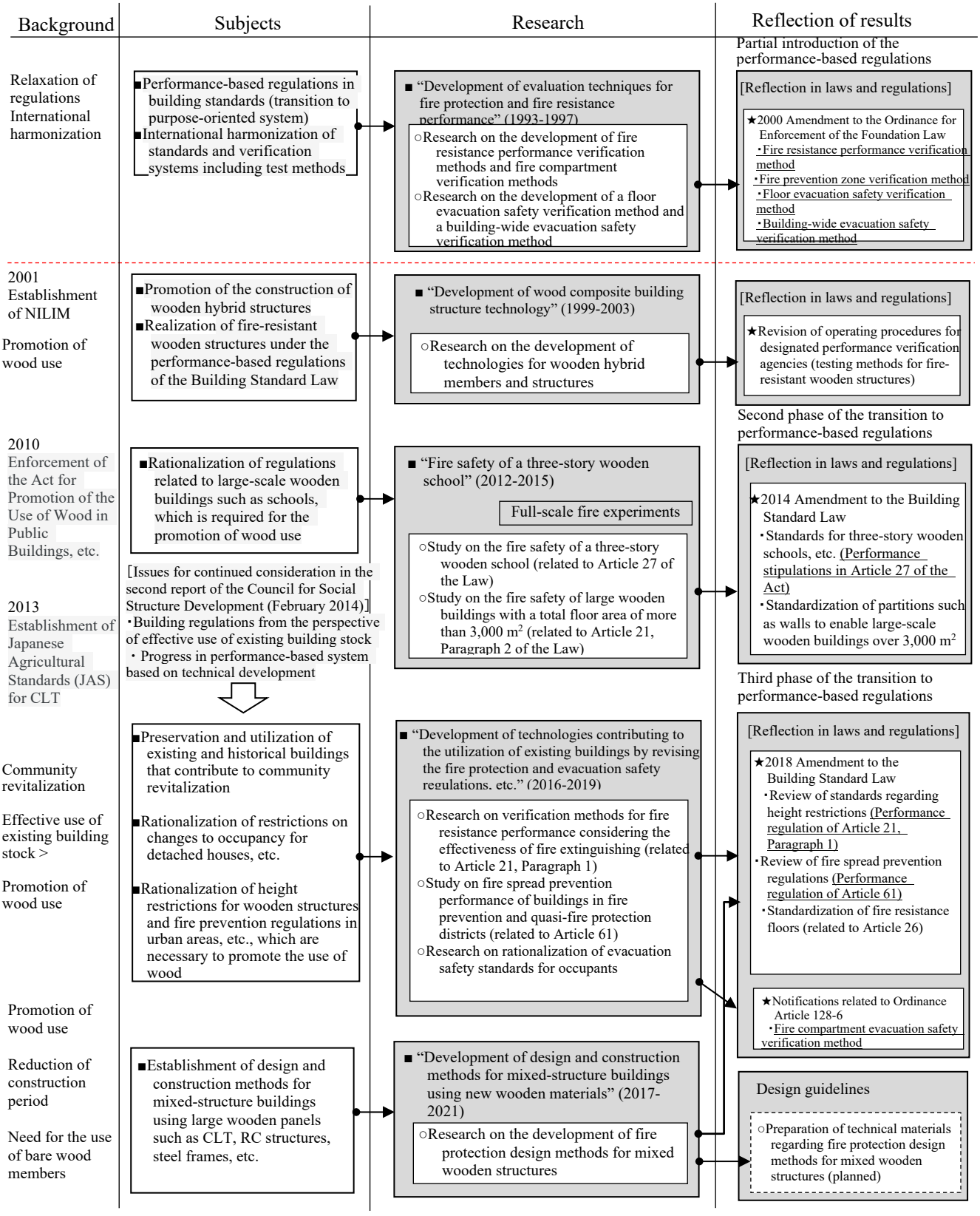
Performance-based fire protection and evacuation safety provisions of the Building Standard Law

1. Outline of Studies and Activities



(1) Introduction of performance-based provisions in the Building Standard Law

After the enactment of the Building Standard Law in 1950, the number of urban fires, which was the most important issue in fire prevention for buildings, gradually decreased due to the improvement of urban structures and modernization of the fire services system. On the other hand, serious fire incidents in department stores and hotels in the 1950s and 1960s, especially those caused by smoke spreading in the building, led to the tightening of fire safety regulations, such as restrictions on interior furnishings and the establishment of evacuation facilities.

In the 1970s, a comprehensive fire safety design method was developed at the former Building Research Institute based on the accumulated engineering knowledge on fire safety in large-scale and multi-occupancy buildings. Using this design method, designs that do not conform to the prescriptive standards of the general regulations are now permitted on a special exception basis, in accordance with Article 38 of the Building Standard Law.

In addition, due to requests from designers, the trend toward performance-based specifications in the building codes (a shift toward a purpose-oriented system), and the need for international harmonization of standards and verification systems, including testing methods, the Building Standard Law was revised in 1998 (and its enforcement ordinance was revised in 2000). In this revision, performance-based specifications were introduced, allowing a building design to receive a building permit without obtaining ministerial approval by using various verification methods, including ones for fire resistance, fire compartment, floor evacuation, and building-wide evacuation.

(2) Research on the development of performance-based fire protection and evacuation safety regulations after the establishment of NILIM

(Research Background)

Unlike the tightening of regulations triggered by large fire incidents or the relaxation of regulations, the adoption of performance-based specifications does not necessarily change the required level of safety performance. However, due to a clear indication of the required level of safety performance and its verification method in contrast to the existing prescriptive standards, a variety of structural methods are permitted, which is expected to expand the design options and promote technological development.

In addition, strict building constraints, such as size restrictions, have been imposed on wooden buildings since before the enactment of the Building Standard Law to prevent fire spreading in urban areas. However, strong demands to promote the use of domestic timber, such as the "Law for the Promotion of the Use of Wood in Public Buildings, etc." enacted in 2010, the public's attachment to wood, and the effective use of existing building stock have led to calls for the practical application of fire-resistant wooden structures, rationalization of fire prevention and evacuation regulations for large-scale wooden buildings, rationalization of restrictions on changes to occupancy for detached houses, and rationalization of fire prevention regulations in urban areas.

Against the backdrop of these social demands, NILIM has continued to launch research projects such as the Comprehensive Technology Development Project since the time of the former Building Research Institute. NILIM has continued to promote research on fire safety verification methods and fire resistance test methods, etc., which are necessary for the further development of the fire protection and evacuation safety regulations into the performance-based form.

(Research Overview)

In the "Development of wood composite building structure technology" implemented in FY1999-2003, wooden members became available as fire-resistant structures due to the revision of the Building Standard Law in 1998, technologies were developed for wooden hybrid members and structures, such as performance verification methods (test methods) for wood-based

fire-resistant structures. The results were reflected in the revision of the operating manuals of designated performance verification organizations. As a consequence, practical application of the "fire-resistant wooden structure" began, based on the ministerial certification.

In the "Fire safety of a three-story wooden school" conducted in FY2012-2015, research on fire safety for large-scale wooden buildings such as schools was conducted, including a full-scale fire experiment of a three-story wooden school through industry-government-academia collaboration, and the "Development of technologies contributing to the utilization of existing buildings by revising fire protection and evacuation safety regulations, etc." conducted in FY2016-2019. In the project, fire experiments were conducted in consideration of the actual state of firefighting activities in recent years, and research was conducted to further define the performance of fire prevention and evacuation regulations. (Details are provided later.)

In addition, in the "Development of design and construction methods for mixed-structure buildings using new wooden materials" (FY2017-2021), which has been implemented since FY2017, CLT (cross-laminated timber) research is underway to establish design and construction technology for mixed-structure buildings using large wooden panels, RC structures, steel frames, etc.

3. Main Research Results

(1) Project Research, "Study on the fire safety of a three-story wooden school (FY2012-2015)"

Schools of three or more stories were required to be fire-resistant buildings, and although fire-resistant wooden structures covered with plasterboard, etc. could be used, it was not permitted to use quasi-fire-resistant structures with exposed wooden material. A research project was launched in 2012 to study the fire safety performance required for three-story wooden schools and large-scale wooden buildings with a total floor area of more than 3,000 m^2.

(Research)

The purpose of this research was to develop technical standards that comprehensively consider safety in terms of the evacuation safety of the occupants, prevention of fire spreading to adjacent buildings due to heating, firebrands, and the safety of firefighters due to rapid structural collapse based on the results of experiments and simulations. The project concluded a joint research agreement with project entities (universities, construction companies, and design firms) and the Building Research Institute, which were selected by the Housing Bureau of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) for the "Promotion of advanced wooden construction standards." Three full-scale fire experiments were conducted using a three-story wooden school. The results confirmed the collapse and fire spread prevention performance up to the end of the evacuation, the effectiveness of the measures to prevent fire spreading to the upper floors at an early stage, and the fire spread prevention performance of the designated walls in the building.

Figure-1 Research flow on the fire safety of a three-story wooden school

(Reflection of results)

Based on the results of this research, the Building Standard Law was revised in 2014 and related government ordinances and notifications revised the standards for three-story wooden schools (Article 27 of the Law was revised to stipulate the performance requirements based on the specific evacuation time (time required to complete evacuation of the entire building)), and the standardization of walls and other compartments (related to Article 21.2 of the Law) to allow the construction of large wooden buildings over (3,000 m^2) as quasi-fire-resistant buildings.

(2) "Development of technologies contributing to the utilization of existing buildings by revising the fire protection and evacuation safety regulations, etc. (FY2016-2019)"

Recent years have seen an increasing need for the effective utilization of existing building stock, such as the preservation and utilization of historical buildings that contribute to regional revitalization and the conversion of detached houses. However, in many cases, restrictions on changes to occupancy have resulted in increased repair costs and abandonment of changes to occupancy. In this context, further enhancement of performance-based specifications for fire protection and evacuation safety of a building was needed. Under these circumstances, a research project was launched in FY2016 to study verification methods for structural fire resistance performance and fire spread prevention performance in fire protection zones, to revise the restrictions associated with changes to occupancy, height restrictions for wooden structures, and fire prevention regulations in urban areas.

(Research)

In this study, in order to examine the criteria for the required performance of the main structure of wooden buildings exceeding the height limit (structural safety performance in the event of fire) that anticipates the effectiveness of ordinary firefighting activities, experiments on firefighting activities were conducted with the cooperation of the Fire and Disaster Management Agency, the National Fire Chiefs Association, and the Tsukuba City Fire Department. As a consequence, a verification method that considers the effect of firefighting activities was developed (Figure-2).

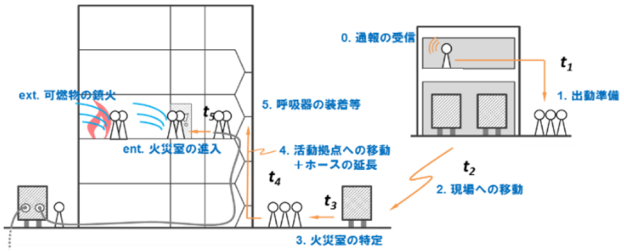
In addition, a verification method was developed for evaluating the equivalency of the fire spread risk of buildings to the level of the current specifications (e.g., fire-resistant construction) by improving the performance of the exterior walls and openings.

(Reflection of results)

Based on the results of this research, the Building Standard Law and the related enforcement ordinances and notifications were revised in 2018. The revisions include the standards for height restrictions (Article 21, Paragraph 1: Performance requirements for major structural components are specified based on the time required for an ordinary fire to be extinguished by firefighting measures) and the fire prevention regulations in urban areas (Article 61: Performance requirements are specified based on the time required for a building to prevent fire spreading to the surrounding areas during an ordinary fire).

(1) Organizing the concept of a structural method that prevents collapse due to the effect of fire extinguishing

(2) Modeling the fire extinguishing time by water discharge



(3-1) Organizing the conditions to support firefighting activities

(3-2) Modeling the water discharge start time (experiment conducted)

(3-3) Modeling the firefighting effectiveness (experimental implementation)

(4) Modeling method for calculating the time required for the main structure due to the start of water discharge and firefighting activity time

Presentation of Notification (Draft)

Figure-2 Research flow on collapse prevention performance in case of fire

3. List of Related Reports and Technical Documents

1) "Development of wood composite building structure technology," NILIM Fire Protection Subcommittee Report (FY1999-2003)
2) Project Research, "Fire safety of a three-story wooden school building - Full-scale fire tests" (FY2012-2015) NILIM Technical Note No. 970 http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn0970.htm
3) "Development of technologies contributing to the utilization of existing buildings by revising the fire prevention and evacuation safety regulations, etc." (FY2016-2019)

4. Future Outlook

Regarding the fire protection and evacuation safety regulations of the Building Standard Law, further performance regulations have been made such as the revisions of the Law in 2014 and 2018 and the development of related Cabinet orders and notifications, reflecting the research results of NILIM, but there are still regulations that have not sufficiently established the

provisions of the prescriptive standards. It is necessary to continue the research and development of new evaluation methods for further improving the performance-based fire protection and evacuation safety regulations.