



**XXIV<sup>th</sup> World  
Road Congress  
Mexico 2011**

Mexico City 2011.

# Issues and Lessons Learned from the Great East Japan Earthquake



# Contents of Today's Presentation

---

1. Overview of the Earthquake and Tsunami
2. Damages on Roads:  
Lessons Learned from the Past
3. Recovery of Roads:  
Emergency Recovery for Affected Area
4. Issues in Road Infrastructure:  
For the "Next" Great Earthquake





# 1. Overview of the Earthquake and Tsunami



By Touhoku Construction Association





# Overview of the Earthquake

- “The Great East Japan Earthquake” occurred at 14:46 on March 11, 2011.
- This was the 4th largest earthquake in the world since 1900.



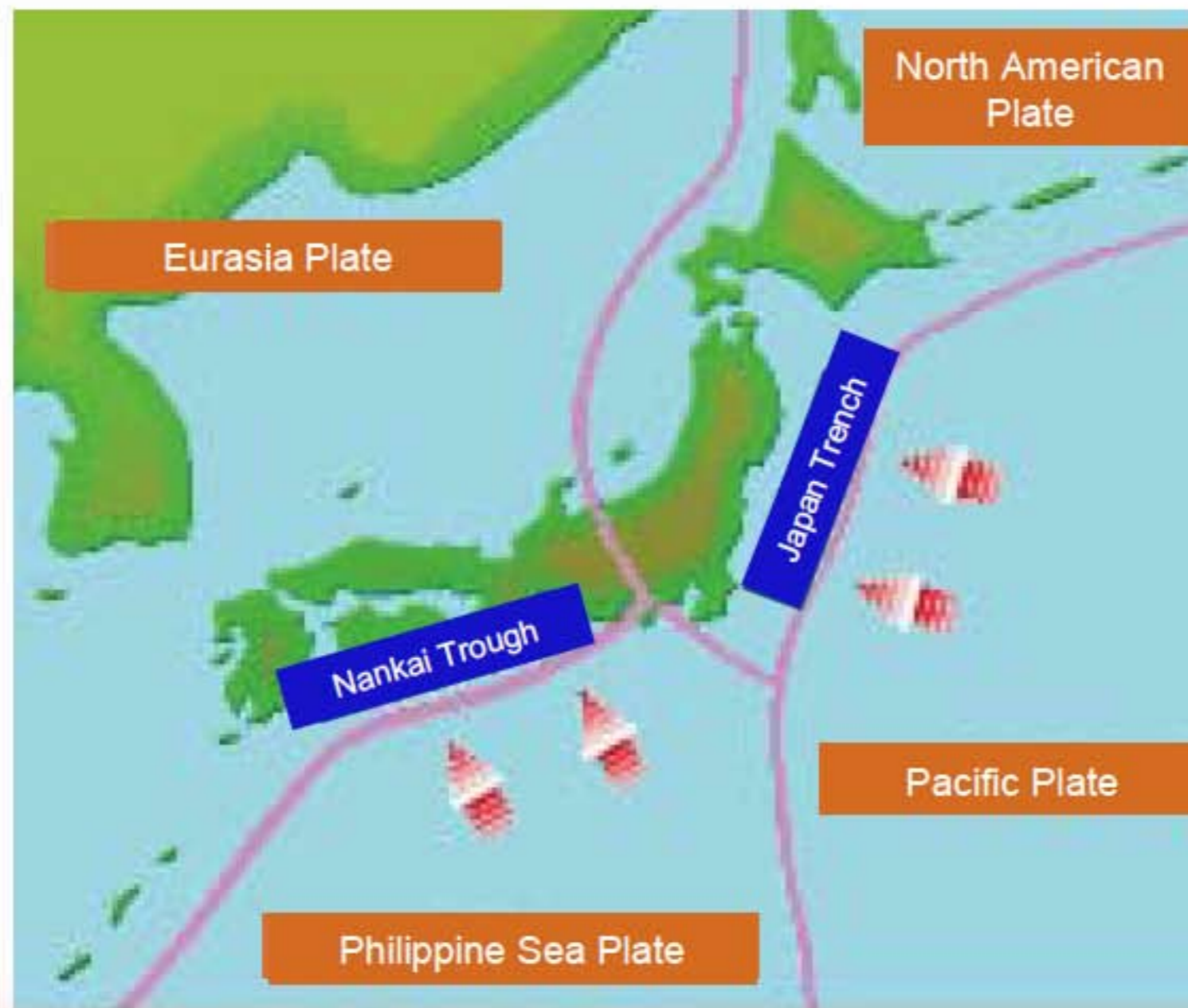
Rank	Date (Japan Time)	Location	Magnitude (Mw)
1	May 23, 1960	Chile	9.5
2	Mar 28, 1964	The Gulf of Alaska	9.2
3	Dec 26, 2004	Western coast of Sumatra, Indonesia	9.1
4	Nov 5, 1952	The Kamchatka	9.0
	Mar 11, 2011	Tohoku area off the Pacific Coast	9.0





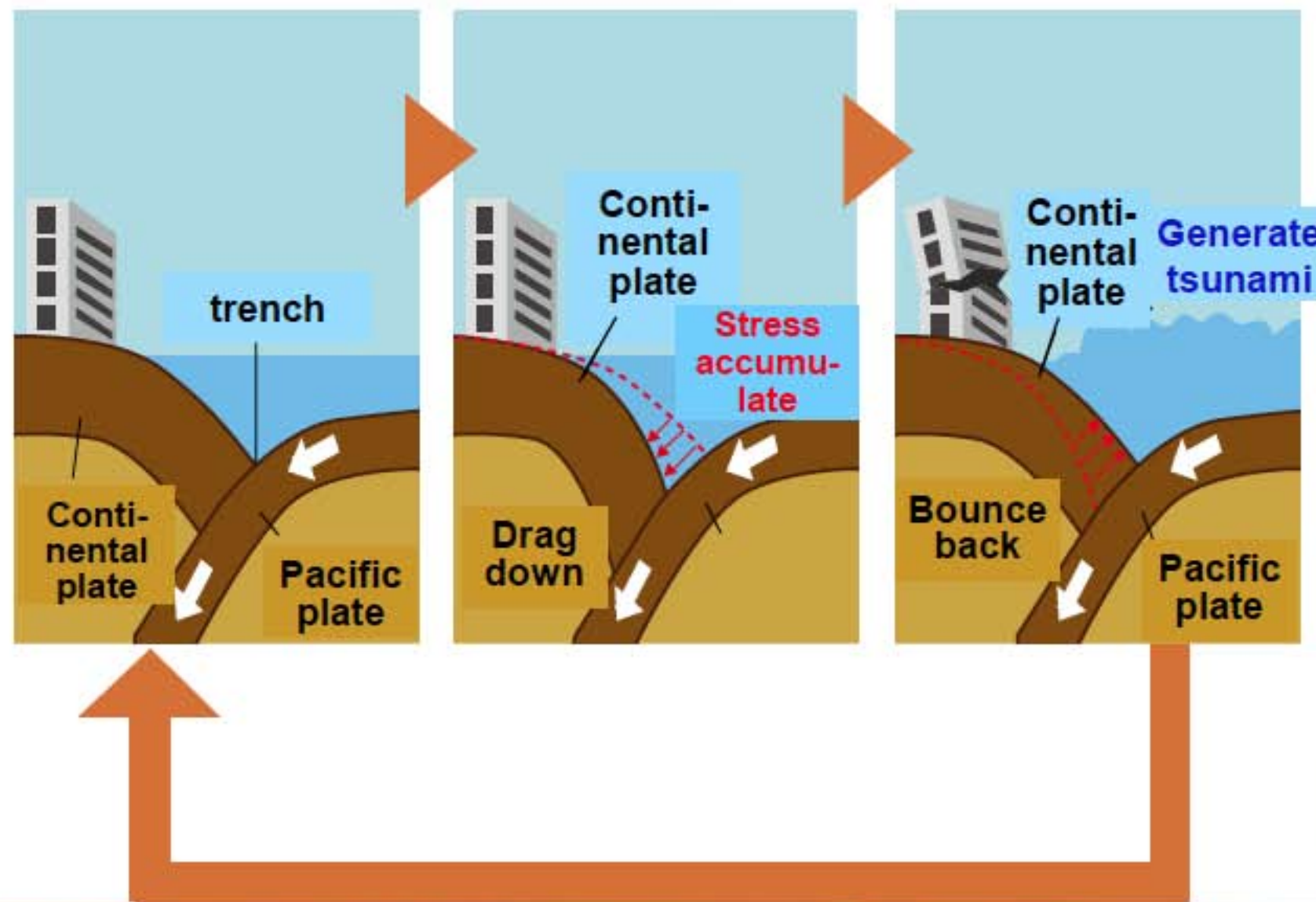
# Mechanism of Earthquake

- This earthquake is categorized as an “interplate” earthquake.



# Mechanism of Interplate Earthquake

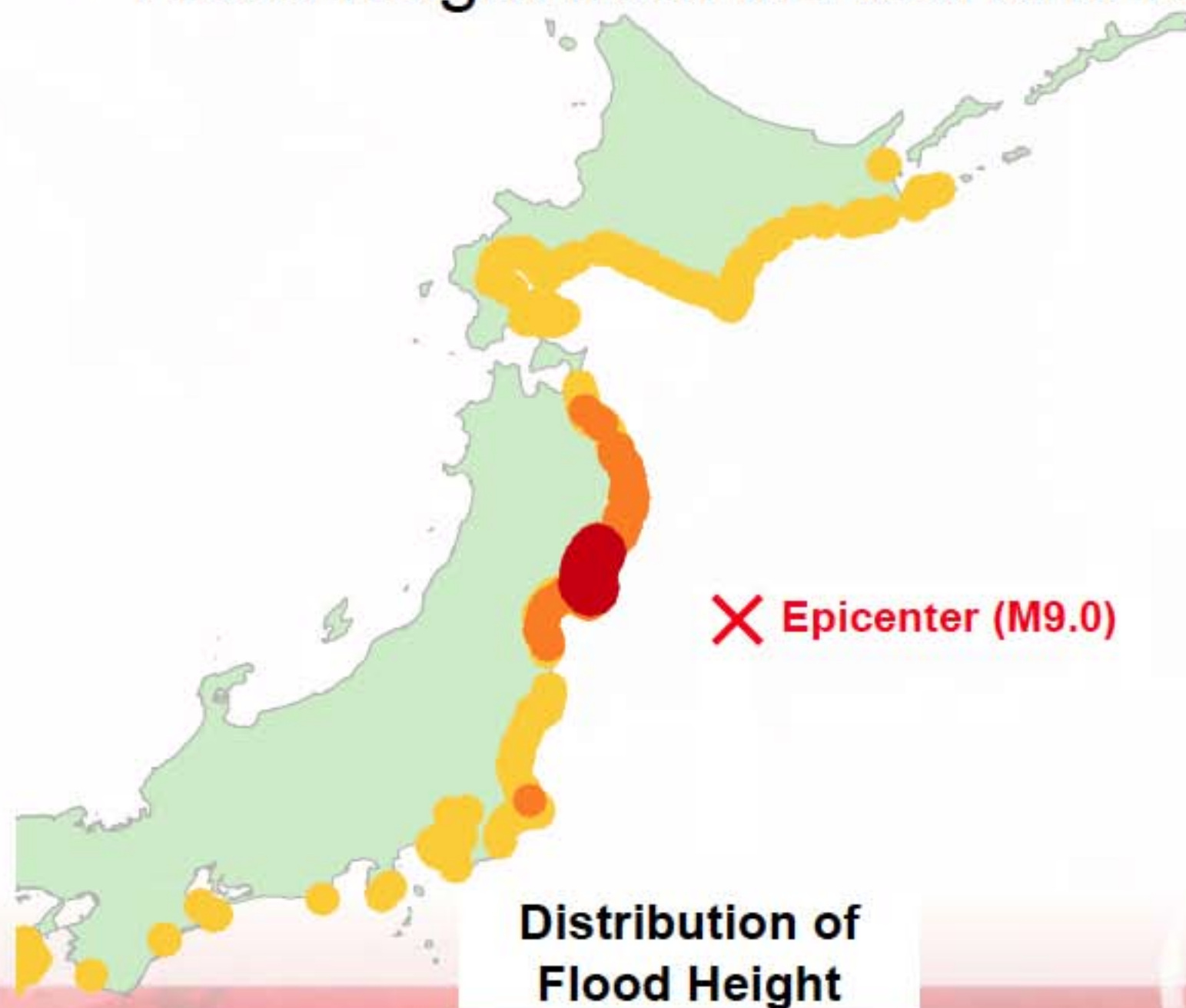
- Earthquakes and tsunamis occur when accumulated stress of a plate bounces back.
- Probability of this earthquake in 30 years was 99%.





# Tsunami Generation

- On the Sanriku Coast, massive tsunami was generated.
- Flood height from the tsunami reached 40 meters.



## Legend

- 0 - 10m
- 10 - 30m
- Over 30m

Source: The 2011 Tohoku Earthquake Tsunami Joint Survey Group  
(<http://www.coastal.jp/tjt/>)





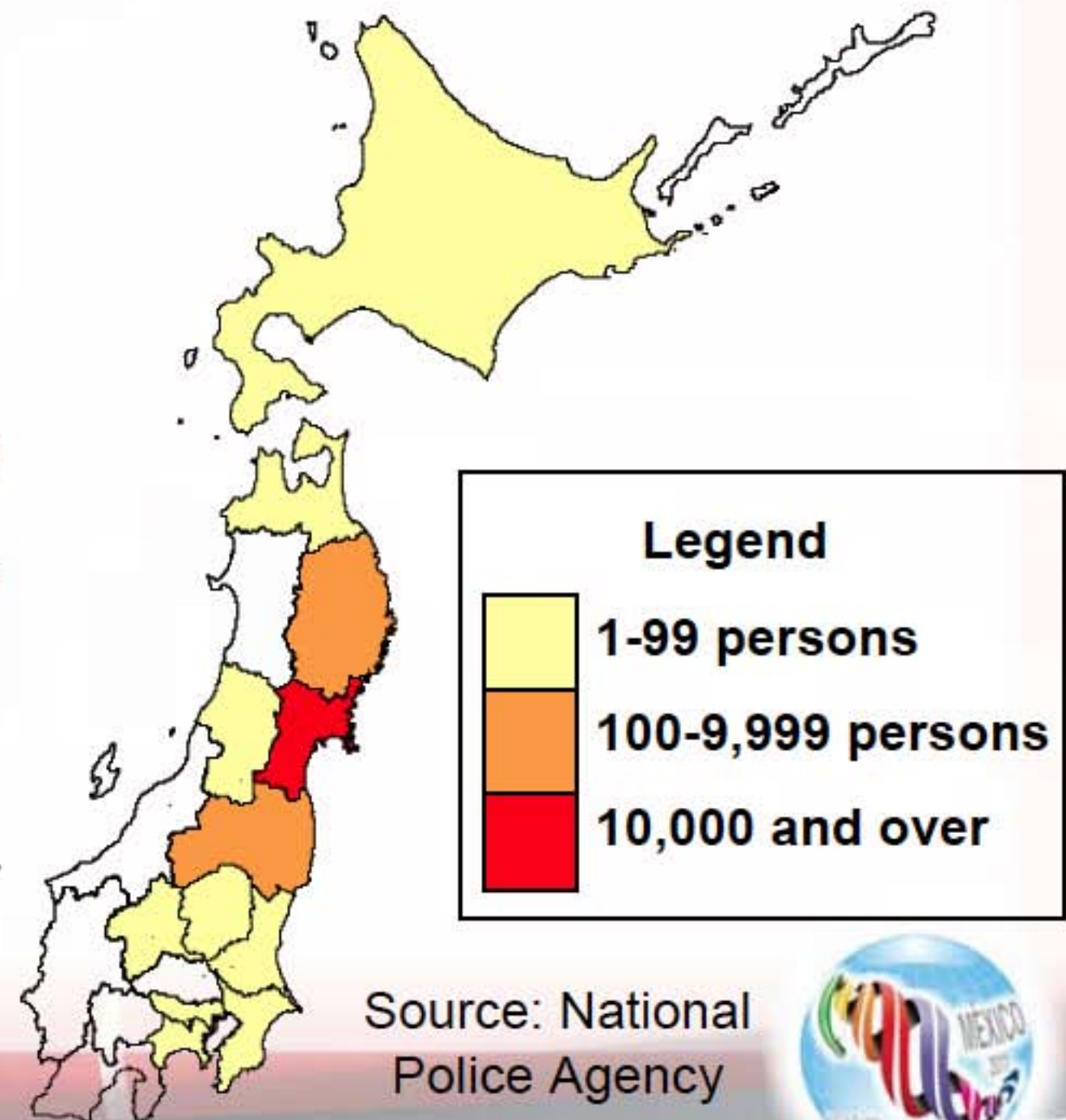
# Overview of Damage

## Human and Property Damage

Number of persons killed/missing  
by prefecture

- Killed : 15,783 persons
- Missing : 4,086 persons
- Injured : 5,932 persons
- Total collapse : 115,185 buildings
- Half collapse : 162,276 buildings

(As of September 12, 2011)

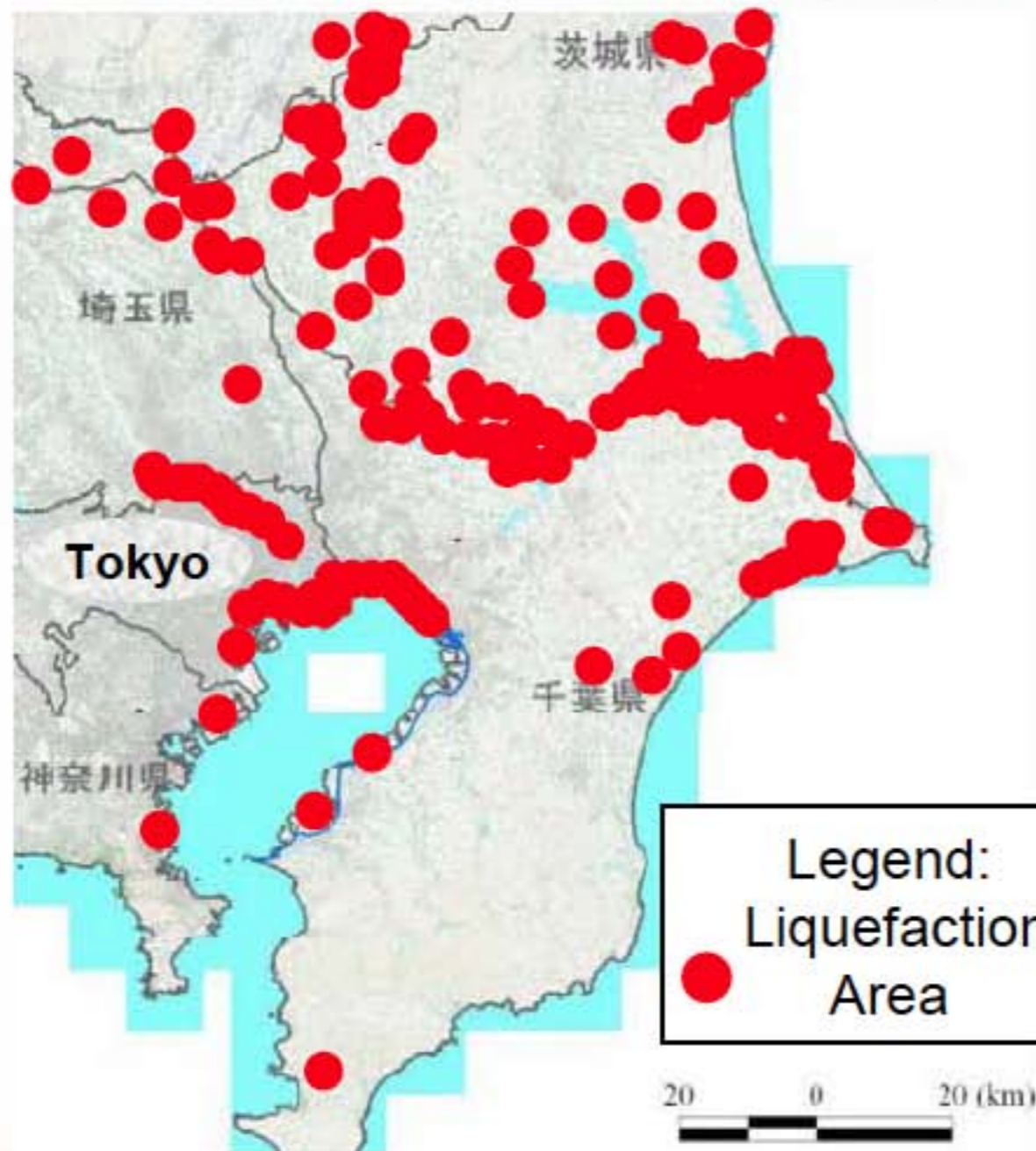




# Overview of Damage

## Large-scale Liquefaction

- In Tokyo Capital Area, liquefaction affected at least 42km<sup>2</sup>.



Areas of Liquefaction  
(Tokyo Capital Area)



Sand boiling  
in reclaimed  
land



Lifted  
Manhole



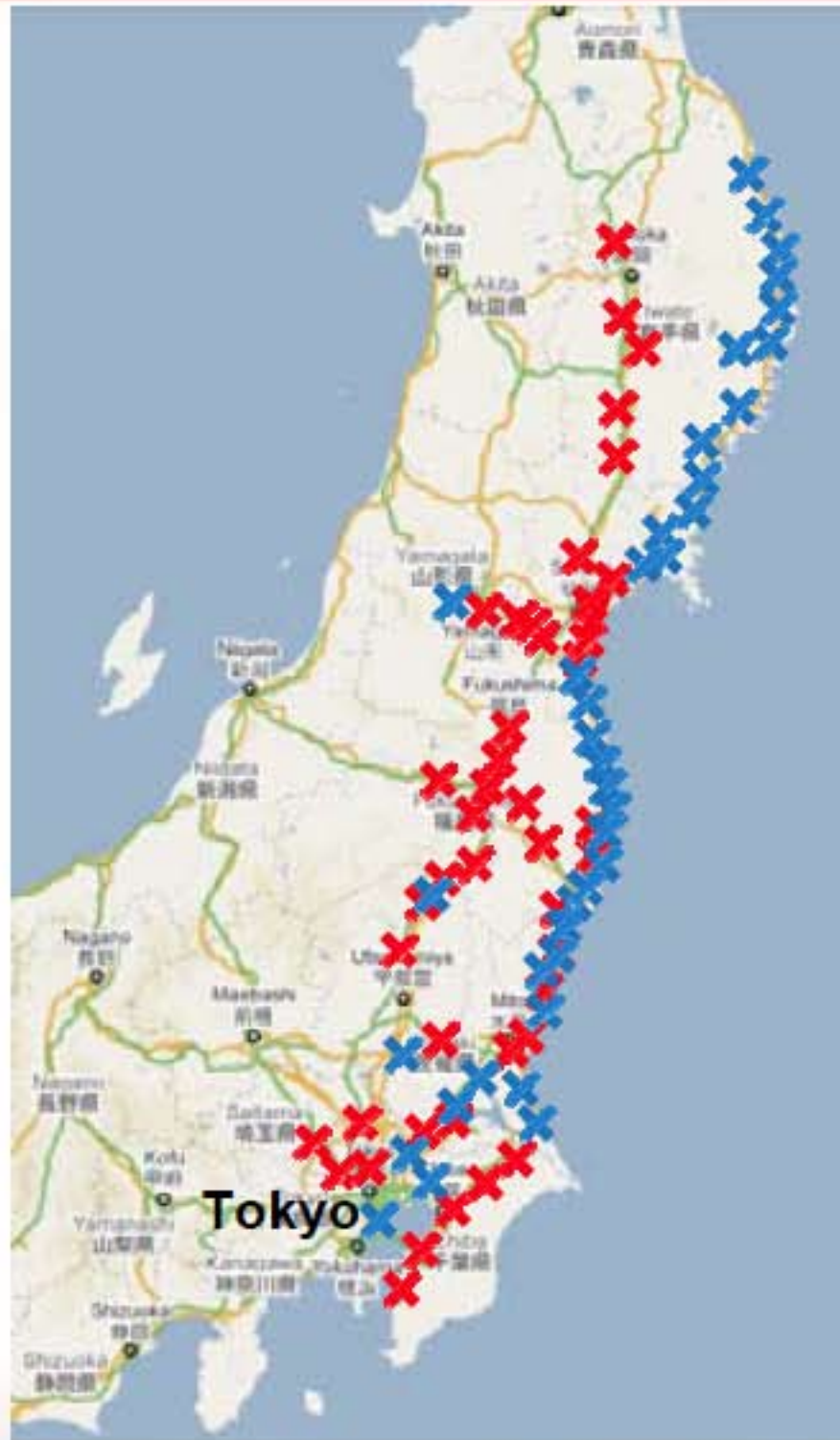


## **2. Damages on Roads: Lessons Leaned from the Past**









# Damage on Trunk Road Network



- Damages were caused on roads in wide areas.
- 15 expressway routes and 69 sections on the national highways were closed, mainly in Tohoku Region.

	Expressway
	National highway
	Closure on expressway
	Closure on national highway





## Damage on Expressways

- Embankments fell on the traffic lanes at 21 locations.
- None of 1,079 expressway bridges in the stricken areas was collapsed.

Route	Length in Service (km)	# of Damaged Embankments	# of Damaged Locations on Lanes
Tohoku Expwy	698	93	16
Joban Expwy	242	116	1
Other	680	137	4
<b>Total</b>	<b>1,620</b>	<b>346</b> locations	<b>21</b> locations



**Yabuki IC – Sukagawa IC  
(Tohoku expressway)**





# Damage on National Highways

- On national highways, a lot of damages were observed (e.g. small cracks on the road surface).
- None of 1,528 bridges had significant damages by earthquake (e.g. collapse).



Near Ishinomaki city  
(Ntn'l Hwy 45)



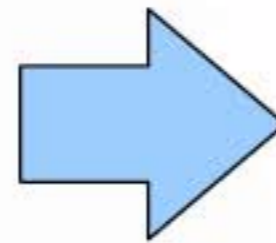


# Lessons Learned from the Past Earthquakes

- Hanshin-Awaji Earthquake (1995) caused significant damages (e.g. structure collapse of Hanshin Expressway).



- Revising Standards
- Seismic Reinforcement



Damages by  
Hanshin-Awaji  
Earthquake (1995)

Jacketed columns and  
connecting  
superstructures





# Damage by Tsunami

- Tsunami flooded roughly 100 km across the national highways.
- Tsunami brought massive debris (e.g. boat, building), which covered roads, towns, and agricultural fields.



Wakabayashi JCT  
(Sendai Tobu expressway)



Natori IC  
(Sendai Tobu expressway)





# Bridges Washed Away by Tsunami

- Five nationally-administrated road bridges were washed away.

Numata  
bridge



Koizumi  
Bridge



Kesen  
Bridge



Mizushiri  
Bridge



Utatsu  
Bridge





## Damage on Other Transport Infrastructure

- Besides roads, the other modes of transport infrastructure were significantly damaged (e.g. Shinkansen, airport, port, etc.).



Sendai Airport



Tohoku  
Shinkansen  
(high-speed  
rail)



Sendai  
Port





# 3. Recovery of Roads: Emergency Recovery for Affected Area





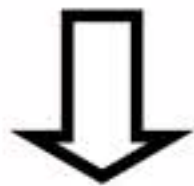
# Steps to Recovery of Roads

- Recovery of the roads consists of the following 3 steps:



## 1. Clearing Roads & Temporary recovery:

Secure traffic of emergency vehicle



## 2. Emergency Recovery: Enable traffic of general vehicle



## 3. Rehabilitation:

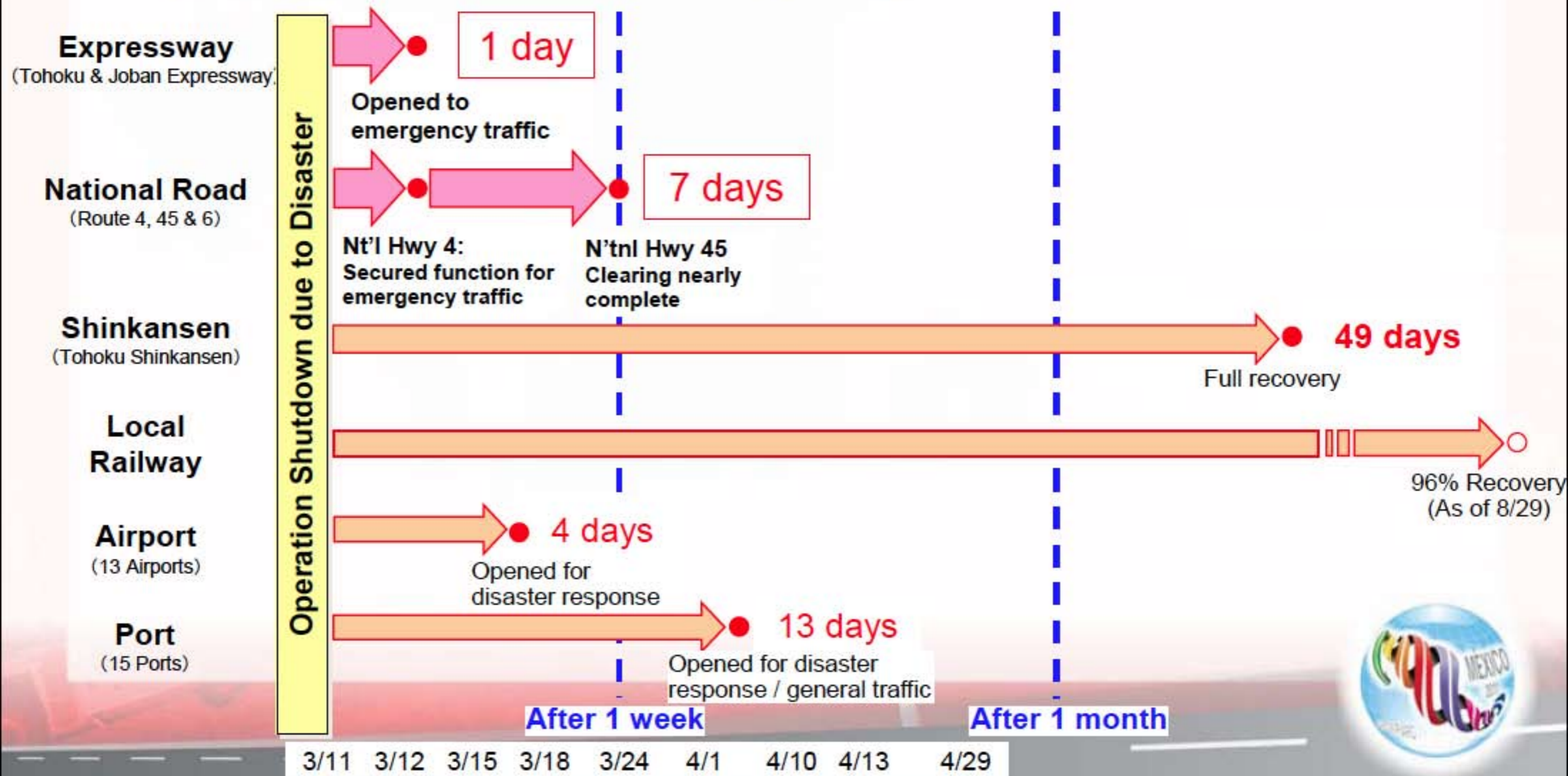
Repair roads back to conditions before disaster while allowing general traffic





# Securing Emergency Traffic Initiated by Roads

- Among transport infrastructures, roads were recovered in the early stage to secure as emergency traffic networks.





# Securing Emergency Traffic in Entire Eastern Japan 1

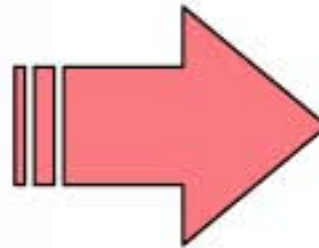
## Recovery Situation of Expressway



- Almost all expressways in Eastern Japan were temporarily recovered in one day and allowed emergency traffic.

**Immediately after  
Earthquake (March 11)**



**One day after  
Earthquake (March 12)**



Legend	
	Open for emergency traffic, etc.
	Closure





# Securing Emergency Traffic in Entire Eastern Japan 2

## Emergency Recovery of Expressway Embankment

- Emergency recovery was completed at the damaged embankment areas on the Joban Expressway six days after the earthquake, and it was opened to general traffic.



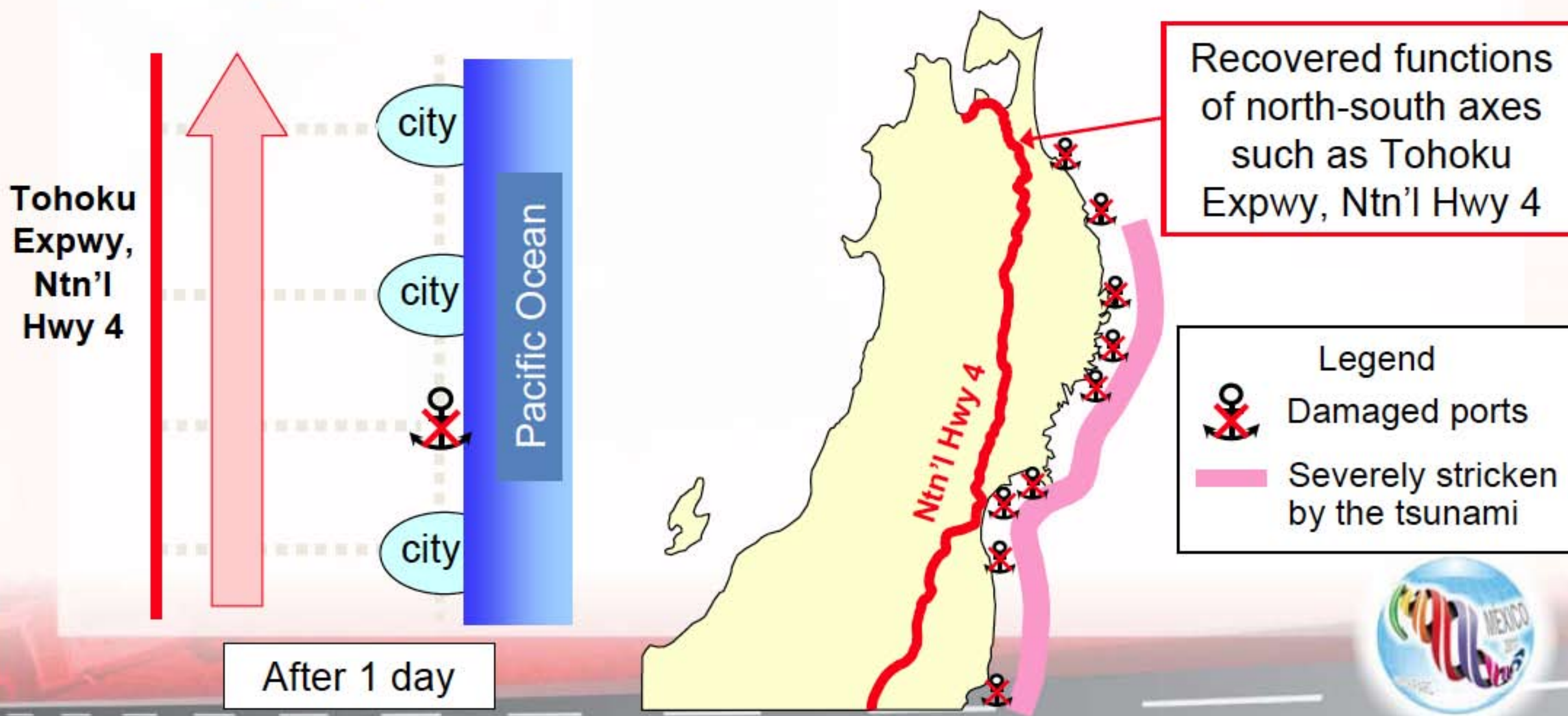


# Securing Emergency Traffic in Tsunami Affected Areas 1

## “Operation Comb”: Immediately after Earthquake

### 1. One day after earthquake (March 12)

- North-south axes in the inland, were recovered for emergency traffic.



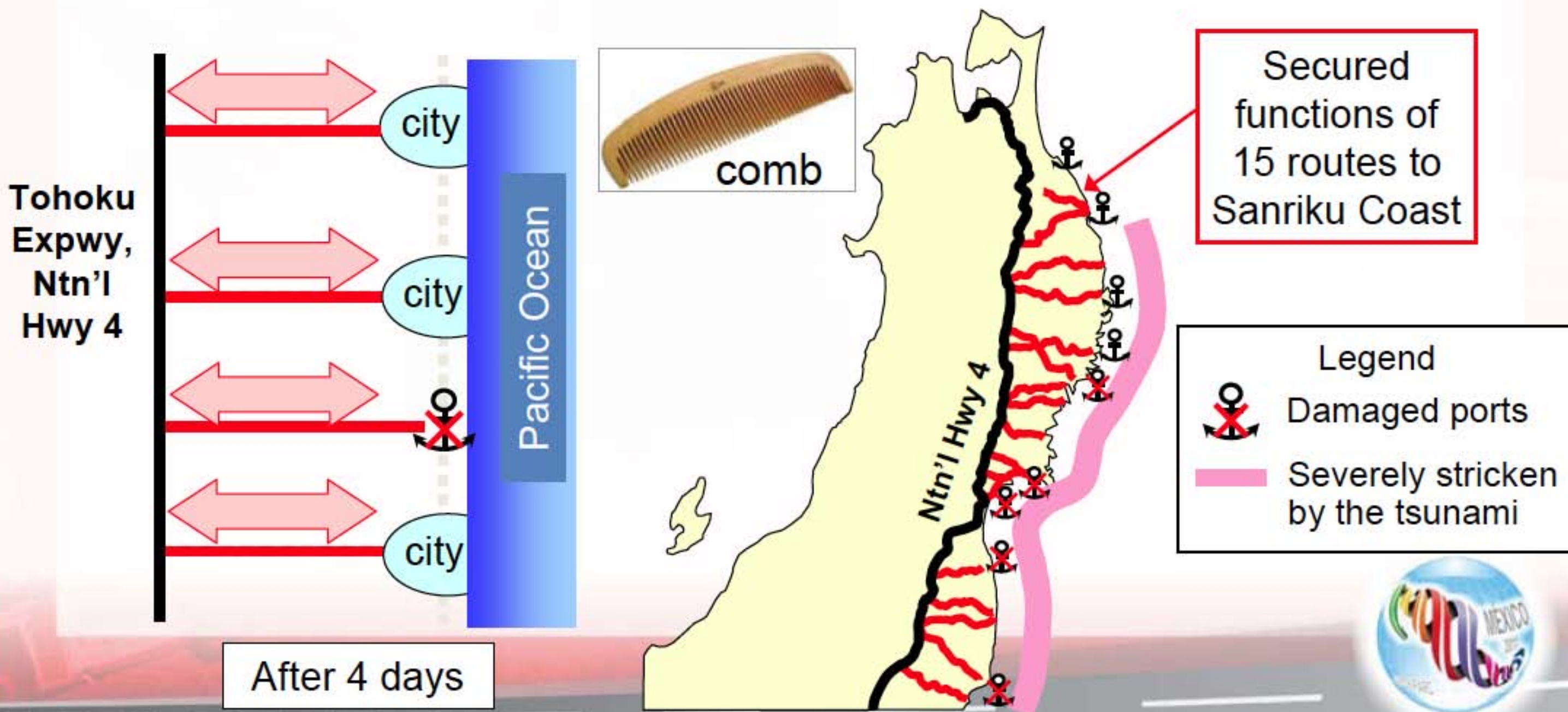


# Securing Emergency Traffic in Tsunami Affected Areas 2

“Operation Comb”: 4 days after Earthquake

## 2. Four days after earthquake (March 15)

- Next, to recover the emergency traffic networks, 15 routes were secured from the inland to the Pacific Coast.





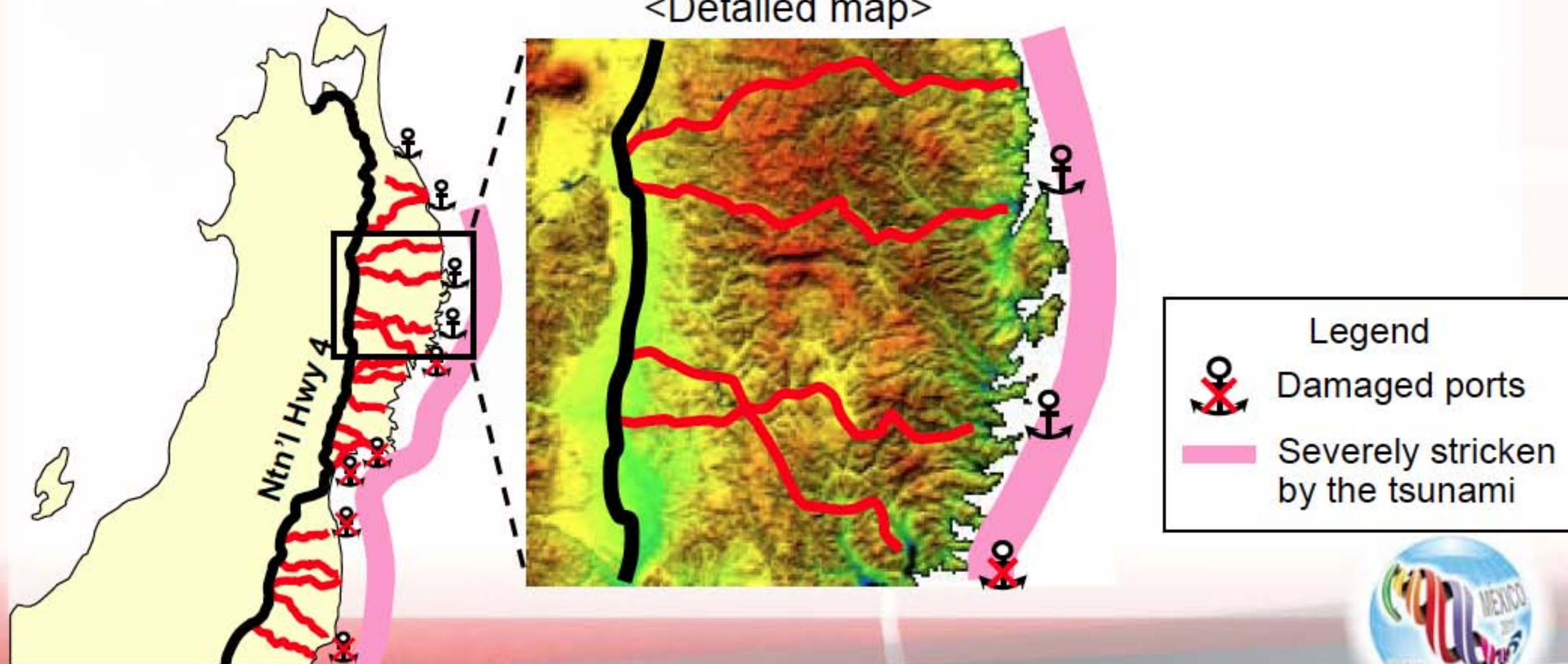
# Securing Emergency Traffic in Tsunami Affected Areas 3

“Operation Comb”: 4 days after Earthquake

## 2. Four days after earthquake (March 15)

- Secured routes from the inland to the coast are winding between mountains.

<Detailed map>



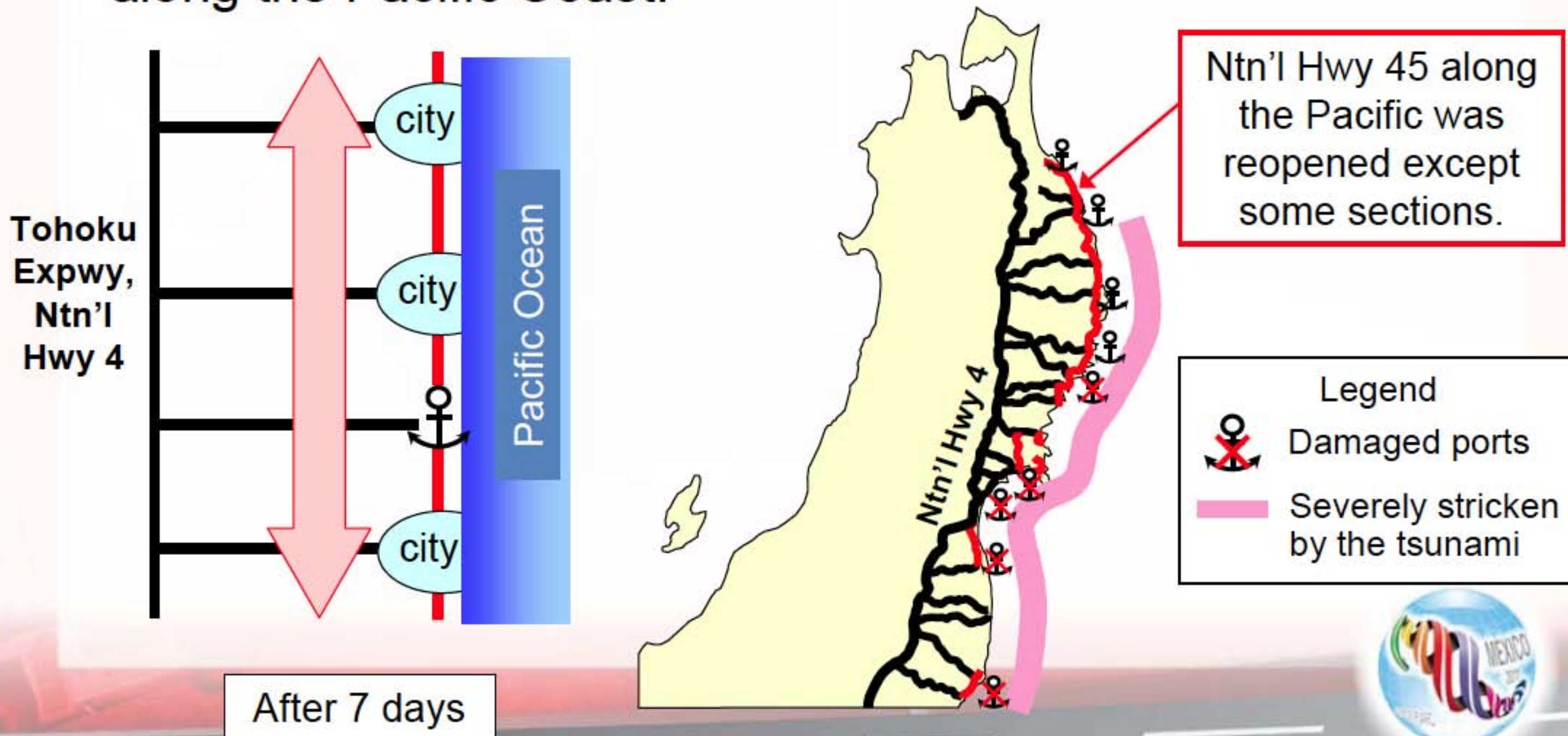


# Securing Emergency Traffic in Tsunami Affected Areas 4

“Operation Comb”: One week after Earthquake

## 3. One week after earthquake (March 18)

- Finally, the transportation functions were recovered along the Pacific Coast.





# Clearing Roads in Tsunami Stricken Areas



By Iwate Prefecture Government





# **4. Issues in Road Infrastructure: For the “Next” Great Earthquake**

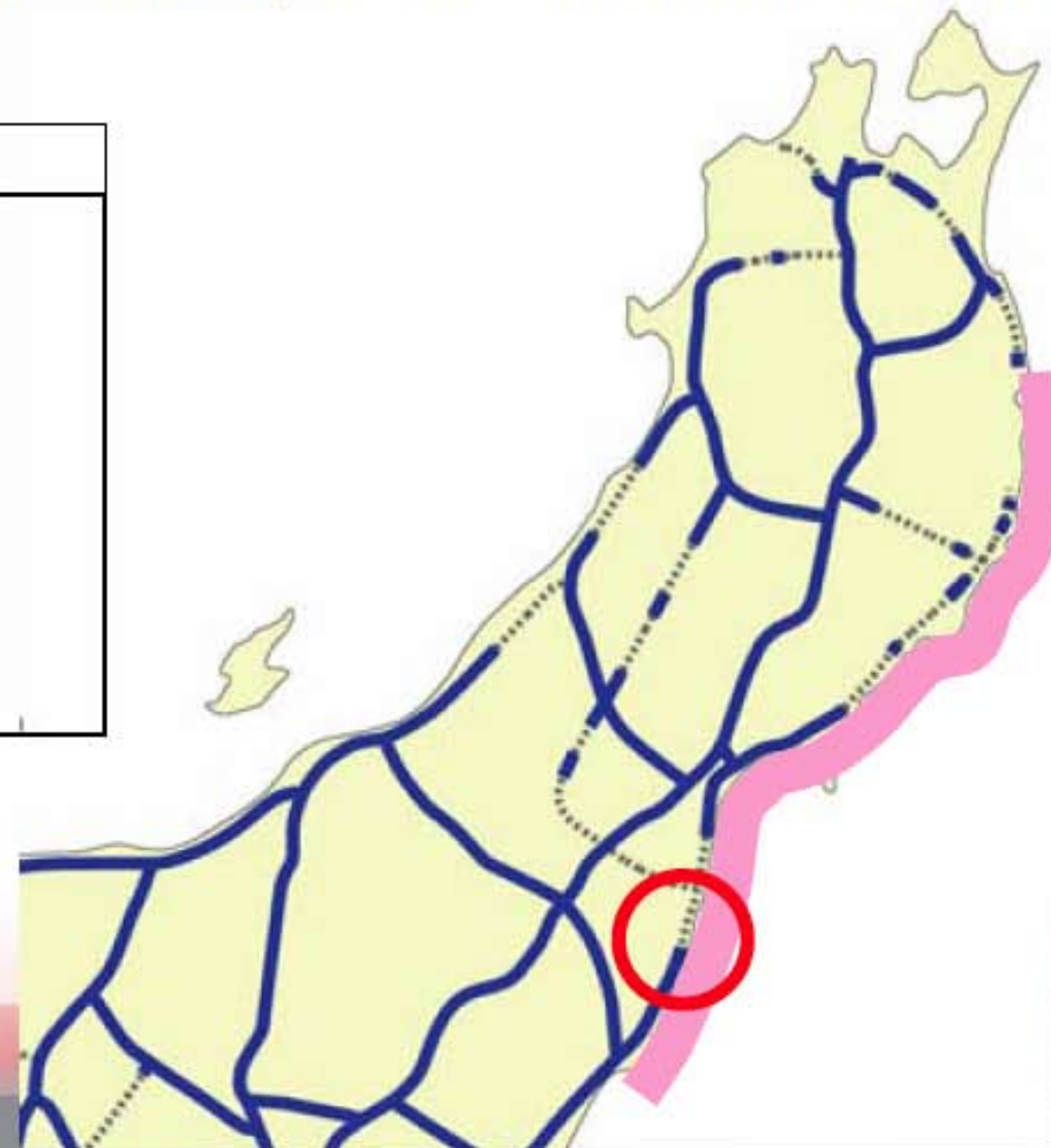
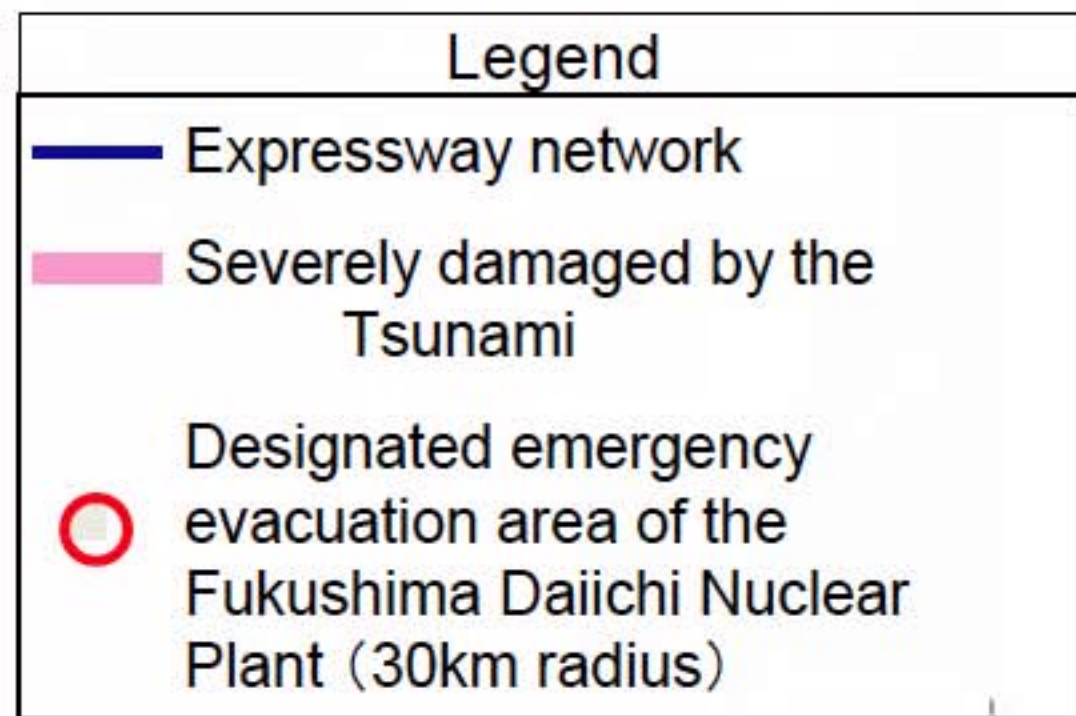




# Effects and Issues of Multilayered Expressways 1

## Expressway Network in Eastern Japan and Disaster Areas

- Affected areas extend mainly along the Pacific Coast where the massive tsunami hit.
  - Expressway network in eastern Japan and the tsunami-stricken areas





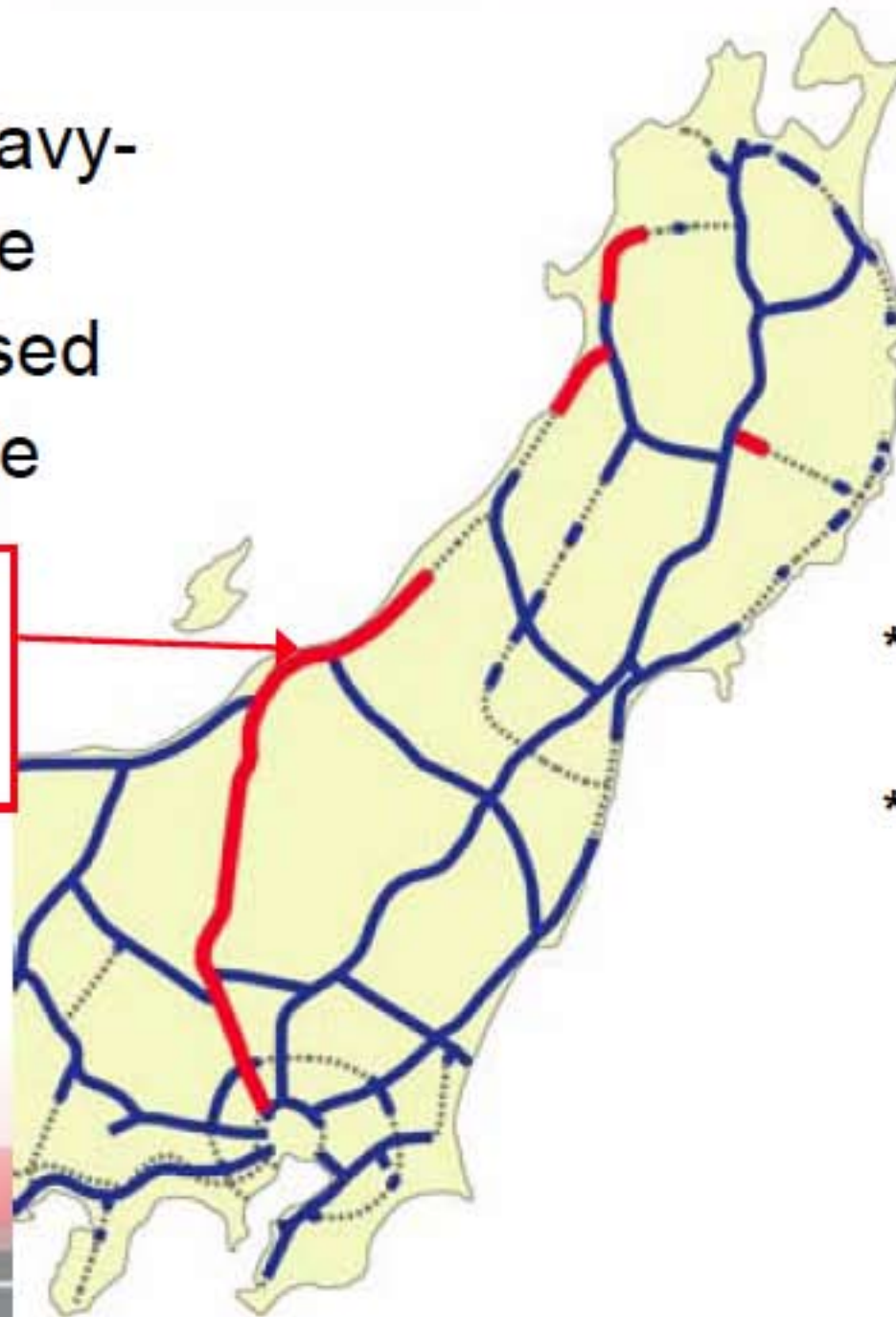
# Effects and Issues of Multilayered Expressways 2

## Freight Network Functioned as Alternative Route

- The freight transport routes along the Sea of Japan functioned as an alternative to the damaged coastal routes along the Pacific.

- Traffic volume of Heavy-duty vehicles on the Expressways increased after the earthquake

**Traffic Increased  
by 30 to 50%**



- \* Before Earthquake:  
March 7(Mo)~10(Th), 2011
- \* After Earthquake:  
March 14(Mo)~17(Th), 2011

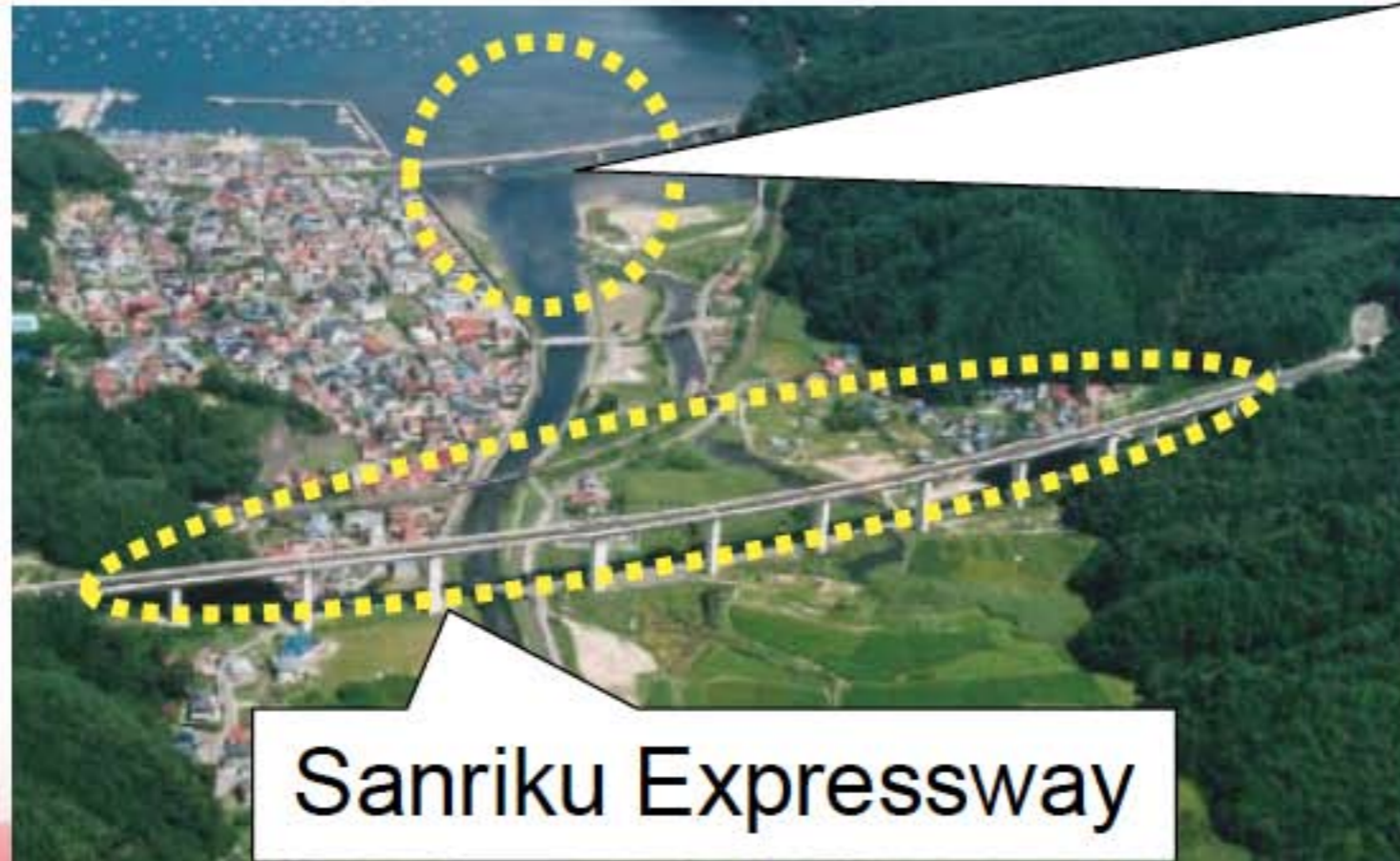




# Effects and Issues of Multilayered Expressways 3

## Undamaged Sanriku Expressway

- Since the Sanriku Expressway along the Pacific had been designed to avoid tsunamis based on the past tsunamis, it was free of damages.
- Reassured the importance of planning road infrastructure taking into account of tsunami risks.



Ntn'l Hwy 45

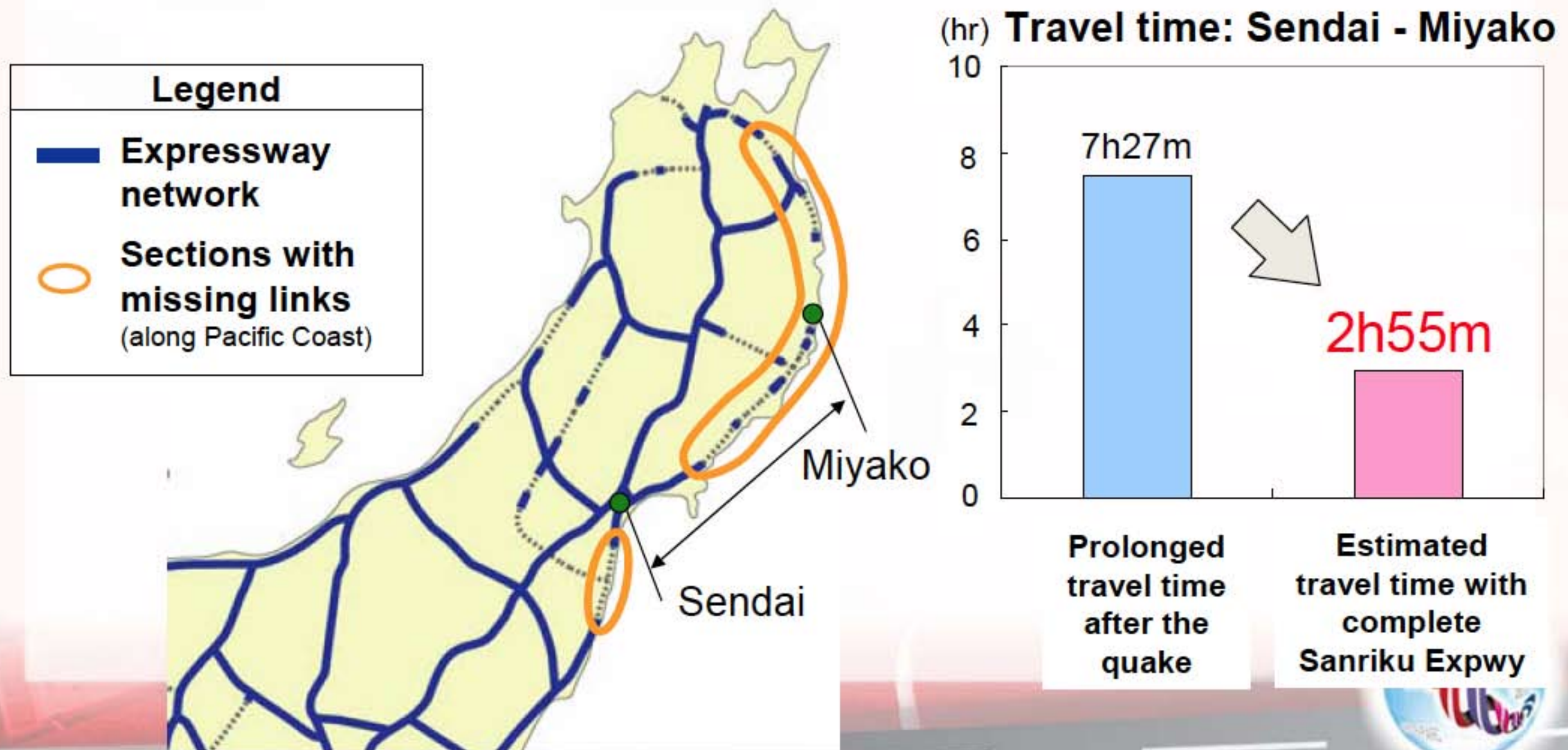




# Effects and Issues of Multilayered Expressways 4

## Missing Links of Expressway along Sanriku Coast

- Sanriku Expressway had been less than 50% complete.
- It left several issues as an emergency traffic network.

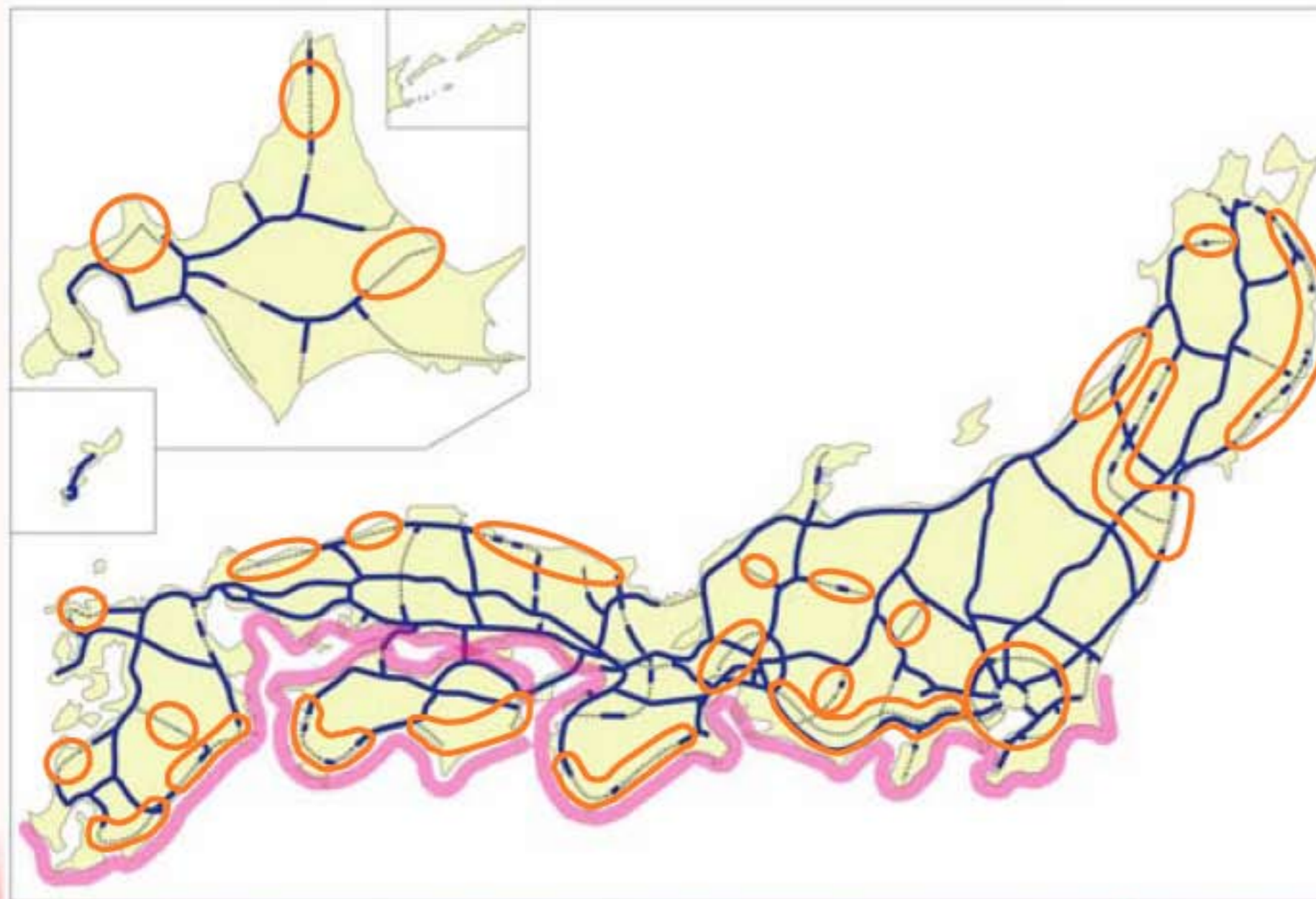






# Effects and Issues of Multilayered Expressways 5

## Expected Tsunami Stricken Areas and Missing Link

- Missing links of the expressways in these high-risk flood areas by tsunamis by possible large-scale earthquakes.



Legend	
	Expressway network
	Estimated tsunami affected areas by Tokai, Tonankai, Nankai earthquakes (Predicted in Dec. 2003, Central Disaster Management Council)
	Sections with missing links





# Necessary Information on Road Immediately after the Earthquake 1

- After the earthquake, each government provided information separately.

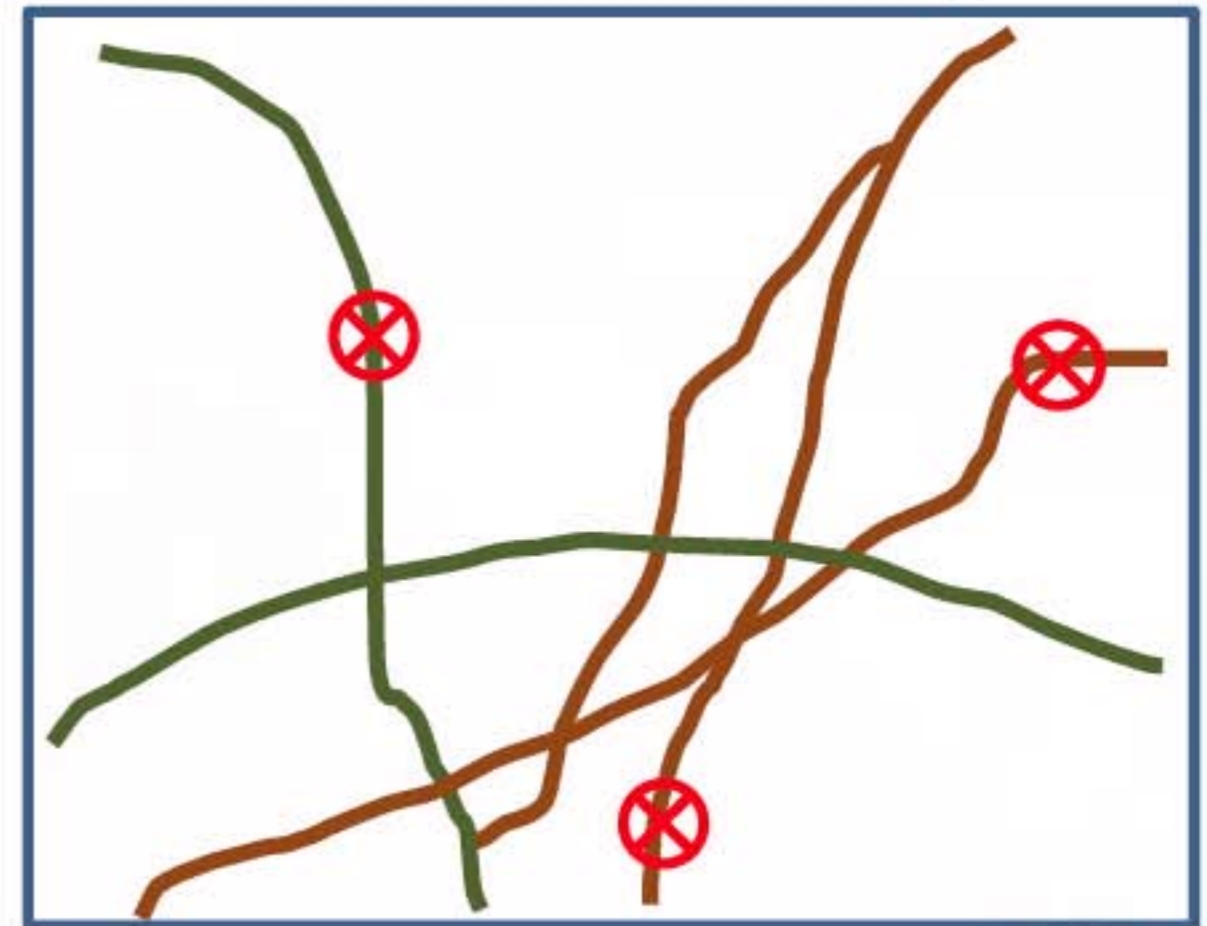
National road



Local road



National government provided consolidated information



12 days after the earthquake

Legend  : Road Closure

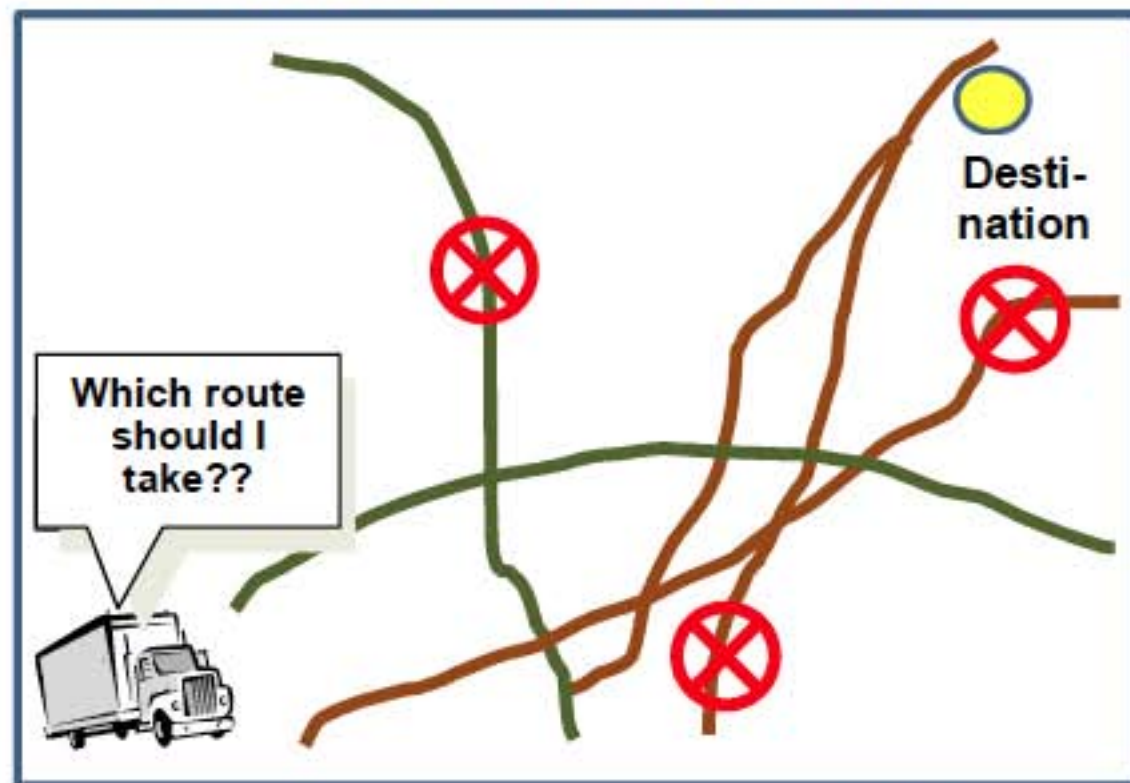




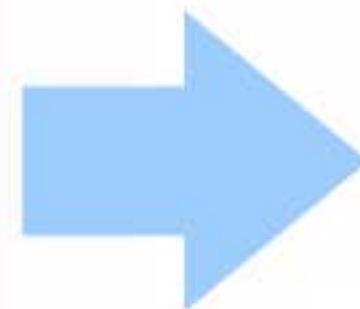
# Necessary Information on Road Immediately after the Earthquake 2

- Road users need information on “available routes” as well as “closed routes” in a situation with a lot of closures.

**Closed routes:  
governments' perspective**

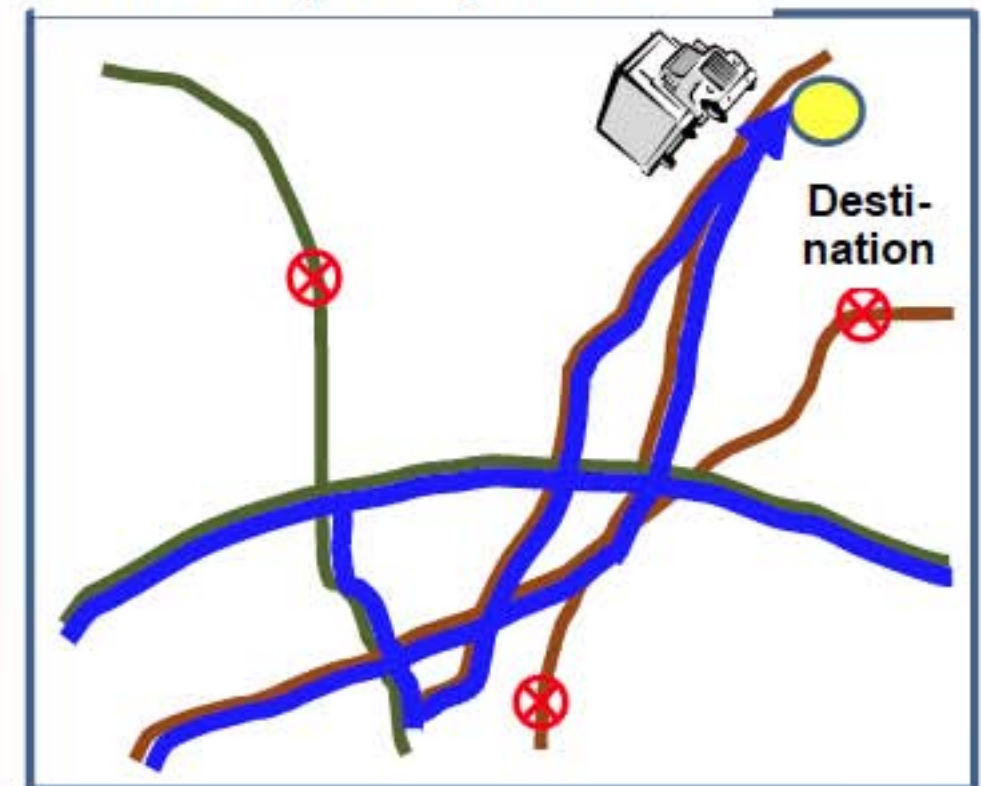


Info. on road closure: 



One month  
after the  
earthquake

**Available routes:  
users' perspective**



Info. on available routes: 





## **5. Issues and Lessons Learned from the Great East Japan Earthquake**





## Issues and Lessons Learned from the Great East Japan Earthquake

1. By having applied the lessons of the past earthquakes, such as the revised standards and associated seismic reinforcements, damages on bridges were significantly reduced.
2. Right after an earthquake, the top priority is to secure emergency traffic networks promptly.
3. We recognized the importance of multilayered expressway networks.
4. Right after disasters, necessary information should not be provided by multiple road administrators separately to avoid confusion. Moreover, road users need information such as available road networks.





**Thank you for  
your kind attention.**



Temporary bridge was built in place of previous bridge washed away by tsunami; A step toward recovery.

