Our measures against earthquakes

Damage by the Great East Japan Earthquake (Tohoku-Pacific Ocean Earthquake)

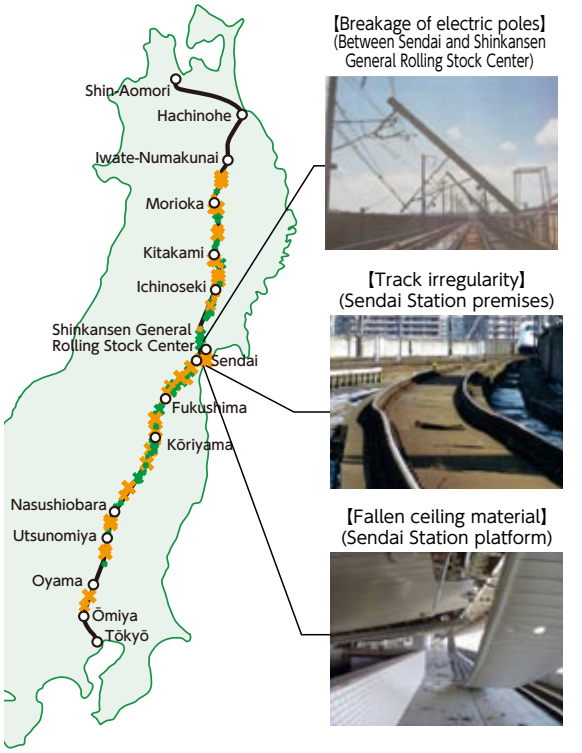
The magnitude 9.0 Tohoku-Pacific Ocean Earthquake occurred on March 11th, 2011, at 14:46, with the epicenter off the Sanriku coast. Zero customer fatalities at stations or on board trains due to the earthquake.

Damage and restoration of railway related facilities following the disaster

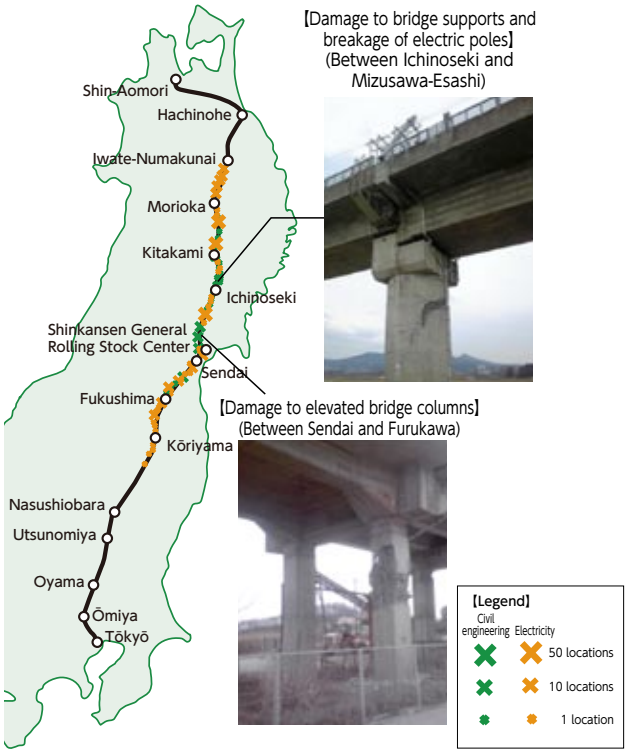
The Great East Japan Earthquake resulted in profound damage to our railway facilities, including the ground facilities for both the Shinkansen and conventional lines.
The following chart outlines the damage incurred by our railway facilities due to the earthquake.

<Major damage to ground facilities for Tohoku Shinkansen>

【Damage caused by the major tremor on Mar. 11th, 2011】



【Damage caused by the aftershock on April 7th, 2011】

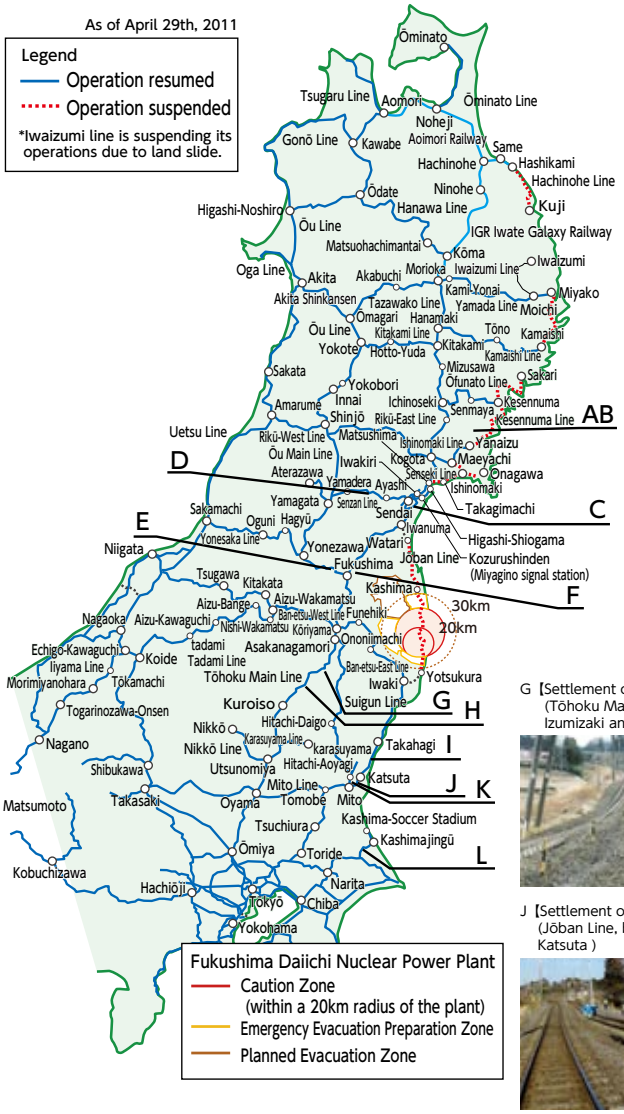


■ Major damage to Tohoku Shinkansen ground facilities

Major damage	March 11 earthquake (main shock)		Aftershocks (after April 7)
	No. of damaged locations	Number of not restored places (as of Apr. 7)	No. of damaged locations
Fractured, tilted, and cracked electric poles	Approx. 540 locations	Approx. 60 locations	Approx. 270 locations
Broken overhead contact lines	Approx. 470 locations	Approx. 30 locations	Approx. 200 locations
Damage to elevated bridge columns	Approx. 100 locations	–	Approx. 20 locations
Track irregularities and damage	Approx. 20 locations	–	Approx. 20 locations
Electrical substation facility failures	Approx. 10 locations	1 location	Approx. 10 locations
Collapse, tilting, and peeling of soundproof walls	Approx. 10 locations	–	2 locations
Breakage and collapse of ceiling materials	5 stations	1 station	2 stations
Sheared bridge girders	2 locations	–	7 locations
Damage to bridge girder supports	Approx. 30 locations	–	Approx. 10 locations
Track damage in tunnels	2 location	–	–
Total	Approx. 1,200 locations	Approx. 90 locations	Approx. 550 locations

* There was no collapse of elevated bridges, bridges, station buildings, or tunnels.

<Major damage to ground facilities for conventional lines>



A【Settlement of embankment】(Tōhoku Main Line, between Nitta and Ishikoshi)

B【Embankment washed away】(Tōhoku Main Line, between Umegasawa and Nitta)

C【Collapse of earth-retaining walls and embankment washed away】(Tōhoku Freight Line, between Nagamachi and Miyagino)

D【Embankment washed away】(Senzan Line, between Sakunami and Yatsumori)

E【Leaning of earth-retaining walls and ballast washed away】(Ōu Main Line, between Niwasaka and Akaiwa)

F【Damage to bridge girder support】(Tōhoku Main Line, between Fukushima and Higashi-Fukushima)

G【Settlement of embankment】(Tōhoku Main Line, between Izumizaki and Yabuki)

H【Collapse of cutting】(Tōhoku Main Line, between Toyohara and Shirasaka)

I【Collapse of platform-retaining walls】Jōban Line, Hitachi-Taga Station)

J【Settlement of embankment】(Jōban Line, between Mito and Katsuta)

K【Leaning of bridge columns】(Suigun Line, between Mito and Hitachi-Aoyagi)

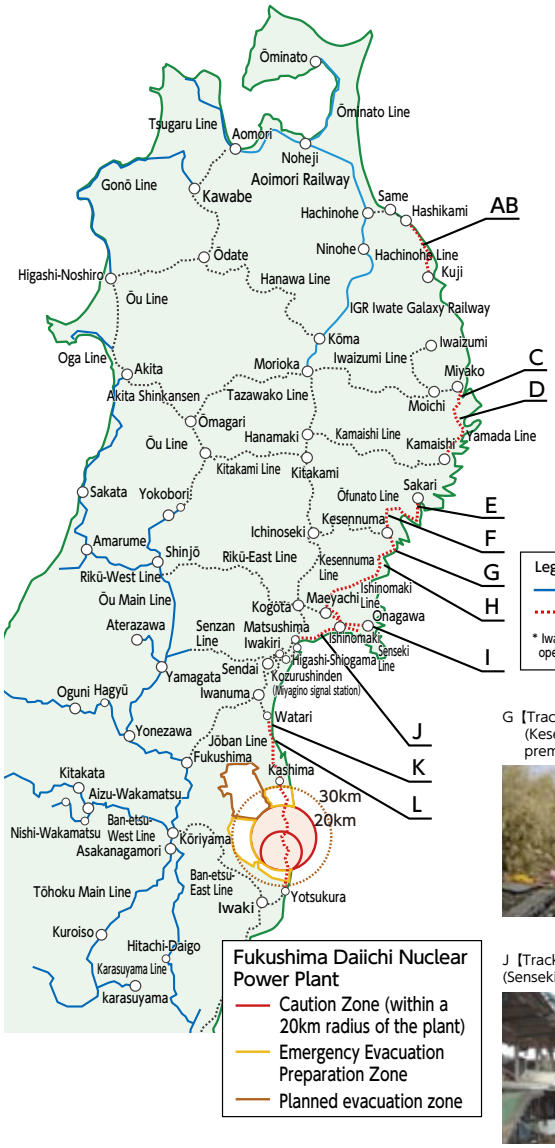
L【Shearing of bridge girders】(Kashima Line, between Nobukata and Kashimajingū)

■ Major damage to the 36 conventional railway lines

Major damage	March 11 earthquake (main shock)		Aftershocks (after April 7)
	No. of damaged locations	Number of not restored places (as of Apr. 7)	No. of damaged locations
Track irregularities	Approx. 2,200 locations	Approx. 130 locations	Approx. 620 locations
Fractured, tilted, and cracked electric poles	Approx. 1,150 locations	Approx. 130 locations	Approx. 90 locations
Outflow of crushed ballast stones	Approx. 220 locations	Approx. 40 locations	1 location
Deformation of platforms	Approx. 220 locations	Approx. 20 locations	Approx. 50 locations
Deformation of civil engineering facilities (embankment, cutting, etc.)	Approx. 170 locations	Approx. 30 locations	Approx. 10 locations
Signal and telecommunication facility failures	Approx. 130 sections	Approx. 30 sections	Approx. 10 sections
Damage to bridges and elevated bridges	Approx. 120 locations	Approx. 20 locations	Approx. 30 locations
Damage to station buildings	Approx. 80 stations	1 station	Approx. 20 stations
Damage to tunnels	Approx. 30 locations	5 locations	2 locations
Electric substation facility failures	Approx. 30 locations	Approx. 10 locations	Approx. 10 locations
Fallen rocks	Approx. 20 locations	–	Approx. 10 locations
Damage to station facilities such as overhead walkways for transfer passengers	Approx. 20 locations	–	4 locations
Broken overhead contact lines	Approx. 10 locations	3 locations	Approx. 10 locations
Total	Approx. 4,400 locations	Approx. 420 locations	Approx. 850 locations

* Major damage to ground facilities on 7 railway lines resulting from the tsunami not included.

<Major damage to ground facilities of seven railway sections resulting from the tsunami>



A【Bridge girder washed away】(Hachinohe Line, between Shukunohe and Rikuchū-Yagi)

B【Tracks washed away】(Hachinohe Line, between Shukunohe and Rikuchū-Yagi)

C【Tracks washed away】(Yamada Line, between Sokei and Tsurugaishi)

D【Bridge girder washed away】(Yamada Line, between Rikuchū-Yamada and Orikasa)

E【Tracks washed away】(Ōfunato Line, Hosoura premises)

F【Tracks washed away】(Ōfunato Line, between Rikuzen-Yahagi and Takekoma)

G【Tracks washed away】(Kesennuma Line, Ōyakaigan premises)

H【Bridge girder washed away】(Kesennuma Line, between Rikuzen-Koizumi and Motoyoshi)

I【Tracks washed away】(Ishinomaki Line, Onagawa premises)

J【Tracks washed away】(Senseki Line, Nobiru premises)

K【Bridge girder washed away】(Jōban Line, between Shinchi and Sakamoto)

L【Tracks washed away】(Jōban Line, Shinchi premises)

■ Major damage (as of May 1st, 2011)

Line name	Railway division	Length	Station building			Track	Total
			No. of stations inspected	No. of stations washed away	No. of other damaged stations	No. of damaged locations	No. of damaged locations
Hachinohe Line	Hashikami–Kuji	Approx. 37 km	12 stations	0 station	2 stations	Approx. 20 locations	Approx. 20 locations
Yamada Line	Miyako–Kamaishi	Approx. 55 km	13 stations	4 stations	4 stations	Approx. 70 locations	Approx. 80 locations
Ōfunato Line	Kesennuma–Sakari	Approx. 44 km	12 stations	6 stations	1 station	Approx. 60 locations	Approx. 70 locations
Kesennuma Line	Maeyachi*–Kesennuma*	Approx. 73 km	21 stations	9 stations	3 stations	Approx. 240 locations	Approx. 250 locations
Ishinomaki Line	Maeyachi–Onagawa	Approx. 32 km	11 stations	1 station	3 stations	Approx. 70 locations	Approx. 70 locations
Senseki Line	Higashi-Shiogama–Ishinomaki*	Approx. 34 km	16 stations	0 station	8 stations	Approx. 380 locations	Approx. 390 locations
Jōban Line	Iwaki–Watari**	Approx. 50 km	14 stations	3 stations	4 stations	Approx. 840 locations	Approx. 850 locations
Total		Approx. 325km	99 stations**	23 stations	25 stations	Approx. 1,680 locations	Approx. 1,730 locations

*The figures do not include station premises.
**The following are excluded from the above data: damage within a 20km radius of the Fukushima Daiichi Nuclear Power Plant; Emergency Evacuation Preparation Zone (between Hisanohama and Kashima: station buildings at 12 stations (excluding Tomioka Station), approx. 70km of track).

Situation of customers on board Shinkansen trains

At the time of the earthquake, 27 Tohoku Shinkansen trains were in operation. However, coastal seismometers of the early earthquake detection system immediately detected the tremor and shut down the electric supply, automatically activating emergency braking to stop all operating Shinkansen trains. Fortunately, the passengers on board Shinkansen trains did not sustain any injury from the tremor.

Evacuating customers to avoid the tsunami

At the time of the earthquake, we evacuated customers from 27 conventional line trains at stations or between stations, and from 34 stations. After the evacuation, five trains were derailed and washed away by the tsunami. However, through the concerted efforts of train crews, station personnel, and dispatchers as well as with the cooperation of customers on board trains and neighboring communities, we were able to safely evacuate our customers and there were no customers hurt by the tsunami at stations or on board trains.


Yamada Line, Tsurugaishi Station, 1647D

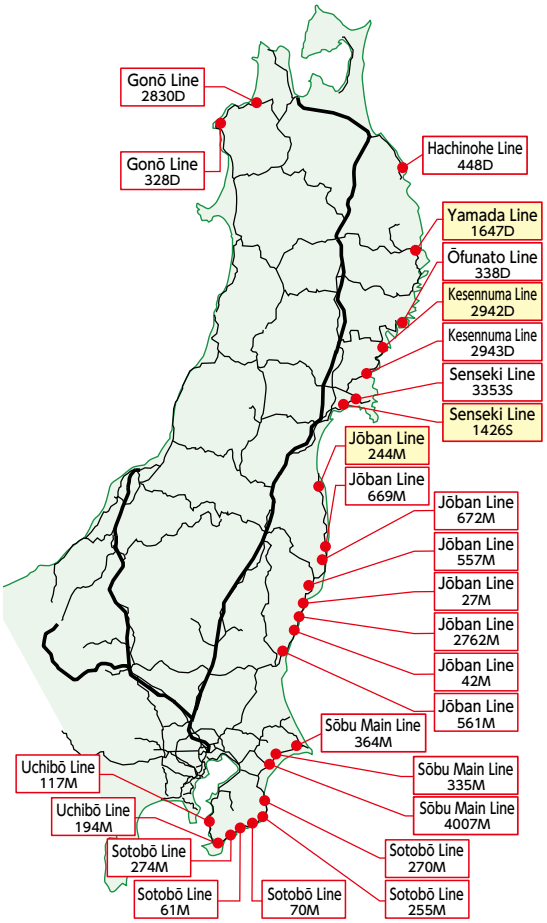

Kesennuma Line, between Saichi and Matsuiwa, 2942D


Senseki Line, Nobiru Station, 1426S


Jōban Line, Shinchi Station, 244M


Ishinomaki Line, Onagawa Station, 1640D

At the time of the earthquake, trains were evacuated to prepare for the tsunami.
(*Trains washed away by the tsunami are indicated in yellow.)



Derailment of a Shinkansen train in a test run

At the time of the earthquake, in the Sendai Station premises of the Tohoku Shinkansen, a test train was in operation at a speed of approx. 70km/h. Though its emergency brake was activated by the earthquake, it derailed at a low speed immediately before stopping. After the derailment, the train ran for approx. 2.5m and then stopped. Since it was on a test run, there were no customers on board the train, resulting in no injury. As anti-earthquake measures for Shinkansen trains, we will steadily take measures such as emergency stopping of trains and seismic reinforcement of facilities and structures, while further promoting research and development of rolling stock and analysis of vibration characteristics of structures such as elevated bridges.



The scene of derailment

Learning from earthquakes in the past such as the Great Hanshin-Awaji Earthquake, the Sanriku Minami Earthquake, Niigata Chuetsu Earthquake, JR East has employed the following three anti-earthquake measures:
①Stopping trains immediately (emergency train stop measures)
②Preventing structural damage (seismic reinforcement measures)
③Minimizing secondary accidents following derailment (preventive measures against derailed trains leaving the track area)

At the time of the Great East Japan Earthquake, in locations with seismic reinforcement, though some of the elevated bridge columns were damaged, we did not observe shear failure and there was no falling or collapsing of elevated bridges. However, on conventional lines some of the bridges without seismic reinforcement were damaged by the tremor. Additionally, the earthquake resulted in the wrecking of electric poles and the collapse of ceiling materials in station buildings. Based on experience derived from the Great East Japan Earthquake, JR East designated the five years from FY2013 as a priority improvement period and has been striving to provide disaster-resilient railways through the introduction of measures such as preparations for a possible earthquake directly beneath the Tokyo metropolitan area, seismic reinforcement for Sendai and other areas, reinforcement of seismic observation systems and anti-disaster telecommunication facilities, with a planned total investment of approximately 300 billion yen.

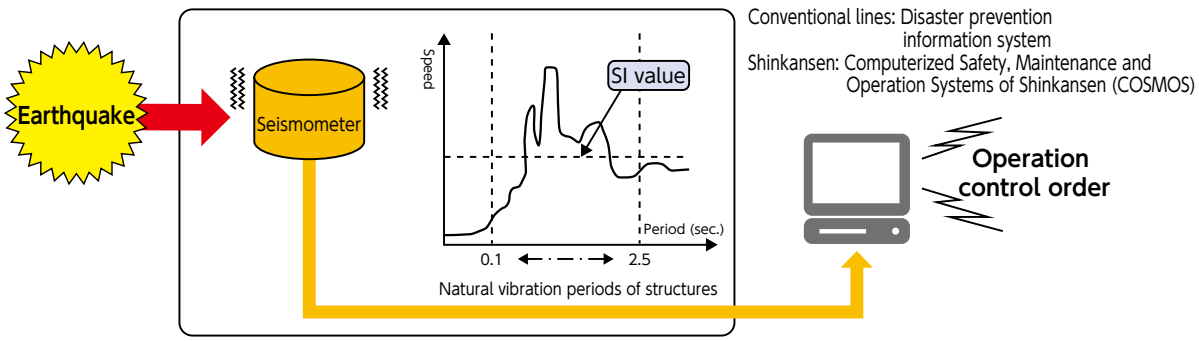
Emergency train stopping measures

Early earthquake alert system for Shinkansen lines

For Shinkansen lines, wayside, coastal, and inland seismometers are installed at 135 locations, and JR East utilizes the Shinkansen early earthquake alert system to detect primary tremors (P-waves) prior to principal shock (S-waves) to stop trains as quickly as possible.
For conventional lines, using information from the Shinkansen early earthquake alert system and also the Earthquake Early Warning of the Japan Meteorological Agency, JR East utilizes systems to activate the emergency brake of trains in the necessary sections. The system has been in service in the Tokyo metropolitan area since December 2007 and in all other areas since April 2009.

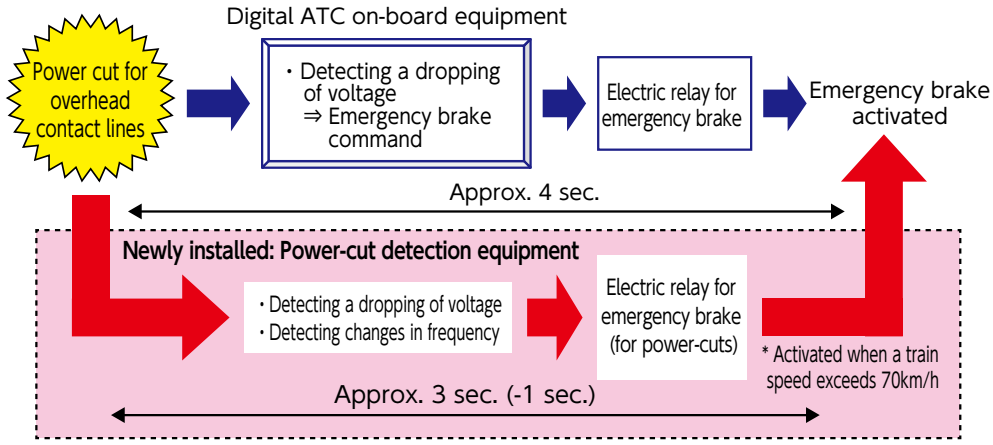
Index for operational restrictions at a time of earthquake

As for operational restrictions for an earthquake, since April 2003 for conventional lines, and since Sep. 2005 for Shinkansen, JR East has been utilizing spectrum intensity (SI value, kine: cm/sec), which is highly relative to damage to structures.
With SI values, JR East is able to take the duration of acceleration force and natural periods of vibration for each structure into consideration to increase the accuracy of its prediction of damage to structures, which was not possible with traditional methods that utilize maximum acceleration (gal: cm/sec2).



Power-cut detection equipment

For Shinkansen, when a wayside seismometer detects the occurrence of an earthquake, the power supply to overhead contact lines is shut off to stop Shinkansen trains. In addition to on-board digital ATC equipment detecting the power cut to the overhead contact line and activating emergency braking, JR East has newly installed power-cut detection equipment to shorten the time required for the detection by approx. 1 sec. to quicken the emergency braking.
Moreover, for E5 and later series of Shinkansen trains, when the power-cut detection equipment activates the emergency brake, an improved braking system can stop the trains with less braking distance by applying stronger braking.

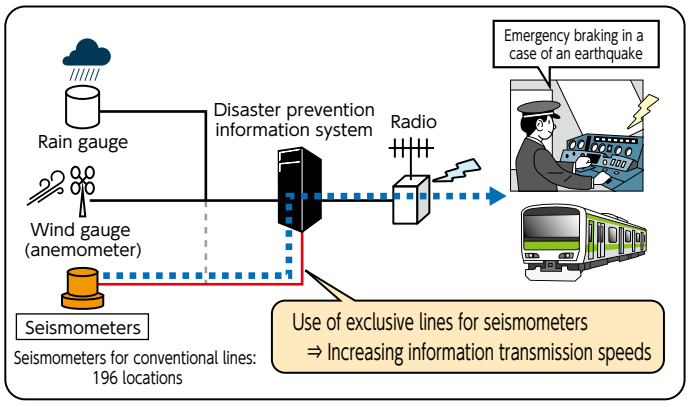


Increased installation of seismometers after the Great East Japan Earthquake

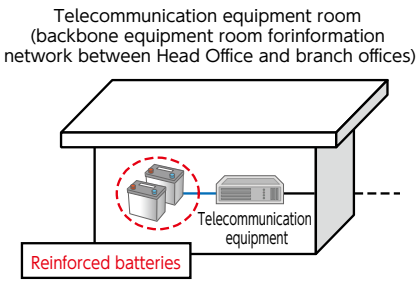
Learning lessons from the Great East Japan Earthquake, JR East installed seismometers at 30 locations inland and in the Tokyo metropolitan area. These seismometers have been in use since Mar. 2012 for conventional lines and since Aug. 2012 for Shinkansen. Additionally, we adopted the Earthquake Early Warning of the Japan Meteorological Agency, which we have been using for conventional lines and Shinkansen since Oct. 2012. Moreover, JR East is working with the relevant ministries and agencies and other railway operators on coordinating and reviewing the utilization of the Seafloor Observation Network for Earthquakes and Tsunamis along the Japan Trench (S-net) created by the National Research Institute for Earth Science and Disaster Prevention.

Increasing transmission speed of earthquake observation values for conventional lines

JR East is increasing the transmission speed of earthquake observation values for conventional lines. At the time of the Great East Japan Earthquake, the power supply was cut for a long time over a wide area and we could not use telecommunication facilities. For this reason, JR East has reinforced telecommunication facilities by strengthening the battery capabilities of telecommunication equipment rooms to 48 hours and by installing emergency outlets for telecommunication equipment in buildings.



Increasing the transmission speed by introducing exclusive lines for seismometers for conventional lines



Reinforced batteries for telecommunication equipment rooms

Seismic reinforcement measures

Seismic reinforcement of elevated bridges

In response to the 1995 Great Hanshin-Awaji Earthquake, JR East reinforced rigid-frame elevated bridges susceptible to shear failure in the Southern Kanto and Sendai areas for both Shinkansen and conventional lines.
Additionally, after the Sanriku Minami Earthquake in 2003, we aimed to complete the seismic reinforcement of elevated bridge columns susceptible to shear failure in all areas for Shinkansen in FY2009. Moreover, at the time of the Niigata Chuetsu Earthquake in 2004, since elevated bridges and bridges were damaged on the Joetsu Shinkansen Line, we completed the seismic reinforcement for Shinkansen in FY2008, a year ahead of schedule and for conventional lines in FY2009 as planned.

				Southern Kanto area	Sendai areas	Other areas
Shinkansen	Susceptible to shear failure	Elevated bridges, bridge columns		Approx. 1,900 columns, approx. 310 units	Approx. 16,600 columns, approx. 2,030 units	
	Susceptible to failure due to bending	Elevated bridges	Without retail premises	Approx. 3,800 columns	Approx. 2,900 columns	Approx. 7,130 columns
			With retail premises	Approx. 1,100 columns	Approx. 410 columns	
		Bridge columns		Approx. 680 units		
Conventional lines	Susceptible to shear failure	Elevated bridges, bridge columns		Approx. 12,500 columns, approx. 530 units	Approx. 100 columns, approx. 10 units	Approx. 940 columns, approx. 820 units
	Susceptible to failure due to bending	Elevated bridges	Without retail premises	Approx. 5,460 columns	Approx. 40 columns	
			With retail premises	Approx. 5,630 columns	Approx. 30 columns	
		Bridge columns		Approx. 1,090 units		

Completed by FY2009 Completed by FY2015 In progress

Currently, we are reinforcing elevated bridge columns susceptible to failure due to bending by strong earthquake motion for Shinkansen and conventional lines in the Southern Kanto and Sendai areas. For some section of conventional lines in other areas, we are reinforcing elevated bridge columns and bridge columns susceptible to shear failure.

Seismic reinforcement of elevated bridge columns by steel plate wrapping

Seismic reinforcement of station buildings

JR East is also reinforcing station buildings and tunnels. We had completed seismic reinforcement of approx. 170 station buildings serving more than 10,000 passengers per day by the end of FY2012, excluding those earmarked for large-scale improvement.
Currently, we are proceeding with the seismic reinforcement of approx. 85 station buildings serving more than 3,000 passengers per day.

Reinforcement by steel frame braces

Reinforcement of columns by steel plate wrapping

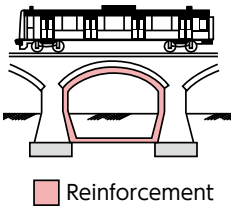
Measures against collapse of civil engineering structures, electric poles, ceilings and walls

Based on the Great East Japan Earthquake and to ensure we are prepared for an earthquake directly beneath the Tokyo metropolitan area, we are proceeding with seismic reinforcement of embankments, cuttings, and brick arched elevated bridges for nine railway sections (approx. 220km) including the Yamanote and Chuo Lines. We will also continue our efforts to complete the seismic reinforcement of bridge columns ahead of schedule.

■ Reinforcement examples for an earthquake directly beneath the Tokyo metropolitan area

Seismic reinforcement of embankment

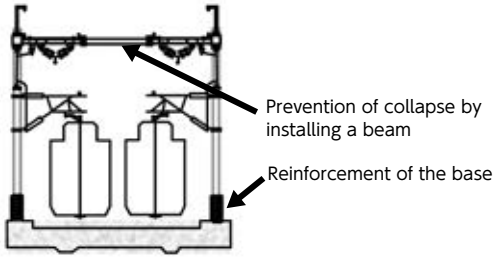
Brick arched elevated bridge



We have also reinforced approx. 2,300 electric poles damaged by the Great East Japan Earthquake on Shinkansen and conventional lines.

■ Electric poles damaged by the Great East Japan Earthquake and reinforcement (image)

【Reinforcement of electric poles and installation of a beam to make it a gate shape】



For station buildings and platforms, we will continue our measures to prevent the collapse of ceilings for approx. 560 stations and of walls for approx. 60 stations.

■ Fallen ceiling material due to the Great East Japan Earthquake and reinforcement by diagonal bracing (image)

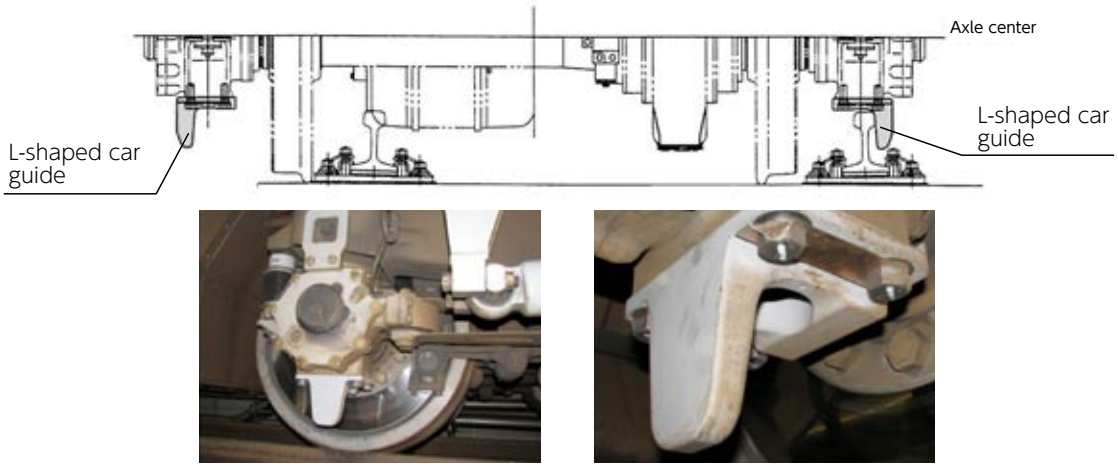
Prevention of secondary accidents after derailment

During the Niigata Chuetsu Earthquake in 2004, one of our Joetsu Shinkansen trains, Toki No. 325, derailed. Based on an investigation of the causes of the derailment, JR East has taken measures such as those described below. At the time of the Great East Japan Earthquake, a test Shinkansen train derailed at low speed. Learning from the results of the investigation of Shinkansen rolling stock and tracks, JR East continues its efforts to further improve its safety measures.

Joetsu Shinkansen trains, Toki No.325

Installation of L-shaped car guides

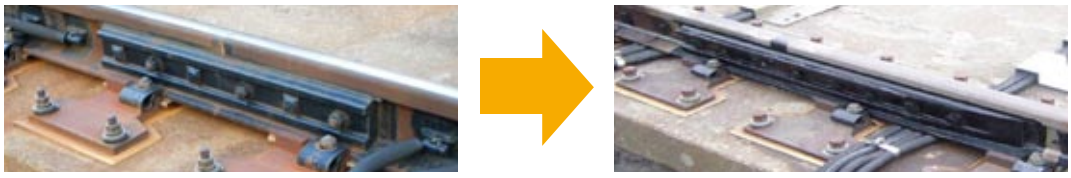
L-shaped car guides are installed on bogies to prevent Shinkansen trains from completely leaving the track in a derailment. We had completed the installation of L-shaped car guides for all Shinkansen by Aug. 2008.



L-shaped car guide

Preventing breakage of glued insulated joints

This is a measure to reduce the impact of wheels and bogie parts on glued insulated joints in a derailment. The glued insulated joints connect rails at transition points for signal circuits. Specifically, the shape of the joint plate was modified to prevent the wheels from directly impacting joint plates and bolts in a derailment. This modification was completed for all railway sections for Shinkansen by the end of FY2012.



Before improving glued insulated joints

After improving glued insulated joints

Rail rollover prevention devices

The device guides the wheels along the rails after a derailment, preventing rail rollover and the rails from completely deviating from the track even when a train derails and its rail fasteners are broken.
As for rail rollover prevention devices for slab tracks, we have been installing the devices since FY2010 in accordance with our plan.

Rail rollover prevention devices

Improvement of emergency telecommunication facilities

To secure information transmission for commercial use when communication is disrupted or communication limits are in place, we have taken the following measures:

Installation of WiMAX terminals and satellite mobile phones

To prepare for disruption in commercial data communication via the in-house intranet, as substitutes we installed WiMAX terminals capable of data communication at Head Office, branch offices and major stations in Dec. 2012.

WiMAX terminals

To prepare for the wrecking of antenna and cables, we have installed satellite mobile phones at Head Office, branch offices and major stations to prevent damage to ground facilities affecting secure commercial communication in Aug. 2012.

Satellite mobile phones

Installation of satellite fixed phones

To prepare for disruption of communication due to physical damage or communication limits, we installed satellite communication facilities capable of commercial audio and data communication via exclusive lines at Head Office, and at Tokyo, Yokohama, Hachioji, Omiya, Takasaki and Chiba branch offices in Mar. 2013.

Satellite fixed phones

At Yokohama and Omiya branch offices, we installed satellite communication facilities into automobiles in Mar. 2013, equivalent to those installed at other branch offices.

An automobile with on-board satellite communication facilities

Measures against tsunamis

Before the Great East Japan Earthquake, we had set operational restriction methods and tsunami danger zones for each location, prepared manuals, and were holding study sessions and conducting drills on guiding passengers to de-board trains for evacuation. We believe that these efforts led to the prompt evacuation of passengers away from tsunami danger zones at the time of the earthquake.

Tsunami evacuation manual

Signs at stations showing evacuation areas

Drill to guide passengers to alight from a train for evacuation

Based on our experiences with tsunamis at times of earthquake, we reviewed the rules, manuals, and drills for the whole JR East Group.

Formulating action guidelines for evacuation to avoid tsunamis

To prepare for a case when there is no time before the arrival of a tsunami, JR East formulated action guidelines for evacuation during tsunamis for each one of its employees to follow in January 2012.

■Action guidelines for evacuation to avoid tsunamis

1. At a time of a large earthquake, be prepared for tsunamis. Gather information by yourselves and if communication lines are disconnected, make your own decisions for evacuation. (Do not afraid to make a mistake.)
2. Once decided to evacuate, by judging conditions of customers, promptly guide customers to evacuate.
3. In alighting from trains, evacuating and gathering information, ask customers and local people to cooperate.
4. Even after evacuation, go to a higher place without being satisfied and thinking this would be high enough.
5. Stay evacuated with customers and do not return to field offices or trains while tsunami warnings are still issued.

Improvement of evacuation signs and routes and conducting drills for evacuation during tsunamis

For railway lines such as the Hachinohe Line, which resumed operations following damage caused by tsunamis, we have improved the signs and routes for evacuation from tsunamis. We will also improve evacuation signs and routes for other railway sections.
Furthermore, in FY2015, we conducted drills on guiding passengers to alight from trains and escape from a tsunami at tsunami-prone locations, assuming that there was no time before the arrival of the tsunami. We will continue these drills every year at the same time of year.

Tsunami evacuation sign (Hachinohe Line)

Evacuation route (Hachinohe Line)

Drill to guide passengers to alight from a train during a tsunami

Efforts to save lives

In the case of an earthquake directly beneath the Tokyo metropolitan area, numerous passengers might be injured and we might need to save the lives of passengers with the help of a limited number of our employees before the arrival of rescuers. For a major earthquake, placing top priority on saving the lives of the injured, JR East has prepared the following first aid kits and is also conducting drills to give personnel necessary first aid skills.

Rescue kits to save injured persons

We installed rescue kits (crowbars, jacks etc.) at each station of the five branch offices in the Tokyo metropolitan area to save injured persons from collapsed walls, furniture and fixtures in Sep. 2012.

Rescue kits

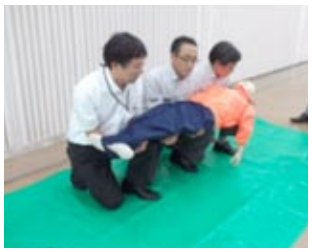
First aid kits to provide first aid to injured persons

We installed first aid kits (triangular bandages, etc.) to care for people's external injuries such as bleeding and fractures at each station within 30km of Tokyo in Mar. 2013.

First aid kits

Training to rescue and save lives

To rescue and save the lives of injured persons by, for example, caring for external injuries and carrying the person to a safer location, we have been conducting training to give personnel the necessary skills since FY2013 in accordance with our plans.



Rescue and life-saving training

General emergency drills

JR East conducts general emergency drills to prepare for an earthquake during disaster preparedness week around Sep. 1st, every year. The drills include the following:

- Drills to operate an on-site disaster countermeasure headquarters at Head Office and each branch office
- Drills for rescuing, life-saving, guiding passengers during an evacuation, and initial firefighting in each district
- Safety confirmation drills for employees and their family members in cooperation with Head Office, branch offices, and field organizations. Additionally, we participate in disaster drills run by local municipalities.

General emergency drills

Participation in drills run by local municipalities