Experience of the Great East Japan Earthquake in 2011

- Abituati da sempre al terremoto -

We have frequently had earthquakes and will continue to have. Therefore, it is necessary to learn lessons from the experiences.

Hiroaki Furumai
Professor,
Graduate School of Engineering,
University of Tokyo
Similarity: Italy and Japan

- Latitude and Elongated shape of the land

*Temperate climate with four seasons*
Similarity: Italy and Japan

- Latitude and Elongated shape of the land

  *Temperate climate with four seasons*

- Food culture of their own

  *with Italian wine and Japanese sake*
Similarity: Italy and Japan

- Latitude and Elongated shape of the land
  *Temperate climate with four seasons*

- Food culture of their own
  *with Italian wine and Japanese sake*

- Abundance of historical heritage
  *Arts, architecture and high quality tourism*
Similarity: Italy and Japan

- Latitude and Elongated shape of the land
  Temperate climate with four seasons
- Food culture of their own
  with Italian wine and Japanese sake
- Abundance of historical heritage
  Arts, architecture and high quality tourism
- Earthquakes and volcanic activity
  eg. 2009 L’Aquila and 2011 East Japan
Great East Japan Earthquake

Date: 11 March 2011  
Duration: 6 minutes  
Magnitude: 9.0 (Mw)  
Depth: 30 km  
Epicenter: $38.322^\circ$ N, $142.369^\circ$ E

Major lifelines such as water supply, electricity, and gas, were totally severed.
Features of the Earthquake and its Disaster

Wide-area and Multiple disasters
- Ocean-trench type earthquake
- Tsunami disaster
- Ground subsidence
- Aftershock continuation
- Radiation leakage from nuclear power plant

Max Wave Height
8.5m (28 ft) +
Max Run-up Height
40.5m (133 ft)

Wide coastal area hit by Tsunami
Water outage and restoration of supply after the Earthquake

Households with water supply resumed: 2.23 million

Households without water supply: 0.059 million

Aftershock (M7.4) 23:32 on April 7
Aftershock (M7.1) 17:16 on April 11
Aftershock (M6.3) 14:07 on April 12

Workshop on "Quando la terra trema: esperienze ed insegnamenti nella gestione dei servizi idrici", October 10, 2013, L'Aquila, Italy
Separation of flexible joint at φ2400 steel pipe for main trunk

Shiroishi City, Miyagi Prefecture

Restoration by welding
Recovery of water supply in Sendai City

Workshop on "Quando la terra trema: esperienze ed insegnamenti nella gestione dei servizi idrici",
October 10, 2013, L'Aquila, Italy
NS type ductile iron pipe is one of earthquake-proof pipes.
Damage at a water treatment plant

@Ishinomaki City, Miyagi

Flexible joint functioned against earthquake.
Damage on distribution tank by aftershock

Before
Courtesy: Ichinoseki City

After
Courtesy: Japan Ductile Iron Pipe Association

@Ichinoseki City, Iwate
Seismic reinforcement rate vs damage rate

Damage rate [case/km]

Seismic reinforcement rate [%] (for distribution main pipes)

Ishinomaki - Intensity 6 upper
Iwaki - Intensity 6 lower
Miyagi-prefecture
Ichinoseki - Intensity 6 lower
Sendai - Intensity 6 upper
Koriyama - Intensity 6 lower
Seismic reinforcement rate in FY-2011
- Main pipe -

Nationwide average
= 32.6%

http://www.jwrc-net.or.jp/taishin-corner/map_top.html

Workshop on "Quando la terra trema: esperienze ed insegnamenti nella gestione dei servizi idrici",
October 10, 2013, L'Aquila, Italy
Seismic reinforcement rate in FY-2011
- Purification plant -

<table>
<thead>
<tr>
<th></th>
<th>FY 2009</th>
<th>FY 2010</th>
<th>FY 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purification Plant</td>
<td>16.8</td>
<td>18.7</td>
<td>19.7</td>
</tr>
</tbody>
</table>

Nationwide average = 19.7%

http://www.jwrc-net.or.jp/taishin-corner/map_top.html
Seismic reinforcement rate in FY-2011 - Distribution tank -

Nationwide average = 41.3%

http://www.jwrc-net.or.jp/taishin-corner/map_top.html
Efficiency and Resilience

We have made efforts to construct water supply system rapidly and have tried to enhance the system efficiency by reducing cost and resources.

However, after the 2011 earthquake, we realized that we were overconfident on our established systems. In fact, we thought that they are kept at high performance level. It is true under usual conditions.

We have to recognize the necessity to pay more and more attention to crisis management and preparedness, considering extremely gigantic earthquake and tsunami.

We should increase the resilience of water supply system as well as system efficiency.
Evaluation of recovery after earthquake

Prompt recovery ability is key factor of resilience.

Performance

Earthquake event

Required level under normal condition

Desirable level under emergent condition

Minimum required level under emergent condition

Outage level

Time

Full damage

It takes more time to recover from full damage condition.

Partial damage

Mitigated damage

More prompt Recovery

Prompt Recovery

Increased Resilience

Delayed Recovery

Workshop on "Quando la terra trema: esperienze ed insegnamenti nella gestione dei servizi idrici", October 10, 2013, L'Aquila, Italy
Evaluation of Resilience of Water Supply System

- Multiple water resources
- Networking and bypass-loop
- Seismic reinforcement
- Energy saving
- Integrated management of water supply and sewerage
- Rescue and supporting, mutual-assistance
- Communication between utility and residents
- 5 water utilities:
  - Surface water source 1
  - Surface water source 2
  - Ground water source 1
  - Ground water source 2

Workshop on "Quando la terra trema: esperienze ed insegnamenti nella gestione dei servizi idrici", October 10, 2013, L'Aquila, Italy
Future tasks for upgrading the resilience

Resilience is actually not only about strong and tough characteristics, but also the readiness and the preparedness to mitigate losses and damage.

1) Multiple water sources and their networking
2) Promotion of seismic reinforcement
3) Energy saving system toward a low-carbon society
4) Integrated management of water supply and sewerage systems
5) Well-organized rescue and supporting system
6) Mutual understanding of utility and residents
Collaboration of Tono City and the University of Tokyo for relief and reconstruction after the Great East Japan Earthquake

Since August 3rd, 2011, UT has been sending “Volunteer Squad” to affected areas. Its base is located in Tono City.

UT Office for relief and reconstruction was established at Tono City building on May 13th, 2011.

The Institute of Gerontology has designed community care-oriented temporary housing for people affected by the earthquake.

UT President Hamada gave a speech on collaboration in Tono City on March 8, 2012.

Toshiaki Honda, Mayor of Tono City (left), and Junichi Hamada, President of the University of Tokyo (right). (April 8th, 2011)

Workshop on "Quando la terra trema: esperienze ed insegnamenti nella gestione dei servizi idrici", October 10, 2013, L'Aquila, Italy
Thank you for attention

furumai@env.t.u-tokyo.ac.jp

Hiroaki Furumai
Professor,
Research Center for Water Environment Technology
University of Tokyo
1) Multiple water sources and their networking
It is important to reconstruct the water supply system into a safer and more stable one by taking bypass-loop and networking of water distribution routes and establishment of multiple water sources.

Wide-area integrated management, Private-Public Partnership

2) Promotion of seismic reinforcement
We keenly realized the necessity of making the high importance of water lifeline more known to the people. It is highly necessary to promote seismic reinforcement of waterworks facilities. The efforts to ensure 100% seismic reinforcement of at least trunk pipelines should be urgently made.

Seismic reinforcement of treatment plant, main pipeline, distribution tank
3) Energy saving water system toward a low-carbon society

Waterworks and sewerage systems should contribute to establishment of a low-carbon society least dependent on electric power. We should be aware of potential energy at water intake and take keen eyes at natural gravity flow.

- Water saving, Water leakage reduction, Small hydroelectric generation

4) Integrated management of water supply and sewerage systems

We have to manage our water infrastructure in an integrated manner, ensuring the minimum level of water supply to residents during a disaster situation, and maintaining the coordinated relationship between water supply and sewerage in an emergency situation.

- Rainwater use, Reclaimed water use
5) Well-organized rescue and supporting system

Among utilities, emergency rescue and repair support should be provided by surrounding utilities without damage. Mutual assistance system should be well organized considering possible disasters.

6) Mutual resilience of utility and residents

As well as increase in resilience of utility facility, it is important to enable communities to become adaptive. We need to win the people's understanding of the justification of spending to invest reinforcement and renewal of facilities.
Features of the Earthquake

- Wide-area and Multiple disasters
  - Gigantic earthquake (Ocean-trench type)
  - Tsunami disaster
  - Ground subsidence
  - Aftershock continuation
  - Radiation leakage from nuclear power plant

- Three types of disaster-stricken region
  - Flattened regions by Tsunami
  - Conventionally recovered regions
  - Nuclear evacuation zone(region) in Fukushima
Efficiency and Resilience

http://en.wikipedia.org/wiki/Efficiency

- Efficiency describes the extent to which time or effort is well used for the intended task or purpose.

We have enhanced the efficiency of water supply system by reducing cost and resources for required performance level under usually expected condition.

http://en.wikipedia.org/wiki/Resilience

- Resilience is defined as “the positive ability of a system or company to adapt itself to the consequences of a catastrophic failure caused by power outage, a fire, a bomb or similar” event.

We should also consider the resilience of water supply system under extremely emergent condition as well as efficiency.