Improvement of Earthquake Disaster-Prevention Safety in Built-up Urban Areas

MURAKAMI Harunobu, Director, Urban Planning Department

(Keywords) Noto Peninsula Earthquake, Great Kanto Earthquake, Urban fire, Densely built-up urban area

1. Introduction

First of all, I wish to express my deepest condolences to all those who perished in the recent Noto Peninsula Earthquake, which occurred on January 1, 2024, and to their families. This earthquake caused a large-scale fire in the Kawaimachi district of Wajima City. The Great Kanto Earthquake, which occurred almost exactly 100 years ago, on September 1, 1923, also caused large-scale urban fires, particularly in Tokyo.

Since improvement of the safety of existing urban areas in earthquakes remains an important policy issue for Japan even today, in this paper, I would like to introduce the trends in national government policies in this connection and related research by the National Institute of Land and Infrastructure Management (NILIM).

2. Fire in 2024 Noto Peninsula Earthquake

According to a statement (issued at 9:00, Jan. 26, 2024) by the Disaster Response Headquarters of the Fire and Disaster Management Agency of Japan's Ministry of Internal Affairs and Communications, the 2024 Noto Peninsula Earthquake caused 17 fires in 10 cities and towns. Among these, NILIM and the Building Research Institute (National Research and Development Agency) dispatched researchers to Kawaimachi in Wajima City, where a large-scale fire developed, and released a damage survey report (quick report) [1] on January 12. According to that report, looking at the surroundings of the fire-devastated area, it appeared that the area contained many low-rise wood-frame dwellings, buildings that had collapsed as a result of seismic motion, and buildings where wood-and-mortar walls had fallen off, and the fire occurred under those urban conditions. It was estimated that the burnt-out area was approximately 50,800 m^2 and contained about 300 buildings, and the final scale of the damage is expected to be determined by the fire department.

3. Urban Fire in Great Kanto Earthquake

The Great Kanto Earthquake became an unprecedented conflagration, in which victims of the fires that occurred after the earthquake accounted for about 90 % of all deaths. As reasons for this kind of large-scale urban fire, it may be noted the Tokyo of that time was an easily-inflammable urban area, being a densely built-up city of wood-frame structures. Weather conditions were also conducive to fires, including a strong southerly wind that was blowing when the earthquake occurred, and firestorms and leaping fires further increased the damage.

The mechanism of these urban fires in the Great Kanto Earthquake was the subject of a television "NHK Special" that was broadcast on September 2-3, 2023, in which NILIM participated from the planning stage. Researchers from NILIM and the Building Research Institute commented on images from the period of the earthquake, which were prepared by high-definition color imaging, and performed an experiment reproducing the firestorms and leaping fire and provided commentary. Readers are invited to view a shorter version of this program, which NHK has made available on YouTube.

Fig. 1 Experiment reproducing a firestorm

4. Trends in National Government Policies

Built-up urban areas, and particularly densely inhabited areas of predominantly wood-frame structures, have various problems, including a lack of wide spaces that might serve as firebreaks, numerous narrow roads and sites with no access to roads, and difficult conditions for firefighting activities, and thus have a high risk of urban fires.

Development and improvement of densely inhabited urban areas are important issues in Japan for protecting the lives and property of the nation's citizens. The measures for achieving this are specified in the "Fundamental Plan for National Resilience" (approved by Cabinet resolution on July 28, 2023). The "Housing Basic Plan (National Plan)" (approved by Cabinet resolution on March 19, 2021) also stipulates that "the land area of densely inhabited areas that are conspicuously dangerous (dangerous densely inhabited areas) when earthquakes occur should be mostly eliminated (by FY 2030)" and calls for "strengthening of soft measures that contribute to the improvement of wide-area disaster prevention readiness (100 % by FY 2025)".

Based on these Cabinet resolutions, the national government and local governments are cooperating in screening dangerous densely inhabited areas by disaster-prevention evaluation methods (danger of fire spread, difficulty of evacuation) developed with the support of NILIM, and are implementing various types of development and improvement measures, as shown in **Fig. 2**, centering on those urban areas.

However, dangerous densely inhabited urban areas still remain, particularly in cities built on hilly land, such as Yokohama and Nagasaki, and historic cities like Kyoto. Thus, in addition to the hard measures taken to date, it has become necessary to minimize the occurrence of urban fires and the ensuing damage by new measures and improvement of wide-area disaster prevention readiness.

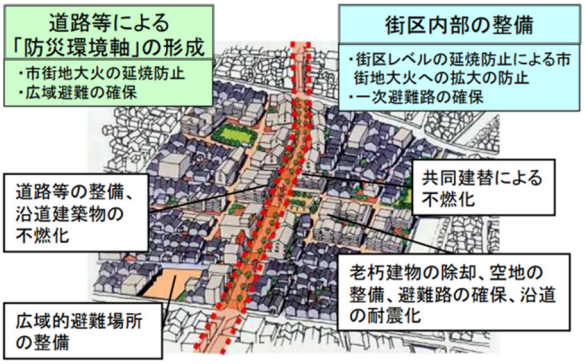

Fig. 2 National government development and improvement measures for densely inhabited urban areas

5. Research by NILIM

Based on the above-mentioned issues, the Urban Planning Department, in cooperation with experts, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), the Building Research Institute and internal support (Building Department, NILIM), began a comprehensive technology development project, "Development of Effective Earthquake Disaster Prevention/Mitigation Technologies for Built-up Urban Areas Using New Technologies, Etc." as a 4-year plan beginning from this year (FY 2023). In this technology development, blockage of roads by fires or collapsed buildings when an earthquake or other disaster strikes a built-up urban area will be detected by drones, AI cameras installed at high locations, etc., and will be incorporated into a plateau or other 3D city model, a fire spread simulation will be conducted, for example, for 24 hours in the future, and the results of an evaluation of the evacuation risk based on the simulation will be visualized by a digital twin. This will then be shared with local residents by using digital devices such as LINE and other social media, leading to early firefighting activities and evacuation activities by residents. Technologies for reevaluation of the disaster mitigation performance of dangerous densely inhabited urban areas will also be carried out, considering the use of these new technologies and improvement of wide-area disaster prevention readiness.

In addition, under the Cabinet Office's BRIDGE Program (for "bridging" the gap between research and development results and social implementation), the Urban Planning Dept., in cooperation with related organizations, is carrying out a 2-year research project, beginning in FY 2023, in which it will attempt to detect urban fires by infrared and SAR observation from a satellite, and link this to a quick, accurate response when a fire occurs by providing the results of predictions of fire spread after detection to local governments and others.

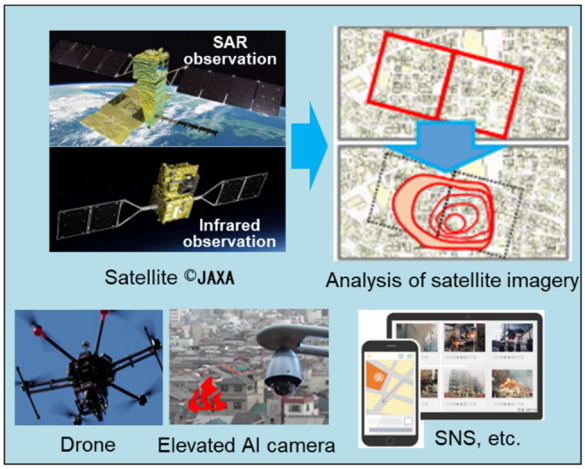

Fig.-3 Image of research using satellite, etc.

6. Conclusion

In today's Tokyo, the number of bare wood-frame houses and other buildings has decreased in comparison with the time of the Great Kanto Earthquake. As a result, the speed of fire spread has decreased to 1/3 to 1/4 of that 100 years ago, and the possibility of an urban fire of the scale of the fire following the Great Kanto Earthquake is also smaller. The scale of fires is also smaller compared to that time, and the danger of "giant" firestorms has also decreased. Nevertheless, even if it is not a giant firestorm, the occurrence of a firestorm as such is still quite conceivable, and large-scale damage is possible if a firestorm encourages the spread of a fire.

It is also possible that fires in urban areas may expand due to unforeseen conditions. In the future, together with further fireproofing, flame-resistance measures and earthquake-resistance measures for built-up urban areas, it will also be important to share the results of predictions of damage in urban fires and other disasters with residents, and to ensure their awareness of advance disaster prevention measures and early evacuation when a fire occurs. The Urban Planning Department is also conscious of the importance of these points, and would like to continue its research efforts and return the results to society.

☞For more information:

1) "Report of survey of fire damage of buildings, etc. by 2024 Noto Peninsula Earthquake (Quick report)"
https://www.nilim.go.jp/lab/bbg/saigai/R5/notojishin02.pdf