

## Special Topics: Damage following the Great East Japan Earthquake and efforts toward restoration and reconstruction

### ○ The Great East Japan Earthquake

The magnitude 9.0 Tohoku-Pacific Ocean Earthquake occurred on March 11th, 2011, at 14:46, with the epicenter off the Sanriku coast. The earthquake produced strong tremors over a wide area, with a giant tsunami sweeping away much of the Pacific Ocean coastal area of the Tohoku and Kanto regions. The quake was followed by a series of strong aftershocks, causing tremendous damage to various regions in eastern Japan. For all of the victims of the earthquake and tsunami, and for those who lost their lives, we would like to extend our deepest sympathies and offer a solemn prayer to them all.

In this series of Special Topics, we will outline the damage to our facilities resulting from the Great East Japan Earthquake and our endeavors toward restoration and reconstruction.

### 1. 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. Despite the intermittent aftershocks following the earthquake, we were able to begin restoration work on our facilities greatly due to the enormous support we received from JR Group companies and other concerned parties. For the Tohoku Shinkansen lines, we were able to resume operations for all railway sections by April 29th, 2011, and return to regular time tables from September 23rd. For our conventional lines, with the exception of the railway sections running along the Pacific Ocean, which received particularly catastrophic damage due to the tsunami, train operations have gradually been able to resume one by one.

The following chart outlines the damage incurred by our railway facilities due to the Great East Japan Earthquake followed by details regarding restoration.

#### ■ Major damage to Tohoku Shinkansen ground facilities (as of May 10, 2011)

| Major damage                                       | March 11 earthquake<br>(main shock) | Aftershocks<br>(after April 7) | No. of damaged<br>locations |
|--|-------------------------------------|--------------------------------|-----------------------------|
| Fractured, tilted, and cracked power poles         | Approx. 540 locations               | Approx. 270 locations          | Approx. 810 locations       |
| Broken overhead contact lines                      | Approx. 470 locations               | Approx. 200 locations          | Approx. 670 locations       |
| Damage to elevated bridge columns                  | Approx. 100 locations               | Approx. 20 locations           | Approx. 120 locations       |
| Track irregularities and damage                    | Approx. 20 locations                | Approx. 20 locations           | Approx. 40 locations        |
| Electrical substation facility failures            | Approx. 10 locations                | Approx. 10 locations           | Approx. 20 locations        |
| Collapse, tilting, and peeling of soundproof walls | Approx. 10 locations                | 2 locations                    | Approx. 10 locations        |
| Breakage and collapse of ceiling materials         | 5 stations                          | 2 stations                     | 7 stations                  |
| Sheared bridge girders                             | 2 locations                         | 7 locations                    | 9 locations                 |
| Damage to bridge girder supports                   | Approx. 30 locations                | Approx. 10 locations           | Approx. 40 locations        |
| Track damage in tunnels                            | 2 locations                         | —                              | 2 locations                 |
| Total  | Approx. 1,200 locations             | Approx. 550 locations          | Approx. 1,750 locations     |

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

## ■ Major damage to conventional line ground facilities (as of May 10, 2011)

Major damage for the 36 railway divisions

| Major damage   | March 11 earthquake (main shock) | Aftershocks (after April 7) | Total                   |
|--|----------------------------------|-----------------------------|-------------------------|
| Track irregularities   | Approx. 2,200 locations          | Approx. 620 locations       | Approx. 2,820 locations |
| Fractured, tilted, and cracked power poles                                       | Approx. 1,150 locations          | Approx. 90 locations        | Approx. 1,240 locations |
| Outflow of crushed ballast stones  | Approx. 220 locations            | 1 location                  | Approx. 220 locations   |
| Deformation of platforms   | Approx. 220 locations            | Approx. 50 locations        | Approx. 270 locations   |
| Deformation of civil engineering facilities (earth filling, earth cutting, etc.) | Approx. 170 locations            | Approx. 10 locations        | Approx. 180 locations   |
| Signal and telecommunication facility failures                                   | Approx. 130 sections             | Approx. 10 sections         | Approx. 140 sections    |
| Damage to bridges and elevated bridges   | Approx. 120 locations            | Approx. 30 locations        | Approx. 150 locations   |
| Damage to station buildings  | Approx. 80 stations              | Approx. 20 stations         | Approx. 100 stations    |
| Damage to tunnels  | Approx. 30 locations             | 2 locations                 | Approx. 30 locations    |
| Electric substation facility failures  | Approx. 30 locations             | Approx. 10 locations        | Approx. 40 locations    |
| Fallen rocks   | Approx. 20 locations             | Approx. 10 locations        | Approx. 30 locations    |
| Damage to station facilities such as overhead walkways for transfer passengers   | Approx. 20 locations             | 4 locations                 | Approx. 20 locations    |
| Broken overhead contact lines  | Approx. 10 locations             | Approx. 10 locations        | Approx. 20 locations    |
| Total  | Approx. 4,400 locations          | Approx. 850 locations       | Approx. 5,250 locations |

※ Major damage to ground facilities in 7 railway divisions resulting from the tsunami (as of May 1, 2011)

## ■ Major damage to ground facilities in 7 railway divisions resulting from the tsunami (as of October 1, 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     |
| Ofunato Line    | Kesennuma-Sakari                              | Approx. 44 km  | 12 stations                 | 6 stations                  | 1 station                     | Approx. 60 locations     | Approx. 70 locations     |
| Kesennuma Line  | Maeyachi <sup>※</sup> -Kesennuma <sup>※</sup> | 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 <sup>※</sup>      | Approx. 34 km  | 16 stations                 | 0 station                   | 8 stations                    | Approx. 380 locations    | Approx. 390 locations    |
| Joban Line      | Iwaki-Watari <sup>※※</sup>                    | Approx. 50 km  | 18 stations                 | 3 stations                  | 4 stations                    | Approx. 840 locations    | Approx. 850 locations    |
| Total           |   | Approx. 325 km | 103 stations <sup>※※※</sup> | 23 stations                 | 25 stations                   | Approx. 1,680 locations  | Approx. 1,730 locations  |

※ The figures do not include station premises.

※※ Inspections for the Evacuation-Prepared Area for the case of an Emergency areas within a 20 km radius of the Fukushima Daiichi Nuclear Power Plant (between Kido and Odaka: for the station buildings at 8 stations (excluding Tomioka Station), and approx. 40 km of tracks) have been postponed.

※※※ In addition to the 103 stations inspected, there are 8 stations for which inspections have been postponed (Kido, Tatsuta, Yonomori, Ono, Futaba, Namie, Momouchi, Odaka, Iwaki-Ota, and Haranomachi).

### ■ Track irregularity (Sendai Station premises)



Before restoration



After restoration

### ■ Collapse of ceiling materials (Sendai Station)



Before restoration



After restoration

## 2. Utilizing our experience from past earthquakes

In learning from the earthquakes to date, JR East has initiated various earthquake countermeasures including the seismic reinforcement of elevated bridges, and improvements to its Earthquake Early Detection System and Earthquake Early Warning System.

In order to utilize the lessons learned from the 1995 Great Hanshin-Awaji Earthquake, JR East instituted a series of seismic reinforcement measures for rigid-frame elevated viaduct support columns and bridge columns which were previously susceptible to shear failures. By the end of March 2008, we had reinforced all these facilities of Shinkansen. Also on our conventional lines, by the end of March 2009, we had completed the same reinforcement for all columns except the places that were related with other construction work in the Southern Kanto and Sendai areas.

As a result, we were able to prevent the collapse of elevated bridge columns at the time of the Great East Japan Earthquake. Currently, we are working to reinforce elevated bridge columns which are susceptible to failure due to bending from intense earthquake motion, aiming to further improve our safety levels against earthquakes.

JR East has introduced a system for the Shinkansen, in which seismometers for the detection of primary tremors (P-waves) are installed along its railway lines and on the coastlines. This system allows us to stop trains as soon as primary tremors are detected.

At the time of the Great East Japan Earthquake, 2 Shinkansen trains were operating in the Sendai area at the speed of approx. 270 km/h. The coastal seismometers were activated to shut down the power supply 12-15 seconds before the earthquake motion exceeded thresholds for operational discontinuation and actuate emergency braking. For conventional lines, our Earthquake Early Warning System was introduced for the Tokyo metropolitan area in December 2007 and in all other areas in April 2009. The system utilizes information obtained from Shinkansen seismometers and Earthquake Early Warnings transmitted by the Japan Meteorological Agency to stop trains in any section of track in the case of a major earthquake.

Additionally, through the lessons we learned from the 2004 Niigata Chuetsu Earthquake in which one of our Joetsu Shinkansen trains was derailed in operation, and from the perspective of preventing secondary accidents following a derailment, JR East has instituted numerous measures aimed at improving our Shinkansen railcars and tracks. At the time of the Great East Japan Earthquake, one of our trains in test operation derailed. As such, we are conducting further investigations into the mechanism of derailment in order to improve such safety measures.

## 3. Issues remaining after the disaster and our countermeasures to them

Immediately after the occurrence of the Great East Japan Earthquake, we established “Headquarters for Earthquake Disaster Control”, headed by President and have strived to protect the customers’ safety as the matter of first priority.

Protecting the lives of passengers and employees at the time of a disaster, and taking prompt action toward restoration are considered of top priority in JR East’s business continuity plan (BCP). At the time of the Great East Japan Earthquake, although our actions were consistent with this principle, we have identified some areas in need of improvement.

In order to better direct passengers to evacuation in the occurrence of a tsunami or damage to our facilities, JR East established an investigative committee following the Great East Japan Earthquake to study and to verify our measures with both hardware and software, and to consider any necessary improvements. Under the Committee, each of the special interest groups of experts has been assigned to investigate the following: understanding the mechanisms of Shinkansen derailment; the verification of train stop systems for Shinkansen and conventional lines; the verification of passenger evacuation guidance at the time of a tsunami; and, measures to counter damage to Shinkansen power poles.

At the time of the Great East Japan Earthquake, even in the Tokyo metropolitan area, many seismometers recorded nearly double the threshold designated for operational cessation, and in most of our railway divisions, many of the inspections were required to be done on foot. Consequently, after taking the range of circumstances into consideration, and the fact that some locations would require restoration work that was judged to take until the following morning, we decided to halt train operations on March 11 and close our ticket gates.

However, as a result of these actions and the condition of station facilities at a number of our stations, we were forced to close the shutters of several passages, which resulted in shutting customers out of those stations. We sincerely understand the grave inconvenience that these decisions caused to so many of our customers. As such, we are currently reviewing the judgments and the handling of each one of our actions on the day of the disaster, and will continue our investigations into measures that support the early resumption of operations, the provision of temporary shelters inside stations, where customers having difficulty in returning to their homes can stay, and stockpiles among others.

Although the epicenter of the Great East Japan Earthquake was located within our service area, the effects of the earthquake spread well beyond those immediate surroundings, extending to encompass a wide range of regions including the Tokyo metropolitan area. For this reason, the scope of the information that we needed to collect was quite vast, and ranged from issues of customer safety and the levels of damage surrounding the epicenter to the transport of passengers in the Tokyo metropolitan area. Although it is our current policy to establish a countermeasure headquarters at both our Head Office and at the Branch Office in the disaster-impacted area at the time of a disaster, we plan to further review our options to more promptly and functionally implement our countermeasures, our procedures for establishing a countermeasure headquarters, and our methods of collecting information.

#### 4. Towards restoration and reconstruction

On April 29, the 50th day after the March 11 disaster, with the resumption of operations between Sendai and Ichinoseki, all sections of the Tohoku Shinkansen lines had resumed operations. In contrast, in the Pacific coastal areas which were severely damaged by the tsunami, as both urban and residential areas have been thoroughly devastated, we also confirm serious damage to our railway facilities that requires a large-scale work for restoration. Currently, several municipalities are in the process of formulating their own reconstruction plans. For some of these areas, we are taking part in the relevant discussion. JR East will work together with national and local governments in its efforts to move forward with the restoration of our railway divisions along the coastal areas damaged by the tsunami, while remaining committed to participate cooperatively in restoring the area as a whole and in the planning of urban development.

Moreover, in order to contribute to increased tourism and the reconstruction of all of the regions in our service area, JR East is providing railway transport support through the Aomori Destination Campaign, the sales of products like the JR East Pass, and the hosting of farm fresh markets at its major terminal stations for the products of quake-hit areas. We are committed to our endeavors to support areas affected by disaster and harmful rumor with the JR East Group's concerted efforts, including "Market for Products from Disaster-affected Areas", in which agricultural products from the affected areas are on sale in stations in the Tokyo metropolitan area.

#### ○ Countermeasures for electricity supply issues

Due to the severe shortage in electricity resulting from the earthquake, while sincerely appreciating the understanding of our customers, we are continuing to work on energy saving at our stations and on board. This summer, in compliance with the Power Use Limitation Order, which was issued for the first time in 37 years, the Government of Japan ordered limitations on the use of electricity. At JR East, we did our utmost to comply with the government's targets for reduction and conserve electricity through such measures as reducing the number of weekday train operations during daytime hours, and by switching off or reducing the lighting at stations and on board.

Since severe electricity shortages are expected to remain for some time, JR East has adopted the principle to continue our energy saving effort through limiting the use of all unnecessary lighting at stations and on board.

\* In the above Special Topics, the Great East Japan Earthquake refers to both the Tohoku-Pacific Ocean Earthquake and the disasters stemming from the nuclear power plants.