide-reaching, but five ministries or ministerial agencies and nine university organizations are involved, and bureaucratic in-fighting has been reported. No central review panel of scientists select research projects, as in the United States (funding is left to the independent ministries), and there is no single lead agency responsible for coordinating the whole prediction program.

With unusual candor, Ohtake and Hamada have written a joint paper in which they say of the prediction program: "The present organizational structure ... is no longer adequate for the growing program.... Serious problems in the program [include] the lack of studies of social aspects of prediction and the absence of a responsible lead agency." As for the Tokai quake, they conclude: "To make the short-term prediction, an integrated system from observation to judgement ... is urged to [decide on] adequate actions for mitigation of an earthquake disaster."

Some Japanese scientists have reportedly become so fed up with problems in the program that they have left the country altogether. Others wait silently and shrug nervously when asked why their discoveries have not been applied to the urgent task of preparing for a major quake.

Japan has been called "Fragile Blossom" for several political and social reasons, but there is a particular sense in which this description is physically, literally true — the densely populated neighborhoods of cities and towns throughout the country are no match for the physical forces that threaten them. And this vulnerability is increasing. Major fires can spread quickly because of closely packed wooden houses, and numerous streets are too narrow for fire engines. Parts of Tokyo lie below sea level and could quickly be inundated. High voltage electric lines cut across residential communities, and storage tanks for chemicals, oil and extremely volatile liquefied natural gas have been placed relatively close to populated areas. So far, few attempts have been made to alter this basic fragility.

The Japanese have thus made significant advances in earthquake prediction and engineering, but application of this new knowledge is still in the preliminary stages. To stimulate adequate preventive measures "will take another great quake," one scientist says sadly. It may not be long in coming. □