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GIS APPLICATION TO DAMAGE DATA MANAGEMENT ON BUILDINGS AND URBAN FACILITIES IN THE JANUARY 17, 1995 HYOGOKEN-NAMBU EARTHQUAKE

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ABSTRACT

Development of a geographic information system (GIS) for earthquake disaster data management is introduced. The paper consists of two parts. In the first part, disaster information management assistance (DIMA) activities are described. These are voluntary activities in which information processing and management assistance is offered to post-earthquake emergency activities by local governments. Some of the useful information installed in the DiMSIS GIS is explained. GIS-based information will allow us to understand the state of the disaster caused by the Hyogoken-nambu earthquake from various aspects. In the second part of the paper, correlation studies between building damage and lifeline damage with geology, ground failure and others should provide important information for future disaster mitigation and preparedness studies. Based on damage data from Nishinomiya City, interrelations among various aspects of the earthquake disaster are presented, by using ARC/INFO GIS.

KEY WORDS

1995 Hyogoken-nambu earthquake; disaster information management; geographic information system (GIS); building damage; lifeline damage; geology; Kobe City; Nishinomiya City.

INTRODUCTION

The January 17, 1995 Hyogoken-nambu earthquake of a magnitude of 7.2 caused the most destructive damages throughout the urban area (the Great Hanshin-Awaji Earthquake Disaster), after the 1923 Kanto Earthquake in Japan. 6,308 people had died and number of injuries is over 41,000 persons. More than 100,000 buildings and houses collapsed or damaged beyond repair. Immediately after the earthquake, the Japan Meteorological Agency (JMA) ranked the earthquake intensity in the most severely shaken regions as VI on the Japanese intensity scale (equivalent to 8 to 9 on the modified Mercalli [MM] scale), but two weeks later it raised the intensity VII (equivalent to 9 or more on the MM scale). Fig. 1 shows areas of JMA earthquake intensity VII (severe shaking). Buildings and houses constructed with wood, reinforced concrete and/or steel sustained various modes of damage in severely shaking areas. The disaster caused by the Hyogoken-nambu earthquake is so extensive that diverse research areas must be activated in order to learn from the calamity. At Urban Earthquake Hazard Research Center, Disaster Prevention Research Institute, Kyoto University, GIS (Geographic Information Systems)-based disaster information management tools are developed for research analysis as same as for emergency operations against the catastrophic disaster caused by earthquakes (Kameda *et al.*, 1993, 1995).

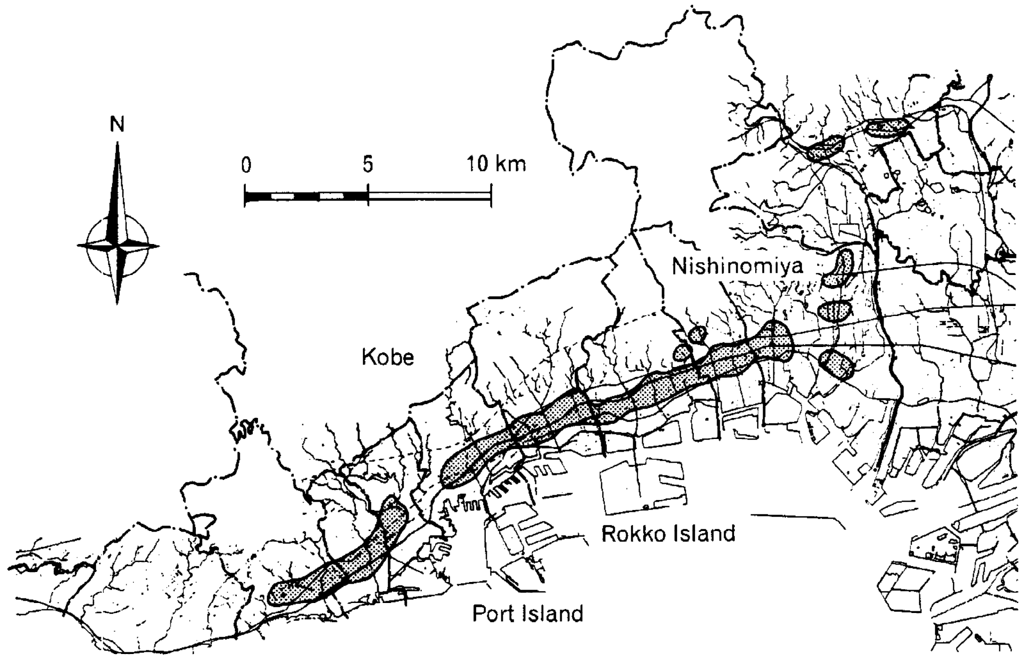


Fig. 1 Areas of JMA earthquake intensity VII.

DISASTER INFORMATION COMPILED IN THE DiMSIS GIS TO FACILITATE DIMA ACTIVITIES

Systems and Base Maps

The GIS used in the DIMA activities has been named DiMSIS, which stands for Disaster Management Spatial Information System. The system operates on Windows 3.1 basis on personal computers. The base maps used herein are Digital Mapping Data with a scale of 1/10,000, compiled by the Geographical Survey Institute (GSI), the Ministry of Construction. To locate damage data by referring to residential addresses, the RINZO-DM mapping system is being used as the front-end processor that identifies exact locations as well as their addresses, owners and other attributes of individual buildings.

Locations of Deaths

Fig. 2 shows the locations where deaths took place during the earthquake. The data were compiled by the Mainichi Newspapers, and input activities were provided by the DPRI, Kyoto University and by Nara University. The casualties posed a tremendous problem in the Hyogoken-nambu earthquake. Correlation studies of these data with other types of damage should provide important information for future disaster mitigation and preparedness studies.

Quick Survey of the Distribution of Collapsed Structures

Fig. 3 shows a rough estimate of the structural damage done and its regional distribution based on aerial photographs taken by the Geographical Survey Institute, on the day of the earthquake and three days after the event. The photos were immediately processed in order to make quick damage estimation, and the data shown in the figure were completed as electronic information one week after the earthquake. It should be noted that the type of information given in Fig. 3 is very important in the immediate post-earthquake crisis management phase. Although the data at this stage may still provide only crude estimates of the damage done, the areas in Fig. 3 in which the data are located agree remarkably well with those in Fig. 2, explained hereafter. This means that the data in Fig. 3 can greatly contribute to increasing the efficiency of the early stage operations of the disaster management activities of various organizations, which must all function under the extreme pressure of competition with time, and for which a quick overall identification of the damage situation is more important than precise data. On the basis of these observations, it is strongly proposed that the type of activities engaged in by the GSI and the dissemination of information be implemented in a standard disaster management protocol, hopefully in a way that their output be provided in much shorter period, say one day after the event.

Fig. 2 Locations of deaths during the earthquake (data compiled by the Mainichi Newspapers).

Fig. 3 Distribution of collapsed buildings based on aerial photographs taken by the Geographical Survey Institute (GSI) on January 17 and 20, 1995.

Detailed Survey of the Distribution of Collapsed Buildings

Detailed damage data are being compiled by various academic societies. The distribution of damaged buildings and their damage status in Chuo Ward, Kobe are shown in Fig. 4. This information has been compiled by reconnaissance teams from the Architectural Institute of Japan (Suzuki *et al*., 1995, Nakashima *et al*., 1995). Chuo Ward was mainly investigated by a team from the DPRI, Kyoto University. The findings should provide a solid basis for learning lessons from such a disaster which should be related to the enhancement of urban seismic safety through future activities. Moreover, the findings should provide very useful, accurate documents from which the details of post-disaster management can be planned. Apparently, this information is not being used effectively for these purposes. One reason may be that the findings collected basically are related to academic motivations, and another is that local governments are not equipped with evaluation and data processing systems. From this observations, it should be pointed out that much should be discussed on efficient use of information in the crisis management during an earthquake emergency to improve our response to such a disaster.

Fig. 4 Distribution of damaged buildings in Chuo Ward, Kobe City.

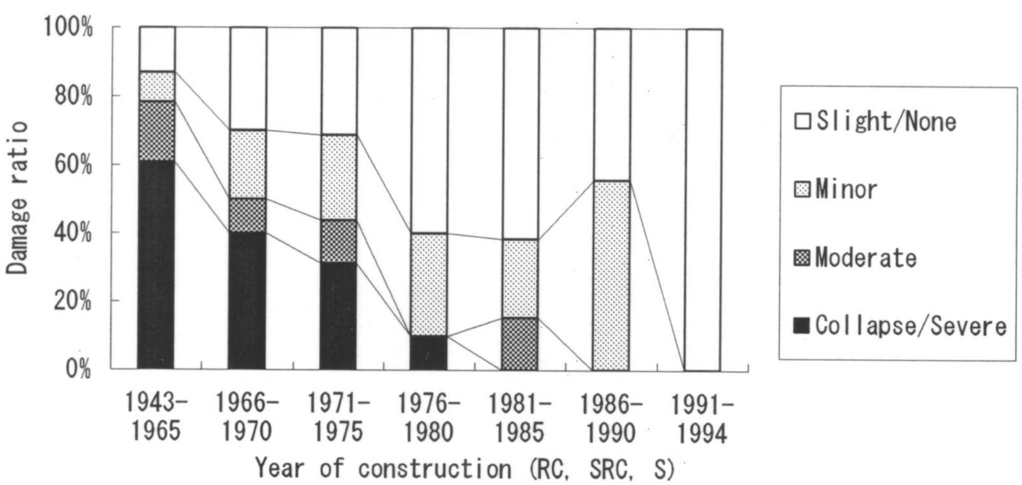


Fig. 5 Correlation between damage ratio and year of construction of buildings examined along the main street at downtown Kobe.

In many cases building damage can be closely correlated with the year of construction. Although newer buildings sometimes suffered internal structural damage, they did not totally or partially collapse. To certify this relation, approximately 100 buildings in a district located to downtown Kobe, where damage was particularly severe, were investigated to identify the year of construction. Fig. 5 plots the relationship between damage levels for reinforced concrete and steel buildings as a function of the construction year for each structure. In 1971 the reinforced concrete design code was changed significantly, providing more appropriate shear resistance and concrete confinement. Also the steel design code was revised in 1970. Furthermore, the new earthquake-resistant design code of building structures was enacted in 1981. It can be observed that buildings constructed before 1971 suffered more significant damage than buildings constructed after 1981. This survey supported quantitatively that the revision of design codes played an important role in mitigating the seismic vulnerability of buildings.

CORRELATION STUDIES BETWEEN DAMAGE DATA ON BUILDINGS AND LIFELINES

Geological Data

Correlation studies of damaged building data with other types of data, - geology, ground shaking, ground failure and urban facility damage including lifeline - should provide important information for future disaster mitigation and preparedness studies. According to data supplying assistance from Nishinomiya City, comprehensive evaluation about the earthquake disaster can be done. Nishinomiya City is a residential area, where the population is above 420,000 before the earthquake. Fig.6(a) shows geological map of southern part of Nishinomiya City. The northern part is a mountain area with Rokko granite. There are some faults among Rokko granite, lower and middle terrace deposits and alluvial deposits. In the south seaside area, reclaimed lands exist where liquefaction occurred during the earthquake (Fig. 6(b)).

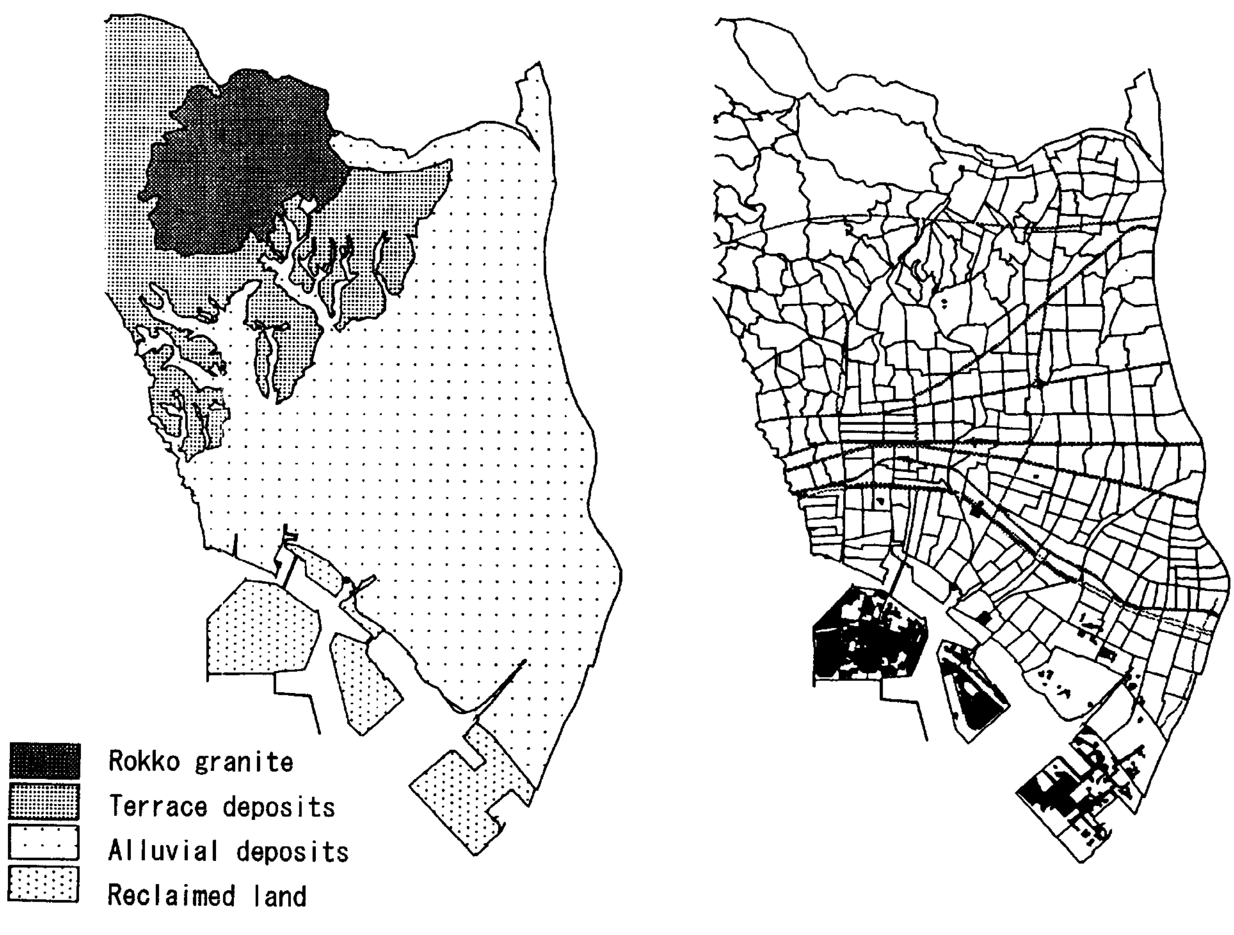


Fig. 6(a) Geological map of southern Nishinomiya.

Fig. 6(b) Map of liquefied sites and subdivision of city area by small town code.

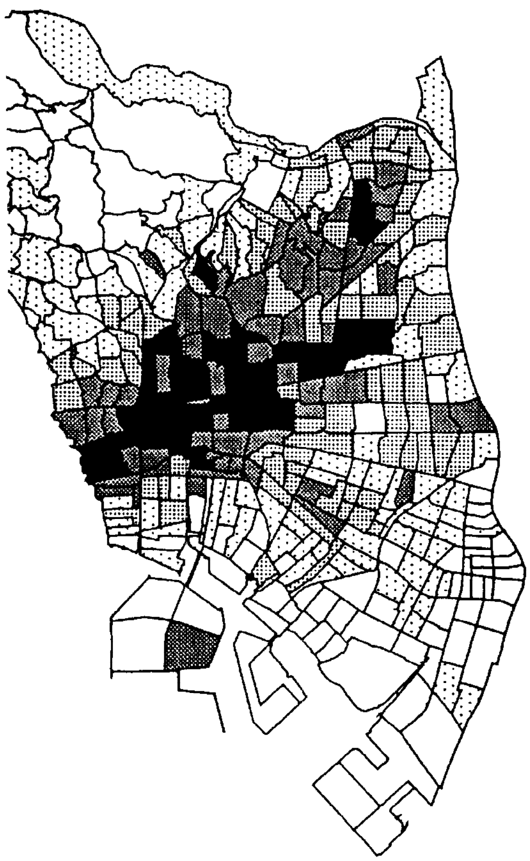


Fig. 7(a) Distribution of ratios of the number of collapsed wood houses to the total number.

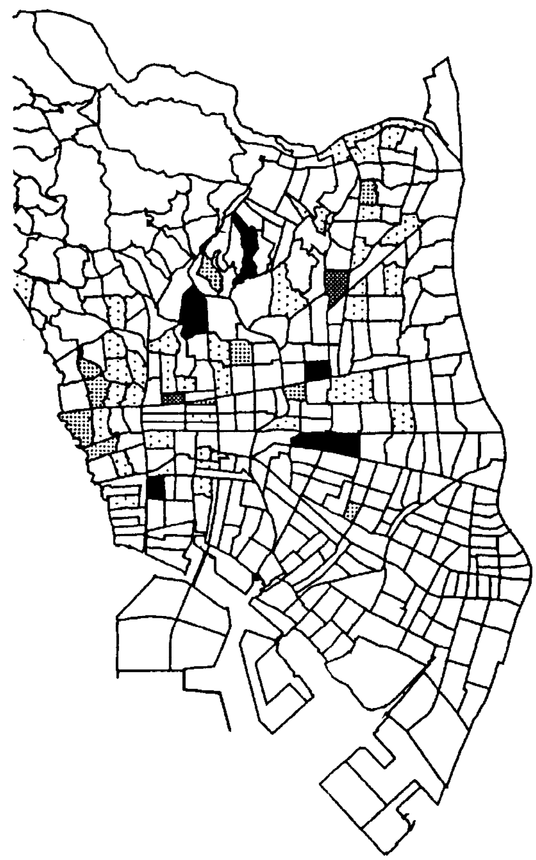
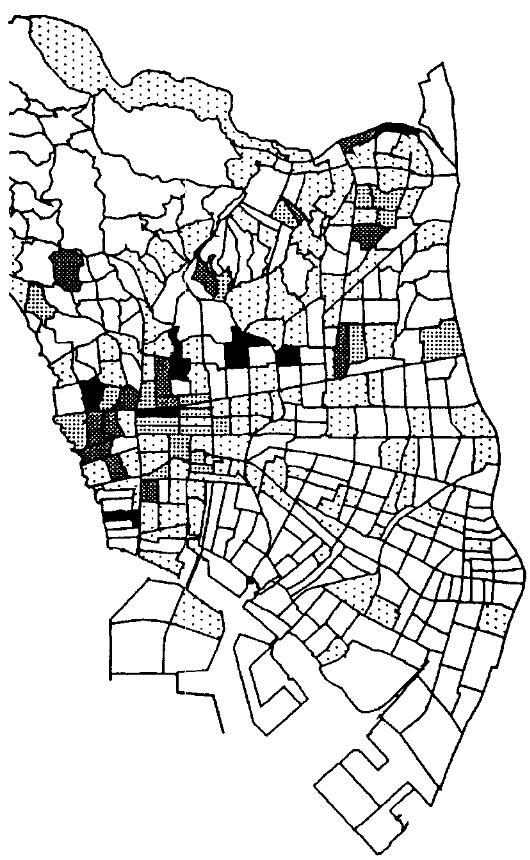


Fig. 7(b) Distribution of ratios of the number of collapsed RC and SRC buildings to the total number.



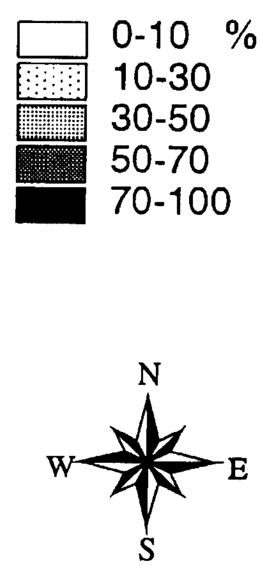


Fig. 7(c) Distribution of ratios of the number of collapsed steel buildings to the total number.

Building Damage

Distribution of collapsed houses and buildings are shown in Fig. 7(a) -(c) by each structural type; wood, reinforced concrete (RC) and steel reinforced concrete (SRC = composite structures), or steel. The severely damaged areas are correspond to the areas of JMA earthquake intensity Ⅶ (Fig. 1), although building damages distribute rather wide band. This result reflects that the municipal government judged rank of building damage more highly.

Lifeline Damage

Fig. 8 indicates water distribution pipelines, where damage locations of pipe are shown by small circles and liquefied area shaded dark. In Fig. 9(a), water distribution pipeline damage is plotted over the geological map. It seems that pipeline failure spreads out both on soft ground near seaside and on boundary area between terrace and alluvial deposits. This result is shown in Fig. 9(b) qualitatively, in which it is ranked with failure numbers per unit pipeline length (1 km). Comparing between the damage distribution of water pipeline and building (see Fig. 7), some differences exist. It is considered that building damage is mainly caused by strong shaking during the earthquake, however pipeline damage occurred on both hard and soft soil. So they must reflect ground shaking and geology and/or soil condition. At next stage of study, intensity of ground shaking should be analyzed.

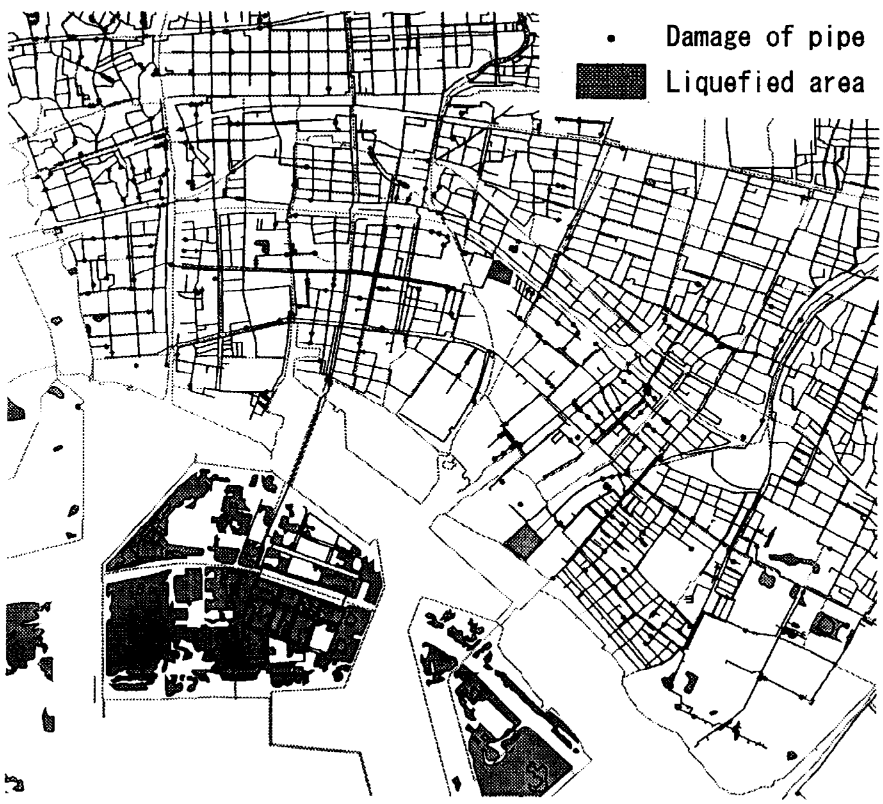


Fig. 8 Water distribution pipelines at southern part of Nishinomiya.

CONCLUSIONS

GIS-based information will allow us to understand the state of the disaster caused by the Hyogoken-nambu earthquake from various aspects. It is expected to constitute a useful database for basic studies of disaster analysis and mitigation. This information is useful as judgmental information in "Disaster information management assistance" activities using the GIS in the post Hyogoken-nambu earthquake period, which are being implemented in part of emergency operations by local governments. Furthermore, based on damage data from Nishinomiya City, interrelations among various aspects of the earthquake disaster, those are building damage and lifeline damage with geology, ground failure and others, are presented.

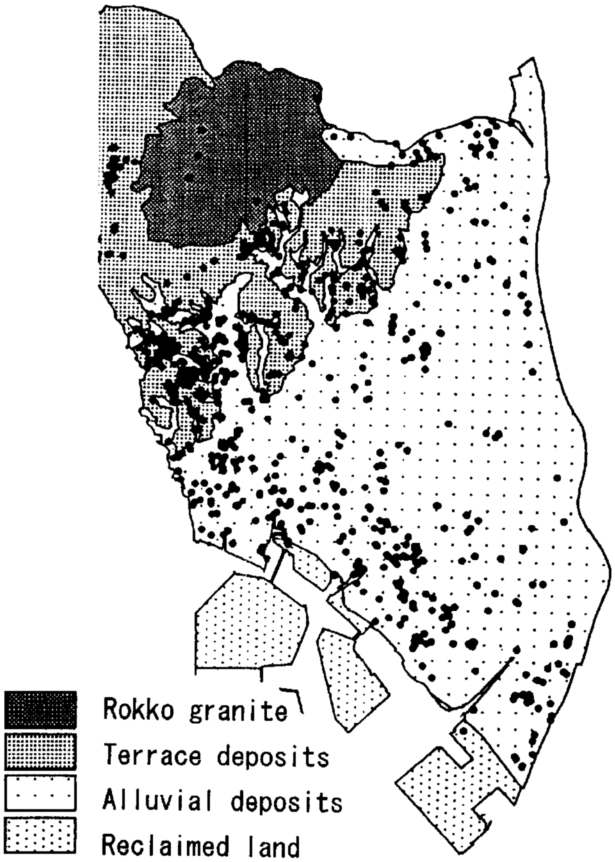


Fig. 9(a) Location of water distribution pipe damage and its geology.

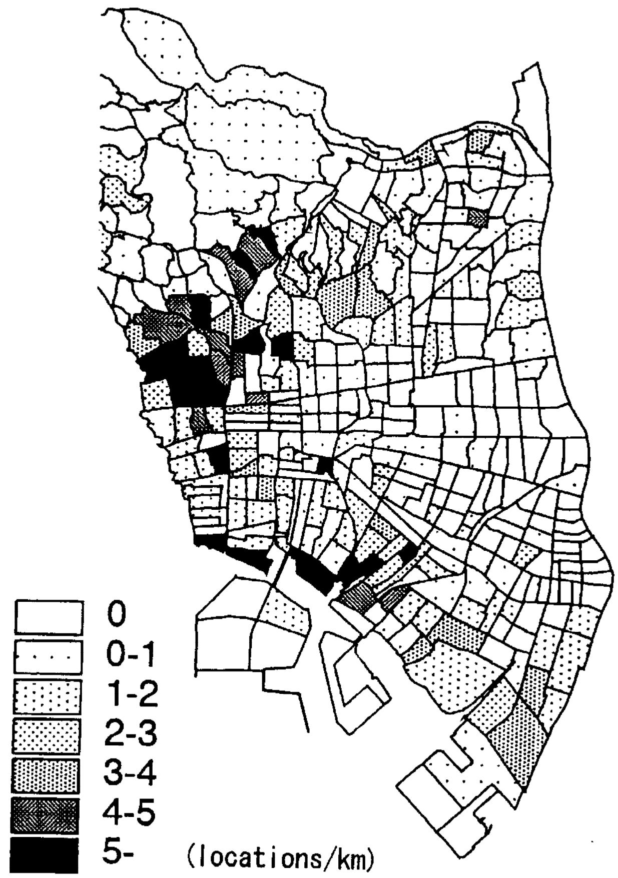


Fig. 9(b) Failure numbers per one kilometer of water distribution pipes.

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