Gallagher | Research Centre

The Great Wave

New research showing the impact of the tsunami that followed the 1923 Great Kanto earthquake

September 1, 2023, marks the 100-year anniversary of the 1923 Great Kanto earthquake in Japan. This megathrust earthquake under the Sagami Trough had a magnitude of 7.9, generating large ground shaking and subsequent fires across the Kanto region. What is less documented is the tsunami that was generated as a result of the earthquake and which caused extensive damage and loss of life to coastal areas around Tokyo. Tohoku University, a Gallagher Research Centre partner, have carried out new research analysing the 1923 Great Kanto earthquake and the tsunami that followed, and it is published here by the GRC.

The damage

The 1923 Great Kanto event caused widespread damage from Southern Kanto to the Tokai region, with over 100,000 people killed or missing and more than 370,000 houses partially or fully destroyed with severe damage to infrastructure, such as electricity, water, roads, and railways. Most of the metropolitan area of Tokyo was burned down due to fires following the earthquake, and these were the main driver of the fatalities (estimated at almost 90%)[1] and building damage. This was largely because the earthquake occurred during the lunchtime preparations. Strong winds further exacerbated the reach of the fires to downtown Tokyo. Because of the scale of the casualties, September 1 has become Japan's disaster prevention day (since 1960) to commemorate the event and increase disaster awareness. Table 1 highlights how this event was the most devastating natural catastrophe in recent history for Japan.

Historical Event Name	Great Kanto	Hanshin-Awaji (Kobe)	Great Tohoku
Date/Time of recurrence	September 1, 1923/11:58	January, 17 1995/05:46	March 11, 2011/14:46
Magnitude	M7.9	M7.3 (M6.9 USGS)	Mw9.0 (M9.1 USGS)
Fatalities/Missing	105,385	6,437	22,318
Number of destroyed houses	293,387	104,906	122,039
Economic Loss (Direct Property Loss)	5.5 billion Yen (Unknown)	9.6 trillion Yen (6.3 trillion Yen)	16.9 trillion Yen (10.4 trillion Yen)
GDP	14.9 billion Yen	522 trillion Yen	497 trillion Yen
Economic Loss/GDP	~37%	~2%	~3%
National Budget	1.4 billion Yen	73 trillion Yen	92 trillion Yen

Table 1: Comparison of damage statistics and losses caused by major historical earthquakes (based on a Cabinet Office report[1] and updated by Gallagher Re). The economic values shown are at date of loss and not adjusted.

Figure 1 shows an estimated ground shaking intensity map of the 1923 event, presented with the current Japan Meteorological Agency (JMA) Shindo intensity scale, based on the number of fully collapsed wooden houses. Severe shaking was estimated in Kanagawa Prefecture and around the tip of Boso Peninsula in Chiba Prefecture, while the shaking in Tokyo was relatively low. The recurrence rate of such an event under the Sagami Trough is estimated to be between 200 to 400 years.

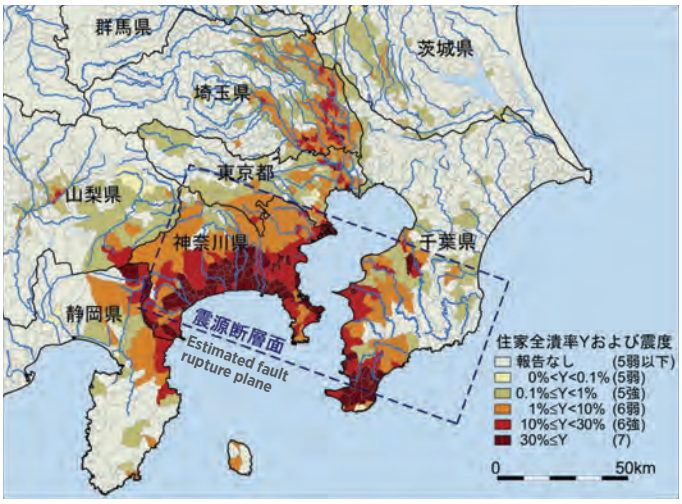

Figure 1: Estimated shake map of the 1923 Great Kanto earthquake. Source: Moroi, T. and Takemura, M.: Re-evaluation on the damage statistics of wooden houses for the 1923 Kanto earthquake and its seismic intensity distribution in and around the Southern Kanto district.[2]

The 1923 event and tsunami

The 1923 event is primarily known for causing extensive damage from the fire following the earthquake, rather than the ground shaking. It also caused damages from landslides and a subsequent tsunami. The epicenter of the 1923 event was located in Sagami Bay with the earthquake fault partially in the sea. This resulted in a tsunami height of several meters in locations around Sagami Bay and further east in Boso Peninsula (Figure 2). The tsunami wave reached the coast within five minutes of the main shake in some areas, and a wave height of 12 meters was observed in Atami in Shizuoka Prefecture. To the east, a 9-meter wave was observed at Tateyama at the southern tip of the Boso Peninsula in Chiba Prefecture.[3,4]

The 1923 tsunami caused extensive damages and loss of life. In Atami, where the wave height of 12 meters was observed, the tsunami water penetrated around 200 meters inland and washed away 162 houses. In Odawara City in Kanagawa Prefecture, there was a report of casualty near a river where 5–6 meters of tsunami merged with a massive landslide caused by the ground shaking (Cabinet Office, 2007).[5] A visualization of the maximum tsunami heights from eyewitnesses and a field survey from the Global Historical Tsunami Database[6] shows high tsunamis observed in both the northeastern side (Kanagawa Prefecture) and the southwestern side (Shizuoka Prefecture) of Sagami Bay.

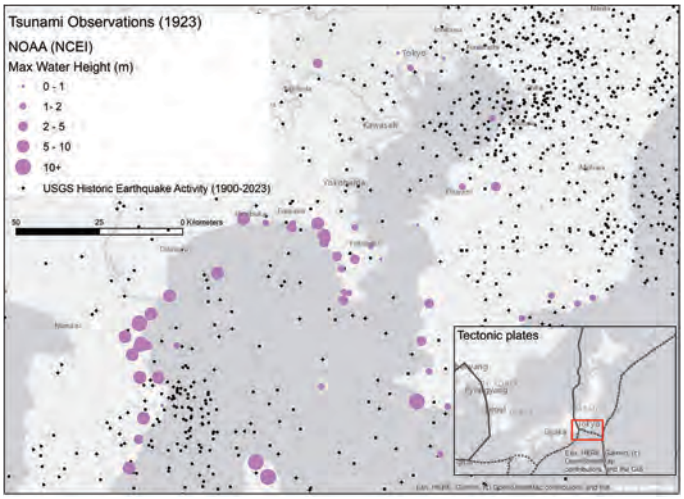

Figure 2: Distribution of the maximum water heights of the 1923 Great Kanto earthquake induced tsunami.[6]

Reassessing the 1923 tsunami

Professor Fumihiko Imamura's team at Tohoku University, a Gallagher Research Centre partner, re-assessed the tsunami induced by the 1923 Great Kanto earthquake using the latest research. The newly proposed fault model by the scientific committee set up by the Cabinet Office of Japan[7] was used to generate an initial condition of the tsunami. The new fault model was re-evaluated according to the amount of vertical crustal movement, observed earthquake intensity and maximum tsunami heights.

The tsunami simulation using Tohoku University's TUNAMI code shows that the large tsunami generated inside Sagami Bay propagates directly towards Shizuoka Prefecture (Figure 3). The tsunami distributes throughout the bay reflecting inside Sagami Bay repeatedly, and then it slowly penetrates Tokyo Bay. In Kamakura City in Kanagawa Prefecture, where over 100 casualties were reported at the time of the 1923 earthquake, and now a popular tourist destination, the tsunami arrives at six minutes and reaches its peak with over 4 meters 11 minutes after the earthquake. It is also observed that 2–3 meters tsunamis repeatedly arrive at its coast every 15–20 minutes with large receding waves observed for many hours.

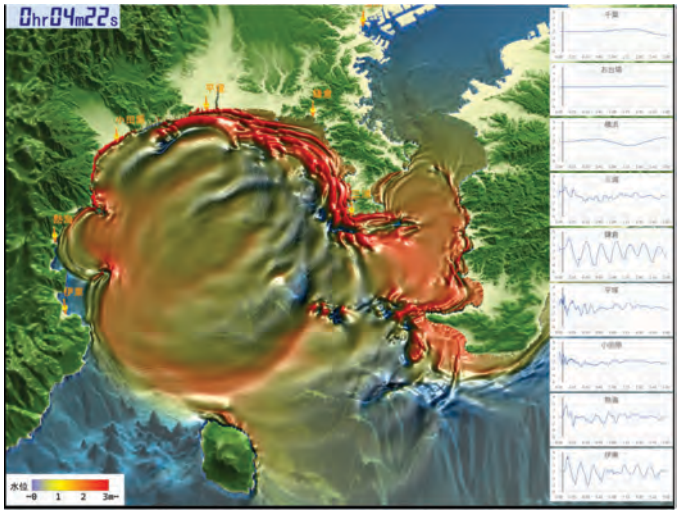

Figure 3: The 1923 Great Kanto tsunami simulation CG, created by Tsunami Engineering Laboratory and Earthquake Induced Tsunami Risk Evaluation Lab (Tokio Marine & Nichido Fire Insurance), IRIDeS, Tohoku University.

Existing historical records only show the location of the maximum tsunami heights. Tohoku University's new simulation reveals temporal information (time series of repeating tsunami waves) for better understanding of this event. The new assessment highlights the potential for an earthquake in Sagami Bay causing a series of large tsunamis arriving soon after the earthquake, and lasting for several hours inside Sagami Bay. This has major implications for evacuation as well as business continuity perspectives. There was no tsunami warning during the 1923 Great Kanto earthquake, but 100 years later in 2023, thanks to a dense observational network of sensors,[3] it would be possible to distribute a tsunami warning within three minutes of an earthquake event.

How can we help?

Gallagher Re with GRC partner Tohoku University have developed tsunami models for Japan and other parts of the world. For more information on Gallagher Re in Japan's Catastrophe Analytics and Gallagher Research Centre, please contact your local client representative.

References

[1]Cabinet Office, Government of Japan (2023) Special website for 100 years of the Great Kanto Earthquake (in Japanese).

[2]*Journal of Japan Association for Earthquake Engineering*, Vol. 2, No. 3, pp.35-71, 2002.

[3]Japan Meteorological Agency (JMA) (2023) Special website for 100 years of the Great Kanto Earthquake (in Japanese).

[4]Cabinet Office, Government of Japan (2006) Special report on the 1923 Great Kanto Earthquake (in Japanese).

[5]Cabinet Office, Government of Japan (2007) "The 1923 Great Kanto Earthquake: Damage caused by ground shaking and tsunami", *Bousai magazine*, No. 39, pages 20-21. (in Japanese).

[6]National Geophysical Data Center/World Data Service (2023): NCEI/WDS Global Historical Tsunami Database. NOAA National Centers for Environmental Information. doi:10.7289/V5PN93H7.

[7]Cabinet Office, Government of Japan (2013) Report on earthquake fault models and cooperated seismic intensity distribution and tsunami height from M7 class earthquake near Tokyo Metropolitan and M8 class earthquake along Sagami Trough (in Japanese).

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