Case Studies on Socio-seismic Zoning of Affected Areas in Use of Cluster Analysis

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1. Introduction

Microzoning of an area to elucidate patial change of seismic hazard has been conducted mostly in relation with ground soil and other natural conditions. As a logical extension, it is important to develop socio-seismic zoning inclusive of social setting. In this view, we applied the cluster nalysis known as effective in urban planning. One is to identify and to sum up equally affected block areas in a city at 2000 Tottoriken-seibu earthquake and the other is to lassify spatially damage features of all the villages around a fault due to 1858 Hietsu earthquake.

2. Method of Analysis

The cluster analysis is a method to lassify any objects in terms of the dissimilarity. Suppose that any objects distributed spatially and measured using physical quantities as seismic intensity, structural damage rate and locations etc are known, then we can define the dissimilarity between any 2 points (i, j) as

$$D=a* [p(i)-p(j)] ^2+b* [d(i)-d(j)] ^2,$$

where [p(i)-p(j)] and [d(i)-d(j)] are differences of a physical quantity and location coordinates. We connect 2 closest objects to get into first level cluster and then continue to connect closer objects to make higher level clusters until we get to the top level cluster in which all the objects are included. Here, ((a, b) coefficients are newly introduced to weigh the first and the second terms under the constraint of a + b=1. As a result, a dendrogram is shown to know classified outcomes visually. We used group average method and normalized Euclid distance as for the step-by-step clustering algorithm. Socio-seismic zoning actually meaningful is considered to recognize 2 to 6 clusters affected equally by an earthquake.

3. Case Studies

1) Clustering in Sakaiminato City at 2000 Tottoriken-seibu earthquake

We have got seismic intensities at all the 44 block areas and using such data a case study was conducted. The dissimilarity is obtained putting p=seismic intensity. The weight coefficients (a, b) are changed while observing the clustered results. Through such analysis, we classified the city area into 2-6 sub-areas. We found that in the semi-top level the city is divided into 2 clusters as northern and southern areas and those correspond to areas shaken heavily and lightly, and that the sub-areas divided into 6 clusters reflect historical and industrial development of the city.

2) Structural damage rates around Atotsugawa fault line

In 1856 an inland shallow earthquake occurred while breaking Atotsugawa fault and caused significant damage to the near-by villages. Based on the damage data to wooden houses, a cluster analysis was made. The dissimilarity equation is identical to the previous case except replacing p by damage rate. We classified all the villages into several clusters and found that the result is similar or even better to that made through inspection in the past.

4. Conclusions

In aims at identifying an equally affected area by an earthquake the cluster analysis for 2 sample cases were made. The results obtained clarified that the cluster analysis is effective to get more reliable grouping of objects distributed spatially in an area than that by inspection and seems promising for wider application in the earthquake protection field.