

Damage of Railway Structures due to 2011 Great East Japan Earthquake

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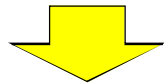
Earthquake and Structural Engineering Lab.
Railway Technical Research Institute

Topics

1. Progress of Aseismic Techniques
for Railway Structures
2. Damage due to 2011 Great East Japan EQ.
 - (1) Damage of Structures due to Seismic Wave
 - (2) Damage of Electric Power Poles
 - (3) Damage due to Tsunami Attack
 - (4) Soil Liquefaction in Tokyo Bay area
3. Running Simulation of a train
4. Urgent Earthquake Detection & Alarm System

Earthquake chronology in Japan

Japanese railways have experienced many huge earthquakes.



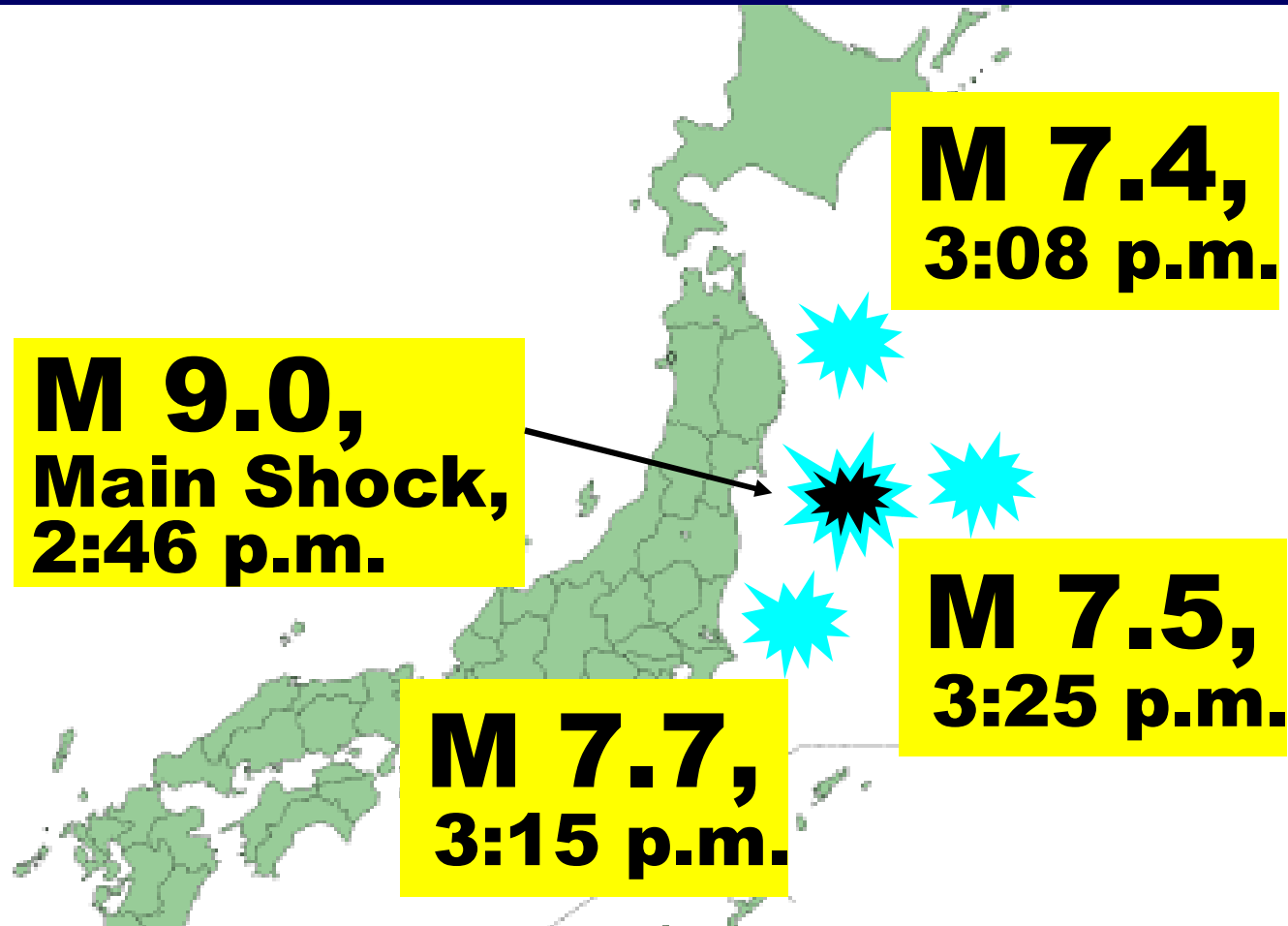
Aseismic techniques have been developed.



Year	Earthquake	M
1923	Great Kanto EQ	7.9
1927	Kita-Tango	7.3
1930	Kita-Izu	7.3
1948	Fukui	7.1
1952	Tokachi-Oki	8.2
1961	Kita-Mino	7.0
1964	Niigata	7.5
1968	Tokachi	7.9
1978	Izu Ohsima Kinkai	7.0
1978	Miyagi-Oki	7.4
1982	Uraga-Oki	7.1
1983	Nihonkai-Chubu	7.7
1993	Hokaido-Nansei-Oki	7.8
1995	Hyogo-ken Nambu	7.2
2000	Tottoki-ken Seibu	7.3
2003	Sanriku-Minami	7.0
2003	Tokachi-Oki	8.0
2004	Niigata-ken Chuetsu	6.8
2007	Niigata-ken Chuetsu-Oki	6.8

2011 Great East Japan EQ.

Earthquakes over M 7 hit the East Japan Area 4 times a day!!!



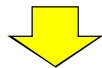
Many after shocks hit the disaster area again and again.

Damage due to main shock

1995 Hyogo-ken Nambu EQ.



Shear Failure

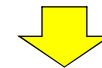


brittle failure

2011 Great East Japan EQ.



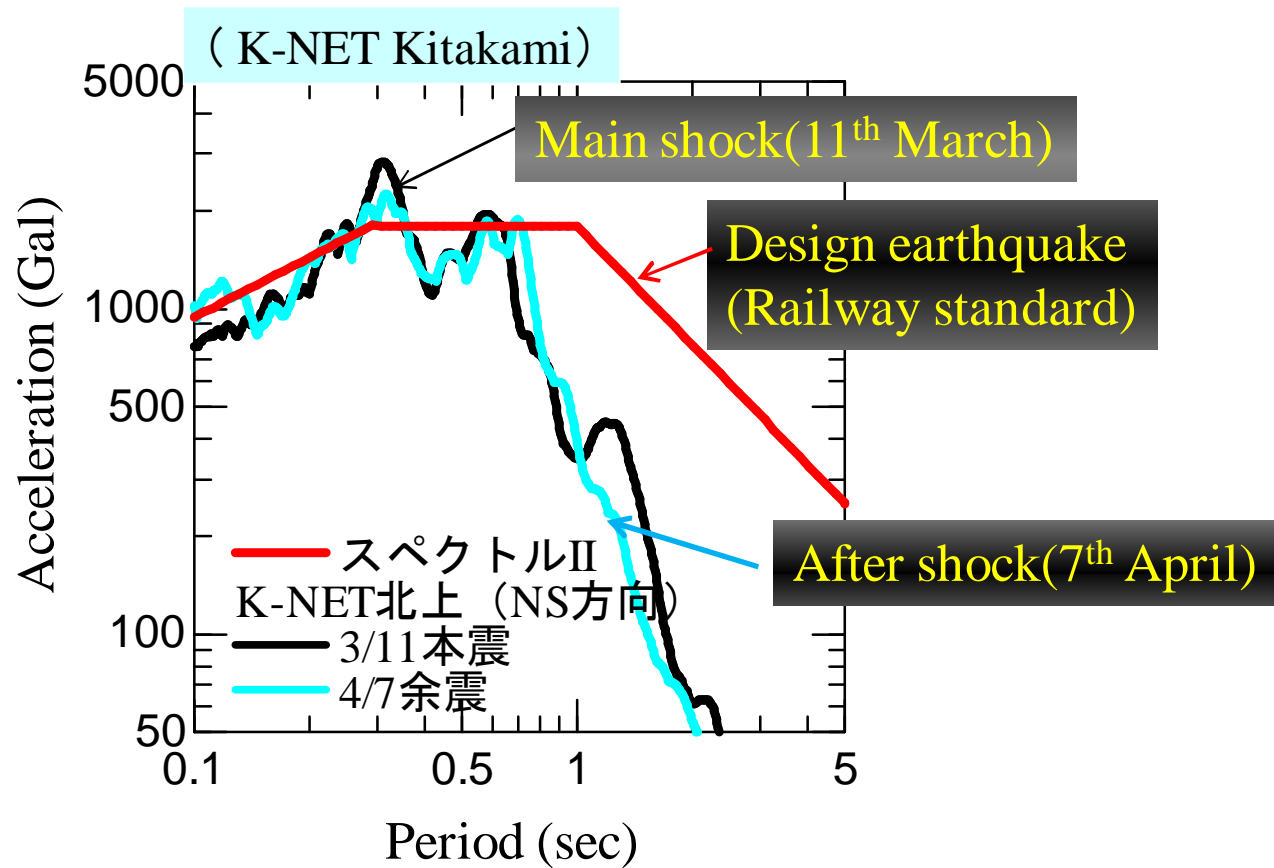
Bending Failure



ductile failure
Easy to repair

Countermeasure Works

After shock



Elastic response spectrum

Almost the same scale after shock occurred in 7th April.

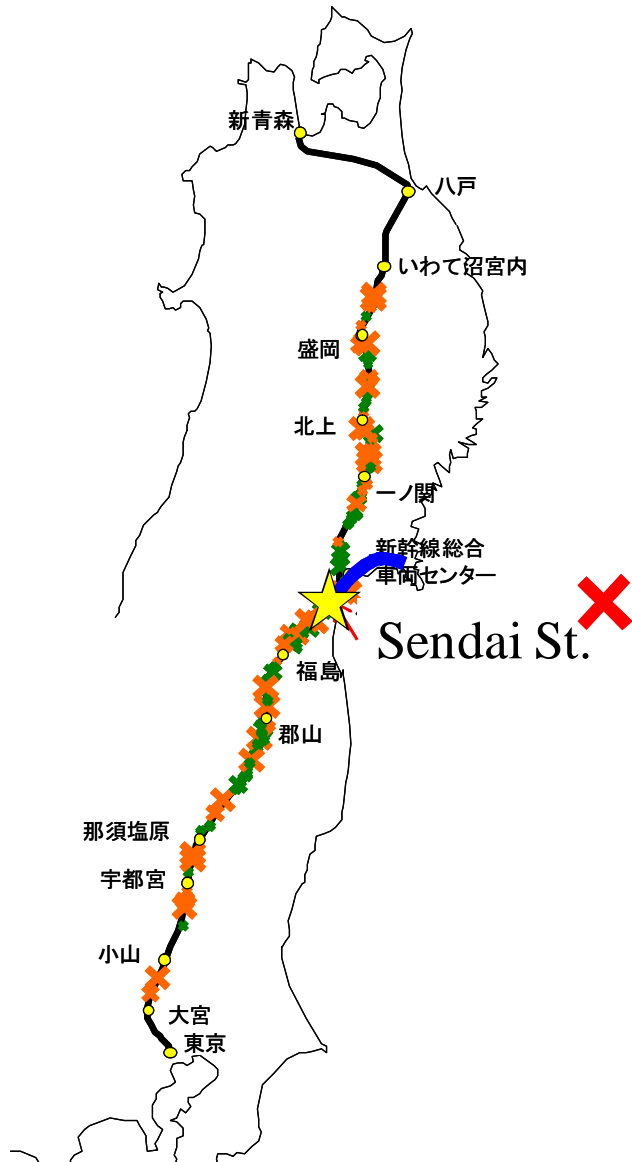
Damage due to After shock

3.11 after main shock



4.7 after the largest after shock

Damage of the Nagamachi viaduct



Damage of the Nagamachi viaduct

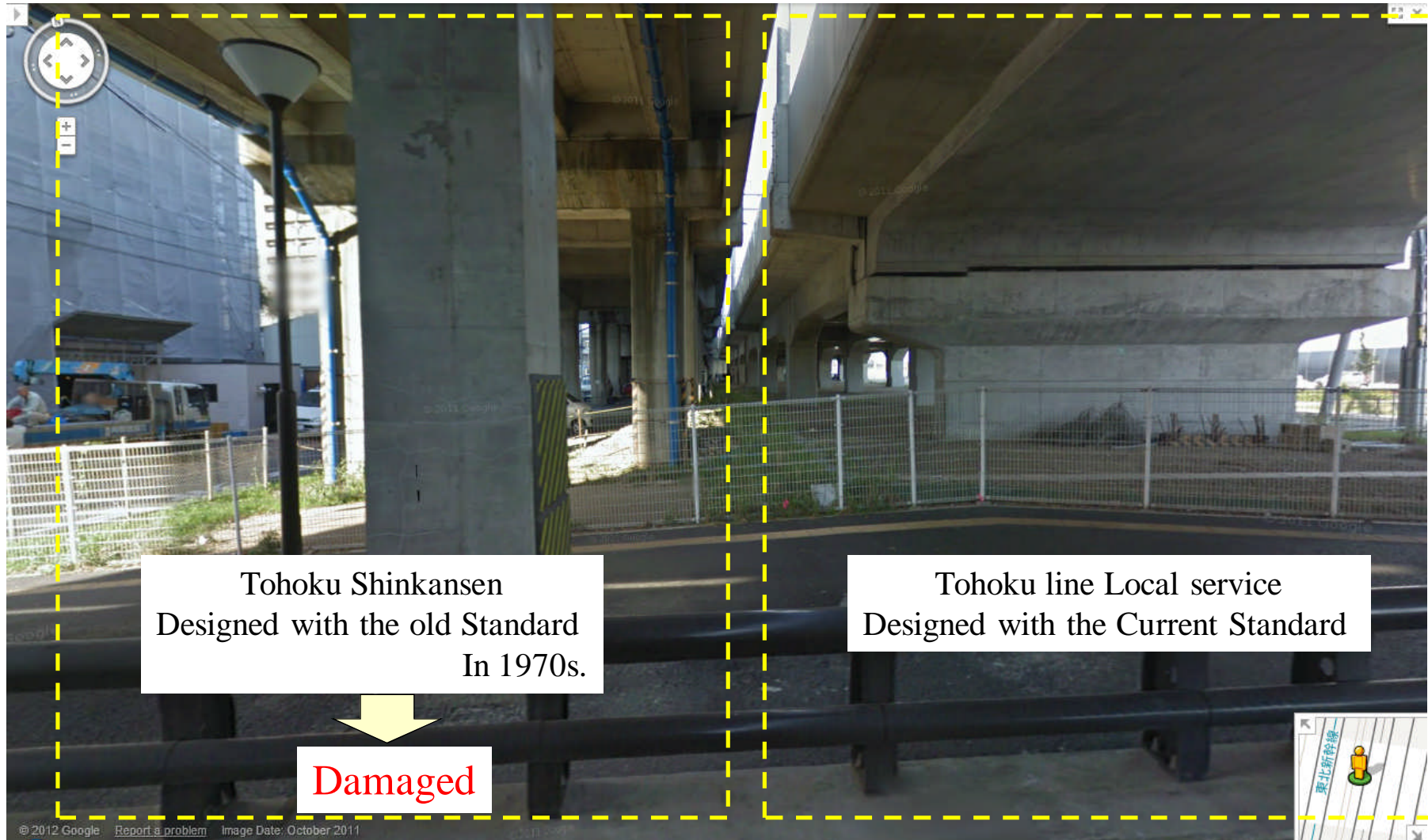
Tohoku
Shinkansen



Tohoku Line
Local Service



Damage due to seismic wave



Tohoku Shinkansen
Designed with the old Standard
In 1970s.

Damaged

Tohoku line Local service
Designed with the Current Standard

Soil Liquefaction



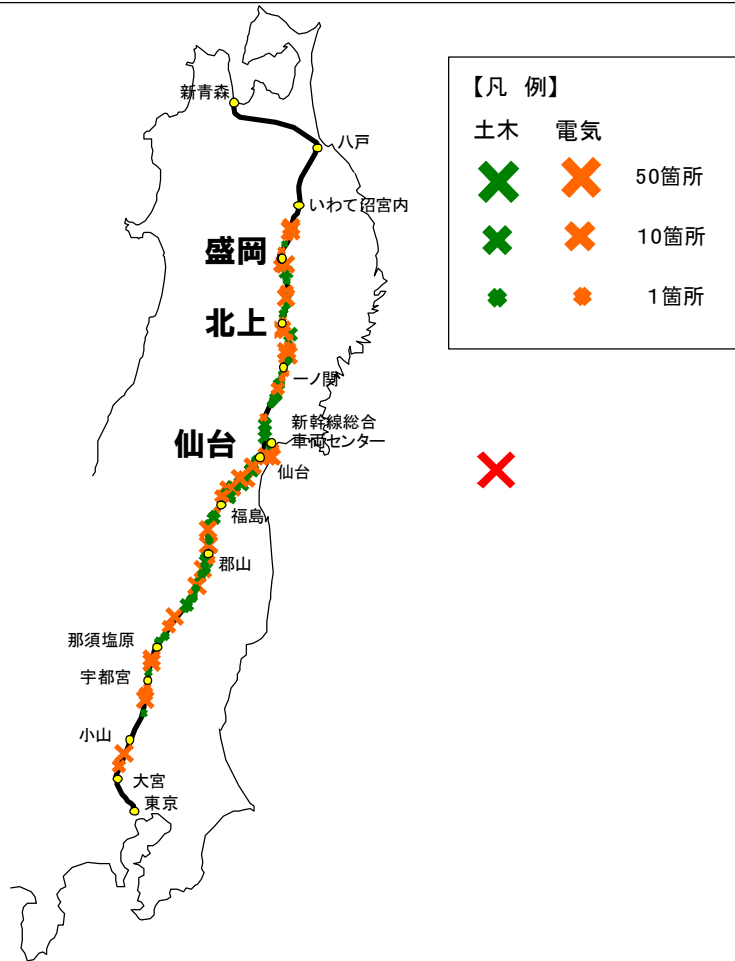
Many electric poles collapsed due to seismic intensity.



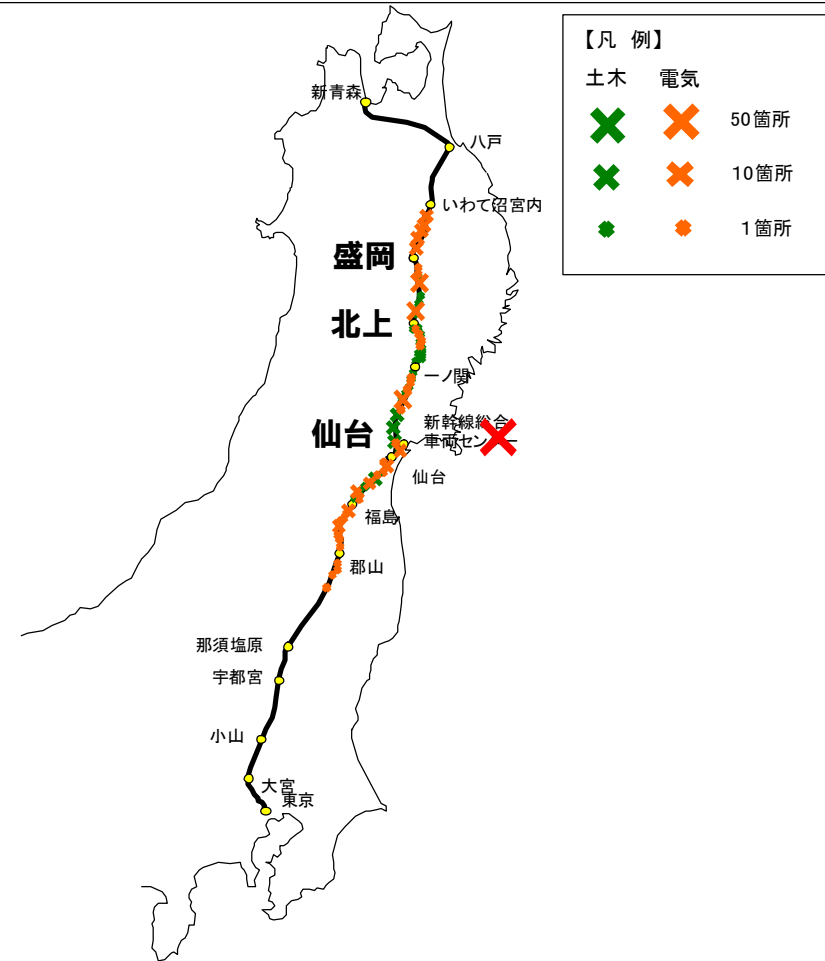
Restoration took long time as compared with other structures.

Damage due to After shock

Main shock (11th March)



After shock (7th April)

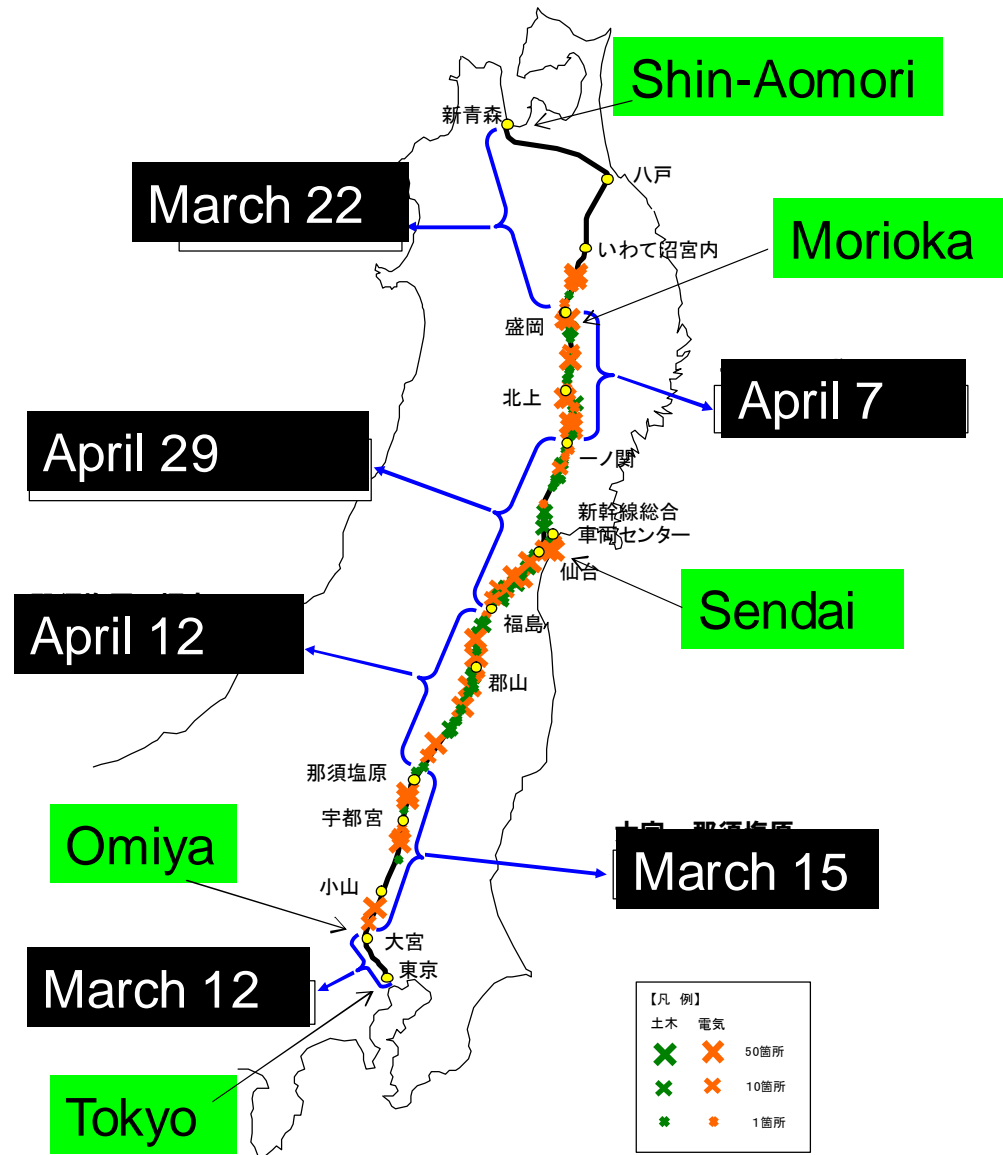


Referred from Web site of JR East (<http://www.jreast.co.jp/press/earthquake/index.html>)

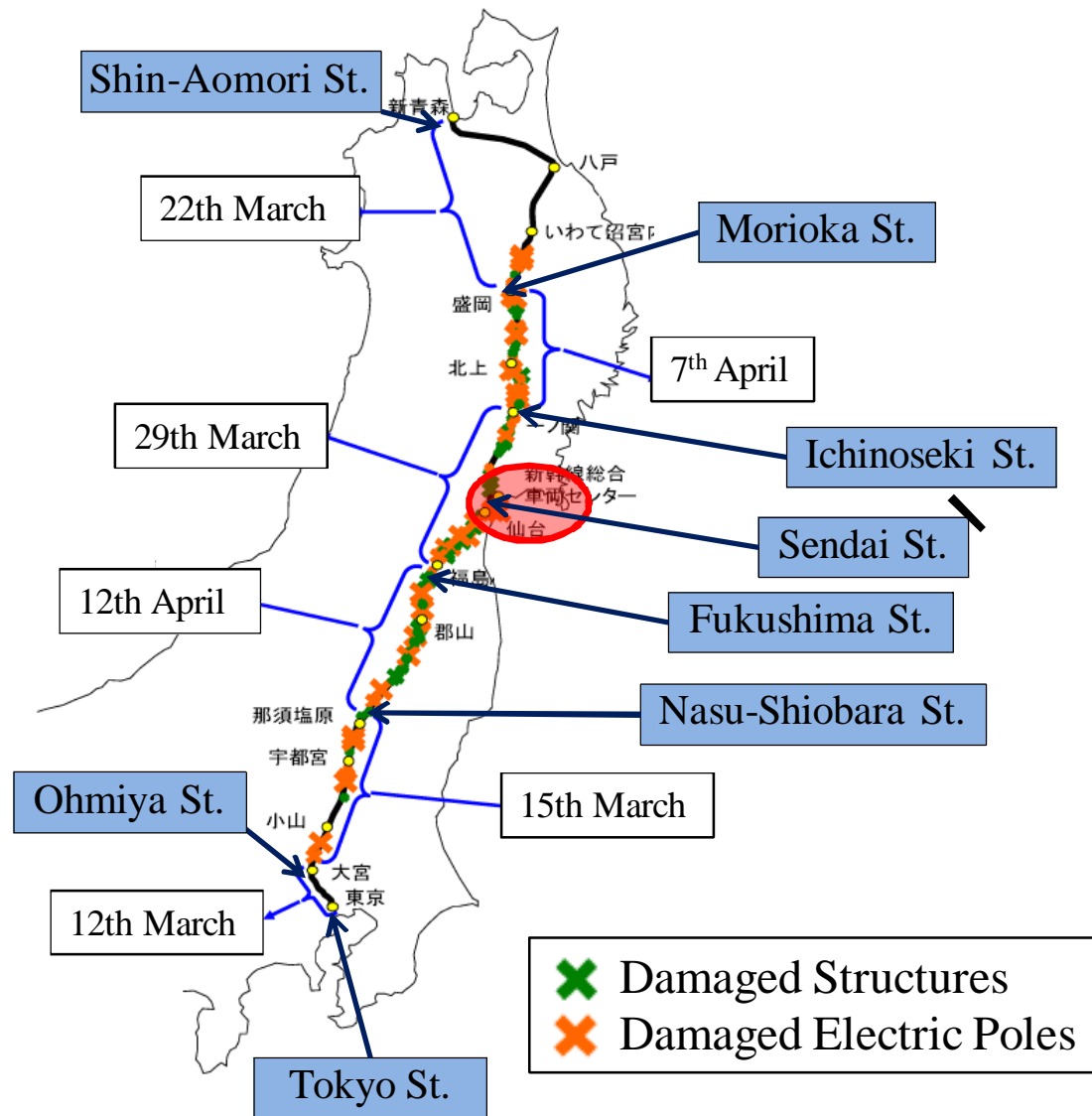
Damage due to After shock

Fully opened
on April 29, 2011

Suspended 48 days
after the earthquake

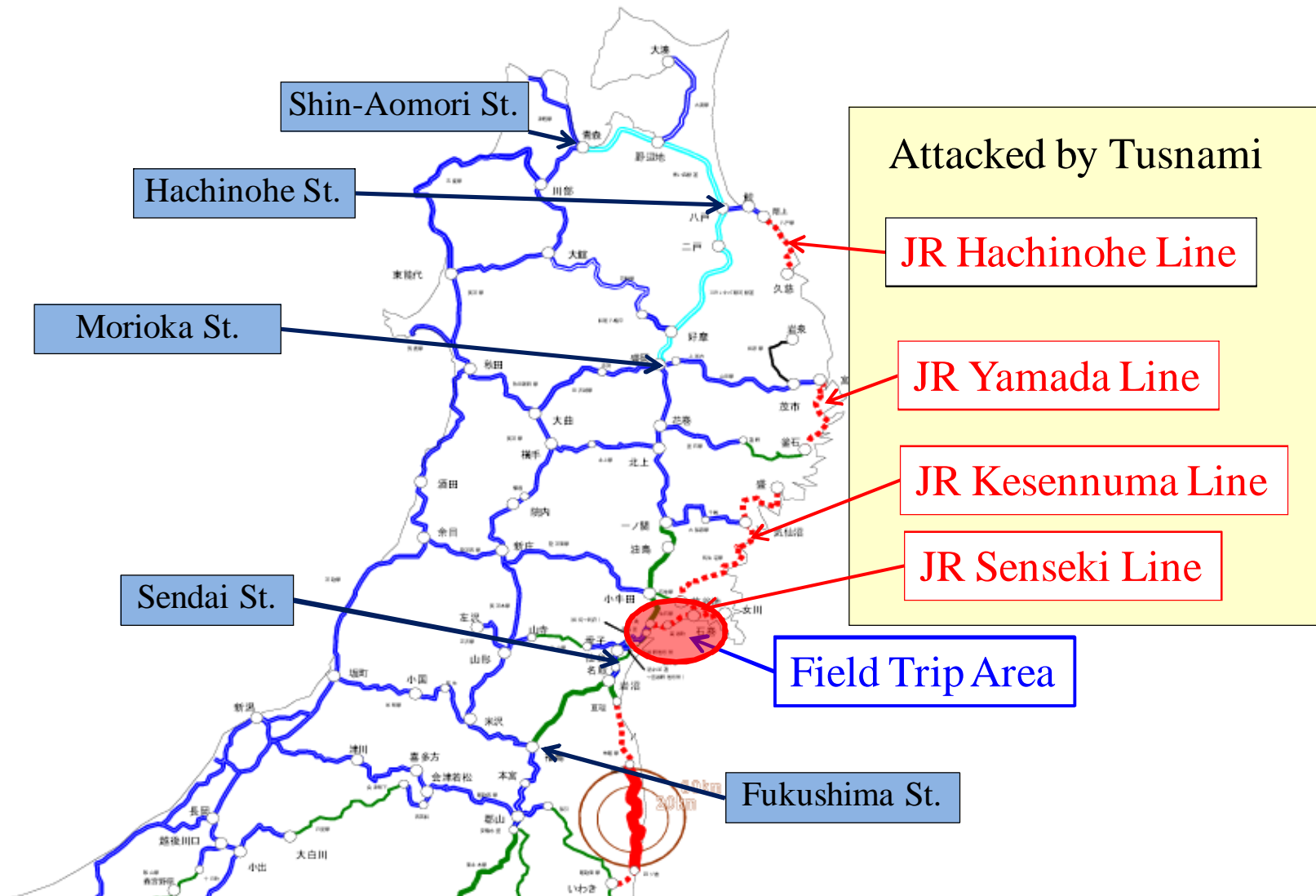


Damages of Tohoku Shinkansen



<http://www.jreast.co.jp/pdf/restore02.pdf>

Damage of Local Lines



<http://www.jreast.co.jp/pdf/restore02.pdf>

Damage by Tsunami



JR Yamada Line
Heigawa Bridge

The bridge girder was washed away
by Tsunami.

Damage by Tsunami



JR Kesennuma Line
Tsuyagawa Bridge

The bridge girder was washed away
and the piers were overturned
by force of Tsunami.

Damage by Tsunami



Senseki-Sen,

Some rigid frame viaducts bore tsunami.

Damage by Tsunami

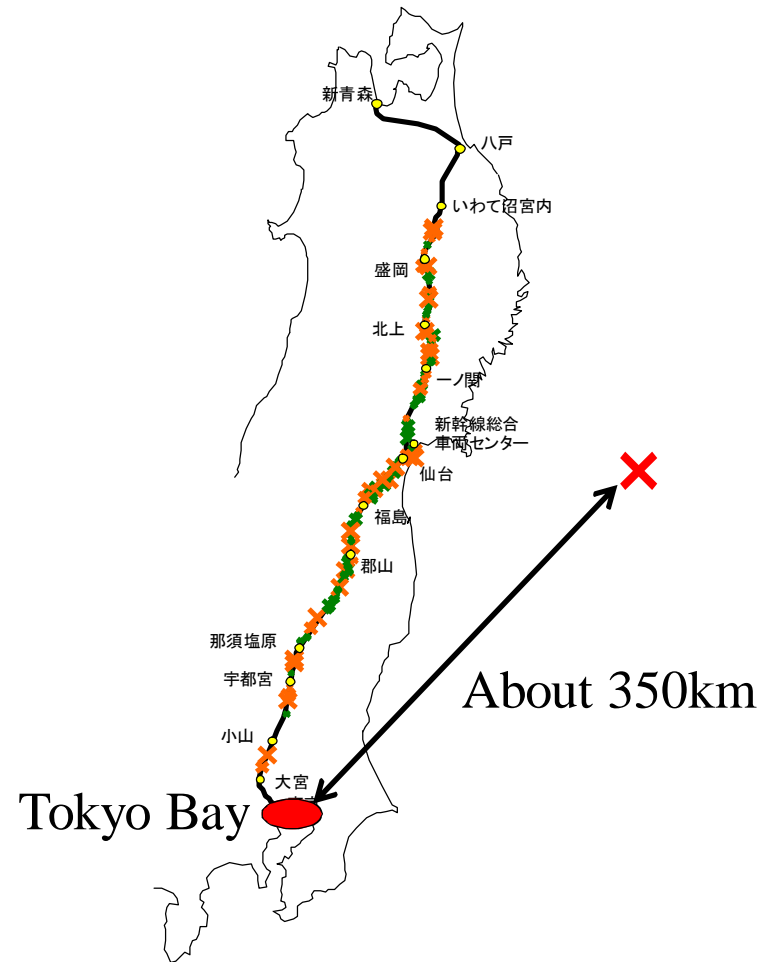
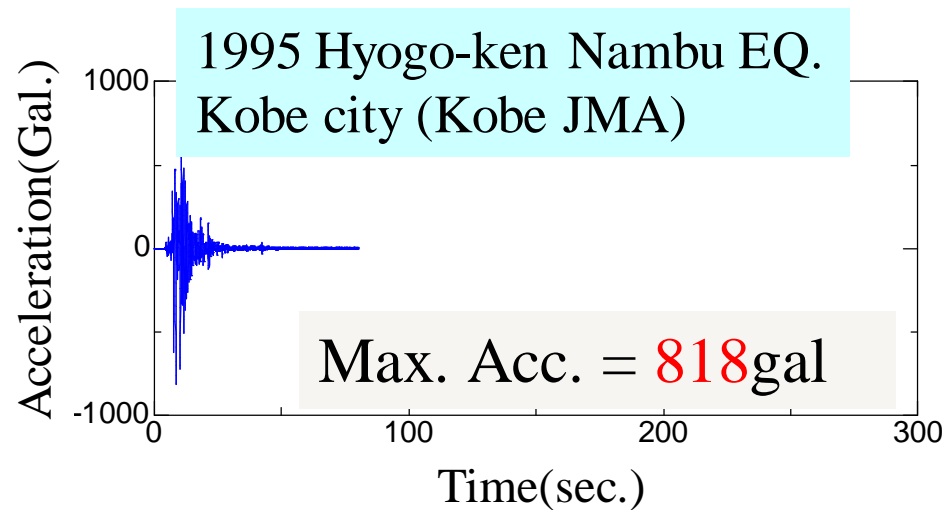
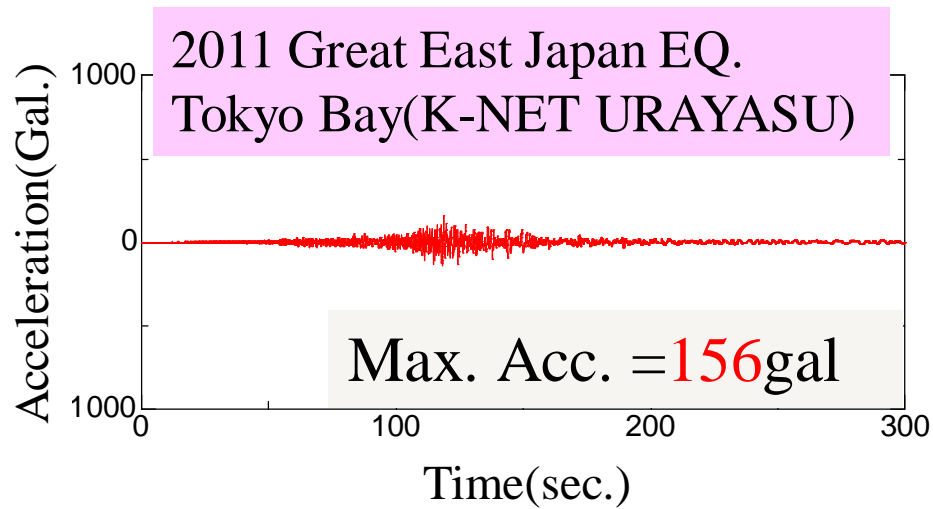


JR Kesen-uma Line
Minami-Kesennuma St.



No passengers on the trains were killed.
Train Crews properly guided passengers
to refuge from Tsunami.

Soil Liquefaction



Comparison between 2011 Great East Japan EQ. and 1995 Hyogo-ken Nambu EQ.

Soil Liquefaction



Soil Liquefaction

Heavy Sand boil



<http://www.nikkei.com/>



Sand boil and settlement of houses



Uplift of manhole



Soil Liquefaction

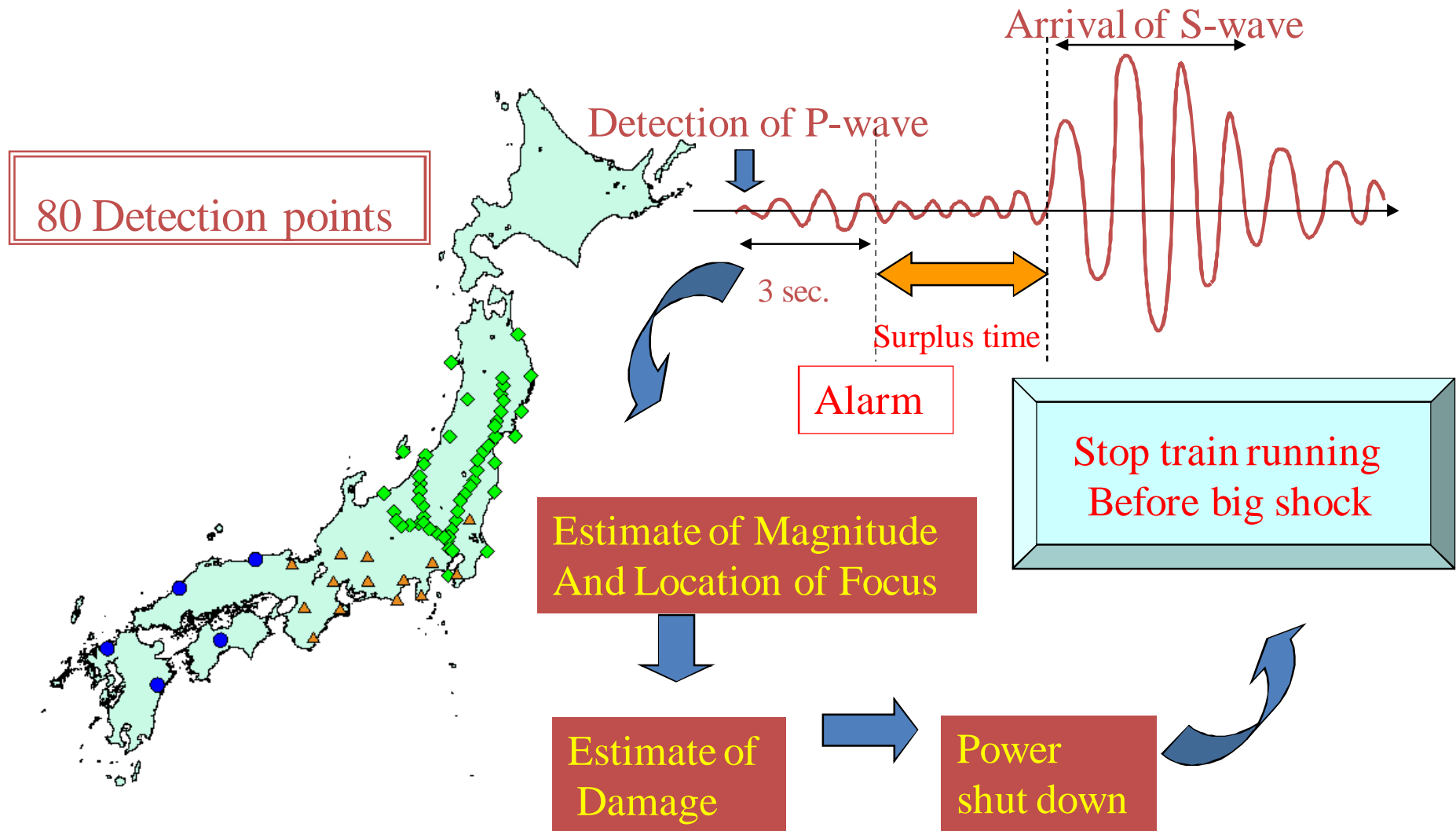


No damage was observed in viaducts which runs at heavy liquefaction area
Because viaducts were designed in consideration of liquefaction in 1970s.

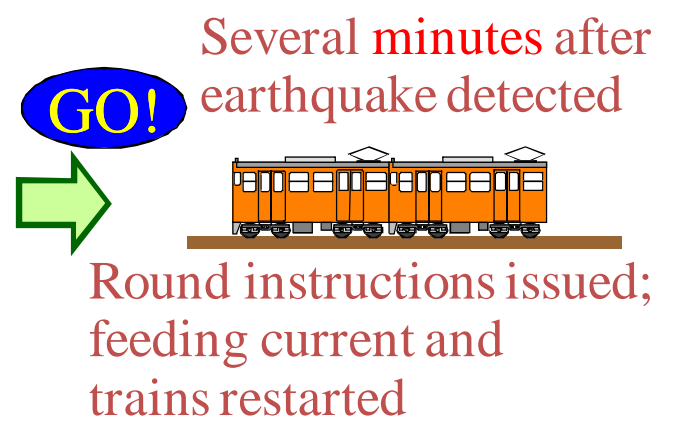
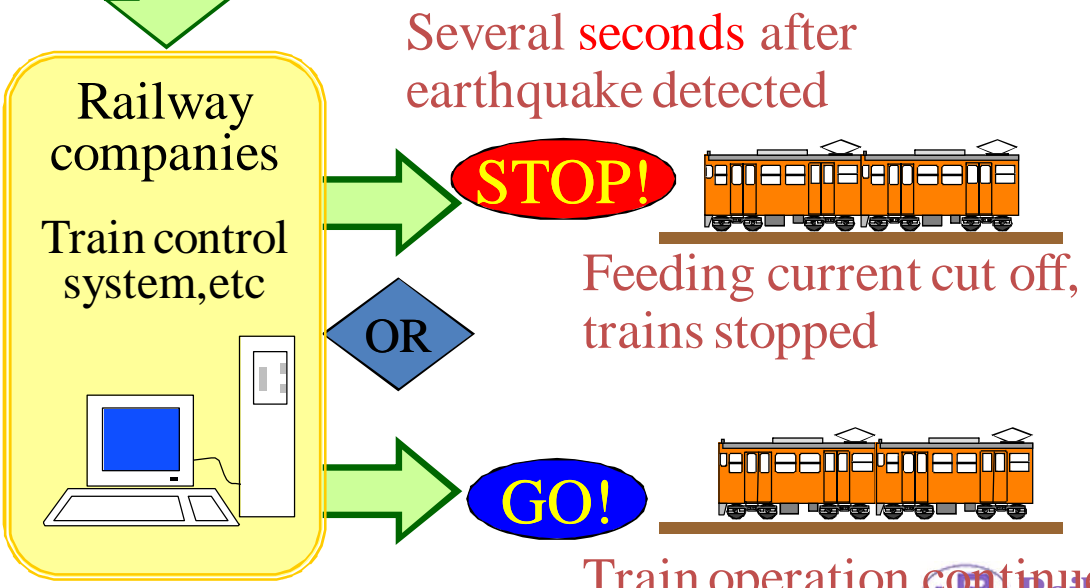
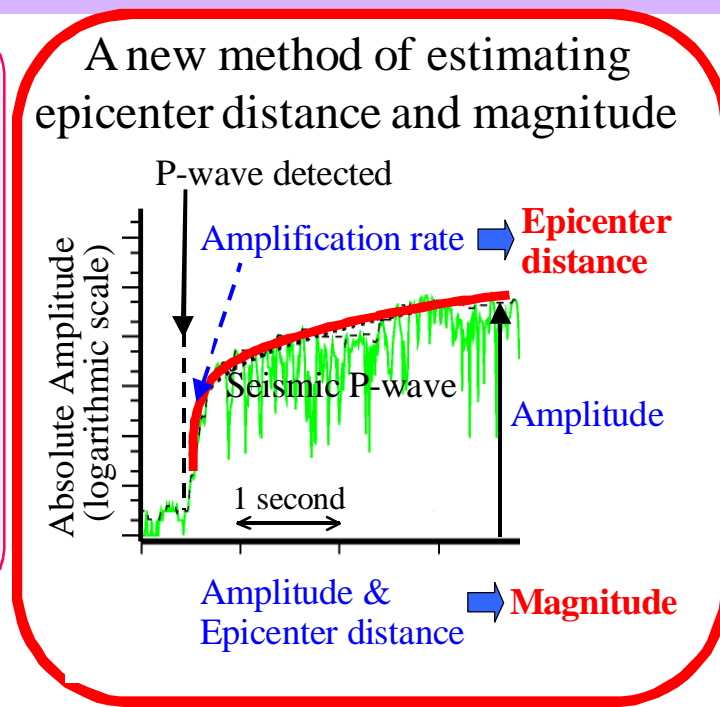
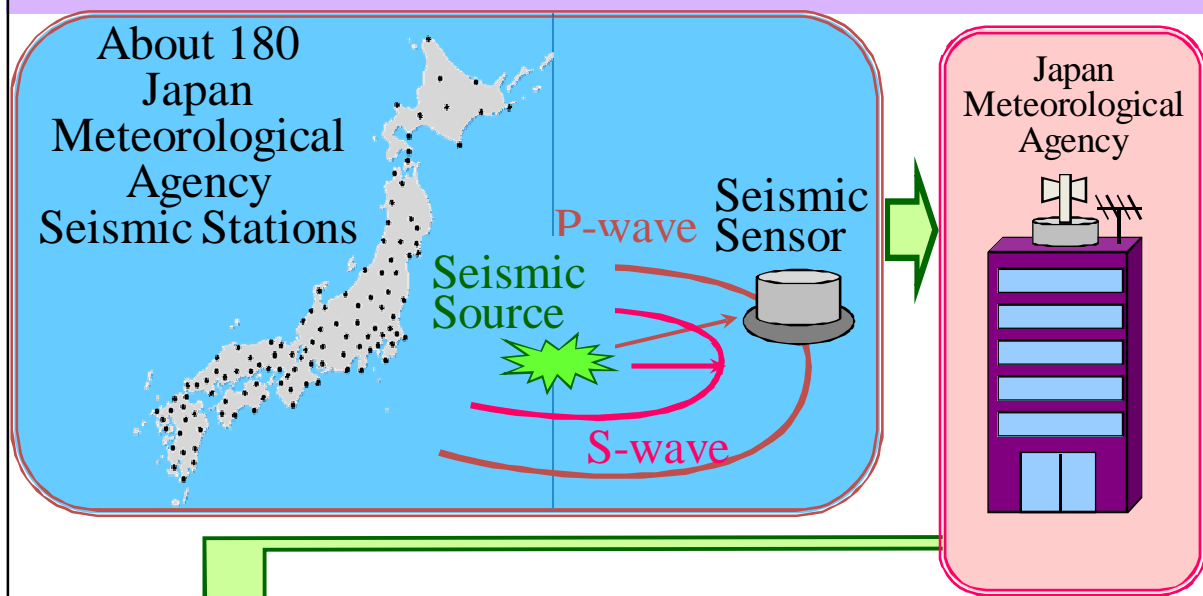
Urgent Earthquake Detection & Alarm System

Running Simulation of a train

Urgent Earthquake Detection & Alarm System



A New System for Early Earthquake Warning



Several seconds after earthquake detected

Several minutes after earthquake detected

Train operation continued

Derailment

Simulation software named “**DIASTARS**”
Dynamic Interaction Analysis for
Shinkansen Train And Railway Structures

Viaduct behaviors



Truck behavior



Damage of railway structures due to 2011 Great East Japan EQ.
was relatively small
because of proper countermeasure works and seismic design method.

Some characteristic damages were observed, such as

- Damage due to after shocks

- Damage of electric power poles

- Liquefaction due to low acceleration and long duration earthquake

- Tsunami Attack.

Now, we have investigated causes and mechanisms of such phenomena.



The End

