Report of the JSME Research Committee on the Great East Japan Earthquake Disaster

Chapter 6

Analysis of Traffic and Physical Distribution within the Disaster Areas

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Abstract

Traffic and physical distribution systems were widely and seriously damaged in the Tohoku area due to the earthquakes and/or tsunami. Many harbors and airports were damaged, and in particular, the Sendai airport was covered with water. In railway systems, infrastructures such as station buildings, railway tracks, rail catenaries, and pillars were widely and seriously damaged. However, the main structures were previously strengthened after the large earthquakes that occurred in Kobe and Niigata, so the damages to the railway systems caused by the earthquakes were not significant. Additionally, new systems such as the Earthquake Early Warning System were developed, which allowed the Shinkansen trains (known as "bullet trains") to be safely stopped prior to the strongest earthquake. In road transportation, roads and traffic signals were damaged, and numerous cars and trucks were carried away by tsunamis. Gas stations were also damaged, causing many cars to be unusable due to the lack of gasoline. A few days after the earthquake, Inter-NAVI information systems were available to drivers through car navigation systems, allowing them to determine which roads could be used, which was very useful for drivers. The "Kushinoha Sakusen" (teeth of comb operation) contributed greatly to the quick recovery of the roadways and logistics operations. As for physical distributions, supply chains were heavily damaged. Many factories of parts suppliers were damaged, so even though assembly makers were not damaged they could not procure parts and had to cease production.

Keywords : Air/Railway/Road Transportation, Earthquake Early Warning System, Inter-NAVI information System, Kushinoha Sakusen, Physical Distribution

1. Air Transportation

Most of the larger ports from Hachinohe in Aomori prefecture to Kashima in Ibaraki prefecture were damaged by the earthquakes and tsunami. However, the international and major ports recovered from the damages quickly. Hachinohe Port began contributing to disaster relief from March 12th and Ibaraki Port, the slowest to recover, resumed normal operations on March 14th (Ministry of Land, Infrastructure, Transport and Tourism, 2013). Several colliers crashed into the harbor, but no serious accidents, such as outflows of oil or large marine fires, occurred.

As for air transportation, a PTB ceiling collapsed, the windows of various airport facilities shattered, and radar facilities were damaged. Minor collisions between airplanes also occurred (Sato, S., 2013). The Sendai airport was seriously damaged by the tsunami, and 11 cracks formed in the runways and taxiways. Landing was impossible at the Sendai, Narita, and Haneda airports, which forced 100 planes to divert.

2. Railway Transportation

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As for railway transportation, infrastructures such as station buildings, railway tracks, rail catenaries, and pillars were widely and seriously damaged by the earthquakes and tsunami. The damages to the Shinkansen lines are shown in Figure 1. The area of damage was wider than that of previous large earthquakes. Many electricity columns were damaged, but there were no serious damages, such as collapsed bridges, due to the effective countermeasures that were put in place after previous large earthquakes. In total, it took 49 days for the lines to return to full operation, which was very quick compared to previous large earthquakes. Operations resumed between Tokyo and Nasushiobara on March 15th. The last line to restart was the line between Sendai and Ichinoseki, for which operations resumed on April 29th. Although 27 Shinkansen trains (known as “bullet trains”) were being operated along the Tohoku line during the earthquake, all trains were able to decrease their speed and stop without any derailments or passenger fatalities. These effective actions were the result of the Earthquake Early Warning System, which was able to detect small P-waves before the large S-waves reached the railways and sent the information to the central operation center. However, one train that was being tested and operated at low speed derailed due to resonance between the basement and upper-roll motions.

The local lines of the JR East Company were directly affected by both the earthquakes and tsunami; however, the Shinkansen lines were not affected by the tsunami. The damages to the electricity columns

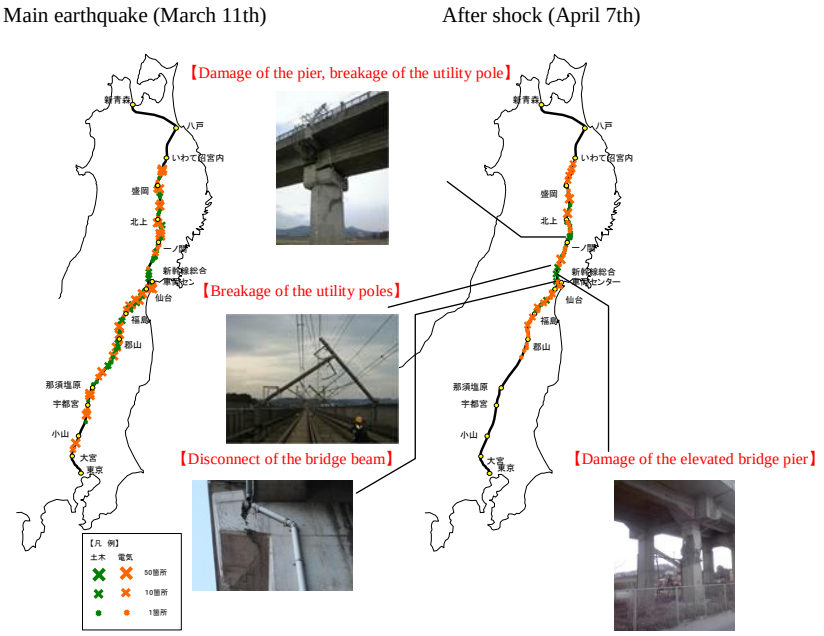

Fig.1 Damage of Tohoku Shinkansen line

Fig.2 Subsidence of embankment

Fig.3 Washed away of track

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were remarkable. Numerous damages, such as the misalignment of the rails (Figure 2) and train tracks that were completely destroyed (Figure 3), were seen in the damaged areas. Damages caused by the tsunami were very serious; not only were tracks washed away but 23 stations on seven different lines became unusable. Many trains were forced to stop between stations near the Pacific coast due to the earthquake. The passengers of 27 trains that were in danger of being affected by the tsunami (five of which were actually struck), were able to evacuate before the tsunami arrived.

In addition to the JR line, numerous tracks and stations were washed out in the North and South Rias lines, which is operated by the Sanriku Railway Company. The control room of the Sendai Airport line was flooded (East Japan Railway Company, 2011). The railway vehicles of the JR Freight Railway Company and tracks for the cargo that run toward the coast were also severely damaged (Tohoku District Transport Bureau, Ministry of Land, Infrastructure, Transport and Tourism, 2013a).

Damages to the elevated bridges and catenaries, liquefaction failure, and cracks were observed in the metropolitan area of Tokyo.

Although there were some severe damages, the following countermeasures against earthquakes that were previously established are considered to have functioned effectively.

1) Infrastructures were reinforced according to the new earthquake resistant standards.
2) Earthquake Early Warning Systems were introduced.
3) Derailment protection devices were equipped to railways.

3. Road Transportation

Highways had already been strengthened, similarly to the Shinkansen lines, so significant damage was not sustained. However, due to the tsunami, 870 km of damages were sustained by highways including 350 km of damage to the Tohoku highway, where numerous cracks formed in the road (Photo 6.3) and, in the worse case, a bridge support was damaged (Photo 6.4). The result was serious disruption to road transportation. Roads were repaired to allow temporary use for emergency vehicles by the morning of March 12th (East Nippon Expressway Company Limited, 2013).

As for normal roads, National Road 45, which is located along the Sanriku coastline, was severely damaged. Numerous cracks formed, some areas of the road were covered with water, and some bridges were washed away by the tsunami. Numerous damages such as cracks, fallen stones, and subsidence appeared on the other national roads.

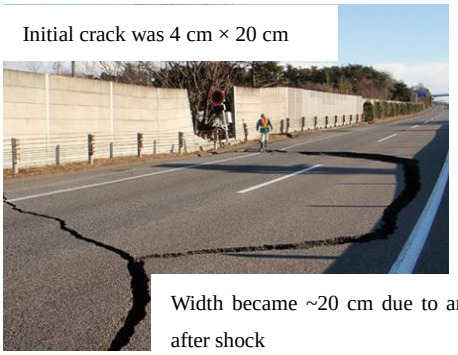

Figure 4 Cracks that formed in a road

Figure 5 Damage to a bridge support

During this earthquake, the “Kushinoha Sakusen” (Teeth of Comb operation) contributed greatly to the quick recovery of the roadways and logistics operations (Tohoku District Transport Bureau, Ministry of Land, Infrastructure, Transport and Tourism, 2013b). Figure 6 shows an outline of the Kushinoha Sakusen. To ensure a quick recovery for the heavily damaged areas near the offshore regions of the Sanriku coast, the

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Tohoku Highway and National Road 45, which run north-to-south and were not heavily damaged, were repaired first. Next, the roads that run east-to-west to the coastal areas were repaired. The other roads that ran along the Sanriku coastline were repaired last. These procedures were determined on the day of the earthquake, and 97% of National Road 45 was usable by March 18th.

As for the information of traffic near the damaged areas, real-time passable road information collected from car navigation systems was released on the Internet. This information was very useful for those who traveled to the damaged areas. The same information systems were introduced for large vehicles.

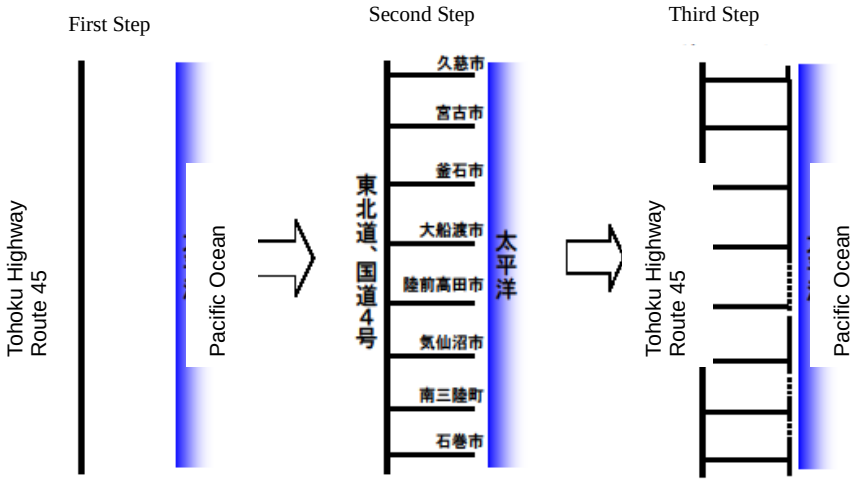

Figure 6 The “Kushinoha Sakusen” (Teeth of Comb operation)

4. Physical Distributions

As for physical distributions, the supply chains in Japan were severely damaged. Physical distribution contractors were affected, making delivery impossible. For companies with their production bases in the stricken areas, production ceased due to the damages to the factories or a rupture in the distribution channel. Moreover, many parts-supplier factories were damaged, so even though assembly makers were not damaged they were not able to procure parts and had to cease production. Not only the direct damages caused by the disaster, but also the subsequent scheduled blackouts had a large influence on the physical distributions. Thus, the brittleness of the supply chains was revealed by this disaster. In addition, fuel shortages in the stricken areas also became a huge problem. Even if the factories and roads had been repaired quickly, it would not have been possible to transport parts and products due to a shortage of gasoline. Special emergency trains that carried fuel to the stricken areas had to bypass the Tohoku line, since it was not usable (KEIDANREN, 2012).

References

East Japan Railway Company, personal communication (2011)

East Nippon Expressway Company Limited, Report on the damage of highways by the Great East Japan Earthquake Disaster and their restoration status, available from < http://www.e-nexco.co.jp/pressroom/tohoku_eq/restoration.html >, (accessed on Jan. 13, 2013) (In Japanese)

KEIDANREN, Report for constructing a resilient distribution supply chain– Lessons from the Great East Japan Earthquake Disaster on March 11, 2011– Report by KEIDANREN, (2012) (In Japanese)

Ministry of Land, Infrastructure, Transport and Tourism, Damage and restoration of ports and harbors at the

ISBN 978-4-88898-244-3

Great East Japan Earthquake Disaster– records of the seismic disaster, and the tasks and improvement points for the future, available from < http://www.mlit.go.jp/common/000193514.pdf,>, (accessed on Jan. 13, 2013) (In Japanese)

Sato, S., Damage of Airports at the Great East Japan Earthquake Disaster and their research tasks, National Institute for Land and Infrastructure Management, available from < http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn0655pdf/ks065515.pdf>, (accessed on Jan. 13, 2013) (In Japanese)

Tohoku District Transport Bureau, Ministry of Land, Infrastructure, Transport and Tourism (editorial supervisor), Revive! Railways in Tohoku district, available from < http://wwwtb.mlit.go.jp/tohoku/td/td-sub100.htm >, (accessed on Jan. 13, 2013a) (In Japanese)

Tohoku District Transport Bureau, Ministry of Land, Infrastructure, Transport and Tourism, About "Operation Comb", available from < http://www.thr.mlit.go.jp/road/jisinkannrenjouhou_110311/kushinohasakusen.html >, (accessed on Jan. 13, 2013b) (In Japanese)

ISBN 978-4-88898-244-3