Japanese Earthquake Researches for Seismic and Tsunami Disaster Resilience

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Contents

1. Short history
2. The Headquarters for Earthquake Research Promotion (HERP)
3. Recent earthquakes
   3.1 The 2016 Kumamoto earthquake
   3.2 The 2011 Tohoku-oki earthquake
4. Estimates
   4.1 The Metropolitan Earthquake and its disaster
   4.2 The Nankai Trough Giant Earthquake and its disaster
5. Summary
(1) History of Earthquake (Prediction) Research in Japan

- 1962: Earthquake Prediction Plan (Blueprint)
- 1965-1998: The 1st to 7th National Earthquake Prediction Program
- 1974-2008: The 1st to 7th National Prediction Program for Volcanic Eruption

The 1995 Hyogoken-nanbu (Kobe) Earthquake

- 1995: Headquarters for EQ Research Promotion
- 1999-2008: The new Program of the Study and Observation for Earthquake Prediction
History of Earthquake (Prediction) Research in Japan (2)

• 2009-2013: The Program of the Study and Observation for Prediction of Earthquake and Volcanic Eruption (Integration of EQ & VE)
  The 2011 Tohoku-oki M9 earthquake

• 2012: Revision of Basic comprehensive policy

• 2014-2018: Earthquake and Volcano Hazards Observation and Research Program (Integration of EQ, VE, and Social Sciences)
Contents

1. Short history

2. The Headquarters for Earthquake Research Promotion (HERP)

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   3.2 The 2011 Tohoku-oki earthquake

4. Estimates
   4.1 The Metropolitan Earthquake and its disaster
   4.2 The Nankai Trough Giant Earthquake and its disaster

5. Summary
2. The Headquarters for Earthquake Research Promotion (HERP)

- Headquarters for Earthquake Research Promotion (地震調査研究推進本部)
  - Policy Committee (政策委員会)
  - Earthquake Research Committee (地震調査委員会)
Disaster prevention measures at national and regional level

HERP

Director: Minister of MEXT (Education, Culture, Sports, Science and Technology)

Policy Committee

Basic Comprehensive Policy for Earthquake observation and research

Earthquake Research Committee (ERC)

Survey and Observation Data and Research Results

Japan Meteorological Agency

Survey, Observations, Research, etc

MEXT, GSI, JMA, JCG, Universities, NIED, JAMSTEC, AIST, NICT, NRIFD
Basic Comprehensive Policy for the Promotion of Earthquake Observation, Measurement, Surveys and Research:

The first plan (1998)

1. Probabilistic Seismic Hazard Assessment
2. Real time hazard information: Earthquake Early Warning (EEW), Tsunami warning
3. Earthquake Prediction in Tokai area
4. Earthquake Prediction Research based on recommendation by Geodesy Council of MEXT
Basic Earthquake Survey and Observation Plan (1997)

1. **Seismic networks**
   - Short period: every 15 - 20 km 1235 (Hi-net: 782, UNV: 231, JMA: 195, AIST: 27)
   - Broad band: every 100 km

2. **Strong Motion Stations**: 15 - 20 km
   (surface: 5700, downhole: 700)
   - Local government: 2,700
   - KiKnet: 452

3. **GPS network** (GNSS: Global Navigation Satellite System)
   - GEONET (GSI): 1477, every 20 - 25 km

4. **Active Fault Survey**: 98 faults - > 114 faults
Basic Observations

Hi-net (782 ※ )

GNSS: GEONET (1342 ※ )

※1 HERP (as of March 2014)
Number of Earthquakes in JMA catalogue per month

Number of stations (NIED)

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Probabilistic Seismic Hazard Map

This map shows the probability of ground motions equal to or larger than seismic intensity 6 Lower, occurring within 30 years from the present.

These maps are expected to be used:

- to raise the public's awareness of earthquake disaster reduction
- to take the earthquake disaster reduction measures more effectively and efficiently
- to evaluate the risks of establishing important facilities and enterprises in a certain area.
Probabilistic Seismic Hazard Map
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Current Basic Comprehensive Policy revised in 2012 after the 2011 Tohoku-oki earthquake (2009-2019)

1. Research for long-term forecast of subduction-related earthquakes and real-time prediction of strong ground motion

2. Tsunami warning: S-Net, DONET,
   Estimation of Large Earthquakes in Nankai area

1. Research on active faults

2. Collaboration with engineering and social sciences for disaster resilience
Probabilistic Seismic Hazard Assessment: A chance of Japanese Seismic Intensity 6- or larger in 30 years: as of Jan. 1 2017

HERP, ERC

• Injury by traffic accidents: 24%
• Suffering from fire: 1.9%

Probability of earthquake occurrence + Site amplification
Monitoring of Waves on Land and Seafloor (MOWLAS)

About 2,2000 stations on land and seafloor
Contribution of MOWLAS to EEW & Tsunami warning

EEW:
- Enhance evacuation
- Stop railway
- Stop operation in a factory

Tsunami warning:
- Better estimate of height and timing

Wave speed of 7 km/s
Tsunami speed of 623 km/h
Contents

1. Short history

2. The Headquarters for Earthquake Research Promotion (HERP)

3. Recent earthquakes
   3.1 The 2016 Kumamoto earthquake
   3.2 The 2011 Tohoku-oki earthquake

4. Estimates
   4.1 The Metropolitan Earthquake and its disaster
   4.2 The Nankai Trough Giant Earthquake and its disaster

5. Summary
India-Japan Workshop on Disaster Risk Reduction 2018

2016, May 14th  Naoshi Hirata @Mashiki town

Death toll
255

Totally destroyed
8,677 houses

As of 2017 Feb. 1

180K people evacuated at maximum
Surface faulting and known active faults

- Along the Futagawa fault zone, about 30 km long, a series of surface faults are found.
- The maximum faulting is **2.2 m right-lateral slip** at Mashiki town, Dozon area.

Right-lateral surface slip

2016, May 14th  Naoshi Hirata @Mashiki town
Major Active faults (97 faults) : as of 2016
-> 114 faults as of 2018

Head quarters for Earthquake Research Promotion (HERP) 
Earthquake Research Committee (ERC)
Probability of M6.8+ in 30 yrs

North
7-13% (9%)

Central
18-27% (21%)

South
7-18% (8%)

Whole Kyushu: 30-42%

Central Kyushu: 18-20%

Cumulative distribution

Probability (%)

© Earthquake Research Committee, Headquarters for Earthquake Research Promotion (HERP)
Probabilistic Seismic Hazard Assessment:
A chance of Japanese Seismic Intensity 6- or larger in 30 years:
as of Jan. 1, 2016

- Injury by traffic accidents: 24%
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©HERP, ERC
Contents

1. Short history
2. The Headquarters for Earthquake Research Promotion (HERP)
3. Recent earthquakes
   3.1 The 2016 Kumamoto earthquake
   3.2 The 2011 Tohoku-oki earthquake
4. Estimates
   4.1 The Metropolitan Earthquake and its disaster
   4.2 The Nankai Trough Giant Earthquake and its disaster
5. Summary
The 2011 Tohoku-oki earthquake and its effects
Deformation of Japanese Islands

Geospatial Information Authority of Japan (GSI)  
GEONET

East-West Compression

GNSS (GPS)  
1400 stations in Japan

©GSI
Co-seismic deformation in 3 minutes

http://mekira.gsi.go.jp/JAPANESE/crstanime_tohoku110311.html

India-Japan Workshop on Disaster Risk Reduction 2018
Loses and Damages of the 2011 Great East Japan Earthquake

(1) Human losses
Fatalities 18,131
Lost 2,829
Injured 6,194
90% of death toll is due to drown

(2) House damages
129,391 houses are totally destroyed
265,096 are half-collapsed
743,298 are partially damaged

(3) There are 330 fires
(As of 17:00 September, 28, 2012)
Aftershocks of the 2011 Tohoku-oki earthquake

Epicenters

2011-March-11, 14:46～
2018-Feb.-28, 24:00 、 Depth 0 - 90km 、 M≥5.0
The 2004 Sumatera-Andaman earthquake (Mw9.1)

(2004-Dec.-26 – 2018-Feb.-28, M≥5.0)

- 4 month later, Mw8.6
- 2.5 yrs later, Mw8.4
- 5.5 yrs later Mw7.8
- 7.5 yrs later, Mw8.6 west of the trench axis
- 11 yrs later, Mw7.6

Contents

1. Short history

2. The Headquarters for Earthquake Research Promotion (HERP)

3. Recent earthquakes
   3.1 The 2016 Kumamoto earthquake
   3.2 The 2011 Tohoku-oki earthquake

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5. Summary
Contents

1. Short history

2. The Headquarters for Earthquake Research Promotion (HERP)

3. Recent earthquakes
   3.1 The 2016 Kumamoto earthquake
   3.2 The 2011 Tohoku-oki earthquake

4. Estimates
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   4.2 The Nankai Trough Giant Earthquake and its disaster

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Tokyo Metropolitan Earthquake

An earthquake which may cause a gigantic earthquake disaster in Tokyo Metropolitan area

◆ Hazard (External force to a society)
An “usually” large earthquake, as large as the 2016 Kumamoto earthquake, which may occur anywhere in Japan

◆ Exposure : Extraordinary large

◆ Disaster isk : Large
Sever Seismic Disaster in Kanto

M8-class earthquakes along the Sagami Trough

1703元禄地震
Genroku EQ
10,000 fatalities

1855安政地震
Ansei-Edo EQ
7,000

1923大正地震
Great Kanto
105,000

M7-class earthquakes caused by subduction of Philippine Sea Plate from the Sagami Trough

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HERP, ERC (2018)
M7 class events associated with Philippine Sea plate subduction

- 太赤線で囲まれた範囲が評価対象領域を示す。
- 細赤線は最大クラスの地震の震源域を示す。
- 破線は本評価で用いたフィリピン海プレート上面の等深線を示す。

M6.7〜7.3の地震
○: 本評価で対象とした地震（9地震）
（参考）
●: 大正関東地震(1923)の余震
○: 前回評価対象とした地震
★: M8クラスのプレート境界地震

HERP, ERC (2014)
Plate structure beneath greater Tokyo by MeSO-net

Philippine Sea Plate

Pacific Plate
Seismic Tomogram beneath southern Kanto: Vs distribution
Seismic Hazard/Risk Estimation

Assumed earthquake beneath southern CBD Tokyo (M7.3)

Centred Disaster Management Council, Cabinet Office (2013)

Estimated fatality: 23,000
Economic losses: JPY 95 trillions

Area with 6- is 4,500 km²
30% of Tokyo, Chiba, Kanagawa, Saitama Prefectures.
Death toll by the southern central business district (CBD) earthquake (winter/evening)

- Crush of buildings, 6,400 (28%)
- Fire, 16,000 (70%)
- Concrete-block wall collapse, 500 (2%)
- Landslide, 600 (0%)
- Totally collapsed/Burned, 610,000
- Injured, 123,000
- Not correctly evacuated
- Total, 23,000

Central Disaster Management Council, Cabinet Office (2013)
Contents

1. Short history

2. The Headquarters for Earthquake Research Promotion (HERP)

3. Recent earthquakes
   3.1 The 2016 Kumamoto earthquake
   3.2 The 2011 Tohoku-oki earthquake

4. Estimates
   4.1 The Metropolitan Earthquake and its disaster
   4.2 The Nankai Trough Giant Earthquake and its disaster

5. Summary
Variety of Nankai Trough earthquakes

- Events in Tokai area and Tonankai area
  ① Simultaneous (1498, 1707)
  ② Short time difference (1854, 1944·1946)

- Tokai earthquake
  ① Rapture stops west of Point Omaezaki (1944)
  ② Rapture extends east of Point Omaezaki (1854)
Intensities by the Gigantic Earthquake in Nankai Trough (Landward case)

◆Loss and damages at the worst case

<table>
<thead>
<tr>
<th>M</th>
<th>Inundated area</th>
<th>Population in inundated areas</th>
<th>Death or lost</th>
<th>Totally Collapsed houses</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.0(9.1)</td>
<td>1,015 km²</td>
<td>1,630K</td>
<td><strong>323K</strong></td>
<td>2,386K</td>
</tr>
</tbody>
</table>

南海トラフ巨大地震の被害想定について（第一次報告） 平成24年8月29日 中央防災会議
Tsunami height (highest tide)

20+-m-high tsunami will hit Tokyo (Islands), Shizuoka, Aichi, Mie, Tokushima, Kochi prefectures
Summary

1. The 2016 Kumamoto Earthquake Sequence brought Seismic Intensity 7 in JMA scale at Mashiki town with an interval of 28 hrs.

2. If the M7 event occur in Tokyo Metropolitan, a loss and damage is tremendous.

3. The effect of the 2011 Tohoku-oki event is still continuing.

4. The Nankai Trough Gigant earthquake is likely to occur and cause a very large loss and damages.
Appendix
Two large earthquakes with JMA seismic intensity 7 at Mashiki town in Kumamoto

- The April 14, 2016 earthquake with a magnitude (M) 6.5
- The April 16, 2016 earthquake with an M 7.3
Statistics on annual occurrence probabilities of natural disasters and accidents in Japan

- **Injury by traffic accidents:** 24%
- **Suffering from fire:** 1.9%

### Natural disasters
- Typhoon passing
- Vicinity of Tokyo Metropolis (nearly 100%)

### Accidents
- Suffering from typhoon
- Injury from fire
- Death from traffic accidents
- Injury from heavy rainfall
- Death from aircraft accidents

### Clinical death/suicide
- Injuries
- Suicide

### Crime
- Burglary (3.4%)
- Snatcher (1.2%)
- Pickpocket (0.58%)
- Robbery (0.16%)
- Murder (0.03%)

### Water level occurrence probabilities for rivers
- Class B river system: 30 years 76%
- Class A river system: 30 years 26%
- 30 years 6%
- 30 years 3%
Seismic intensity describes the scale of the ground motion at a particular location. It varies with the distance from the epicenter and the surface geology at each point. JMA's seismic intensity scale has 10 degrees (0 (imperceptible), 1, 2, 3, 4, 5 lower, 5 upper, 6 lower, 6 upper, 7).