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On shaky ground: Is Tokyo prepared for the 'Big One'?

A powerful earthquake that shook the capital in October has fueled fresh fears of an impending temblor that could devastate the world's largest city

Experts are divided over whether Tokyo is prepared to handle a megaquake. | GETTY IMAGES

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The late author Sakyo Komatsu's best-selling 1973 sci-fi novel "Japan Sinks" depicts the Japanese archipelago being consumed by the sea following a series of catastrophic earthquakes, volcanic eruptions and tsunamis.

Adapted numerous times over the years across various media, the two-volume epic highlighted the geological risks facing the quake-prone nation and foreshadowed the disasters it would face in the decades to come.

So it felt like an ominous coincidence when a Japanese television drama series based on the novel premiered on Oct. 10, three days after a magnitude-5.9 earthquake shook Tokyo and its surrounding prefectures.

The 10:41 p.m. jolt derailed the front cars of a Nippori-Toneri liner, an automated guideway transit system that runs between the capital's northern Arakawa and Adachi wards. Passenger trains and subway lines in and around the city temporarily halted operations, leaving crowds of commuters stranded at stations. Fires broke out and water pipes burst. Two hundred and fifty homes in Shinjuku Ward experienced power outages and more than 75,000 elevators halted automatically, trapping 28 people. In total, 32 were injured.

The temblor, which measured an upper 5 on the seven-point Japanese seismic intensity scale, was the largest shake Tokyoites had experienced since March 11, 2011, when a magnitude-9 earthquake struck off the northeastern coast of Japan, triggering massive tsunamis, killing nearly 16,000 people and leaving thousands more missing.

(https://cdn-japantimes.com/wp-content/uploads/2021/11/np_file_125348.jpeg)

Emergency crews attempt to extinguish a fire that broke out at an oil refinery in Ichihara, Chiba Prefecture, following a magnitude-9 earthquake off the coast of northeastern Japan on March 11, 2011. | KYODO

Still, the late-evening convulsion would pale in comparison to the scale of what researchers say the metropolitan sprawl of 37.8 million people should be preparing for: A major earthquake that could result in one of the worst natural disasters recorded in history. The last big quake struck the capital nearly 100 years ago. It's only a matter of time before it happens again, experts say.

The question is, when?

Anywhere, anytime

The Meteorological Agency immediately tried to dispel concerns that the Oct. 7 quake was a foreshock of the anticipated "Big One," explaining that such a seismic event will have a relatively shallow focus, whereas the one that just took place with an epicenter in northwestern Chiba Prefecture was deeper and smaller in magnitude.

That didn't help quell the fear, however. Magazines and newspapers began running stories citing various experts warning of an impending giant earthquake that could see the city left in ruins. It's not only the so-called *shuto chokka jishin* (earthquake directly beneath the capital) people should be worried about,

academics said. There's also the Nankai Trough megathrust earthquake that could shake vast portions of the archipelago and result in deaths and damages far beyond those seen in the aftermath of March 2011.

(https://cdn-japantimes.com/wp-content/uploads/2021/11/np_file_125339.jpeg)
The area around Asakusa's Sensoji temple following the Great Kanto Earthquake on Sept. 1, 1923 | PUBLIC DOMAIN / VIA WIKICOMMONS

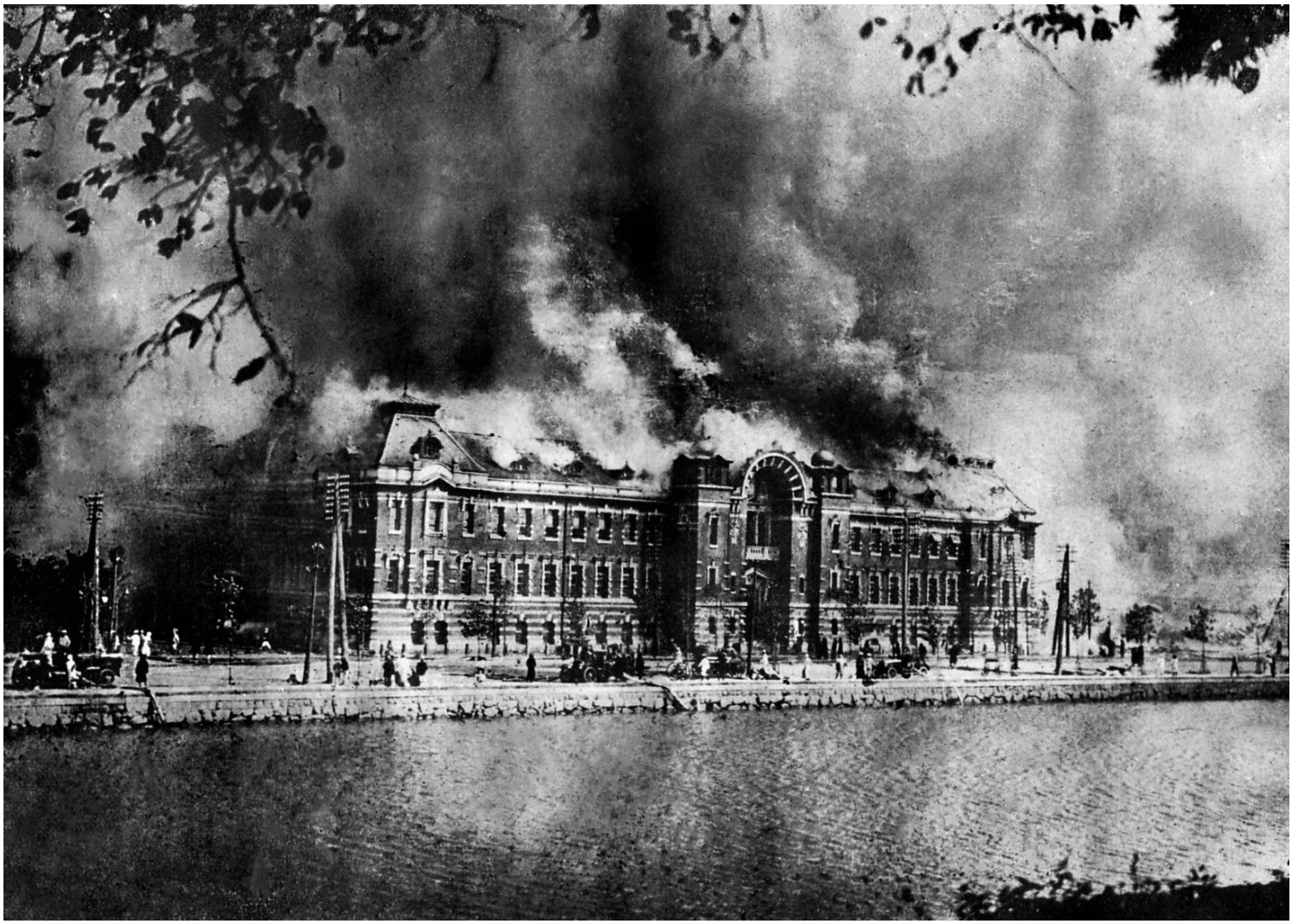
"Seismic activity is increasing since the 2011 earthquake that was of a scale of once in 1,000 years," says Hiroki Kamata, professor emeritus of geoscience at Kyoto University. That quake — the largest in the nation's recorded history — was accompanied by widespread crustal displacements (https://www.jica.go.jp/english/our_work/thematic_issues/disaster/earthquake/overview.html), with the Oshika Peninsula in Miyagi Prefecture shifting 5.3 meters to the east and sinking 1.2 meters.

"The strain caused by the 2011 displacements is triggering earthquakes ," Kamata says. "We should expect them in frequent intervals for another 20 years or so."

Japan is sitting on or near the boundaries of four tectonic plates and lies along the seismic Pacific Ring of Fire, where a majority of the planet's earthquakes and volcanic eruptions occur. In fact, 18.5% of earthquakes in the world take place in Japan (https://www.mlit.go.jp/river/earthquake/en/future/index.html). That effectively means quakes can happen anywhere in the nation at any given time.

The greater Tokyo area, meanwhile, is located on three layers of plates: the North American Plate from the north, the Philippine Sea Plate from the south sliding under it and the Pacific Plate from the east underlying them both. These plates constantly grind together, triggering deadly temblors.

The capital has experienced a number of large-scale earthquakes in the past, including the 1703 Genroku Earthquake and the 1923 Great Kanto Earthquake, the latter being a magnitude-7.9 shaker that pummeled tens of thousands of buildings, triggered landslides and tsunamis, and engulfed the city in a raging inferno, killing an estimated 100,000 people.



(https://cdn-japantimes.com/wp-content/uploads/2021/11/np_file_125341.jpeg)

Flames engulf the Metropolitan Police Department building in Marunouchi on Sept. 1, 1923, following the Great Kanto Earthquake. | PUBLIC DOMAIN / VIA WIKICOMMONS

In 2013, the government issued a report (http://www.bousai.go.jp/jishin/syuto/taisaku_wg/pdf/syuto_wg_siryo01.pdf) predicting that there is a 70% chance of a magnitude-7 earthquake striking the capital region in the next 30 years. In a worst-case scenario, the quake could kill up to 23,000 people, cause more than ¥95 trillion in damage and destroy 610,000 homes.

That's still a fraction of the damage that could be wrought by a giant earthquake along the Nankai Trough, a massive ocean-floor trench stretching off the southern coast of Japan from Shizuoka Prefecture to the island of Kyushu. Marking the subduction of the Philippine Sea Plate beneath the Eurasian Plate, friction at the Nankai Trough has led to occasional large-scale convulsions.

Since the 1361 Shohei Earthquake, these earthquakes have happened in roughly 90- to 150-year intervals, with the most recent being the 1946 Nankai Earthquake that struck off Kii Peninsula in western Japan, killing 1,330 people.

"We can't predict when a big quake will hit directly beneath the capital — it could be tomorrow or not for a while. But Nankai Trough earthquakes have struck in regular intervals, and it will definitely strike again," Kamata says. He predicts the next one is likely to happen in the mid-2030s.

And when it does, the damage inflicted could affect well over a third of the nation's population, from Kagoshima to Chiba prefectures. The government estimates that a giant quake of magnitude 8 to 9 has a 70-80% probability of striking along the trough within the next 30 years, killing as many as 320,000 people and causing damage of up to ¥220 trillion.

"A Nankai Trough earthquake will see Tokyo shake much more violently compared to the 2011 quake," says Nobuo Fukuwa, a professor at the Disaster Mitigation Research Center at Nagoya University.

(https://cdn-japantimes.com/wp-content/uploads/2021/11/np_file_125343.jpeg)
Buildings in Yokohama were flattened by the Great Kanto Earthquake on Sept. 1, 1923. | PUBLIC DOMAIN / VIA WIKICOMMONS

Big quakes, whether it be one directly under Tokyo or a Nankai Trough-type convulsion, could destroy levees and inundate areas below sea level where an estimated 1.5 million people live. Severe liquefaction could take place in areas of reclaimed land near Tokyo Bay. Fires could break out in many old neighborhoods with high concentrations of wooden homes that account for a total of 8,600 hectares in the capital. Gas, water and electricity will likely be lost to varying extent, while public transportation will be thrown into a state of chaos. Millions will be stranded as a result.

The Kanto Plain, home to Tokyo and a quarter of Japan's population, is geologically on shaky ground.

"Essentially, Tokyo has been built in an area with very high risks of hazards," Fukuwa says. "And if the city is destroyed by disaster, the rest of the nation will suffer as well since Tokyo is the center of both political and economic activity. That's why I believe Tokyo needs to be downsized or have its functions moved elsewhere."

Geographical weakness

Tokyo's vulnerability may be exacerbated by the fact that it's a city essentially built on water, with more than 100 rivers and canals flowing below its surface.

In fact, much of what is described as *shitamachi*, or lowland areas concentrated in the east of the capital, was under the sea more than 7,000 years ago, says Manabu Takahashi, a specially appointed professor at Ritsumeikan University's Research Center for Pan-Pacific Civilizations.

"That means the shitamachi neighborhoods are shaken easily," he says. "But that doesn't mean the *yamanote*, or highland areas, are safe, since there are many rivers running through these neighborhoods as well."

Comparing old aerial photographs of Tokyo to contemporary shots, Takahashi says it's evident that much of what used to be swamps and valleys have been flattened and transformed into residential areas during the 1960s and 1970s when the city's population soared. "That means people living in the yamanote neighborhoods could be occupying land that used to be ancient gorges."

(https://cdn-japantimes.com/wp-content/uploads/2021/11/np_file_125344.jpeg)

The lowland neighborhoods of Nihonbashi and Kanda in Tokyo lie in ruin after the Great Kanto Earthquake on Sept. 1, 1923. | PUBLIC DOMAIN / VIA WIKICOMMONS

Meanwhile, there are more than 800 known hills in Tokyo's 23 wards, mostly made from volcanic ash that could easily crumble in the event of a powerful quake or extreme rain.

And in case a strong temblor strikes south of Tokyo Bay — in the ocean-floor trench known as the Sagami Trough — tsunamis could flood Tokyo's vast subway networks and underground shopping promenades, Takahashi says.

"Even a small tsunami of 10 centimeters could cause great panic," he says. "There are numerous disaster scenarios Tokyo needs to be prepared for."

Prediction difficulties

Scientists can predict with relative accuracy where an earthquake could strike since temblors take place at plate boundaries and tend to happen where they have occurred before. That's why the government has been releasing its assessments of potential damage inflicted by anticipated shakers such as a Nankai Trough earthquake.

"The problem is, we don't know when it will happen," says Toshiyasu Nagao, an expert on earthquake prediction at Tokai University's Institute of Oceanic Research and Development. Small quakes, or foreshocks, sometimes occur before a major quake, but many earthquakes don't have foreshocks, and light tremors are not necessarily followed by large earthquakes.

"Many statistically relevant precursors have been confirmed, and theories regarding the mechanism of precursors have been proposed," Nagao says. "But these are yet to be proved and at this stage we cannot make accurate predictions."

(https://cdn-japantimes.com/wp-content/uploads/2021/11/np_file_125337.jpeg)
An artist's depiction of a fire storm in Tokyo following the 1923 Great Kanto Earthquake | PUBLIC DOMAIN / VIA WIKICOMMONS

However, observation technology such as the High Sensitivity Seismograph Network (Hi-net), which consists of around 800 stations across the nation monitoring microearthquakes, and the Global Navigation Satellite System have dramatically improved the knowledge of what is happening underground. These include deep low-frequency tremors at plate boundaries and slow slip events, Nagao says.

"That has allowed the government to issue warnings when it detects abnormal phenomena increasing the risk of a Nankai Trough earthquake," he says.

In November 2017, the government introduced a new system to alert residents in tsunami-prone Pacific coastal areas in central and southwestern Japan when the possibility of a powerful earthquake focused on the trough heightens.

The warnings will urge residents to examine evacuation routes and check their supplies and will be issued when a quake with a magnitude of 7 or more occurs along the trough, for example, or when unusual tectonic movements are observed.

Such forecasts are still imperfect, however, and major earthquakes could strike unannounced. That means it's up to every individual living in this seismically active nation to protect their own lives.

Be prepared

When the magnitude-5.9 earthquake struck Tokyo in October, Akihiko Hamanaka, an official at the metropolitan government's disaster prevention department, was still at his office.

As the building shook, he and his team immediately began gathering information from the city's wards and municipalities to assess the damage and scale of the event while communicating with the police and fire departments.

(https://cdn-japantimes.com/wp-content/uploads/2021/11/np_file_125347.jpeg)
Commuters wait for taxis in front of Shinagawa Station in Tokyo in the early hours of Oct. 8 after train services were disrupted following a magnitude-5.9 earthquake. | KYODO

Hamanaka ended up pulling an all-nighter. He and his colleagues at his department are required to live in close proximity to the Metropolitan Government Building so they can promptly respond to disasters. While this quake was strong, it luckily wasn't the "Big One" officials are bracing for.

"If a major earthquake strikes, the city will establish a disaster response headquarters and concentrate its resources on handling the crisis with the various parties involved in relief missions. My section will essentially serve as the nerve center for such an operation," he says.

Over the years, the capital has been investing in its infrastructure in anticipation of a massive quake.

The city designates roughly 1,000 kilometers of emergency transport roads and has issued an ordinance to improve the quake-resiliency of buildings along those routes and has been burying overhead power lines.

Meanwhile, the city has been promoting the fireproofing of buildings in areas with close-set wooden houses, while installing earthquake-resistant joints for water and sewage pipes. For fiscal 2021, the Tokyo government allocated a budget of ¥139.9 billion for such projects.

"In terms of restoring lifelines, we estimate it will take a week for electricity, 14 days for telecommunications, 30 days for water and 60 days for gas," Hamanaka says.

But while infrastructure and technological measures to protect against earthquakes have improved over the years, Hamanaka says individual and community preparation is crucial in the event of a catastrophe.

(https://cdn-japantimes.com/wp-content/uploads/2021/11/np_file_125350.jpeg)
Commuters walk home after train services halted due to a devastating earthquake that struck Japan on March 11, 2011. | KYODO

Some studies estimate that during the Great Hanshin Earthquake of 1995 that destroyed parts of the port city of Kobe and killed 6,434 people, around 80% of survivors who were rescued from their homes were pulled out by their neighbors.

"You need to protect your own life, and communities need to protect their own communities (https://www.japantimes.co.jp/community/2021/03/08/issues/ten-years-3-11-disaster-preparation/)," Hamanaka says.

In Komatsu's apocalyptic disaster novel, Dr. Yusuke Tadokoro, the geophysicist who predicts the sinking of Japan, ultimately decides to perish with the archipelago.

While the prospect of an entire nation being consumed by the sea may sound improbable, it is a reminder to always be vigilant in Japan — the earthquake capital of the world.