Architectural Research to Respond to Changes in Social Needs

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1. Introduction

Building Department has engaged in research to realize safer, more secure, and more attractive buildings that meet the increasingly diverse and sophisticated needs of society by bringing together knowledge and other expertise in the fields of structure, fire protection, materials, and equipment.

This paper introduces some representative studies from the viewpoint of “architectures that respond to changes in social needs.”

2. Research to Realize Green Society

1) Promoting the Use of Wood in Mid- to High-Rise and Large-Scale Architectures

In order to realize a green society that aims to be carbon neutral by 2050, there is a need to expand the use of wood, which is highly effective in reducing greenhouse gas emissions, in buildings. To achieve this, it is necessary to establish design methods for structures and fire-proof performance that will serve as common rules for advancing the use of wood in mid- to high-rise and large-scale architectures. For this purpose, we conducted a comprehensive project, “Development of Design and Construction Technology for Mixed Structure Architecture with the Use of New Wooden Materials,” (FY2017-2021), to facilitate the realization of mid-rise complex structure architecture by combining the wooden construction using large wooden panels with reinforced concrete construction, steel construction, other wooden structure methods, etc. In particular, we set up prototype types of structures, including a type in which a wooden frame is freely installed inside a large RC structure (Photo 1) and the wooden components are shown on the interior surface, and then we verified, with experiments, the performance levels of structure, fire resistance, durability and sound insulation required to realize each type, and developed design and construction methods.

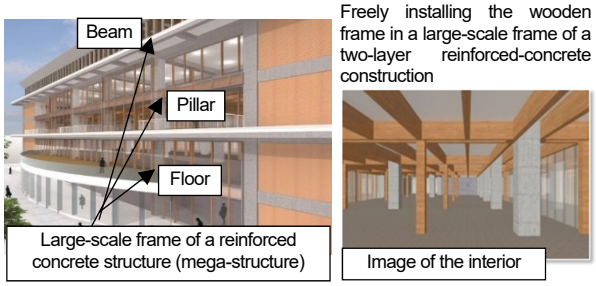


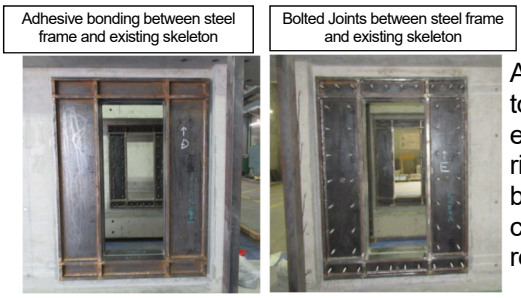
Photo 1. Example of the prototypes of frame form in mixed structure architecture

We will attempt to reflect achievements in research related to notifications in relation to the Building Standards Act, guidebooks of technological standards, etc. In addition, we will sum up the research achievements on the standard specifications of joint parts etc. and examples of the design of prototype architectures to support their proliferation as general technology. For the further promotion of the use of wood in architecture, on the other hand, we think that it is necessary to continue to cope with problems such as sophisticated structural design, fire-proof/fire-prevention design, securing durability performance, etc.

2) Promoting the Longevity and Efficient Use of Existing Reinforced Concrete Construction Housing Complexes

The degradation of housing complex aggregates, which were provided in large quantities during and after the rapid growth period, into old towns has become a social problem. In order to promote "environmentally friendly apartment complex revitalization" toward the realization of a green society, it is necessary to further extend the service life and effective utilization of existing RC housing complexes.

For this purpose, we are implementing the comprehensive project, “Development of Regeneration Technology for Suburban Housing Estates in Response to the Mature Society” (FY2018-2022). In relation to the evaluation of durability performance concerning the longevity of existing reinforced concrete housing complexes, we have been making efforts towards achieving the sophistication of evaluation methods by combining the influence of reinforcing bar corrosion etc. from local degradation risks in addition to conventional resistance to carbonation. As for housing aggregates, where the aging of the population is advancing and vacant houses are increasing, the efficient use of stock and promotion of the provision of houses is desirable to support the child-rearing generation, and also from the viewpoint of sustainability of the suburban housing estates. We are therefore developing a design method to expand space by creating openings in the structural walls between dwelling units of existing RC housing complexes, and a reinforcement technique to restore structural performance after the creation of openings (Photo 2), through experiments and other verification.



A loading test to verify and evaluate rigidity and bearing capacity after reinforcement

Photo 2. Testing of steel frame reinforcement around opening formation

3. Research for disaster prevention and disaster mitigation

1) Strengthening cities by promoting renewal of obsolete architecture

Realization of the regeneration of cities and strengthening cities by renewing obsolete architecture is an urgent problem. How we dispose of existing piles from obsolete architecture while promoting the renewal of architectures in narrow land at the center of cities etc. is one part of this problem.

For this purpose, we are implementing the comprehensive project, "Development of Technologies to Contribute to the Regeneration and Strengthening of Cities with Rational Structural Regulation Concerning Architectures and Land" (FY2020-2023). The project aims to develop (1) evaluation methods for structural safety when existing piles are reinforced and reused, (2) evaluation and design methods for structural safety when existing and new piles are used together, (3) performance evaluation methods for backfilling ground when existing piles are removed and backfilled (Photo 3), and so on through experiments and other verification, in order to enable various treatment methods for existing piles in consideration of freedom of architectural design and economic rationality.

Photo 3. Verifying the characteristics of the soil after removing existing piles

(Left) Removing existing piles (the end-cutting withdrawal method with casing)
(Right) Horizontal loading test of new piles installed on refilled land after removal

2) Resistance of roofs of existing architectures to strong wind

Typhoon 21 in 2018, Typhoon 15 in 2019, and other large-scale typhoons in recent years caused a large amount of damage to roof tiles on architectures, the roof trusses of wooden constructions, and so forth, which obstructed the continuity of residence and smooth recovery. It is anticipated that the influence from climate change may increase the damage occurring from large-scale typhoons; thus, the protection of weak portions of roofs from strong winds is an urgent task.

For this purpose, we are implementing the project, "Research on Anti-wind Examination and Technical Evaluation of the Reinforcement of Thatching Materials on Roofs of Existing Architectures" (FY2021-2023). The project aims to improve the wind resistance of roofs of existing buildings through the development of (1) wind resistance diagnosis methods to identify weak points of roofing materials, and (2) evaluation methods for reinforcement techniques according to the identified weak points and the required wind resistance performance level (from the level equivalent to the Building Standard Law to the highest level assumed to apply to disaster base buildings, etc.). Through these research efforts, we intends to induce improvements in the wind resistance of the roofs of existing buildings.

3) Sophistication of Fire-Prevention Performance of Non-residential Architectures

A fire at a physical distribution warehouse in Miyoshi Town, Saitama Prefecture, in February 2017 required a long time to extinguish, and caused a high level of economic damage including the disruption of the continuity of the business. While the sophistication of fire-prevention performance of non-residential architectures is one of our tasks, there is currently no system for evaluating fire-prevention performance of non-residential architectures and expressing it to the owner of the construction etc. in an attractive way.

For this purpose, we are implementing the project, "Development of New Performance Indices and Evaluation Programs Contributing to the Sophistication of Fire-prevention Performance of Non-residential Architectures" (FY2020-2022). The project aims to develop new indices for the comprehensive evaluation of functional continuity performance and a program for the evaluation of functional continuity performance in consideration of physical damage, recovery periods, etc. up to the level of members based on the results of the predicted characteristics of a fire inside the architecture at the time of the occurrence of the fire.

Note that, recently, there have been fires at physical distribution warehouses etc. that took a long time to extinguish and fire incidents with many victims. We think it is necessary to continuously conduct research to contribute to further measures in consideration of the problems associated with fire prevention or evacuation from existing non-residential architectures.

4. Toward New Research Triggered by the Covid-19 Pandemic

The Building Department continues to conduct research to precisely correspond to a various needs for architectures in relation to the variance and

sophistication of social needs.

We are conducting, starting in FY2022, our new comprehensive project, "Development of Technology to Evaluate the Performance of Houses and Architectures Corresponding to the Changes in the Social Environment" (FY2022-2026). The spread of novel coronavirus infection has triggered an increase in working from home, as well as the need for the home evacuation etc. at the time of a disaster. In consideration of such changes, we will develop (1) an evaluation method that is rational and easy to understand in terms of sound insulation performance and natural light permeation, (2) an evaluation method for anti-seismic performance from the viewpoint of the continuous use of houses and architectures after a large-scale earthquake, (3) an evaluation method of the continuous use of elevators after a large-scale earthquake, and so forth, leading to the propagation of high-performance the houses and architectures that may be attractive to consumers.

☞ Click here for more details

1) The website of the Architecture Research Department
http://www.nilim.go.jp/japanese/organization/kenchiku/jkenchiku.htm