Estimate of volume of debris on the road after earthquake

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1. Introduction

For earthquakes which occur in urban areas such as earthquakes that directly hits Tokyo area and earthquake that directly hits Chubu area・Kinki area, it is extremely important to immediately eliminate road obstacles for emergency routes, etc. in view of the magnitude of the impacts on society, etc. following the earthquake. In this research, as basic data necessary for planning in relation to actions of road administrators after earthquake such as elimination of road obstacles and with the object of earthquakes which occur in urban areas, obstacles (earthquake debris and neglected vehicles) which cause decreased function of road transportation system on emegency routes, etc. and the extent of decreased function were clarified and its estimation method was studied.

2. Organizing actual conditions of earthquake debris occurred on main roads

Actual conditions of earthquake debris occurred on the main roads by the collaping of buildings, etc. by the road side were organized by deciphering aerial photgraphs taken of the 1995 Hyogo-ken Nanbu Earthquake. Information on width and length, etc. of protruded earthquake debris on the road and the properties of collapsed buildings (wooden・non-wooden, low-rise・high rise), etc. were summed up as follows.

(1) Frequency of occurrence of earthquake debris on main roads per length of road 4 (items / km) at most and comparatively lower than narrow streets[(1)].

(2) There was not much difference in length of protrusion between wooden and non-wooden.

3. Formulation of estimate equation of volume of earthquake debris on main roads

'Building-to-land ratio', 'floor area ratio' and 'use district', etc. which data were relatively easily available from city planning summary drawings, etc. used as variables in order to estimate volume of debris. In estimating the width of earthquake debris (a), a coefficient of each variable was calculated by regression analysis and (Formula-1) was set up.

$$a = -3.479 + 0.621 \cdot X1 + 7.509 \cdot X2/100 + 0.607 \cdot X3/100 + X4 \quad \cdots \text{(Formula-1)}$$

X1: number of building stories X2: building-to-land ratio (%) X3: floor area ratio (%)

X4: use district: residential district: 0.585, neiborhood business district: -0.311, business district: -2.585, semi-industrial district: 1.155, industrial district: 2.857

Height of debris (h(m)) and length of debris (L(m)) were used as a function of width of debris (a(m)) and following (Formula-2 and 3) were set up by regression analysis using the measured values. In addition, assuming that debris are triangular prisms, volume (V (m^3)) can be obtained as (Formula-4) using width of debris (a), height of debris (h) and length of debris (L).

$$h = 0.32 \cdot a + 0.853 \quad \cdots \text{(Formula-2)}$$

$$L = 1.089 \cdot a + 7.487 \quad \cdots \text{(Formula-3)}$$

$$V = a \times h \times L / 2 \quad \cdots \text{(Formula-4)}$$

4. Forecasting method of neglected vehicle quantity

In order to forecast quantity of neglected vehicles in time of earthquake disasters, the generation status was investigated utilizing aerial photgraphs at the time of Hyogo-ken Nanbu Earthquake. Comparing the photographs taken in the afternoon of January 17, the day of Hyogo-ken Nanbu Earthquake with the photographs taken in the morning of next day 18th, if there were vehicles on the same place, they were regarded as neglected vehicles and the result of discriminated quantity of neglected vehicles was listed in the Table. Since the earthquake occurred early in the morning, the number of neglected vehicles was not so many.

Table: Generation status of neglected vehicles by aerial phtograph discrimination

Routes	Block length	Number	Number/length
National Route 2 (Direct control national route)	19.2 km	52	2.7 / km
Yamate-kansen Route (main local roads)	12.5 km	78	6.2 / km

5. Conclusion

By discrimating aerial photographs at the time of Hyogo-ken Nanbu Earthquake, the generation status of earthquake debris on the main roads, etc. caused by collapsed buildings, etc. by the road side was organized and the estimate equation was formulated. In addition, it generated the quantity of organized neglected vehicles. It is hoped that the above will enable to forecast volume of debris, etc. on roads post-earthquake to some extent will contribute to advance preparation of equipment, etc. necessary for elimination of debris, etc.

[Reference] (1) Functional disorder of street network and its influence focusing on 'street blockades phenomenon' in Hanshin Awaji Earthquake, Japan Society Civil Engineering Journal, October, 1997 Hitoshi IEDA et.al