第 I 部門

GIS Analysis of Damage Pattern in Nagaoka Water Pipelines during the Niigata-Chuetsu Earthquake

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1- Abstract

Present study explains the results of GIS analysis of damage pattern in Nagaoka City water pipelines during the Niigata-Chuetsu Earthquake. Various databases of pipeline network, geomorphology, ground motion and damage locations are overlaid by using ArcGIS. As a result, the pipe damage ratio in slope area shows higher values in comparison with other geomorphologies. In addition, damage pattern analysis of pipelines by different diameters indicates that the distribution of pipeline damage for small and large diameters is different.

2- Outline of Earthquake

Among the major earthquakes that attacked Japan, the Niigata earthquake that took place on October 23, 2004 with magnitude of 6.8 and focal depth of 13 km was the violent one in the past decade since 1995 Kobe Earthquake. The maximum seismic intensity was 7 at Kawaguchi-Machi and in the most parts of area with severe damage including Nagaoka City, the seismic intensity was 6+ or 6-. In Niigata area the dead and severely injured people were 40 and 4,486 respectively and damaged households were up to 100,000.

3- Water Supply System in Nagaoka City and Statistical Analysis

Nagaoka City Water Bureau supplies water to 70,000 households and 189,000 persons, in which water supply stopped just after the earthquake. The supply area could be divided into plane (lowlands) in the west part of the Shinano-river and mountain (uplands) in the east. The total length of pipes is nearly 1,100km, in which 37% has a diameter less than 75mm, 57% between 100 to 350mm and 6% more than 400mm, also for pipeline with diameter of more than 75mm, 85% pipes was ductile iron pipe (DIP) without aseismic joints. According to the emergency response and repair works, Tsurugaoka and Takamachi were two parts in the eastern area where high damage of pipelines was observed. Through the statistical analysis of the Nagaoka water supply network, damage ratio (DR) of pipelines with respect to the pipes diameter is presented in Fig. 1. This figure shows that pipes with small diameter have higher DR than large pipes under the same influence of earthquake shaking.

4- GIS Analysis of Damage Pattern in Buried Water Pipelines

In order to study the damage patterns of water pipelines in Nagaoka City, a geographical information system (GIS) database was established. Pipeline information as well as geomorphology, and landuse maps were gathered and digitized immediately after the Niigata earthquake. In statistics of pipeline damage, 313 failure points were counted, meanwhile, for pipeline with diameter of less than 150mm, 246 failure points and for diameters of more than 150mm, 67 failure points were used in this analysis. The pipelines were divided into three groups according to their diameters: 1) small diameter, $\phi \leq 50$mm and $75\text{mm} \leq \phi \leq 125$mm, 2) medium diameter, $\phi = 150$mm and 200mm, and 3) large diameter, $\phi > 200$ mm. In the first step, the geomorphology map was overlaid with pipeline damage locations as well as water supply network. Then, to perform damage analysis, the study area is divided into 1 km × 1 km grid and for each

group of pipelines the damage ratio is calculated by dividing the number of damage by the total length of water pipelines in each grid. For example, overlaying the pipeline network and damage locations with Nagaoka District as well as damage ratio of pipelines in each mesh with respect to different diameters are shown through the Fig. 2 to Fig. 4. Also number of pipe damage in any type of geomorphology due to the pipe diameter is presented in Fig. 5. From these figures, it can be illustrated that in the case of large pipes diameter, pipe damage shows higher values in natural slope compared with other geomorphologies. In addition, damage ratio of the medium pipe diameter has higher values in both slope on mountain and natural slope. Furthermore, damage ratio with respect to the small diameter shows higher values in natural slope, valley plain and gravelly terrace.

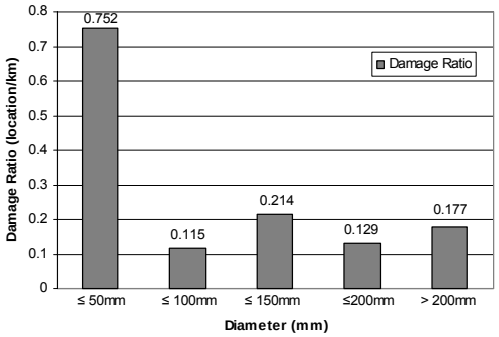

Fig. 1. DR of pipelines due to pipes diameter

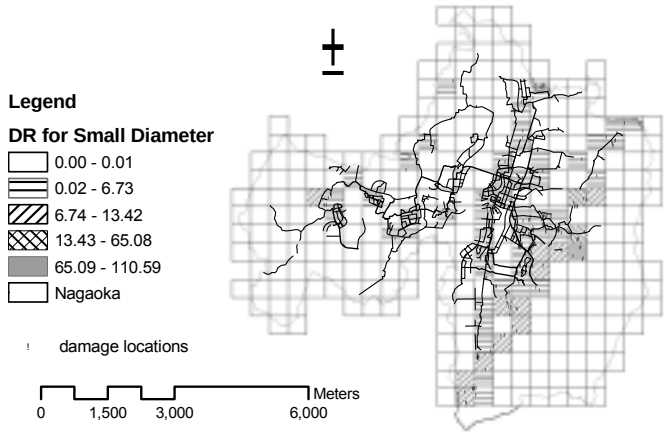

Fig. 2. Damage pattern of pipelines with small diameter

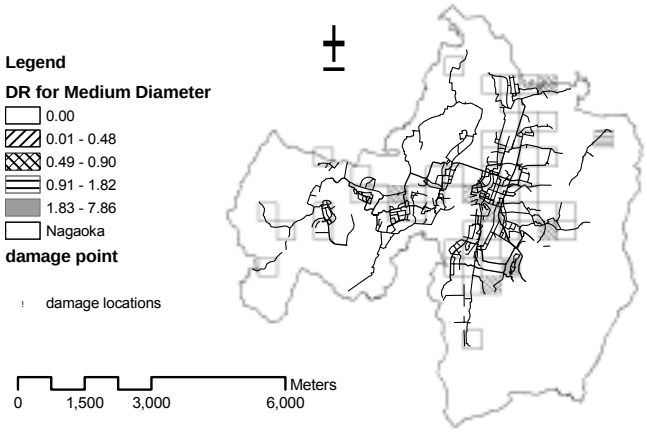

Fig. 3. Damage pattern of pipelines with medium diameter

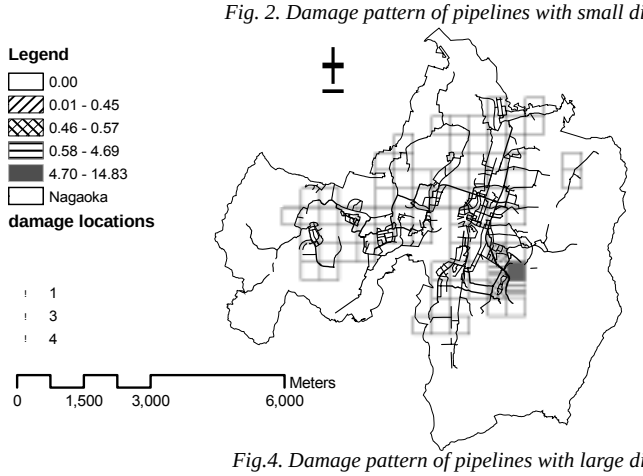

Fig.4. Damage pattern of pipelines with large diameter

5- **Conclusions**

The followings could be concluded in this study:

1- Pipe damage ratio in slope area showed higher values compared with other geomorphologies.

2- Niigata earthquake showed remarkable data of pipe damage in slope, so that more attention should be paid to piping criteria in slope and ridge area in pipeline seismic design code.

3- Finally, it can be supported from present study that pipes with small diameter had higher DR than large pipes under the same influence of earthquake shaking.

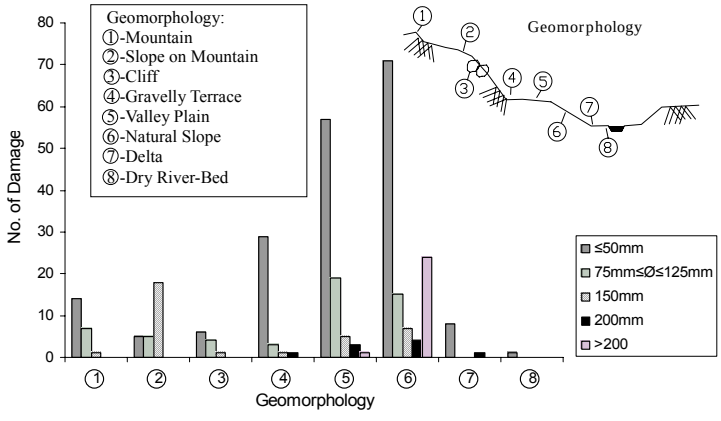

Fig.5. Number of damage for different diameters due to geomorphology

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