Research and Development Initiatives to Overcome Vulnerabilities of Housing in Large Modern Urban Areas in Disasters

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1. Introduction

This paper describes countermeasures against the vulnerabilities that are assumed to be possible when a large modern urban area such as Tokyo suffers a disaster, based on the 100 years since the Great Kanto Earthquake that struck Tokyo in 1923.

In the Great Kanto Earthquake, fires spread through wood-frame houses which had collapsed or were damaged by seismic motion (maximum seismic intensity: 6 on the Japanese scale), and about 90 % of the victims, totaling more than 100,000 persons, died in fires. Looking at more recent major earthquake disasters, in the Great Hanshin-Awaji earthquake (1995), collapsed buildings claimed the lives of approximately 80 % of the more than 6,000 victims, and in the Great East Japan Earthquake (2011), which claimed more than 18,000 lives (excluding disaster-related deaths of persons who died later), about 90 % of the victims drowned in the tsunami following the earthquake.

Thus, the types of damage differ greatly, depending not only on the scale and location of the earthquake, but also on the region and the characteristics of the society affected by the earthquake. When con sidering countermeasures for large-scale earthquake damage in large modern urban areas, it is necessary to implement measures based on the vulnerabilities of the infrastructure of daily life, which was highly developed in metropolitan areas.

The following mention several related efforts by the Housing Department in the past, and introduces the types of vulnerabilities to be addressed and the issues studied in connection with countermeasures.

2. Securing Power Necessary for Continuing Living

Since modern urban life is supported by various kinds of lifelines, even when a building does not suffer direct damage after a disaster, there is a high possibility that it will become difficult to continue living at home if lifelines stop, etc. In particular, power outages have a serious impact. For this reason, increasing the number of dwellings where people can continue living in their own homes after a disaster will lead to reductions in the number of evacuees who must be accommodated in evacuation shelters and the number of temporary housing units required, and will also contribute to quick recovery and improved resilience of the region.

Therefore, in "Study on Design Targets for Self-sustaining Energy Systems to Ensure Post-Disaster Residential Continuity" (FY2020-FY2022), first, the requirements for continued living during a power outage after a disaster were studied, focusing on energy-saving systems consisting of photovoltaic power (PV) generation and storage batteries for dwellings. Concretely, a method for calculating electric power demand (power consumption) reflecting the necessary minimum or priority equipment/devices for continued living and the condition of their use, and the power supply to cover that demand was constructed.

In this research, a questionnaire survey of households that had experienced a power outage for a period exceeding a half-day during a large-scale disaster [1] was conducted to clarify the electric power usage necessary for continued living after a disaster, and the equipment/devices necessary for continued living under the condition of a lifeline

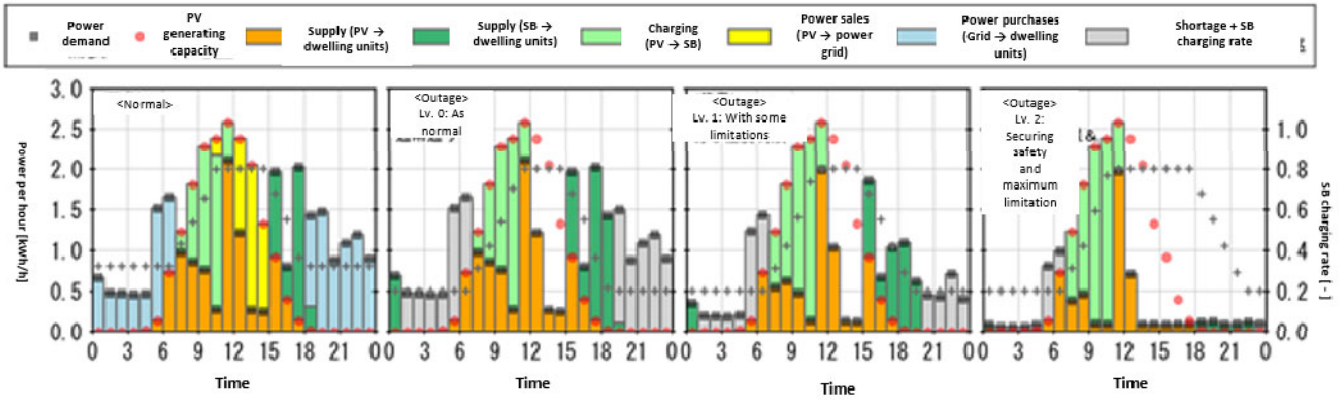

Fig. Example of calculation of power demand in 24 hours after a power outage occurs and power supply capacity by photovoltaic power generation (PV, 4.0 kWh) and storage batteries (SB, 12.0 kW)

stoppage were identified. A method for calculating the power supply of the above-mentioned energy-saving system was constructed corresponding to the conditions of the power outage and the use of devices by the family members, based on the method for calculating residential energy conservation standards, by setting or assuming two levels of equipment/device use patterns, in which power consumption was reduced by measures such as having the family gather and spend time in certain rooms (living-dining-kitchen and couple's bedroom). Together with this, technical information on cases of malfunction of the PV power generation and storage battery system, measures to avoid or minimize such problems, precautions during a disaster, etc. was also collected and arranged.

The results will be arranged and provided in the future so that they can also be applied to apartment houses and regional units.

3. Evaluation of Continuity of Use of Elevators after Large Earthquakes

The percentage of households living in high-rise multi-unit complexes in large cities is increasing, and it is essential to use elevators in order to live there continuously after a disaster. However, a method for evaluating the continuity of use of elevators has not been established. To enable continuous use of elevators after a disaster, verification from the following viewpoints is necessary: ① Safe stopping at the specified position during a disaster (to avoid passengers being trapped and prevent injury), ② Response to recovery by an automatic diagnosis and recovery system (also including remote response), ③ Response to disruptions of the lifeline (electric power), and ④ Response to disruptions of the maintenance network.

Research on these issues is being carried out in "Research on Performance Evaluation Technologies for Housing/Buildings Responding to Changes in the Social Environment" (FY 2022-FY 2026). For example, for ②, a survey of the effects of the inter-story drift angle of buildings on impaired functioning of elevators and the effectiveness of a system that detects that condition and performs automatic diagnosis and recovery are being studied.

4. Evacuation Support Technologies for Elderly People and Disabled Persons during Disasters

The number of elderly people and disabled persons living in medium- and high-rise multi-unit complexes in large cities is increasing, and it may be difficult for such persons to evacuate during a disaster that includes a power outage. On the other hand, while preparation of barrier-free technologies for everyday life is progressing, so-called "emergency barrier-free" still faces many issues.

As concrete examples, it is difficult to evacuate from upper floors using stairs, it is impossible to use elevators during power outages, there are limits (unusable) use elevators during fires, and the use of evacuation equipment assumes only use by able-bodied persons.

To address these issues, in "Development of Evaluation Standards for Evacuation Support Technologies for Elderly/Disabled Persons during Disasters in Apartment Houses, Etc." (FY 2015-FY 2017), evacuation plans and evacuation support technologies were systematically arranged, and ergonomic experiments were carried out toward the creation of evaluation standards for new evacuation support technologies, aiming at the establishment of a performance evaluation method and operation and maintenance techniques.

In this study, prototype of a new evacuation support device was developed and installed, and its effectiveness was compared with that of the existi ng evacuation ladders and escape chutes by operation experiments and psychological evaluation experiments. For example, in the operation experiments, the time required for evacuation by young subjects wearing and using the above-mentioned devices was measured, etc., assuming a person carrying an infant, an elderly person, and a person paralyzed on one side of the body.

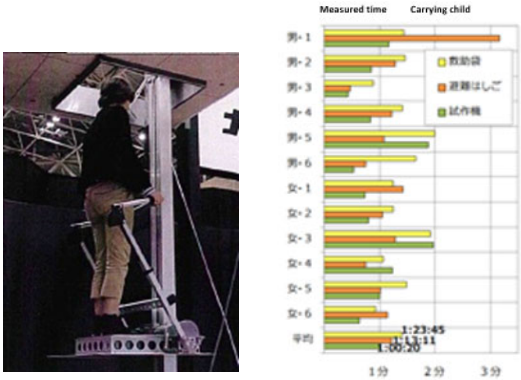

Fig. Condition of experiment using a prototype device and example of experimental results

5. Conclusion

Continuing progress is being made in the efforts of local public organization to encourage condominiums that enable "at-home evacuation" during disasters by certification systems such as the "'Mori no Miyako' Disaster Prevention Improvement Condominium Certification System" in Sendai City, "Tokyo 'Todomaru' Mansions" in Metropolitan Tokyo, and the "Yokohama Disaster Prevention Capability Improvement Condominium Certification System," and the Housing Department will also continue research and development to provide support to those efforts in the future.

☞For more information

1) TECHNICAL NOTE of the National Institute for Land and Infrastructure Management No. 1271,
" Online survey targeting households that have experienced power outages due to natural disasters"
https://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1271.htm