Damage Analysis of Air Valves of Drinking Water Pipeline in the 2016 Kumamoto Earthquake

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2. A Questionnaire Survey on Damage to Air Valve of Water System in the 2016 Kumamoto Earthquake
   - Broken Parts and Factors
   - The breakage points for each damage factor
3. Relation between Leakage from Air Valve and the Peak Ground Velocity
4. Conclusion

Research Background

In the 2011 Tohoku earthquake

Even in case of no direct damage such as rupture of a water pipe,

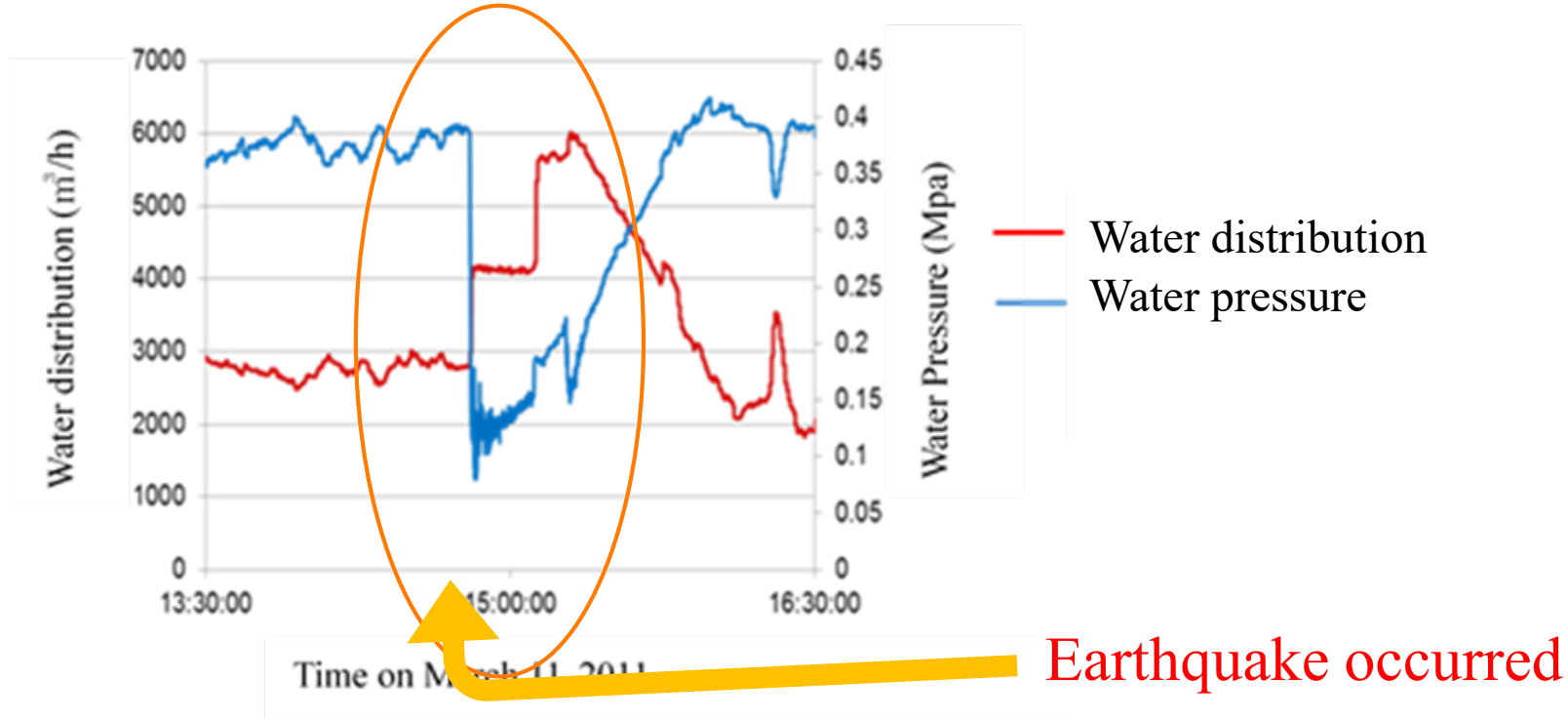
immediately after the earthquake…

- Rapid increase in flow rate
- Rapid water pressure drop

Abnormal behavior of water distribution system occurred.

It significantly reduced the performance of water supply system.

Research Background



Changes in water distribution and water pressure
at the western part of Saitama City during the 2011 Tohoku earthquake

- Such abnormal behaviors have been reported in Tokyo and Osaka so far.
- In the 2011 Tohoku earthquake a lot of damage to the air valve was reported, causing many leakage damage.

Research Background

- In the 2016 Kumamoto earthquake
  - The damage rate of the valves such as air valves is not small compared damage of water pipes.

Damages to pipelines and valves in the 2016 Kumamoto earthquake

	Number of damage points	Damage rate(point/km)
Pipes	296	0.087
Valves	144	0.042

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A Questionnaire Survey in the 2016 Kumamoto Earthquake

- The purpose :

  to investigate the actual condition and causes of the damage

- The target area:

  the entire Kyushu region

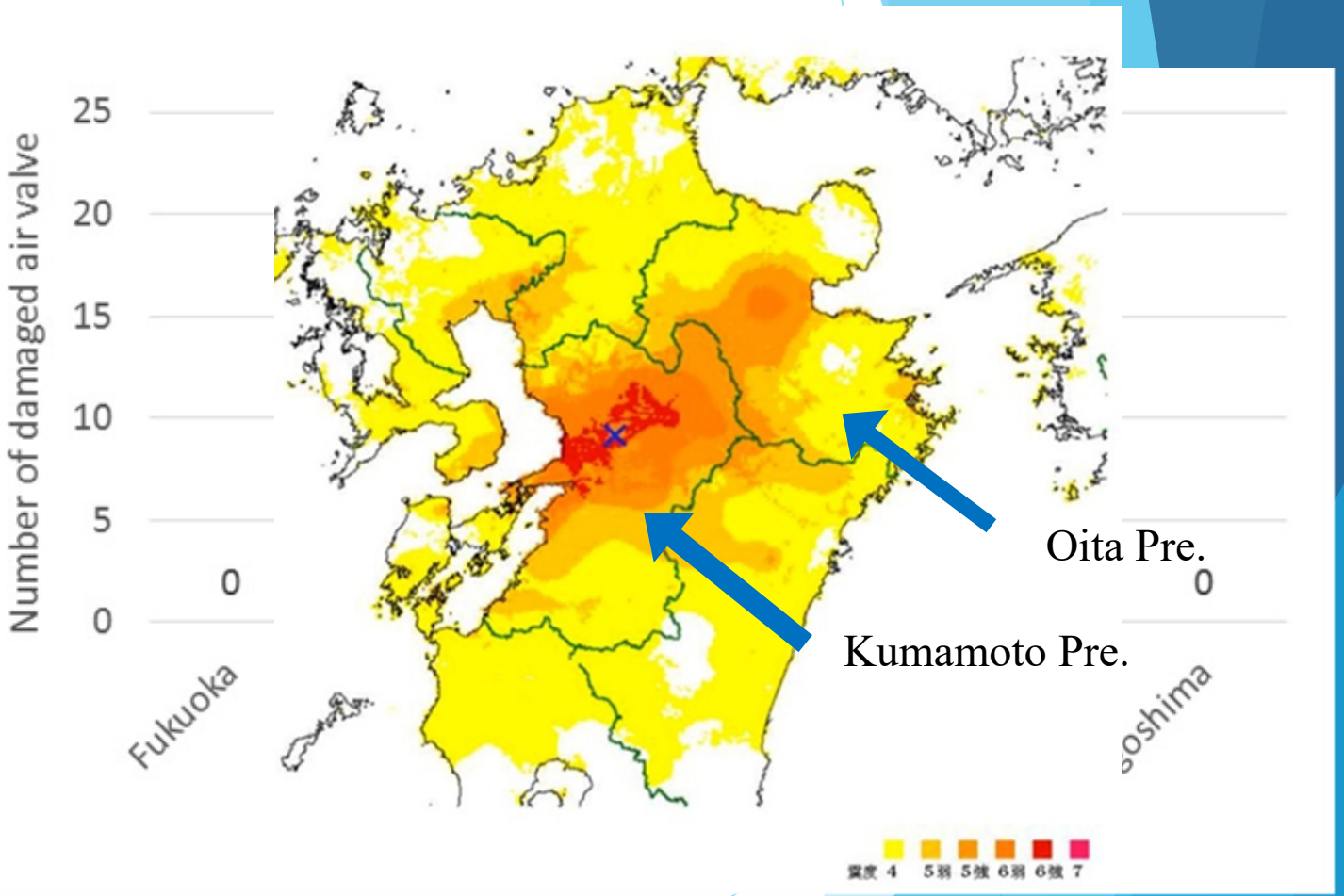
  209 water utilities in seven prefectures

A Questionnaire Survey in the 2016 Kumamoto Earthquake

The damage was concentrated in Kumamoto Prefecture and Oita Prefecture where earthquake shake was relatively big.

Air valve damage has also occurred in areas relatively far from the epicenter such as Saga Prefecture and Miyazaki Prefecture.

As a factor of damage to the air valve, it is possible to think other than earthquake shaking



Number of damage to air valve in each prefecture

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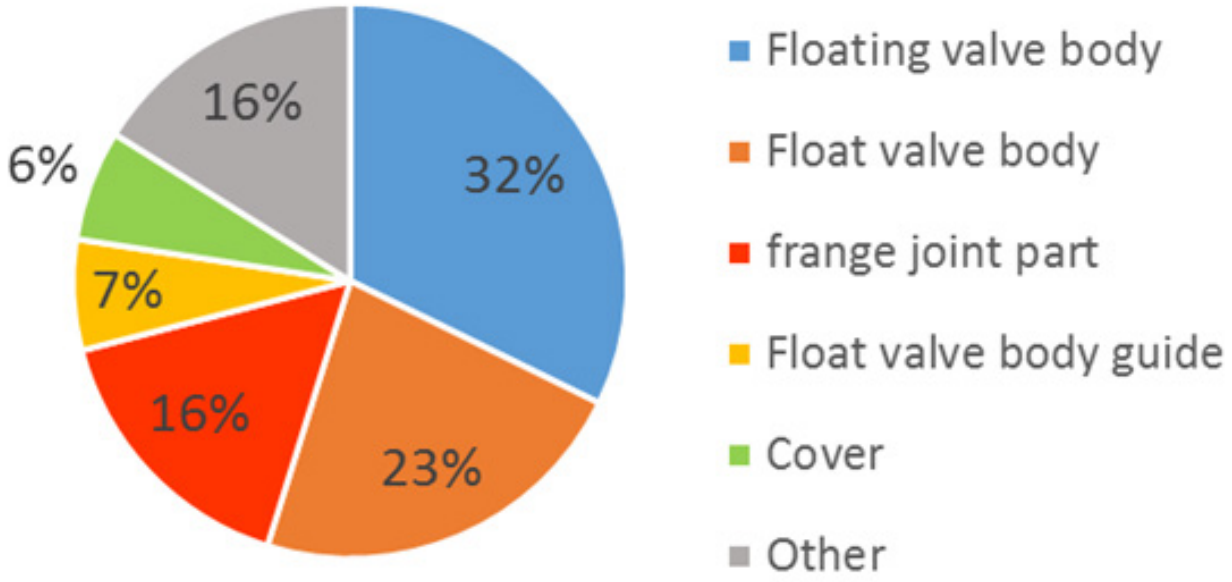
Broken Parts and Factors

- Broken Parts
  - The floating valve body had the most damage and then the float valve body.
  - The float valve body guide / cover are also susceptible part to the influence of water pressure fluctuation, and it is thought that it was influenced this time as well.
  - The damage of the flange joint part accounts for 16%



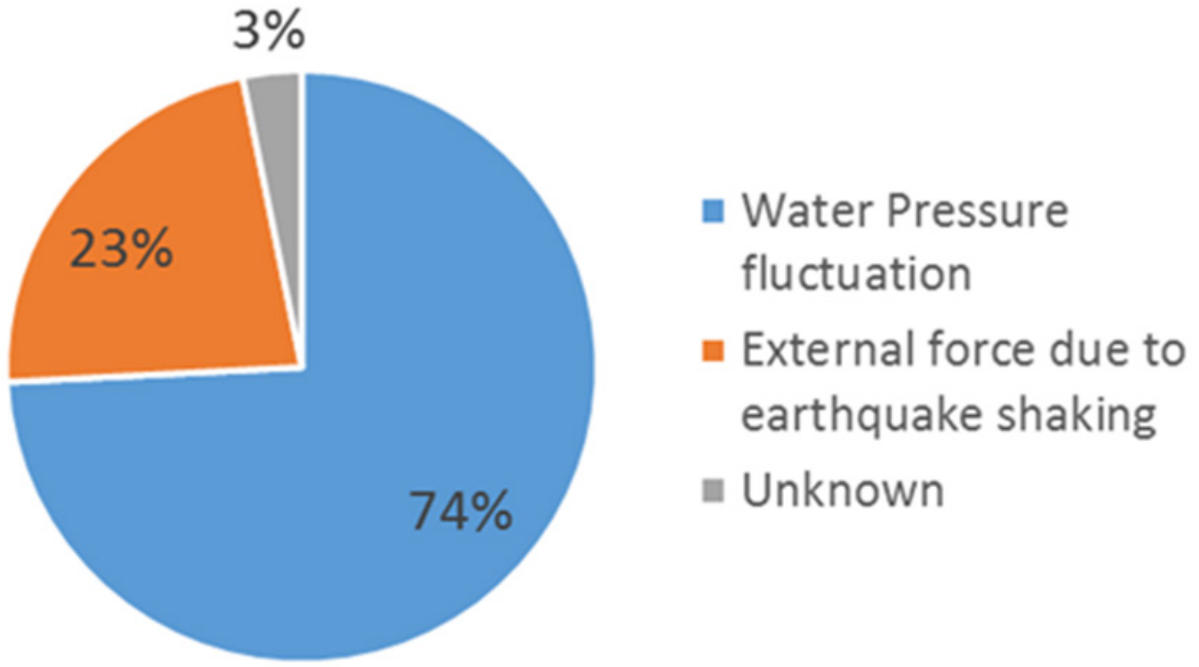
Broken part of air valve

Broken Parts and Factors

- Factor of damage

  - Air valve damage caused by water pressure fluctuation is 70% or more.

  - Damage due to the external force of earthquake shaking has also occurred 23%



Factor of damage to air valve

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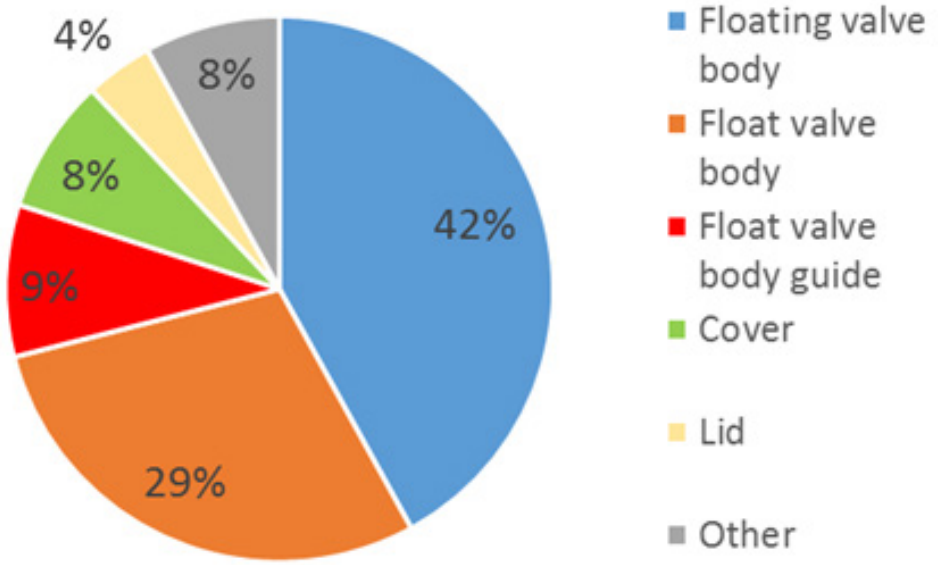
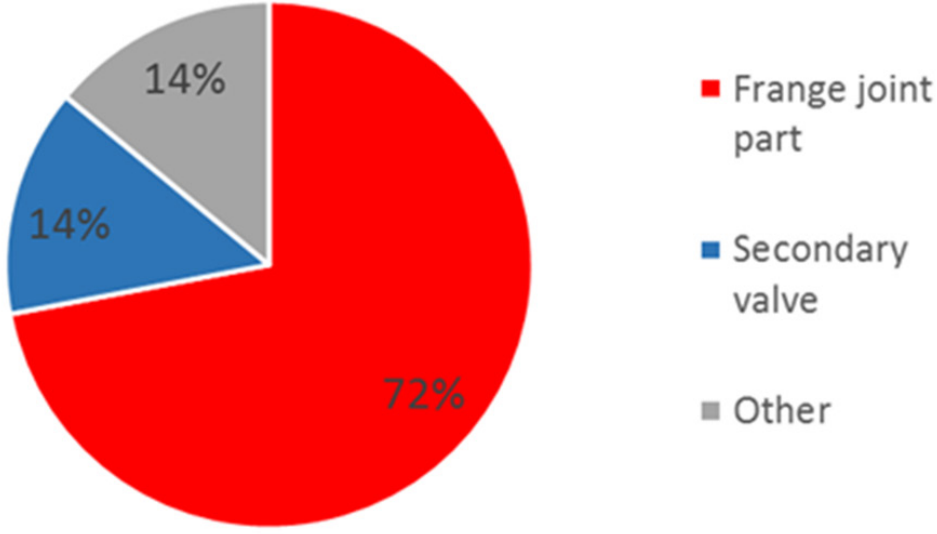
The breakage points for each damage factor



Damage parts due to water pressure variation in pipe



Damage parts due to external force applied to the valve body

- Water pressure variation in pipe
  - Damage of float valve body and the floating valve body accounts for 70% or more.

- External force applied to the valve body
  - The breakage of the flange joint part accounts for 70% or more.

Damaged floating valve body

Leakage from flange joint

Damaged float valve body

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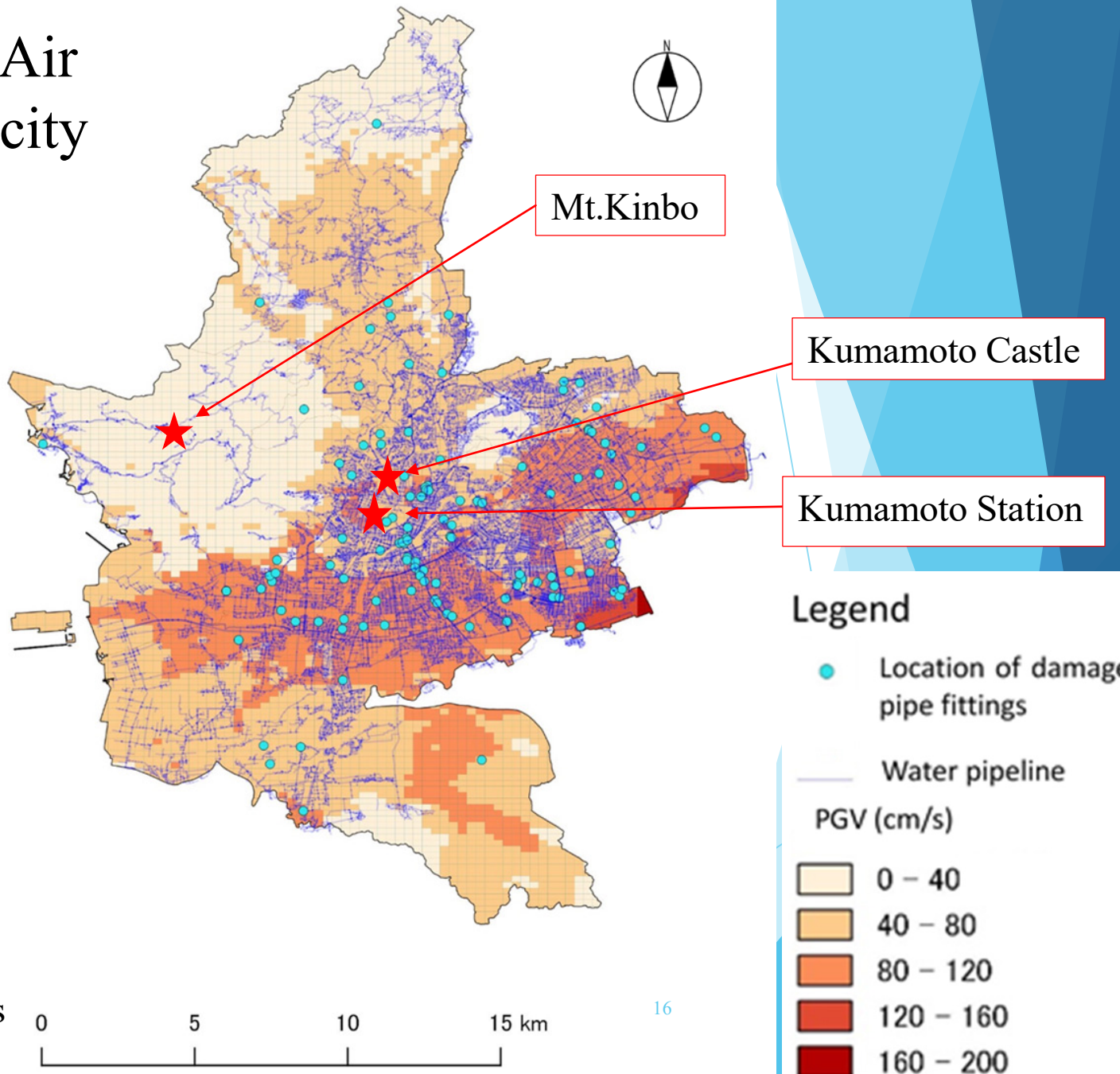
Relation between Leakage from Air Valve and the Peak Ground Velocity

- Relation between air valve leakage damage and PGV

  - The water pipeline network spreads all over Kumamoto city excluding mountainous areas.

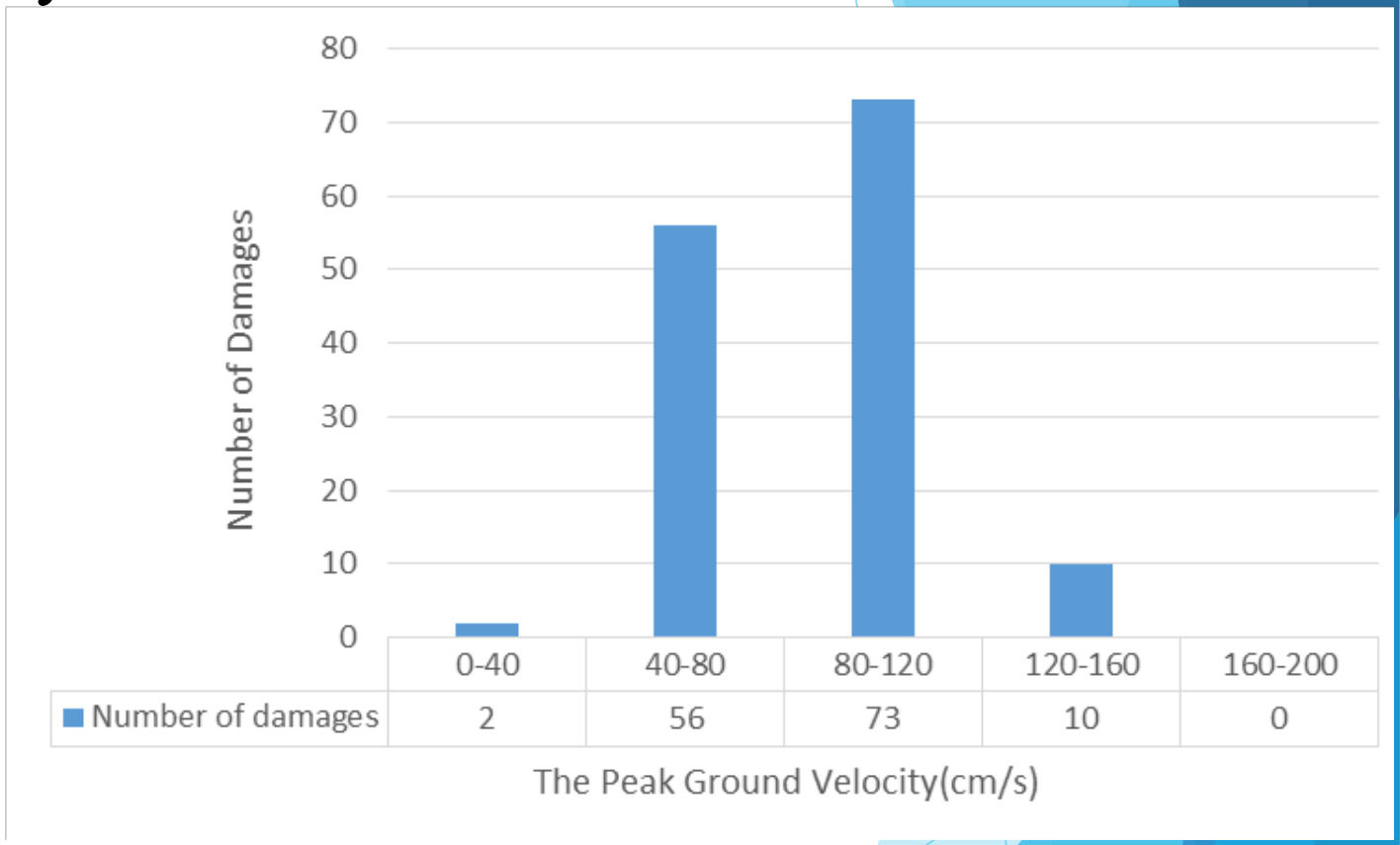
  - The damage to pipe fittings occurred almost entirely around the central and eastern parts of Kumamoto City.



Distribution of PGV and damage to pipe fittings

Relation between Leakage from Air Valve and The Peak Ground Velocity

- Number of damage to fitting in each PGV range
  - There are many damage at the point where the PGV is 80 cm / s or more.
  - Damages in the area of 40 to 80 cm / s also increased to more than 50 cases
  - Damage was also confirmed at less than 40 cm / s although only 2 cases were damaged.



Number of damage to fitting in each PGV range

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Conclusion (1)

- Damage of the floating valve body / float valve body accounted for a large proportion as the damaged part.
- The damage of the flange joint part occupies about 15% of the whole and it is the third most damaged portion.
- The damage to pipe fittings concentrated in the central and eastern parts of the city where the distribution of pipeline is dense, and in the region where PGV was large.
- It was found that some damage to pipe fittings occurred even in the areas where PGV was relatively small. Therefore, the magnitude of the seismic vibration affects damage to pipe fittings, but it is possible that factors other than seismic vibration affect pipe fittings and cause damage and leakage even if the seismic vibration is small.

Conclusion (2)

- Measures against sudden changes in water pressure to the floating valve body and the float valve body are of utmost importance as countermeasures against earthquakes.

- Countermeasures against earthquake shaking are, however, indispensable for the part in contact with the outside such as the flange joint part.

Thank you for your kind attention.