

Analysis of the Causes of Damage to Building Structures in the 2024 Noto Peninsula

Building
Department

- In order to analyze the causes of damage to building structures in the 2024 Noto Peninsula Earthquake and to examine the direction of the measures to be taken, the NILIM has established a committee consisting of experts of building structure, called the "Committee that performs analysis of the causes of damage to building structures in the 2024 Noto Peninsula Earthquake," in collaboration with the Housing Bureau of the Ministry of Land, Infrastructure, Transport and Tourism and the Building Research Institute.
- The Committee carries out analysis of the cause of damage for each of the structure types (wooden, reinforced concrete, foundation ground, steel frame made, non-structural members, tsunami damage, seismic isolation structure) of buildings, by collecting organizing the results of site surveys conducted by the NILIM and the Building Research Institute as well as the results of survey implemented by various institutions, and publicized an interim summary on November 1, 2024. <https://www.nilim.go.jp/lab/bcg/kisya/html/kisya20241101.htm>

Research introduction

1. Status of damage to wooden buildings

In the city areas of Wajima City, Suzu City, and Anamizu Town where there was great damage to buildings, we analyzed the tendencies of damage by using the results of complete enumeration conducted in collaboration with the Architectural Institute of Japan.

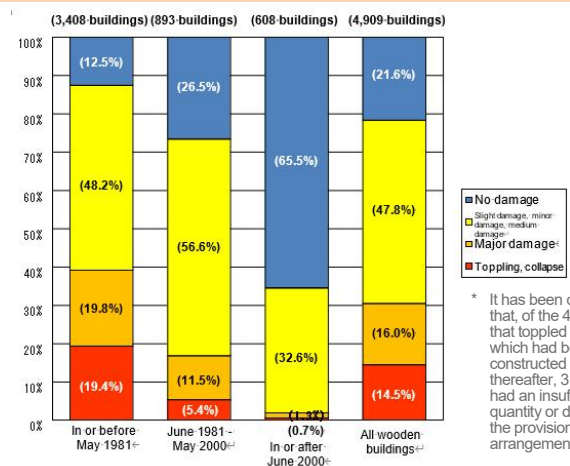
- The percentage of toppling of wooden buildings conforming to the former seismic standards was remarkably higher than that of wooden buildings after the introduction of the new seismic standards. In the wooden buildings after the introduction of the new seismic standards, the percentage of toppling was extremely low in 2000 and thereafter in which the specifications of joints have been clarified.

* The construction years are classified into before 1981 conforming to the former seismic standards, 1981 and thereafter in which the new seismic standards were introduced, and 2000 and thereafter in which the current provisions have been applied.

- The percentage of damage to wooden buildings that underwent seismic retrofitting was lower than that of the wooden building conforming to the former seismic standards that did not undergo seismic retrofitting, and damage was mitigated by seismic retrofitting.
- In houses that obtained seismic grade 2 or grade 3 under the Housing Performance Indication System and houses that obtained approval of a long-term excellent house, there were no houses that suffered toppling, collapse, or major damage, and most of them suffered no damage.

<Direction of the measures to be taken>

- Further facilitation of seismic retrofitting
 - Familiarization of the "Safety Ensuring Measures Manual for Wooden Housing" concerning wooden buildings conforming to the former seismic standards
 - Familiarization and propagation of the "Efficient Seismic Diagnosis Method" that are applicable to, of the wooden buildings conforming to the new seismic standards, those not conforming to the specifications that were clarified in 2000
 - Provision of support by means of the Housing and Building Safety Stock Formation Project, Etc



* It has been confirmed that, of the 4 buildings that toppled or collapsed, which had been constructed in 2000 or thereafter, 3 buildings had an insufficient wall quantity or did not meet the provisions of wall arrangement balance.

Status of damage to wooden buildings by construction period



2. Status of damage to reinforced concrete buildings

- Regarding reinforced concrete buildings supported on pile foundations, one of them toppled, and several of them were inclined. As for the factors of damage, a decline in supporting force of the piles due to damage, movement of the piles during the earthquake, but they are not clear at present.
- In the reinforced concrete buildings conforming to the former seismic standards, damage was identified such as shear destruction of columns, destruction of column-beam joints, and shear destruction of mullion walls.



Shear destruction of a column

<Direction of the measures to be taken>

- For buildings conforming to the former seismic standards, further facilitation of seismic retrofitting
- Analysis of the cause of inclination/toppling damage to reinforced concrete buildings supported on pile foundations



Toppling damage to a reinforced concrete building



Inclination damage to a reinforced concrete building

3. Status of damage to steel frame buildings

- Among steel frame buildings, 3 buildings conforming to the former seismic standards toppled or collapsed.



Collapse of 2nd and 3rd floors of a steel frame building



Layered collapse of the 1st floor of a steel frame building

<Direction of the measures to be taken>
 • For buildings conforming to the former seismic standards, further facilitation of seismic retrofitting

4. Status of damage to non-structural members, effects of seismic retrofitting

- Detachment of the entire ceiling was not identified, but the fall of part of the ceiling plates and detachment of steel-made substrates were identified. Falls of interior walls, exterior walls and damage to glass were observed.
- Regarding the buildings that had undergone seismic retrofitting, there was no damage of toppling or collapse, and the effectiveness of the retrofitting was confirmed.



Ceiling collapse damage



Exterior wall detachment damage



Exterior glass breakage damage



Reinforced concrete building that had undergone seismic retrofitting (no toppling/collapse damage)

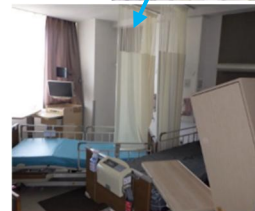
<Direction of the measures to be taken>
 • For existing ceilings falling under the category of specified ceilings, further facilitation of seismic diagnosis and seismic retrofitting
 • Familiarization of precautions for design and construction to prevent damage to interior and exterior walls

5. Continued usability of buildings

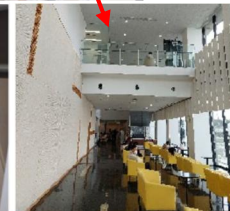
- Regarding buildings with seismic isolation structure, no damage to the structural frame was identified.
- In a ward having seismic isolation structure of a hospital, no tip-over damage of furniture, and the continued use of functions after the earthquake was pursued.



Photo: Japan Society of Seismic Isolation (general)



Status of a hospital ward having seismic-resistant structure after the earthquake



Status of a hospital ward having seismic isolation structure after the earthquake

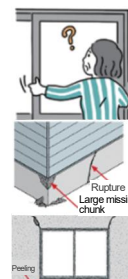
<Direction of the measures to be taken>

- Promotion of the utilization of "Functional Continuity Guidelines for Buildings That Serve as Disaster Management Sites, Etc."

- Wooden housing in areas shaken greatly by the earthquake may have lowered structural capacity due to damage.
- Familiarization of the "Safety Check of Wooden Housing After an Earthquake" is required so that it can be determined if residents can continue to live there.



Pamphlet of the "Safety Check of Wooden Housing After an Earthquake"



Windows have become hard to open and close

There is great damage to the foundation

Damage to exterior wall is relatively great

When falling under any of the above, consult the municipality or an expert.

6. Seismic zoning factor and damage to buildings

- The seismic zoning factor used in the structural calculation of a building is set to 0.7 to 1.0 based on the size and frequency of ground motion in the past. On the other hand, large earthquakes have occurred frequently in recent years in regions with a low seismic zoning factor as well, and the northern part of Noto has a seismic zoning factor of 0.9.
- * The seismic zoning factor is a factor used when calculating the seismic force used for design when performing the structural calculation of a building. Based on the records of earthquakes in the past in each region, a value of 0.7 to 1.0 is determined for each region, based on the degrees of earthquake damage in the past, and the sizes and frequency of the earthquakes that occurred.
- In the 2024 Noto Peninsula Earthquake, regarding the buildings that are considered to have been constructed by performing structural calculation using the seismic zoning factor after the introduction of the new seismic standards, damage such as toppling due to the seismic zoning factor was not identified.

<Direction of the measures to be taken>

- Study of how the standards using the seismic zoning factor ought to be based on the situation where large ground motion occurred frequently in a region where the seismic zoning factor is less than 1.0, verification of the status of damage to buildings caused by ground motion in such region, the intent of the Building Standard Law that specifies the minimum standard.

○In future, we will continue to conduct studies about analysis of the causes of damage to the inclination and toppling of reinforced concrete buildings supported on pile foundations as well as investigation and analysis of the relationship between earthquake damage and continuous usability, and others.

☞For related articles, refer to:

- Survey of fire damage caused by the 2024 Noto Peninsula Earthquake (pp. 13 - 14 of this document)
- About damage to wooden buildings in the 2024 Noto Peninsula Earthquake (pp. 68 - 69 of this document)