

Earthquakes: major risk at a greater risk

By William J. Broad

THE doom mongers are wrong, scientists say. The killer earthquakes that have shaken the globe in the last month and taken thousands of lives in Turkey, Greece and now Taiwan are no sign that the end is nigh. By all estimates, the number of large jolts around the globe is below average this year, and it is simply bad luck that the recent upheavals have ripped through populated areas, levelling thousands of buildings and leaving tens of thousands of people dead, missing and homeless.

But more bad luck is coming, experts agree. Even though the rate of earthquakes over time seems to be more or less unchanging, the world's population explosion means that more people are moving into quake zones, which are often near coasts. The result, experts say, is the prospect of continuing trauma as urban areas erupt with what seems like nearly endless bursts of destruction.

A million people have died in earthquakes this century, experts say. The next century might see 10 times as many deaths, with a million lost in a single blow, they add, unless major steps are taken to fortify dozens of sprawling cities expected to teem with billions of added residents.

"It is inevitable," said Klaus H. Jacob, an earthquake expert at

buildings and all the infrastructure that support our civilization, communications and the like, the risk goes up."

John Boatwright, a geophysicist at the United States Geological Survey in Menlo Park, Calif, agreed. "In many places in the world, we have been building up

More and more people are living in major cities along the edges of the tectonic plates that form the earth's crust. The boundary areas are prime sites for earthquakes, and experts worry that earthquake deaths will rise as population increases there

infrastructure like crazy," he said. "We have to regard ourselves as really lucky" and the rash of recent tragedies as warnings of trouble ahead.

Roger Bilham, an earthquake expert at the University of Colorado now at Oxford University on a Guggenheim fellowship to study the rising urban risk, said the

quake-resistant structures. "That will be the spur."

Frank Press, author of *Understanding Earth* (Freeman, 1998) and a past president of the National Academy of Sciences, said Tokyo was one of the biggest worries given its global financial importance and history of devastating quakes. One in 1923 took 143,000 lives.

He said a future blow to the Tokyo area, now home to more than 10 million people, might "damage the world economy," setting off a downward spiral in advanced and developing nations. Dr Press added that the Bank of Tokyo has quietly studied the likely cost of such an upheaval to Japan and the world, and concluded that it could be dire.

The United Nations is accelerating studies of the urban earthquake hazard as part of its global effort to help stem the toll of natural disasters.

Paradoxically, given the growing danger to cities, experts say that the earth's dynamism, including its volcanoes and earthquakes, restless plates and splintering rocks, is essential to making the planet habitable or life in general and humans in particular, they add, the overall benefits for outweigh the risks.

"A planet without plate tectonics is dead," said Dr Press, who as President Jimmy Carter's science adviser helped propel the nation's programme to explore other worlds.

What makes the earth alive geologically is the slow release from its interior of heat, which fires out molten rock as volcanoes and pushes a dozen or so huge crystal plates into one another, causing rocks to break apart in earthquakes. As in most rocky bodies of the solar system, the planet's heat arises mainly from the slamming together eons ago of its rocky components and the radioactive decay of such elements as uranium, potassium and thorium.

This heat forces the earth's plates to move like conveyor belts, recycling millions of tons of crust each day. New plate material is ejected volcanically at long mid-ocean ridges. From there it spreads out across the ocean floor and is eventually destroyed hundreds or thousands of miles away as the cooling slab collides with and then sinks beneath other plates, plunging headlong back into the hot earth.

Over time, scientists say, all this action has helped produce the oceans, the atmosphere, the continents and fertile dirt, making the planet remarkably lush.

Does the solar system harbour hints of similar dynamism? Are there extraterrestrial quakes?

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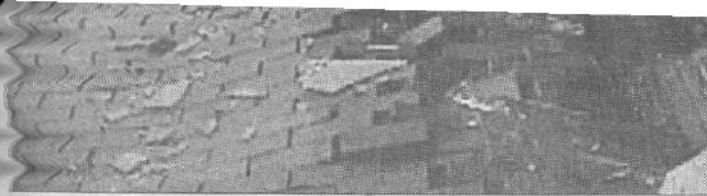
planetary scientists were drawing up plans to land quake sensors on such remote bodies, adding that similar dreams had gone unfulfilled for decades and might be sidetracked again.

"It is embarrassing," he said. "We have a good qualitative view of what happened in the early days of the solar system but few details about its current state of geological activity."

On the earth, the action can be disastrous when square miles of homes and buildings are erected near the borders of the ambulatory slabs of crust that make up the planet's surface and slowly grind past one another about as fast as fingernails grow. These seams are the world's main quake zones, producing the vast majority of jolts.

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Lamont-Doherty, the earth sciences research centre of Columbia University. "More and more people, and more and more buildings, are at stake. As the world gets more populous and richer, allowing a more built-up environment, higher

next quarter century might see three 'megacities' hit hard, with three million lives lost.

"That is quite possible," he said, adding that disasters of such biblical dimensions might finally prod the world to get serious about

there extraterrestrial quakes.

The Apollo astronauts found the Moon to be geologically dead. Its small size, which makes for a large surface area relative to its mass, was judged as having let its interior heat radiate into space long ago.

But now scientists are looking closely at Mars and several of Jupiter's moons, which are squeezed and probably heated by enormous tidal forces from the giant planet. Such places are seen as likely candidates for quakes and possibly life thriving in warm, dark,

Over the ages, the collision and separation of plates have produced the continents and their coastlines. The invisible seams are often nearby and potentially deadly for cities. California's famed San Andreas fault, for instance, is part of the larger process whereby the Pacific plate inches past the North American plate, keeping the golden state jumping and Angelenos edgy. The whole Pacific is ringed by analogous seams.

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Philippine and Eurasian plates, ensuring a long history of upsets. Last week's quake had more than 1,000 aftershocks and took at least 2,000 lives.

Thousands of earthquakes occur around the globe every day, though most are small and only a few strike cities.

Waverly J. Person, director of the National Earthquake Information Centre, in Golden, Colo., an arm of the United States Geological Survey, said historical records showed that the shaking of the earth by big quakes was in a relative lull right now, despite the apparent rash of recent upsets.

"Many people say these quakes are a sign that the earth is ending," Dr Person said. "Well, the earth has been coming to an end for a long time."

Despite the lull, experts say the dangers will rise as more people inhabit cities near coasts and quake belts. Today, a third of the earth's population lives within 60 miles of a coast, experts

say, and that fraction is expected to grow, increasing the vulnerability of people to both earthquakes and hurricanes.

Dr Bilham of the University of Colorado wrote a pioneering paper on the rising quake hazard that was published in the journal *Nature* in 1988 and has explored the field ever since. He said the world now has 27 megacities, which the United Nations defines as holding at least eight million people, and that more than a third of these dense urban regions are near quivering plate boundaries.

The major cities at risk, he said, in addition to Los Angeles, Tokyo and Taipei, the capital of Taiwan, include Athens, Istanbul, in Turkey, Tehran, the capital of Iran, Islamabad, Calcutta (India) Jakarta (Indonesia) and Manila.

"The probability of any one megacity being hit is quite low," Dr Bilham noted. "But if you take as plate boundary that has 10 cities, the probability increases and I

tury," he said, "unless we pay better attention to erecting stronger homes and buildings."

"These earthquakes in the last year of the millennium are going to be an interesting test," Dr. Seih added. "Do we go on with business as usual, and fatalistically accept that we're going to lose tens of thousands of people a year? Or do we say, 'No, we have the know-how to survive more completely.'"

He said he had just returned from Turkey, where he had examined a riot of devastated buildings. "A lot that collapsed were new," he said, noting that such failures killed widely.

Both Turkey and Taiwan have building codes similar to California's, which are meant to let people get out alive in a major earthquake even if a structure is seriously damaged. Protective steps include reinforcing concrete walls and pillars, digging deep foundations and adding special joints that ease internal stresses when buildings start to shake and sway.

Experts say the codes are better enforced in Taiwan than in Turkey. That discrepancy, they say, added to the size of the Middle East disaster, which killed more than 15,000 people, and injured perhaps as many as twice that number. The total is unclear because of the slow recovery from the ruin.

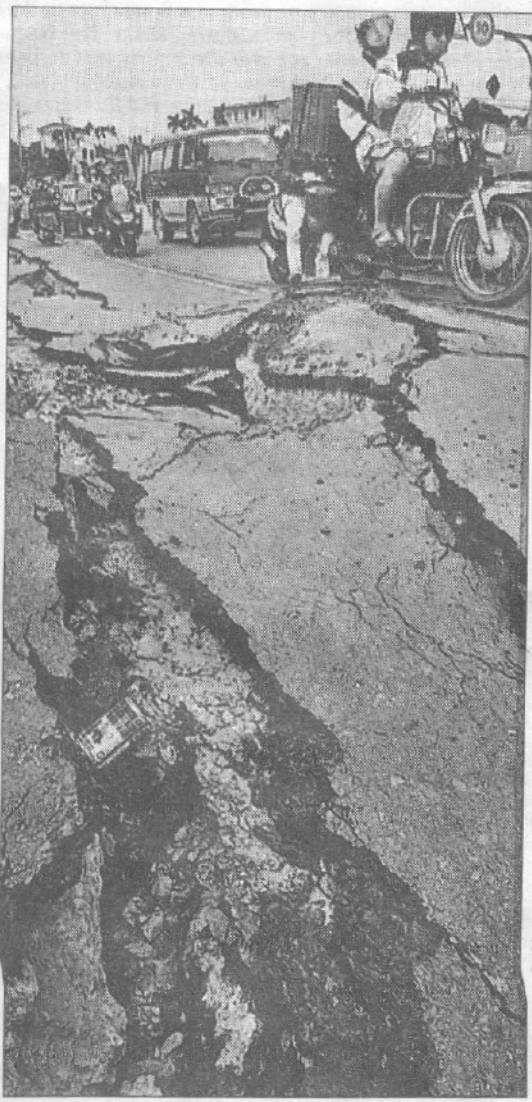
Dr. Bilham of the University of Colorado, who recently returned to his sabbatical at Oxford from inspection trips to Turkey and Greece, said he was optimistic for the new century because so many new buildings would be constructed that in theory could be much stronger.

"It's buildings that kill people," said Dr Bilham, a geophysicist, "not earthquakes."

Retrofitting to modern earthquake standards is very expensive, he said, costing upwards of half a building's value. But in new construction, earthquake precautions can add just 10 to 20 percent to building costs.

"So the good news is that if we come to grips with the reality that earthquakes will keep hitting planet earth, and acknowledge a certain future of shaking in cities, then we'll build buildings that don't fall down," he said. "By acting now, we can save a lot lives." The problem, he added, is that most developing countries, which most need the safeguards, tend to be mired in economic countries, which most need the safeguards, tend to be mired in economic conflicts worsened by exploding populations. or instance, in one part of India, he said, planners faced a choice of whether to erect 150 buildings that wee earthquake resistant or 200 that wee not.

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Kerry Seih, a seismic expert at the California Institute of Technology, said the overall risk was rising. "There are a lot of big cities around the world that are going to be eaten in the coming cen-

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"They built 200," Dr Bilham noted. "That is the kind of decision that is going on around the world."

In time, he added, probably after a series of urban disasters, and surely by the year 3000, "I'd be very surprised if we don't build buildings that don't fall down."—*Dawn/The NYT Science Service.* ■