Issues on Transport and Location Planning of Temporary Disposal Sites for Earthquake Rubble

Kiyomasa YAMANAKA* and Takashi NISHIMURA**

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Synopsis

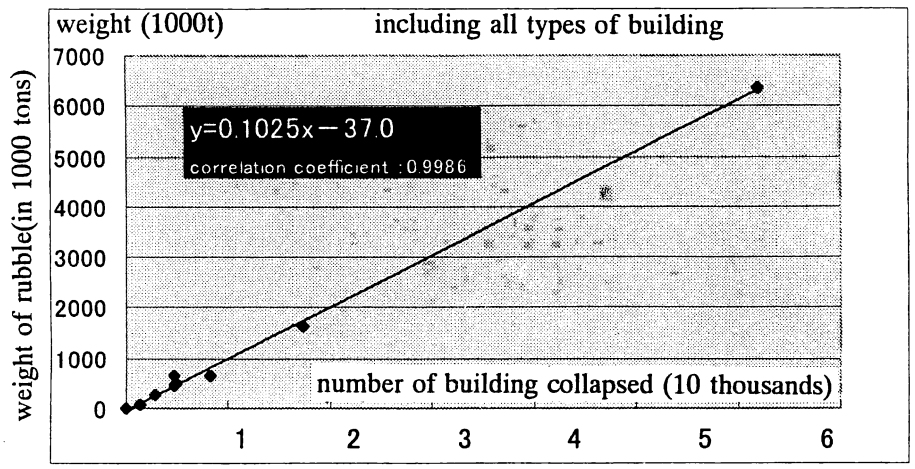
Many facilities and building were destroyed casused by the Hanshin-Awaji Great Earthquake,and enormous amount of rubble arose,and rapid transport and disposal became necessary. Rubble disposal is done by the following flow; dismantling of collapsed buildings → carrying rubble to the temporary disposal sites → intermediate disposal (classifing,recycling,burning etc.) → final disposal (filling in the sea or valley). The temporary disposal sites are necessary because a vast amount of rubble can not be treated in the existing disposal plants. Location of temporary disposal sites decides the efficiency of whole rubble disposal. In this paper, rubble generation and intermediate disposal of the rubble were analyzed and several types of mathmatical formulation for location planning of the temporary intermediate disposal sites were considered

Keywords : Hanshin-Awaji Great Earthquake, earthquake rubble, rubble generation, intermediate disposal, location planning

1. Analysis of the rubble generation

A relationship between the number of the collapsed building and volume of the rubble generation was analyzed based on the each city basis. The proportion of the collapsed building types was 75.8% wooden, 19.4% rein-forced and 4.8% steel-framed in the damaged citis and towns.

Not only the weight of the rubble, but also the volume of the rubble was analyzed for transportation and disposal problem. The results were shown in Figure-1 and Table-1.



number of collapsed buildings (ten thousands)

Figure-1 Relationship between weight of rubble and number of collapsed buildings in (city average)

* Civil Engineer,Dept.of Public Works, Hyogo Prefecture

**Professor, Dept. of Civil Engineering

Table-1 The averagd rubble weight and volume from unit floorage of collapsed building

waste type	weight(kg/m^2)	volume(m^3/m^2)	ratio(m^3/t)
wooden	69.8	0.26	3.725
concrete	171	0.151	0.883
metal	6.2	0.023	3.71
tile, glass, pottery	79	0.065	0.823
plastic	0.7	0.004	5.714
others	30	0.036	1.2

2. Classification of the rubble disposal sites actually used

The temporary disposal sites of the earthquake rubble actually used in each city were classified as shown in Figure-2 and Figure-3. Types of the land use of the disposal sites were play grounds, flood plains, developing lands, existing waste plants, parks, large parking lots, the reclaimed lands and others. Areas of the developing lands and reclaimed lands situated along seaside were considerably large, and others were comparably small.

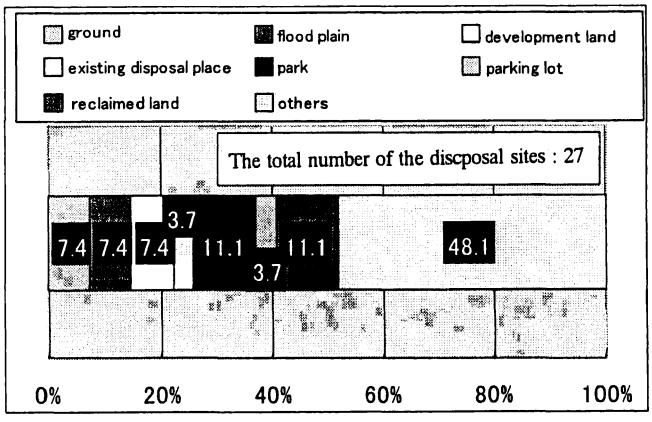


Figure-2 The classification of the temporary disposal sites

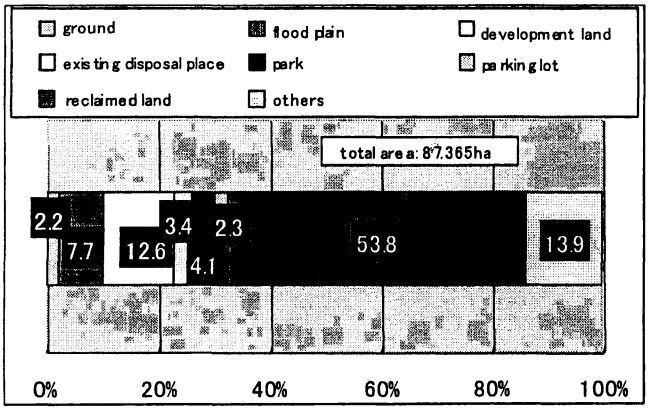
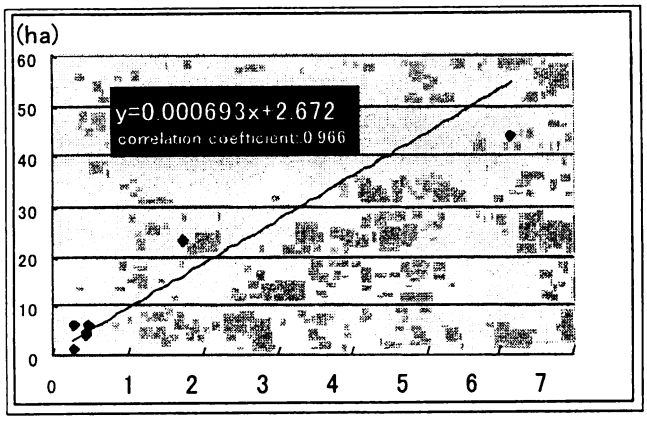


Figure-3 Classification of the area of the temporary disposal sites

3. The total area of the temporary disposal sites in each city

The scales of the total area of the temporary disposal sites in the seven typical damaged cities were plotted in Figure-4. The seven cities are Kobe, Amagasaki, Nishinomiya, Ashiya, Itami, Takarazuka and Kawanishi. From this figure, the averaged area for the temporary disposal sites is appeared to be 7.46 ha per ten thousands collapsed buildings.



number of the buildings collapsed (10 thousands)

Figure-4 Relationship between the scale of the temporary disposal sites and the number of buildings collapsed, in city area basis

4. Intermediate treatment of rubble at the temporary disposal sites

The intermediate treatment of the earthquake rubble at the temporary disposal sites aims to classify,to reduce weight by burning or recycle. Results of the case study of the intermediate treatments at the temporary disposal sites in seven cities are shown in Table-2, in which averaged ratios of weight reduction or recycling are calculated for each city. The reduction ratio means the rate of weight reduction by wooden material burning divided by the total rubble weight,and the recycling ratio means the recycled weight of metallic and wooden materials divided by the total rubble weight. The recycled ratio of Kobe city was very low because of the disability of intermediate treatment from the over-capacity concentration of the rubble.

Table-2 Reduction and recycling ratio at the intermediate treatment

	Reduction weight rate(%)	Recycle ratio(%)
Kobe City	8.1	0.9
Nishinomiya City	8.8	8.1
Amagasaki City	8.9	21.5
Ashiya City	15.6	21.9
Takarazuka City	6.5	24.4
Kawanishi City	24.5	8.1
Akashi City	11.3	32.8

5. Issues on the planning model for the temporary disposal site

5.1 Objectives of the planning model

There are several aims desired to be introduced in the planning model of the location of temporary disposal sites. As such objectives, the following measures will be considered,

① transportation cost of the rubble from point of generations to the temporary disposal sites, and from the temporary disposal sites to the final disposal sites,

② usage cost of the temporary disposal sites if the private lands are utilized to the temporary disposal sites, the compensation cost will be necessary,though public lands utilized for the temporary disposal sites also cost opportunity costs,

③ environmental impact around route and intermediate disposal sites the rubble transport and disposal affect environmentally along the transport route and around the temporary disposal sites.

5.2 Restraints of the problem

Some restraints are necessary for the program formulation. As such retraints, the following measures will be considered,

① total area of the temporary disposal sites the rubble generation points and volume with waste type are assumed to be decided from the magnitude of the earthquake for each city, and the total area of the temporary disposal sites is given, then the summation of the temporary disposal sites is restricted to exceed the required total area,

② the averaged reduction and recycling ratios at the intermediate disposal are given by the technical level at then time.

5.3 Some assumptions

① locations of the final disposal sites are given,

② candidates for the temporary disposal sites are given with transportation cost between every pair of the rubble generation point and the temporary disposal site, by the network flow assignment technique,

③ road network condition is given with blocked streets and narrowed streets, according to the practical road situations,

④ environmental impact rates are given with heavy truck running or intermediate treatment(crashing, burning,etc.), at the temporary disposal site,

⑤ rubble generation point is assumed to be the center of the predetermined district.

5.4 Type of formulation

There are several objectives in the location planning of the temporary disposal sites for the earthquake rubble as described above. Then the optimal solution will be expressed by the multi-objectives programming problem. If the parameters of the problem will be assumed to be constant for simplification, the problem will be formulated as a goal-programming with multiple linear objectives. This multi-objective linear programming problem is able to be solved for practical use. But more simple formulation will be also useful for alternative plan. As such simplification, the following type of linear programming formulation will be considered, for example,

① only the total transportation cost of rubble transport is minimized, then this will be a linear programming problem, the well-known transportation problem,

② the total environmental impact is minimized under the predetermined volume of the earthquake rubble, then this will be also linear.

6. Summary of the analysis

In this paper, the rubble transport and intermediate treatment at the temporary disposal sites in the case of the Hanshin-Awaji earthquake were analyzed in several cities around Kobe. In this analsis,

① a relationship between the number of the damaged buildings and the volume of the rubble generation was obtained based on the city unit analysis, and

② the temporary disposal sites were also analyzed, and averaged area of the temporary disposal site was appeared to be 3.2 ha in this study, and about 7.5 m2 was required to treat a single averaged building in the temporary disposal site, and

③ the weight reduction rates, by burning wooden materials or recycling metallic or wooden materials, were obtained in the case of relating cities.

On the location model for the temporary disposal sites, some possible objective and restraint measures were enumerated with necessary assumptions for problem simplification. Linear programming approach will be utilized in some type of the partial problem.

References

1) Environmental Creation Center, 1997, Disposal records of the disaster waste, Hyogo Prefecture(English equivalent;in Japanese)