01 What is the Seismic Vulnerability Map?

This Seismic Vulnerability Map shows the distribution of the magnitude of seismic shaking caused by earthquakes.

Waves traveling through the ground have regional characteristics. They are affected by the stratification* of the ground and valley lowlands and plateaus. The entire Minato City area has been analyzed from an engineering perspective and displayed according to a seismic intensity scale.

The seismic intensity indicated on this map is the average magnitude of shaking predicted based on the scale of the earthquake and the distance from the source; shaking may be stronger or weaker than this, depending on how the earthquake occurs.

What is stratification?
On the surface of the earth and at the bottom of the sea, sediments and other materials are deposited upward as the age of the earth progresses. Strata are formed when these sediments are deposited in layers without mixing with each other.

02 Purpose of Creation

In addition to raising the disaster awareness of each and every resident of the City, we have prepared this report with the aim of creating a disaster-resistant town that refers to seismic intensity when building new buildings or renovating existing ones.

03 Anticipated Earthquakes

Earthquake directly under the southern part of central Tokyo (M7.3)

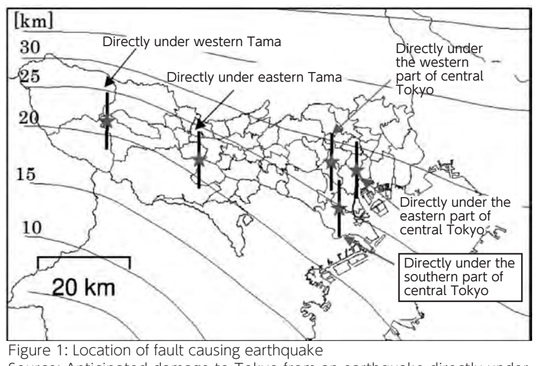
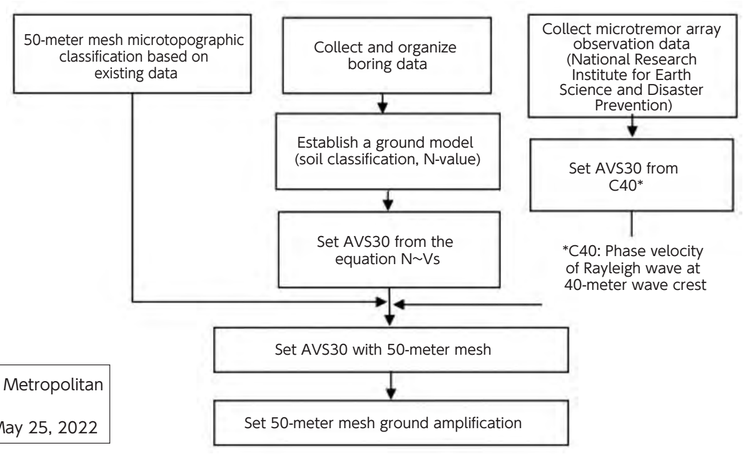


Figure 1: Location of fault causing earthquake
Source: Anticipated damage to Tokyo from an earthquake directly under the Tokyo metropolitan area
The * symbol indicates the epicenter.

04 Process of Creating the Seismic Vulnerability Map

The Seismic Vulnerability Map is created based on the estimated seismic intensity of an earthquake directly under the south part of central Tokyo (M7.3), as indicated in the "Anticipated damage to Tokyo from an earthquake directly under the Tokyo metropolitan area" released by the Tokyo Metropolitan Government. It also expresses seismic vulnerability in detail by indicating measured seismic intensity (a measurement which provides a more detailed classification of the seismic intensity scale) up to the first decimal point.



Created by: Tokyo Metropolitan Government
Publication date: May 25, 2022

05 Magnitude and Seismic intensity

Magnitude indicates the size of the earthquake

"Magnitude" is a measure of the size of the fault movement itself that occurred at the source of the quake. The size (magnitude) of an earthquake is determined by the size of the fault plane that has shifted underground and the amount of displacement. The energy of the seismic waves emitted by the fault movement is indirectly expressed as the magnitude using the maximum amplitude of seismographs.

Seismic intensity indicates the shaking of the earthquake

"Seismic intensity" is a measure of how much an earthquake shakes at a given point. When an earthquake occurs, seismic waves travel through the ground in all directions. The way the seismic waves travel differs depending on the distance from the source, ground conditions, and other factors, so the magnitude of the tremor differs depending on the location. The magnitude of this shaking is measured at each location, and the seismic intensity of each location is determined.

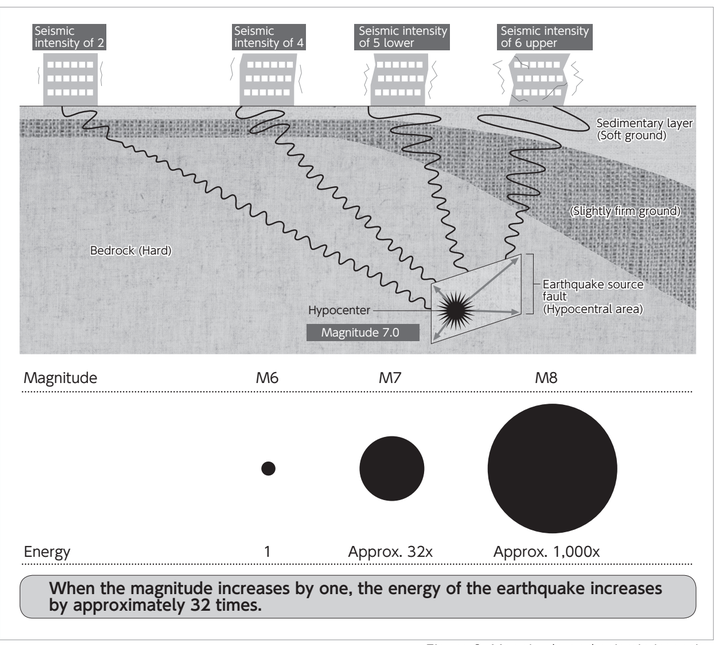


Figure 2: Magnitude and seismic intensity

06 Seismic Vulnerability and the Topographical Formation of Minato City

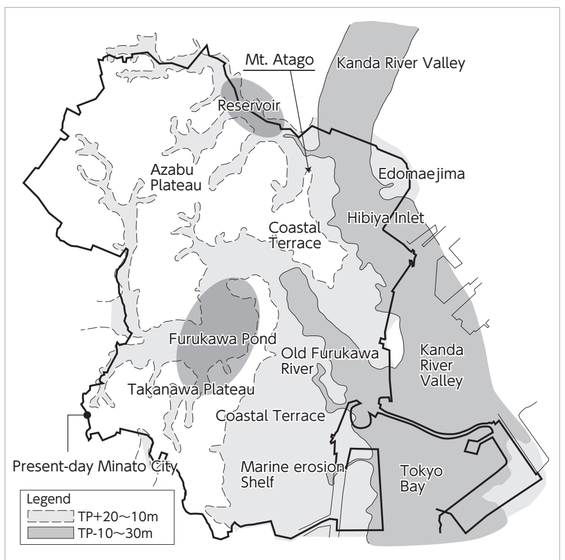


Figure 3: Old topography

Figure 3 shows the basal map of the alluvial stratum.
The alluvial stratum is the stratum accumulated from the last glacial maximum (period of the maximum fall of the sea level) approximately 20,000 years ago. The flood plains and riverbeds cut away by rivers and the low wetlands were naturally filled in and built up by pebbles, sand, grained soil and fossil shells with the rise in sea level.

The difference in shading indicates the depth of the bottom of the alluvial stratum.

The light gray part enclosed by the dotted line is an area of TP +20 to -10m.

The dark gray area enclosed by the solid line is an area of TP -10 to -30m.

TP ±0 is an abbreviation of Tokyo Peil, which is the average water level of the observed tides (Tokyo Bay average sea level) based on the Reiganjima watermark established on the riverbank extending in front of Shinkawa 2-chome, Chuo City. The Japanese datum of leveling, which is the standard for measuring height in Japan, is located in Nagata-cho in Chiyoda City at TP +24.39 m. What is commonly referred to as elevation is the height based on this Japanese datum of leveling, and the 0-meter elevation point indicates TP +24.39 m. All boring data in Minato City was calculated, and by creating one map, we came to understand the regional characteristics in terms of topography and strata.

Please compare the surface seismic vulnerability map and the basal map of the alluvial stratum.
There are two water systems in Minato City, the Hibiya Inlet and its tributaries as the Kanda River Valley (Higashinomiya Gosho → Tameike → Nishi-shimbashi), and the Furukawa Pond and the Old Furukawa River, which created the Azabu and Takanawa plateaus. These two rivers, which created a u-shaped valley and a v-shaped valley in the glacial period, were submerged in the Shimo-sueyoshi and Jomon periods and soft ground built up. It can be seen that the shaking is greater in this region because of the soft strata.
It can be seen that the Shimbashi and Hamamatsucho areas are noticeably more prone to shaking, as determined by a ground survey conducted by the Tokyo Metropolitan Government.

07 How Seismic Waves are Transmitted by Stratums

The destruction that occurs at the hypocenter becomes a wave and is transmitted through the ground, reaching us on the surface of the earth. The seismic wave is transmitted quickly in firm ground located deep underground and is transmitted slowly in soft ground. It gradually progresses towards the surface of the earth and finally reaches the foundations of buildings. (See Figure 5 for the types of seismic waves.)

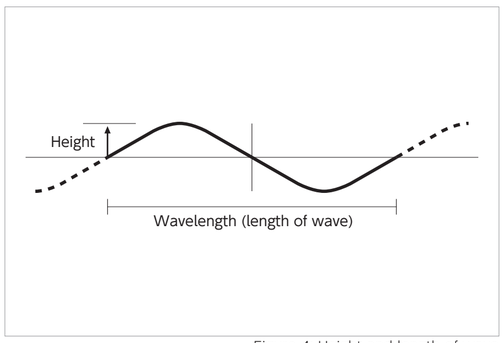


Figure 4: Height and length of wave

What happens to the waves in the strata of the soil?

Since seismic waves are waves, they have the characteristic of bending upward as they are transmitted from firm ground to soft ground. At that time, the flowing wavelength becomes longer and the waves become larger.

Also, seismic waves are reflected and transmitted many times, just like ocean waves that hit the shoreline and bounce back, for example. In this way they come and go in the subsurface soil layers.

See the two waveform figures given below.
These are based on calculations of wave propagation for two sites in Minato City, one on firm ground in the form of a plateau (Waveform Figure 1) and the other on soft ground in an old buried river (Waveform Figure 2).
The same seismic wave was entered using the solidified sand deep in the ground as the base (the base wave depicted in the bottom row of each waveform figure).

These figures represent the boundaries of each stratum and the shape of the waves at the surface and on the earth's surface as they travel through four different strata toward the earth's surface.

The results show that the height of waves is greater on soft ground than on firm ground.

We can also see that the waves do not subside easily in soft ground.

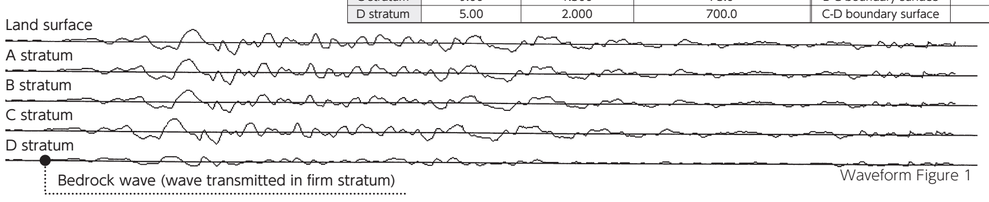
	Magnification of land surface from the lowest stratum	Waveform
Firm ground	2.4	Minor rattling and shaking
Soft ground	4.0	Large rocking and shaking

Firm ground

Minor rattling and shaking

The configuration assuming firm ground is as follows. Maximum acceleration in the bedrock is 100 (gal or cm/sec²).

Stratification condition	Stratum thickness (m)	Stratum density (t/m³)	Shear wave propagation velocity of stratum (m/sec)	Boundary surface (measurement position)	Maximum acceleration of stratum (m/sec²)
A stratum	13.00	1.500	75.0	Ground surface	400.1
B stratum	4.80	1.800	170.0	A-B boundary surface	403.8
C stratum	9.00	1.500	75.0	B-C boundary surface	243.3
D stratum	5.00	2.000	700.0	C-D boundary surface	332.9



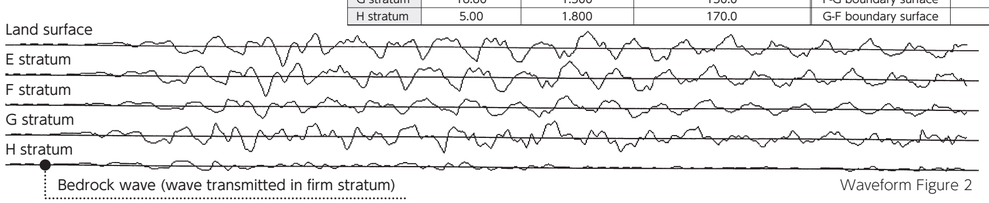
Waveform Figure 1

Soft ground

Large rocking and shaking

The configuration assuming firm ground is as follows. Maximum acceleration in the bedrock is 100 (gal or cm/sec²).

Stratification condition	Stratum thickness (m)	Stratum density (t/m³)	Shear wave propagation velocity of stratum (m/sec)	Boundary surface (measurement position)	Maximum acceleration of stratum (m/sec²)
E stratum	6.80	1.400	150.0	Ground surface	-248.3
F stratum	1.40	1.800	170.0	E-F boundary surface	-248.3
G stratum	18.80	1.500	150.0	F-G boundary surface	-229.5
H stratum	5.00	1.800	170.0	G-F boundary surface	-251.9



Waveform Figure 2

08 Types of Seismic Waves

Here we will briefly explain the types of seismic waves.

Seismic waves are broadly divided into two types. A body wave is transmitted in the earth's interior and a surface wave is transmitted on an extremely thin portion of the land surface and is caused by a body wave' s arrival to the land surface.

Seismic body waves include P waves (vertical waves) and S waves (horizontal waves). P waves arrive first to the land surface when there is an earthquake and cause shaking, and are followed by the arrival of S waves. P waves are parallel waves with respect to the direction of the transmission of the wave, and pushing and pulling occurs due to the breaking up of the ground. S waves travel vertically in the direction a wave transmits, similar to the motion of a rope.

As P wave shaking is not that strong, they are not linked to major damage. However, S waves may cause major damage due to the strength of the wave.

Surface waves include Rayleigh waves and Love waves. Although the transmission speed of both waves is about the same, they are smaller than S waves and are the last to arrive due to transmission through the surface layer of soft stratum.

Surface waves have a large shaking amplitude, long period, and long shaking times.

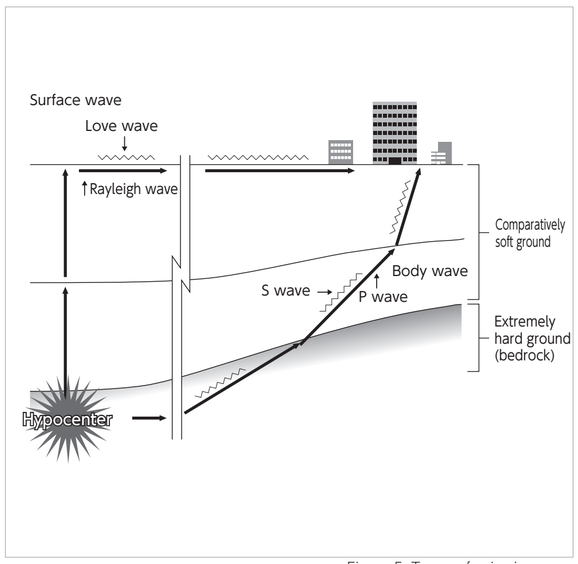


Figure 5: Types of seismic waves

Rayleigh waves resemble the way snakes move, and are transmitted in an elliptical shape. Love waves include vertical waves with respect to the wave transmission direction.

09 Q&A Concerning Seismic Vulnerability

Q **Are places which are seismically vulnerable dangerous?**

A Strata that are seismically vulnerable tend to have proportionally more relaxed (long wavelength) waves. Conversely, strata that are less prone to shaking are located on hard plateaus and tend to rattle (short wavelength).
Each building built there also has an inherent period (equivalent to the length of a wave) that responds to the way it shakes, so the way it shakes depends on the actual earthquake.
The inherent period of the building and the predominant period of the ground differ, so the same level of caution should be exercised everywhere.
Buildings are also designed according to their location, which ensures the safety of the building.

Q **What is the difference between the old Seismic Vulnerability Map and the new one?**

A The distribution of seismic vulnerability is different from the old seismic vulnerability map because the assumed earthquake has been changed and the accuracy of the ground model has been improved.

The Minato City Disaster Prevention App is now available

In light of the 2011 Tohoku Earthquake and Tsunami, Minato City is currently offering the "Minato City Disaster Prevention App" free of charge to promote and raise awareness of disaster prevention among City residents, businesses, and others. Please use this app to check your disaster risk and prepare for disasters. (Only tablets or smartphones are supported.) In addition, each hazard map can be viewed in the app's "Minato City Disaster Prevention Map".

Main content

"Minato City Disaster Prevention Map," "Minato City Disaster Prevention Map by District," "Water Level and Rainfall Information (link)," "Safety Information," and "Minato City Disaster Prevention Information E-mail Service (link)."
"Disaster Emergency Message Dial (link)," "Railway Service Information (link)," "Buzzer Function (linked to device)"
"Light Function (linked to device)," "Various Disaster Prevention Pamphlets"

How to download the Minato City Disaster Prevention App

By scanning the QR code shown on the right, you will connect to the download screen. You can also find the app by searching for the keywords "Minato City Disaster Prevention App" on the app download service.

App Store (for iPhone)
Google Play (for Android)

Information on Disaster Prevention in Minato City

By scanning the QR code on the right, you will be redirected to that page.

Minato City Urban Planning Information Service

Minato City Disaster Prevention and Urban Development Guidelines